# QUANTUM HARDWARE OF LIVING MATTER

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# 0.1 Background

*T(opological) G(eometro)D(ynamics)* is one of the many attempts to find a unified description of basic interactions. The development of the basic ideas of TGD to a relatively stable form took time of about half decade [16]. The great challenge is to construct a mathematical theory around these physically very attractive ideas and I have devoted the last twenty-three years for the realization of this dream and this has resulted in seven online books [1, 2, 4, 5, 3, 6, 7] about TGD and eight online books about TGD inspired theory of consciousness and of quantum biology [10, 8, 9, 13, 11, 12, 14, 15].

Quantum T(opological)D(ynamics) as a classical spinor geometry for infinite-dimensional configuration space, p-adic numbers and quantum TGD, and TGD inspired theory of consciousness have been for last decade of the second millenium the basic three strongly interacting threads in the tapestry of quantum TGD.

For few yeas ago the discussions with Tony Smith generated a fourth thread which deserves the name 'TGD as a generalized number theory'. The work with Riemann hypothesis made time ripe for realization that the notion of infinite primes could provide, not only a reformulation, but a deep generalization of quantum TGD. This led to a thorough and extremely fruitful revision of the basic views about what the final form and physical content of quantum TGD might be.

The fifth thread came with the realization that by quantum classical correspondence TGD predicts an infinite hierarchy of macroscopic quantum systems with increasing sizes, that it is not at all clear whether standard quantum mechanics can accommodate this hierarchy, and that a dynamical quantized Planck constant might be necessary and certainly possible in TGD framework. The identification of hierarchy of Planck constants whose values TGD "predicts" in terms of dark matter hierarchy would be natural. This also led to a solution of a long standing puzzle: what is the proper interpretation of the predicted fractal hierarchy of long ranged classical electro-weak and color gauge fields. Quantum classical correspondences allows only single answer: there is infinite hierarchy of p-adically scaled up variants of standard model physics and for each of them also dark hierarchy. Thus TGD Universe would be fractal in very abstract and deep sense.

TGD forces the generalization of physics to a quantum theory of consciousness, and represent TGD as a generalized number theory vision leads naturally to the emergence of p-adic physics as physics of cognitive representations. The seven online books [1, 2, 4, 5, 3, 6, 7] about TGD and eight online books about TGD inspired theory of consciousness and of quantum biology [10, 8, 9, 13, 11, 12, 14, 15] are warmly recommended to the interested reader.

# 0.2 Basic Ideas of TGD

The basic physical picture behind TGD was formed as a fusion of two rather disparate approaches: namely TGD is as a Poincare invariant theory of gravitation and TGD as a generalization of the old-fashioned string model.

## 0.2.1 TGD as a Poincare invariant theory of gravitation

The first approach was born as an attempt to construct a Poincare invariant theory of gravitation. Space-time, rather than being an abstract manifold endowed with a pseudo-Riemannian structure, is regarded as a surface in the 8-dimensional space $H = M^4_+ \times CP_2$, where $M^4_+$ denotes the interior of the future light cone of the Minkowski space (to be referred as light cone in the sequel) and $CP_2 = SU(3)/U(2)$ is the complex projective space of two complex dimensions [2, 18, 19, 5]. The identification of the space-time as a submanifold [21, 22] of $M^4 \times CP_2$ leads to an exact Poincare invariance and solves the conceptual difficulties related to the definition of the energy-momentum in General Relativity [Misner-Thorne-Wheeler, Logunov *et al*]. The actual choice $H = M^4_+ \times CP_2$ implies the breaking of the Poincare invariance in the cosmological scales but only at the quantum level. It soon however turned out that submanifold geometry, being considerably richer in structure than the abstract manifold geometry, leads to a geometrization of all basic interactions. First, the geometrization of the elementary particle quantum numbers is achieved. The geometry of $CP_2$ explains electro-weak and color quantum numbers. The different H-chiralities of $H$-spinors correspond to the conserved baryon and lepton numbers. Secondly, the geometrization of the field concept results. The projections of the $CP_2$ spinor connection, Killing vector fields of $CP_2$ and of $H$-metric to four-surface define classical electro-weak, color gauge fields and metric in $X^4$.

### 0.2.2 TGD as a generalization of the hadronic string model

The second approach was based on the generalization of the mesonic string model describing mesons as strings with quarks attached to the ends of the string. In the 3-dimensional generalization 3-surfaces correspond to free particles and the boundaries of the 3- surface correspond to partons in the sense that the quantum numbers of the elementary particles reside on the boundaries. Various boundary topologies (number of handles) correspond to various fermion families so that one obtains an explanation for the known elementary particle quantum numbers. This approach leads also to a natural topological description of the particle reactions as topology changes: for instance, two-particle decay corresponds to a decay of a 3-surface to two disjoint 3-surfaces.

### 0.2.3 Fusion of the two approaches via a generalization of the space-time concept

The problem is that the two approaches seem to be mutually exclusive since the orbit of a particle like 3-surface defines 4-dimensional surface, which differs drastically from the topologically trivial macroscopic space-time of General Relativity. The unification of these approaches forces a considerable generalization of the conventional space-time concept. First, the topologically trivial 3-space of General Relativity is replaced with a "topological condensate" containing matter as particle like 3-surfaces "glued" to the topologically trivial background 3-space by connected sum operation. Secondly, the assumption about connectedness of the 3-space is given up. Besides the "topological condensate" there is "vapor phase" that is a "gas" of particle like 3-surfaces (counterpart of the "baby universies" of GRT) and the nonconservation of energy in GRT corresponds to the transfer of energy between the topological condensate and vapor phase.

## 0.3 The five threads in the development of quantum TGD

The development of TGD has involved four strongly interacting threads: physics as infinite-dimensional geometry; p-adic physics; TGD inspired theory of consciousness and TGD as a generalized number theory. In the following these five threads are briefly described.

### 0.3.1 Quantum TGD as configuration space spinor geometry

A turning point in the attempts to formulate a mathematical theory was reached after seven years from the birth of TGD. The great insight was "Do not quantize". The basic ingredients to the new approach have served as the basic philosophy for the attempt to construct Quantum TGD since then and are the following ones:

a) Quantum theory for extended particles is free(!), classical(!) field theory for a generalized Schrödinger amplitude in the configuration space $CH$ consisting of all possible 3-surfaces in $H$. "All possible" means that surfaces with arbitrary many disjoint components and with arbitrary internal topology and also singular surfaces topologically intermediate between two different manifold topologies are included. Particle reactions are identified as topology changes [23, 24, 25]. For instance, the decay of a 3-surface to two 3-surfaces corresponds to the decay $A \rightarrow B + C$. Classically this corresponds to a path of configuration space leading from 1-particle sector to 2-particle sector. At quantum level this corresponds to the dispersion of the generalized Schrödinger amplitude localized to 1-particle sector to two-particle sector. All coupling constants should result as predictions of the theory since no nonlinearities are introduced.

b) Configuration space is endowed with the metric and spinor structure so that one can define various metric related differential operators, say Dirac operator, appearing in the field equations of the theory.

### 0.3.2 p-Adic TGD

The p-adic thread emerged for roughly ten years ago as a dim hunch that p-adic numbers might be important for TGD. Experimentation with p-adic numbers led to the notion of canonical identification mapping reals to p-adics and vice versa. The breakthrough came with the successful p-adic mass calculations using p-adic thermodynamics for Super-Virasoro representations with the super-Kac-Moody algebra associated with a Lie-group containing standard model gauge group. Although the details of the calculations have varied from year to year, it was clear that p-adic physics reduces not only the ratio of proton and Planck mass, the great mystery number of physics, but all elementary particle mass scales, to number theory if one assumes that primes near prime powers of two are in a physically favored position. Why this is the case, became one of the key puzzless and led to a number of arguments with a common gist: evolution is present already at the elementary particle level and the primes allowed by the p-adic length scale hypothesis are the fittest ones.

It became very soon clear that p-adic topology is not something emerging in Planck length scale as often believed, but that there is an infinite hierarchy of p-adic physics characterized by p-adic length scales varying to even cosmological length scales. The idea about the connection of p-adics with cognition motivated already the first attempts to understand the role of the p-adics and inspired 'Universe as Computer' vision but time was not ripe to develop this idea to anything concrete (p-adic numbers are however in a central role in TGD inspired theory of consciousness). It became however obvious that the p-adic length scale hierarchy somehow corresponds to a hierarchy of intelligences and that p-adic prime serves as a kind of intelligence quotient. Ironically, the almost obvious idea about p-adic regions as cognitive regions of space-time providing cognitive representations for real regions had to wait for almost a decade for the access into my consciousness.

There were many interpretational and technical questions crying for a definite answer. What is the relationship of p-adic non-determinism to the classical non-determinism of the basic field equations of TGD? Are the p-adic space-time region genuinely p-adic or does p-adic topology only serve as an effective topology? If p-adic physics is direct image of real physics, how the mapping relating them is constructed so that it respects various symmetries? Is the basic physics p-adic or real (also real TGD seems to be free of divergences) or both? If it is both, how should one glue the physics in different number field together to get *The Physics*? Should one perform p-adicization also at the level of the configuration space of 3-surfaces? Certainly the p-adicization at the level of super-conformal representation is necessary for the p-adic mass calculations. Perhaps the most basic and most irritating technical problem was how to precisely define p-adic definite integral which is a crucial element of any variational principle based formulation of the field equations. Here the frustration was not due to the lack of solution but due to the too large number of solutions to the problem, a clear symptom for the sad fact that clever inventions rather than real discoveries might be in question.

Despite these frustrating uncertainties, the number of the applications of the poorly defined p-adic physics growed steadily and the applications turned out to be relatively stable so that it was clear that the solution to these problems must exist. It became only gradually clear that the solution of the problems might require going down to a deeper level than that represented by reals and p-adics.

### 0.3.3 TGD as a generalization of physics to a theory consciousness

General coordinate invariance forces the identification of quantum jump as quantum jump between entire deterministic quantum histories rather than time=constant snapshots of single history. The new view about quantum jump forces a generalization of quantum measurement theory such that observer becomes part of the physical system. Thus a general theory of consciousness is unavoidable outcome. This theory is developed in detail in the books [10, 8, 9, 13, 11, 12, 14, 15].

#### Quantum jump as a moment of consciousness

The identification of quantum jump between deterministic quantum histories (configuration space spinor fields) as a moment of consciousness defines microscopic theory of consciousness. Quantum jump involves the steps

$$\Psi_i \rightarrow U\Psi_i \rightarrow \Psi_f \quad ,$$

where $U$ is informational "time development" operator, which is unitary like the S-matrix characterizing the unitary time evolution of quantum mechanics. $U$ is however only formally analogous to Schrödinger time evolution of infinite duration although there is *no* real time evolution involved. It is not however clear whether one should regard U-matrix and S-matrix as two different things or not: $U$-matrix is a completely universal object characterizing the dynamics of evolution by self-organization whereas S-matrix is a highly context dependent concept in wave mechanics and in quantum field theories where it at least formally represents unitary time translation operator at the limit of an infinitely long interaction time. The S-matrix understood in the spirit of superstring models is however something very different and could correspond to U-matrix.

The requirement that quantum jump corresponds to a measurement in the sense of quantum field theories implies that each quantum jump involves localization in zero modes which parameterize also the possible choices of the quantization axes. Thus the selection of the quantization axes performed by the Cartesian outsider becomes now a part of quantum theory. Together these requirements imply that the final states of quantum jump correspond to quantum superpositions of space-time surfaces which are macroscopically equivalent. Hence the world of conscious experience looks classical. At least formally quantum jump can be interpreted also as a quantum computation in which matrix $U$ represents unitary quantum computation which is however not identifiable as unitary translation in time direction and cannot be 'engineered'.

### The notion of self

The concept of self is absolutely essential for the understanding of the macroscopic and macro-temporal aspects of consciousness. Self corresponds to a subsystem able to remain un-entangled under the sequential informational 'time evolutions' $U$. Exactly vanishing entanglement is practically impossible in ordinary quantum mechanics and it might be that 'vanishing entanglement' in the condition for self-property should be replaced with 'subcritical entanglement'. On the other hand, if space-time decomposes into p-adic and real regions, and if entanglement between regions representing physics in different number fields vanishes, space-time indeed decomposes into selves in a natural manner.

It is assumed that the experiences of the self after the last 'wake-up' sum up to single average experience. This means that subjective memory is identifiable as conscious, immediate short term memory. Selves form an infinite hierarchy with the entire Universe at the top. Self can be also interpreted as mental images: our mental images are selves having mental images and also we represent mental images of a higher level self. A natural hypothesis is that self $S$ experiences the experiences of its subselves as kind of abstracted experience: the experiences of subselves $S_i$ are not experienced as such but represent kind of averages $\langle S_{ij}\rangle$ of sub-subselves $S_{ij}$. Entanglement between selves, most naturally realized by the formation of join along boundaries bonds between cognitive or material space-time sheets, provides a possible a mechanism for the fusion of selves to larger selves (for instance, the fusion of the mental images representing separate right and left visual fields to single visual field) and forms wholes from parts at the level of mental images.

### Relationship to quantum measurement theory

The third basic element relates TGD inspired theory of consciousness to quantum measurement theory. The assumption that localization occurs in zero modes in each quantum jump implies that the world of conscious experience looks classical. It also implies the state function reduction of the standard quantum measurement theory as the following arguments demonstrate (it took incredibly long time to realize this almost obvious fact!).

a) The standard quantum measurement theory a la von Neumann involves the interaction of brain with the measurement apparatus. If this interaction corresponds to entanglement between microscopic degrees of freedom $m$ with the macroscopic effectively classical degrees of freedom $M$ characterizing the reading of the measurement apparatus coded to brain state, then the reduction of this entanglement in quantum jump reproduces standard quantum measurement theory provide the unitary time evolution operator $U$ acts as flow in zero mode degrees of freedom and correlates completely some orthonormal basis of configuration space spinor fields in non-zero modes with the values of the zero modes. The flow property guarantees that the localization is consistent with unitarity: it also means 1-1 mapping of quantum state basis to classical variables (say, spin direction of the electron to its orbit in the external magnetic field).

b) Since zero modes represent classical information about the geometry of space-time surface (shape, size, classical Kähler field,...), they have interpretation as effectively classical degrees of freedom and are the TGD counterpart of the degrees of freedom $M$ representing the reading of the measurement apparatus. The entanglement between quantum fluctuating non-zero modes and zero modes is the TGD counterpart for the $m-M$ entanglement. Therefore the localization in zero modes is equivalent with a quantum jump leading to a final state where the measurement apparatus gives a definite reading.

This simple prediction is of utmost theoretical importance since the black box of the quantum measurement theory is reduced to a fundamental quantum theory. This reduction is implied by the replacement of the notion of a point like particle with particle as a 3-surface. Also the infinite-dimensionality of the zero mode sector of the configuration space of 3-surfaces is absolutely essential. Therefore the reduction is a triumph for quantum TGD and favors TGD against string models.

Standard quantum measurement theory involves also the notion of state preparation which reduces to the notion of self measurement. Each localization in zero modes is followed by a cascade of self measurements leading to a product state. This process is obviously equivalent with the state preparation process. Self measurement is governed by the so called Negentropy Maximization Principle (NMP) stating that the information content of conscious experience is maximized. In the self measurement the density matrix of some subsystem of a given self localized in zero modes (after ordinary quantum measurement) is measured. The self measurement takes place for that subsystem of self for which the reduction of the entanglement entropy is maximal in the measurement. In p-adic context NMP can be regarded as the variational principle defining the dynamics of cognition. In real context self measurement could be seen as a repair mechanism allowing the system to fight against quantum thermalization by reducing the entanglement for the subsystem for which it is largest (fill the largest hole first in a leaking boat).

### Selves self-organize

The fourth basic element is quantum theory of self-organization based on the identification of quantum jump as the basic step of self-organization [I1]. Quantum entanglement gives rise to the generation of long range order and the emergence of longer p-adic length scales corresponds to the emergence of larger and larger coherent dynamical units and generation of a slaving hierarchy. Energy (and quantum entanglement) feed implying entropy feed is a necessary prerequisite for quantum self-organization. Zero modes represent fundamental order parameters and localization in zero modes implies that the sequence of quantum jumps can be regarded as hopping in the zero modes so that Haken's classical theory of self organization applies almost as such. Spin glass analogy is a further important element: self-organization of self leads to some characteristic pattern selected by dissipation as some valley of the "energy" landscape.

Dissipation can be regarded as the ultimate Darwinian selector of both memes and genes. The mathematically ugly irreversible dissipative dynamics obtained by adding phenomenological dissipation terms to the reversible fundamental dynamical equations derivable from an action principle can be understood as a phenomenological description replacing in a well defined sense the series of reversible quantum histories with its envelope.

### Classical non-determinism of Kähler action

The fifth basic element are the concepts of association sequence and cognitive space-time sheet. The huge vacuum degeneracy of the Kähler action suggests strongly that the absolute minimum space-time is not always unique. For instance, a sequence of bifurcations can occur so that a given space-time branch can be fixed only by selecting a finite number of 3-surfaces with time like(!) separations on the orbit of 3-surface. Quantum classical correspondence suggest an alternative formulation. Space-time surface decomposes into maximal deterministic regions and their temporal sequences have interpretation a space-time correlate for a sequence of quantum states defined by the initial (or final) states of quantum jumps. This is consistent with the fact that the variational principle selects preferred extremals of Kähler action as generalized Bohr orbits.

In the case that non-determinism is located to a finite time interval and is microscopic, this sequence of 3-surfaces has interpretation as a simulation of a classical history, a geometric correlate for contents of consciousness. When non-determinism has long lasting and macroscopic effect one can identify it as volitional non-determinism associated with our choices. Association sequences relate closely with the cognitive space-time sheets defined as space-time sheets having finite time duration and psychological time can be identified as a temporal center of mass coordinate of the cognitive space-time sheet. The gradual drift of the cognitive space-time sheets to the direction of future force by the geometry of the future light cone explains the arrow of psychological time.

**p-Adic physics as physics of cognition and intentionality**

The sixth basic element adds a physical theory of cognition to this vision. TGD space-time decomposes into regions obeying real and p-adic topologies labelled by primes $p = 2, 3, 5, ....$ p-Adic regions obey the same field equations as the real regions but are characterized by p-adic non-determinism since the functions having vanishing p-adic derivative are pseudo constants which are piecewise constant functions. Pseudo constants depend on a finite number of positive pinary digits of arguments just like numerical predictions of any theory always involve decimal cutoff. This means that p-adic space-time regions are obtained by gluing together regions for which integration constants are genuine constants. The natural interpretation of the p-adic regions is as cognitive representations of real physics. The freedom of imagination is due to the p-adic non-determinism. p-Adic regions perform mimicry and make possible for the Universe to form cognitive representations about itself. p-Adic physics space-time sheets serve also as correlates for intentional action.

A more more precise formulation of this vision requires a generalization of the number concept obtained by fusing reals and p-adic number fields along common rationals (in the case of algebraic extensions among common algebraic numbers). This picture is discussed in [E1]. The application this notion at the level of the imbedding space implies that imbedding space has a book like structure with various variants of the imbedding space glued together along common rationals (algebraics). The implication is that genuinely p-adic numbers (non-rationals) are strictly infinite as real numbers so that most points of p-adic space-time sheets are at real infinity, outside the cosmos, and that the projection to the real imbedding space is discrete set of rationals (algebraics). Hence cognition and intentionality are almost completely outside the real cosmos and touch it at a discrete set of points only.

This view implies also that purely local p-adic physics codes for the p-adic fractality characterizing long range real physics and provides an explanation for p-adic length scale hypothesis stating that the primes $p \simeq 2^k$, $k$ integer are especially interesting. It also explains the long range correlations and short term chaos characterizing intentional behavior and explains why the physical realizations of cognition are always discrete (say in the case of numerical computations). Furthermore, a concrete quantum model for how intentions are transformed to actions emerges.

The discrete real projections of p-adic space-time sheets serve also space-time correlate for a logical thought. It is very natural to assign to p-adic pinary digits a $p$-valued logic but as such this kind of logic does not have any reasonable identification. p-Adic length scale hypothesis suggest that the $p = 2^k - n$ pinary digits represent a Boolean logic $B^k$ with $k$ elementary statements (the points of the $k$-element set in the set theoretic realization) with $n$ taboos which are constrained to be identically true.

### 0.3.4 TGD as a generalized number theory

Quantum T(opological)D(ynamics) as a classical spinor geometry for infinite-dimensional configuration space, p-adic numbers and quantum TGD, and TGD inspired theory of consciousness, have been for last ten years the basic three strongly interacting threads in the tapestry of quantum TGD. For few yeas ago the discussions with Tony Smith generated a fourth thread which deserves the name 'TGD as a generalized number theory'. It relies on the notion of number theoretic compactifiction stating that space-time surfaces can be regarded either as hyper-quaternionic, and thus maximally associative, 4-surfaces in $M^8$ identifiable as space of hyper-octonions or as surfaces in $M^4 \times CP_2$ [E2].

The discovery of the hierarchy of infinite primes and their correspondence with a hierarchy defined by a repeatedly second quantized arithmetic quantum field theory gave a further boost for the speculations about TGD as a generalized number theory. The work with Riemann hypothesis led to further ideas.

After the realization that infinite primes can be mapped to polynomials representable as surfaces geometrically, it was clear how TGD might be formulated as a generalized number theory with infinite primes forming the bridge between classical and quantum such that real numbers, p-adic numbers, and various generalizations of p-adics emerge dynamically from algebraic physics as various completions of the algebraic extensions of rational (hyper-)quaternions and (hyper-)octonions. Complete algebraic, topological and dimensional democracy would characterize the theory.

What is especially satisfying is that p-adic and real regions of the space-time surface could emerge automatically as solutions of the field equations. In the space-time regions where the solutions of field equations give rise to in-admissible complex values of the imbedding space coordinates, p-adic solution can exist for some values of the p-adic prime. The characteristic non-determinism of the p-adic differential equations suggests strongly that p-adic regions correspond to 'mind stuff', the regions of space-time where cognitive representations reside. This interpretation implies that p-adic physics is physics of cognition. Since Nature is probably extremely brilliant simulator of Nature, the natural idea is to study the p-adic physics of the cognitive representations to derive information about the real physics. This view encouraged by TGD inspired theory of consciousness clarifies difficult interpretational issues and provides a clear interpretation for the predictions of p-adic physics.

### 0.3.5 Dynamical quantized Planck constant and dark matter hierarchy

By quantum classical correspondence space-time sheets can be identified as quantum coherence regions. Hence the fact that they have all possible size scales more or less unavoidably implies that Planck constant must be quantized and have arbitrarily large values. If one accepts this then also the idea about dark matter as a macroscopic quantum phase characterized by an arbitrarily large value of Planck constant emerges naturally as does also the interpretation for the long ranged classical electro-weak and color fields predicted by TGD. Rather seldom the evolution of ideas follows simple linear logic, and this was the case also now. In any case, this vision represents the fifth, relatively new thread in the evolution of TGD and the ideas involved are still evolving.

#### Dark matter as large $\hbar$ phase

D. Da Rocha and Laurent Nottale [92] have proposed that Schrödinger equation with Planck constant $\hbar$ replaced with what might be called gravitational Planck constant $\hbar_{gr} = \frac{GmM}{v_0}$ ($\hbar = c = 1$). $v_0$ is a velocity parameter having the value $v_0 = 144.7 \pm .7$ km/s giving $v_0/c = 4.6 \times 10^{-4}$. This is rather near to the peak orbital velocity of stars in galactic halos. Also subharmonics and harmonics of $v_0$ seem to appear. The support for the hypothesis coming from empirical data is impressive.

Nottale and Da Rocha believe that their Schrödinger equation results from a fractal hydrodynamics. Many-sheeted space-time however suggests astrophysical systems are not only quantum systems at larger space-time sheets but correspond to a gigantic value of gravitational Planck constant. The gravitational (ordinary) Schrödinger equation would provide a solution of the black hole collapse (IR catastrophe) problem encountered at the classical level. The resolution of the problem inspired by TGD inspired theory of living matter is that it is the dark matter at larger space-time sheets which is quantum coherent in the required time scale [D6].

Already before learning about Nottale's paper I had proposed the possibility that Planck constant is quantized [E9] and the spectrum is given in terms of logarithms of Beraha numbers: the lowest Beraha number $B_3$ is completely exceptional in that it predicts infinite value of Planck constant. The inverse of the gravitational Planck constant could correspond a gravitational perturbation of this as $1/\hbar_{gr} = v_0/GMm$. The general philosophy would be that when the quantum system would become non-perturbative, a phase transition increasing the value of $\hbar$ occurs to preserve the perturbative character and at the transition $n = 4 \rightarrow 3$ only the small perturbative correction to $1/\hbar(3) = 0$ remains. This would apply to QCD and to atoms with $Z > 137$ as well.

TGD predicts correctly the value of the parameter $v_0$ assuming that cosmic strings and their decay remnants are responsible for the dark matter. The harmonics of $v_0$ can be understood as corresponding to perturbations replacing cosmic strings with their n-branched coverings so that tension becomes $n^2$-fold: much like the replacement of a closed orbit with an orbit closing only after $n$ turns. $1/n$-sub-harmonic would result when a magnetic flux tube split into n disjoint magnetic flux tubes. Also a model for the formation of planetary system as a condensation of ordinary matter around quantum coherent dark matter emerges [D6].

#### Dark matter as a source of long ranged weak and color fields

Long ranged classical electro-weak and color gauge fields are unavoidable in TGD framework. The smallness of the parity breaking effects in hadronic, nuclear, and atomic length scales does not however seem to allow long ranged electro-weak gauge fields. The problem disappears if long range classical electro-weak gauge fields are identified as space-time correlates for massless gauge fields created by dark matter. Also scaled up variants of ordinary electro-weak particle spectra are possible. The identification explains chiral selection in living matter and unbroken $U(2)_{ew}$ invariance and free color in bio length scales become characteristics of living matter and of bio-chemistry and bio-nuclear physics. An attractive solution of the matter antimatter asymmetry is based on the identification of also antimatter as dark matter.

#### p-Adic and dark matter hierarchies and hierarchy of moments of consciousness

Dark matter hierarchy assigned to a spectrum of Planck constant having arbitrarily large values brings additional elements to the TGD inspired theory of consciousness.

a) Macroscopic quantum coherence can be understood since a particle with a given mass can in principle appear as arbitrarily large scaled up copies (Compton length scales as $\hbar$). The phase transition to this kind of phase implies that space-time sheets of particles overlap and this makes possible macroscopic quantum coherence.

b) The space-time sheets with large Planck constant can be in thermal equilibrium with ordinary ones without the loss of quantum coherence. For instance, the cyclotron energy scale associated with EEG turns out to be above thermal energy at room temperature for the level of dark matter hierarchy corresponding to magnetic flux quanta of the Earth's magnetic field with the size scale of Earth and a successful quantitative model for EEG results [M3].

Dark matter hierarchy leads to detailed quantitative view about quantum biology with several testable predictions [M3]. The applications to living matter suggests that the basic hierarchy corresponds to a hierarchy of Planck constants coming as $\hbar(k) = \lambda^k(p)\hbar_0$, $\lambda \simeq 2^{11}$ for $p = 2^{127-1}$, $k = 0, 1, 2, ...$ [M3]. Also integer valued sub-harmonics and integer valued sub-harmonics of $\lambda$ might be possible. Each p-adic length scale corresponds to this kind of hierarchy and number theoretical arguments suggest a general formula for the allowed values of Planck constant $\lambda$ depending logarithmically on p-adic prime [C6]. Also the value of $\hbar_0$ has spectrum characterized by Beraha numbers $B_n = 4cos^2(\pi/n)$, $n \geq 3$, varying by a factor in the range $n > 3$ [C6]. It must be however emphasized that the relation of this picture to the model of quantized gravitational Planck constant $h_{gr}$ appearing in Nottale's model is not yet completely understood.

The general prediction is that Universe is a kind of inverted Mandelbrot fractal for which each bird's eye of view reveals new structures in long length and time scales representing scaled down copies of standard physics and their dark variants. These structures would correspond to higher levels in self hierarchy. This prediction is consistent with the belief that 75 per cent of matter in the universe is dark.

*1. Living matter and dark matter*

Living matter as ordinary matter quantum controlled by the dark matter hierarchy has turned out to be a particularly successful idea. The hypothesis has led to models for EEG predicting correctly the band structure and even individual resonance bands and also generalizing the notion of EEG [M3]. Also a generalization of the notion of genetic code emerges resolving the paradoxes related to the standard dogma [L2, M3]. A particularly fascinating implication is the possibility to identify great leaps in evolution as phase transitions in which new higher level of dark matter emerges [M3].

It seems safe to conclude that the dark matter hierarchy with levels labelled by the values of Planck constants explains the macroscopic and macro-temporal quantum coherence naturally. That this explanation is consistent with the explanation based on spin glass degeneracy is suggested by following observations. First, the argument supporting spin glass degeneracy as an explanation of the macro-temporal quantum coherence does not involve the value of $\hbar$ at all. Secondly, the failure of the perturbation theory assumed to lead to the increase of Planck constant and formation of macroscopic quantum phases could be precisely due to the emergence of a large number of new degrees of freedom due to spin glass degeneracy. Thirdly, the phase transition increasing Planck constant has concrete topological interpretation in terms of many-sheeted space-time consistent with the spin glass degeneracy.

*2. Dark matter hierarchy and the notion of self*

The vision about dark matter hierarchy leads to a more refined view about self hierarchy and hierarchy of moments of consciousness [J6, M3]. The larger the value of Planck constant, the longer the subjectively experienced duration and the average geometric duration $T(k) \propto \lambda^k$ of the quantum jump.

Quantum jumps form also a hierarchy with respect to p-adic and dark hierarchies and the geometric durations of quantum jumps scale like $\hbar$. Dark matter hierarchy suggests also a slight modification of the notion of self. Each self involves a hierarchy of dark matter levels, and one is led to ask whether the highest level in this hierarchy corresponds to single quantum jump rather than a sequence of quantum jumps. The averaging of conscious experience over quantum jumps would occur only for sub-selves at lower levels of dark matter hierarchy and these mental images would be ordered, and single moment of consciousness would be experienced as a history of events. The quantum parallel dissipation at the lower levels would give rise to the experience of flow of time. For instance, hadron as a macro-temporal quantum system in the characteristic time scale of hadron is a dissipating system at quark and gluon level corresponding to shorter p-adic time scales. One can ask whether even entire life cycle could be regarded as a single quantum jump at the highest level so that consciousness would not be completely lost even during deep sleep. This would allow to understand why we seem to know directly that this biological body of mine existed yesterday.

The fact that we can remember phone numbers with 5 to 9 digits supports the view that self corresponds at the highest dark matter level to single moment of consciousness. Self would experience the average over the sequence of moments of consciousness associated with each sub-self but there would be no averaging over the separate mental images of this kind, be their parallel or serial. These mental images correspond to sub-selves having shorter wake-up periods than self and would be experienced as being time ordered. Hence the digits in the phone number are experienced as separate mental images and ordered with respect to experienced time.

*3. The time span of long term memories as signature for the level of dark matter hierarchy*

The simplest dimensional estimate gives for the average increment $\tau$ of geometric time in quantum jump $\tau \sim 10^4$ $CP_2$ times so that $2^{127} - 1 \sim 10^{38}$ quantum jumps are experienced during secondary p-adic time scale $T_2(k = 127) \simeq 0.1$ seconds which is the duration of physiological moment and predicted to be fundamental time scale of human consciousness [L1]. A more refined guess is that $\tau_p = \sqrt{p}\tau$ gives the dependence of the duration of quantum jump on p-adic prime $p$. By multi-p-fractality predicted by TGD and explaining p-adic length scale hypothesis, one expects that at least $p = 2$-adic level is also always present. For the higher levels of dark matter hierarchy $\tau_p$ is scaled up by $\hbar/\hbar_0$. One can understand evolutionary leaps as the emergence of higher levels at the level of individual organism making possible intentionality and memory in the time scale defined $\tau$ [L2].

Higher levels of dark matter hierarchy provide a neat quantitative view about self hierarchy and its evolution. For instance, EEG time scales corresponds to $k = 4$ level of hierarchy and a time scale of .1 seconds [J6], and EEG frequencies correspond at this level dark photon energies above the thermal threshold so that thermal noise is not a problem anymore. Various levels of dark matter hierarchy would naturally correspond to higher levels in the hierarchy of consciousness and the typical duration of life cycle would give an idea about the level in question.

The level would determine also the time span of long term memories as discussed in [M3]. $k = 7$ would correspond to a duration of moment of conscious of order human lifetime which suggests that $k = 7$ corresponds to the highest dark matter level relevant to our consciousness whereas higher levels would in general correspond to transpersonal consciousness. $k = 5$ would correspond to time scale of short term memories measured in minutes and $k = 6$ to a time scale of memories measured in days.

The emergence of these levels must have meant evolutionary leap since long term memory is also accompanied by ability to anticipate future in the same time scale. This picture would suggest that the basic difference between us and our cousins is not at the level of genome as it is usually understood but at the level of the hierarchy of magnetic bodies [L2, M3]. In fact, higher levels of dark matter hierarchy motivate the introduction of the notions of super-genome and hyper-genome. The genomes of entire organ can join to form super-genome expressing genes coherently. Hyper-genomes would result from the fusion of genomes of different organisms and collective levels of consciousness would express themselves via hyper-genome and make possible social rules and moral.

## 0.4 Bird's eye of view about the topics of the book

In this book I will discuss in detail the view about the quantum hardware of living systems taking seriously the new physics predicted by TGD. Since the vision is bound to be look highly speculative, it is good to emphasize that the most important predictions follow almost without any reference to the classical field equations using only quantum classical correspondence.

*1. The implications deriving from the topology of space-time surface and from the properties of induced gauge fields*

Quantum classical correspondence and the properties of the simplest extremals of Kähler action have served as the basic guideline in the attempts to understand the new physics predicted by TGD. The most dramatic predictions follow without even considering field equations in detail by using only quantum classical correspondence. These predictions form the backbone of TGD and TGD inspired theory of living mater.

The notions of many-sheeted space-time, topological field quantization and the notion of field/magnetic body, follow from simple topological considerations. The observation that space-time sheets can have arbitrarily large sizes and their interpretation as quantum coherence regions forces to conclude that in TGD Universe macroscopic and macro-temporal quantum coherence are possible in arbitrarily long scales. It took a relatively long time to realize that perhaps the only manner to understand this is a generalization of the quantum theory itself by allowing Planck constant to be dynamical and quantized. TGD leads indeed to a "prediction" for the spectrum of Planck constants and macroscopic quantum phases with large value of Planck constant allow an identification as a dark matter hierarchy.

Also long ranged classical color and electro-weak fields are an unavoidable prediction and it took a considerable time to make the obvious conclusion: TGD Universe is fractal containing fractal copies of standard model physics at various space-time sheets and labeled by the collection of p-adic primes assignable to elementary particles and by the level of dark matter hierarchy characterized partially by the value of Planck constant labeling the pages of the book like structure formed by singular covering spaces of the imbedding space $M^4 \times CP_2$ glued together along a four-dimensional back. Particles at different pages are dark relative to each other since purely local interactions defined in terms of the vertices of Feynman diagram involve only particles at the same page.

The new view about energy and time finding a rigorous formulation in terms of zero energy ontology means that the sign of inertial energy depends on the time orientation of the space-time sheet and that negative energy space-time sheets serve as correlates for communications to the geometric past. This alone leads to profoundly new views about metabolism, long term memory, and realization of intentional action.

*2. Vacuum degeneracy of Kähler action as a correlate for quantum criticality and 4-dimensional spin glass degeneracy*

The general properties of Kähler action, in particular its vacuum degeneracy and the failure of the classical determinism in the conventional sense, have also very profound implications. Space-time surface as a generalization of Bohr orbit provides not only a representation for quantum state but also for sequences of quantum jumps and thus contents of consciousness. Vacuum degeneracy implies spin glass degeneracy in 4-D sense reflecting quantum criticality which is the fundamental characteristic of TGD Universe.

*3. The simplest extremals of Kähler action as correlates for asymptotic self organization patterns*

The detailed study of the simplest extremals of Kähler action interpreted as correlates for asymptotic self organization patterns provides additional insights [D1]. $CP_2$ type extremals representing elementary particles, cosmic strings, vacuum extremals, topological light rays ("massless extremal", ME), flux quanta of magnetic and electric fields represent the basic extremals. Pairs of wormhole throats identifiable as parton pairs define a completely new kind of particle carrying only color quantum numbers in ideal case and I have proposed their interpretation as quantum correlates for Boolean cognition. MEs and flux quanta of magnetic and electric fields are of special importance in living matter.

Topological light rays have interpretation as space-time correlates of "laser beams" of ordinary or dark photons or their electro-weak and gluonic counterparts. Neutral MEs carrying em and $Z^0$ fields are ideal for communication purposes and charged $W$ MEs ideal for quantum control. Magnetic flux quanta containing dark matter are identified as intentional agents quantum controlling the behavior of the corresponding biological body parts utilizing negative energy $W$ MEs. Bio-system in turn is populated by electrets identifiable as electric flux quanta.

*4. Topics discussed in the book*

1. Three chapters of this book are devoted to the model of high $T_c$ super-conductivity relying strongly on the notions of quantum criticality and dark matter.
2. Two chapters discuss quantum antenna hypothesis inspired by MEs and the notion of wormhole magnetic fields. Notice that the notion of wormhole magnetic field was introduced much before the hypothesis that bosons have a natural identification as wormhole contacts emerged.
3. Two chapters are devoted to the possible biological implications of the hypothesis that dark matter corresponds to macroscopic quantum phases characterized by a large value of Planck constant and is the key actor in living matter.
4. A possible identification of quantum correlates of sensory qualia is discussed assuming that qualia are in one-one correspondence with the increments of quantum numbers in quantum jump. Also a simple model for sensory receptor is introduced.

I must apologize the fact the implications of the dark matter revolution have not been thoroughly considered in this book. Same applies to the implications of zero energy ontology.

The seven online books about TGD [1, 2, 4, 5, 3, 6, 7] and eight online books about TGD inspired theory of consciousness and quantum biology [10, 8, 9, 13, 11, 12, 14, 15] are warmly recommended for the reader willing to get overall view about what is involved.

## 0.5 The contents of the book

### 0.5.1 PART I: Bio-systems as super-conductors

#### Bio-systems as superconductors: part I

In this chapter the description of super-conductivity in many-sheeted space-time is discussed. The notion of many-sheeted space-time alone provides strong motivation for this and I have developed various ideas about high $T_c$ super-conductivity in parallel with ideas about living matter as a macroscopic quantum system. A further motivation and a hope for more quantitative modelling comes from the discovery of various non-orthodox super-conductors including high $T_c$ superconductors, heavy fermion super-conductors and ferromagnetic superconductors. The standard BCS theory does not work for these super-conductors and the mechanism for the formation of Cooper pairs is not understood. There is experimental evidence that quantum criticality is a key feature of many non-orthodox super-conductors. TGD provides a conceptual framework and bundle of ideas making it possible to develop models for non-orthodox superconductors.

*1. Quantum criticality, hierarchy of dark matters, and dynamical $\hbar$*

Quantum criticality is the basic characteristic of TGD Universe and quantum critical superconductors provide an excellent test bed to develop the ideas related to quantum criticality into a more concrete form.

The hypothesis that $\hbar$ is dynamical possessing quantized spectrum adds further content to the notion of quantum criticality. Phases with different values of $\hbar$ behave like dark matter with respect to each other in the sense that they do not have direct interactions. In large $\hbar$ phases various quantum time and length scales are scaled up which means macroscopic and macro-temporal quantum coherence.

The great idea is that the transition to large $\hbar$ phase occurs when perturbation theory based on the expansion in terms of gauge coupling constant ceases to converge: Mother Nature would take care of the problems of theoretician. The transition to large $\hbar$ phase obviously reduces gauge coupling strength $\alpha$ so that higher orders in perturbation theory are reduced whereas the lowest order "classical" predictions remain unchanged. A possible quantitative formulation of the criterion is that maximal 2-particle gauge interaction strength parameterized as $Q_1Q_2\alpha$ satisfies the condition $Q_1Q_2\alpha \simeq 1$.

A further hypothesis is that in the transition to large $\hbar$ phase the scaling $\hbar \rightarrow n\hbar/v_0$, where $n$ is integer and $v_0 \simeq 2^{-11}$ is expressible in terms of the ratio of Planck length to $CP_2$ length scale.

The only coupling constant strength of theory is Kähler coupling constant $g_K^2$ which appears in the definition of the Kähler function $K$ characterizing the geometry of the configuration space of 3-surfaces (the "world of classical worlds"). The exponent of $K$ defines vacuum functional analogous to the exponent of Hamiltonian in thermodynamics. The allowed values of $g_K^2$, which are analogous to critical temperatures, are determined by quantum criticality requirement and labelled by p-adic primes. $\hbar$ appears in the commutation and anticommutation relations of various superconformal algebras but not in the vacuum functional. For a given p-adic length scale space-time sheets with all allowed values of $\hbar$ are therefore possible. Hence the spectrum of quantum critical fluctuations could in the ideal case correspond to the spectrum of $\hbar$ coding for the scaled up values of Compton lengths and other quantal lengths and times. If so, large $\hbar$ phases could be crucial for understanding of quantum critical superconductors, in particular high $T_c$ superconductors.

TGD actually predicts an infinite hierarchy of phases behaving like dark or partially dark matter with respect to the ordinary matter and the value of $\hbar$ is only one characterizer of these phases. These phases, especially so large $\hbar$ phase, seem to be essential for the understanding of even ordinary hadronic, nuclear and condensed matter physics. This strengthens the motivations for finding whether dark matter might be involved with quantum critical super-conductivity.

*2. Many-sheeted space-time concept and ideas about macroscopic quantum phases*

Many-sheeted space-time leads to obvious ideas concerning the realization of macroscopic quantum phases.

1. The dropping of particles to larger space-time sheets is a highly attractive mechanism of super-conductivity. If space-time sheets are thermally isolated, the larger space-time sheets could be at extremely low temperature and super-conducting.

2. The possibility of large $\hbar$ phases allows to give up the assumption that space-time sheets characterized by different p-adic length scales are thermally isolated. The scaled up versions of a given space-time sheet corresponding to a hierarchy of values of $\hbar$ are possible such that the scale of kinetic energy and magnetic interaction energy remain same for all these space-time sheets. For instance, for scaled up variants of space-time sheet having size scale characterized by $L(151) = 10$ nm (cell membrane thickness) the critical temperature for superconductivity could be higher than room temperature.

3. The idea that wormhole contacts can form macroscopic quantum phases and that the interaction of ordinary charge carriers with the wormhole contacts feeding their gauge fluxes to larger space-time sheets could be responsible for the formation of Cooper pairs, have been around for a decade. The realization that wormhole contacts can be regarded as parton-antiparton pairs with parton and antiparton assignable to the light-like causal horizons accompanying wormhole contacts, opens the doors for more concrete models. The simplest idea is that em charged Cooper pairs can be modelled as a pair of charged particles at a space-time sheet $X_c^4$ topologically condensed to the background space-time sheet $Y^4$ of condensed matter system. The Coulombic binding energy of charges particles with the quarks and antiquarks assignable to the wormhole throats feeding the em gauge flux to $Y^4$ could be responsible for the energy gap.

4. Quantum classical correspondence has turned out be a very powerful idea generator. For instance, one can ask what are the space-time correlates for various notions of condensed matter such as phonons, BCS Cooper pairs, holes, etc... For instance, TGD predicts the existence of negative energy space-time sheets so that ordinary particles can and must exist in negative energy states (in cosmological scales the density of inertial energy is predicted to vanish). The question is whether holes could have quite concrete representation as negative energy space-time sheets carrying negative energy particles and whether the notion of Cooper pair of holes could have this kind of space-time correlate.

*3. Model for high $T_c$ superconductivity*

These general ideas lead to a concrete model for high $T_c$ superconductors as quantum critical superconductors allowing to understand the characteristic spectral lines as characteristics of the Cooper pair. The model for quantum critical electronic Cooper pairs generalizes to Cooper pairs of fermionic ions and for sufficiently large $\hbar$ stability criteria, in particular thermal stability conditions, can be satisfied in a given length scale. Also high $T_c$ superfluidity based on dropping of bosonic atoms to Cooper pair space-time sheets where they form Bose-Einstein condensate is possible and part of copper atoms are predicted to be dark matter.

At qualitative level the model explains various strange features of high $T_c$ superconductors such as the existence of pseudogap: this is due to the fact that two kinds of super-conductivities corresponding to BCS type large $\hbar$ supra currents at interior and boundary supra currents carried by wormholy Cooper pairs. At quantitative level the model predicts correctly the four poorly understood photon absorption lines and allows to understand the critical doping ratio. The current carrying structures have structure similar to that of axon including the double layered structure of cell membrane and also the size scales are predicted to be same so that the idea that axons are high $T_c$ superconductors is highly suggestive.

*4. Empirical evidence for high $T_c$ superconductivity in bio-systems*

The evidence for super-conductivity in bio-systems. DNA should be insulator but under some circumstances it becomes conductor and perhaps even high $T_c$ quantum critical super-conductor. Also evidence for Josephson effect has been reported. The so called ORMEs patented by Hudson are claimed to behave like superconductors: unfortunately the academic world has not taken these claims seriously enough to test them. The claimed properties of ORMEs conform with high quantum critical $T_c$ super-conductivity and superfluidity. The strange findings about the strange quantal behavior of ionic currents through cell membranes suggest the presence of ionic supra currents.

**Bio-systems as superconductors: part II**

The general model for quantum control and coordination relies crucially on the existence of a hierarchy of superconductors associated with the self hierarchy (self defined as a quantum system able to avoid bound state entanglement with environment) controlling the ionic densities at atomic space-time sheets via many-sheeted ionic flow equilibrium and being quantum controlled with the mediation of the fractal hierarchy of MEs.

*1. General mechanisms for superconductivity*

The many-sheeted space-time concept provides a very general mechanism of superconductivity based on the 'dropping' of charged particles from atomic space-time sheets to larger space-time sheets. The first guess was that larger space-time sheets are very dry, cool and silent so that the necessary conditions for the formation of high $T_c$ macroscopic quantum phases are met.

The possibility of large hbar quantum coherent phases makes however the assumption about thermal isolation between space-time sheets un-necessary. At larger space-time sheet the interactions of the charged particles with classical em fields generated by various wormhole contacts feeding gauge fluxes to and from the space-time sheet in question give rise to the necessary gap energy. The simplest model for Cooper pair is space-time sheet containing charged particles having attractive Coulombic interaction with the quarks and antiquarks associated with the throats of the wormhole contacts.

A crucial element is quantum criticality predicting that superconductivity appears at the fluctuating boundaries of competing ordinary and large $\hbar$ phases for nuclei. This assumption predicts several anomalous phenomena such as cold fusion and nuclear transmutations. Also high $T_c$ superfluidity of bosonic atoms dropped to space-time sheets of electronic Cooper pairs becomes possible besides ionic super conductivity. Even dark neutrino superconductivity can be considered below the weak length scale of scaled down weak bosons.

Magnetic and $Z^0$ magnetic flux tubes and walls are especially interesting candidates for supra current carries. In this case the Cooper pairs must have spin one and this is indeed possible for wormholy Cooper pairs. The fact that the critical magnetic ($Z^0$ magnetic) fields can be very weak or large values of $\hbar$ is in accordance with the idea that various almost topological quantum numbers characterizing induced magnetic fields provide a storage mechanism of bio-information.

This mechanism is extremely general and works for electrons, protons, ions, charged molecules and even exotic neutrinos so that an entire zoo of high $T_c$ bio-superconductors, super-fluids and Bose-Einstein condensates is predicted. Of course, there are restrictions due to the critical temperature and it seems that only electron, neutrino, and proton Cooper pairs are possible at room temperature.

1. The experimental data about the effects of ELF em fields at cyclotron frequencies of various ions in Earth's magnetic field on bio-systems provide support for this scenario. Most remarkably, the cyclotron frequencies of biologically important ions correspond to the important frequencies of EEG and the time scale of nerve pulse corresponds to $n = 3$ multiple of proton cyclotron frequency so that a direct quantitative contact with brain consciousness results.

2. Electronic super conductors are of type II with defect regions being typically cylindrical: DNA sequences, proteins, microtubules,... could provide examples of the defect regions. One ends up also with a model of high $T_c$ super conductors in which the interaction of the electrons with wormhole BE condensate gives rise to Cooper pairs. The model explains elegantly the basic peculiar features of the high $T_c$ superconductors.

3. Long ranged $Z^0$ force due to anomalous weak isospin of nuclei and $Z^0$ charged wormholes make possible also $Z^0$ ionic superconductivity and even dark neutrino super conductivity. For instance, $Z^0$ ionic superconductivity is crucial in the model for the quantum correlate of hearing: audible frequencies are mapped to $Z^0$ cyclotron frequencies. Dark neutrino super conductors are of type I in the interesting length scale range and defect regions are stripe like. Besides cell and endoplasma membranes, epithelial sheets consisting of two cell layers and some larger structures in cortex could correspond to regions of this kind and the interpretation as a physical realization of cognitive hierarchy suggests itself.

*2. Superconductivity at magnetic flux quanta in astrophysical length scales*

Magnetic flux tubes of Earth's magnetic field are crucial for the TGD based model of superconductivity. Since the models of auroras assume that the magnetic flux lines act effectively as conducting wires, the natural hypothesis is that superconductivity is an astrophysical phenomenon. This leads to a model of auroras explaining the latest findings and providing further insights to the superconductivity and the manner how it breaks down. Critical temperature is the temperature at which the join along boundaries bonds making possible the leakage of the supra currents to the non-superconducting space-time sheets become possible and can be gigantic as compared to the temperature at the superconducting space-time sheets.

*3. Fractal hierarchy of EEGs*

There are three contributions to EEG besides neural noise: Schumann frequencies, cyclotron frequencies, and the frequencies associated with Josephson junctions determined by the sum of the constant voltage and voltage perturbation determined by the superposition of cyclotron frequencies. Cyclotron contribution can be interpreted as a control signal from a magnetic body in question labelled by $k_d$ and affects both the ions at the flux sheets traversing DNA and the Josephson junction. The coherent state of photons generated by Josephson current corresponds to a reaction to this signal received by the magnetic body as a feedback. Schumann frequencies can be assigned to the control by magnetic body of Earth and correlate with the collective aspects of consciousness.

The analysis of the Josephson current leads to the conclusion that the frequencies in the coherent state of photons are in general sums and differences of Josephson frequency and harmonics of cyclotron frequencies. For small amplitudes this implies that alpha band to which the cyclotron frequencies most biologically important bosonic ions corresponds has as satellites theta and beta bands. Higher harmonics correspond to gamma and higher bands having also satellites. For large amplitudes EEG becomes chaotic which is indeed the property of beta band during say intense concentration or anxiety. The findings of Nunez about narrow 1-2 Hz wide bands at 3,5,7 Hz and 13,15,17 Hz confirm with the prediction of satellite bands and fix the Josephson frequency to 5 Hz. This picture explains the general characteristics of EEG in wake-up state qualitatively and quantitatively.

In order to understand the characteristics during various stages of deep sleep one must assume that the cyclotron frequency scale of ions is scaled down by a factor of 1/2. One explanation is that right *resp.* left brain hemisphere corresponds to $Z = 2$ *resp.* $Z = 1$ quantization condition $Z \int BdS = n\hbar$ for the magnetic flux. $Z = 2$ case allows only doubly charged bosonic ions at magnetic flux sheets. $Z = 1$ case also also singly charged ions be their bosons or fermions and for this option magnetic field is scaled down by a factor of 1/2. The alternative explanation is that during sleep only Bose-Einstein condensates of singly charged exotic ions resulting when color bond inside nucleus becomes charged are present. This reduces the scale of cyclotron frequencies by a factor 1/2 and leaves only theta and delta bands. During stage 4 sleep only only DNA cyclotron frequencies in delta band are around 1 Hz and just above the thermal threshold are predicted to be present. For $k_d = 3$ and magnetic field scaled up by $\lambda$ and flux tube area scaled down by $\lambda^{-2}$ DNA frequencies are scaled up to kHz for $Z = 2$ flux quantization and might define neuronal synchronization frequencies.

*4. The effects of ELF em fields on brain*

The experimental data about the effects of ELF em fields at cyclotron frequencies of various ions in the magnetic field $B_{end} = 2B_E/5 = .2$ Gauss, where $B_E = .5$ Gauss is the nominal Earth's magnetic field, on vertebrate brains provide a test bench for the fractal hierarchy of EEGs. As a matter fact, it was the attempt to explain these effects, which eventually led to the discovery of the fractal hierarchy of EEGs and ZEGs.

The reported effects occur for harmonics of cyclotron frequencies of biologically important ions in $B_{end}$. They occur only in amplitude windows. The first one is around $10^{-7}$ V/m and second corresponds to the range $1-10$ V/m: the amplitudes of EEG waves are in the range 5-10 V/m. The effects are present only in the temperature interval 36-37 C.

The temperature interval has interpretation in terms of quantum criticality of high $T_c$ superconductivity (both interior and boundary super currents are possible in this interval). Amplitude windows correspond to resonant EEG bands if the voltage perturbations contribute to the voltages over Josephson junctions and are thus coded to EEG. That the effects occur only for cyclotron frequencies and in the amplitude windows can be understood if there is AND gate involved. The voltage signal affects the interior of the cell nucleus opening communication line to the magnetic body if a harmonic of cyclotron frequency is in question. The signal affects also the Josephson junction which sends a signal to magnetic body if the voltage of the perturbation is large enough and corresponds to a frequency in the resonance band of EEG. The response of the magnetic body affects nucleus only if the communication line is open. This AND gate eliminates very effectively the effects of neural noise.

**Bio-systems as Superconductors: Part III**

This chapter is devoted to further applications of the theory of high $T_c$ superconductors as quantum critical superconductors involving dark matter hierarchy and large values of $\hbar$. The theory is applied to explain the strange findings about ionic currents through cell membrane, exotic neutrino superconductivity and the notion of cognitive neutrino pair are discussed, and the possibility that superconductivity and Bose-Einstein condensates are involved with atmospheric phenomena is considered.

*1. Strange behavior of cellular water and quantal ionic currents through cell membrane*

The fact that cellular water does not leak out of cell in a centrifugal force suggests that some fraction of water inside cell is in different phase. One explanation is that the nuclei of water inside cell are in doubly dark phase whereas electrons are in singly dark phase (having Compton length of 5 nm and perhaps directly "visible" using day technology!) as indeed predicted by the model of high Tc superconductivity. This conceptual framework could explain various findings challenging the notions of ionic pumps.

The empirical findings challenging the notions of ionic pumps and channels, nicely summarized by G. Pollack in his book, provide a strong support for the notions of many-sheeted space-time and ionic super-conductivity.

1. The selectivity of the cell membrane implies that channels cannot be simple sieves and there must be complex information processing involved.

2. The needed number of pumps specialized to particular ions is astronomical and the first question is where to put all these channels and pumps. On the other hand, if the cell constructs the pump or channel specialized to a given molecule only when needed, how does it know what the pump looks like if it has never seen the molecule? The needed metabolic energy to achieve all the pumping and channelling is huge. Strangely enough, pumping does not stop when cell metabolism stops.

3. One can also wonder why the ionic currents through cell membrane look quantal and are same through cell membrane and silicon rubber membrane.

These observations suggest strongly the presence non-dissipative ionic currents and quantum self-organization. The TGD based explanation would be in terms of high $T_c$ electronic and possibly even ionic superconductivity associated with cell membrane made possible by the large $\hbar$ phase for nuclei and electrons in the interior of cell. It however seems that thermal stability conditions allow only protonic Cooper pairs in the model of ionic Cooper pairs based on direct generalization of the model of high $T_c$ electronic super conductivity. This does not however mean that quantal ionic currents would be absent. This empirical input also supports a view about homeostasis as a many-sheeted ionic flow equilibrium controlled by larger space-time sheets with the mediation of massless extremals (MEs) serving as space-time correlates for Bose-Einstein condensates of massless bosons (also of scaled down dark electro-weak bosons and gluons).

In the proposed picture one can understand how extremely low densities of ions and their supra currents can control much higher ion densities at the atomic space-time sheets. The liquid crystal nature of the bio-matter is crucial for the model. This vision allows also much better understanding of the effects of ELF em fields on bio-matter. Also the effects of homeopathic remedies and acupuncture known to crucially involve electromagnetic frequency signatures of chemicals can be understood if homeostasis is based on many-sheeted ionic flow equilibrium.

*2. Dark $Z^0$ magnetic fields and cognition*

Similar arguments as in the em case apply in the scale $L_w$=.2 $\mu$m for $Z^0$ magnetic transitions with scale about $10^4$ eV much above the thermal energy scale. The hierarchy of length scales is now $L_w$=.2 $\mu$m, .4 mm, .8 m,.... $L_w$=.4 mm, possibly characterizing mm sized cortical modules, corresponds roughly to a frequency scale 40/A Hz, A atomic weight. The thermal stability supports the earlier idea that $Z^0$ force, dark neutrino superconductivity, $\nu\overline{\nu}$ wormhole contacts, and ZEG relate to cognition which must be thermally insulated whereas electromagnetic interactions would relate to sensory perception which could be highly sensitive even to temperature differences.

*3. Dark neutrino super conductivity*

Neutrinos play a key role in TGD based model for cognition and hearing and it is interesting to see whether this model survives the radically different interpretation of long ranged weak fields forcing to introduce large $\hbar$ variants of $k = 113$ weak bosons. The notion of cognitive neutrino pair generalizes elegantly to $\nu\overline{\nu}$ wormhole contact such that $\nu$ is dark neutrino coupling to exotic light weak bosons. The model for quantum critical electronic superconductivity discussed in previous chapter generalizes in a rather straightforward manner and together with its electronic counterpart correctly predicts and provides interpretation for the fundamental biological length scales.

A strong deviation from the previous picture is that one must however assume that the neutrinos which are most relevant for cognition correspond to $k = 127$ and mass of order .5 MeV. Quantum model of hearing, which is one of the quantitative victories of TGD inspired theory of consciousness, is not affected appreciably if one requires that the Gaussian Mersennes $k = 167, 163, 157$ label scaled down copies of charged leptons with $k = 113$ defining the mass scales of exotic weak bosons. Neutrino mass scale should be much lower than .5 eV mass of exotic electron (the metabolic energy quantum by the way) rather than .5 MeV mass scale.

The large neutrino mass scale could be understood as effective mass scale if the neutrino space-time sheets are connected by color magnetic flux tubes with $k = 127$ quarks at their ends in the same manner as nucleons form nuclear strings in TGD based model of nucleus. Also leptomesons, which have been identified as pion like bound states of color octet leptons and explain the anomalous production of electron pairs in the scattering of heavy nuclei just above Coulomb wall, could be understood as exotic $k = 167$ lepton space-time sheets connected together by color bonds having $k = 127$ quarks at their ends. There would be quark-antiquark pair per lepton making possible color octet state.

*4. Atmospheric phenomena and superconductivity*

There is a considerable evidence that various electromagnetic time scales associated with the atmospheric phenomena correspond to those associated with brain functioning. If magnetic sensory canvas hypothesis holds true, this is just what is expected. In this section these phenomena are considered in more detail with the aim being to build as concrete as possible vision about the dynamics involving the dark matter Bose-Einstein condensates at super-conducting magnetic and $Z^0$ magnetic flux quanta.

Tornadoes and hurricanes provide the first example of self-organizing systems for which Bose-

Einstein condensates of dark matter at magnetic and $Z^0$ magnetic flux quanta might be of relevance. Auroras represent a second phenomenon possibly involving supra currents of Cooper pairs and of exotic ions. Lightnings, sprites and elves might also involve higher levels of dark matter hierarchy. p-Adic length scale hypothesis and the hierarchy of Planck constants provide a strong grasp to these far from well-understood phenomena and allow to build rather detailed models for them as well as to gain concrete understanding about how dark matter hierarchy manifests itself in the electromagnetic phenomena at the level of atmosphere.

## 0.5.2 PART II: Topological light rays and wormhole magnetic fields

### Quantum antenna hypothesis

So called massless extremals are non-vacuum extremals of both Kähler action and the EYM action serving as effective action of the theory. These extremals have cylindrical geometry and are carriers of purely classical vacuum currents and Einstein tensor, which are both light like. These vacuum currents generate coherent states of photons and gravitons with frequences coming as multiples of the basic frequency determined by the length of the microtubule. It is proposed that microtubules and other linear structures could act as quantum antennae so that coherent light is for brain same as radiowaves for us. Massless extremals associated with axonal microtubules or axons themselves could serve as waveguides for the photons of coherent light and realize the notion of neural window abstracted from the paradigm of holographic brain. Vacuum currents could be also behind the ability of the bio-systems to form representations of the external world.

There is indeed evidence for the quantum antenna hypothesis: some monocellulars are known to possess primitive microtubular vision, bio-photons of Popp could could be generated by massless extremals and the observations of Callahan support the view that odor perception of insects relies on maserlike emissions by the odour molecules. The coherent light emitted in sonoluminescence could be generated by lightlike vacuum currents associated with regions with size given roughly by the diameter of microtubule when vapour-to-liquid phase transition occurs at the final stage of the bubble collapse. Also the observed direct transformation of kinetic energy of fluid motion to chemical energy could involve generation of massless extremals.

The lightlike boundaries of MEs have the same miraculous conformal properties as the boundary of future lightcone and MEs also allow holography in the sense of quantum gravity and string models and there are good hopes to generalize the construction of the configuration space geometry and quantum TGD to take into account the classical non-determinism of Kähler action. MEs provide a justification for the intuition that the supercanonical and superconformal symmetries of the lightcone boundary $\delta M^4_+ \times CP_2$, which are cosmological symmetries, generalize to approximate macroscopic symmetries acting on the lightlike boundaries of the space-time sheets inside future lightcone and broken only by quantum gravity. Supercanonical symmetries almost-commute with Poincare symmetries and the gigantic almost-degenerate supercanonical multiplets defined by genuinely quantum gravitational state functionals in the 'world of worlds' correspond in a well-defined sense to higher abstraction level expected to be crucial for understanding consciousness. MEs are also taylor-made for quantum holography and teleportation. Quantum holography conceptualization inspires much more detailed views about how bio-systems process information and how this information becomes conscious.

### Wormhole magnetic fields

It is argued that two purely TGD based concepts: topological field quantization and wormhole BE condensate are fundamental for the understanding of biosystems.

*1. Basic concepts*

Quantum classical correspondence suggests that gauge charges and p-adic coupling constant should have space-time counterparts. The first problem is to define precisely the concepts like classical gauge charge, gauge flux, topological condensation and evaporation. The crucial ingredients in the model are so called $CP_2$ type extremals. The realization that # contacts (topological sum contacts and $\#_B$ contacts (join along boundaries bonds) are accompanied by causal horizons which carry quantum numbers and allow identification as partons leads to a solution of this problem.

The partons associated with topologically condensed $CP_2$ type extremals carry elementary particle vacuum numbers whereas the parton pairs associated with # contacts connecting two space-time sheets with Minkowskian signature of induced metric define parton pairs. These parton pairs do not correspond to ordinary elementary particles. Gauge fluxes through # contacts can be identified as gauge charges of the partons. Gauge fluxes between space-time sheets can be transferred through # and $\#_B$ contacts concentrated near the boundaries of the smaller space-time sheet.

*2. Model for topologically quantized magnetic fields*

Topological field quantization replaces classical magnetic fields with bundles of flux tubes parallel to the field lines; flux tubes are cylindrical 3-surfaces with outer boundary. In particular, *"wormhole magnetic fields"* having charged wormholes situated at the boundaries of the flux tubes as their sources, are possible and are vacuum configurations in the sense that they do not contain ordinary matter at all. Since wormholes are very light particles, they suffer BE condensation, and the resulting structure is macroscopic quantum system.

If the space-time sheets associated with the wormhole magnetic field have opposite time orientation, the structure can have vanishing net energy and is thus an ideal candidate for a mindlike space-time sheet (or pair of these). These structures can be glued to the boundary of material space-time sheet and they form a cognitive local representation for the classical fields at the material space-time sheets by a direct mimicry! Thus wormhole magnetic fields and more general structures of the same kind could realize quantum physicist's version about the computer scientist's dream about universe consisting of Turing machines emulating each other.

*3. Models for Comorosan effect, phantom DNA effect, and homeopathy*

It is shown that the concept of wormhole magnetic field leads to a rather detailed understanding of *Comorosan effect* and *phantom DNA effect*. Homeopathy could be explained in terms of the mindlike space-time sheets mimicking the properties of the drug and left to the solution in the repeated dilution of the drug. Wormhole magnetic fields provide a quantum mechanism of control from distance, say of the control of the behavior of cell organelles by cell nucleus as well as a model for the memory of bio-system in terms of integer valued winding numbers identifiable as quantized momenta of wormhole supra currents. Wormhole magnetic fields can also represent defects of electron and neutrino super conductors and serve as a templates for the topological condensation of ordinary matter. The fact that wormhole flux tubes are *hollow* cylinders, is in nice accordance with this idea (microtubules, axonal membranes, etc. are hollow cylinders).

*4. TGD inspired model for psychokinesis*

A model of psychokinesis (PK) based on the concept of wormhole magnetic field is proposed. The basic philosophy is that PK is not just some isolated exotic phenomenon but only a special case of the voluntary control of bodily motions, which we all routinely perform. The only difference is that the range of voluntary control extends over the boundaries of the body in case of PK. The conclusion is that PK phenomena must involve classical long range fields, which give for bio-systems spatial extension larger than what is visible (that is hands with which to grasp on external object!). According to TGD inspired theory of consciousness, cell, and even DNA can be conscious, and perform choices. Thus the model should also provide understanding about small scale bio-control such as the (possibly voluntary!) control of the motion of cell organelles performed by cell nucleus. There is also alternative approach to the understanding of psychokinesis based on the possibility of creation of space-time sheets having negative time orientation and negative classical energy density and one could consider the possibility that poltergeist effects could involve this mechanism. Many-sheeted space-time concept makes possible also psychokinesis based on levitation: what is needed that subsystem is able to topologically condense to a sufficiently large space-time sheet carrying very weak gravitational fields.

### 0.5.3 PART III: Dark matter and living matter

**Dark Nuclear Physics and Condensed Matter**

The unavoidable presence of classical long ranged weak (and also color) gauge fields in TGD Universe has been a continual source of worries for more than two decades. The basic question has been whether $Z^0$ charges of elementary particles are screened in electro-weak length scale or not. For a long time the hypothesis was that the charges are feeded to larger space-time sheets in this length scale rather than screened by vacuum charges so that an effective screening results in electro-weak length scale.

A more promising approach inspired by the TGD based view about dark matter assumes that weak charges are indeed screened for ordinary matter in electro-weak length scale but that dark electro-weak bosons correspond to much longer symmetry breaking length scale.

*1. What darkness means?*

It is not at all obvious what darkness means and one can consider two variants.

1. The weak form of darkness states that only some field bodies of the particle consisting of flux quanta mediating bound state interactions between particles become dark. One can assign to each interaction a field body (em, $Z^0$, $W$, gluonic, gravitational) and p-adic prime and the value of Planck constant characterize the size of the particular field body. One might even think that particle mass can be assigned with its em field body and that Compton length of particle corresponds to the size scale of em field body.

2. The strong form of the hypothesis states that particle space-time sheet is distinguishable from em field body and can become dark. The space-time sheet of the particle would be associated with the covering $H = M^4 \times CP_2 \rightarrow H/G_a \times G_b$, where $G_a$ and $G_b$ are subgroups of $SU(2)$ characterizing Jones inclusions, and would be analogous to a many-sheeted Riemann surface. The large value of $\hbar$ in dark matter phase would mean that Compton lengths and -times are scaled up. A model of dark atom based on this view about darkness leads to the notion of $N$-atom (each sheet of the multiple covering can carry electron so that Fermi statistics apparently fails).

Nuclear string model suggests that the sizes of color flux tubes and weak flux quanta associated with nuclei can become dark in this sense and have size of order atomic radius so that dark nuclear physics would have a direct relevance for condensed matter physics. If this happens, it becomes impossible to make a reductionistic separation between nuclear physics and condensed matter physics and chemistry anymore.

*2. What dark nucleons are?*

The basic hypothesis is that nuclei can make a phase transition to dark phase in which the size of both quarks and nuclei is measured in Angstroms. For the less radical option this transition could happen only for the color, weak, and em field bodies. Proton connected by dark color bonds super-nuclei with inter-nucleon distance of order atomic radius might be crucial for understanding the properties of water and perhaps even the properties of ordinary condensed matter. Large $\hbar$ phase for weak field body of $D$ and $Pd$ nuclei with size scale of atom would explain selection rules of cold fusion.

*3. Anomalous properties of water and dark nuclear physics*

A direct support for partial darkness of water comes from the $H_{1.5}O$ chemical formula supported by neutron and electron diffraction in attosecond time scale. The explanation would be that one fourth of protons combine to form super-nuclei with protons connected by color bonds and having distance sufficiently larger than atomic radius.

The crucial property of water is the presence of molecular clusters. Tedrahedral clusters allow an interpretation in terms of magic Z=8 protonic dark nuclei. The icosahedral clusters consisting of 20 tedrahedral clusters in turn have interpretation as magic dark dark nuclei: the presence of the dark dark matter explains large portion of the anomalies associated with water and explains the unique role of water in biology. In living matter also higher levels of dark matter hierarchy are predicted to be present. The observed nuclear transmutation suggest that also light weak bosons are present.

*4. Implications of the partial darkness of condensed matter*

The model for partially dark condensed matter inspired by nuclear string model and the model of cold fusion inspired by it allows to understand the low compressibility of the condensed matter as being due to the repulsive weak force between exotic quarks, explains large parity breaking effects in living matter, and suggests a profound modification of the notion of chemical bond having most important implications for bio-chemistry and understanding of bio-chemical evolution.

**Quantum Coherent Dark Matter and Bio-Systems as Macroscopic Quantum Systems**

In this chapter a general vision about the unexpected relationships between cosmology, hadron physics, and biology is discussed. The vision is based on p-adic fractality implying that physics and consciousness should share same basic elements in all scales, and to quite recent dramatic discoveries in astrophysics and hadron physics suggesting that the value of Planck constant might be dynamical as I have proposed earlier. One implication is that living systems would correspond to a large value of Planck constant. This would mean that elementary quantum units correspond to systems consisting of very many elementary particles and that characteristic time and length scales are scaled up from those predicted by ordinary quantum theory so that macroscopic and macro-temporal quantum coherence become possible. *1. Dark matter as macroscopic quantum phase with a gigantic value of Planck constant*

A rather unexpected support for the macroscopic quantum coherence comes from the work of D. Da Rocha and Laurent Nottale who have proposed that Schrödinger equation with Planck constant $\hbar$ replaced with what might be called gravitational Planck constant $\hbar_{gr} = \frac{GmM}{v_0}$ ($\hbar = c = 1$). $v_0$ is a velocity parameter having the value $v_0 = 144.7 \pm .7$ km/s giving $v_0/c = 4.6 \times 10^{-4}$. This is rather near to the peak orbital velocity of stars in galactic halos. Also subharmonics and harmonics of $v_0$ seem to appear. The support for the hypothesis coming from empirical data is impressive.

Nottale and Da Rocha believe that their Schrödinger equation results from a fractal hydrodynamics. Many-sheeted space-time however suggests astrophysical systems are not only quantum systems at larger space-time sheets but correspond to a gigantic value of gravitational Planck constant. The gravitational (ordinary) Schrödinger equation would provide a solution of the black hole collapse (IR catastrophe) problem encountered at the classical level. The resolution of the problem inspired by TGD inspired theory of living matter is that it is the dark matter at larger space-time sheets which is quantum coherent in the required time scale.

I have proposed already earlier the possibility that Planck constant is quantized. The spectrum is given in terms of integers $n$ characterizing the quantum phases $q = exp(i\pi/n)$. The Planck constants associated with $M^4$ and $CP_2$ degrees of freedom are predicted to be different in general and arbitrarily large values of Planck constants are possible so that $\hbar_{gr} = GMm/v_0$ can be understood in this framework. The general philosophy would be that when the quantum system would become non-perturbative, a phase transition increasing the value of $\hbar$ occurs to preserve the perturbative character. This would apply to QCD and to atoms with $Z > 137$ as well.

The integers $n$ which correspond to polygons constructible using ruler and compass are number theoretically preferred. This gives very strong constraints on planetary masses, their general mass scale, and also on the value of $v_0$. The constraints are satisfied with accuracy better than 10 per cent.

TGD predicts correctly the value of the parameter $v_0$ assuming that cosmic strings and their decay remnants are responsible for the dark matter. The harmonics of $v_0$ can be understood as corresponding to perturbations replacing cosmic strings with their n-branched coverings so that tension becomes $n^2$-fold: much like the replacement of a closed orbit with an orbit closing only after $n$ turns. $1/n$-subharmonic would result when a magnetic flux tube split into n disjoint magnetic flux tubes.

The rather amazing coincidences between basic bio-rhythms and the periods associated with the states of orbits in solar system suggest that the frequencies defined by the energy levels of the gravitational Schrödinger equation might entrain with various biological frequencies such as the cyclotron frequencies associated with the magnetic flux tubes. For instance, the period associated with $n = 1$ orbit in the case of Sun is 24 hours within experimental accuracy for $v_0$.

*2. How the scaling of $\hbar$ affects physics?*

It is relatively easy to deduce the basic implications of the scaling of $\hbar$.

1. If the rate for the process is non-vanishing classically, it is not affected in the lowest order. For instance, scattering cross sections for say electron-electron scattering and $e^+e^-$ annihilation are not affected in the lowest order since the increase of Compton length compensates for the reduction of $\alpha_{em}$. Photon-photon scattering cross section, which vanishes classically and is proportional to $\alpha_{em}^4\hbar^2/E^2$, scales down as $1/\hbar^2$.

2. Higher order corrections coming as powers of the gauge coupling strength $\alpha$ are reduced since $\alpha = g^2/4\pi\hbar$ is reduced. Since one has $\hbar_s/\hbar = \alpha Q_1 Q_2/v_0$, $\alpha Q_1 Q_2$ is effectively replaced with a

universal coupling strength $v_0$. In the case of QCD the paradoxical sounding implication is that $\alpha_s$ would become very small.

3. The binding energy scale $E \propto \alpha_{em}^2 m_e$ of atoms scales as $1/\hbar^2$ so that a partially dark matter for which protons have large value of $\hbar$ does not interact appreciably with the visible light. Scaled down spectrum of binding energies would be the experimental signature of dark matter. The resulting atomic spectrum is universal and binding energy scale $\alpha^2 m_e$ is replaced with $v_0^2 m_e$ which corresponds to $\sim$ .115 eV and wavelength of $\simeq$ 10.78 $\mu$m, a typical size of cell. Bohr radius is 12.2 nm for dark hydrogen atom whereas the thickness of cell membrane is about 10 nm. It would be amazing if living matter would exhibit scaled down atomic spectra with this universal energy scale.

*3. Hadronic black holes and new view about dark matter*

Important steps in the development of ideas were stimulated by the findings made during period 2002-2005 in Relativist Heavy Ion Collider (RHIC) in Brookhaven compared with the discovery of America and for full reason. In particular, the observed production of black-hole like object in heavy ion collisions support the view that in non-perturbative phase of QCD matter possesses large value of $\hbar$ and becomes thus analogous to dark matter. Even more, the earlier model for macroscopic quantum states as resulting when conformal weights of partons become complex such that net conformal weight is real, leads to a general hypothesis that conformal confinement is what forces the system to behave like single coherent quantum unit with large value of $\hbar$. Surprisingly precise analogies with black hole formation and evaporation or equivalently with big crush followed by big bang describable as scaled down version of TGD inspired cosmology, emerge.

*4. Consciousness and cosmology*

Consciousness and cosmology represents a rather weird association from the point of view of materialistically inclined cosmologist. p-Adic physics of cognition however predicts that cognitive consciousness is unavoidably a cosmic phenomenon as far its space-time correlates are considered. Magnetic flux tube hierarchy provides the template for the evolution of conscious, intelligent systems in all length scales in TGD Universe, and bio-systems are predicted to possess magnetic bodies of astrophysical size. Adding to this the enormous spectrum of non-deterministic vacuum extremals (with respect to inertial energy) of field equations allowing interpretation as space-time correlates of intentional action, one has good motivations for a serious consideration of the possibility that intentionality might be realized in astrophysical length scales. There is even some evidence that Sun might act as an intentional system. Fortunately, these speculations are not empty since rather dramatic testable phenomena are predicted.

*5. Dark matter and living matter*

The notion of magnetic body containing macroscopic quantum phases responsible for bio-control introduced already earlier, and the fact that dark matter would reside at magnetic flux tubes, motivate the hypothesis that living matter is actually dark matter with the large value of Planck constant determining the characteristic time and length scales of a conscious system. Complex conformal weights for single particles states and closely related to the zeros of Riemann Zeta would make the many-particle system living. p-Adic fractality allows to deduce rather striking similarities between biology, cosmology, and hadron physics.

*6. Dark matter and classical long range electro-weak and color gauge fields*

Long ranged classical electro-weak and color gauge fields are unavoidable in TGD framework. The smallness of the parity breaking effects in hadronic, nuclear, and atomic length scales does not however seem to allow long ranged electro-weak gauge fields. The problem disappears if long range classical electro-weak gauge fields are identified as space-time correlates for massless gauge fields created by dark matter. The identification explains chiral selection in living matter and unbroken $U(2)_{ew}$ invariance and free color in bio length scales are predicted to characterize bio-chemistry and bio-nuclear physics. An attractive solution of the matter antimatter asymmetry is based on the identification of also antimatter as dark matter.

### About the new physics behind quantum biology

This chapter was originally about the new physics behind qualia. The model of qualia indeed involves a lot of new physics: many-sheeted space-time; massless extremals; exotic Super Virasoro representations associated with discrete qualia; magnetic and cyclotron phase transitions associated with quantum critical quantum spin glass phases of exotic super conductors at cellular space-time sheets; classical color and electro-weak gauge fields in macroscopic length scales, to name the most important ingredients. Gradually the chapter however expanded so that it touches practically all new physics possibly relevant to TGD inspired quantum biology. Various physical mechanisms are discussed in exploratory spirit rather than restricting the consideration to those ideas which seem to be the final word about quantum biology or qualia just at this moment.

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# Part I

# BIO-SYSTEMS AS SUPER CONDUCTORS

# Chapter 1

# Bio-Systems as Super-Conductors: Part I

## 1.1 Introduction

In this chapter various TGD based ideas related to the role of super-conductivity in bio-systems are studied. TGD inspired theory of consciousnses provides several motivations for this.

1. Supra currents and Josephson currents provide excellent tools of bio-control allowing large space-time sheets to control the smaller space-time sheets. The predicted hierarchy of dark matter phases characterized by a large value of $\hbar$ and thus possessing scaled up Compton and de Broglie wavelengths allows to have quantum control of short scales by long scales utilizing de-coherence phase transition. Quantum criticality is the basic property of TGD Universe and quantum critical super-conductivity is therefore especially natural in TGD framework. The competing phases could be ordinary and large $\hbar$ phases and supra currents would flow along the boundary between the two phases.

2. It is possible to make a tentative identification of the quantum correlates of the sensory qualia quantum number increments associated with the quantum phase transitions of various macroscopic quantum systems [K3] and various kind of Bose-Einstein condensates and super-conductors are the most relevant ones in this respect.

3. The state basis for the fermionic Fock space spanned by $N$ creation operators can be regarded as a Boolean algebra consisting of statements about $N$ basic statements. Hence fermionic degreees of freedom could correspond to the Boolean mind whereas bosonic degrees of freedom would correspond to sensory experiencing and emotions. The integer valued magnetic quantum numbers (a purely TGD based effect) associated with the defect regions of super conductors of type I provide a very robust information storage mechanism and in defect regions fermionic Fock basis is natural. Hence not only fermionic super-conductors but also their defects are biologically interesting [L1, M6].

### 1.1.1 General ideas about super-conductivity in many-sheeted space-time

The notion of many-sheeted space-time alone provides a strong motivation for developing TGD based view about superconductivity and I have developed various ideas about high $T_c$ super-conductivity [24] in parallel with ideas about living matter as a macroscopic quantum system. A further motivation and a hope for more quantitative modelling comes from the discovery of various non-orthodox super-conductors including high $T_c$ superconductors [24, 41, 40], heavy fermion super-conductors and ferromagnetic superconductors [19, 21, 20]. The standard BCS theory does not work for these super-conductors and the mechanism for the formation of Cooper pairs is not understood. There is experimental evidence that quantum criticality [18] is a key feature of many non-orthodox super-conductors. TGD provides a conceptual framework and bundle of ideas making it possible to develop models for non-orthodox superconductors.

#### Quantum criticality, hierarchy of dark matters, and dynamical $\hbar$

Quantum criticality is the basic characteristic of TGD Universe and quantum critical superconductors provide an excellent test bed to develop the ideas related to quantum criticality into a more concrete form.

The hypothesis that Planck constants in $M^4$ and $CP_2$ degrees of freedom are dynamical possessing quantized spectrum given as integer multiples of minimum value of Planck constant [A9] adds further content to the notion of quantum criticality.

Phases with different values of $M^4$ and $CP_2$ Planck constants given by $\hbar(M^4) = n_a\hbar_0$ and $\hbar(CP_2) = n_b\hbar_0$ behave like dark matter with respect to each other in the sense that they do not have direct interactions except at criticality corresponding to a leakage between different sectors of imbedding space glued together along $M^4$ or $CP_2$ factors. The scalings of $M^4$ and $CP_2$ covariant metrics are from anyonic arguments given by $(n_b/n_a)^2$ and 1 so that the value of effective $\hbar$ appearing in Schrödinger equation is given by $\hbar/\hbar_0 = n_a/n_b$ and in principle can have all positive rational values. In large $\hbar(M^4)$ phases various quantum time and length scales are scaled up which means macroscopic and macro-temporal quantum coherence.

Number theoretic considerations favor the hypothesis that the integers corresponding to Fermat polygons constructible using only ruler and compass and given as products $n_F = 2^k \prod_s F_s$, where $F_s = 2^{2^s} + 1$ are distinct Fermat primes, are favored. The reason would be that quantum phase $q = exp(i\pi/n)$ is in this case expressible using only iterated square root operation by starting from rationals. The known Fermat primes correspond to $s = 0, 1, 2, 3, 4$ so that the hypothesis is very strong and predicts that p-adic length scales have satellite length scales given as multiples of $n_F$ of fundamental p-adic length scale. $n_F = 2^{11}$ corresponds in TGD framework to a fundamental constant expressible as a combination of Kähler coupling strength, $CP_2$ radius and Planck length appearing in the expression for the tension of cosmic strings, and seems to be especially favored in living matter [M3].

The only coupling constant strength of theory is Kähler coupling constant $g_K^2$ which appears in the definition of the Kähler function $K$ characterizing the geometry of the configuration space of 3-surfaces (the "world of classical worlds"). The exponent of $K$ defines vacuum functional analogous to the exponent of Hamiltonian in thermodynamics. The allowed value(s) of $g_K^2$, which is (are) analogous to critical temperature(s), is (are) determined by quantum criticality requirement. Contrary to the original hypothesis inspired by the requirement that gravitational coupling is renormalization group invariant, $\alpha_K$ does not seem to depend on p-adic prime whereas gravitational constant is proportional to $L_p^2$. The situation is saved by the assumption that gravitons correspond to the largest non-super-astrophysical Mersenne prime $M_{127}$ so that gravitational coupling is effectively RG invariant in p-adic coupling constant evolution [C3].

$\hbar(M^4)$ and $\hbar(CP_2)$ appear in the commutation and anticommutation relations of various super-conformal algebras. Only the ratio $\hbar/\hbar_0 = n_a/n_b$ of $M^4$ and $CP_2$ Planck constants appears in Kähler action and is due to the fact that the $M^4$ and $CP_2$ metrics of the imbedding space sector with given values of Planck constants are proportional to the corresponding Planck constants [A9]. This implies that Kähler function codes for radiative corrections to the classical action, which makes possible to consider the possibility that higher order radiative corrections to functional integral vanish as one might expect at quantum criticality. For a given p-adic length scale space-time sheets with all allowed values of Planck constants are possible. Hence the spectrum of quantum critical fluctuations could in the ideal case correspond to the spectrum of Planck constants coding for the scaled up values of Compton lengths and other quantal lengths and times. If so, large $\hbar$ phases could be crucial for understanding of quantum critical superconductors, in particular high $T_c$ superconductors. For a fixed value of $n_a/n_b$ one obtains zoomed up versions of particles with size scaled up by $n_a$.

A further great idea is that the transition to large $\hbar$ phase occurs when perturbation theory based on the expansion in terms of gauge coupling constant ceases to converge: Mother Nature would take care of the problems of theoretician. The transition to large $\hbar$ phase obviously reduces gauge coupling strength $\alpha$ so that higher orders in perturbation theory are reduced whereas the lowest order "classical" predictions remain unchanged. A possible quantitative formulation of the criterion is that maximal 2-particle gauge interaction strength parameterized as $Q_1Q_2\alpha$ satisfies the condition $Q_1Q_2\alpha \simeq 1$.

TGD actually predicts an infinite hierarchy of phases behaving like dark or partially dark matter with respect to the ordinary matter [F6] and the value of $\hbar$ is only one characterizer of these phases. These phases, especially so large $\hbar$ phase, seem to be essential for the understanding of even ordinary hadronic, nuclear and condensed matter physics [F6, F8, F10]. This strengthens the motivations for finding whether dark matter might be involved with quantum critical super-conductivity.

Cusp catastrophe serves as a metaphor for criticality. In the recent case temperature and doping are control variables and the tip of cusp is at maximum value of $T_c$. Critical region correspond to the cusp catastrophe. Quantum criticality suggests the generalization of the cusp to a fractal cusp. Inside the critical lines of cusp there are further cusps which corresponds to higher levels in the hierarchy of dark matters labelled by increasing values of $\hbar$ and they correspond to a hierarchy of subtle quantum coherent dark matter phases in increasing length scales. The proposed model for high $T_c$ super-conductivity involves only single value of Planck constant but it might be that the full description involves very many values of them.

#### Many-sheeted space-time concept and ideas about macroscopic quantum phases

Many-sheeted space-time leads to obvious ideas concerning the realization of macroscopic quantum phases.

1. The dropping of particles to larger space-time sheets is a highly attractive mechanism of super-conductivity. If space-time sheets are thermally isolated, the larger space-time sheets could be at extremely low temperature and super-conducting.

2. The possibility of large $\hbar$ phases allows to give up the assumption that space-time sheets characterized by different p-adic length scales are thermally isolated. The scaled up versions of a given space-time sheet corresponding to a hierarchy of values of $\hbar$ are possible such that the scale of kinetic energy and magnetic interaction energy remain same for all these space-time sheets. For instance, for scaled up variants of space-time sheet having size scale characterized by $L(151) = 10$ nm (cell membrane thickness) the critical temperature for superconductivity could be higher than room temperature.

3. The idea that wormhole contacts can form macroscopic quantum phases and that the interaction of ordinary charge carriers with the wormhole contacts feeding their gauge fluxes to larger space-time sheets could be responsible for the formation of Cooper pairs, have been around for a decade [J5]. The rather recent realization that wormhole contacts can be actually regarded as space-time correlates for Higgs particles leads also to a new view about the photon massivation in super-conductivity.

4. Quantum classical correspondence has turned out be a very powerful idea generator. For instance, one can ask what are the space-time correlates for various notions of condensed matter such as phonons, BCS Cooper pairs, holes, etc... For instance, TGD predicts the existence of negative energy space-time sheets so that ordinary particles can and must exist in negative energy states (in cosmological scales the density of inertial energy is predicted to vanish [D5]). The question is whether holes could have quite concrete representation as negative energy space-time sheets carrying negative energy particles and whether the notion of Cooper pair of holes could have this kind of space-time correlate.

### 1.1.2 Model for high $T_c$ superconductivity

The model for high $T_c$ super-conductivity relies on the notions of quantum criticality, dynamical Planck constant, and many-sheeted space-time.

These ideas lead to a concrete model for high $T_c$ superconductors as quantum critical superconductors allowing to understand the characteristic spectral lines as characteristics of interior and boundary Cooper pairs bound together by phonon and color interaction respectively. The model for quantum critical electronic Cooper pairs generalizes to Cooper pairs of fermionic ions and for sufficiently large $\hbar$ stability criteria, in particular thermal stability conditions, can be satisfied in a given length scale. Also high $T_c$ superfluidity based on dropping of bosonic atoms to Cooper pair space-time sheets where they form Bose-Einstein condensate is possible.

At qualitative level the model explains various strange features of high $T_c$ superconductors. One can understand the high value of $T_c$ and ambivalent character of high $T_c$ super conductors suggesting both BCS type Cooper pairs and exotic Cooper pairs with non-vanishing spin, the existence of pseudogap and scalings laws for observables above $T_c$, the role of stripes and doping and the existence of a critical doping, etc... An unexpected prediction is that coherence length is actually $\hbar/\hbar_0 = 2^{11}$ times longer than the coherence length predicted by conventional theory so that type I super-conductor would be in question with stripes serving as duals for the defects of type I super-conductor in nearly critical magnetic field replaced now by ferromagnetic phase.

At quantitative level the model predicts correctly the four poorly understood photon absorption lines and the critical doping ratio from basic principles. The current carrying structures have structure locally similar to that of axon including the double layered structure of cell membrane and also the size scales are predicted to be same so that the idea that axons are high $T_c$ superconductors is highly suggestive.

### 1.1.3 Empirical evidence for high $T_c$ superconductivity in bio-systems

The evidence for super-conductivity in bio-systems. DNA should be insulator but under some circumstances it becomes conductor [99] and perhaps even high $T_c$ quantum critical super-conductor. Also evidence for Josephson effect has been reported [27]. The so called ORMEs patented by Hudson [102] are claimed to behave like superconductors: unfortunately the academic world has not taken these claims seriously enough to test them. The claimed properties of ORMEs conform with high quantum critical $T_c$ super-conductivity and superfluidity. The strange findings about the strange quantal behavior of ionic currents through cell membranes [46] suggest the presence of ionic supra currents. This evidence is discussed in the next chapter [J2].

## 1.2 General TGD based view about super-conductivity

Today super-conductivity includes besides the traditional low temperature super-conductors many other non-orthodox ones [17]. These unorthodox super-conductors carry various attributes such cuprate, organic, dichalcogenide, heavy fermion, bismute oxide, ruthenate, antiferromagnetic and ferromagnetic. Mario Rabinowitz has proposed a simple phenomenological theory of superfluidity and super-conductivity which helps non-specialist to get a rough quantitative overall view about super-conductivity [17].

### 1.2.1 Basic phenomenology of super-conductivity

#### Basic phenomenology of super-conductivity

The transition to super-conductivity occurs at critical temperature $T_c$ and involves a complete loss of electrical resistance. Super-conductors expel magnetic fields (Meissner effect) and when the external magnetic field exceeds a critical value $H_c$ super-conductivity is lost either completely or partially. In the transition to super-conductivity specific heat has singularity. For long time magnetism and super-conductivity were regarded as mutually exclusive phenomena but the discovery of ferromagnetic super-conductors [19, 21] has demonstrated that reality is much more subtle.

The BCS theory developed by Bardeen, Cooper, and Schrieffer in 1957 provides a satisfactory model for low $T_c$ super-conductivity in terms of Cooper pairs. The interactions of electrons with the crystal lattice induce electron-electron interaction binding electrons to Cooper pairs at sufficiently low temperatures. The electrons of Cooper pair are at the top of Fermi sphere (otherwise they cannot interact to form bound states) and have opposite center of mass momenta and spins. The binding creates energy gap $E_{gap}$ determining the critical temperature $T_c$. The singularity of the specific heat in the transition to super-conductivity can be understood as being due to the loss of thermally excitable degrees of freedom at critical temperature so that heat capacity is reduced exponentially. BCS theory has been successful in explaining the properties of low temperature super conductors but the high temperature super-conductors discovered in 1986 and other non-orthodox superconductors discovered later remain a challenge for theorists.

The reasons why magnetic fields tend to destroy super-conductivity is easy to understand. Lorentz force induces opposite forces to the electrons of Cooper pair since the momenta are opposite. Magnetic field tends also to turn the spins in the same direction. The super-conductivity is destroyed in fields for which the interaction energy of magnetic moment of electron with field is of the same order of magnitude as gap energy $E_{gap} \sim T_c$: $e\hbar H_c/2m \sim T_c$.

If spins are parallel, the situation changes since only Lorentz force tends to destroy the Cooper pair. In high $T_c$ super-conductors this is indeed the case: electrons are in spin triplet state ($S = 1$) and the net orbital angular momentum of Cooper pair is $L = 2$. The fact that orbital state is not $L = 0$ state makes high $T_c$ super-conductors much more fragile to the destructive effect of impurities than conventional super-conductors (due to the magnetic exchange force between electrons responsible for magnetism). Also the Cooper pairs of $^3He$ superfluid are in spin triplet state but have $S = 0$.

The observation that spin triplet Cooper pairs might be possible in ferro-magnets stimulates the question whether ferromagnetism and super-conductivity might tolerate each other after all, and the answer is affirmative [21]. The article [19] provides an enjoyable summary of experimental discoveries.

#### Basic parameters of super-conductors from universality?

Super conductors are characterized by certain basic parameters such as critical temperature $T_c$ and critical magnetic field $H_c$, densities $n_c$ and $n$ of Cooper pairs and conduction electrons, gap energy $E_{gap}$, correlation length $\xi$ and magnetic penetration length $\lambda$. The super-conductors are highly complex systems and calculation of these parameters from BCS theory is either difficult or impossible.

It has been suggested [17] that these parameters might be more or less universal so that they would not depend on the specific properties of the interaction responsible for the formation of Cooper pairs. The motivation comes from the fact that the properties of ordinary Bose-Einstein condensates do not depend on the details of interactions. This raises the hope that these parameters might be expressible in terms of some basic parameters such as $T_c$ and the density of conduction electrons allowing to deduce Fermi energy $E_F$ and Fermi momentum $k_F$ if Fermi surface is sphere. In [17] formulas for the basic parameters are indeed suggested based on this of argumentation assuming that Cooper pairs form a Bose-Einstein condensate.

1. The most important parameters are critical temperature $T_c$ and critical magnetic field $H_c$ in principle expressible in terms of gap energy. In [17] the expression for $T_c$ is deduced from the condition that the de Broglie wavelength $\lambda$ must satisfy in supra phase the condition

   $$\lambda \geq 2d = 2(\frac{n_c}{g})^{-1/D} \tag{1.2.1}$$

   guaranteing the quantum overlap of Cooper pairs. Here $n_c$ is the density of Bose-Einstein condensate of Cooper pairs and $g$ is the number of spin states and $D$ the dimension of the condensate. This condition follows also from the requirement that the number of particles per energy level is larger than one (Bose-Einstein condensation).

   Identifying this expression with the de Broglie wavelength $\lambda = \hbar/\sqrt{2mE}$ at thermal energy $E = (D/2)T_c$, where $D$ is the number of degrees of freedom, one obtains

   $$T_c \leq \frac{h^2}{4Dm}(\frac{n_c}{g})^{2/D} \ . \tag{1.2.2}$$

   $m$ denotes the effective mass of super current carrier and for electron it can be even 100 times the bare mass of electron. The reason is that the electron moves is somewhat like a person trying to move in a dense crowd of people, and is accompanied by a cloud of charge carriers increasing its effective inertia. In this equation one can consider the possibility that Planck constant is not the ordinary one. This obviously increases the critical temperature unless $n_c$ is scaled down in same proportion in the phase transition to large $\hbar$ phase.

2. The density of $n_c$ Cooper pairs can be estimated as the number of fermions in Fermi shell at $E_F$ having width $\Delta k$ deducible from $kT_c$. For $D = 3$-dimensional spherical Fermi surface one has

   $$\begin{aligned} n_c &= \frac{1}{2}\frac{4\pi k_F^2\Delta k}{\frac{4}{3}\pi k_F^3}n \ , \\ kT_c &= E_F - E(k_F-\Delta k) \simeq \frac{h^2 k_F\Delta k}{m} \ . \end{aligned} \tag{1.2.3}$$

Analogous expressions can be deduced in $D = 2$- and $D = 1$-dimensional cases and one has

$$n_c(D) = \frac{D}{2}\frac{T_c}{E_F}n(D) \ . \tag{1.2.4}$$

The dimensionless coefficient is expressible solely in terms of $n$ and effective mass $m$. In [17] it is demonstrated that the inequality 1.2.2 replaced with equality when combined with 1.2.4 gives a satisfactory fit for 16 super-conductors used as a sample.

Note that the Planck constant appearing in $E_F$ and $T_c$ in Eq. 1.2.4 must correspond to ordinary Planck constant $\hbar_0$. This implies that equations 1.2.2 and 1.2.4 are consistent within orders of magnitudes. For $D = 2$, which corresponds to high $T_c$ superconductivity, the substitution of $n_c$ from Eq. 1.2.4 to Eq. 1.2.2 gives a consistency condition from which $n_c$ disappears completely. The condition reads as

$$n\lambda_F^2 = \pi = 4g \ .$$

Obviously the equation is not completely consistent.

3. The magnetic penetration length $\lambda$ is expressible in terms of density $n_c$ of Cooper pairs as

$$\lambda^{-2} = \frac{4\pi e^2 n_c}{m_e} \ . \tag{1.2.5}$$

The ratio $\kappa \equiv \frac{\lambda}{\xi}$ determines the type of the super conductor. For $\kappa < \frac{1}{\sqrt{2}}$ one has type I super conductor with defects having negative surface energy. For $\kappa \geq \frac{1}{\sqrt{2}}$ one has type II super conductor and defects have positive surface energy. Super-conductors of type I this results in complex stripe like flux patterns maximizing their area near criticality. The super-conductors of type II have $\kappa > 1/\sqrt{2}$ and the surface energy is positive so that the flux penetrates as flux quanta minimizing their area at lower critical value $H_{c_1}$ of magnetic field and completely at higher critical value $H_{c_2}$ of magnetic field. The flux quanta contain a core of size $\xi$ carrying quantized magnetic flux.

4. Quantum coherence length $\xi$ can be roughly interpreted as the size of the Cooper pair or as the size of the region where it is sensible to speak about the phase of wave function of Cooper pair. For larger separations the phases of wave functions are un-correlated. The values of $\xi$ vary in the range $10^3 - 10^4$ Angstrom for low $T_c$ super-conductors and in the range $5 - 20$ Angstrom for high $T_c$ super-conductors (assuming that they correspond to ordinary $\hbar$!) the ratio of these coherence lengths varies in the range $[50 - 2000]$, with upper bound corresponding to $n_F = 2^{11}$ for $\hbar$. This would give range $1-2$ microns for the coherence lengths of high $T_c$ super-conductors with lowest values of coherence lengths corresponding to the highest values of coherence lengths for low temperatures super conductors.

Uncertainty Principle $\delta E \delta t = \hbar/2$ using $\delta E = E_{gap} \equiv 2\Delta$, $\delta t = \xi/v_F$, gives an order of magnitude estimate for $\xi$ differing only by a numerical factor from the result of a rigorous calculation given by

$$\xi = \frac{4\hbar v_F}{E_{gap}} \ . \tag{1.2.6}$$

$E_{gap}$ is apart from a numerical constant equal to $T_c$: $E_{gap} = nT_c$. Using the expression for $v_F$ and $T_c$ in terms of the density of electrons, one can express also $\xi$ in terms of density of electrons.

For instance, BCS theory predicts $n = 3.52$ for metallic super-conductors and $n = 8$ holds true for cuprates [17]. For cuprates one obtains $\xi = 2n^{-1/3}$ [17]. This expression can be criticized since cuprates are Mott insulators and it is not at all clear whether a description as Fermi gas makes sense.

The fact that high $T_c$ super-conductivity involves breakdown of anti-ferromagnetic order might justify the use of Fermi gas description for conducting holes resulting in the doping.

For large $\hbar$ the value of $\xi$ would scale up dramatically if deduced theoretically from experimental data using this kind of expression. If the estimates for $\xi$ are deduced from $v_F$ and $T_c$ purely calculationally as seems to be the case, the actual coherence lengths would be scaled up by a factor $\hbar/\hbar_0 = n_F$ if high $T_c$ super-conductors correspond to large $\hbar$ phase. As also found that this would also allow to understand the high critical temperature.

### 1.2.2 Universality of parameters in TGD framework

Universality idea conforms with quantum criticality of TGD Universe. The possibility to express everything in terms of density of critical temperature coding for the dynamics of Cooper pair formation and the density charge carriers would make it also easy to understand how p-adic scalings and transitions to large $\hbar$ phase affect the basic parameters. The possible problem is that the replacement of inequality of Eq. 1.2.2 with equality need not be sensible for large $\hbar$ phases. It will be found that in many-sheeted space-time $T_c$ does not directly correspond to the gap energy and the universality of critical temperature follows from the p-adic length scale hypothesis.

#### The effective of p-adic scaling on the parameters of super-conductors

*1. The behavior of the basic parameters under p-adic scaling and scaling of Planck constant*

p-Adic fractality expresses as $n \propto 1/L^3(k)$ would allow to deduce the behavior of the various parameters as function of the p-adic length scale and naive scaling laws would result. For instance, $E_{gap}$ and $T_c$ would scale as $1/L^2(k)$ if one assumes that the density $n$ of particles at larger space-time sheets scales p-adically as $1/L^3(k)$. The basic implication would be that the density of Cooper pairs and thus also $T_c$ would be reduced very rapidly as a function of the p-adic length scale. Without thermal isolation between these space-time sheets and hight temperature space-time sheets there would not be much hopes about high $T_c$ super-conductivity.

In the scaling of Planck constant basic length scales scale up and the overlap criterion for super-conductivity becomes easy to satisfy unless the density of electrons is reduced too dramatically. As found, also the critical temperature scales up so that there are excellent hopes of obtain high $T_c$ super-conductor in this manner. The claimed short correlation lengths are not a problem since they are calculational quantities. As a matter fact, the

*2. Could gap energies be universal?*

Suppose that the super-conducting electrons are at a space-time sheet corresponding to some p-adic length scale. They can leak to either larger or smaller space-time sheets via the formation of join along boundaries bonds. The energy $E_J$ associated with the formation of a join along boundaries bond connecting two space-time sheets characterized by $k_1$ and $k_2$ mediating transfer of Cooper pair to smaller space-time sheet defines a potential barrier so that for thermal energies below this energy no join along boundaries bonds are formed to smaller space-time sheets. The gap energy deduced from $T_c$ would not necessarily correspond in this case to the binding energy of Cooper pair but to the energy $E_J > E_{gap}$ of the join along boundaries bond.

One can imagine two options for $E_J$ in the approximation that the interaction energy of Cooper pair with surroundings is neglected.

Option I: The formation of JAB is a process completely independent from the flow of Cooper pair through it and thermal photons are responsible for it. In this case the order of magnitude for $E_J$ would naturally correspond to $\hbar/L(k_1)$. Cell size $L(167) = 2.5$ $\mu$m would correspond to $E_J \sim .4$ eV which does not make sense.

Option II: One cannot separate the flow of the Cooper pair through the JAB from its formation involving the localization to smaller space-time sheet requiring thermal photon to provide the difference of zero point kinetic energies. $E_J$ would naturally correspond to the difference $\Delta E_0 = E_0(k_1) - E_0(k_2)$ of zero point kinetic energies $E_0(k) = D\pi^2\hbar^2/4mL^2(k)$ of the Cooper pair, where $D$ is the effective dimensionality of the sheets. The reason why JABs inducing the flow $k_1 \rightarrow k_2$ of charge carriers are not formed spontaneously must be that charge carriers at $k_1$ space-time sheet are in a potential well. This option seems to work although it is certainly oversimplified since it neglects the interaction energy of Cooper pairs with other particles and wormhole throats behaving effectively like particles.

If $E_J$ given as difference of zero point kinetic energies, determines the critical temperature rather than $E_{gap}$, universality of the critical temperature as a difference of zero point kinetic energies is predicted. In this kind of situation the mechanism binding electrons to Cooper pairs is not relevant for what is observed as long as it produces binding energy and energy gap between ground state and first excited state larger than the thermal energy at the space-time sheet in question. This temperature is expected to scale as zero point kinetic energy. As already found, the work of Rabinowitz [17] seems to support this kind of scaling law.

*3. Critical temperatures for low and high $T_c$ super conductors*

Consider now critical temperatures for low and high $T_c$ electronic super-conductors for option II assuming $D = 3$.

1. For low $T_c$ super conductors and for the transition $k_2 = 167 \rightarrow k_1 = 163$ this would give $\Delta E_0 = E_0(163) \sim 6 \times 10^{-6}$ eV, which corresponds to $T_c \sim .06$ K. For $k_2 = 163 \rightarrow 157$ this would give $\Delta E \sim 1.9 \times 10^{-4}$ eV corresponding to 1.9 K. These orders of magnitude look rather reasonable since the coherence length $\xi$ expected to satisfy $\xi \leq L(k_2)$, varies in the range $.1 - 1$ $\mu$m for low $T_c$ super conductors.

2. For high $T_c$ super-conductors with $\xi$ in the range $5 - 20$ Angstrom, $E_J \sim 10^{-2}$ eV would give $k_1 = 149$, which would suggest that high $T_c$ super-conductors correspond to $k = 151$ and $\xi \ll L(k_2 = 151) = 10$ nm (cell membrane thickness). In this case $\Delta << E_J$ is quite possible so that high $T_c$ super-conductivity would be due to thermal isolation rather than a large value of energy gap. This provides a considerable flexibility concerning the modelling of mechanisms of Cooper pair formation.

*4. $E_J < E_{gap}$ case as a transition to partial super-conductivity*

For $E_J < E_{gap}$ the transition at $T_c \simeq E_J$ does not imply complete loss of resistivity since the Cooper pairs can flow to smaller space-time sheets and back without being destroyed and this is expected to induce dissipative effects. Some super-conductors such as $ZrZn_2$ ferromagnet do not lose their resistivity completely and the anomaly of specific heat is absent [19]. The mundane explanation is that super-conductivity exists only in clusters.

### The effect of the scaling of $\hbar$ to the parameters of BCS super-conductor

It is of interest to study the behavior of the various parameters in the transition to the possibly existing large $\hbar$ variant of super-conducting electrons. Also small scalings of $\hbar$ are possible and the considerations to follow generalize trivially to this case. Under what conditions the behavior of the various parameters in the transition to large $\hbar$ phase is dictated by simple scaling laws?

*1. Scaling of $T_c$ and $E_{gap}$*

$T_c$ and $E_{gap}$ remain invariant if $E_{gap}$ corresponds to a purely classical interaction energy remaining invariant under the scaling of $\hbar$. This is not the case for BCS super-conductors for which the gap energy $\Delta$ has the following expression.

$$\begin{aligned}
\Delta &= \hbar\omega_c exp(-1/X) \ , \\
X &= n(E_F)U_0 = \frac{3}{2}N(E_F)\frac{U_0}{E_F} \ , \\
n(E_F) &= \frac{3}{2}\frac{N(E_F)}{E_F} \ . \\
\omega_c &= \omega_D = (6\pi^2)^{1/3}c_s n_n^{1/3} \ . 
\end{aligned} \tag{1.2.7}$$

Here $\omega_c$ is the width of energy region near $E_F$ for which "phonon" exchange interaction is effective. $n_n$ denotes the density of nuclei and $c_s$ denotes sound velocity.

$N(E_F)$ is the total number of electrons at the super-conducting space-time sheet. $U_0$ would be the parameter characterizing the interaction strength of of electrons of Cooper pair and should not depend on $\hbar$. For a structure of size $L \sim 1$ $\mu$ m one would have $X \sim n_a 10^{12} \frac{U_0}{E_F}$, $n_a$ being the number of exotic electrons per atom, so that rather weak interaction energy $U_0$ can give rise to $\Delta \sim \omega_c$.

The expression of $\omega_c$ reduces to Debye frequency $\omega_D$ in BCS theory of ordinary super conductivity. If $c_s$ is proportional to thermal velocity $\sqrt{T_c/m}$ at criticality and if $n_n$ remains invariant in the scaling of $\hbar$, Debye energy scales up as $\hbar$. This can imply that $\Delta > E_F$ condition making scaling non-sensible unless one has $\Delta \ll E_F$ holding true for low $T_c$ super-conductors. This kind of situation would *not* require large $\hbar$ phase for electrons. What would be needed that nuclei and phonon space-time sheets correspond to large $\hbar$ phase.

What one can hope is that $\Delta$ scales as $\hbar$ so that high $T_c$ superconductor would result and the scaled up $T_c$ would be above room temperature for $T_c > .15$ K. If electron is in ordinary phase $X$ is automatically invariant in the scaling of $\hbar$. If not, the invariance reduces to the invariance of $U_0$ and $E_F$ under the scaling of $\hbar$. If $n$ scales like $1/\hbar^D$, $E_F$ and thus $X$ remain invariant. $U_0$ as a simplified parametrization for the interaction potential expressible as a tree level Feynman diagram is expected to be in a good approximation independent of $\hbar$.

It will be found that high in high $T_c$ super-conductors, which seem to be quantum critical, a high $T_c$ variant of phonon mediated superconductivity and exotic superconductivity could be competing. This would suggest that the phonon mediated superconductivity corresponds to a large $\hbar$ phase for nuclei scaling $\omega_D$ and $T_c$ by a factor $\simeq 2^{11}$.

Since the total number $N(E_F)$ of electrons at larger space-time sheet behaves as $N(E_F) \propto E_F^{D/2}$, where $D$ is the effective dimension of the system, the quantity $1/X \propto E_F/n(E_F)$ appearing in the expressions of the gap energy behaves as $1/X \propto E_F^{-D/2+1}$. This means that at the limit of vanishing electron density $D = 3$ gap energy goes exponentially to zero, for $D = 2$ it is constant, and for $D = 1$ it goes zero at the limit of small electron number so that the formula for gap energy reduces to $\Delta \simeq \omega_c$. These observations suggests that the super-conductivity in question should be 2- or 1-dimensional phenomenon as in case of magnetic walls and flux tubes.

*2. Scaling of $\xi$ and $\lambda$*

If $n_c$ for high $T_c$ super-conductor scales as $1/\hbar^D$ one would have $\lambda \propto \hbar^{D/2}$. High $T_c$ property however suggests that the scaling is weaker. $\xi$ would scale as $\hbar$ for given $v_F$ and $T_c$. For $D = 2$ case the this would suggest that high $T_c$ super-conductors are of type I rather than type II as they would be for ordinary $\hbar$. This conforms with the quantum criticality which would be counterpart of critical behavior of super-conductors of type I in nearly critical magnetic field.

*3. Scaling of $H_c$ and $B$*

The critical magnetization is given by

$$H_c(T) = \frac{\Phi_0}{\sqrt{8\pi}\xi(T)\lambda(T)} \qquad (1.2.8)$$

where $\Phi_0$ is the flux quantum of magnetic field proportional to $\hbar$. For $D = 2$ and $n_c \propto \hbar^{-2}$ $H_c(T)$ would not depend on the value of $\hbar$. For the more physical dependence $n_c \propto \hbar^{-2+\epsilon}$ one would have $H_c(T) \propto \hbar^{-\epsilon}$. Hence the strength of the critical magnetization would be reduced by a factor $2^{-11\epsilon}$ in the transition to the large $\hbar$ phase with $n_F = 2^{-11}$.

Magnetic flux quantization condition is replaced by

$$\int 2eBdS = n\hbar 2\pi \ . \qquad (1.2.9)$$

$B$ denotes the magnetic field inside super-conductor different from its value outside the super-conductor. By the quantization of flux for the non-super-conducting core of radius $\xi$ in the case of super-conductors of type II $eB = \hbar/\xi^2$ holds true so that $B$ would become very strong since the thickness of flux tube would remain unchanged in the scaling.

### 1.2.3 Quantum criticality and super-conductivity

The notion of quantum criticality has been already discussed in introduction. An interesting prediction of the quantum criticality of entire Universe also gives naturally rise to a hierarchy of macroscopic quantum phases since the quantum fluctuations at criticality at a given level can give rise to higher level macroscopic quantum phases at the next level. A metaphor for this is a fractal cusp catastrophe for which the lines corresponding to the boundaries of cusp region reveal new cusp catastrophes corresponding to quantum critical systems characterized by an increasing length scale of quantum fluctuations.

Dark matter hierarchy could correspond to this kind of hierarchy of phases and long ranged quantum slow fluctuations would correspond to space-time sheets with increasing values of $\hbar$ and size. Evolution as the emergence of modules from which higher structures serving as modules at the next level would correspond to this hierarchy. Mandelbrot fractal with inversion analogous to a transformation permuting the interior and exterior of sphere with zooming revealing new worlds in Mandelbrot fractal replaced with its inverse would be a good metaphor for what quantum criticality would mean in TGD framework.

#### How the quantum criticality of superconductors relates to TGD quantum criticality

There is empirical support that super-conductivity in high $T_c$ super-conductors and ferromagnetic systems [19, 20] is made possible by quantum criticality [18]. In the experimental situation quantum criticality means that at sufficiently low temperatures quantum rather than thermal fluctuations are able to induce phase transitions. Quantum criticality manifests itself as fractality and simple scaling laws for various physical observables like resistance in a finite temperature range and also above the critical temperature. This distinguishes sharply between quantum critical super conductivity from BCS type super-conductivity. Quantum critical super-conductivity also exists in a finite temperature range and involves the competition between two phases.

The absolute quantum criticality of the TGD Universe maps to the quantum criticality of subsystems, which is broken by finite temperature effects bringing dissipation and freezing of quantum fluctuations above length and time scales determined by the temperature so that scaling laws hold true only in a finite temperature range.

Reader has probably already asked what quantum criticality precisely means. What are the phases which compete? An interesting hypothesis is that quantum criticality actually corresponds to criticality with respect to the phase transition changing the value of Planck constant so that the competing phases would correspond to different values of $\hbar$. This hypothesis seems to work in the case of high $T_c$ super-conductivity. The prediction is that quantum criticality sets on at some critical temperature $T_{c_1} > T_c$ meaning the emergence of exotic Cooper pairs which are however unstable against decay to ordinary electrons so that the super-conductivity in question gives rise to ordinary conductivity in time scales longer than the lifetime of exotic Cooper pair dictated by temperature. These exotic Cooper pairs can also transform to BCS type Cooper pairs which are stable below $T_c$.

#### Scaling up of de Broglie wave lengths and criterion for quantum overlap

Compton lengths and de Broglie wavelengths are scaled up by an integer $n$, whose preferred values correspond to $n_F = 2^k \prod_s F_s$, where $F_s = 2^{2^s} + 1$ are distinct Fermat primes. In particular, $n_F = 2^{k11}$ seem to be favored. The scaling up means that the overlap condition $\lambda \geq 2d$ for the formation of Bose-Einstein condensate can be satisfied and the formation of Cooper pairs becomes possible. Thus a hierarchy of large $\hbar$ super-conductivities would be associated with to the dark variants of ordinary particles having essentially same masses as the ordinary particles.

Unless one assumes fractionization, the invariance of $E_F \propto \hbar_{eff}^2 n^{2/3}$ in $\hbar$ increasing transition would require that the density of Cooper pairs in large $\hbar$ phase is scaled down by an appropriate factor. This means that supra current intensities, which are certainly measurable quantities, are also scaled down. Of course, it could happen that $E_F$ is scaled up and this would conform with the scaling of the gap energy.

### Possible implications of charge and spin fractionization

Masses as given by representations of super conformal algebras and p-adic thermodynamics are invariant under changes of the Planck constants. The original assumption that Poincare quantum numbers are invariant in Planck constant changing quantum transition is however too strong and conflicts with the model explaining quantization of planetary orbits in terms of gigantic value of $\hbar$ [D6, J6]. What happens is spin fractionization with unit of spin replaced with $n_a/n_b$ and fractionization of color and presumably of also electro-weak charges with unit given by $n_b/n_a$. For instance, $n_a/n_b$ fractionization would happen for angular momentum quantum number $m$, for the integer $n$ characterizing the Bohr orbits of atom, harmonic oscillator, and integers labelling the states of particle in box.

The fractionization can be understood in terms of multiple covering of $M^4$ by symmetry related $CP_2$ points formed in the phase transition increasing $\hbar$ [A9]. The covering is characterized by $G_b \subset SU(2) \subset SU(3)$ and fixed points correspond to orbifold points. The copies of imbedding space with different $G$ are glued with each other along $M^4$ factors at orbifold point, representing origin of $CP_2$.

An interesting implication of spin fractionization is that for $n_a$ and $n_b = 1$ the unit of spin would become $n_a$ standard units. This might be interpreted by saying that minimum size of a Bose Einstein condensate consisting of spin 1 Cooper pairs is $n_b/2$ Cooper pairs with spin 1. On the other hand charge could be fractionized to $e/n_b$ in this case. A possible interpretation is that electron is delocalized to $n_a$ separate $G_a$ related sheets of the $M^4$ covering of $CP_2$ projection such that each of them carries a fractional charge $e/n_a$. Geometrically this would correspond to a ring consisting of $n_a$ discrete points.

### Quantum critical super-conductors in TGD framework

For quantum critical super-conductivity in heavy fermions systems, a small variation of pressure near quantum criticality can destroy ferromagnetic (anti-ferromagnetic) order so that Curie (Neel) temperature goes to zero. The prevailing spin fluctuation theory [22] assumes that these transitions are induced by long ranged and slow spin fluctuations at critical pressure $P_c$. These fluctuations make and break Cooper pairs so that the idea of super-conductivity restricted around critical point is indeed conceivable.

Heavy fermion systems, such as cerium-indium alloy $CeIn_3$ are very sensitive to pressures and a tiny variation of density can drastically modify the low temperature properties of the systems. Also other systems of this kind, such as $CeCu_2Ge_2$, $CeIn_3$, $CePd_2Si_2$ are known [19, 21]. In these cases super-conductivity appears around anti-ferromagnetic quantum critical point.

The last experimental breakthrough in quantum critical super-conductivity was made in Grenoble [20]. URhGe alloy becomes super-conducting at $T_c = .280$ K, loses its super-conductivity at $H_c = 2$ Tesla, and becomes again super-conducting at $H_c = 12$ Tesla and loses its super-conductivity again at $H = 13$ Tesla. The interpretation is in terms of a phase transition changing the magnetic order inducing the long range spin fluctuations.

TGD based models of atomic nucleus [F8] and condensed matter [F10] assume that weak gauge bosons with Compton length of order atomic radius play an essential role in the nuclear and condensed matter physics. The assumption that condensed matter nuclei possess anomalous weak charges explains the repulsive core of potential in van der Waals equation and the very low compressibility of condensed matter phase as well as various anomalous properties of water phase, provide a mechanism of cold fusion and sono-fusion, etc. [F10, J6]. The pressure sensitivity of these systems would directly reflect the physics of exotic quarks and electro-weak gauge bosons. A possible mechanism behind the phase transition to super-conductivity could be the scaling up of the sizes of the space-time sheets of nuclei.

Also the electrons of Cooper pair (and only these) could make a transition to large $\hbar$ phase. This transition would induce quantum overlap having geometric overlap as a space-time correlate. The formation of join along boundaries bonds between neighboring atoms would be part of the mechanism. For instance, the criticality condition $4n^2\alpha = 1$ for BE condensate of $n$ Cooper pairs would give $n = 6$ for the size of a higher level quantum unit possibly formed formed from Cooper pairs. If one does not assume invariance of energies obtained by fractionization of principal quantum number, this transition has dramatic effects on the spectrum of atomic binding energies scaling as $1/\hbar^2$ and practically universal spectrum of atomic energies would result [J6] not depending much on nuclear charge. It seems that this prediction is non-physical.

Quantum critical super-conductors resemble superconductors of type I with $\lambda \ll \xi$ for which defects near thermodynamical criticality are complex structures looking locally like stripes of thickness $\lambda$. These structure are however dynamical in super-conducting phase. Quite generally, long range quantum fluctuations due to the presence of two competing phases would manifest as complex dynamical structures consisting of stripes and their boundaries. These patterns are dynamical rather than static as in the case of ordinary spin glass phase so that quantum spin glass or 4-D spin glass is a more appropriate term.

The breaking of classical non-determinism for vacuum extremals indeed makes possible space-time correlates for quantum non-determinism and this makes TGD Universe a 4-dimensional quantum spin glass. The model for high $T_c$ super-conductors leads to the conclusion that the boundaries between the two phases are the carriers of the supra currents. Wormhole contacts appear naturally at boundaries and the mere assumption that $q\overline{q}$ type wormhole contacts feed the em gauge flux of electrons from the space-time sheet of Cooper pair to a larger space-time sheet predicts correctly the properties of high $T_c$ Cooper pairs.

**Could quantum criticality make possible new kinds of high $T_c$ super-conductors?**

The transition to large $\hbar$ phase increases various length scales by $n/v_0$ and makes possible long range correlations even at high temperatures. Hence the question is whether large $\hbar$ phase could correspond to ordinary high $T_c$ super-conductivity. If this were the case in the case of ordinary high $T_c$ super-conductors, the actual value of coherence length $\xi$ would vary in the range $5-20$ Angstrom scaled up by a factor $n/v_0$ to $n-40n$ $\mu$m to be compared with the range $.2-2$ $\mu$m for low $T_c$ super-conductors. The density of Cooper pairs would be scaled down by an immensely small factor $2^{-33}/n^3$ from its value deduced from Fermi energy so that neither high $T_c$ nor ordinary super-conductors can correspond to larger $\hbar$ phase for electrons.

Large $\hbar$ phase for some nuclei might be involved and make possible large space-time sheets of size at least of order of $\xi$ at which conduction electrons forming Cooper pairs would topologically condense like quarks around hadronic space-time sheets (in [F10] a model of water as a partially dark matter with one fourth of hydrogen ions in large $\hbar$ phase is developed).

Consider for a moment the science fictive possibility that super conducting electrons for some quantum critical super-conductors to be discovered or already discovered correspond to large $\hbar$ phase with $\hbar(k) = n_F\hbar_0$ keeping in mind that this affects only quantum corrections in perturbative approach but not the lowest order classical predictions of quantum theory. For $n_F = n/v_0 \simeq n2^{k11}$ with $k = 1, n = 1$ the size of magnetic body would be $L(149) = 5$ nm, the thickness of the lipid layer of cell membrane. For $k = 2, n = 1$ the size would be $L(171) = 10$ $\mu$m, cell size. If the density of Cooper pairs is of same order of magnitude as in case of ordinary super conductors, the critical temperature is scaled up by $2^{k11}$. Already for $k = 1$ the critical temperature of 1 K would be scaled up to $4n^2 \times 10^6$ K if $n_c$ is not changed. This assumption is not consistent with the assumption that Fermi energy remains non-relativistic. For $n = 1$ $T_c = 400$ K would be achieved for $n_c \rightarrow 10^{-6}n_c$, which looks rather reasonable since Fermi energy transforms as $E_F \rightarrow 8 \times 10^3 E_F$ and remains non-relativistic. $H_c$ would scale down as $1/\hbar$ and for $H_c = .1$ Tesla the scaled down critical field would be $H_c = .5 \times 10^{-4}$ Tesla, which corresponds to the nominal value of the Earth's magnetic field.

Quantum critical super-conductors become especially interesting if one accepts the identification of living matter as ordinary matter quantum controlled by macroscopically quantum coherent dark matter. One of the basic hypothesis of TGD inspired theory of living matter is that the magnetic flux tubes of the Earth's magnetic field carry a super-conducting phase and the spin triplet Cooper pairs of electrons in large $\hbar$ phase might realize this dream. That the value of Earth's magnetic field is near to its critical value could have also biological implications.

### 1.2.4 Space-time description of the mechanisms of super-conductivity

The application of ideas about dark matter to nuclear physics and condensed matter suggests that dark color and weak forces should be an essential element of chemistry and condensed matter physics. The continual discovery of new super-conductors, in particular of quantum critical superconductors, suggests that super-conductivity is not well understood. Hence super-conductivity provides an obvious test for these ideas. In particular, the idea that wormhole contacts regarded as parton pairs living at two space-time sheets simultaneously, provides an attractive universal mechanism for the formation of Cooper pairs and is not so far-fetched as it might sound first.

### Leading questions

It is good to begin with a series of leading questions.

1. The work of Rabinowitch [17] suggests that that the basic parameters of super-conductors might be rather universal and depend on $T_c$ and conduction electron density only and be to a high degree independent of the mechanism of super-conductivity. This is in a sharp contrast to the complexity of even BCS model with its somewhat misty description of the phonon exchange mechanism.
Questions: Could this mean that there exists a simple universal description of various kinds of super-conductivities? Could this mechanism involve large $\hbar$ phase for nuclei in case of quantum critical super-conductivity? Could wormhole contacts or their Bose-Einstein condensate play some role. Are the Cooper pairs of quantum critical super-conductors at the boundaries of the competing phases?

2. The effective masses of electrons in ferromagnetic super-conductors are in the range of 10-100 electron masses [19] and this forces to question the idea that ordinary Cooper pairs are current carriers. Quantum classical correspondence requires that bound states involve formation of join along boundaries bonds between bound particles. In the case of Cooper pairs in ordinary superconductors the length of join along boundaries bonds between electrons should be of order $10^3 - 10^4$ Angstroms. This looks rather strange.
Questions: Could quantum classical correspondence help to identify the mechanism giving rise to Cooper pairs? The simplest model of pair is as a space-time sheet with size of order $\xi$ so that the electrons are "outside" the background space-time. Could the Coulomb interaction energy of electrons with positively charged wormhole throats carrying parton numbers and feeding em gauge flux to the large space-time sheet be responsible for the gap energy? Could wormhole throats carry also quark quantum numbers and form color singlet like structures connected by long color flux tubes so that color force would be ultimately responsible for the stability of Cooper pair? In case of single electron condensed to single space-time sheet the em flux could be indeed feeded by $u$ and $\overline{d}$ type wormhole contacts to larger space-time sheet. Or could electrons be free-travellers bound to structures involving also other particles?

3. Quantum classical correspondence forces to ask for the space-time correlates for the existing quantum description of phonons.
Questions: What are the space-time sheets associated with phonons? Could the microscopic description of phonons in atomic length scales rely on the oscillations of wormhole contact Bose-Einstein condensates at the boundaries of nucleon space-time sheets with size scale of order atom size? Could the dark weak length scale which is of order atomic size replace lattice constant in the expression of sound velocity? What is the space-time correlate for sound velocity?

4. The new super-conductors possess relatively complex chemistry and lattice structure.
Questions: Could it be that complex chemistry and lattice structure makes possible something very simple which is a transition to dark nuclear phase so that size of dark quarks involved would be scaled up to $L(k \rightarrow k+22 \rightarrow k+44)$, say $k = 113 \rightarrow 135 \rightarrow 157)$, and the size of hadronic space-time sheets would be scaled up as $k = 107 \rightarrow 129 \rightarrow 151$? Could it be that also other p-adic primes are possible as suggested by the p-adic mass calculations of hadron masses predicting that hadronic quarks can correspond to several values of $k$? Could it be that the Gaussian Mersennes $(1+i)^k - 1$, $k = 151, 157, 163, 167$ spanning the p-adic length scale range 10 nm-2.5 $\mu$m correspond to p-adic length especially relevant for super-conductivity.

### Photon massivation, coherent states of Cooper pairs, and wormhole contacts

The existence of wormhole contacts have been one of the most exotic predictions of TGD. The realization that wormhole contacts can be regarded as parton-antiparton pairs with parton and antiparton assignable to the light-like causal horizons accompanying wormhole contacts, and that Higgs particle corresponds to wormhole contact [F2], opens the doors for more concrete models of also super-conductivity involving massivation of photons.

The formation of a coherent state of wormhole contacts would be the counterpart for the vacuum expectation value of Higgs. The notions of coherent states of Cooper pairs and of charged Higgs challenge the conservation of electromagnetic charge. The following argument however suggests that coherent states of wormhole contacts form only a part of the description of ordinary super-conductivity. The basic observation is that wormhole contacts with vanishing fermion number define space-time correlates for Higgs type particle with fermion and antifermion numbers at light-like throats of the contact.

The ideas that a genuine Higgs type photon massivation is involved with super-conductivity and that coherent states of Cooper pairs really make sense are somewhat questionable since the conservation of charge and fermion number is lost. A further questionable feature is that a quantum superposition of many-particle states with widely different masses would be in question. The interpretational problems could be resolved elegantly in zero energy ontology [C2] in which the total conserved quantum numbers of quantum state are vanishing. In this picture the energy, fermion number, and total charge of any positive energy state are compensated by opposite quantum numbers of the negative energy state in geometric future. This makes possible to speak about superpositions of Cooper pairs and charged Higgs bosons separately in positive energy sector.

Rather remarkably, if this picture is taken seriously, super-conductivity can be seen as providing a direct support for both the hierarchy of scaled variants of standard model physics and for the zero energy ontology.

### Phonon exchange mechanism

Sound waves correspond to density variations of condensed matter. If dark gluons and exotic weak bosons with weak scale of order atomic radius explain the low compressibility of condensed matter [F10] then these forces should be essential for the description of what happens for sound waves below the atomic length scale. In particular, the lattice length appearing in Debye frequency should be expressible in terms of dark weak length scale.

Quantum classical correspondence requires that phonons should have identification as space-time sheets and that sound velocity is coded in the geometry of the space-time sheet. This interpretation of course makes sense only if the space-time sheet of phonon is in contact with atoms so that atomic oscillations induce oscillations of the induced gauge fields inside it.

The obvious objection against this picture is that one can imagine the possibility of free phonons analogous to photons connecting nuclei with say distance of micrometer and having no contact with the nuclei in between. One can of course turn the situation around and ask whether free phonons are the hen and lattice oscillations the egg. Could free photons exist and induce resonant oscillations of atomic nuclei if their velocity is consistent with the sound velocity deducible from the lattice constant and elastic constant for the interactions between atoms?

The existence of warped vacuum extremals, and in general the huge vacuum degeneracy of field equations, suggest how this space-time representation of phonons might occur. The simplest warped extremal corresponds to the mapping $M^4 \rightarrow CP_2$ defined as $\Phi = \omega m^0$, where $\Phi$ is coordinate of the geodesic circle of $CP_2$ with other coordinates being constant. The induced metric is $g_{m^0m^0} = 1 - R^2\omega^2/4$, $g_{ij} = -\delta_{ij}$. Light velocity with respect to $M^4$ coordinates, which are physically preferred coordinates, is reduced to $v = \sqrt{1 - R^2\omega^2/4}$. The crazy guess would be that the reduced signal velocity could have interpretation as sound velocity with the previous prerequisites.

For small perturbations of vacuum extremals the term coming from the variation with respect to the induced metric vanishes, and the only contribution comes from the variation of the induced Kähler form. As a consequence, the field equations reduce to empty space Maxwell's equations $j_K^\alpha = 0$ for the induced Kähler form in the induced metric of determined by vacuum extremal in the lowest non-trivial order. This means that the maximal signal velocity is in general reduced and the reduction can be very large as the case of warped vacuum extremals demonstrates. The longitudinal Kähler electric field associated with phonons would serve as a correlate for the longitudinal sound waves.

In higher orders the solution develops a non-vanishing Kähler current $j_K^\alpha$ and this relates naturally to the fact that the phonon exchange involves dissipation. In the case of the simplest warped vacuum extremals the relevant parameter for the perturbation theory is $\omega R$ which is near to unity so that perturbative effects can be quite sizable if the phonons are representable in the proposed manner. The non-vanishing of the vacuum Lorentz force $j_K^\alpha J_{\alpha\beta}$ serves as a space-time correlate for the presence of dissipative effects. For the known solutions of field equations the Lorentz force vanishes and the interpretation is that they represent asymptotic self-organization patters. Phonons would be different and represent transient phenomena.

If this interpretation is correct, the phonon mechanism for the formation of Cooper pairs could have a description in terms of the topological condensation of electrons at space-time sheets representing phonons connecting atomic nuclei. The essential point would be that electrons of Cooper pair would be outside the space-time in well-defined sense. Also now wormhole contacts would be involved but the Coulomb interaction energy of delocalized electrons with charged wormhole throats would be negligible as compared to the interaction energy with nuclei.

### Space-time correlate for quantum critical superconductivity

The series of leading questions has probably given reader a hunch about what the mechanism of super-conductivity could be in the quantum critical case.

*1. Exotic Cooper pair as a pair of space-time sheets of scaled up electrons feeding their gauge fluxes to a larger space-time sheet via $q\overline{q}$ type wormhole contacts*

Quantum critical electronic super-conductivity requires new kind of Cooper pairs which are responsible for supra currents in the temperature range $[T_c, T_{c_1}]$ inside stripe like regions (flux tubes). These Cooper pairs are quantum critical against decay to ordinary electrons so that in time scale characterizing quantum criticality so that super-conductivity is reduced to conductivity whose temperature dependence is characterized by scaling laws. Below $T_c$ large $\hbar$ variants of BCS Cooper pairs are good candidates for supra current carriers and would result from exotic Cooper pairs. A model for the exotic Cooper pairs is considered in the sequel. Boundary plays an essential role in that the Cooper pairs at boundary must be in quantum critical phase also below $T_c$ since otherwise the transformation of ordinary electrons to large $\hbar$ BCS type Cooper pairs and vice versa is not possible.

If wormhole contact for large $\hbar$ electron corresponds to $e^+e^-$ pairs, one ends up with a stability problem since the annihilation of electron and $e^+$ at wormhole throat can lead to the disappearance of the space-time sheet. If there are two wormhole contacts corresponding to quark anti-quark pairs the situation changes. The requirement that the net charge of wormhole throats is +2e implies $u\overline{d}$ configuration for upper wormhole throats and its conjugate for the lower wormhole throats. If the wormhole throats of each electron carry net color quantum numbers the binding of electrons by color confining force would guarantee the stability of the exotic Cooper pair. This would require that wormhole throats form a color singlet not reducible to product of pion type $u\overline{d}$ type color singlets.

BCS type Cooper pair results when both electrons end up at same space-time sheet of exotic Cooper pair via a join along boundaries bond. This hopping would also drag the wormhole contacts with it and the second space-time sheet could contract. These Cooper pairs can in principle transform to pairs involving only two join along boundaries contacts carrying $e^+e^-$ pairs at their throats. For these Cooper pairs case the binding of electrons would be due to phonon mechanism.

*2. General comments*

Some general comments about the model are in order.

1. High $T_c$ super conductors are Mott insulators and antiferromagnets in their ground state, which would suggest that the notion of non-interacting Fermi gas crucial for BCS type description is not useful. Situation is however not so simple if antiferromagnetic phase and magnetically disordered phase with large $\hbar$ for nuclei compete at quantum criticality. Large $\hbar$ makes possible high $T_c$ variant of BCS type superconductivity in magnetically disordered phase in interior of rivulets but it is possible to get to this phase only via a phase consisting of exotic Cooper pairs and this is possible only in finite temperature range below $T_c$.

2. For both exotic and phonon mediated super-conductivity Cooper pair can be said to be outside the space-time sheet containing matter. Assuming a complete delocalization in the exotic case, the interaction energy is the expectation value of the sum of kinetic and Coulombic interaction energies between electrons and between electrons and wormhole throats. In the case of phonon space-time sheets situation is different due to the much larger size of Cooper pair space-time sheet so that Coulomb interaction with wormhole throats provides the dominating contribution to the binding energy.

3. The explicit model for high $T_c$ super-conductivity relies on quantum criticality involving long ranged quantum fluctuations. The mechanism seems could apply in all cases where quantum

critical fluctuations can be said to be carriers of supra currents and exotic super-conductivity vanishes when either phase dominates completely. In the case of high $T_c$ super-conductors quantum criticality corresponds to a quite wide temperature range, which provides support for the quantum criticality of TGD Universe.

### 1.2.5 Super-conductivity at magnetic flux tubes

Super-conductivity at magnetic flux tubes of magnetic flux quanta is one the basic hypothesis of the TGD based model of living matter. There is also evidence for magnetically mediated super-conductivity in extremely pure samples [23]. The magnetic coupling was only observed at lattice densities close to the critical density at which long-range magnetic order is suppressed. Quantum criticality suggests that the super-conductivity appears at the boundaries of two competing phases and that Cooper pairs correspond to space-time sheets feeding their em gauge charge via $q\overline{q}$ type wormhole contacts to larger space-time sheet.

Almost the same model as in the case of high $T_c$ and quantum critical super-conductivity applies to magnetic flux tubes. Now the flux quantum contains BE condensate of exotic Cooper pairs interacting with wormhole contacts feeding the gauge flux of Cooper pairs from the magnetic flux quantum to a larger space-time sheet. The interaction of spin 1 Cooper pairs with the magnetic field of flux quantum orients their spins in the same direction. Large value of $\hbar$ guarantees thermal stability even in the case that different space-time sheets are not thermally isolated.

#### Superconductors at the flux quanta of the Earth's magnetic field

Magnetic flux tubes and magnetic walls are the most natural candidates for super-conducting structures with spin triplet Cooper pairs. Indeed, experimental evidence relating to the interaction of ELF em radiation with living matter suggests that bio-super-conductors are effectively 1- or 2-dimensional. $D \leq 2$-dimensionality is guaranteed by the presence of the flux tubes or flux walls of, say, the magnetic field of Earth in which charge carries form bound states and the system is equivalent with a harmonic oscillator in transversal degrees of freedom.

The effect of Earth's magnetic field is completely negligible at the atomic space-time sheets and cannot make super conductor 1-dimensional. At cellular sized space-time sheets magnetic field makes possible the confinement of the electron Cooper pairs in harmonic oscillator states. The critical temperature is however extremely low for ordinary value of $\hbar$ and either thermal isolation between space-time sheets or large value of $\hbar$ can save the situation.

An essential element of the picture is that topological quantization of the magnetic flux tubes occurs. In fact, the flux tubes of Earth's magnetic field have thickness of order cell size from the quantization of magnetic flux. The observations about the effects of ELF em fields on bio-matter [58, 45] suggest that similar mechanism is at work also for ions and in fact give very strong support for bio-super conductivity based on the proposed mechanism.

#### Energy gaps for superconducting magnetic flux tubes and walls

Besides the formation of Cooper pairs also Bose-Einstein condensation to the ground state occurs and the stability of Bose-Einstein condensate requires an energy gap which must be larger than the temperature at the magnetic flux tube.

There are several energies to be considered.

1. The Coulombic binding energy of Cooper pairs with the wormhole contacts feeding the em flux from magnetic flux tube to a larger space-time sheet defines an energy gap which is expected to be of order $E_g = \alpha/L(k)$ giving $E_g \sim 10^{-3}$ eV for $L(167) = 2.5$ $\mu$m giving a rough estimate for the thickness of the magnetic flux tube of the Earth's magnetic field $B = .5 \times 10^{-4}$ Tesla.

2. In longitudinal degrees of freedom of the flux tube Cooper pairs can be described as particles in a one-dimensional box and the gap is characterized by the length $L$ of the magnetic flux tube and the value of $\hbar$. In longitudinal degrees of freedom the difference between $n = 2$ and $n = 1$ states is given by $E_0(k_2) = 3h^2/4m_eL^2(k_2)$. Translational energy gap $E_g = 3E_0(k_2) = 3h^2/4m_eL^2(k_2)$ is smaller than the effective energy gap $E_0(k_1) - E_0(k_2) = h^2/4m_eL^2(k_1) - h^2/4m_eL^2(k_2)$ for $k_1 > k_2 + 2$ and identical with it for $k_1 = k_2 + 2$. For $L(k_2 = 151)$ the zero point kinetic energy

is given by $E_0(151) = 20.8$ meV so that $E_g$ corresponds roughly to a temperature of 180 K. For magnetic walls the corresponding temperature would be scaled by a factor of two to 360 K and is above room temperature.

3. Second troublesome energy gap relates to the interaction energy with the magnetic field. The magnetic interaction energy $E_m$ of Cooper pair with the magnetic field consists of cyclotron term $E_c = n\hbar eB/m_e$ and spin-interaction term which is present only for spin triplet case and is given by $E_s = \pm\hbar eB/m_e$ depending on the orientation of the net spin with magnetic field. In the magnetic field $B_{end} = 2B_E/5 = .2$ Gauss ($B_E = .5$ Gauss is the nominal value of the Earth's magnetic field) explaining the effects of ELF em fields on vertebrate brain, this energy scale is $\sim 10^{-9}$ eV for ordinary value of $\hbar$ and $\sim 2n \times 10^{-6}$ eV for $\hbar = n2^{11} \times \hbar(1)$. At the next level of dark hierarchy the energy would be $4n^2 \times 10^{-3}$ eV and would still correspond to a temperature $4n^2$ K.

The smallness of translational and magnetic energy gaps in the case of Cooper pairs at Earth's magnetic field could be seen as a serious obstacle.

1. Thermal isolation between different space-time sheets provides one possible resolution of the problem. The stability of the Bose-Einstein condensation is guaranteed by the thermal isolation of space-time if the temperature at the magnetic flux tube is below $E_m$. This can be achieved in all length scales if the temperature scales as the zero point kinetic energy in transversal degrees of freedom since it scales in the same manner as magnetic interaction energy.

2. The transition to large $\hbar$ phase could provide a more elegant way out of the difficulty. The criterion for a sequence of transitions to a large $\hbar$ phase could be easily satisfied if there is a large number of charge Cooper pairs at the magnetic flux tube. Kinetic energy gap remains invariant if the length of the flux tube scales as $\hbar$. If magnetic flux is quantized as a multiple of $\hbar$ and flux tube thickness scales as $\hbar^2$, $B$ must scale as $1/\hbar$ so that also magnetic energy remains invariant under the scaling. This would allow to have stability without assuming low temperature at magnetic flux tubes.

## 1.3 TGD based model for high $T_c$ super conductors

The model of exotic Cooper pairs has been already described and since high $T_c$ superconductors are quantum critical, they provide an attractive application of the model.

### 1.3.1 Some properties of high $T_c$ super conductors

Quite generally, high $T_c$ super-conductors are cuprates with CuO layers carrying the supra current. The highest known critical temperature for high $T_c$ superconductors is 164 K and is achieved under huge pressure of $3.1 \times 10^5$ atm for LaBaCuO. High $T_c$ super-conductors are known to be super conductors of type II.

This is however a theoretical deduction following from the assumption that the value of Planck constant is ordinary. For $\hbar = 2^{11}\hbar_0$ $\xi$ would be scaled up accordingly and type I super-conductor would be in question. These super-conductors are characterized by very complex patterns of penetrating magnetic field near criticality since the surface area of the magnetic defects is maximized. For high $T_c$ super-conductors the ferromagnetic phase could be regarded as an analogous defect and would indeed have very complex structure. Since quantum criticality would be in question the stripe structure would fluctuate with time too in accordance with 4-D spin glass character.

The mechanism of high $T_c$ super conductivity is still poorly understood [57, 46]. It is agreed that electronic Cooper pairs are charge carriers. It is widely accepted that electrons are in relative d-wave state rather than in s-wave (see [32] and the references mentioned in [57]). Cooper pairs are believed to be in spin triplet state and electrons combine to form $L = 2$ angular momentum state. The usual phonon exchange mechanism does not generate the attractive interaction between the members of the Cooper pair having spin. There is also a considerable evidence for BCS type Cooper pairs and two kinds of Cooper pairs could be present.

High $T_c$ super conductors have spin glass like character [29]. High $T_c$ superconductors have anomalous properties also above $T_c$ suggesting quantum criticality implying fractal scaling of various observable quantities such as resistivity. At high temperatures cuprates are anti-ferromagnets and Mott insulators meaning freezing of the electrons. Superconductivity and conductivity is known to occur along dynamical stripes which are antiferromagnetic defects.

These findings encourage to consider the interpretation in terms of quantum criticality in which some new form of super conductivity which is not based on quasiparticles is involved. This superconductivity is assignable with the quantum fluctuations destroying antiferromagnetic order and replacing it with magnetically disordered phase possibly allowing phonon induced super-conductivity.

The doping of the super-conductor with electron holes is essential for high $T_c$ superconductivity and the there is a critical doping fraction $p = .14$ at which $T_c$ is highest. There is considerable evidence that holes gather on one-dimensional stripes with thickness of order few atom sizes and lengths in the range 1-10 nm [46], which are fluctuating in time scale of $10^{-12}$ seconds. These stripes are also present in non-conductong and non-superconducting state but in this case they do not fluctuate. One interpretation for the fluctuations is as oscillations analogous to acoustic wave and essential for the binding of Cooper pairs. Quantum criticality suggests an alternative interpretation.

$T_c$ is inversely proportional to the distance $L$ between the stripes. One interpretation is in terms of generalization of the Debye frequency to 2-dimensional case. One could also consider phonons with wavelength equal to the distance between the stripes. A further interpretation would be that full super-conductivity requires delocalization of electrons also with respect to stripes so that $T_c$ would be proportional to the hopping probability of electron between neighboring stripes expected to be proportional to $1/L$ [46]. Later a TGD based interpretation will be discussed.

#### From free fermion gas to Fermi liquids to quantum critical systems

The article of Jan Zaanen [40] gives an excellent non-technical discussion of various features of high $T_c$ super-conductors distinguishing them from BCS super-conductors. After having constructed a color flux tube model of Cooper pairs I found it especially amusing to learn that the analogy of high $T_c$ super-conductivity as a quantum critical phenomenon involving formation of dynamical stripes to QCD in the vicinity of the transition to the confined phase leading to the generation of string like hadronic objects was emphasized also by Zaanen.

BCS super-conductor behaves in a good approximation like quantum gas of non-interacting electrons. This approximation works well for long ranged interactions and the reason is Fermi statistics plus the fact that Fermi energy is much larger than Coulomb interaction energy at atomic length scales.

For strongly interacting fermions the description as Fermi liquid (a notion introduced by Landau) has been dominating phenomenological approach. $^3$He provides a basic example of Fermi liquid and already here a paradox is encountered since low temperature collective physics is that of Fermi gas without interactions with effective masses of atoms about 6 times heavier than those of real atoms whereas short distance physics is that of a classical fluid at high temperatures meaning a highly correlated collective behavior.

Many-sheeted space-time provides a possible explanation of the paradox. Space-time sheets containing join along boundaries blocks of $^3He$ atoms behave like gas whereas the $^3He$ atoms inside these blocks form a liquid. An interesting question is whether the $^3He$ atoms combine to form larger units with same spin as $^3He$ atom or whether the increase of effective mass by a factor of order six means that $\hbar$ as a unit of spin is increased by this factor forcing the basic units to consist of Bose-Einstein condensate of 3 Cooper pairs.

High Tc super conductors are neither Fermi gases nor Fermi liquids. Cuprate superconductors correspond at high temperatures to doped Mott insulators for which Coulomb interactions dominate meaning that electrons are localized and frozen. Electron spin can however move and the system can be regarded as an anti-ferromagnet. CuO planes are separated by highly oxidic layers and become super-conducting when doped. The charge transfer between the two kinds of layers is what controls the degree of doping. Doping induces somehow a delocalization of charge carriers accompanied by a local melting of anti-ferromagnet.

Collective behavior emerges for high enough doping. Highest $T_c$ results with 15 per cent doping by holes. Current flows along electron stripes. Stripes themselves are dynamical and this is essential for both conductivity and superconductivity. For completely static stripes super-conductivity disappears and quasi-insulating electron crystal results.

Dynamical stripes appear in mesoscopic time and length scales corresponding to 1-10 nm length scale and picosecond time scale. The stripes are in a well-defined sense dual to the magnetized stipe like structures in type I super-conductor near criticality, which suggests type I super-conductivity: as found large $\hbar$ Cooper pairs would make it possible. The stripes are anti-ferromagnetic defects at which neighboring spins fail to be antiparallel. It has been found that stripes are a very general phenomenon appearing in insulators, metals, and superconducting compounds [45].

#### Quantum criticality is present also above $T_c$

Also the physics of Mott insulators above $T_c$ reflects quantum criticality. Typically scaling laws hold true for observables. In particular, resistivity increases linearly rather than transforming from $T^2$ behavior to constant as would be implied by quasi-particles as current carriers. The appearance of so called pseudo-gap [39] at $T_{c1} > T_c$ conforms with this interpretation. In particular, the fact pseudo-gap is non-vanishing already at $T_{c_1}$ and stays constant rather than starting from zero as for quasi-particles conforms with the flux tube interpretation.

#### Results from optical measurements and neutron scattering

Optical measurements and neutron scattering have provided especially valuable microscopic information about high $T_c$ superconductors allowing to fix the details of TGD based quantitative model.

Optical measurements of copper oxides in non-super-conducting state have demonstrated that optical conductivity $\sigma(\omega)$ is surprisingly featureless as a function of photon frequency. Below the critical temperature there is however a sharp absorption onset at energy of about 50 meV [58]. The origin of this special feature has been a longstanding puzzle. It has been proposed that this absorption onset corresponds to a direct generation of an electron-hole pair. Momentum conservation implies that the threshold for this process is $E_g + E$, where $E$ is the energy of the 'gluon' which binds electrons of Cooper pair together. In case of ordinary super-conductivity $E$ would be phonon energy.

Soon after measurements, it was proposed that in absence of lattice excitations photon must generate two electron-hole pairs such that electrons possess opposite momenta [58]. Hence the energy of the photon would be $2E_g$. Calculations however predicted soft rather than sharp onset of absorption since pairs of electron-hole pairs have continuous energy spectrum. There is something wrong with this picture.

Second peculiar characteristic [54, 55, 51] of high $T_c$ super conductors is resonant neutron scattering at excitation energy $E_w = 41$ meV of super conductor. This scattering occurs only below the critical temperature, in spin-flip channel and for for favored momentum exchange $(\pi/a, \pi/a))$, where $a$ denotes the size of the lattice cube [54, 55, 51]. The transferred energy is concentrated in a remarkably narrow range around $E_w$ rather than forming a continuum.

In [25] is is suggested that e-e resonance with spin one gives rise to this excitation. This resonance is assumed to play the same role as phonon in ordinary super conductivity and ee resonance is treated like phonon. It is found that one can understand the dependence of the second derivative of the photon conductivity $\sigma(\omega)$ on frequency and that consistency with neutron scattering data is achieved. The second derivative of $\sigma(\omega)$ peaks near 68 meV and assuming $E = E_g + E_w$ they found nearly perfect match using $E_g = 27$ meV. This would suggest that the energy of the excitations generating the binding between the members of the Cooper pair is indeed 41 meV, that two electron-hole pairs and excitation of the super conductor are generated in photon absorption above threshold, and that the gap energy of the Cooper pair is 27 meV. Of course, the theory of Carbotte *et al* does not force the 'gluon' to be triplet excitation of electron pair: also other possibilities can be considered.

### 1.3.2 Vision about high $T_c$ superconductivity

The following general view about high $T_c$ super-conductivity as quantum critical phenomenon suggests itself.

### Interpretation of critical temperatures

The two critical temperatures $T_c$ and $T_{c_1} > T_c$ are interpreted as critical temperatures. $T_{c_1}$ is the temperature for the formation of a quantum critical phase consisting of ordinary electrons and exotic Cooper pairs with large value of Planck constant. Quantum criticality of exotic Cooper pairs prevails for temperatures below $T_{c_1}$ in the case that one has conductivity. For completely static stripes there is no conductivity. The absence of fluctuations suggests the loss of quantum criticality. One interpretation could be that exotic Cooper pairs are there but there can be no conductivity since the necessary transition of incoming ordinary electrons to large $\hbar$ dark electrons and back is not possible. $T_c$ is the temperature at which BCS type Cooper pairs with large Planck constant become possible and exotic Cooper pairs can decay to the ordinary Cooper pairs.

### Model for exotic and BCS type Cooper pairs

Exotic Cooper pair is modelled as a pair of large $\hbar$ electrons with zoomed up size at space-time sheets $X^4_c$ topologically condensed to the background space-time sheet $Y^4$ of condensed matter system. The Coulombic binding energy of charged particles with the quarks and antiquarks assignable to the two wormhole throats feeding the em gauge flux to $Y^4$ could be responsible for the energy gap. Color force would bind the two space-time sheets to exotic Cooper pair.

Electrons of exotic Cooper pair can also end up a to same space-time sheet and possibly but not necessarily feed their em fluxes via two wormhole contacts carrying electron-positron pairs. In this case they are bound by the usual phonon interaction and form ordinary Cooper pair with large value of Planck constant.

The origin of the large $\hbar$ electrons must somehow relate to the breaking of antiferromagnetic phase by stripes. The neighboring electrons in stripe possess parallel spins and could therefore form a pair transforming to a large $\hbar$ Cooper pair bound by color force. This mechanism would be the TGD counterpart for the mechanism allowing the superconducting phases at different stripes to fuse to a single super-conducting phase at longer length scales.

Various lattice effects such as superconductivity-induced phonon shifts and broadenings, isotope effects in $T_c$, the penetration depth, infrared and photoemission spectra have been observed in the cuprates [41]. This would support the view that quantum criticality involves the competition between exotic and large $\hbar$ variant of BCS type super-conductivity and the proposed mechanism transforming exotic Cooper pair to BCS type pairs. The loss of antiferromagnetic order for higher dopings would make possible BCS type phonon induced super-conductivity with spin singlet Cooper pairs.

### What is the value of $\hbar$?

The observed stripes would carry large $\hbar$ electrons attracted to them by hole charge. The basic question concerns the value of $\hbar$ which in the general case is given by $\hbar = n_a/n_b$ where $n_i$ is the order of the maximal cyclic subgroup of $G_i$.

1. The thickness of stripes is few atomic sizes and the first guess is that scaled up electrons have atomic size. The requirement that the integer $n_a$ defining the value of $M^4$ Planck constant correspond to a n-polygon constructible using only ruler and compass gives strong constraints. An even stronger requirement would be that subgroup $G_a \subset SU(2)$ characterizes the Jones inclusion involved and thus the covering of $CP_2$ by $M^4$ points, corresponds to exceptional group via McKay correspondence, leaves only one possibility: $N(G_b) = 120$ which corresponds to $E_8$ Dynkin diagram having $Z_5$ as maximal cyclic subgroup and involving Golden Mean. The p-adic length scale of electron would be scaled up: $L(127) \rightarrow 5L(127) \simeq L(127 + 12) = L(139) \simeq 1.6$ Angstrom. This picture is not consistent with the model involving cell membrane length scale and the appearance of 50 meV energy scale which can be interpreted in terms of Josephson energy for cell membrane at criticality for nerve pulse generation is too intriguing signal to be dismissed.

2. The length of stripes is in the range 1-10 nm and defines second length scale in the system. If the Compton wavelength of scaled up electron corresponds to this length then $n_a = n_F = 2^{11}$ whose powers are encountered in the quantum model of living matter would suggest itself, and would predict the effective p-adic length scale electron to be $L(127 + 22) = L(149) = 5$ nm,

the thickness of the lipid layer of the cell membrane which brings in mind cell membrane and bio-superconductivity. It will be found that simple stability arguments favor this size scale for scaled up electrons and size $L(151)$ for the exotic Cooper pairs. The minimum option is that only the exotic Cooper pairs making possible super-conductivity above $T_c$ and broken by quantum criticality against transition to ordinary electron need have size of order $L(151) = 10$ nm.

3. The coherence length for high $T_c$ super conductors is reported to 5-20 Angstroms. The naive interpretation would be as the size of BCS type Cooper pair which would suggest that scaled up electrons have at most atomic size. There is however a loophole involved. The estimate for coherence length in terms of gap energy is given by $\xi = \frac{4\hbar v_F}{E_{gap}}$. If coherence length is estimated from the gap energy, as it seems to be the case, then the scaling up of Planck constant would increase coherence length by a factor $n_F$ and give coherence length in the range $1-4\ \mu m$.

4. The dependence $T_c \propto 1/L$, where $L$ is the distance between stripes is a challenge for the model since it would seem to suggest that stripe-stripe interaction is important for the energy gap of BCS type Cooper pairs. One can however understand this formula solely in terms of 2-dimensional character of high $T_c$ super-conductors. To see this, consider generalization of the 3-D formula

$$\begin{aligned} E_{gap} &= \hbar\omega_c exp(-1/X) \\ \omega_D &= (6\pi^2)^{1/3} c_s n_n^{1/3} \end{aligned}$$

for the gap energy to 2-dimensional case. Since only the nuclei inside stripes contribute to high $T_c$ super-conductivity it is natural to replace 3-dimensional formula for Debye frequency in 2-dimensional case with

$$\omega_D = k c_s n_h^{1/2} \quad ,$$

where $n_h$ is the 2-dimensional density of holes and $k$ a numerical constant. Since one has $n_h \propto 1/L^2$ this indeed predicts $E_{gap} \propto 1/L$.

### Quantum criticality below $T_{c_1}$

Exotic Cooper pairs would be present below the higher critical temperature $T_{c_1}$ associated with high $T_c$ super-conductors and start to transform to BCS type Cooper pairs at $T_c$. Also the reverse process occurs. In the intermediate temperature range they would be unstable against transition changing the value of Planck constant to ordinary ones and this instability would break the exotic super-conductivity to ordinary conductivity with resistance obeying scaling law as a function of temperature typical for quantum critical systems. The complete stability of stripes would indicate that the exotic Cooper pairs are present but conductivity is not possible since ordinary electrons entering to the system cannot transformed to exotic Cooper pairs.

### Why doping by holes is necessary?

In high $T_c$ super-conductivity doping by holes plays a crucial role. What is known that holes gather to the stripes and that there is a critical doping at which $T_c$ is maximum. Cusp catastrophe as a general model for phase transition suggests that that super-conductivity is possible only in finite range for the hole concentration. This is indeed the case.

The holes form a positive charge density and this inspires the idea that Coulomb attraction between exotic Cooper pairs of electrons and holes leads to the formation of stripes. Stripes provide also electrons with parallel spins which can transform to exotic large $\hbar$ Cooper pairs at quantum criticality with respect to $\hbar$.

One should also understand the upper limit for the hole concentration.

1. The first explanation is that super-conductivity is not preserved above critical hole concentration due to the loss of fractal stripe structure. Part of the explanation could be that beyond critical hole concentrations it is not possible to arrange the stripes to a fractal lattice formed by a lattice of "super-stripes" which are lattices of stripes of thickness $L(151)$ containing the observed stripes

such that super-stripes have separation $d \geq L(151)$. Doping fraction $p$ gives an estimate for the distance $d$ between super-stripes as $d = xL(151)$, $x = r/p - 1$, where $r$ is the fraction of atoms belonging to stripe inside super-stripe and $p$ is doping fraction. $x = 2/5$ and $p = .15$ gives $d = 5L(151)/3$. Note that ideal fractality would require $x/(1+x) = r$ giving $r \simeq p/2$.

2. One could also consider the possibility that large $\hbar$ BCS super-conductivity is not lost above critical hole concentration but is useless since the transformation of ordinary current carrying electrons to large $\hbar$ exotic Cooper pairs would not be possible. Thus a quantum critical interface allowing to transform ordinary current to supra current is necessary.

#### Zeros of Riemann $\zeta$ and quantum critical super conductors

A long standing heuristic hypothesis has been that the radial conformal weights $\Delta$ assignable to the functions $(r_M/r_0)^{\Delta}$ of the radial lightlike coordinate $r_M$ of $\delta M^4_+/-$ of lightcone boundary in super-canonical algebra consisting of functions in $\delta M^4_\pm \times CP_2$ are expressible as linear combinations of zeros of Riemann Zeta. Quantum classical correspondence in turn inspires the hypothesis that these conformal weights can be mapped to the points of a geodesic sphere of $CP_2$ playing the role of conformal heavenly sphere.

The arguments of [C1] suggest that radial conformal weight $\Delta$ in fact depends on the point of geodesic sphere $S^2$ in $CP_2$ and is given in terms of the inverse $\zeta^{-1}(z)$ of Riemann $\zeta$ having the natural complex coordinate $z$ of $S^2$ as argument. This implies a mapping of the radial conformal weights to the points of the geodesic sphere $CP_2$. Linear combinations of zeros correspond to algebraic points in the intersections of real and p-adic space-time sheets and are thus in a unique role from the point of view of p-adicization. This if one believes the basic conjecture that the numbers $p^s$, $p$ prime and $s$ zero of Riemann Zeta are algebraic numbers.

Zeros of Riemann Zeta have been for long time speculated to closely relate to fractal and critical systems. If the proposed general ansatz for super-canonical radial conformal weights holds true, these speculations find a mathematical justification.

Geometrically the transition changing the value of $\hbar(M^4)$ correspond to a leakage of partonic 2-surfaces between different copies of $M^4 \times CP_2$ with same $CP_2$ factor and thus same value of $\hbar(CP_2)$ but different scaling factor of $CP_2$ metric. $M^4$ metrics have the same scaling factor given by $n_b^2$.

Critical 2-surfaces can be regarded as belonging to either factor which means that points of critical 2-surfaces must correspond to the $CP_2$ orbifold points, in particular, $z = \xi^1/\xi^2 = 0$ and $z = \xi^1/\xi^2 = \infty$ remaining invariant under the group $G \subset SU(2) \subset SU(3)$ defining the Jones inclusion, that is the north and south poles of homologically non-trivial geodesic sphere $S^2 \subset CP_2$ playing the role of heavenly sphere for super-canonical conformal weights. If the hypothesis $\Delta = \zeta^{-1}(z)$ is accepted, the radial conformal weight corresponds to a zero of Riemann Zeta: $\Delta = s_k$ at quantum criticality.

At quantum level a necessary prerequisite for the transition to occur is that radial conformal weights, which are conserved quantum numbers for the partonic time evolution, satisfy the constraint $\Delta = s_k$. The partonic 2-surfaces appearing in the vertices defining S-matrix elements for the phase transitions in question need not be of the required kind. It is enough that $\Delta = s_k$ condition allows their evolution to any sector of $H$ in question. An analogous argument applies also to the phase transitions changing $CP_2$ Planck constant: in this case however leakage occurs through a partonic 2-surface having single point as $M^4$ projection (the tip of $M^4_\pm$).

Quantum criticality for high temperature super-conductivity could provide an application for this vision. The super conducting stripe like regions are assumed to carry Cooper pairs with a large value of $M^4$ Planck constant corresponding to $n_a = 2^{11}$. The boundary region of the stripe is assumed to carry Cooper pairs in critical phase so that super-canonical conformal weights of electrons should satisfy $\Delta = s_k$ in this region. If the members of Cooper pair have conjugate conformal weights, the reality of super-canonical conformal weight is guaranteed. The model predicts that the critical region has thickness $L(151)$ whereas scaled electron with $n = 2^{11}$ effectively correspond to $L(127+22) = L(149)$, the thickness of the lipid layer of cell membrane. This picture would suggests that the formation and stability of the critical region is essential for the formation of phase characterized by high $T_c$ super-conductivity with large value of Planck constant and forces temperature to a finite critical interval. In this framework surface super-conductivity would be critical and interior super-conductivity stable.

These observations in turn lead to the hypothesis that cell interior corresponds to a phase with large $M^4$ Planck constant $\hbar(M^4) = 2^{11}\hbar_0$ and cell membrane to a quantum critical region where the above mentioned condition $\Delta = s_k$ is satisfied. Thus it would seem that the possibility of ordinary electron pairs to transform to large $\hbar$ Cooper pairs is essential in living matter and that the transition takes place as the electron pairs traverse cell membrane. The quantum criticality of cell membrane might prevail only in a narrow temperature range around T=37 C. Note that critical temperature range can also depend on the group $G$ having $C_n$, $n = 2^{11}$ cyclic group as maximal cyclic group ($C_n$ and $D_n$ are the options).

### 1.3.3 A detailed model for the exotic Cooper pair

#### Qualitative aspects of the model

High $T_c$ superconductivity suggests that the Cooper pairs are stripe like structures of length 1-10 nm. The length of color magnetic flux tube is characterized by the p-adic length scale in question and $L(151) = nm$ is highly suggestive for high $T_c$ superconductors.

These observations inspire the following model.

1. The space-time sheet of the exotic Cooper pair is obtained in the following manner. Take two cylindrical space-time sheets which have radius of order $L(149)$. One could of course argue that flux tubes can have this radius only along CuO plane and must flattened in the direction orthogonal to the super-conducting plane with thickness of few atomic units in this direction. The assumption about flattening leads however to a very large electronic zero point kinetic energy. Furthermore, in the absence of flattening supra phases belonging to different CuO planes combine to form single quantum coherent phase so that coherence length can be longer than the thickness of CuO layer also in orthogonal direction.

2. Assume that the cylinders they contain electrons with $u$ wormhole throat at top and $\overline{d}$ wormhole throat at bottom feeding the em gauge flux to the larger space-time sheet. Connect these parallel flux tubes with color magnetic bonds. If the $u\overline{d}$ states associated with the flux tubes are not in color singlet states, color confinement between wormhole quarks binds the electronic space-time sheets together and electrons are "free-travellers". These exotic Cooper pairs are energy minima for electrons are in large $\hbar$ phase if the electron kinetic energy remains invariant in $\hbar$ changing phase transition. This is achieved by fractionization of quantum numbers characterizing the kinetic energy of electron.

3. If the flux tubes carry magnetic flux electron spins are parallel to the magnetic field in minimum energy state. If the magnetic flux rotates around the resulting singlet sheeted structure the spin directions of electrons are opposite and only $S = 0$ state is possible as a minimum energy state since putting electrons to the same flux tube would give rise to a repulsive Coulomb interaction and also Fermi statistics would tend to increase the energy.

4. The homological magnetic monopoles made possible by the topology of $CP_2$ allows the electrons to feed their magnetic fluxes to a larger space-time sheet via $u$ throat where it returns back via $\overline{d}$ throat. A 2-sheeted monopole field is in question. The directions of the magnetic fluxes for the two electrons are independent. By connecting the flux tubes by color bonds one obtains color bound electrons. In this kind of situation it is possible to have $S = 1$ state even when electrons are at different flux tubes portions so that energies are degenerate in various cases. The resulting four combinations give $S_z = \pm 1$ states and two $S_z = 0$ states which means spin triplet and singlet. Interestingly, the first 23 year old model of color confinement was based on the identification of color hyper charge as homological charge. In the recent conceptual framework the space-time correlate for color hyper charge $Y$ of quark could be homological magnetic charge $Q_m = 3Y$ so that color confinement for quarks would have purely homological interpretation at space-time level.

5. One can also understand how electrons of Cooper pair can have angular momentum ($L = 2$ in case of high $T_c$ Cooper pairs and $L = 0$ in case of $^3$He Cooper pairs) as well as correlation between angular momentum and spin. The generation of radial color electric field determined by the mechanical equilibrium condition $E + v \times B = 0$ inside give portion of flux tube implies that electrons rotate in same direction with velocity $v$. A non-vanishing radial vacuum $E$ requires that flux tube portion contains cylindrical hole inside it. Without hole only $v = 0$ is possible.

Assume that the directions of radial $E$ and thus $v$ can be freely chosen inside the vertical portions of flux tube. Assume that also $v = 0$ is possible in either or both portions. This allows to realize $L_z$ values corresponding to $L = 0, 1, 2$ states.

6. Since quarks in this model appear only as parton pairs associated with wormhole contacts, one expects that the corresponding p-adic mass scale is automatically determined by the relevant p-adic length scale, which would be $L(151)$ in case of high $T_c$ superconductors. This would mean that the mass scale of inertial mass of wormhole contact would be $10^2$ eV even in the case that p-adic temperature is $T_p = 1$. For $T_p = 2$ the masses would be extremely small. The fact that the effective masses of electrons can be as high as $100m_e$ [19] means that the mass of wormhole contact does not pose strong constraints on the effective mass of the Cooper pair.

7. The decay of Cooper pair results if electrons are thrown out from 2e space-time sheet. The gap energy would be simply the net binding energy of the system. This assumption can make sense for high $T_c$ super-conductors but does not conform with the proportionality of the gap energy to Debye frequency $\omega_D = v_s/a$ in the case of ordinary super-conductors for which phonon space-time sheets should replace color flux tubes.

8. Both the assumption that electrons condensed at $k = 149$ space-time sheets result from scaled up large $\hbar$ electrons and minimization of energy imply the scales $L(149)$ and $L(151)$ for the space-time sheets involved so that there is remarkable internal consistency. The model explains the spins of the exotic Cooper pairs and their angular momenta. The dark BSC type Cooper pairs are expected to have $S = 0$ and $L = 0$.

**Quantitative definition of the model**

There are several poorly understood energies involved with high $T_c$ super-conductors below $T_c$. These are $E_g = 27$ meV, $E_1 = 50$ meV, $E_w = 41$ meV, and $E_2 = 68$ meV. These numbers allow to fix the wormholy model for quantum critical super-conductors to a high degree.

Consider now a quantitative definition of the model.

1. p-Adic length scale hypothesis combined with the ideas about high $T_c$ super-conductivity in living matter plus the fact that the stripe like defects in high $T_c$ superconductors have lengths 1-10 nm suggests that the length scales $L(151) = 10$ nm corresponding to cell membrane thickness and $L(149) = 5$ nm corresponding to the thickness of its lipid layer are the most important p-adic length scales. Of course, also $L(145 = 5 \times 29) = 1.25$ nm could be important. $L(151)$ would be associated with the structure consisting of two flux tubes connected by color bonds.

2. The kicking of electrons from $k = 151$ to $k = 149$ space-time sheet should define one possible excitation of the system. For wormhole contacts kicking of electron to smaller space-time sheet is accompanied by the kicking of wormhole contacts from the pair $(151, 157)$ to a pair $(149, 151)$ of smaller space-time sheets. This can be achieved via a flow along JABs $157 \rightarrow 151$ and $151 \rightarrow 149$. Also the dropping of electrons from color flux tube to larger space-time sheet defines a possible transition.

3. Assume that given electrons reside inside electronic flux tubes connected having $u$ and $\overline{d}$ at their ends and connected by color bonds. Assume that electrons are completely delocalized and consider also the configuration in which both electrons are in the same electronic flux tube. The total energy of the system is the sum of zero point kinetic energies of electrons plus attractive Coulomb interaction energies with $u$ and $\overline{d}$ plus a repulsive interaction energy between electrons which contributes only when electrons are in the same flux tube. Minimum energy state is obviously the one in which electrons are at different flux tubes.

   By effective one-dimensionality the Coulomb potential can be written as $V(z) = \alpha Qz/S$, where $S$ is the thickness of the flux tube. It is assumed that $S$ scales $L(k)^2/y$, $y > 1$, so that Coulomb potential scales as $1/L(k)$. The average values of Coulomb potential for electron quark interaction ($Q(u) = 2/3$ and $Q(\overline{d}) = 1/3$) and ee interaction are

$$
\begin{aligned}
V_{eq} &= \frac{y}{2}V(k) \ , \\
V_{ee} &= \frac{y}{3}V(k) \ , \\
V(k) &= \frac{\alpha}{L(k)} \ .
\end{aligned} \tag{1.3.1}
$$

One can introduce a multiplicative parameter $x$ to zero point kinetic energy to take into account the possibility that electrons are not in the minimum of kinetic energy. The color interactions of wormhole throats can of course affect the situation.

With these assumptions the estimate for the energy of the 2e space-time sheet is

$$
\begin{aligned}
E_{2e}(k) &= 2xT(k) - 2V_{eq} + \epsilon V_{ee} = 2xT(k) - y(1-\frac{\epsilon}{3})V(k) \ , \\
T(k) &= \frac{D}{2}\frac{\pi^2}{2m_eL^2(k)} \ , \\
V(k) &= \frac{\alpha}{L(k)} \ .
\end{aligned} \tag{1.3.2}
$$

Here $\epsilon = 1/0$ corresponds to the situation in which electrons are/are not in the same flux tube. One has $x \geq 1$ and $x = 1$ corresponds to the minimum of electron's kinetic energy. If the maximum area of the tube is $\pi L(151)^2$, one should have $y \leq \pi$. The effective dimension is $D = 1$ for flux tube. $k = 151$ and $k = 149$ define the most interesting p-adic length scales now.

4. By p-adic scaling one has

$$
E_{2e}(k) = 2^{151-k} \times 2xT(151) - 2^{(151-k)/2} \times y(1-\frac{\epsilon}{3})V(151) \ . \tag{1.3.3}
$$

The general form of the binding energy implies that it has maximum for some value of $k$ and the maximum turns out to correspond to $k = 151$ with a rather reasonable choice of parameters $x$ and $y$.

One could also require a stability against the transition $151 \rightarrow 149$. Here a difficulty is posed by the fact that color interaction energy of wormhole contacts probably also changes. One can however neglect this difficulty and look what one obtains. In this approximation stability condition reads as

$$
E_{2e}(149) - E_{2e}(151) = 6xT(151) - y(1-\frac{\epsilon}{3})V(151) > 0 \ . \tag{1.3.4}
$$

One obtains

$$
\frac{y}{x} \leq \frac{6T(151)}{V(151)} = \frac{6}{\alpha}\frac{\pi^2}{2m_eL(151)} \simeq 3.54 \ . \tag{1.3.5}
$$

For $k > 151$ the binding energy decreases so fast that maximum of the binding energies at $k = 151$ might be guaranteed by rather reasonable conditions on parameters.

5. The general formula $\lambda$ is expected to make sense and gives rather large $\lambda$. The BCS formula for $\xi$ need not make sense since the notion of free electron gas does not apply. A good guess is that longitudinal $\xi$ is given by the height $L(151) = 10$ nm of the stripe. Transversal $\xi$, which is in the range 4-20 Angstroms, would correspond to the thickness of the color magnetic flux tube containing electrons. Hence the scale for $\xi$ should be smaller than the thickness of the stripe.

**Estimation of the parameters of the model**

It turns out to be possible to understand the energies $E_2$, $E_1$, $E_w$ and $E_g$ in terms of transitions possible for wormhole contact option. The values of the parameters $x$ and $y$ can be fitted from the following conditions.

1. The largest energy $E_2 = 68$ meV is identified as the binding energy in the situation in which electrons are at different flux tubes. Hence one has $E_{2e}(\epsilon = 0) = -E_2$ giving

$$-2xT(151) + yV(151) = E_2 \ . \tag{1.3.6}$$

   The peak in photo-absorption cross section would correspond to the dropping of both electrons from the flux tube to a much larger space-time sheet.

2. The energy $E_g = 27$ meV is identified as the binding energy in the situation that electrons are at the same flux tube so that $E_g$ represents the energy needed to kick electrons to a much larger space-time sheet. This gives

$$-2xT(151) + \frac{2}{3}yV(151) = E_g \ . \tag{1.3.7}$$

3. $E_w$ corresponds to the difference $E_2 - E_g$ and has an interpretation as the energy needed to induce a transition from state with $\epsilon = 0$ (electrons at different flux tubes) to the state with $\epsilon = 1$ (electrons at the same flux tube).

$$E_{2e}(151, \epsilon = 1) - E(2e)(151, \epsilon = 0) = \frac{y}{3}V(151) = E_w \ . \tag{1.3.8}$$

   This condition allows to fix the value of the parameter $y$ as

$$y = \frac{3E_w}{V(151)} \ . \tag{1.3.9}$$

   Condition 1) fixes the value of the parameter $x$ as

$$x = \frac{E_w}{T(151)} \ . \tag{1.3.10}$$

   Using $V(151) \simeq 144$ meV and $T(151) = 20.8$ meV this gives $y = .8539 < \pi$ and $x = 1.97$. The area of the color flux tube is .27 per cent about $S_{max} = \pi L^2(151)$ so that its radius equals in a good approximation $L(149)$, which looks rather large as compared to the estimated thickness of the visible stripe. $x = 1.97$ means that the electron's kinetic energy is roughly twice the minimal one. $y/x = .43$ satisfies the bound $y/x < 6T(151)/V(151) = .87$ guaranteing that the binding energy is maximum for $k = 151$. This result is rather remarkable.

4. The model should explain also the energy $E_1 \simeq 50$ meV at which sharp photon absorption sets on. The basic observation is that for neuronal membrane 50 mV corresponds to the critical voltage for the generation of nerve pulse. In super-conductor model of cell membrane 50 meV is identified as the energy of Josephson photon emitted or absorbed when Cooper pair moves from cell interior to exterior of vice versa. Thus 50 meV energy *might* correspond to the energy of Josephson photon and kick BCS type Cooper pair between the two layers of the double-layered super stripe.

   Note that 50 meV corresponds to a thermal energy of 3-D system at T= 333 K (60 C). This is not far from 37 C, which would also suggest that high $T_c$ super-conductivity is possible at room temperatures. In the case of cell membrane quantum criticality could among other things make possible the kicking of the large $\hbar$ BCS type Cooper pairs between lipid layers of cell membrane. If so, neurons would be quantum critical only during nerve pulse generation.

   One can consider also alternative explanation. 50 meV is not much higher than 41 meV so that it could relate to the $\epsilon = 0 \rightarrow 1$ transition. Recoil effects are negligible. Perhaps $m = 1$ rotational excitation of electron of 2e system residing at the same flux tube and having energy $E = 9$ meV is in question. This excitation would receive the spin of photon. The energy scale of electronic rotational excitations is $\hbar^2/2m_eL^2(149) \sim 8.4$ meV if the radius of the flux tube is $L(149)$.

To sum up, the model allows to understand the four energies assuming natural values for adjustable parameters and predicts that $k = 151$ corresponds to stable Cooper pairs. It seems that the model could apply to a large class of quantum critical super-conductors and scaled up electrons might be involved with all condensed matter phenomena involving stripes.

#### Model for the resonance in neutron scattering

The resonance in neutron scattering is usually understood as a resonance in the scattering from the modification of the lattice induced by the formation of stripes and this scattering gives the crucial information about cross-like structure of Fermi surface of holes suggesting crossed stripes. One can also consider the possibility that the scattering is on exotic Cooper pairs which could always accompany stripes but as such need not give rise to super-conductivity or not even conductivity unless they are in quantum critical state.

Consider now the TGD based model for neutron scattering based on the proposed model for Cooper pairs.

1. Neutrons couple naturally to the magnetic field accompanying color magnetic field at the space-time sheet of Cooper pair by magnetic moment coupling. As found, $E_w = 41$ meV can be interpreted as the energy needed to induce the $\epsilon = 0 \rightarrow 1$ transition. Spin flip necessarily occurs if the electron is kicked between the vertical flux tubes.

2. Resonance would result from the coherent coupling to the wormhole BE condensate making scattering rate proportional to $N^2$, where $N$ denotes the number of wormhole contacts, which is actually identical with the total number of super conducting electrons. Therefore the prediction of the TGD based model is very similar to the prediction of [25]. The absence of the resonance above critical temperature suggests that exotic Cooper pairs are not present above $T_c$. The presence of quantum criticality also above $T_c$ suggests that Cooper pairs decay to wormholy space-time sheets containing single electron plus wormholy pion $u\overline{d}$ responsible for the ordinary conductivity. The transition is possible also for these space-time sheets but they do not form Bose-Einstein condensate so that the resonance in neutron scattering is predicted to be much weaker for temperatures above the critical temperature. For overcritical doping the resonance should be absent if exotic Cooper pairs are possible only at the boundaries of two phases disappearing at critical doping.

3. The momentum transfer associated with the resonance is located around the momentum $(\pi/a, \pi/a)$ in resiprocal lattice [53], where $a$ denotes the length for the side of the lattice cell. The only possible conclusion is that in the scattering neutron momentum is transferred to the lattice whereas the remaining small momentum is transferred to the momentum of wormhole BE condensate. Thus the situation is analogous to that occurring in Mössbauer effect.

**What is the origin of picosecond time scale**

The model should also predict correctly the picosecond and 1-10 nm length scales. Quantum criticality suggests that picosecond time scale relates directly to the 10 nm length scale via p-adic length scale hypothesis. $L(151) = 10$ nm defining the size for color flux tubes containing electrons of Cooper pair and lower limit for the distance between predicted super-stripes would correspond to a p-adic time scale $T(151) \sim 10^{-16}/3$ seconds for ordinary Planck constant. For $\hbar = 2^{22}\hbar_0$ this time scale would be scaled up to about $.15n$ picoseconds. This kind of length scale corresponds for electron to $n_F = 2^{22}$ rather than $n_F = 2^{11}$. One could however argue that by the very definition of quantum quantum criticality several values of $n_F$ must be involved. The quantum model of EEG indeed assumes this kind of hierarchy [M3]. Note that $n_F = 3 \times 2^{12}$ would give picosecond scale as also (157).

Just for fun one can also consider the possibility that this time scale is due to the large $\hbar$ phase for nuclei and hadrons. Large $\hbar$ for nuclei and quarks would means gigantic Compton lengths and makes possible macroscopic quantum phase competing with ordinary phase. If one accepts TGD based model for atomic nuclei where $k = 129$ corresponds to the size of the magnetic body of ordinary nuclei [F8], the super-stripes could involve also the color magnetic bodies of dark hadrons. The size of color magnetic body for ordinary hadrons is $L(k_{eff} = 107 + 22 = 129)$ and therefore $L(k_{eff} = 129 + 22 = 151)$ for dark hadrons. This of course forces the question whether the nuclei along stripes correspond to dark nuclei. Large $\hbar$ phase for hadrons means also scaling up of the basic purely hadronic time scales. Notice that neutral pion lifetime $\sim 2 \times 10^{-16}$ seconds would be scaled up by a factor $2^{11}$ to .2 picoseconds.

**Why copper and what about other elements?**

The properties of copper are somehow crucial for high $T_c$ superconductivity since cuprates are the only known high $T_c$ superconductors. Copper corresponds to $3d^{10}4s$ ground state configuration with one valence electron. This encourages to think that the doping by holes needed to achieve super-conductivity induces the dropping of these electrons to $k = 151$ space-time sheets and gives rise to Cooper pairs.

More generally, elements having one electron in $s$ state plus full electronic shells are good candidates for doped high $T_c$ superconductors. If the atom in question is also a boson the formation of atomic Bose-Einstein condensates at Cooper pair space-time sheets is favored. Superfluid would be in question. Thus elements with odd value of $A$ and $Z$ possessing full shells plus single $s$ wave valence electron are of special interest. The six stable elements satisfying these conditions are $^{5}$Li, $^{39}$K, $^{63}$Cu, $^{85}$Rb, $^{133}$Cs, and $^{197}$Au. Partially dark Au for which dark nuclei form a superfluid could correspond to what Hudson calls White Gold [102] and the model for high $T_c$ superconductivity indeed explains the properties of White Gold.

### 1.3.4 Speculations

**21-Micrometer mystery**

21 micrometer radiation from certain red giant stars have perplexed astronomers for more than a decade. Emission forms a wide band (with width about 4 micrometers) in the infrared spectrum which suggests that it comes form a large complex molecule or a solid or simple molecules found around starts. Small molecules are ruled out since they produce narrow emission lines. The feature can be only observed in very precise evolutionary state, in the transition between red giant phase and planetary nebular state, in which star blows off dust that is rich in carbon compounds. There is no generally accepted explanation for 21-micrometer radiation.

One can consider several explanations based on p-adic length scale hypothesis and some explanations might relate to the wormhole based super-conductivity.

1. 21 micrometers corresponds to the photon energy of 59 meV which is quite near to the zero point point kinetic energy 61.5 meV of proton Cooper pair at $k = 139$ space-time sheet estimated from the formula

$$\Delta E(2m_p, 139) = \frac{1}{2}\frac{\pi^2}{(2m_p)L(169)^2} = \frac{1}{8}\Delta E(m_p, 137) \simeq 61.5\ meV \quad .$$

Here the binding energy of the Cooper pair tending to reduce this estimate is neglected, and this estimate makes sense only apart from a numerical factor of order unity. This energy is liberated when a Cooper pair of protons at $k = 139$ space-time sheet drops to the magnetic flux tube of Earth's magnetic field (or some other sufficiently large space-time sheet). This energy is rather near to the threshold value about 55 meV of the membrane potential. This observation and the presence of the carbon compounds leads to ask whether bio-superconductors and perhaps even some primitive forms of life might be involved.

2. 21 micrometer radiation could also result when electrons at $k = 151$ space-time sheet drop to a large enough space-time sheet and liberate their zero point kinetic energy. Scaling argument gives for the zero point kinetic energy of electron at $k = 151$ space-time sheet the value $\Delta(e, 151) \simeq$ 57.5 meV which is also quite near to the observed value. If electron is bound to wormhole with quantum numbers of $\overline{d}$ Coulombic binding energy changes the situation.

3. A possible explanation is as radiation associated with the transition to high $T_c$ super conducting phase. There are two sources of photons. Radiation could perhaps result from the de-excitations of wormhole BE condensate by photon emission. $\lambda = 20.48$ micrometers is precisely what one expects if the space-time sheet corresponds to $p \simeq 2^k$, $k = 173$ and assumes that excitation energies are given as multiples of $E_w(k) = 2\pi/L(k)$. This predicts excitation energy $E_w(173) \simeq$ 61.5 meV. Unfortunately, this radiation should correspond to a sharp emission line and cannot explain the wide spectrum.

**Ionic high $T_c$ superconductivity and high $T_c$ super-fluidity**

The model of electronic superconductivity generalizes to the case of fermionic ions in almost trivial manner. The stability condition determining the p-adic length scale in question is obtained by replacing electron mass with the mass $Am_p$ of ion and electron charge with the charge $Ze$ of the ion. The expression of binding energy as sum of kinetic energy and Coulombic interaction energy has the general form

$$T_e + V_{ee} + V_{eq} = \frac{a_e}{L^2(k)} - \frac{b_e}{L(k)} , \tag{1.3.11}$$

and gives maximum binding energy for

$$L = \frac{2a_e}{b_e} \simeq L(151) . \tag{1.3.12}$$

The replacement of electrons with ions of charge $Z$ induces the replacements

$$\begin{aligned} a_e &\rightarrow \frac{m_e}{Am_p} a_e , \\ b_e &\rightarrow Z^2 b_e , \\ L &\rightarrow \frac{m_e}{AZ^2 m_p} L_e \simeq \frac{1}{AZ^2} L(129) . \end{aligned} \tag{1.3.13}$$

This scale would be too short for ordinary value of $\hbar$ but if the nuclei are in large $\hbar$ phase, $L$ is scaled up by a factor $\simeq n \times 2^{11}$ to $L(k_{eff}) = nL(k + 22)$. This gives

$$L(k) \simeq \frac{n}{AZ^2} L(151) . \tag{1.3.14}$$

This length scale is above $L(137)$ for $AZ^2 < 2^7 n = 128n$: $n = 3$ allows all physical values of $A$. If $L(135)$ is taken as lower bound, one has $AZ^2 < 2^9 n$ and $n = 1$ is enough.

Second constraint comes from the requirement that the gap temperature defined by the stability against transition $k \rightarrow k - 2$ is above room temperature.

$$3 \times \frac{\pi^2\hbar^2}{2Am_pL^2(k)} \simeq 2^{-k+137}\frac{.5}{A} \quad \text{eV} \geq T_{room} \simeq .03 \quad \text{eV} \quad . \tag{1.3.15}$$

Since the critical temperature scales as zero point kinetic energy, it is scaled down by a factor $m_e/Am_p$. $k \geq 137$ would give $A \leq 16$, $k = 135$ would give $A \leq 64$, and $k = 131$ allows all values of $A$.

The Bose-Einstein condensates of bosonic atoms giving rise to high $T_c$ super fluidity are also possible in principle. The mechanism would be the dropping of atoms to the space-time sheets of electronic Cooper pairs. Thermal stability is achieved if nuclei are in doubly dark nuclear phase and electrons correspond to large $\hbar$ phase. Electronic Cooper pairs would correspond to $k_{eff} = 151+22 = 173$ space-time sheets with size about 20 $\mu$m. This is also the size scale of the Bohr radius of dark atoms [J6]. The claimed properties of so called ORMEs [102] make them a possible candidate for this kind of phase.

### Are living systems high $T_c$ superconductors?

The idea about cells and axons as superconductors has been one of the main driving forces in development of the vision about many-sheeted space-time. Despite this the realization that the supra currents in high $T_c$ superconductors flow along structure similar to axon and having same crucial length scales came as a surprise. Axonal radius which is typically of order $r = .5$ $\mu$m. $\lambda = 2^{11}$ would predict $r = .2$ $\mu$m. The fact that water is liquid could explain why the radius differs from that predicted in case of high $T_c$ superconductors.

Interestingly, Cu is one of the biologically most important trace elements [48]. For instance, copper is found in a variety of enzymes, including the copper centers of cytochrome c-oxidase, the Cu-Zn containing enzyme superoxide dismutase, and copper is the central metal in the oxygen carrying pigment hemocyanin. The blood of the horseshoe crab, Limulus polyphemus uses copper rather than iron for oxygen transport. Hence there are excellent reasons to ask whether living matter might be able to build high $T_c$ superconductors based on copper oxide.

### Neuronal axon as a geometric model for current carrying "rivers"

Neuronal axons, which are bounded by cell membranes of thickness $L(151)$ consisting of two lipid layers of thickness $L(149)$ are high $T_c$ superconductors (this was not the starting point but something which popped out naturally). The interior of this structure is in large $\hbar$ nuclear phase, which is partially dark. Since the thickness of the tube should be smaller than the quantum size of the dark nuclei, a lower limit for the radius $r$ of the corresponding nuclear space-time sheets is obtained by scaling up the weak length scale $L_w(113) = 2^{(11-89)/2}L_w(89)$ defined by W boson Compton length by a factor $2^{22}$ to doubly dark weak length scale $L_w = 2^{22}L_w(113) = .2$ $\mu$m.

These flux tubes with radius $r > L_w$ define "rivers" along which conduction electrons and various kinds of Cooper pairs flow. Scaled up electrons have size $L(k_{eff} = 149)$ corresponding to 5 nm, the thickness of the lipid layer of cell membrane. The observed quantum fluctuating stripes of length 1-10 nm might relate very closely to scaled up electrons with Compton length 5 nm, perhaps actually representing zoomed up electrons!

According to the model of dark Cooper pairs the $k = 149$ flux tubes at which electrons are condensed should be hollow. What comes in mind first is that a cylinder with radius $L(149)$ is in question having a hollow interior with say atomic radius.

The original assumption that exotic *resp.* BCS type Cooper pairs reside at boundaries *resp.* interior of the super-conducting rivulet. It would however seem that the most natural option is that the hollow cylindrical shells carry all supra currents and there are no Cooper pairs in the interior. If exotic Cooper pairs reside only at the boundary of the rivulet or the Cooper pairs at boundary remain critical against exotic-BCS transition also below $T_c$, the time dependent fluctuations of the shapes of stripes accompanying high $T_c$ super-conductivity can be understood as being induced by the fluctuations of membrane like structures. Quantum criticality at some part of the boundary is necessary in order to transform ordinary electron currents to super currents at the ends of rivulets. In biology this quantum criticality would correspond to that of cell membrane.

## 1.4 Exotic atoms, wormhole super conductivity and wormhole magnetic fields

Exotic atom, wormhole super conductivity and wormhole magnetic fields are purely TGD based concepts and it seems that these concepts might be involved with the transition from organic chemistry to biochemistry. There is certainly much more involved, in particular the long range color and weak forces discussed in [F10].

### 1.4.1 Exotic atoms

For ordinary atoms all electrons are condensed on the "atomic" condensation level. One could however think the possibility that some electrons, most probably some valence electrons with high value of principal quantum number $n$, condense to the lower condensation level, at which atom itself is condensed. This process would give rise to exotic atoms. The exotic counterpart of atom with charge Z would behave chemically as element with $Z - n(val)$, where $n(val)$ is the number of exotic valence electrons. The energy levels of electron at the exotic condensate level should depend only very weakly on the nuclear charge of the parent atom: only the number of valence electrons is what matters. In particular, "electronic" alchemy becomes in principle possible by dropping some electrons on the lower condensate level. One can consider two options depending on whether the dropped electrons are ordinary or dark.

*1. Dropped electrons are not dark*

The model to be represented is the first version about exotic super-conductivity which was based on the idea about wormhole contact as a counterpart of phonon. Much later it became obvious that charged wormhole contacts can be in fact be identified as counterparts for charged Higgs field making photons massive. This aspect is not discussed below.

The exotic electrons see the Coulomb field of nucleus with effective charge $n(val)$. This charge and gravitational flux flows from the atomic condensate level via the tiny wormhole contacts located near the boundaries of atomic condensate level. If the electric flux of the wormhole is quantized with proton charge as unit there are $n(val)$ wormhole contacts, with each wormhole carrying one unit of electric charge. Note that the minimal unit of flux is naturally 1/3 of elementary charge and the detection of electric flux of this size would be a triumph of the theory. In order to be able to evaluate the energy levels of this pseudo hydrogen atom one must know something about the mass of the wormhole contacts. The following physical considerations give estimate for the mass.

p-Adic length scale hypothesis states that physically most interesting length/mass scales are in one-one- correspondence with p-adic primes $p$ near prime powers of two ($p \simeq 2^k$, $k$ prime) and p-adic mass scale is given by $m \sim 1/L(p)$, where $L(p)$ is p-adic length scale expressible in terms of Planck length as $L(p) \simeq 10^4\sqrt{p}\sqrt{G}$. The representation of wormhole contact as parton pair suggests that apart from effects related to the binding of wormhole throats to single unit, the inertial mass is just the sum of contributions of parton and antiparton associated with the throats carrying opposite gauge quantum numbers. If the time orientations of the space-time sheets involved are opposite, the energies can sum up to zero and the wormhole contact carries no mass. Otherwise the mass is sum of the two masses and the dominant contribution to their mass is determined by the length scale associated with the smaller space-time sheet and thus proportional to $1/\sqrt{p_1}$. In atomic length scales this would give mass of order $10^4$ eV and in the length scale corresponding to room temperature mass would be of order $10^{-2}$ eV. Atoms ($k = 137$) can feed they electromagnetic gauge fluxes directly to "lower" p-adic condensate levels (such as $k = 149$) rather than $k = 139$ to minimize the contribution of wormhole masses to energy.

The small mass of wormhole implies that for atoms with sufficiently high $Z$ it could be energetically favorable to drop electrons to the lower condensate level. Very light wormhole contacts are described by d'Alembertian operator associated with the induced metric of the 3-dimensional surface describing the boundary of atomic surface and having one time like direction.

Wormhole contacts are free to move along the boundary of the atomic 3-surface. If wormhole contacts are very light but not exactly massless, it is clear that wormhole contacts behave as bosons restricted to this surface and that state they condense on ground state. For very light but not massless wormhole contacts the lowest state has energy equal to rest mass of the wormhole and next state has energy of order $\pi/a \sim 10^4\ eV$, where $a$ is the radius of atom. Therefore very light wormhole contacts BE condense on the ground state and give rise to a constant charge distribution on the spherical shell surrounding atom. For exactly massless wormhole contacts the zero energy state is not possible and localization of massless wormhole contacts on surface of atomic size would require energy of order $10^4\ eV$. In the interior of this shell electrons are free and in exterior they move in the field of this charge distribution and form bound states. The energies of the electrons at "lower" space-time sheet depend only weakly on the value of Z (only via the dependence of the size of atomic 3-surface on Z) so that the spectral lines associated with the exotic atoms should be in certain sense universal.

The dropping of electrons of heavy atoms, such as Gold or Pb, to the lower space-time sheet, might be energetically favorable or require only a small energy and be induced by, say, absorption of a visible light. Once single electron is dropped it becomes more favorable for second electron to drop since the potential well in the final state is now deeper. The fact, that wormhole contacts form BE Einstein condensate, gives transition probability proportional to $N^2$ instead of $N$, $N$ being the number of wormhole contacts already present. In this manner even cascade like process could become possible leading to drop of all valence electrons to the lower space-time sheet. One could even end up from heavy metal such as lead to pseudo-Xenon noble gas evaporating instantaneously!

*2. Could exotic valence electrons be dark?*

The basic objection against the proposed model is that the proposed wormhole mechanism has no experimental support. If temperature is same at the space-time sheets carrying the dropped electrons, it is not possible to have high $T_c$ super-conductivity for conventional mechanisms.

The valence electrons could however be also dark, which would mean that at some radius atomic electric gauge fluxes flow to a dark space-time sheet and is shared to $n_b$ sub-fluxes so that the each sheet carries flux $n_{val}/n_b$. For $n_a/n_b > 1$ the fractionization of the radial electric gauge flux could make the states of valence electrons thermally unstable. $n_a/n_b > 1$ would however favor the formation of Cooper pairs and thus high $T_c$ variant of conventional super-conductivity with critical temperature scaled up by $n_a^2$.

The presence of Ca, Na and K ions in cells and their importance for the functioning of cell membrane could be also due to the fact that these ions are formed when some of the valence electrons transform to dark electrons and become super-conducting. An alternative explanation is that also the nuclei in question are dark and $n_a/n_b$ is so high that atomic binding energies for valence electrons are below thermal threshold and cold plasma of dark ions is formed. These electrons could form Cooper pairs for large enough $n_a/n_b$. Magnetic flux sheets are excellent candidates for these space-time sheets. The observed ions would result via a phase transition of these ions to ordinary ones. Chemically the resulting elements would behave like noble gas. This kind of mechanism might be involved also with the formation of high $T_c$ super-conductors.

### 1.4.2 Mono-atomic elements as dark matter and high $T_c$ super-conductors?

The ideas related to many-sheeted space-time began to develop for a decade ago. The stimulation came from a contact by Barry Carter who told me about so called mono-atomic elements, typically transition metals (precious metals), including Gold. According to the reports these elements, which are also called ORMEs ("orbitally rearranged monoatomic elements") or ORMUS, have following properties.

1. ORMEs were discovered and patented by David Hudson [102] are peculiar elements belonging to platinum group (platinum, palladium, rhodium, iridium, ruthenium and osmium) and to transition elements (gold, silver, copper, cobalt and nickel).

2. Instead of behaving as metals with valence bonds, ORMEs have ceramic like behavior. Their density is claimed to be much lower than the density of the metallic form.

3. They are chemically inert and poor conductors of heat and electricity. The chemical inertness of these elements have made their chemical identification very difficult.

4. One signature is the infra red line with energy of order .05 $eV$. There is no text book explanation for this behavior. Hudson also reports that these elements became visible in emission spectroscopy in which elements are posed in strong electric field after time which was 6 times longer than usually.

The pioneering observations of David Hudson [102] - if taken seriously - suggest an interpretation as an exotic super-conductor at room temperature having extremely low critical magnetic fields of order of magnetic field of Earth, which of course is in conflict with the standard wisdom about super-conductivity. After a decade and with an impulse coming from a different contact related to ORMEs, I decided to take a fresh look on Hudson's description for how he discovered ORMEs [102] with dark matter in my mind. From experience I can tell that the model to be proposed is probably not the final one but it is certainly the simplest one.

There are of course endless variety of models one can imagine and one must somehow constrain the choices. The key constraints used are following.

1. Only valence electrons determining the chemical properties appear in dark state and the model must be consistent with the general model of the enhanced conductivity of DNA assumed to be caused by large $\hbar$ valence electrons with $r = \hbar/\hbar_0 = n$, $n = 5, 6$ assignable with aromatic rings. $r = 6$ for valence electrons would explain the report of Hudson about anomalous emission spectroscopy.

2. This model cannot explain all data. If ORMEs are assumed to represent very simple form of living matter also the presence electrons having $\hbar/\hbar_0 = 2^{k11}$, $k = 1$, can be considered and would be associated with high $T_c$ super-conductors whose model predicts structures with thickness of cell membrane. This would explain the claims about very low critical magnetic fields destroying the claimed superconductivity.

Below I reproduce Hudson's own description here in a somewhat shortened form and emphasize that must not forget professional skepticism concerning the claimed findings.

**Basic findings of Hudson**

Hudson was recovering gold and silver from old mining sources. Hudson had learned that something strange was going on with his samples. In molten lead the gold and silver recovered but when "I held the lead down, I had nothing". Hudson tells that mining community refers to this as "ghost-gold", a non-assayable, non-identifiable form of gold.

Then Hudson decided to study the strange samples using emission spectroscopy. The sample is put between carbon electrodes and arc between them ionizes elements in the sample so that they radiate at specific frequencies serving as their signatures. The analysis lasts 10-15 seconds since for longer times lower electrode is burned away. The sample was identified as Iron, Silicon, and Aluminum. Hudson spent years to eliminate Fe, Si, and Al. Also other methods such as Cummings Microscopy, Diffraction Microscopy, and Fluorescent Microscopy were applied and the final conclusion was that there was nothing left in the sample in spectroscopic sense.

After this Hudson returned to emission spectroscopy but lengthened the time of exposure to electric field by surrounding the lower Carbon electrode with Argon gas so that it could not burn. This allowed to reach exposure times up to 300 s. The sample was silent up to 90 s after which emission lines of Palladium (Pd) appeared; after 110 seconds Platinum (Pt); at 130 seconds Ruthenium (Ru); at about 140-150 seconds Rhodium; at 190 seconds Iridium; and at 220 seconds Osmium appeared. This is known as fractional vaporization.

Hudson reports the boiling temperatures for the metals in the sample having in mind the idea that the emission begins when the temperature of the sample reaches boiling temperature inspired by the observation that elements become visible in the order which is same as that for boiling temperatures.

The boiling temperatures for the elements appearing in the sample are given by the following table.

| Element | $Ca$ | $Fe$ | $Si$ | $Al$ | $Pd$ | $Rh$ |
|---|---|---|---|---|---|---|
| $T_B/^oC$ | 1420 | 1535 | 2355 | 2327 | >2200 | 2500 |
| Element | $Ru$ | $Pt$ | $Ir$ | $Os$ | $Ag$ | $Au$ |
| $T_B/^oC$ | 4150 | 4300 | $> 4800$ | $> 5300$ | 1950 | 2600 |

Table 2. Boiling temperatures of elements appearing in the samples of Hudson.

Hudson experimented also with commercially available samples of precious metals and found that the lines appear within 15 seconds, then follows a silence until lines re-appear after 90 seconds. Note that the ratio of these time scales is 6. The presence of some exotic form of these metals suggests itself: Hudson talks about mono-atomic elements.

Hudson studied specifically what he calls mono-atomic gold and claims that it does not possess metallic properties. Hudson reports that the weight of mono-atomic gold, which appears as a white powder, is 4/9 of the weight of metallic gold. Mono-atomic gold is claimed to behave like super-conductor.

Hudson does not give a convincing justification for why his elements should be mono-atomic so that in following this attribute will be used just because it represents established convention. Hudson also claims that the nuclei of mono-atomic elements are in a high spin state. I do not understand the motivations for this statement.

### Claims of Hudson about ORMEs as super conductors

The claims of Hudson that ORMES are super conductors [102] are in conflict with the conventional wisdom about super conductors.

1. The first claim is that ORMEs are super conductors with gap energy about $\Delta = .05$ eV and identifies photons with this energy resulting from the formation of Cooper pairs. This energy happens to correspond one of the absorption lines in high $T_c$ superconductors.

2. ORMEs are claimed to be super conductors of type II with critical fields $H_{c1}$ and $H_{c2}$ of order of Earth's magnetic field having the nominal value $.5 \times 10^{-4}$ Tesla [102]. The estimates for the critical parameters for the ordinary super conductors suggests for electronic super conductors critical fields, which are about .1 Tesla and thus by a factor $\sim 2^{11}$ larger than the critical fields claimed by Hudson.

3. It is claimed that ORME particles can levitate even in Earth's magnetic field. The latter claim looks at first completely nonsensical. The point is that the force giving rise to the levitation is roughly the gradient of the would-be magnetic energy in the volume of levitating super conductor. The gradient of average magnetic field of Earth is of order $B/R$, $R$ the radius of Earth and thus extremely small so that genuine levitation cannot be in question.

### Minimal model

Consider now a possible TGD inspired model for these findings assuming for definiteness that the basic Hudson's claims are literally true.

*1. In what sense mono-atomic elements could be dark matter?*

The simplest option suggested by the applicability of emission spectroscopy and chemical inertness is that mono-atomic elements correspond to ordinary atoms for which valence electrons are dark electrons with large $\hbar/\hbar_0 = n_a/n_b$. Suppose that the emission spectroscopy measures the energies of dark photons from the transitions of dark electrons transforming to ordinary photons before the detection by de-coherence increasing the frequency by the factor $r = \hbar/\hbar_0$. The size of dark electrons and temporal duration of basic processes would be zoomed up by $r$.

Since the time scale after which emission begins is scaled up by a factor 6, there is a temptation to conclude that $r = n_a/n_b = 6$ holds true. Note that $n = 6$ corresponds to Fermat polygon and is thus preferred number theoretically in TGD based model for preferred values of $\hbar$ [A9]. The simplest possibility is that the group $G_b$ is trivial group and $G_a = A_6$ or $D_6$ so that ring like structures containing six dark atoms are suggestive.

This brings in mind the model explaining the anomalous conductivity of DNA by large $\hbar$ valence electrons of aromatic rings of DNA. The zooming up of spatial sizes might make possible exotic effects and perhaps even a formation of atomic Bose-Einstein condensates of Cooper pairs. Note however that in case of DNA $r = 6$ not gives only rise to conductivity but not super-conductivity and that $r = 6$ cannot explain the claimed very low critical magnetic field destroying the super-conductivity.

*2. Loss of weight*

The claimed loss of weight by a factor $p \simeq 4/9$ is a very significant hint if taken seriously. The proposed model implies that the density of the partially dark phase is different from that of the ordinary phase but is not quantitative enough to predict the value of $p$. The most plausible reason for the loss of weight would be the reduction of density induced by the replacement of ordinary chemistry with $\hbar/\hbar_0 = n_a/n_b = 6$ chemistry for which the Compton length of valence electrons would increase by this factor.

*3. Is super-conductivity possible?*

The overlap criterion is favorable for super-conductivity since electron Compton lengths would be scaled up by factor $n_a = 6, n_b = 1$. For $\hbar/\hbar_0 = n_a = 6$ Fermi energy would be scaled up by $n_a^2 = 36$ and if the same occurs for the gap energy, $T_c$ would increase by a factor 36 from that predicted by the standard BCS theory. Scaled up conventional super-conductor having $T_c \sim 10$ K would be in question (conventional super-conductors have critical temperatures below 20 K). 20 K upper bound for the critical temperature of these superconductors would allow 660 K critical temperature for their dark variants!

For large enough values of $n_a$ the formation of Cooper pairs could be favored by the thermal instability of valence electrons. The binding energies would behave as $E = (n_b/n_a)^2 Z_{eff}^2 E_0/n^2$, where $Z_{eff}$ is the screened nuclear charge seen by valence electrons, $n$ the principal quantum number for the valence electron, and $E_0$ the ground state energy of hydrogen atom. This gives binding energy smaller than thermal energy at room temperature for $n_a/n_b > (Z_{eff}/n)\sqrt{2E_0/3T_{room}} \simeq 17.4 \times (Z_{eff}/n)$. For $n = 5$ and $Z_{eff} < 1.7$ this would give thermal instability for $n_a = 6$.

Interestingly, the reported .05 eV infrared line corresponds to the energy assignable to cell membrane voltage at criticality against nerve pulse generation, which suggests a possible connection with high $T_c$ superconductors for which also this line appears and is identified in terms of Josephson energy. .05 eV line appears also in high $T_c$ superconductors. This interpretation does not exclude the interpretation as gap energy. The gap energy of the corresponding BCS super-conductor would be scaled down by $1/n_a^2$ and would correspond to 14 K temperature for $n_a = 6$.

Also high $T_c$ super-conductivity could involve the transformation of nuclei at the stripes containing the holes to dark matter and the formation of Cooper pairs could be due to the thermal instability of valence electrons of Cu atoms (having $n = 4$). The rough extrapolation for the critical temperature for cuprate superconductor would be $T_c(Cu) = (n_{Cu}/n_{Rh})^2 T_c(Rh) = (25/36)T_c(Rh)$. For $T_c(Rh) = 300$ K this would give $T_c(Cu) = 192$ K: accoding to Wikipedia cuprate perovskite has the highest known critical temperature which is 138 K. Note that quantum criticality suggests the possibility of several values of $(n_a, n_b)$ so that several kinds of super-conductivities might be present.

### ORMEs as partially dark matter, high $T_c$ super conductors, and high $T_c$ super-fluids

The appearance of .05 eV photon line suggest that same phenomena could be associated with ORMEs and high $T_c$ super-conductors. The strongest conclusion would be that ORMEs are $T_c$ super-conductors and that the only difference is that $Cu$ having single valence electron is replaced by a heavier atom with single valence electron. In the following I shall discuss this option rather independently from the minimal model.

*1. ORME super-conductivity as quantum critical high $T_c$ superconductivity*

ORMEs are claimed to be high $T_c$ superconductors and the identification as quantum critical superconductors seems to make sense.

1. According to the model of high $T_c$ superconductors as quantum critical systems, the properties of Cooper pairs should be more or less universal so that the observed absorption lines discussed in the section about high $T_c$ superconductors should characterize also ORMEs. Indeed, the reported 50 meV photon line corresponds to a poorly understood absorption line in the case of high $T_c$ cuprate super conductors having in TGD framework an interpretation as a transition in which exotic Cooper pair is excited to a higher energy state. Also Copper is a transition metal and is one of the most important trace elements in living systems [48]. Thus the Cooper pairs could be identical in both cases. ORMEs are claimed to be superconductors of type II and quantum critical superconductors are predicted to be of type II under rather general conditions.

2. The claimed extremely low value of $H_c$ is also consistent with the high $T_c$ superconductivity. The supra currents in the interior of flux tubes of radius of order $L_w = .2\ \mu$m are BCS type supra currents with large $\hbar$ so that $T_c$ is by a factor $2^{11}$ higher than expected and $H_c$ is reduced by a factor $2^{-11/2}$. This indeed predicts correct order of magnitude for the critical magnetic field.

3. $r = \hbar/\hbar_0 = 2^{11}$ is considerably higher that $r = 6$ suggested by the minimum model explaining emission spectroscopic results of Hudson. Of course, several values of $\hbar$ are possible and the values $r \in \{5, 6, 2^{k11}\}$ are indeed assumed in TGD inspired model of living matter and generalize EEG [M3]. Thus internal consistency would be achieved if ORMEs are regarded as a very simple form of living matter.

4. The electronic configurations of Cu and Gold are chemically similar. Gold has electronic configuration $[Xe, 4f^{14}5d^{10}]6s$ with one valence electron in $s$ state whereas Copper corresponds to $3d^{10}4s$ ground state configuration with one valence electron. This encourages to think that the doping by holes needed to achieve superconductivity induces the dropping of these electrons to $k = 151$ space-time sheets and gives rise to exotic Cooper pairs. Also this model assumes the phase transition of some fraction of Cu nuclei to large $\hbar$ phase and that exotic Cooper pairs appear at the boundary of ordinary and large $\hbar$ phase.

   More generally, elements having one electron in $s$ state plus full electronic shells are good candidates for doped high $T_c$ superconductors. Both Cu and Au atoms are bosons. More generally, if the atom in question is boson, the formation of atomic Bose-Einstein condensates at Cooper pair space-time sheets is favored. Thus elements with odd value of $A$ and $Z$ possessing full shells plus single $s$ wave valence electron are of special interest. The six stable elements satisfying these conditions are $^5$Li, $^{39}$K, $^{63}$Cu, $^{85}$Rb, $^{133}$Cs, and $^{197}$Au.

*2. "Levitation" and loss of weight*

The model of high $T_c$ superconductivity predicts that some fraction of Cu atoms drops to the flux tube with radius $L_w = .2\ \mu$m and behaves as a dark matter. This is expected to occur also in the case of other transition metals such as Gold. The atomic nuclei at this space-time sheet have high charges and make phase transition to large $\hbar$ phase and form Bose-Einstein condensate and superfluid behavior results. Electrons in turn form large $\hbar$ variant of BCS type superconductor. These flux tubes are predicted to be negatively charged because of the Bose-Einstein condensate of exotic Cooper pairs at the boundaries of the flux tubes having thickness $L(151)$. The average charge density equals to the doping fraction times the density of Copper atoms.

The first explanation would be in terms of super-fluid behavior completely analogous to the ability of ordinary superfluids to defy gravity. Second explanation is based on the electric field of Earth which causes an upwards directed force on negatively charged BE condensate of exotic Cooper pairs and this force could explain both the apparent levitation and partial loss of weight. The criterion for levitation is $F_e = 2eE/x \geq F_{gr} = Am_pg$, where $g \simeq 10$ m$^2$/s is gravitational acceleration at the surface of Earth, $A$ is the atomic weight and $m_p$ proton mass, $E$ the strength of electric field, and $x$ is the number of atoms at the space-time sheet of a given Cooper pair. The condition gives $E \geq 5 \times 10{-}10Ax$ V/m to be compared with the strength $E = 10^2 - 10^4$ V/m of the Earths' electric field.

An objection against the explanation for the effective loss of weight is that it depends on the strength of electric field which varies in a wide range whereas Hudson claims that the reduction factor is constant and equal to 4/9. A more mundane explanation would be in terms of a lower density of dark Gold. This explanation is quite plausible since there is no atomic lattice structure since nuclei and electrons form their own large $\hbar$ phases.

*4. The effects on biological systems*

Some monoatomic elements such as White Gold are claimed to have beneficial effects on living systems [102]. 5 per cent of brain tissue of pig by dry matter weight is claimed to be Rhodium and Iridium. Cancer cells are claimed to be transformed to healthy ones in presence of ORMEs. The model for high $T_c$ super conductivity predicts that the flux tubes along which interior and boundary supra currents flow has same structure as neuronal axons. Even the basic length scales are very precisely the same. On basis of above considerations ORMEs are reasonable candidates for high $T_c$ superconductors and perhaps even super fluids.

The common mechanism for high $T_c$, ORME- and bio- super-conductivities could explain the biological effects of ORMEs.

1. In unhealthy state superconductivity might fail at the level of cell membrane, at the level of DNA or in some longer length scales and would mean that cancer cells are not anymore able to communicate. A possible reason for a lost super conductivity or anomalously weak super conductivity is that the fraction of ORME atoms is for some reason too small in unhealthy tissue.

2. The presence of ORMEs could enhance the electronic bio- superconductivity which for some reason is not fully intact. For instance, if the lipid layers of cell membrane are, not only wormhole-, but also electronic super conductors and cancer involves the loss of electronic super-conductivity then the effect of ORMEs would be to increase the number density of Cooper pairs and make the cell membrane super conductor again. Similar mechanism might work at DNA level if DNA:s are super conductors in "active" state.

*5. Is ORME super-conductivity associated with the magnetic flux tubes of dark magnetic field $B_d = 0.2$ Gauss?*

The general model for the ionic super-conductivity in living matter, which has developed gradually during the last few years and will be discussed in detail later, is based on the assumption that super-conducting particles reside at the super-conducting magnetic flux tubes of Earth's magnetic field with nominal value $B_E = .5$ Gauss. It later became clear that the explanation of ELF em fields on vertebrate brain requires $B_d = .2$ Gauss rather than $B_E$ as was erratically assumed in the original model. The interpretation was as dark magnetic field $B_d = .2$ Gauss.

The predicted radius $L_w = .2$ $\mu$m is consistent with the radius of neuronal axons. For $\hbar \rightarrow n \times 2^{11}\hbar$, $n = 3$, the radius is 1.2 $\mu$m and still smaller than the radius $d$ of flux tube of $B_E$ of order $d = 5$ $\mu$m and scales up as $d \rightarrow \sqrt{B_d/B_E}\sqrt{r}d = \sqrt{5r/2}d$ in the replacement $\hbar/\hbar_0 \rightarrow r$, $B_E \rightarrow B_d$. Consistency is achieved even for $r = 1$ and for $r = 6$ the radius corresponds to the size of large neuron. The most natural interpretation would be that these flux tubes topologically condense at the flux tubes of $B_d$ or $B_E$. Both bosonic ions and the Cooper pairs of electrons or of fermionic ions can act as charge carriers so that actually a whole zoo of super-conductors is predicted. There is even some support for the view that even molecules and macromolecules can drop to the magnetic flux tubes [K6].

### Nuclear physics anomalies and ORMEs

At the homepage of Joe Champion [129] information about claimed nuclear physics anomalies can be found.

1) The first anomaly is the claimed low temperature cold fusion mentioned at the homepage of Joe Champion [129]. For instance, Champion claims that Mercury (Z=80), decays by emission of proton and neutrons to Gold with Z=79 in the electrochemical arrangement described in [129].

2) Champion mentions also the anomalous production of Cadmium isotopes electrochemically in presence of Palladium reported by Tadahiko Mizuno.

The simplest explanation of the anomalies would be based on genuine nuclear reactions. The interaction of dark nuclei with ordinary nuclei at the boundary between the two phases would make possible genuine nuclear transmutations since the Coulomb wall hindering usually cold fusion and nuclear transmutations would be absent (Trojan horse mechanism). Both cold fusion and reported nuclear transmutations in living matter could rely on this mechanism as suggested in [F8, F9, F10, J6].

### Possible implications

The existence of exotic atoms could have far reaching consequences for the understanding of bio-systems. If Hudson's claims about super-conductor like behavior are correct, the formation of exotic atoms in bio-systems could provide the needed mechanism of electronic super-conductivity. One could even argue that the formation of exotic atoms is the magic step transforming chemical evolution to biological evolution.

Equally exciting are the technological prospects. If the concept works it could be possible to manufacture exotic atoms and build room temperature super conductors and perhaps even artificial life some day. It is very probable that the process of dropping electron to the larger space-time sheet requires energy and external energy feed is necessary for the creation of artificial life. Otherwise the Earth and other planets probably have developed silicon based life for long time ago. Ca, K and Na ions have central position in the electrochemistry of cell membranes. They could actually correspond to exotic ions obtained by dropping some valence electrons from $k = 137$ atomic space-time sheet to larger space-time sheets. For instance, the $k = 149$ space-time sheet of lipid layers could be in question.

The status of ORMEs is far from certain and their explanation in terms of exotic atomic concept need not be correct. The fact is however that TGD predicts exotic atoms: if they are not observed TGD approach faces the challenge of finding a good explanation for their non-observability.

### 1.4.3 Wormholes and super-conductors

#### Charged wormhole contacts behave like super conductor

Wormhole contacts are bosons and suffer Bose-Einstein condensation to the ground state at sufficiently low temperatures. Their masses are very small and they are mobile in the directions tangential to the surface of atom. Very light but not exactly massless wormhole contacts look therefore ideal candidates for super conducting charge carriers. The em current of wormhole contacts at the "lower" space-time sheet however corresponds to opposite current on the atomic space-time sheet so that actually motion of dipoles is in question (dipole moment is extremely small). Kind of "apparent" super conductivity is in question, which looks real, when one restricts attention to either space-time sheet only. It should be noticed that the dropping of electrons to lower space-time sheets is not absolutely necessarily for wormhole super conductivity since wormhole contacts can appear as genuine particles. For instance, magnetic fields created by rotating wormhole contacts on the boundaries of magnetic flux tubes are possible.

What is required for macroscopic wormhole super conductivity is the formation of a join along boundaries condensate at the atomic space-time sheet. This implies that wormhole contacts move freely in the outer surfaces defined by this condensate. Wormhole contacts condense on ground state since there is large energy gap: for very light wormholes and join along boundaries condensate of size L the order of magnitude for the gap is about $\pi/L$. Wormhole contacts can appear as super conducting "charge carriers" also at lower condensate levels. The energy gap allows objects with size of order $10^{-5} - 10^{-4}$ meters in room temperature: later it will be suggested that the largest macroscopic quantum systems in brain are of this size. If the thermalization time for between degrees of freedom associated with different space-time sheets is long, wormhole contacts can form metastable BE condensates also in longer length scales.

It has recently become clear that wormhole contacts can be seen as space-time counterparts for Higgs type particles [F2] so that nothing genuinely new would be involved. Coherent states of wormhole contacts could appear also in the description of the ordinary super-conductivity in terms of coherent states of Cooper pairs and charged Higgs type particles making sense in the zero energy ontology [C2]. Mathematically the coherent states of wormholes and Cooper pairs are very similar so that one can indeed speak about wormhole super-conductivity. For instance, both states are described by a complex order parameter. One can of course ask whether charged wormhole contacts and Cooper pairs could be seen as dual descriptions of super-conductivity. This need not be the case since standard Higgs mechanism provides an example of a presence of only wormhole contact Bose-Einstein condensate.

#### Wormhole magnetic fields as templates for bio-structures?

Wormhole magnetic fields are structures consisting of two space-time sheets connected by wormhole contacts (a more detailed treatment will be found in later chapters). The space-time sheets do not contain ordinary matter and the rotating wormhole contacts near the boundaries of the space-time sheets create magnetic fields of same strength but of opposite sign at the two space-time sheets involved. An attractive possibility is that not only ordinary but also wormhole magnetic fields could correspond to defects in bio super conductors and that they serve as templates for the formation of living matter. DNA and the hollow microtubular surfaces consisting of tubulin molecules are excellent examples of structures formed around defects of type II super conductor. The stripe like regions associated with the defects of superconductor could in turn correspond to wormhole magnetic or $Z^0$ magnetic fields serving as templates for the formation of cell membranes, epithelial cell sheets and larger structures of same kind.

Super conducting space-time sheets indeed form p-adic hierarchy and same holds true for the sizes of defects characterized by the coherence length $\xi$ in case of super conductors of type II and by the magnetic penetration depth $\lambda$ in case of super conductors of type I. The assumption that defects correspond to wormhole magnetic fields means that defect is a two-sheeted structure with wormhole magnetic field at larger sheet $k$ cancelling the original magnetic field in the region of defect whereas the upper sheet contains the field as such. If upper sheet $k_1$ is super-conductor and the penetrating field is below the critical field $B_c(k)$, the field can penetrate only to the sheet $k$ in the region near boundaries of the higher level space-time sheet such that the field strength is so large (by flux conservation) that it exceeds the critical value. This is achieved by the presence of supra currents near the boundaries of the smaller space-time sheet $k$.

In the case of super conductor of type II penetration occurs as flux tubes in the entire space-time sheet $k_1$, when the field strength is in the critical range $(H_{c_1}, H_{c_2})$. This hierarchical penetration in principle continues up to atomic length scales and once can say that defects decompose into smaller defects like Russian doll. It might well be that the fractal structure of defects is a basic architectural principle in bio-systems. Also the amplification of magnetic flux can take place: in this case two sheets contain magnetic fields having opposite directions.

Also defects formed by genuine wormhole magnetic fields are possible: in this case no external field is needed to create the defect. This kind of defects are especially interesting since their 3-space projections need not be closed flux tubes. Topologically these defects are closed as required by the conservation of magnetic flux since the magnetic flux flows from space-time sheet to another one at the ends of the defect behaving like magnetic monopoles.

In the case that the space-time sheets of wormhole magnetic field have opposite time orientations, the particles at the two space-time sheets have opposite inertial energies and it is in principle possible to generate these kind of states from vacuum. A possible interpretation for negative energy particles at the second sheet of the field quantum of wormhole magnetic field is as space-time correlates for holes.

An interesting working hypothesis is that wormhole magnetic fields serve as templates for the formation of bio-structures. The motivations are that defect regions could be regarded as realization for the reflective level of consciousness in terms of fermionic Fock state basis and that the surrounding 3-surface is in super conducting state so that also primitive sensory experiencing becomes possible. One could even say that defects formed by wormhole flux tubes are the simplest intelligent and living systems; that the type of super conductor (I or II) gives the simplest classification of living systems and that systems of type I are at higher level in evolution than systems of type II. A possible example of defects of type II are all linear bio-structures such as DNA, proteins, lipids in the cell membrane, microtubules, etc... Examples of defects of type I would be provided by cell membranes, epithelial sheets and the bilayered structures in the cortex.

### How magnetic field penetrates in super conductor?

There are motivations for finding a mechanism for the amplification of magnetic fields although the original motivation coming from attempt to explain the claimed levitation of ORMEs in the Earth's magnetic field has disappeared.

1. Magnetic flux is channelled to flux tubes when it penetrates to super-conductors of type $II$ and the strength of the magnetic field is scaled up roughly as $\lambda/\xi$ in this process.

2. Cells are known to be sensitive for very weak magnetic fields.

3. TGD proposal for the information storage in terms of topological integers related to magnetic fields also requires that the weak magnetic macroscopic fields prevailing inside brain are somehow amplified to stronger fields in microscopic length scales.

The basic mechanism for the amplification is the current of wormhole contacts induced by external magnetic field at given condensate level, which in turn serves as a source for a secondary magnetic field at higher level. Since the mass of the wormhole contact is very small the resulting current of wormhole contacts and thus the induced secondary magnetic field is strong.

1. The relevant portion of the many sheeted space-time consists of "our" space-time sheet and many sheets above it and at the top is the atomic space-time sheet. At "our" space-time sheet external magnetic field induces em surface current of wormhole contacts at this level. This current is concentrated on 2-dimensional surfaces, which corresponds to the boundaries of 3-surfaces at the previous level of the hierarchy. The interaction of wormhole contacts with the magnetic field is via the vector potential associated with the external magnetic field on "our" sheet. To get rid of unessential technicalities it is useful to assume cylindrical geometry at each space-time sheet: cylindrical surfaces with axis in same direction are considered and the radii of these surfaces get smaller in the higher levels of the topological condensate.

2. Let us study what happens to the wormhole contacts on the cylindrical surface in constant magnetic field in the direction of the cylinder of radius $R$, when the magnitude of the magnetic field increases gradually. One has to solve d'Alembert type wave equation for the scalar field (describing wormhole contacts on cylinder in the vector potential associated with the external magnetic field, which is constant on the cylinder and in direction of the atzimutal coordinate $\phi$: $A_\phi = BR/2$. Ground states correspond to the with minimum energy solutions. Vector potential gives just constant contribution to the d'Alembert equation and for small enough values of $B$ the constant, nonrotating solution remains energy minimum. When the condition $eA_\phi = m$, $m = 1, 2, ...$ is satisfied one however gets rotating solution with angular momentum $L_z = m$ with same energy as the original vacuum solution! This implies that at the critical values

$$B_{cr,m} = \frac{(2m+1)}{eR^2} \ , \tag{1.4.1}$$

the solution with $L_z = m$ becomes unstable and is replaced with $L_z = m + 1$ to achieve energy minimum.

3. At the higher condensation level the current of wormhole contacts generate a surface current

$$\begin{aligned} K &= n(\#)ev \ , \\ v &= \frac{m}{RE} \ , \end{aligned} \tag{1.4.2}$$

where $n(\#)$ is surface density of the wormhole contacts and $v = R\omega$ is the velocity of rotating wormhole contacts: $v$ is quantized from the quantization of angular momentum. $E$ is the energy of rotating wormhole. This surface current gives rise to axial magnetic field $B = n(\#)ev$ in the interior of the cylinder at the higher condensate level.

4. The magnetic field can penetrate also to the higher levels of the hierarchy via exactly the same mechanism. At higher levels the requirement that magnetic flux is quantized implies relativistic energies for wormhole contacts and therefore one has $K = n(\#)ev \simeq n(\#)e$. The magnetic fields at various levels have quantized values not depending much on the original magnetic field!

5. In non-relativistic situation one has $v \simeq eBR/m(\#)$ and the relationship $B(higher) = K$ following from Maxwell equations gives

$$\begin{aligned} B(higher) &= \mu_R(p_1, p_2)B(lower) \ , \\ \mu_R(p_1, p_2) &= \frac{e^2 n(\#)R}{m(\#)} \ . \end{aligned} \tag{1.4.3}$$

Nonrelativistic wormhole contacts amplify the magnetic field at the larger space-time sheet by a factor $\mu_R(p_1, p_2)$. $\mu_R(p_1, p_2) \sim 10^6$ is required to explain Hudson's claims if penetration takes place in single step: of course multistep process is also possible. It is useful to express the parameters $m$ and $R$ and $n(\#)$ at given p-adic condensation level in terms of the p-adic length scale $L(p)$ as

$$
\begin{aligned}
m(\#) &= \frac{m_0}{L(p)} \quad m_0 << 1 \ , \\
R &= R_0 L(p) \ , \\
v &= \frac{m}{m_0 R_0} << 1 \ , \\
n(\#) &= \frac{n_0}{L^2(p)} \ .
\end{aligned}
\tag{1.4.4}
$$

By fractality the dimensioness numbers $m_0, R_0, n_0$. should not depend strongly on p-adic condensation level. The expression for the amplification factor $\mu_R(p_1, p_2)$ in non-relativistic case reads as

$$
\mu_R(p_1,p_2) = \frac{e^2 n_0 R_0}{m_0} \ . \tag{1.4.5}
$$

Situation of course becomes relativistic for suitably large values of integer $m$.

## 1.5 Evidence for electronic super conductivity in bio-systems

There exists some evidence for super-conductivity in bio-systems. DNA should be insulator but under some circumstances it becomes conductor [99] and perhaps even high $T_c$ super-conductor. Also evidence for Josephson effect has been reported [27].

### 1.5.1 DNA as a conductor?

Barton *et al* [99] have done several experiments between 1993-1997 related to the conductivity properties of DNA double helix. The conclusion is that DNA double helix has the ability to do chemistry at distance: *"A DNA molecule with a chemical group artificially tethered to one end appears to mediate a chemical change far down the helix, causing a patch of damaged DNA to be mended."*.

What seems to occur is flow of electron current along DNA with very small resistance. Typically the experiments involve electron donator and acceptor separated by a long distance along DNA. When acceptor is radiated it goes to excited state and an electron current flows from donator to acceptor as a consequence. Standard wisdom tells that this should not be possible. The current should flow by quantum tunnelling between adjacent building units of DNA and it should diminish exponentially with distance. For proteins this is known to be the case. In experiments however no distance dependence was observed. Irradiation with visible light was also involved.

There exist a theory which assumes that the current could flow along the interior of double DNA, that is the region between the bases of strand and complementary strand. The electron would be delocalized in bases rings which would form a stack along DNA. The current would flow by tunnelling also now but the tunnelling probability would be so large that distance dependence would be weak. The critics of Barton argue that this model cannot explain all the experiments of Barton and that the model is not in accordance with basic organic chemistry and biology: ordinary sun light should have rather drastic effects on us. Barton admits that they do not understand the mechanism.

TGD suggests a possible explanation of phenomenon in terms of dark atoms or partially dark atoms for which valence electrons are dark.

1. The bases of DNA contain 5 or 6-cycles: both correspond to Fermat polygons. This symmetry suggests dark phase with $G_a \subset SU(2)$ having maximal cyclic group $Z_5$ or $Z_6$ so that one would have $n_a = 5$ or $n_a = 6$ depending on the cycle. This identification would provide first principle explanation for why just these cycles appear in living matter. Most naturally organic atoms would be ordinary but some electrons would reside on dark space-time sheets corresponding to $n_a = 5$ or $n_a = 6$ and $n_b = 1$.

2. The scaled up size of the electronic orbital would be roughly $(n_a n^2/Z_{eff}^2)a_0$ and by a factor $n_a^2$ larger than the size of ordinary orbital. The large distance of valence electrons suggest $Z_{eff} = 1$ as a first guess, which would imply delocalization of electrons in the length scale $625a_0 \sim 312$ nm for Rb and $900a_0 \sim 45$ nm for Rh. For the estimate $Z_{eff} \sim 10$ deduced below the delocalization would occur in length scales 3 nm and 9 nm which is probably quite enough since there is one DNA triplet per one nanometer if the conduction occurs as a sequence of replacements of a hole with electron analogous to the falling down of domino pieces.

3. The fact that the ratio $6/5 = 1.2$ is rather near to the ratio $45/37 = 1.22$ of nuclear charges of Rh and Rb atoms would guarantee that the binding energy of the valence electron for Rh atom with $n_a = 6$ is reasonably near to that for Rb atom with $n_a = 5$. This encourages to think that the mechanism of conductivity involves the ionization of dark valence electron of acceptor atom so that it can receive the dark valence electron of the donor atom. Delocalization makes this process possible.

4. The DNA environment would induce the phase transition of Rh and Ru atoms to partially dark atoms. The binding energy of the dark valence electron is reduced to $E = (n_b/n_a)^2 Z_{eff}^2 E_0/n^2$, where $Z_{eff}$ is the screened nuclear charge seen by valence electrons, $n = 5$ the principal quantum number for the valence electron in the recent case, and $E_0 = 13.6$ eV the ground state energy of hydrogen atom. $Z_{eff} = 1$ would give .02 eV binding energy which is quite too small. If the binding energy reduces to that of a visible photon parameterized as $E = x$ eV one obtains the condition

$$Z_{eff} = n_a n\sqrt{E/E_0} \simeq 5n_a\sqrt{x/13.6} \ .$$

For Rh $x = 2$ would give $Z_{eff} = 11.5$ and $Z_{eff} = 9.6$ for Rb.

### 1.5.2 DNA as a super-conductor?

Also in the model of ORMEs as dark matter led to $n_a = 6, n_b = 1$ in super-conducting phase. This suggests DNA super-conductivity is based on the same mechanism as the explanation of superconductivity assigned with ORMEs. In particular, the energy $E = .05$ eV associated with the critical potential of neuronal membrane could correspond to the gap energy of the DNA super-conductor and this could relate directly to the activation of DNA. As found, the dark variant of a conventional super-conductor with gap energy around 10 K would give rise to a dark superconductor with a gap energy around room temperature. The estimate $E_{gap} = E/n_a^2$ gives 14 K for $n_a = 6$ and 20 K for $n_a = 5$ for the gap energy. DNA carries -2 units of electric charge per single nucleotide and the interpretation could be as one dark Cooper pair per nucleotide. $n_a = 6$ would give the higher critical temperature.

The fact that there is a twist $\pi/10$ per single nucleotide in DNA double strand led to the proposal that DNA pr RNA might serve as a minimal topological quantum computer with computation based on braiding S-matrix and characterized by $n_a = 5$ [E9]. Perhaps dark Cooper pairs having $n_a = 5$ with charge fractionized to five identical fractions along 5-cycles could relate to the topological quantum computation.

DNA strand and its conjugate could form a pair of weakly coupled super-conductors forming kind of a scaled down version for the pairs formed by the inner and outer lipid layers of the axonal membrane or cell interior and exterior. Both DNA strand and double strand corresponds to the secondary p-adic length scale $L(71, 2) \simeq 4.4$ Angstroms. The soliton sequences associated with the phase differences of super-conducting order parameter over the Josephson junctions connecting DNA strands, and idealizable as a continuous one-dimensional Josephson junction, could serve as a quantum control mechanism. Josephson junctions could correspond to MEs which propagate with very low effective phase velocity along the DNA strand. The mathematics would be essentially that of a gravitational pendulum [M2]. Soliton like structures associated with DNA have been proposed also by Peter Gariaev [82].

#### Aromatic rings and large $\hbar$ phases

Aromatic rings contain odd number of $\pi$ delocalized electron pairs with atoms in the same plane. The delocalization of $\pi$ electrons in the ring is used to explain the stability of these compounds [69].

Benzene is the classical example of this kind of structure. Delocalization and DNA conductivity suggest interpretation in terms $n_a = 5$ or $n_a = 6$ phase and raises the question whether the delocalization of electrons could occur also in the orthogonal direction and whether it could give rise to Cooper pairs.

Aromatic rings consisting of 5 or 6 carbons are very common in biology. DNA basis have been already mentioned. Carbohydrates consist of monosaccharide sugars of which most contain aromatic ring (glucose used as metabolic fuel are exception). Monoamine neurotransmitters are neurotransmitters and neuromodulators that contain one amino group that is connected to an aromatic ring by a two-carbon chain (-CH2-CH2-). The neurotransmitters known a monoamines are derived from the four aromatic amino acids phenylalanine, tyrosine, histidine, tryptophan. Also norepinephrine, dopamine, and serotonin involve aromatic rings As a rule psychoactive drugs involve aromatic rings: for instance, LSD contains four rings.

These observations inspire the question whether the compounds containing aromatic rings serve as junctions connecting pre- and postsynaptic neurons and induce Josephson currents between them. If Josephson radiation codes for the mental images communicated to the magnetic body, the psychoactive character of these compounds could be understood. One can also ask whether these compounds induce quantum criticality making possible generation of large $\hbar$ phases?

### Graphene as another example of dark electron phase?

The behavior of electrons in graphene, which is two-dimensional hexagonal carbon crystal with a thickness of single atomic layer, is very strange [125]. Electrons behave as massless particles but move with a velocity which is 1/300 of light velocity. Graphene is an excellent conductor. TGD can provide a model for these peculiar properties.

1. One can regard graphene as a giant molecule and the hexagonal ring structure suggests that $M^4$ Planck constant is scaled up by a factor of 6 and that dark free electron pairs are associated with the ring structures. If also $CP_2$ Planck is scaled up with the same factor, chemistry is not affected although the size scale of electron wave functions is scaled up by a factor of 6. Just as in the case of DNA, the rings containing delocalized free electron pairs could be responsible for the anomalously high conductivity of graphene. If quantum critical super-conductor is in question, the super-conductivity could become possible in lower temperature.

2. Consider now the explanation for the vanishing of the rest mass. The general mass formula predicted by p-adic thermodynamics [F2] states that particle mass squared is given by the thermal average of the conformal weight and that conformal weight and thus also mass squared is additive in bound states:

$$(\sum_i p_i)^2 = \sum_i m_i^2 \tag{1.5.1}$$

The assumption $p_i^2 = m_i^2$ makes sense only for massless partons moving collinearly. In the QCD based model of hadrons only longitudinal momenta and transverse momentum squared are used as labels of parton states, which would suggest that one has

$$\begin{aligned} p_{i,||}^2 &= m_i^2 \ , \\ -\sum_i p_{i,\perp}^2 + 2\sum_{i,j} p_i \cdot p_j &= 0 \ . \end{aligned} \tag{1.5.2}$$

The masses would be reduced in bound states: $m_i^2 \rightarrow m_i^2 - (p_T^2)_i$. This could explain why massive quarks can behave as nearly massless quarks inside hadrons. In the recent case electrons would become massless if one has hadron like many electron states (free electron pairs?) with $p_T^2 = m_e^2$.

3. TGD also predicts the possibility of anomalous time dilation in the absence of gravitational field implying also reduction of light velocity. The simplest example are vacuum extremals corresponding to the warped imbedding $\phi = \omega t$ to $M^4 \times S^1$,$S^1$ a geodesic sphere of $CP_2$, which have induced metric for which time component of metric is $g_{tt} = 1 - R^2\omega^2$ instead of $g_{tt} = 1$. Light velocity defined from the time taken to get from point A to B is reduced by a factor $\sqrt{g_{tt}}$ from its maximal value. If the space-time sheets carrying the electrons have $g_{tt} = 1/300$, one can understand the reduction of light velocity.

### 1.5.3 Conducting DNA and metabolism

Besides charge transfer also energy transfer along DNA could be of importance in living systems.

#### Could metabolism involve electronic visible-dark phase transitions at DNA level?

If the dark valence electron associated with an ordinary atom is transformed to ordinary electron, the binding energy of the electron increases which means a liberation of a considerable amount of energy. This phase transition could liberate a large amount of metabolic energy in a coherent manner and might be involved with metabolism at molecular level.

#### Could the transfer of electrons along DNA make possible energy transfer?

One important function made possible by the dropping of electrons to larger space-time sheets is the transfer of not only charge but also energy through long distances and metabolism might well use this mechanism. The typical energy liberated when ATP molecule is used is about .5 eV. In the model of ATP [K6] it is suggested that energy metabolism involves the circulation of protons between atomic ($k = 137$) space-time sheets and magnetic flux tubes of Earth. The dropping of proton from $k = 137$ atomic space-time sheet to much larger space-time sheet liberates this energy as zero point kinetic energy and generation of ATP molecule involves kicking of three protons back to the atomic space-time sheets by using metabolic energy.

ATP might provide only the mechanism responsible for the energy transfer over short distances. The dropping of any ion from any space-time sheet to a larger space-time sheet is possible and liberates a definite amount of usable energy. When the smaller space-time sheet corresponds to a super-conducting space-time sheet, the ions or their Cooper pairs can be rapidly transferred as dissipation free supra currents to the region, where the energy is needed. This long distance energy transfer mechanism could be associated with all kinds of linear structures: DNA, proteins, microfilaments, microtubules, axons etc... The magnitude of the energy quantum released would be fixed by the p-adic length scale hypothesis and the mass of the ion or of the Cooper pair. The acceleration in endogenous electric fields provides a mechanism kicking the ions back to the smaller space-time sheets.

Because of their low mass, electrons are exceptional. The dropping of an electronic Cooper pair from $k = 139$ some space-time sheet presumably associated with the hydrogen bonds of length about 3 nm connecting the nucleotides of different DNA strands would liberate a huge energy of about 120 eV. The corresponding UV photon has frequency not far from the miracle frequency associated with $k = 151$ p-adic length scale, which is the first of the four subsequent p-adic miracle length scales corresponding to Gaussian Mersennes. The dropping of electron Cooper pair from the space-time sheet of the DNA strand of thickness of order $4 - 5$ Angstroms, which presumably corresponds to the secondary p-adic length scale $L(71, 2) \simeq 4.4$ Angstroms, liberates energy of about 15 eV, which in turn corresponds to the p-adic miracle length scale $L(157)$. This would mean that all miracle length scales would correspond to some energy unit of energy metabolism [K6]!

An interesting question relates to the possible function of this UV photon. The wavelength $\lambda = L(151)$ corresponds to the thickness of the cell membrane. It is also to the minimal length of DNA sequence (10 DNA triplets) with the property that the net winding is a multiple of $2\pi$ ($3 \times 2\pi$). By its reflection symmetry this helical sequence might serve as a subunit of DNA sequence. The ends of this subunit could act as mirrors connected by MEs carrying Bose-Einstein condensed photons propagating back and worth between the mirrors. The energy liberated by the electron as an UV photon could BE condense to this kind of ME.

At least in the case of monocellulars having DNA at cell membrane, the photon could also be reflected between the outer and inner boundary of the cell membrane.

### 1.5.4 Some empirical evidence for super conductivity in bio-systems

There is indirect evidence for electronic super conductivity in bio-systems. The basic signatures are photon emission and absorption with energies coming as multiples of the potential difference between two weakly coupled super conductors and voltage-current characteristics of Josephson current. The evidence is related to the tunnelling of electrons between a weakly coupled pair of super conductors.

According to [30], for several biological systems involving nerve or growth processes the square of the activation energy is a linear function of temperature over a moderate range of physiological temperatures. This behavior may be predicted from the hypothesis that the rate of biological process is controlled by single electron tunnelling between micro-regions of super-conductivity. In TGD framework natural candidates for this kind of regions are the lipid layers of cell membranes and cells themselves.

Positive experimental evidence for Josephson effect is reported and discussed in [27]. The evidence is based on the observation of voltage-current characteristic typical to the Josephson current flowing between weakly coupled super conductors, which are identified as neighboring cells. Also the radiation of photons with energies which are multiples of the potential difference between the weakly coupled super conductors is used as an empirical signature. The potential difference is about 15 nV and in competely different range as the potential difference of order .05 V between the lipid layers of the cell membrane. Various species of organisms can detect weak magnetic fields from .1 to 5 gauss and this is in accordance with the existence of Josephson junction in systems, which are super conductors of type II in critical region between $H_{c_1}$ and $H_{c_2}$. The detection of magnetic fields could be based on the same mechanism as the operation of SQUIDs.

### 1.5.5 Microtubular space-time sheets as super conductors?

Microtubules are fashionable candidate for a macroscopic quantum system. Microtubules are the basic structural units of cytoskeleton and it has been suggested that cytoskeleton might play the role of nervous system at single cell level and provide the key element for understanding bio-systems as macroscopic quantum systems [92]. Microtubules are hollow cylindrical tubes with inner and outer radii of 14 $nm$ and 25 $nm$ respectively so that the thickness of the cylinder corresponds roughly to the length scale $\hat{L}(151)$. Microtubules consist of dimers of $\alpha$ and $\beta$ tubulines having at least two conformations: the position of electron centrally placed in the $\alpha$-tubulin-$\beta$-tubulin juncture probably determines the conformation. Tubulin dimers have size $\sim 8$ $nm$ not far from the length scale $\hat{L}(157)$. There are 13 columns of tubulin dimers along the microtubule. The skew hexagonal pattern of microbutules exhibits pattern made up of 5 right handed and 8 left handed helical arrangements.

For left handed arrangement $2\pi$ rotation corresponds to a distance $\sim 64$ $nm$ $\sim \hat{L}(163)$ along the length of the microtubule [27, 93]. It has been suggested [92] that the electric dipole moments of tubulin dimers form a macroscopic quantum system analogous to a spin system. An alternative possibility is that microtubules might be super conducting. The cylindrical geometry is ideal for the creation of constant magnetic fields inside the tube by helical supracurrents flowing along the surface of the microtubule. The electrons determining the conformation of the tubulin dimer are the most obvious candidates for Cooper pairs. Perhaps the electrons corresponding to a given conformation of tubulin could form delocalized Cooper pairs.

The numbers 5 and 8 correspond to Fermat polygons which suggests that $G_a$ with $n_a = 5 \times 8 = 40$ defining order of maximal cyclic subgroup is involved. $n_a = 40$ was also obtained from the requirement that the 20 aminoacids can be coded by the many-electron states of dark N-hydrogen atom having $n_b = 1$ [F10]. Super-conductivity would correspond to $n_b = 1$ so that by the previous argument the critical temperature would be scaled up by a factor $n_a^2 = 1600$ from that of a conventional super-conductor. The possible problems relate to the thermal stability of light atoms if also nuclei are dark, which is however not expected.

The hypothesis that microtubules are infrared quantum antennas with average length giving rise to .1 eV infrared photon fits nicely with the super conductor idea. The fact that .1 eV is the basic energy scale of wormhole atomic physics explains the average length of microtubules. In case of Cooper pairs there is natural coupling to the Josephson currents related to Josephson junctions between lipid layers of the cell membrane. The coupling of wormhole supra currents to coherent photons contains two contributions. The first contribution is the coupling of the wormhole current to the difference of the gauge potentials describing topologically condensed coherent photons on the two space-time sheets.

The second contribution is proportional to the difference of dielectric constants on the two space-time sheets and is non-vanishing even when the topological condensates of coherent photons are identical.

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# Chapter 2

# Bio-Systems as Super-Conductors: Part II

## 2.1 Introduction

The general model for quantum control and coordination relies crucially on the existence of a hierarchy of superconductors associated with the self hierarchy (self defined as a quantum system able to avoid bound state entanglement with environment) controlling the ionic densities at atomic space-time sheets via many-sheeted ionic flow equilibrium and being quantum controlled with the mediation of the fractal hierarchy of MEs.

### 2.1.1 General mechanisms for superconductivity

The many-sheeted space-time concept provides a very general mechanism of superconductivity based on the 'dropping' of charged particles from atomic space-time sheets to larger space-time sheets. The first guess was that larger space-time sheets are very dry, cool and silent so that the necessary conditions for the formation of high $T_c$ macroscopic quantum phases are met.

The possibility of large $\hbar$ quantum coherent phases makes however the assumption about thermal isolation between space-time sheets un-necessary. At larger space-time sheet the interactions of the charged particles with classical em fields generated by various wormhole contacts feeding gauge fluxes to and from the space-time sheet in question give rise to the necessary gap energy. The simplest model for Cooper pair is space-time sheet containing charged particles having attractive Coulombic interaction with the quarks and antiquarks associated with the throats of the wormhole contacts.

A crucial element is quantum criticality predicting that superconductivity appears at the fluctuating boundaries of competing ordinary and large $\hbar$ phases for nuclei. This assumption predicts several anomalous phenomena such as cold fusion and nuclear transmutations. Also high $T_c$ superfluidity of bosonic atoms dropped to space-time sheets of electronic Cooper pairs becomes possible besides ionic super conductivity. Even dark neutrino superconductivity can be considered below the weak length scale of scaled down weak bosons.

Magnetic and $Z^0$ magnetic flux tubes and walls are especially interesting candidates for supra current carries. In this case the Cooper pairs must have spin one and this is indeed possible for wormholy Cooper pairs. The fact that the critical magnetic ($Z^0$ magnetic) fields can be very weak or large values of $\hbar$ is in accordance with the idea that various almost topological quantum numbers characterizing induced magnetic fields provide a storage mechanism of bio-information.

This mechanism is extremely general and works for electrons, protons, ions and even charged molecules so that an entire zoo of high $T_c$ bio-superconductors and super-fluids is predicted. All atoms and ions can be regarded as completely ionized $Z^0$ ions and also $Z^0$ superconductors (or super fluids) are predicted.

1. The experimental data about the effects of ELF em fields at cyclotron frequencies of various ions in Earth's magnetic field on bio-systems [58] provide support for this scenario. Most remarkably, the cyclotron frequencies of biologically important ions correspond to the important frequencies

of EEG and the time scale of nerve pulse corresponds to $n = 3$ multiple of proton cyclotron frequency so that a direct quantitative contact with brain consciousness results.

2. Electronic super conductors are of type II with defect regions being typically cylindrical: DNA sequences, proteins, microtubules,... could provide examples of the defect regions. One ends up also with a model of high $T_c$ super conductors in which the interaction of the electrons with wormhole BE condensate gives rise to Cooper pairs. The model explains elegantly the basic peculiar features of the high $T_c$ superconductors.

3. Long ranged $Z^0$ force due to anomalous weak isospin of nuclei [F8, F10] and $Z^0$ charged wormholes make possible also $Z^0$ ionic superconductivity and even dark neutrino super conductivity. For instance, $Z^0$ ionic superconductivity is crucial in the model for the quantum correlate of hearing: audible frequencies are mapped to $Z^0$ cyclotron frequencies. Dark neutrino super conductors are of type I in the interesting length scale range and defect regions are stripe like. Besides cell and endoplasma membranes, epithelial sheets consisting of two cell layers and some larger structures in cortex could correspond to regions of this kind and the interpretation as a physical realization of cognitive hierarchy suggests itself.

### 2.1.2 Bio-structures as defect regions or large $\hbar$ regions of quantum critical superconductors

The original hypothesis was that defects of superconductors are represented as so called wormhole magnetic fields and serve as templates for the formation of various bio-structures is very attractive. Also fractal defects inside defects structures are possible. One can speculate that various linear structures common in bio-systems correspond to defects of electronic type II super conductors at various space-time sheets. There are also obvious candidates for structures identifiable as defect regions of super conductors of type I.

The identification of high $T_c$ superconductors as quantum critical superconductors suggest a different interpretation in which the superconducting regions correspond to boundaries between phases having different values of $\hbar$. These regions would also consist of dynamical stripe like regions.

Besides cell membranes, epithelial sheets consisting of two cell layers and some larger structures in cortex could correspond to regions of this kind and the interpretation as a physical realization of cognitive hierarchy suggests itself. The critical temperatures of dark neutrino super conductors formed by join along boundaries condensates turn out to be smaller than room temperature but this is not a problem since the temperatures at non-atomic space-time sheets are extremely low.

### 2.1.3 Superconductivity at magnetic flux quanta in astrophysical length scales

Magnetic flux tubes of Earth's magnetic field are crucial for the TGD based model of superconductivity. Since the models of auroras assume that the magnetic flux lines act effectively as conducting wires, the natural hypothesis is that superconductivity is an astrophysical phenomenon. This leads to a model of auroras explaining the latest findings and providing further insights to the superconductivity and the manner how it breaks down. Critical temperature can be identified as the temperature at which the join along boundaries bonds making possible the leakage of the supra currents to the non-superconducting space-time sheets become possible and can be gigantic as compared to the temperature at the superconducting space-time sheets if space-time sheets are thermally isolated. On the other hand, the possibility of large $\hbar$ phases in principle makes possible arbitrarily high critical temperatures in a given length scale.

p-Adic length scale hierarchy and the hierarchy of dark matters labelled by values of $\hbar$ suggest the existence of an entire hierarchy of super conducting space-time sheets giving rise to a hierarchy of cognitive representations (abstractions about abstractions about...). The possibility of complex conformal weights expressible in terms of zeros of Riemann Zeta such that the net conformal weight is real, and the hierarchy of algebraic extensions of p-adic number fields suggest the existence of additional hierarchies.

### 2.1.4 Fractal hierarchy of EEGs and ZEGs

There are three contributions to EEG besides neural noise: Schumann frequencies, cyclotron frequencies, and the frequencies associated with Josephson junctions determined by the sum of the constant voltage and voltage perturbation determined by the superposition of cyclotron frequencies. Cyclotron contribution can be interpreted as a control signal from a magnetic body in question labelled by $k_d$ and affects both the ions at the flux sheets traversing DNA and the Josephson junction. The coherent state of photons generated by Josephson current corresponds to a reaction to this signal received by the magnetic body as a feedback. Schumann frequencies can be assigned to the control by magnetic body of Earth and correlate with the collective aspects of consciousness.

The analysis of the Josephson current [M3] leads to the conclusion that the frequencies in the coherent state of photons are in general sums and differences of Josephson frequency and harmonics of cyclotron frequencies. For small amplitudes this implies that alpha band to which the cyclotron frequencies most biologically important bosonic ions corresponds has as satellites theta and beta bands. Higher harmonics correspond to gamma and higher bands having also satellites. For large amplitudes EEG becomes chaotic which is indeed the property of beta band during say intense concentration or anxiety. The findings of Nunez [38] about narrow 1-2 Hz wide bands at 3,5,7 Hz and 13,15,17 Hz confirm with the prediction of satellite bands and fix the Josephson frequency to 5 Hz. This picture explains the general characteristics of EEG in wake-up state qualitatively and quantitatively.

In order to understand the characteristics during various stages of deep sleep one must assume that the cyclotron frequency scale of ions is scaled down by a factor of 1/2. One explanation is that right *resp.* left brain hemisphere corresponds to $Z = 2$ *resp.* $Z = 1$ quantization condition $Z \int BdS = n\hbar$ for the magnetic flux. $Z = 2$ case allows only doubly charged bosonic ions at magnetic flux sheets. $Z = 1$ case also also singly charged ions be their bosons or fermions and for this option magnetic field is scaled down by a factor of 1/2. The alternative explanation is that during sleep only Bose-Einstein condensates of singly charged exotic ions resulting when color bond inside nucleus becomes charged are present. This reduces the scale of cyclotron frequencies by a factor 1/2 and leaves only theta and delta bands. During stage 4 sleep only only DNA cyclotron frequencies in delta band are around 1 Hz and just above the thermal threshold are predicted to be present. For $k_d = 3$ and magnetic field scaled up by $\lambda$ and flux tube area scaled down by $\lambda^{-2}$ DNA frequencies are scaled up to kHz for $Z = 2$ flux quantization and might define neuronal synchronization frequencies.

The generalization of the model for EEG hierarchy to the case of ZEG is straightforward and cyclotron frequency spectrum is essentially the same [M3]. $Z^0$ ions are obtained when nuclear color bonds become charged and the combination of ordinary and exotic ionization can produce also em neutral $Z^0$ ions. Any atom, almost always boson, has an exotically charged counterpart with same statistics so that very rich spectrum of Bose-Einstein condensates results.

### 2.1.5 The effects of ELF em fields on brain

The experimental data about the effects of ELF em fields at cyclotron frequencies of various ions in Earth's magnetic field on vertebrate brains provide a test bench for the fractal hierarchy of EEGs. As a matter fact, it was the attempt to explain these effects, which eventually led to the discovery of the fractal hierarchy of EEGs and ZEGs.

The reported effects occur for harmonics of cyclotron frequencies of biologically important ions in Earth's magnetic field. They occur only in amplitude windows. The first one is around $10^{-7}$ V/m and second corresponds to the range $1-10$ V/m: the amplitudes of EEG waves are in the range 5-10 V/m. The effects are present only in the temperature interval 36-37 C.

The temperature interval has interpretation in terms of quantum criticality of high $T_c$ superconductivity (both interior and boundary super currents are possible in this interval). Amplitude windows correspond to resonant EEG bands if the voltage perturbations contribute to the voltages over Josephson junctions and are thus coded to EEG. That the effects occur only for cyclotron frequencies and in the amplitude windows can be understood if there is AND gate involved. The voltage signal affects the interior of the cell nucleus opening communication line to the magnetic body if a harmonic of cyclotron frequency is in question. The signal affects also the Josephson junction which sends a signal to magnetic body if the voltage of the perturbation is large enough and corresponds to a frequency in the resonance band of EEG. The response of the magnetic body affects nucleus only if the communication line is open. This AND gate eliminates very effectively the effects of neural noise.

## 2.2 Models for ionic superconductivity and topological condensation at the magnetic flux quanta of endogenous magnetic field

In this section the model for ionic superconductivity is constructed as a straightforward generalization of the model of high $T_c$ electronic superconductivity: the basic prediction is that only ions with $A < 4$ (in practice protons) can form stable Cooper pairs at room temperature. The new model for the topological condensation at magnetic flux quanta of mendogenousagnetic field differs radically from the earlier model and allows to understand that effects of ELF em fields on brain. Bose-Einstein condensates of bosonic ions are predicted to be of special importance for the functioning of living systems. Also a quantitative understanding of the effects of Schumann resonances and EEG emerges.

### 2.2.1 Model for ionic superconductivity

The model of ionic super-conductivity is a direct generalization of corresponding model for high $T_c$ electronic super conductivity.

1. Electron is topologically condensed at a cylindrical space-time sheets of radius $L(k = 149) = 5$ nm and length $L(151) = 10$ nm and carrying magnetic monopole flux flowing through the wormhole throat at the upper end of the cylindrical sheet to the larger space-time sheet and returning back through the throat at the lower end of the sheet. Magnetic monopole flux made possible by the topology of $CP_2$ is necessary in order to have spin 1 Cooper pairs.

2. The two causal horizons associated with each wormhole contact carry quantum numbers of quark and antiquark and the charges of quark and antiquark at electron space-time sheet sum up to the negative of electron charge. The two flux tubes of this kind are connected by color bonds such that the state does not reduce to a product of color singlets. Hence color confinement is responsible for the formation of Cooper pair.

3. The requirement that the binding energy is maximum as a function of p-adic length scale implies that $k = 151$ corresponds to the length of the electronic flux tube and $k = 149$ to its radius.

Exactly the same mechanism works also in the case of ions and the only differences come from the different mass and charge of ion.

1. The weak length scale $L_w = .2$ $\mu$m associated with doubly dark $k = 113$ weak bosons gives an upper bound for the size of the Cooper pair. The requirement that the binding energy is minimum forces this length for the Cooper pair if one assumes that the diameter of ionic flux tube equals to its length.

2. For proton regarded as a particle in 1-D box the scale of excitation energy inside flux tube is $\Delta E \sim 3\pi^2\hbar^2/2m_pL_w^2 = .31$ eV for $\hbar = 2^{11}\hbar_0$ and safely above the maximum photon energy $E_{th} = 2.882T = .086$ eV of black body radiation at room temperature $T = 300$ K. For $A \geq 4$ nuclei this energy scale is below $E_{th}$ ($A = 4$ gives $E = .078$ eV). Thus it would seem that only protonic Cooper pairs are relevant for living systems at $k_d = 1$ level of dark matter hierarchy. For $^7Li_+$ ion this energy corresponds to .04 eV. One cannot exclude the possibility that for effectively 2- or 1-D systems lithium Cooper pairs might be marginally stable. In the case of electronic Cooper pairs one has $\Delta E \sim 3 = .06$ eV ($E_{th} = \Delta E$ corresponds to $T = 219$ K) so that thermal stability criterion is marginally satisfied at room temperature.

### 2.2.2 Model for Bose-Einstein condensation in endogenous magnetic field

The effects of ELF em fields on living matter suggest that quantal cyclotron transitions are involved. This does not conform with intuitive expectations since cyclotron energy scale is ridiculously as compared to the thermal energy at room temperature.

The earlier model based on ordinary $\hbar$ assumed thermal isolation between space-time sheets and that large space-time sheets are cold so that BE condensates are possible. Thermal stability in fractal sense requires that temperature scales like cyclotron energy as a function of p-adic length scale. Flux quantization implies that $T$ scales like zero point kinetic energy: $T(k) \propto 1/L^2(k)$.

One can criticize the assumption about thermal isolation. Second criticism concerns the assumed flux quantization. The flux tubes of the endogenous magnetic field have radius which is at most $5L(167) = 8\ \mu$m. This however suggests that ions and atoms can be in two states depending on whether they are condensed at magnetic flux tubes or not. In the absence of topological condensation to magnetic flux tubes no cyclotron transitions or spin flips should occur. The states in which ions do not respond to magnetic field have not been however observed. Usually it is assumed that no flux quantization occurs in macroscopic length scales but this assumption is in conflict with the idea that there are no preferred length scales. The scaling up of flux quantum by scaling of $\hbar$ could resolve this problem.

### A model for the condensation of ordinary ion to dark magnetic flux tube

One particular set of preferred values of $\hbar_{eff} = n_a/n_b$ suggested by the model of living matter is as powers of $\lambda = 2^{11}$. Dark ions at space-time sheets having $(n_a = \lambda^k, n_b = 1)$, $k > 1$, are thermally unstable at room temperature since the atomic energy scale would be $\lambda^{-k}E_0$. The only possibility is that ion itself has small enough a value of $n_a/n_b$. The simplest possibility is $(n_a = 1, n_b = 1)$.

The next question concerns the magnetic interaction between ion and dark magnetic flux tube. The magnetic flux from the dark flux quantum must be feeded to the space-time sheet of ion and return back. This is indeed possible since it is $M^4_+$ projection which is zero-dimensional and corresponds to the tip of $M^4_+$ at the 2-surface which corresponds to parton just intermediate between two sectors. The 2-dimensionality of $CP_2$ projection allows non-vanishing magnetic flux. That magnetic flux cannot flow between sectors with different value of $n_b$ might relate to Meissner effect. If so, the values of $n_b$ for super-conductor and its environment would be different.

Since $n_a$ sheets fuse to single one at the leakage point, the magnetic flux feeded to the ordinary space-time sheet of ion is $n_a$-fold so that cyclotron energy is $n_a$-fold too. One can equally well consider the situation also by assuming that the magnetic flux of ion is shared by the $N(G_a)$ flux sheets of the dark magnetic field and returns back to ion. The total magnetic interaction energy summed over the $N(G_a)$ identical $G_a$-related sheets is scaled up by $n_a$ since the value of Planck constant is $n_a$ time larger.

If the dark magnetic flux sheets with $k > 1$ contain nuclei, they form a fully ionized plasma at room temperature, and have cyclotron energies which are $Z/A$ times the cyclotron energy of proton. For $B = .2$ Gauss this gives $f_c = (2Z/A)(f_p/2) = (2Z/A) \times 150$ Hz.

### Why the endogenous magnetic field corresponds to .2 Gauss?

For years I erratically believed that the magnitude of the magnetic field assignable to the biological body is $B_E = .5$ Gauss, the nominal value of the Earth's magnetic field. Probably I had made the calculational error at very early stage when taking $Ca^{++}$ cyclotron frequency as a standard. I am grateful for Bulgarian physicist Rossen Kolarov for pointing to me that the precise magnitude of the magnetic field implying the observed 15 Hz cyclotron frequency for $Ca^{++}$ is .2 Gauss and thus slightly smaller than the minimum value .3 Gauss of $B_E$. This value must be assigned to the magnetic body carrying dark matter rather than to the flux quanta of the Earth's magnetic field. This field value corresponds roughly to the magnitude of $B_E$ at distance 1.4R, $R$ the radius of Earth.

Dark matter hierarchy leads to a detailed quantitative view about quantum biology with several testable predictions. The applications to living matter suggests that the basic hierarchy corresponds to a hierarchy of Planck constants coming as $\hbar_{eff}(k) = \lambda^k(p)\hbar_0$, $\lambda = 2^{11}$ for $p = 2^{127-1}$, $k = 0, 1, 2, ...$. Each p-adic length scale corresponds to this kind of hierarchy. Number theoretical arguments suggest a general formula for the allowed values of $\lambda$ [A9] as $\lambda = n$ where $n$ characterizes the quantum phase $q = exp(i\pi/n)$ characterizing Jones inclusion [C6]. The values of $n$ for which quantum phase is expressible in terms of squared roots are number theoretically preferred and correspond to integers $n$ expressible as $n = 2^k \prod_n F_{s_n}$, where $F_s = 2^{2^s} + 1$ is Fermat prime and each of them can appear only once. $n = 2^{11}$ obviously satisfies this condition. The lowest Fermat primes are $F_0 = 3, F_1 = 5, F_2 = 17$. The prediction is that also n-multiples of p-adic length scales are possible as preferred length scales. The unit of magnetic flux scales up as $h_0 \rightarrow h = nh_0$ in the transition increasing Planck constant: this is achieved by scalings $L(k) \rightarrow nL(k)$ and $B \rightarrow B/n$.

$B_{end} = .2 = 2B_E/5$ with $k = 169$, $\hbar = 5\hbar_0$, with flux tubes of radius 25 $\mu$m carrying flux $2h_5$ is the most natural option since gives a direct connection with the Earth's magnetic field. Furthermore, the model for EEG forces to assume that also the presence of the magnetic field $B_{end}/2$ and this gives the minimal flux $h_5$. Note that $n = 5$ is the minimal value of $n$ making possible universal topological quantum computation with Beraha number $B_n = 4cos^2(\pi/n)$ equal to Golden Mean [E9].

**How to identify the personal magnetic body?**

The notion of magnetic body is central in the TGD inspired theory of living matter. Every system possesses magnetic body. If EEG corresponds to the purely personal aspects of consciousness, the magnetic body associated with human body should be of order Earth size. This however raises the question about how to distinguish between the magnetic bodies of Earth and of human body. As a matter fact, this problem turned out to be a pseudo problem due to calculational error. The value of the endogenous magnetic field is $B = .2$ Gauss from experiments of Blackman and others and corresponds to p-adic length scale $L(169)$ and $\hbar = 5\hbar_0$ level in dark matter hierarchy carrying two flux quanta $h_5$ whereas Earth's magnetic field would correspond to $L(169)$ and $n = 1$. What is nice is that $n = 5$ is the minimal value of $n$ making universal topological quantum computation possible [E9].

One can argue that it is the neuronal time scale of millisecond rather than EEG time scale which serves as a correlate for the conscious experiences assignable solely to our biological body and that EEG is associated with the social aspects of our behavior. The problem with this argument is that our conscious experience contains contributions from much longer time scales than millisecond. The following argument based on a simple model for magnetic flux quanta allows to discuss this problem more quantitatively.

There are several manners to achieve quantization of magnetic flux with dynamical $\hbar$.

1. One possibility is that the area $S$ of flux quantum scales as $\hbar^2$. In this case flux quantization implies that $B$ and cyclotron frequency scale as $1/\hbar$ whereas cyclotron energy is invariant under the scaling of $\hbar$.

2. Second possibility is that the value of magnetic field remains invariant and $S$ scales as $\hbar$. This is especially natural when flux quanta are magnetic flux walls. In this case cyclotron frequencies remain invariant but cyclotron energy scales as $\hbar$. The considerations of this chapter provide support for both quantizations in living matter.

For the latter option one can consider both tubular and sheet like flux quanta.

1. For tubular flux quanta $k_d = 4$ level of dark matter hierarchy the radii of tubular flux quanta would be about $2^{22} \times L(169) = L(169 + 44 = 213) = 20$ m for the Earth's magnetic field $B_E$. For the endogenous magnetic field $B_{end} = .2$ Gauss the radii of fundamental flux tubes would be $5L(169)$, the size of a large neuron. Using the above described identifications the radii of flux tubes would be scaled up by a factor 5 to about $2^{22} \times 5 \times L(169) = 100$ m. This length scale would define the size scale for the quantum coherence regions of the Bose-Einstein condensates of bosonic ions. This scale is enough to guarantee that the behavior of ions in $B_{end}$ is consistent with the model based on single-sheeted space-time.

2. For $B_{end} = .2$ Gauss one can consider flux sheets with a total transversal length $5 \times L(169 + 4 \times 22) = 5L(257) = 4 \times 10^5$ km, which corresponds to about 62 Earth radii. Strongly folded flux sheets of this thickness might be associated with living matter and connect their DNAs to single coherent structure. The photon frequency corresponding to the wavelength $5L(257)$ is 1 Hz and characterizes delta band. One can however argue that DNA thickness which happens to be $\simeq 5L(169)/\lambda \simeq 12.5$ nm, slightly above cell membrane thickness of 10 nm, defines a more natural thickness of the flux sheet. In this case the width of the flux sheet would be scaled up by a factor $\lambda$ to $8.9 \times 10^8$ km about $1.4 \times 10^5$ Earth radii: note that the length scale of the plasma sheet at night side extending to about 1000 Earth radii. Let us refer to these alternatives as option I and II respectively.

The question is whether one can assign a convoluted flux sheet of this width to a single human body or brain. Suppose that the magnetic flux flows in head to tail direction so that the magnetic flux sheet arrives to the human body through a string of cortical neurons. This means that the flux quantum traverses neuronal nuclei such that they are arranged like text lines of a book page along the flux sheet. This structure could closely correlate with the organization of central nervous system and give rise to what might be called super genes.

The total length of DNA in single human cell is about one meter. The DNA of about $8 \times 10^7$ neurons ($1.6 \times 10^{10}$) neutrons would be required for option I (II) *if the contribution of DNA length dominates the width*. The italics are absolutely essential here! If the number of cortical neurons in single layer is about $8 \times 10^7$ which corresponds roughly to an average neuron radius of $10^{-5}$ meters then the flux sheet should go through all neurons in the uppermost neuron layer for option I. This cannot be the case and $k_d = 4$ flux sheets must traverse through several organisms so that they necessarily correspond to collective aspects of consciousness: the mind of Mother Gaia. Also the estimate $\lambda^4 L(151) < L < \lambda^4 L(169)$ for the over all size $L$ of scaled up dark variant of cell nucleus suggests that single magnetic flux sheet traverses cells of organisms in an area of size $L > 180$ km.

If one assumes that the text lines on flux sheet are fully written, a more realistic candidate for the personal magnetic body would correspond to $k_d = 3$ with $B = \lambda B_{end}$ to achieve thermal stability. 1 Hz DNA cyclotron band would for $Z = 2$ flux quantization scale up to kHz band possibly involved with neuronal synchrony and defining the time scale of the nerve pulse. Flux quantization requires flux sheets with width scaled down by $\lambda^{-2}$ to 40 km. This requires neuronal strings traversing at least $4 \times 10^4$ neuronal nuclei which the highly convoluted cortex can easily accommodate. If the personal magnetic body can be regarded as a fractally scaled up cell nucleus, the estimate 80 m $< L <$ 176 km for the size of the personal magnetic body emerges for $\lambda = 2^{11}$.

The fact is however that our consciousness involves contributions from much longer time scales than millisecond. This raises difficult questions about our identity. Do I correspond to a single flux quantum of $B_{end}$ after all: could it be that only a small fraction of these flux sheets corresponds to neuronal DNA and the empty parts of text lines are waiting for the evolution of larger brain to be fully written? How much of the contents of my conscious experience is from my own biological body? Why my sensory experience is dictated by my this particular biological body and why I possess intentional control only over it.

### The definition of the model

The new model for the topological condensation at magnetic flux quanta of endogenous magnetic field $B_{end} = .2$ Gauss is based on the dark matter hierarchy with levels characterized by the value of $\hbar(k) = \lambda^{k_d}\hbar_0$, $\lambda = 2^{11}$.

1. There are several levels of dynamics. In topological condensation the internal dynamics of ions is unaffected and $\hbar$ has the ordinary value. The formation of Cooper pairs involves dynamics at $k_d = 1$ level of dark matter hierarchy. Also the dynamics of ionic Cooper pairs remains unaffected in the topological condensation to magnetic flux quanta obeying $k > 1$ dynamics.

2. Cyclotron energies scale as as $\lambda^{k_d}$ so that for a sufficiently high value of $k$ thermal stability of cyclotron states at room temperature is achieved. Spin interaction energy $\mu \cdot B \propto S \cdot B$ scales as $1/\hbar$ since four-momentum and angular momentum are by Poincare symmetry invariant under the scaling of $\hbar$ (the highly non-trivial implications of the invariance of angular momentum are discussed in [C6]). Hence spin interaction energy has the ordinary value. Unless thermal isolation is assumed, spin degrees of freedom are thermalized, and only cyclotron degrees of freedom can be quantum coherent. This is a testable prediction distinguishing between the new and old model.

3. If the flux quanta of $B_{end}$ correspond to $k_d = 4$ level of dark matter hierarchy, cyclotron energies $E = (\hbar/2\pi) \times ZeB/Am_p$ are scaled up by a factor $\lambda^4 = 2^{44}$ from their ordinary values and are above thermal energy at room temperature for $A \leq 233Z$, where $Z$ is the charge of the ion. Even for $Z = 1$ this includes all stable nuclei. Bose-Einstein condensates of bosonic ions are thus possible at room temperatures at Earth's surface. Cooper pairs of fermionic ions are possible only for $A \leq 4$ leaving in practice only protons into consideration. Also bosonic molecular ions can suffer BE condensation.

### Schumann resonances, EEG and large $k_d = 4$ level of dark matter hierarchy

The photon frequency corresponding to the wavelength $5 \times L(256)$ (size scale of magnetic flux quanta assignable to living matter) is 1.5 Hz and defines delta band. The corresponding energy is $E = .238$ eV which is above than the maximum photon energy $E_{th} = .085$ eV of black body radiation at T=300 K. The frequency $f = 10$ Hz, which corresponds to secondary p-adic length scale associated with Mersenne prime $M_{127}$ characterizing electron, and defines fundamental biological rhythm, corresponds to $E = .67$ eV.

The nominal value 7.8 Hz of the lowest Schumann resonance frequency [38] corresponds to .52 eV which is in the range of energies assignable to the metabolic energy quantum. $A \leq 233Z$ corresponds to $f_{min} = 1.29$ Hz which corresponds to delta band. The higher Schumann frequencies 14, 20, 26, 33, 39, and 45 Hz correspond to energies .9, 1.3, 1.7, 2.2, 2.6, and 3.0 eV. The corresponding photon energies belong to infrared and visible range in the case of ordinary photons. The Schumann frequencies 26, 33, and 39 Hz correspond to red, green, and blue light.

These observations suggest that EEG corresponds to $k_d = 4$ space-time sheets and that EEG frequencies correspond to dark photon energies above the thermal energy at body temperature. The dominance of theta and delta bands during sleep state could be due to the fact that the EEG photons at these energies are not able to induce metabolic effects. The reported strong effects of the lowest Schumann resonance frequency on human brain could be interpreted in terms of a metabolic resonance. Lowest Schumann resonance could also serve as a biological clock synchronizing the behavior of living matter in Earth length scale. Higher Schumann resonance frequencies could define a global reference for the representation of visible colors.

### Bose-Einstein condensates of bosonic ionized atoms

The number of elements for which ions are bosons is not very large. The following table lists the cyclotron frequencies of bosonic ions which are biologically important for $B_{end} = .2 \times 10^{-4}$ Tesla.

| Ion | $f_1/Hz$ | $E_1/eV$ |
|---|---|---|
| $^6Li^+$ | 50.1 | 3.3 |
| $^{24}Mg^{2+}$ | 25.0 | 1.65 |
| $^{16}O^{2-}$ | 37.6 | 2.48 |
| $^{32}S^{2-}$ | 18.8 | 1.24 |
| $^{40}Ca^{2+}$ | 15.0 | .99 |
| $^{55}Mn^{2+}$ | 11.4 | .75 |
| $^{56}Fe^{2+}$ | 10.8 | .71 |
| $^{59}Co^{2+}$ | 10.0 | .66 |
| $^{64}Zn^{2+}$ | 9.4 | .62 |
| $^{80}Se^{2-}$ | 7.6 | .5 |

Table 1. The first columns give the cyclotron frequencies and cyclotron energies for biologically relevant bosonic ions in $B_{end} = .2 \times 10^{-4}$ Tesla. The third column gives cyclotron energy.

The table inspires some comments.

1. For $Li^+$ the dominating isotope $^7Li^+$ is fermion. $^6Li^+$ is boson and its abundance is 5 per cent. $Li^+$ ions are used as medications in mania and represents mood stabilizer [56]. A possible explanation is that the cyclotron oscillations of Bose-Einstein condensate of $^6Li^+$ ions serve as a biological clock helping to stabilize the mood. The cyclotron frequency is however 50 Hz and higher than thalamocortical resonance frequency having nominal value 40 Hz.

   An alternative explanation for the effect of $Li^+$ is based on the observation that $^7Li_+$ has cyclotron frequency equal to 42.9 Hz for $B_{end} = .2 \times 10^{-4}$ Tesla, which is at the upper limit of the 40 Hz resonance band. The presence of lithium ions or their Cooper pairs could enhance thalamocortical resonance.

   These hypothesis could be tested by looking whether the use of pure $A = 6$ ($A = 7$) isotope of $Li^+$ amplifies the beneficial effect and the use of $A = 7$ ($A = 6$) isotope nullifies it.

2. For $Mg^{2+}$ cyclotron energy corresponds to the energy of photon of green light. Chlorophyll is not able to convert nutrients to sugar without magnesium, which suggests that cyclotron transitions of Mg BE condensate are at least partially responsible for the green color of plants. Mg BE condensate could control the coherent occurrence of photosynthesis in the size scale of plant.

3. For oxygen ion the cyclotron frequency is 37.6 Hz and rather near to $\sim 40$ Hz thalamocortical resonance frequency, which suggests that the cyclotron transitions of oxygen ions might play key role in inducing coherent firing of neurons at this frequency. This would mean that oxygen would be much more than a mere provider of metabolic energy. Note also that $\Delta n = 3$ cyclotron transition of $Na^+$ ion corresponds to frequency 39 Hz and might be involved with the synchronous firing.

4. $Ca^{2+}$ ions play a unique role in the functioning of living matter. In particular, calcium waves appearing in a wide range of time scales are known to serve a crucial role in nervous system [39]. $Ca^{2+}$ corresponds to .99 eV cyclotron energy scale, which is twice the energy of metabolic energy quantum. Hence one can ask whether the cyclotron transitions of $Ca^{2+}$ BE condensate could induce a collective emission of metabolic energy quanta and in this manner induce coherent metabolic activity in the scale of entire body.

5. The cyclotron frequencies Mn, Fe, Co, Cu, and Zn are in alpha band and corresponding cyclotron energies are somewhat above metabolic energy quantum. These energy quanta could drive protons from larger space-time sheet to $k = 137$ atomic space-time sheet. 10 Hz frequency is known to define an important biological clock and Co ions could be essential for the functioning of this clock. $n = 3$ multiple of $Co^{2+}$ cyclotron frequency corresponds to the 30 Hz threshold of gamma band known to be important for cognition. Also $3f_c(Fe^{2+}) = 32.2$ Hz and $3f_c(Mn^{2+}) = 34.2$ belong to gamma band. The presence of Bose-Einstein condensates of these ions in length scale of $5L(212) = 141$ km could mean that these bio-rhythms are shared by different organisms inside regions of this size.

6. The fact that the cyclotron frequency of $Se^{2-}$ ion, which is known to be a biologically important trace element, corresponds to the nominal value of the metabolic energy quantum, raises the question whether Selenium BE condensate might act as a metabolic synchronizer.

**Cyclotron frequencies and Schumann frequencies**

Even in the case that Cooper pairs of fermionic ions are not thermally stable, the cyclotron transitions of fermionic ions like $K^+$, $Cl^-$, and $Na^+$ are expected to be important. In the following table cyclotron frequencies and energies of some fermionic ions are given. Notice that the cyclotron energy of $K^+$ ion corresponds to metabolic energy quantum. Quite generally fermionic ions cannot be involved with the generation of Josephson part of EEG.

| Ion | $f/Hz$ | $E_c/eV$ |
|---|---|---|
| $^7Li_+$ | 42.9 | |
| $F^-$ | 15.8 | 1.04 |
| $Na^+$ | 13 | .86 |
| $Al^+$ | 11.1 | .73 |
| $Cl^-$ | 8.5 | .56 |
| $K^+$ | 7.5 | .50 |
| $Cu^+$ | 4.8 | 333.9 |
| $Ag^+$ | 2.8 | .18 |
| $I^+$ | 2.4 | .16 |
| $Au^+$ | 1.5 | .10 |

Table 2. The first columns give cyclotron frequencies and corresponding cyclotron energies for some ions in $B_{end} = .2 \times 10^{-4}$ Tesla for some fermionic ions.

The first thing to notice is the close relationship of cyclotron frequencies with the lowest resonance frequencies in the spectrum of geo-electromagnetic field starting from 5 Hz, so called Schumann frequencies [38], are $7.8, 14, 20, 26, 33, 39$ and 45 Hz. 5 Hz corresponds roughly to the threshold 4 Hz of theta frequency range below which EEG spectrum lies during sleep which suggests that wake-up state involves the coupling of brain with geo-electro-magnetic activity. 7.8 Hz corresponds to the threshold for alpha waves associated with wake-up state without cognition; 14 Hz corresponds to threshold of 13 Hz for beta waves accompanying cognitive activities, and 33 Hz is quite near to the threshold 30 Hz for gamma waves known to be important in the temporal coding of sensory data.

Consider now examples of cyclotron frequencies keeping in mind that Schumann frequencies vary typically within 1 Hz interval around their mean values [38].

1. As already noticed, the frequencies, which are multiples of 15 Hz can be assigned to $Ca^{2+}$ ion. The excitations $n = 3, 5, 7, ..$ correspond to the frequencies $45, 75, 105, ...$ Hz. All these frequencies have been observed. The two lowest frequencies correspond to Schumann frequencies 14 and 45 Hz with accuracy of 1 Hz.

2. $Na_+$ has $A = 23$ and gives $f = 13$ Hz. This is the lower bound for the frequency of beta EEG waves which are associated with conscious cognition. This would suggest that the presence of em field of 13 Hz frequency correlates with large fluxes of $Na_+$ ions through the axonal cell membrane during nerve pulse generation. This could result from increased amplitude of $Na_+$ Josephson current facilitating the emission of nerve pulses at the second half of the EEG cycle. Silencing of mind by meditation or closing eyes reduces amplitudes associated with EEG frequencies below 13 Hz and conscious cognition disappears.

   $n = 3$ excitation of $Na_+$ corresponds to 39 Hz, which is one of the Schumann frequencies and quite near to the 40 Hz resonant frequency associated with the thalamocortical circuit. This could correspond to jumping of $Na_+$ ions from ground state to $n = 3$ state or vice versa. $n = 5$ quantum jumps correspond to 65 Hz which is average EEG frequency during REM sleep! Thus 13, 39 and 65 Hz frequencies correspond to the basic signatures of conscious cognition. The two lowest transition frequencies correspond to Schumann frequencies 14 and 45 Hz within accuracy of 1 Hz.

3. $K_+$ has $A = 39$ and gives $f = 7.5$ Hz, which is theta frequency rather near to the lowest Schumann resonance frequency 7.8 Hz. $K_+$ ion flux could correlate with em fields in the range of the alpha frequencies creating cyclotron resonance. Theta activity dominates during sleep and Adey's observations [58] demonstrate that 7 Hz ELF field increases reaction times. Second and third transition frequencies are within 1.5 Hz Schumann frequencies 20 and 37.5 Hz.

4. $Cl_-$ ion has $A = 35$ and gives $f = 8.5$ Hz. Chloride ion has inhibitory effect. $n = 3, 7, ..$ excitations correspond to 25.5, 42.5 Hz,... Rather interestingly, frequencies rather near to 40 Hz associated with thalamo-cortical loops appear as excitations for all ions relevant to nerve pulse activity. Note that 39 Hz is also Schumann frequency. Two lowest transition frequencies of $Cl_-$ are quite near to Schumann frequencies 7.8 and 25 Hz.

5. $Fe^{2+}$ has $A = 56$ and corresponds to 10.7 Hz. $3f_c(Fe^{2+}) = 32.2$ Hz is rather near to Schumann frequency 33 Hz whereas $Co^{2+}$ corresponds to 10 Hz in excellent accuracy. $Co$ has especially large nuclear magnetic moment and serves as a natural magnet. $Fe^{2+}$ and/or $Co^{2+}$ could be present in magnetic sensory organ possessed also by humans making it possible to navigate using magnetic fields. Yarrow suggests that $Co$ makes $B_{12}$ magnetic vitamin [58] so that it can serve as fundamental biological clock at frequency very precisely equal to 10 Hz. $Co$ is carried by $B_{12}$ vitamin and is known to be important for normal consciousness: among other things the lack of $B_{12}$ causes fatigue, blurred vision and cognitive problems.

6. $Mg^{2+}$ has A=24 and $f = 25$ Hz which is near to Schumann frequency: $n = 3$ corresponds 75 Hz. Charged polypeptides could also form BE condensates and be involved with cyclotron mechanism: they are rather heavy and their cyclotron frequencies are in Hz range. Negatively charged organic molecules are indeed known to be present in neurons.

To sum up, surprisingly many magnetic transition frequencies are near to Schumann frequencies which suggests strong resonant interaction between brain and geo-electromagnetic fields.

#### What about proton's cyclotron frequency?

There are good reasons to expect that the cyclotron frequency of proton and its odd harmonics play an important role in brain functioning. The cyclotron frequency of proton in $B_{end} = .2$ Gauss is $f(p) = 300$ Hz. The frequency associated with $n = 3$ transition would be $3f(p) = 900$ Hz. Third harmonics of cyclotron frequencies of many ions with $f_c$ in alpha band belong to gamma band known to relate to cognition. Perhaps this is true also in the case of proton.

The duration of single bit of the memetic codeword consisting of 127 bits and having total duration defined by the p-adic timescale $T^{(2)}_{M_{127}} = .1$ seconds corresponds to the frequency $f_m = 1027$ Hz. This frequency is by 10 per cent higher than the cyclotron frequency of proton for $B_{end} = .2$ Gauss. If magnetic homeostasis is realized, as will be discussed later, and if it allows 10 per cent variation of the strength of magnetic field as the width 1 Hz of alpha band suggests, it is possible to realize this frequency as proton's cyclotron transition frequency.

The frequency of neuronal synchronization, which is obviously associated with cognitive processing, is $\simeq 1$ kHz and might well be identifiable with $f_m$. The maximum rate of neuronal firing is slightly below kHz: this rate however corresponds to the rate of quantum jumps rather than oscillation frequency at space-time level.

#### Bose-Einstein condensates of bosonic molecular ions

Also biologically relevant bosonic molecular ions such $SO_4^{2-}$, $CO_3^{2-}$, $NO_3^-$, $NO_2^-$ could form Bose-Einstein condensates. The cyclotron frequencies for bosonic molecular ions satisfying the thermal stability condition $A \leq 233 \times Z$ at room temperature are typically in theta and delta band and above $f_{min} = 1.29$ Hz.

DNA is negatively charged and an interesting question is whether DNA satisfies the stability condition. The molecular weights of DNA nucleotides A,T,C,G are 132,126,96,149. The molecular weight of deoxyribose sugar attached to the nucleotide is 100 and that of phosphate group $PO_4^{2-}$ is 95. Altogether this makes molecular weights 327, 321, 291, 344. Since phosphate group is doubly charged this structure has cyclotron energy which is higher than thermal energy. Also DNA sequences satisfy the thermal stability condition. The presence of DNA Bose-Einstein condensates at magnetic flux quanta could mean that DNA can be transferred between different organisms along these space-time sheets and that DNAs of different organisms of same species could form quantum coherent systems inside regions where magnetic field can be regarded as a constant.

## 2.3 Magnetic genome, magnetic homeostasis, and magnetic circulation?

The view about the interaction of magnetic flux sheets with DNA leads to a rather far reaching vision about what genetic code really is. The notions of magnetic homeostasis and magnetic circulation are also highly suggestive.

### 2.3.1 The new view about genetic code

The concrete realization of the personal magnetic body or actually hierarchy of them labelled by $k_d = 0, 1, ..., 7$ was already discussed in section discussing the difference between personal magnetic body and that of Earth. The cautious proposal was that the personal magnetic body consists at $k = 169$ level of flux tubes of Earth's magnetic field with thickness $L(169)$ and width which scales as $\lambda^{k_d}$, $\lambda \simeq 2^{11}$. $k_d = 7$ would give total length of about $1.28 \times 10^{12}$ km, which could correspond to the size of magnetosphere of Sun. If the flux tube have thickness $L(169)/\lambda = 2.5$ nm, which would naturally correspond to the thickness of DNA, $k = 7$ would correspond to about 136 light years and the assignment of cosmic consciousness with crown chakra would be really well justified. This length of flux tube would require that it traverses through about $10^{15}$ cell nuclei and cells of human body might be enough.

For $k_d < 4$ level the cyclotron frequencies in Earth's magnetic field do not correspond to cyclotron energies above thermal threshold so that stronger magnetic fields associated with $k < 169$ are necessary if cyclotron energies are to be of biological significance. It would seem that $k_d = 3$ defines upper bound in this respect: in this case $L(151)$ corresponds to cyclotron energies above thermal threshold for $A \leq 55Z$.

Those for whom pictures about mitosis are familiar might have had the feeling that the chromosomes are indeed bound to threads and that division of a dipole magnetic field to two occurs during cell division. This encourages to speculate about the possible implications of the proposed realization of magnetic bodies corresponding to $k_d \geq 3$ levels of dark matter hierarchy.

1. The flux tube with given value of $k_d$ need not go through every gene. It is also possible that same gene topologically condenses at flux sheets characterized by several values of $k_d$. These assignments are in principle dynamical. The flux sheets would obviously define a functional hierarchy such that at each level quite different structures or functions are coded. A natural guess would be that dark genes at level $k_d$ code structure and functions related to dark matter at level $k_d$. This increases dramatically the representative power of genome and would explain why the amount of human genome differs only little from that of much more primitive organisms such as wheat or fishes.

   The emergence of dark matter hierarchy would be the manner to make genes multi-functional and bring in a hierarchy of increasingly refined abstraction hierarchy. In vertebrates the really significant evolution would take place at this level. This also allows a new perspective to the mysterious introns, the 95 per cent portion of DNA christened as "junk DNA" by materialistic biologists, as a part of genome codes mostly for functions associated with dark matter levels.

2. For $k_d \geq 2$ single human genome with a total length $\sim 1$ m of DNA cannot correspond to entire width of the magnetic flux sheet which is about 40 km for $k_d = 3$. This means that the flux sheet must traverse through a large number of genes and bind them to single super gene (this would occur even in the case that the flux sheet is branched). For $k = 7$ the number of genomes traversed could be $\sim 10^{15}$ if they have thickness of 1.28 nm. The number of neurons in human brain is estimated to be $\sim 10^{12}$ so that also other cells must be added to the necklace.

   These super genes would be very literally light highly convoluted pages of book containing sequences of nucleons as text lines. The pages of this book would be dynamical and the evolution of individual would presumably be like writing this enormous body book and expressing it in various manners. They would provide an exponentially explosive representational power and the relation of genome itself to super-genome would be like that of bit to a large collection of computer programs. This would also mean that brain would have use quantum computational capacity (for TGD based model for topological quantum computation see [E9]).

3. Even more dramatic generalization of genome can be considered. There is in principle no reason why magnetic flux sheets could not pass through several organisms so that kind of hyper-genes would result. These hyper-genes could make possible the emergence of complex social structures with individuals obeying rules making possible complex behavioral patterns. In this case there is practically no upper bound for $k_d$.

### 2.3.2 Magnetic homeostasis and magnetic circulation?

The possible importance of the precise value of the local magnetic field for say memetic code [L1] suggests that living matter has learned to control local magnetic field inside magnetic flux tubes just as it controls salt level of biological water.

In particular, $B_E$ could have slightly different values at different levels $k_d$ of dark hierarchy (cyclotron energies can be above thermal threshold only for $k_d \geq 4$). Cell differentiation could lead to the differentiation of the local value of $B_E$ and the value could vary even inside single cell nucleus, and be slightly different for genes characterized by different value of $k_d$ (that is, topologically condensed at flux sheet with this value of $k_d$).

There is rather precise analogy with blood flow since both incompressible velocity field of blood and magnetic field are divergenceless: one can imagine magnetic flux to flow along 'B-veins' (magnetic flux tubes) along organism or at least CNS. Variation of the magnetic field strength would be forced by the variation of the thickness of the flux tube since magnetic flux is conserved just as the variation of the thickness of blood veins affects blood flow. Artificial small alteration of local magnetic from outside would only interfere with this control.

For instance, alpha peak drifts in Hz range and this could be due the variation of the value of local magnetic field varies as much as 10 per cent. If this variation is due to the homeostatic variation of the local magnetic field, absolute variation should increase for higher frequencies: at the upper end of gamma band it would be 9 Hz. An alternative explanation for drifting is in terms of amplitude modulation: amplitude modulation of frequency $f_1$ by frequency $f$ implies that original frequency is split to frequencies $f_1 \pm f$. In this case the amplitude of drifting does not depend on frequency.

#### Magnetic circulation

The analogy with blood flow suggests that one could speak about $B$-circulation completely analogous to blood circulation: $B$-circulation could be crucial for bio-system to act as macroscopic quantum system. $B$-circulation would naturally accompany neural circuitry. It could be also accompany ordinary blood circulation physically or could form an independent system. The association with blood circulation would provide prerequisites for quantum control of also blood circulation and metabolism. The control could be based on MW frequency Josephson currents associated with ELF em fields inducing conformational changes of proteins coherently in large regions in turn giving rise to needed synchronous biochemical self-organization processes. Also $Z^0$ magnetic circulation system is plausible.

#### Temperature dependence of the local magnetic field strength

EEG frequencies are known to change with temperature [58]. The assumption that the thickness of magnetic flux tubes depends on temperature implies that EEG frequency scale varies with temperature. One might think that this kind of mechanism could partially explain why a serious hibernation leads to a lower level of arousal. The results of Blackman [77] suggesting that ELF effects with given frequency disappear when body temperature is not in the range $36-37$ C inspires the hypothesis that quantum critical high $T_c$ superconductivity is possible only in the range 36-37 C. This obviously provides a more plausible explanation for the effect of hibernation. In this picture the extreme importance of temperature regulation for the functioning of organism could be seen as a prerequisite for continual quantum control by magnetic transition frequencies from $k=4$ magnetic body.

Circadial temperature variation can be something like 20 Kelvins , which means relative variation about 10 per cent for poikilotherms, which is of same order as alpha frequency drifting. The relative width of the cyclotron resonance would be from this about 7 per cent ($\Delta f/f = \Delta B/B \propto \Delta T/T$).

The observation that widely separated brain regions tend to fluctuate in unisono [57] is not easy to understand if one imagines brain as consisting of independent oscillators. If important EEG frequencies correspond to magnetic transition frequencies, the fluctuations can be understood as induced from fluctuations of the local magnetic field possibly induced by the organism itself.

#### Why the increase of the local magnetic field strength by factor of ten does not raise alpha band to heaven?

The increase of the local magnetic field strength by a factor $10-20$ is known to induce stress [58] and confuse biological timekeeper mechanisms but it certainly cannot raise alpha band above 100 Hz. Resolution of the this objection is simple. The size of the volume in which artificially generated magnetic field prevails determines the value of $k_d$ and p-adic length scale $L(k)$ in question. $k_d$ is definitely smaller than $k_d = 4$ associated with the flux sheets corresponding to the Earth's magnetic field. Secondly, the ability to perturb the magnetic field at $k_d = 4$ flux sheets associated with DNA would presumably require a refined technology. If organism has developed magnetic homeostasis, it tends to keep the magnetic field constant inside the flux sheets just as cell tends to keep salt concentration constant.

Assuming that $k_d$ is fixed, p-adic length scale hypothesis suggests that the increase of local field strength of flux quantum by a factor four would cause change of p-adic scale since $p \simeq 2^k$, $k = 167$ is the next p-adic length scale below $k = 169$: this scale is by a factor 2 shorter so that magnetic field scales up by a factor of 4. Of course, it could be also that the increase of the local magnetic field with strength defined macroscopically by flux per area might only tend to thicken the flux tubes or increase their volume density rather than increasing the value of the magnetic field inside flux tube.

### 2.3.3 Some remarks and questions

**Synchronizing effect of Earth's magnetic field**

Earth's magnetic field acts as grand synchronizer of biorhythms of even separate organisms. Magnetic homeostasis does not prevent the effects due to the variation of Earth's magnetic field on human consciousness.

The close correlation of various cycles of biological and brain activity, in particular sleep-wake cycle, with periodic circadial variations of the geomagnetic field [58], is consistent with this. Magnetic storms change temporarily the value of the local magnetic field and also this should have effects on consciousness. The statistics about mental hospitals supports this view [58]. Also Persinger has proposed that the modulations of Earth's magnetic field caused by geomagnetic perturbations have effect on human consciousness [56, 58]. Michael Persinger has studied extensively the effects of Schumann resonances on brain and has even explained religious and UFO experiences as correlates of this interaction [84, 85, 86].

Also the diurnal changes of magnetic field caused by Moon having period of 25 hours are known and this variation seems to provide fundamental biological clock which sets on in absence of the normal 24 rhythm regulated by sunlight. The diurnal variations of the geomagnetic field are also responsible for sleep-awake rhythm: the increased melatonin secretion during dark hours correlate with the variation of Earth's magnetic field.

It is also known that that the exposure to magnetic fields 10-20 times geomagnetic field induces stress in rabbits and slowed reaction time in humans; that the absence of geomagnetic field leads to a complete de-syncronization of biorhytms and that the synchorization of ELF biorhytms is coupled to ELF geomagnetic pulsations [58]. In particular, pineal gland serves as biological timekeeper with cyclotron frequency of $Co^{2+}$ ion defining the basic time unit of .1 seconds.

Dr. Phil Callahan [82] claims on basis of intensive experimental work that there is a tendency of political strifes and wars to concentrate on regions where Schumann resonances are weak. This would not be surprising since Schumann resonances act as collective bio-rhytms if vertebrate brains are connected to the magnetic body of Earth.

*3. What happens to astronaut's magnetic body*

There is an old objection against the notion of magnetic body. If the local value of Earth's magnetic field is crucial for the brain functioning, astronauts should experience grave difficulties or at least dramatic changes in the character of consciousness. A possible estimate for the weakening of the local magnetic field is based on the scaling law $B \propto 1/r^3$ for dipole field. In this case a rough estimate for the relative change of the EEG frequency scale is $\Delta f/f = 3\Delta R/R \sim 6$ per cent for satellites moving below the ionosphere. This should affect the state of consciousness.

As a matter fact, there is reported evidence [93, 94] that cosmonauts spending months in MIR had strange altered states of consciousness involving among other things precognition of the difficulties to be countered by MIR and receiving advices and identification experiences with other people and life forms, even dinosaurs of ancient Earth!

In the many-sheeted space-time the situation looks like following.

1. Astronauts draw the magnetic flux sheets connecting them to the magnetic body of Earth and higher level magnetic bodies with them. Only $k_d = 4$ level might be affected since for $k_d > 4$ the length scale involved, which corresponds to height of ionosphere, is shorter the than the distance travelled.

2. At the level of cell nuclei nothing dramatic need happen. Energetically the stretching magnetic flux sheets associated with DNA is not a problem since the energy densities involved are rather tiny. Furthermore, if the flux sheets carry homological monopole flux, they could highly stable against increase of length since they would have magnetic monopole wormhole contacts at their ends.

3. The question is what happens for the $k_d = 4$ Josephson junction associated with 180 km thick layer composed of litosphere and connecting brain to magnetic body of Earth? Could the Josephson current run still now but from litosphere to the magnetic sheets to the brain of astronaut and back to the ionosphere? A long period in space might change the situation and this could relate to the strange experiences of astronauts. If the contribution of $k_d = 4$

level weakens it might happen that $k_d > 4$ levels with longer time scale begin to dominate the consciousness.

4. The experiences are also consistent with TGD based view about geometric time and possibility of geometric memories extending beyond the duration of individual life cycle. If one takes seriously the report about dinosaurs, which lived for $\sim 10^8$ years ago, $k_d = 9$ level which corresponds to Josephson period of $5.44 \times 10^9$ years, could have contributed to the conscious experience of astronauts.

5. *What the reduction of Earth's magnetic field means?*

The strength of Earth's magnetic field has reduced 50 per cent during last 1.000 years. The fact that an exponential evolution of civilization has occurred during this period, is perhaps not an accident. Surprisingly many magnetic transition frequencies happen to be near to Schumann resonance frequencies. During this period the weakening of Earth's magnetic field has reduced cyclotron frequency spectrum of heavy ions from $3-8$ Hz range to the range $1.5-4$ Hz. Rather remarkably, delta frequencies near 3 Hz correspond to a peak in the frequency spectrum of so called sferics associated with lightning activity [46].

These observations suggest the emergence of strong interaction between brain and higher levels of the self hierarchy based on spherics and Schumann resonances. Assuming temporal linearity, the reduction of Earth's magnetic field has been 25 per cent after Newton and 5 per cent during last 100 years. Perhaps an exponential development of mathematical consciousness made possible by the activation of cyclotron frequencies of heavy ions with high nuclear and electronic angular momenta and allowing large number of conscious-to-us magnetic transitions, and possibly also involving some kind of fine tuning is taking place.

The weakening of Earth's magnetic field probably relates to a forthcoming change in the polarity of Earth's magnetic field. One might guess that the personal magnetic bodies are not affected appreciably during this period but that the violent change of Earth's magnetic field induces dramatic effects on collective aspects of consciousness at $k_d = 4$ level as the findings of Callahan suggest.

### What about spin flips?

The natural question is whether also spin flips to which Larmor frequencies are associated could be important. If anomalous magnetic moment vanishes Larmor frequency differs by a factor 1/2 from cyclotron frequency: $f_L = f_c/2$ so that spin flip frequency is same as cyclotron frequency. For atomic nuclei the Larmor frequency tends to be larger than cyclotron frequency as the table of Appendix demonstrates. The effects of em fields in living matter at Larmor frequencies have not been however reported.

The natural expectation is that Larmor frequency behaves in the same manner as cyclotron frequency in the scaling of Planck constant and this is indeed the case since spin scales as $\hbar_{eff}$. This allows to consider the possibility that also spin flip transitions are of interest and perhaps define correlates for sensory qualia.

Spin flip frequencies are in general of order few hundred Hz for $B = .2$ Gauss. The eight ions listed in the table below have however exceptionally low Larmor frequencies and, very importantly, the singly ionized states have vanishing electronic spin for all ions except Rh and Ir for which electronic configuration corresponds to $J - e = 2/2$ (non-vanishing electronic spin implies that the Larmor frequency of ion is of order $f_L = f_c(e)/2 \simeq 3 \times 10^5$ Hz). This suggests that electromagnetic spin flip transitions for these ions at least could be related to our consciousness. Note that K, Ag and Au have spin flip frequencies near to the harmonics of the fundamental frequencies of exotic super-canonical representations important in EEG frequency range. Note that the spin flip frequency of $K$ is 39.1 Hz which is in 40 Hz thalamocortical resonance band. The spin flip frequency 82.2 Hz for Cl might relate to the resonance frequency 80 Hz associated with retina.

| Ion | (Z,A,S) | $f_1/Hz$ | $f_{flip}/Hz$ | J |
|---|---|---|---|---|
| $Cl$ | (17,35,F) | 8.5 | 82.2 | 3/2 |
| $K$ | (19,39,F) | 7.5 | 39.1 | 3/2 |
| $Rb$ | (37,85,F) | 3.5 | 81.0 | 5/2 |
| $Y$ | (39,89,F) | 3.4 | 41.2 | 1/2 |
| $Rh$ | (45,103,F) | 2.9 | 26.6 | 1/2 |
| $Ag$ | (47,107,F) | 2.8 | 34.2 (39.2) | 1/2 |
| $Ir$ | (77,193,F) | 1.6 | 17.0 | 3/2 |
| $Au$ | (79,197,F) | 1.5 | 14.0 | 3/2 |

Table 3. The ions for which electronic spin vanishes in ground state and minimum spin flip frequency $f_{flip}$ is below 90 Hz. $f_{flip}$ is defined as $f_{min} = 2f_L/J$m, where $J$ is nuclear spin. $Ag$ allows two stable isotopes with almost same abundances and the values of $f_{flip}$ are given for both.

**What about $Z^0$ magnetic transitions?**

The idea that $Z^0$ magnetic magnetic transitions might be relevant for biomatter have been discussed already earlier. The identification of the sources of long ranged classical weak fields as dark matter forces however a profound modification of the earlier picture.

The TGD based models for atomic nuclei [F8] and condensed matter [F10] suggest strongly that the dark variant of $k = 113$ copy of $k = 89$ electro-weak physics is essential for understanding of not only the anomalies of water but also the basic properties of condensed matter. Also other copies of electro-weak physics with arbitrarily small weak mass scale are implied by the fact that long ranged classical weak fields are unavoidable in TGD Universe. Also the scaled down copies of color physics with arbitrarily low mass scales for quarks are a basic prediction of TGD.

If classical $Z^0$ magnetic field is present and if nuclei possess anomalous weak charges due to the presence of color bonds with quark and antiquark at their ends carrying non-vanishing net weak charges coupling to $k = 113$ dark weak bosons, one must consider also $Z^0$ cyclotron frequencies given by

$$\begin{aligned}
&\Omega = \frac{N(u\overline{d})}{A} \times Q_Z(u\overline{d}) \times \frac{g_Z B_Z}{eB} \times \Omega_p \ , \quad \Omega_p = \frac{eB}{m_p} \ , \\
&Q_Z(u\overline{d}) = \frac{1}{2} - sin^2(\theta_W) \ .
\end{aligned} \tag{2.3.1}$$

Here $N(u\overline{d})$ is anomalous $Z^0$ charge of the nucleus due to weakly charged color bonds connecting nucleons with quark and antiquark at their ends using $u\overline{d}$ $Z^0$ charge $Q(u\overline{d})$ as unit. $\Omega_p$ is proton cyclotron frequency, which is about 300 Hz for $B = B_E = .5$ Gauss. The dependence on the $Z^0$ magnetic transition frequencies on the mass of nucleus is same as in the electromagnetic case.

The doubly dark weak bosons with weak length scale $L_w = 2^{22}L_w(113) = .2$ $\mu$m should be key actors in TGD based model of living matter. Since the quantization of magnetic flux uses $\hbar$ as unit the quantum of $Z^0$ flux over a given area is multiplied by a factor $2^{22}$ for doubly dark weak bosons. Also the energy $\hbar\omega_c$ associated with the cyclotron frequency is multiplied by a factor $2^{22}$ so that energies are by a factor $2^{44}$ higher for cyclotron transitions in flux quantized $Z^0$ magnetic field than one might expect. In the case of dark quarks it would be natural to use $2(Q_Z(u\overline{d})$ as unit of charge in the quantization of magnetic flux so that the flux quantization reads $2Q_Z(u\overline{d})\int B_Z dA = n2^{22}\hbar 2\pi$.

$Z^0$ flux quanta with radius $L_w = .2$ $\mu$m are expected to be of special interest. Consider the field corresponding to single flux quantum in this case. Using the fact that Earth's magnetic field taken to have nominal value .4742 Tesla corresponds to a single quantum of flux through a disk of radius $L(k = 169)$, one obtains that the $Z^0$ cyclotron frequency and energy in this case are given by

$$\begin{aligned}
\Omega_c(2^{22}\hbar) &= 2^{22}\Omega_c(\hbar)2^{22}\frac{N(u\overline{d})}{A} \times Q_Z(u\overline{d}) \times (\frac{L(169)}{L_w})^2\omega_p(B_E) \\
&\simeq \frac{N(u\overline{d})}{A} \times 750 \ GHz \ , \\
E_c(2^{22}\hbar) &= 2^{44}E_c(\hbar) \simeq \frac{N(u\overline{d})}{A} \times 10^4 \ eV \ .
\end{aligned} \tag{2.3.2}$$

Note that $\Omega_c$ and $E_c$ do not depend on the unit of flux quantization. Cyclotron frequencies are in $10^{12}$ GHz range but energies in $10^4$ eV range and corresponds to ordinary photon wavelength of about atomic length scale. In the earlier picture frequencies were in 10 Hz range. The energies involved are well above the thermal energy in room temperature. For the first level of dark matter hierarchy the frequency scale would be .375 GHz and energy scale 25 meV which is below thermal energy at room temperature.

Also ordinary nuclei containing charged color bonds would couple to dark weak bosons with weak length scale having nominal value $L_w = 2^{11}L_w(113) = 1$ Angstrom. In this case $Z^0$ magnetic fields would have $2^{11}$ stronger strength that in previous case and cyclotron energies would be same.

## 2.4 Fractal hierarchy of Josephson junctions and hierarchy of generalized EEGs

One can imagine two manners to realize the hierarchy of EEGs and Josephson junctions.

1. The original model was based on a too restricted view about the generalized imbedding space and led to a model of Josephson junctions assigned to a fractal hierarchy of cell membrane like structures with arbitrarily large thickness for the scaled up variant of cell membrane but possessing same membrane potential as ordinary cell membrane. This assumption is very strong and could quite well be unrealistic.

2. Few years later a further generalization of the imbedding space emerged allowing hierarchy of Josephson junctions assignable to cell membrane itself. This option looks much more realistic and will be discussed after a brief summary of the generalization of the notion imbedding space. The generalization of the imbedding space is discussed in more detail in Appendix.

### 2.4.1 Generalization of the notion of imbedding space

Quite generally, the hierarchy of Planck constant is realized by generalizing the notion of imbedding space such that one has a book like structure with various almost-copies of imbedding space glued together like pages of book. Each page of book correspond to a particular level of dark matter hierarchy and darkness means that there are no Feynman diagrams in which particles with different value of Planck constant would appear. The interactions between different levels of hierarchy involve the transfer of the particles mediating the interaction between different pages of the book. Physically this means a phase transition changing the value of Planck constant assignable to the particle so that particle's quantum size is scaled. At classical level the interactions correspond to the leakage of magnetic and electric fluxes and radiation fields between different pages of the book.

#### Original view about generalized imbedding space does not allow understanding of quantum Hall effect

The original generalization of the imbedding space was too restricted and the belief that the proposed generalization of the imbedding space could explain naturally phenomena like quantum Hall effect involving fractionization of quantum numbers like spin and charge turned out to be wrong. The idea was that a given page of the book like structure would correspond to an orbifold obtained from $H = M^4 \times CP_2$ by identifying the points of $H$ obtained from each other by the action of group $G_a \times G_b$, where the factors act in $M^4$ and $CP_2$ degrees of freedom. As a matter fact, this identification implies just the opposite of fractionization if these quantum numbers are assigned with the symmetries of the imbedding space. For instance, quantization unit for orbital angular momentum becomes $n_a$ where $Z_{n_a}$ is the maximal cyclic subgroup of $G_a$.

One can however imagine of obtaining fractionization at the level of imbedding space for space-time sheets, which are analogous to multi-sheeted Riemann surfaces (say Riemann surfaces associated with $z^{1/n}$ since the rotation by $2\pi$ understood as a homotopy of $M^4$ lifted to the space-time sheet is a non-closed curve. Continuity requirement indeed allows fractionization of the orbital quantum numbers and color in this kind of situation.

**Extension of imbedding space by allowing coverings**

This means an extension of the imbedding space by allowing also $G_a$ *resp.* $G_b$-fold coverings of $\hat{M}^2 = M^4\backslash M^2$ *resp.* $\hat{CP}_2 = CP_2\backslash S^2$, where $M^2$ corresponds to 2-D Minkowski space defined by the fixing of rest frame and direction of quantization axis of angular momentum and $S^2$ to a homologically trivial geodesic sphere of $CP_2$ which corresponds to a particular choice of group $SO(3) \subset SU(3)$ and thus fixing of quantization axes of color isospin. The surfaces $X^4 \subset M^4 \times S^2$ are vacuum extremals as required by internal consistency of the theory. The leakage between different pages of book occurs via manifolds $M^4 \times S^2$ and $M^2 \times CP_2$ which correspond to quantum criticality. The extreme form of quantum criticality corresponds to leakage through $M^2 \times S^2$.

The book has four kinds of pages:

1) $[\hat{M}^4/G_a] \times [\hat{CP}_2/G_b]$ with Planck constant $\hbar/\hbar_0 = n_a/n_b$: $n_i$ is the order of maximal cyclic subgroup of $G_i$. Only these pages were included in the original "book": the problem concerning biological applications is that large values of Planck constant require high rotational symmetries;

2) $[\hat{M}^4\text{"}\times\text{"}G_a] \times [\hat{CP}_2/G_b]$ with $\hbar/\hbar_0 = 1/(n_a n_b)$: "$\times$"$G_i$ refers to $G_i$ covering. Note that Planck constant is always smaller than its standard value $\hbar_0$ ($n_a = n_b = 1$) in this case implying for instance that the binding energy scale of hydrogen atom is scaled up;

3) $[\hat{M}^4\text{"}\times\text{"}G_a] \times [\hat{CP}_2\text{"}\times\text{"}G_b]$ with $\hbar/\hbar_0 = n_b/n_a$;

4) $[\hat{M}^4/G_a] \times [\hat{CP}_2\text{"}\times\text{"}G_b]$ with $\hbar/\hbar_0 = n_a n_b$; note that in this case the Planck constant is maximal.

**Maximimation of Planck constant in quantum control and communication in living matter**

The pages of type 4) are the most promising candidates concerning the understanding of living matter, at least the quantum control of living matter.

1. $G_a$ symmetry is implied in $M^4$ degrees of freedom since the restriction to the orbifold $\hat{M}^4/G_a$ is equivalent to the $G_a$-invariance of quantum states. Molecular rotational symmetries correspond typically to small groups $G_a$.

2. $G_a = Z_n$, $n = 5, 6$ are favored for molecules containing aromatic cycles. Also genuinely 3-dimensional tedrahedral, octahedral, and icosahedral symmetries appear in living matter. In this kind of situation one could have for given $G_a$ the hierarchy $n_b = 2^{11k}$) giving rise to large values of Planck constant. This hierarchy might be realized both at the level of DNA and cell membrane.

3. Also the hierarchy of EEGs could correspond to this hierarchy and one could assume that cell membrane gives rise to the entire hierarchy. Also other powers of 2 could occur in the hierarchy.

### 2.4.2 The new model for the hierarchy of Josephson junctions

The original model for EEG led was based on the generalization of imbedding space obtained by gluing together almost-copies of imbedding space such that copies where effectively orbifolds $H/G$ $G = G_a \times G_b$ the product of discrete subgroups of rotational group SO(3) and $SO(3) \subset SU(3)$. The model forced the admittedly weird looking assumption that cellular Josephson junctions are accompanied by their fractally scaled up variants with cell membrane thickness $2^{11k}$, $k = 0, 1, 2, ...$ with very precisely same value of electric field. This means quite a strong assumption about the dark matter hierarchy.

After few of years after developing the first version of the model the obvious questions are whether one could avoid such a strong assumption about dark matter hierarchy and whether one could assume that Josephson junctions in hierarchy have the same thickness defined by cell membrane thickness. This seems to be possible.

The further generalization of imbedding space by allowing $G_a-$ *resp.* $G_b$-coverings of $M^4\backslash M^2$ *resp.* $CP_2\backslash S^2$ leads to a more general formula for Planck constant. If imbedding space corresponds to $n_b$-fold covering of $CP_2\backslash S^2$ then Planck constant is proportional to $n_b$. This means that besides $n_a$-fold symmetry in $M^4$ degrees of freedom also $n_b$-fold covering in $CP_2$ degrees of freedom makes possible to make Planck constant large.

This would suggest that cell membrane Josephson junctions for large values of Planck constant to $n_b$-fold $CP_2$-coverings of ordinary cell membrane Josephson junctions with electronic Cooper pairs at the sheets of covering. The value of Planck constant would be $n_a n_b$-fold for pages of type 4) discussed in previous subsection. If the thickness of Josephson junction is not changed one obtains only the scaling of photon wavelengths for a given photon energy.

Cyclotron frequency would remain invariant but Josephson frequency would be scaled down since one has $f_J = ZeV/\hbar$. This kind of slowing down of oscillation of the Josephson current should have interpretation in terms of the modified topology in $CP_2$ degrees of freedom. The simplest interpretation would be that covering means that oscillation corresponds to a closed orbit in $CP_2$ degrees of freedom which for $n_b$-fold covering closes only after $n_b$ cycles. It seems that this option is the more realistic one.

### p-Adic fractal hierarchy of Josephson junctions is possible also in the new model

The older model postulated a hierarchy of Josephson junctions which involved two hierarchies, dark matter hierarchy and p-adic hierarchy in a kind of resonance for living matter systems. The unrealistic looking assumption was that there exists a hierarchy of cell membrane like structures with increasing thickness scaled up by factor $2^{11k}$ acting as Josephson junctions and characterized by the same voltage as ordinary cell membrane.

In the new model the dark hierarchy of Josephson junctions is replaced with a hierarchy of layers of the onion-like magnetic body assignable to the ordinary cell membrane. It is of course still possible to have hierarchy of Josephson junctions at least in length scales regarded usually as biologically relevant. The voltage through the junction need not however be same as for the ordinary cell membrane anymore.

In particular, twin primes abundant in the p-adic length scale range assignable to living matter could define double layered structures acting as Josephson junctions.

| | | | | |
|---|---|---|---|---|
| $(k,k+2)$ | $(137,139)$ | $(149,151)$ | $(167,169=13^2)$ | $(179,181)$ |
| $L(k)$ | $.78\ A$ | $5\ nm$ | $2.5\mu m$ | $.32\ mm$ |
| $(k,k+2)$ | $(191,193)$, | $(197,199)$ | | |
| $L(k)$ | $1\ cm$ | $8\ cm$ | | |

Table 4. Twin primes define especially interesting candidates for double membrane like structures defining Josephson junctions. Also included the pair $(137, 13^2 = 169)$ although $k = 169$ is not prime. The two largest scales could relate to structures appearing in brain.

### An objection against the older model for the fractal hierarchy of Josephson junctions

There is a counter argument against the hierarchy of cell membrane like structures with a scaled up thickness coming as powers of $2^11$. The electric field involved with the higher levels of Josephson junction hierarchy is very weak: something like $10^{-7}$ V/m for lito-ionospheric Josephson junctions (of thickness about 176 km from the scaling of the cell membrane thickness by $\lambda^4 = 2^{44}$) which might be responsible for EEG. The electric field of the Earth at space-time sheets corresponding to ordinary matter is much stronger: about $10^2 - 10^4$ V/m at the surface of Earth but decreasing rapidly as ionosphere is approached being about .3 V/m at 30 km height. The estimate for the voltage between ionosphere and Earth surface is about 200 kV [41].

The many-sheeted variant of Faraday law implies that on order to have a voltage of order .08 V over lito-ionospheric Josephson junction at dark matter space-time sheet, the voltage over ionospheric cavity must be almost completely compensated by an opposite voltage over litosphere so that lito-ionospheric double layer could be seen as a pair of capacitor plates in a radial electric field of order $10^{-7}$ V/m generated by the charge density in sub-litospheric part of Earth. This condition requires fine-tuning and therefore looks unrealistic.

A natural distance scale in which the electric field is reduced would correspond to 10-20 km thick layer in which whether phenomena are present. The mirror image of this layer would be Earth's crust. The cell membrane counterpart would be a dipole layer like charge density between the lipid layers of the cell membrane. Note that the electric field at dark matter space-time can be constant. However, as far as Josephson junction is considered, it is only the net voltage what matters.

The new model for EEG implies fractal onion-like hierarchy of dark magnetic bodies assignable to cell membrane labelled by the values $\hbar/\hbar_0 = 2^{11k}$. As already noticed, the older model differed from the new one in that it predicts similar hierarchy of cell membrane like structures defining Josephson junctions with same membrane potential.

### 2.4.3 The two hierarchies of Josephson junctions and generalized EEGs

Two hierarchies are possible. One can have a p-adic hierarchy of Josephson junctions with an increasing thickness of the corresponding membrane like structure and to each membrane like structure one can assign a dark hierarchy of generalized EEGs corresponding to powers of $2^{11}$.

#### p-Adic hierarchy of membrane like structures accompanied by Josephson junctions

The first hierarchy correspond to the p-adic length scales varying in the range of biologically relevant p-adic length scales $L(k)$ involving membrane like structures. Twin primes $(k, k+2)$ are good candidates here (Table 4). Second hierarchy corresponds to dark matter hierarchy for which length scales come in powers $211k_dL(k))$. The general prediction is that $\lambda$ is power of two and $k = 11$ is favored value because it corresponds to a fundamental constant in TGD. There are also other arguments supporting the exactness of this value.

Since 11 p-adic length scales combine naturally to form single block in this hierarchy, there is a strong temptation to assume that p-adic length scales $k = 151, 147, 163, 167, 169$ form the fundamental block. Same length scale can have interpretation as several different p-adic length scales belonging to different levels of dark hierarchy. This is expected to induce an interaction between various levels of dark matter hierarchy.

The size of cell nucleus varies in the range $(L(169) = 5\ \mu m, 2L(169) = 10\ \mu m)$. This is consistent with the assumption that cell nucleus provides the fundamental representation for this block. This would mean that at least the multiply coiled magnetic flux quantum structures associated with DNA appear as fractally scaled up copies.

Each dark matter level corresponds to a block of p-adic length scales $L(k)$, $k = 151, ..., 169$. Also new length scales emerge at given level $k_d$ and correspond to $L(k)$, $k > 169$. The dark copies of all these length scales are also present. Hence something genuinely new would emerge at each level.

#### Fractal hierarchy of magnetic bodies assignable to cell

Second hierarchy corresponds to a dark matter hierarchy involving powers $2^{11k}$ of given p-adic length scale assignable to biological membrane like structure.

The emergence of a genuinely new structure or function in evolution would correspond to the emergence of new level in this fractal hierarchy. Quantum criticality would be essential: phases corresponding $k_d$ and $k_d + 1$ levels would compete at quantum criticality.

The flux sheet or tubes through cell membranes should integrate to larger structures at the higher levels of dark matter hierarchy implying the integration of sensory inputs from a large number of cells to single coherent input at higher levels of dark matter hierarchy. One can think two options: the sensory inputs from cell membranes are communicated directly to the magnetic body or via cell nuclei. The second option would require that the flux sheets or tubes starting from cell membrane traverse also the DNA.

1. $k_e = 0$ would correspond to cell nucleus since electronic and possible neutrino superconductivity made possible by scaled up variant of weak interactions can correspond to ordinary $\hbar$. One could assume for definiteness that the magnetic body involved as size scale of cell membrane thickness at this level but could also consider some larger size which is scaled up at higher levels of the hierarchy by the scaling factor $2^{k11}$.

2. $k_d = 1$ would correspond to the emergence magnetic bodies with sizes below 4 cm. This size scale could be assigned to organs bounded by epithelial sheets (double cell layers) of thickness about 20 $\mu$m. Also in the new model these layers could define Josephson junctions but with some other voltage than that associated with the cell membrane.

3. $k_d = 2$ would correspond to layers of thickness 4 cm and structures with size smaller than 80 m. Obviously genuinely dark level is in question now. The layers of this Josephson junction could be assignable to left and right halves of central nervous system. The interpretation in terms of dark matter around the magnetic body of organs suggests also itself. $k_d = 3$ corresponds to the emergence of double layered dark matter structures of thickness 80 m and size scale below 160 km. Now dark matter condensed around magnetic bodies of magnetic bodies of organs could be in question.

4. $k_d = 4$ could correspond to the emergence of EEG assignable to flux sheets of personal magnetic body. The bilayered structure has thickness of 80+80 km and the analog of cell nucleus has minimum $512 \times 160 = 8$ Mm and corresponds to Earth size scale (Earth radius is 6.96 Mm).

It must be emphasized that also other values of $k$ besides $k = 168$ with $n = 5$ can be considered. In particular, the values $k = 151, 157, 163, 167$ corresponding to Gaussian Mersennes are especially promising candidates for characterizing endogenous magnetic fields. The model of EEG in turn leads to the conclusion that also $k = 169$ with $n = 5$ must be present. The relevant length scales vary accordingly.

### Dark hierarchy of EEGs

The dark hierarchy of Josephson junctions with fixed size characterized by a p-adic length scale most naturally assignable to a member of twin prime pair defining a fractal hierarchy of EEGs is the basic element of the model of generalized EEG.

*1. Josephson junctions provide a representation of electric field as biological action induced by generalized EEG*

Each junction has a background voltage over it. The basic hierarchy involves the p-adic length scales $L(k)$, $k = 151, ..., 169$. One could consider the possibility that not only $k = 151$ but all these length scales and also twin primes define their own Josephson junctions with their own values of Josephson potential. Note however that if the Josephson voltage behaves like $1/L_(k)$ - as the naive scaling would suggest - then Josephson energy $E_J = ZeV$ is below the thermal energy for $k > 151$.

Josephson current can be written as

$$J \propto sin(2eVt + 2e \int V_1 dt) \ ,$$

where $V$ corresponds to the background voltage analogous to resting potential of cell membrane and varies in rather narrow limits. $V_1(t)$ represents external perturbation.

The frequency of $V_1$ is represented as a period of periodic multiplicative modulation of the $V_0$. $J$ itself is not periodic. There is however a periodicity with a period $T = n/f$, where $f$ is frequency of $V_1$ for $f_J = mf/n$. There are two interesting limits. For $f_J^1 = 2eV_1/2\pi\hbar \gg f_J$ amplitude $V_1$ is represented as frequency since in reasonable approximation frequencies $f_\pm = f_J \pm f_J^1$ dominate. Second limit corresponds to $f_J^1 \ll f_J$. In this case the dominating frequencies are $f_\pm = f_J \pm f$

Josephson frequency would define a kind of drum beat whereas the frequencies associated with $V_1$ would represent the rest of the music. Josephson frequency $f_J = eV/2\pi\hbar$ indeed turns out to belong to the scaled up variant of delta band of EEG and thus defines the analog of drum beat and corresponds to a resonance frequency in delta band for the scaled up variants of EEG. Josephson frequency defines a candidate for the time unit in which the time scale of memories and intentional action of the living system are measured.

The coherent photon state generated by $J$ defines representation of $V_1$ as a generalized EEG and biological representations result when the photons interact with the living matter.

The reactions of the Josephson junctions corresponding to different p-adic length scales $k = 151, ..., 169$ (if really present!) to external electric field are different due to $V_1 \propto L(k) \propto 2^{(k-151)/2}$ proportionality and independence of $V$ on $k$.

*2. Thermodynamical considerations*

Josephson energy does not depend on the level of dark matter hierarchy and is thus above thermal energy since this holds true in the case of cell membrane. From the resting potential whose nominal value is often taken to be for .08 V, $f_J$ corresponds roughly to the energy 1.6 eV roughly twice the energy allowed by thermal stability. Thermal stability of drum beat would allow 140 °C temperature. The growth temperatures of thermophilic bacteria can be even higher than 100 °C.

Nerve pulse is generated when the potential drops to .05 eV: the corresponding Josephson energy is .01 eV which is above thermal threshold for $T \leq 70$ C. For organisms possessing no nervous systems, in particular bacteria, this constraint is not relevant. The energy $E = 1$ eV is twice the energy $E = .05$ eV, which is a universal transition energy of Cooper pairs of high $T_c$ electronic super conductor [J1]. The generation of nerve pulse might involve these transitions.

*3. Josephson frequencies*

Resting potential corresponds to the Josephson frequency $f_J = 5.95 \times 10^{13}$ Hz. Infrared radiation with intensity spectrum having characteristics of coherent state of photons would be a signature of this current. The Josephson frequency corresponding to threshold potential is $f_J = 3.36 \times 10^{13}$ Hz.

$f_J$ scales like $f_J \simeq \lambda^{-k_d}$ as a function of the level of the dark matter hierarchy. For $k_d = 4$ one obtains $f_J = 3.38$ Hz using $\lambda = 2^{11}$. This frequency belongs to delta band (defined as the the frequency range .25-5 Hz).

**Levels of dark matter hierarchy as a physical counterpart of chakras?**

The model identifying generalized EEG as coherent photons emitted by Josephson junction suggest that $k_d = 7$ corresponds to the highest level of dark matter hierarchy for humans. This brings in mind the seven chakras central for Eastern mystic traditions. The magnetic flux quanta would enter the body through organs which are assignable to a particular value of $k_d$ and chakras could be identified as groups of organs with a given value of $k_d$. An alternative possibility is that the space-time sheets at level $k_d$ are joined to the level $k_d + 1$ by Josephson junctions. In this case it is not necessary to have connections directly from the level of DNA.

The magnetic bodies involved include the magnetic body associated with biological body, presumably that associated with $k_{em} = 2$, magnetic body of Earth for $k_{em} = 4$, magnetic body associated with plasma sheet at night side of Earth's magnetosphere, the magnetic body of Sun for $k_{em} = 6$ and that of solar system for $k_{em} = 7$. Note however that the endogenous magnetic field is $B_{end} = .2$ Gauss and relates to $B_E = .5$ Gauss by a scaling factor. This suggests that personal magnetic bodies in the hierarchy interact with the astrophysical magnetic bodies but are not identical with them.

Josephson period associated with the largest chakra would would correlate with the time scales of intentional action and memories and would give a criterion making possible to estimate which levels are present for a given kind of organism or part of organism.

Of course, detailed one-to-one map between chakra picture and dark matter hierarchy is not possible. There are however common elements, most importantly the hierarchical structure of conscious experience leading from animal consciousness (root chakra) to cosmic consciousness (crown chakra). Chakra hierarchy should also have direct counterpart at the level of evolution of living organisms.

Hence it could be that two ideas, chakras and the idea about delicate interaction between astrophysical objects and human consciousness, hated bitterly by skeptics, find a natural place in dark matter hierarchy.

**What is the precise value of $\lambda$?**

The precise value of $\lambda$ is important if one wants to assign the amplitude windows to resonance bands of EEG.

1. By the general model for quantization of Planck constant already discussed $\lambda$ can correspond to a power of 2 and hence $\lambda = 2^{11}$ is strongly favored.

2. $\lambda = 2^{11}$ implies a precise resonance between dark length scales and ordinary p-adic length scales. If $\lambda$ is integer and if it equals to $2^{11}$ then also lower powers of 2 can in principle appear in the dark matter hierarchy as sub-harmonics $\lambda/2^k$ (this is indeed predicted by integer quantization of Planck constant).

3. The interpretation of the Josephson period associated with the highest level of dark matter as the time scale for intentional action and memory allows to estimate the value of largest $k$ relevant for humans and it turns out that the scaled up Josephson frequency corresponds to a

period of 80 years for this option meaning that $k_d = 7$ naturally corresponds to the highest level in the dark matter hierarchy associated with humans.

4. $\lambda = 2^{11}$ option predicts for the length scale associated with $k_d = 4$ magnetic body a value having direct physical interpretation.

5. $\lambda = 2^{11}$ option provides a plausible interpretation for amplitude windows in terms of EEG resonance bands.

**Josephson frequencies for various levels of dark matter hierarchy**

The following tables list the Josephson frequencies for doubly charged current carriers for the levels of dark matter hierarchy corresponding to $k_d = 0, ..., 7$ using the value .08 V/m for the resting potential for $\lambda = 2^{11}$.

The powers of $\lambda = 2^{11}$ are allowed by the requirement that the scaling $\hbar = n\hbar_0$ of Planck constant corresponds to a quantum phase $q = exp(i\pi/n)$ assignable to an n-polygon constructible using only ruler and compass. In this case one has $n = n_F = 2^k \times \prod_k F_{n_k}$, where each Fermat prime $F_n = 2^{2^n} + 1$, $n = 0, 1..., 4$ can appear only once. The quantum phase $exp(i\pi/n_F)$ is expressible using using only iterated square root operation [C6] and same applies to the algebraic extension of p-adic numbers is needed for $p \ mod\ 4 = 3$. This is not true for $\lambda = 2176$ so that $v_0 = 2^{-11}$ remains the only candidate.

For $\lambda = 2^{11}$ the Josephson period for $k_d = 7$ is $\simeq$ 80 years, which roughly corresponds to the duration of human life cycle. $k_d = 6$ corresponds to $\simeq$ 14.3 days and $k_d = 5$ to $\simeq$ 10.1 minutes.

Note that there is no dependence on the p-adic length scale $k = 151, ..., 169$. Also the frequencies corresponding to the .05 V corresponding to the potential at which nerve pulse is generated are listed. For singly charged bosonic ions the frequency would be $f_J/2$. For fermionic ions Josephson currents are not of course possible.

| $k_d$ | 0 | 1 | 2 | 3 |
|---|---|---|---|---|
| $f_J(80\ mV)/Hz$ | 5.95e+13 | 2.91e+10 | 1.42e+07 | 6.93e+03 |
| $f_J(50\ mV)/Hz$ | 3.72e+13 | 1.82e+10 | 8.87e+06 | 4.33e+03 |
| $k_d$ | 4 | 5 | 6 | 7 |
| $f_J(80\ mV)/Hz$ | 3.38 | 6.18e-4 | 2.85e-7 | 1.31e-10 |
| $f_J(50\ mV)/Hz$ | 2.11 | 1.0e-3 | 5.04e-07 | 2.46e-10 |

Table 5. The Josephson frequencies $f_J = 2eV/2\pi\hbar$ of doubly charged particles for $\lambda = 2^{11}$ corresponding to the resting potential .08 V and threshold potential .05 V for nerve pulse generation for $\lambda = 2^{11}$.

### 2.4.4 A more precise identification of layers of magnetic body

By fractally scaling up from the case of cell membrane one can assign to a given level of dark matter hierarchy the p-adic length scales $L(k)$, $k = 151, ..., 169$ scaled by the power $2^{11k}$ as a sequence of onion like layers of the magnetic body at given level of dark matter hierarchy in the newer model. In the older model the onion layers of magnetic body scaled by $2^{11k}$ would correspond to Josephson junctions having key properties of the scale up cell membrane. The discussion below relies on the newer model.

**$k_d = 0$ level**

In the new model Josephson junctions involved with EEG are assigned with cell membrane. Note that electronic and exotic neutrino super-conductivities correspond to the ordinary value of $\hbar$. The Josephson frequency is 29.8 THz and corresponds to infrared photons. The observation of photons with spectrum having characteristics of coherent photon state generated by Josephson current is a testable experimental prediction.

An interesting question is whether membrane proteins acting as receptors and possibly also as channels and pumps correspond to a concrete realization of Josephson junctions and could be seen as being analogous to living organisms populating the cell membrane. Josephson junction would correspond to the protein magnetic body connecting cell interior to the magnetic body of cell. Second question is where the magnetic flux tube of the personal magnetic body flows in the cell interior and exterior. As a matter fact, the radius 18 $\mu$m of flux quanta for $B_{end} = .2$ Gauss resolves this question and suggests that large neurons of vertebrate brain are essential concerning the effects of ELF fields on brain.

If topological magnetic monopole flux flowing to a larger space-time sheet through wormhole contacts and returning back at the other end of the junction in the similar manner is in question, this question is avoided. The Josephson junctions identifiable as protein magnetic bodies can be associated with also other membrane bounded structures, in particular organelles inside cell, say cell nucleus.

With inspiration coming from the experiments of Gariaev [51] I have proposed that EEG has fractally scaled-up counterparts such that ordinary EEG would correspond to $k = 169$ level and scaled up variants to primes $k = 151, 157, 163, 167$ (at least). The model worked assuming that magnetic field scales like $B \propto 1/L(k)$: this is consistent with highly convoluted flux sheets. This scaling is just the reversal for the scaling of Josephson frequencies of external voltage perturbations as $f_J \propto L(k)$. These magnetic flux quanta can be associated with the coiling hierarchy of DNA.

#### $k_d = 1$ level

In this case one has $L(151) \rightarrow L(151 + 22 = 173) = 40$ $\mu$m. The upper bound for the size of layers of magnetic body would be $\lambda \times L(173) \simeq 4$ cm. Epithelial sheets consisting of double cell layer and surrounding organs correspond to size scale $L(173)$.

Josephson frequency is 29 GHz and corresponds to the time scale for the conformational dynamics of proteins. Josephson junctions could define a pacemaker for this dynamics and perturbations of the resting potential would serve a control purpose.

#### $k_d = 2$ level

The scale assignable to the corresponding layer of magnetic body is $\lambda = 2^{11}$ $L(195) = 4$ cm. The upper bound for these structures is 80 m and $L(169)$ corresponds now to 20 m length scale. This would require that magnetic flux sheets traverse through cell nuclei of a large number of organisms and thus define hyper-genes responsible for the social aspects of the behavior. At least the interiors of these structures must correspond to dark matter. The proposal that the magnetic flux sheets of $k_d = 4$ magnetic body flow through DNA of neurons generalizes to the proposal that flux sheets of $k_d = 2$ magnetic body flow through the DNA of cells which are at a lower level in the differentiation hierarchy. Josephson frequency would be 14 MHz.

#### $k_d = 3$ level

In this case the layer of magnetic body would have thickness $L(217) = 80$ m. The Josephson frequency would be 6.9 kHz. The length of DNA needed to guarantee minimal flux quantum width would be $\lambda^3 L(169) \simeq 40$ km so that roughly $4 \times 10^4$ cell nuclei are needed if most of the width of flux sheet corresponds to DNA. Thus supergenes would necessarily emerge at this level and involve organisms in a region of size scale 176 km. $k_d = 3$ layer of magnetic body defined by the magnetic flux sheet going through cell nuclei have size scale characterizing litosphere and ionospheric cavity.

#### $k_d = 4$ level

As already proposed, $k_d = 4$ level could correspond to that level in the hierarchy of personal magnetic bodies which connects organism to the magnetic body of Earth.

The length scale $\lambda^4 L(151)$ equals to 176 km for $\lambda = 2^{11}$. The cavity between ionosphere and Earth surface is about 100 km thick whereas litosphere plate has thickness about 80 km [42]. The layer responsible for atmospheric phenomena is about 10 km thick. 180 km thickness is consistent with 176 km thickness predicted by $\lambda = 2^{11}$. Litosphere plate + atmosphere and ionosphere above atmosphere could thus form the counterpart of bilayered cell membrane. This hypothesis makes sense since its is dark matter which is involved with the Josephson junction in question. If this where the case living organisms would be analogous to the proteins defining receptors, ionic channels, and pumps at the cell membrane. For this option the convoluted magnetic flux tubes defining Josephson junctions could carry monopole flux which returns back at the larger space-time sheet. In this hyper-genes would involve organisms in the scale of entire Earth.

In this picture vertebrates would be like magnetic plants extending from the bottom of litosphere to the ionosphere. These Josephson junctions would presumably connect parts of the magnetic body of Earth to each other. Josephson frequency is 3.4 Hz and belongs to theta band in EEG. The frequency is somewhat higher than the 3 Hz frequency associated with absence seizures. 3-4 Hz posterior rhythm is established in EEG of 3 months old child in awake state. 5 Hz rhythm is established at the age of 6 months. A possible interpretation is that perturbing oscillatory voltage is superposed on the 3.4 Hz drum beat.

#### $k_d > 4$ levels

$k_d = 5$ corresponds to the length scale $L(151 + 5 \times 22 = 261) = .32$ Mkm to be compared with the solar radius $R = .7$ Mkm and Earth radius $6.3 \times 10^3$ km. Earth's rotating inner magnetosphere extends at night side to about 100 Earth radii which is of same order of magnitude as $L(261)$. The rather remarkable finding that equatorial plasma sheet is self-organizing system [43] which seems to represent in electron distributions patterns resembling "flowers", "eyes", etc... might have deeper meaning if plasma sheet corresponds to $k_d = 5$ level of dark matter hierarchy. I have indeed suggested the interpretation of these patterns as magnetospheric sensory representations [M1, N1].

Because of its size Sun could correspond to $k_d = 5$ level naturally. A possible interpretation is that all planets are accompanied by dark matter hierarchy involving also this size scale but that only in case of Sun there is considerable density of visible matter associated with this dark matter. In the case of Earth only plasma sheet would be associated to this level.

$k_d = 6$ corresponds to the length scale .64 Gkm and is of the same order of magnitude as the size of the planetary system (the distance to Sun about $AU = .146$ Gkm). $k_d = 7$ corresponds to the length scale 1.28 Tkm and could correspond to the size of solar magnetosphere. This size scale is .14 light years. The distance of nearest star is about 4 light years.

One can argue that a flux tube of thickness $L = 5L(169)/\sqrt{2}$ cannot follow every twist and turn of the highly convoluted DNA double strand. Many-sheeted space-time might save the situation. On the other hand, if the thickness of flux sheet is $L/\lambda = 8.8$ nm, it has almost the thickness of cell membrane and could adopt the shape of the convoluted DNA strand. The transversal dimension of base pair is indeed about 1.2 nm meaning that the thickness of the double strand is about 2.5 nm. Note that $k = 167$ could correspond to flux sheets traversing only single strand.

In this case the width of the flux sheet would be about 136 light years so that $k_d = 7$ level would indeed conform with the assignment of cosmic consciousness with the crown chakra. In this case the flux sheet should flow through $\sim 10^{15}$ neurons or cells and bind them to single string defining kind of super genome. The total number of cells in human body is estimated to be around $10^{14}$ so that hyper genes involving large number of different organisms should appear at this level if most of the flux sheet cross section contains DNA. As already noticed the estimate for the size of the scaled up version of nucleus implies that hyper-genes should appear already at $k_d = 2$ level.

### 2.4.5 Relation with the structure of CNS

Page of a book is rather precise metaphor for the magnetic flux sheet going through a linear array of strings of nuclei. This raises several questions. Do the lines of the text of this book correspond to axons in neural circuits? Do the pages correspond to larger structures formed by the axons? This might hold true for sufficiently large values of $k_d$, say $k_d \geq 2$.

Books are made for reading and one can thus ask whether the book metaphor extends. Could the observed moving brain waves scanning cortex relate to the "reading" of the information associated with these sheets of book by the magnetic body and does our internal speech correspond to this "reading"? One is also forced to ask whether these brain waves are induced by waves propagating along magnetic flux quanta of the magnetic body of Earth or personal magnetic body in the case that it has components other than magnetic flux sheets serving as Josephson junctions.

## 2.5 The effects of ELF fields on brain and high $T_c$ ionic super conductivity

The article 'Spin the tale on the dragon' by David Jarron [58] gives excellent popular review about the history of the bio-electromagnetic research and about the frequencies for which electromagnetic fields have special effects on living matter and brain. The material from this article led to the realization of how brain manages to be a macroscopic quantum system in TGD Universe. A more technical view about the effects can be found from review articles of Adey and Blackman [70, 45]. The online review article of Cherry [44] provides a good technical representation about various effects of weak ELF em fields and ELF modulated radiofrequency em fields on brain and an extensive list of references.

### 2.5.1 Summary about effects of ELF em fields on brain

The work by pioneers of bio-electromagnetism (Wertheimer, Milham, Marino, Becker, Adey, Blackman and many others) which began already at sixties led to amazing discoveries about ELF fields on brain. The article of Blackman [45] provides a detailed summary of these developments. The results of the work of Bawin, Adey, Blackman and others can be summarized by saying that radio frequency em fields amplitude modulated by ELF frequencies affect in certain frequency and amplitude windows brain tissue [71, 41, 43]. The function of the radio frequency carrier wave is to facilitate the penetration of em field into tissue and its frequency is not essential for the occurrence of the effect. Presumably nonlinear effects give rise to a secondary wave with modulation frequency which is the primary source of effects.

#### Basic effects

The effects of ELF em fields on brain include chemical, physiological and behavioral changes within windows in frequency and field intensity. It is essential that the effects have been observed only in vertebrates which thus possess EEG. A good summary is the online review article of Cherry [44].

The well documented and established non-thermal biological effects of EMR include significant alteration of cellular calcium ion homeostasis, reduction of melatonin, and the detection of Schumann Resonances by human and avian brains. A key effect is change in $Ca^{2+}$ homeostasis: $Ca^{2+}$ it is involved with both pre- and postsynaptic steps of nerve pulse transmission and also with intracellular communication. For instance, $Ca^{2+}$ is involved with gene expression, the development and plasticity of nervous system, modulation of synaptic strengths, and with $Ca^{2+} - c$AMP signal transduction process.

Change in $Ca^{2+}$ homeostasis has harmful effects in central nervous system, endocrine system and immune system. At the level of CNS this means changes of reaction time and behavioral alternations. At the level of neuro-endocrine system a good example is the reduction of the melatonin production in pineal gland having wide variety of harmful effects since melatonin serves as effective scavenger of free radicals: among the effects are DNA strand breakage, chromosome aberrations and problems with gap junction communications. Melatonin is also crucial for healthy sleep and for the reduction of cholesterol and blood pressure. In case of immune system an example is provided by the change of functioning of lymphosytes in turn reducing the competence of immune system making the subject more vulnerable to allergens, toxins and viruses.

#### Amplitude windows

Two main amplitude windows have been seen. For the first window ELF em fields have values of electric field in tissue around $10^{-7}$ V/m. The effects are high level effects and associated with navigation and prey detection in marine vertebrates and with the control of human biological rhythms. For ELF modulated radio frequency fields (RF) and microwaves (MW) the intensities are around $1-10$ V/m. In this case the effects are neurophysiological effects are lower level effects at the level of the brain tissue. In case of brain tissue maximal sensitivity to electromagnetic fields occurs between 6 and 20 Hz.

In order to get grasp about orders of magnitude, it is good to notice that cell membrane electric field has a strength about $10^7$ V/m whereas EEG electric fields in the range $5-10$ V/m. The fact that the second intensity window corresponds to $1-10$ V/m suggests that the em field simulates the em field associated with EEG: a valuable guideline in attempts to understand what is involved. For Schumann resonances electric field is of order .6 mV/m. For sferics (em perturbations associated with lightnings) magnetic field strength is not above nTesla: this corresponds to electric field strength 10 V/m associated also with EEG waves [46]. Field strength of V/m corresponds roughly to energy flux $\mu W/m^2$.

The presence of windows and weak intensities implies that the effects cannot be thermal. A good metaphor is the effect of radio noise on radio receiver: it occurs at definite frequency and destroys the information content of the original transmission.

**The effects occur at harmonics of cyclotron resonance frequencies**

Blackman also discovered that odd multiples 15, 45, 75, 105... of 15 Hz had much stronger effect on tissue than even multiples 30, 60, 90... Hz and realized a possible role of Earth's magnetic field [42]: it must be however emphasized that the value of magnetic field in question is $B_{end} = .2$ Gauss and smaller than $B_E = .5$ Gauss. A possible interpretation is that harmonics of cyclotron frequencies might be the information carrying frequencies in EEG.

In response to the results and speculations of Blackman, Liboff formulated ionic cyclotron resonance (ICR) model [80] based on the realization that the frequencies in question correspond to multiples of the cyclotron frequencies of $Ca^{2+}$ ion in a magnetic field $B_{end} = .2$ Gauss. This model was classical. Later Blanchard and Blackman proposed so called ionic parametric resonance model (IPR) [44]. This phenomenological model combines ICR model with ideas about atomic physics. There are several objections against ICR model; classical orbits of ions in Earth's magnetic field have radius of order meters; dissipative effects and Brownian forces do not allow cyclotron orbits; charge-to mass ratios appearing in cyclotron frequencies correspond to vacuum rather than water environment characterized by a large value of dielectric constant; it is difficult to understand why odd multiples of cyclotron frequencies give rise to stronger effects [45]. Some of these objections apply also to IPR model.

The pattern of data seems to suggest that the interaction occurs at quantum level. This is in dramatic conflict with the predictions of the standard quantum theory and with the standard view about space-time.

**Are quantal effects in question?**

The conclusion that the effect of ELF fields on brain represents quantum effects associated with the transitions of ions confined in magnetic field having same strength as Earth's magnetic field, is supported by the following observations.

1. The frequencies $15, 30, 45, 60, 75$ Hz having effect on primates are multiples of the same basic frequency $f = 15$ Hz, which turns out to be the cyclotron frequency of $Ca^{2+}$ ion in magnetic field $B_{end} = .2$ Gauss. That these frequencies come in multiples is a direct signature of quantum: in classical world only basic frequency $f = 15$ Hz should have effects (forcing ions to rotational motion around field lines with this frequency.

2. Even multiples of 15 Hz have a weak but non-vanishing effect. Transitions are not possible at all in the lowest order of perturbation theory since the interaction Hamiltonian describing the transitions in question has non-vanishing matrix elements only between states of opposite parities in the dipole approximation applying when the wavelength of the radiation is much larger than the size of the radiating system [16]. Odd and even values of $n$ for cyclotron states have opposite parities so that $\Delta n$ odd rule results. In higher orders of perturbation theory also transitions for which transition frequency is even multiple of the cyclotron frequency are possible. This observation provides additional strong support for the hypothesis that quantum transitions are involved.

There are however also objections.

1. The cyclotron energy scale is about $10^{-14}$ eV and ridiculously small as compared to the energy scale .086 eV defined by room temperature so that quantal effects should be masked completely by thermal noise.

2. Also ELF em fields at spin flip frequencies (Larmor frequencies) should induce transitions. To my best knowledge these have not been reported.

3. The wave functions of ions in magnetic field are confined in a region of size of order

$$r_n \sim \sqrt{2n/eB} \ ,$$

which is of the order of cell size: macroscopic quantum state is in question. In fact, the value $.5 \times 10^{-4}$ Tesla for Earth's magnetic fields corresponds to the p-adic length scale $L(169) = 5$ $\mu$m rather precisely for minimal value of the magnetic flux quantized as $ZeBS = n2\pi$ obtained for $n = 1$ ($S$ denotes the area of the flux tube) and $Z = 2$. If one requires quantum classical correspondence, very large values of $n$ are required and cyclotron radii would be much larger than flux tube radius.

A common resolution of all these objections is provided by large $\hbar$ phases and hierarchy of magnetic flux sheets with $B$ scaling like $1/hbar$ meaning that cyclotron frequencies scale down similarly and cyclotron energies remain invariant. Same applies to spin flip energies scaling in the same manner as cyclotron energies (for some time I thought that the scaling behaviors are different). By the quantization of the magnetic flux, predicted by TGD also classically, the minimal radius of the magnetic flux tube for the magnetic field of Earth of cell size for ordinary value of $\hbar$ but scales like $\hbar$ if magnetic field remains invariant and flux quantization $BS = n2\pi\hbar$ implying $S \propto \hbar$ holds true. This implies consistency with classical theory for large values of $\hbar = \lambda^{k_d}\hbar_0$, $\lambda \simeq 2^{11}$.

**A brief summary of the model**

Some work is required to end up with the following interpretation based on a model for how the different levels of dark matter hierarchy communicate and control.

1. Ions with charge $Z$, mass $m$ and spin $S$ in the external magnetic field behave quantum mechanically like harmonic oscillator with energies quantized as

$$E = E_c + E_L \ , \quad E_c = (n + \tfrac{1}{2})\hbar\omega_c \ , \quad E_L = S_z \tfrac{g\omega_c}{2} \ , \quad \omega_c = \tfrac{ZeB}{m} \ \ (c = 1) \ . \tag{2.5.1}$$

The first contribution corresponds to cyclotron contribution. For a given value of $n$ the component of angular momentum in the direction of $B$ has $n+1$ values $n, n-2, ..., -n$. $E_L$ denotes spin (Larmor) contribution. $g$ is so called Lande factor which for free elementary fermions equals to $g = 2$. Since $S_z$ is invariant under the scalings of $\hbar$, Larmor contribution is negligible as compared to cyclotron contribution for large values of $\hbar$. The contribution to energy coming from the free motion in the direction of magnetic field has not been written.

2. The model for high $T_c$ superconductivity involving competition of two superconductivities, one associated with cell interior and second with cell membrane is the starting point. These phases coexist in a narrow range around critical temperature and 36-37 C range where the effects are observed is a good candidate for this range.

3. Experimental findings suggests strongly that external em field induces resonant transitions between cyclotron states: these transitions are identified as transitions inside the cell/nucleus or its fractally scaled up variant. For $k_d = 4$ level of dark matter hierarchy cyclotron energy scale turns out to be above the thermal energy $2.88T$ of photons at maximum intensity of black body radiation at room temperature for $A \leq 223Z$. Cyclotron radiation can drive charged particles to smaller space-time sheets and this is essential for the metabolism and this process is expected to be part of the interaction of ELF em fields with cell nucleus. The scale of cyclotron energies for $k_d = 4$ level of dark matter hierarchy is indeed turns out to be consistent with this assumption.

4. The ELF em field used in the experiments have electric fields strengths in two windows: one around $10^{-7}$ V/m and second corresponding to $1-10$ V/m. Even in the latter case the field is by a factor of order million weaker than membrane potential: the notion of many-sheeted space-time allows to understand why so weak fields can have effects on biomatter. Amplitude windows are a further mystery related with the interaction of ELF em fields with brain tissue: if ELF em field defines potential difference $eV$ associated with a Josephson junction, one might understand this effect in terms of quantum jumps induced by Josephson current with frequency $f = ZeV/2\pi$.

5. Dark matter hierarchy leads to the hypothesis that there is entire hierarchy of EEGs generated as coherent photon states by Josephson currents associated with the Josephson junctions whose thickness scales as $\hbar$ and frequency scales as $1/\hbar$ so that cyclotron energy remains invariant and is above the thermal threshold. For each value of $\hbar$ there is also p-adic hierarchy corresponding to $k = 151, ...., 169$ with same Josephson frequency: these levels combine to form single block for dark matter hierarchy formed from the scaled up variants of this block. At least the magnetic flux tube structure of DNA and membrane structure appear as scaled up copies. The lowest level corresponds to cellular or nuclear membrane and ordinary value of $\hbar$.

6. Josephson current is of form $J \propto sin(2eVt + 2e\int V_1 dt)$ and its amplitude does not depend on the strength of the perturbation $V_1$. $V_1$ is same for all values of $\hbar$ but scales like $L(k)$ as function of p-adic length scale for given value of $\hbar$. Perturbation is represent as EEG pattern communicated to the magnetic body of fractally scaled up variant of cell or cell nucleus, which reacts appropriately. At the limit when the Josephson frequency $f_J^1 = 2eV_1/2\pi\hbar$ of perturbation satisfies $f_J^1 \gg f_c$, the amplitude of perturbation is coded to frequencies $f_\pm = f_J^1 \pm f_J$ in the EEG in a good approximation.

7. The response of the system is that of AND gate. $V_1$ induces in the neuronal nucleus or its scaled up counterpart cyclotron transitions if the frequency is correct. If this the case, cell nucleus opens up communication line receiving possible control signals from the magnetic body at higher level of hierarchy. $V_1$ induces in Josephson junctions effects if the amplitude is in the amplitude window guaranteing that the frequencies $f_\pm$ belong to EEG resonance bands (or their scaled up variants. In this case magnetic body receives representation of $V_1$ as coherent photons and responds. If communication line is open the response induces in the cell nucleus gene translation and other activities necessary for the biological response. The model implies that cyclotron frequencies code for the biologically relevant information carried out by classical electric fields so that noise is eliminated very effectively.

### 2.5.2 Interpretation of the temperature window

The effects of ELF em fields on matter have been observed only in a temperature window 36-37 C around body temperature. The model of high $T_c$ super-conductivity as a quantum critical phenomenon predicts that there is a narrow interval around $T_c$ around which two competing phases corresponding to ordinary value and scaled up value of $\hbar$ compete. More generally, dark matter hierarchy should correspond to a hierarchy of quantum criticalities. A fractal hierarchy of cusp catastrophes such that the next cusp is inside the critical line of the previous cusp would be a convenient manner to visualize the situation. Each big leap in the evolution corresponds to the emergence of a new level $k_d$ in the dark matter hierarchy made possible by the external conditions allowing co-presence and competition of phases corresponding to $k_d - 1$ and $k_d$.

Quantum critical high $T_c$ super-conductivity for electrons and protons (at least) is the essential prerequisite for the existence of Josephson currents through the cell membrane and its scaled up variants, and thus the hierarchy of generalized EEGs. Electronic super-conductivity is expected to be possible in a very limited temperature range usually idealized with single critical temperature. Quantum critical phase is analogous spin glass phase possible in a finite interval around critical temperature, and one can indeed speak of quantum spin glass phase for which the analogs of regions with fixed direction of magnetization are 4-dimensional rather than 3-dimensional and static. This relates to the breaking of the strict classical determinism of the basic variational principle of TGD having interpretation in terms of space-time correlate for quantum non-determinism in long time and length scales. Quantum coherence and quantum nondeterminism in long scales is obviously what makes system living. An educated guess is that the critical range of temperatures allowing quantum criticality and high $T_c$ super-conductivity is just 36-37 C: this in turn implies that the effects of ELF em fields occur only in this temperature range.

### 2.5.3 Interpretation of amplitude windows in terms of resonance bands of generalized EEGs

**Basic observations**

The first amplitude window corresponds to $E \in [1, 10]$ V/m. Second window is around $E = 10^{-7}$ V/m. The following observations are crucial in attempt to understand what these windows correspond to.

1. The ratio of average electric fields for amplitude windows is $\sim 5 \times 10^7$. This is not too far from $\lambda^2 \simeq 4 \times 10^6$. This would suggest that the two windows correspond to levels $k$ and $k+2$ of dark matter hierarchy.
2. In Josephson junctions electric field is converted to voltage which in turn defines Josephson frequency. The voltage over junction is represented as a Josephson current generating coherent state of photons. The electric field is thus represented as biological actions induced by the absorption of coherent (dark photons) photons. Also the decoherence of these photons to ordinary photons would be involved.

These observations allow to construct a model for amplitude based on the idea that they correspond to resonance bands for generalized EEGs associated with p-adic and dark matter hierarchies.

**Could amplitude windows correspond to the resonant EEG bands for the generalized EEGs?**

In the proposed model of EEG the amplitude of oscillatory perturbation $V_1 sin(2\pi f t)$ of the voltage of Josephson junction is coded to Josephson frequency $f_J^1 = 2eV_1/2\pi\hbar$ and for $f_J^1 \gg f$, the frequencies $f_\pm = f_J \pm f_J^1$ appear in the generalized EEG spectrum as fundamental frequencies so that amplitude is coded to frequency. The frequency $f$ itself defines the duration of the periodically occurring modulation of Josephson current. This would suggest that the amplitude windows correspond to frequencies $f_J \pm f_J^1$ belonging to the resonant bands in the generalized EEG.

The requirement $f_J^1 > f_c$, the condition that $f_J^1$ and $f_J$ are of same order of magnitude, and the condition that the scaled down counterpart of $f_\pm = f_J \pm f_J^1$ in ordinary EEG belongs to the range of EEG frequencies, fix uniquely the selection of $k$ and $k_d$ for both $E \in [1-10]$ V/m and $E = 10^{-7}$ V/m.

**Josephson frequencies associated with amplitude windows**

In the table below the Josephson frequencies associated with the perturbations $E = 1$ V/m, $E = 10$ V/m and $E = 10^{-7}$ V/m as a function of p-adic length scale. There is no dependence on the level of dark matter hierarchy.

| k | 151 | 157 | 163 | 167 | 169 |
|---|---|---|---|---|---|
| $f_J^1/MHz(1\ V/m)$ | 3.72 | 29.8 | 238 | 952 | 1905 |
| $f_J^1/MHz(10\ V/m)$ | 37.2 | 298 | 2380 | 9520 | 19050 |
| $f_J^1/Hz(10^{-7}\ V/m)$ | 0.37 | 2.98 | 23.8 | 95.2 | 190.5 |

Table 6. Josephson frequencies $f_J^1$ having relevance for periodic perturbations satisfying $f_J^1/f \gg 1$ as a function of p-adic length scale. The frequencies are given for $E = 1V/m$, $E = 10$ V/m and $E = 10^{-7}$ V/m.

It is quite possible that also other values of $k$ in the range $151, ...., 172$ are possible and this is indeed suggested with the experience with p-adic mass calculations which favor also other values of $k$ besides integers.

**Amplitude window $1-10$ V/m**

In this case $f_J^1 \gg f_c$ condition is trivially satisfied. $k_d = 2$ is the only possible choice for dark matter level and corresponds to 2+2 cm Josephson junctions. $k = 151$ and $k = 157$ are the only possible candidates for the p-adic length scale in question. For $k = 157$ the upper limit for $f_J^1$ however corresponds to a frequency above the range 1-100 Hz of EEG frequencies so that this option looks implausible.

In order to utilize the intuition about ordinary EEG, one can translate scaled down the frequencies by a factor $\lambda^{-2}$. For $k = 151$ the scaled down frequencies satisfy

1. $f_+ \in [4.48, 12.85]$ Hz and $f_- \in [2.62, 5.75]$ Hz for $\lambda = 2^{11}$,

2. $f_+ \in [4.08, 12.45]$ Hz and $f_- \in [2.22, 6.15]$ Hz for $\lambda = 2.17 \times 10^3$.

   $f_+$ and $f_-$ cover delta, theta, and alpha bands and part of beta band. If the proposed interpretation is correct, the detailed dependence of the effect on $V_1$ should reflect the resonance band structure of EEG in this region.

**Amplitude window around $E = 10^{-7}$ V/m**

The condition $f_J^1 > f_c$ allows $f_\pm$ type EEG resonance only for $k = 163$ and $k_d = 4$ level of dark matter hierarchy.

1. For $\lambda = 2^{11}$ one has $f_+ = 27.1$ Hz and $f_- = f_J^1 - f_J = 20.4$ Hz. 27 Hz frequency corresponds to a resonance frequency in the EEG of dog induced by stimulation with monochromatic light [38]. $f_- = 20.4$ is very near to the second harmonic of the fundamental 10 Hz alpha peak and Schumann frequency 20 Hz.

2. $\lambda = 2.17 \times 10^3$ gives $f_+ = 26.4$ Hz and $f_- = 21.1$ Hz. $f_+$ is between Schumann resonance 26 Hz and 27 Hz resonance.

$\lambda = 2^{11}$ is favored by the following observation. $f \sim 3$ Hz peak in EEG correlates with spike activity accompanying absence seizures. For $k = 151$ one has $f_- = f_J(151) - f_J^1 = 3.38 - .37$ Hz $= 3.01$ Hz for $\lambda = 2^{11}$. Slowly varying perturbations with frequency $f < f_J^1(157)$, perhaps some cyclotron frequency, could induce resonant oscillation with frequency $\simeq 3$ Hz, which corresponds to A=100 ($^{99}Ru$).

### 2.5.4 Why it is necessary to have both cyclotron frequency and amplitude in the window?

The explanation of amplitude windows leaves for cyclotron frequencies a very passive role and there seems to be no special reason for why the frequency of $V_1$ should correspond to cyclotron frequency. What seems to be the simplest interpretation for the situation is that there is a kind of AND gate involved. A non-vanishing net effect requires too separate effects which can be assigned with the membrane and interior of the structure involved, most naturally cell nucleus or its scaled up counterpart. This makes sense if one assumes that the magnetic flux sheets have DNA strands or as fractality suggests, their scaled up variants as transversal sections.

This conforms with the general vision that high $T_c$ superconductivity involves two different competing super conductivities at quantum criticality, which presumably corresponds to the temperature interval 36-37 C in the recent case. Quantum criticality is a necessary prerequisite that AND gate gives result 1. The supra currents flowing in the interior of cell or its nucleus correspond to large $\hbar$ variant of BCS superconductivity. Second superconductivity corresponds to surface supra currents flowing along the membrane of cell or nucleus. For the surface super-conductivity the notion of Josephson junction makes sense only in synaptic contacts or gap junctions since the electrons of Cooper pair belong to different lipid layers. Josephson junctions between interior and exterior are a sensible concept if both are in large $\hbar$ phase. For cell nucleus inside cell this holds true. This kind of Josephson junctions could be also between two cells in synaptic contacts or gap junctions. This consideration generalizes straightforwardly to the scaled up version of cell and cell nucleus.

Consider now how the hierarchy of AND gates could be realized.

1. At cell membrane the perturbation $V_1$ affects Josephson junctions. For this effect the value of the frequency is not essential as long as the condition $\omega_J^1 \gg \omega$ is satisfied. $V_1$ affects generalized EEG. This means essentially a representation of $V_1$ in terms of EEG frequency and communication of this information to higher level magnetic body, which then reacts to situation by sending a control signal. The effects are therefore high level "behavioral" rather than direct "physiological" effects (this is of course relative concept due to the hierarchy). Indeed, in case of $E = 10^{-7}$ V/m perturbations the effects are high level effects affecting prey detection and navigation. Note that the size of the effect do not depend on the amplitude as long as $\omega_J^1 \gg \omega_c$ is satisfied since it is the phase of Josephson current rather than amplitude that is affected by $V_1$. This is absolutely essential for the universality of EEG amplitudes. If EEG wave indeed results it has amplitude in the range 5-10 V/m it it is expected to induce similar effect at $k_d = 2$ level of hierarchy if the proposed interpretation for $E \in [1-10]$ effects is correct. This means that also communication to lower levels occurs automatically. Here the amplitude window condition is guaranteed by the properties of Josephson current.

2. $V_1$ induces also cyclotron transitions in the cell nucleus or its fractally scaled up counterpart and in this manner affects the competing BCS type interior supra currents and BE condensates. Any controlled biological activity must involve the activation of genome inducing the translation of genes to amino-acid sequences needed to realize the needed action. Hence the AND gate could be realized in a simple manner: cyclotron transitions would simply turn the communication line from magnetic body to nucleus on. If the frequency is wrong, the higher level magnetic body receives the message and responds but since the nucleus does not experience the cyclotron transitions it is off-line and nothing happens. If amplitude is not in the window but frequency is correct, the communication lines is on but no signal goes to the magnetic body and no command for action is received.

## 2.6 What is EEG made of?

The usual classification of EEG frequencies by EEG bands is more or less a convention and the definitions of various bands vary in frustratingly wide ranges. In a more ambitious approach bands should be replaced with some substructures identified on basis of their physical origin and function. In the proposed framework this is possible. This identification of substructures of course applies only to that part of EEG from which noise is subtracted. The contribution of neural activity is one such source of noise, often regarded as the only contribution.

### 2.6.1 Basic contributions to EEG and ZEG

There are three fundamental contributions to EEG (or hierarchy of EEGs) besides the neuronal noise. This picture applies more or less as such also to ZEG.

1. Schumann resonances whose interpretation should be clear. These frequencies do not depend on magnetic field strengths assignable with magnetic flux sheets and characterize Earth's magnetic field and collective aspects of consciousness.

2. Cyclotron frequencies generated in cyclotron transitions of ions. An attractive guess is that cyclotron frequencies correspond directly to the control signals from the magnetic body or that they result as a consequence of the generalization actions of the magnetic body so that Josephson junctions and magnetic body would form a closed feedback loop. For instance, ions could drop during generalized motor actions to excited cyclotron states at dark magnetic flux quanta and their decay would produce dark cyclotron photons. Cyclotron frequencies can be classified to those associated with bosonic and fermionic ions respectively. The transitions of Bose-Einstein condensates of bosonic ions are of special interest. The scale of these frequencies could be be subject to homeostatic regulation which is local and can vary even inside genes of a given nucleus.

3. The frequencies generated by Josephson currents as coherent photons. Harmonics of cyclotron frequencies shifted upwards and downwards by Josephson frequency $f_J = 5$ Hz. If the amplitude of the perturbation at cyclotron frequency is strong the EEG looks locally like it would consists of amplitudes with frequencies $f_{\pm} = f_J^1 \pm f_J$ during most of the cyclotron period so that the

visual inspection of time evolution of EEG can be rather misleading. Since these frequencies are involved with communications to the magnetic body of Earth, the natural guess would be that they correlate with the neural processing.

The following general overview about quantum communication and control emerges in this framework.

1. Cyclotron frequencies relate to the control of the biological body by the magnetic body and could be assigned with the magnetic flux sheets going through DNA since it is genome where protein synthesis is initiated and is thus the optimal intermediate step in the cellular control.

2. One of the basic functions of cell membranes is to perceive the chemical environment using various kinds of receptors as sensors. Neurons have specialized to receive symbolic representations of the sensory data of primary sensory organs about the situation in the external world. Receptor proteins would communicate cell level sensory input to the magnetic body via MEs parallel to magnetic flux tubes connecting them to the magnetic body. We ourselves would be in an abstract sense fractally scaled up counterparts of receptor proteins and associated with dark matter iono-lito Josephson junction connecting the parts of magnetosphere below litosphere and above magnetosphere.

3. This picture would explain why the temperature of brain must be in the narrow range 36-37 K to guarantee optimal functionality of the organism. If interior superconductivity is lost, magnetic body receives sensory data but is paralyzed since its desires cannot be realized. If boundary superconductivity is lost, magnetic body can move but is blind.

4. In the length scales below the weak length scale $L_w$ also charged weak bosons behave as massless particles and the exchange of virtual $W$ bosons makes possible a nonlocal charge transfer. Dark quark-antiquark pairs associated with the color bonds of the atomic nuclei can become charged via the emission of dark $W$ boson and thus produce and exotic ion. The same can happen at the higher levels of dark matter hierarchy. This provides a nonlocal quantal mechanism inducing or changing electromagnetic polarization in turn inducing ordinary charge flows and thus making possible quantum control.

5. Massless extremals (MEs, topological light rays) serve as correlates for dark bosons. Besides neutral massless extremals (em and $Z^0$ MEs) TGD predicts also charged massless extremals obtained from their neutral counterparts by a mere color rotation (color and weak quantum numbers are not totally independent in TGD framework). The interpretation of the charged MEs has remained open hitherto. Charged $W$ MEs (hierarchy of WEGs!) could induce long length scale charge entanglement of Bose-Einstein condensates by inducing exotic ionization of ionic nuclei. State function reduction could lead to a state containing a Bose-Einstein condensate in exotically ionized state.

   In this manner the dark charge inside neuron and thus by Faraday's law also membrane potential could be affected by magnetic body. The generation of nerve pulse could rely on the reduction of the resting potential below the critical value by this kind of mechanism inducing charge transfer between cell interior and exterior. The mechanism might apply even in the scale of magnetic body and make possible the control of central nervous system. Also remote mental interactions, in particular telekinesis, might rely on this mechanism.

To sum up, charged massless extremals could be seen as correlates for nonlocal quantum control by affecting charge equilibria whereas neutral MEs would serve as correlates for coordination and communication. Color charged MEs could also induce color charge polarization and flows of color charges and thus generate visual color qualia by the capacitor mechanism discussed in [K3].

### 2.6.2 Classification of cyclotron frequencies

Consider now the classification of cyclotron frequencies ($B_{end} = .2$ Gauss will be assumed).

1. Cyclotron frequencies can be classified those associated with atomic and molecular ions. For biologically important atomic ions most frequencies are above 7.5 Hz. For molecular ions frequencies are lower and for DNA sequences the frequencies are in delta band. Thermal stability

condition suggest a lower bound of $\sim 1$ Hz for significant frequencies of this kind. Thus it would seem that delta band dominating during deep sleep corresponds to DNA and possibly other bio-molecules and EEG during wake-up state corresponds to atomic ions.

2. Atomic ions can be classified into bosonic and fermionic ions. Practically all biologically important bosonic ions have $Z=2$ and in alpha band: $f(^6Li^+) = 50$ Hz and $f(Mg^{2+}) = 25$ Hz are the only frequencies above alpha band. Situation is essentially the same for biologically interesting ions too. $^7Li^+$ is exception and corresponds to 42.9 Hz: as a fermionic ion it does not possess satellites and does not contribute to Josephson part of EEG. Thus the frequency range $7.5-15$ Hz is very strongly represented and expected to be fundamental.

3. Also the position in the periodic table of elements provides a classificational criterion but this criterion does not seem to be so useful as thought originally.

4. The integer $n$ characterizing the harmonic of the cyclotron frequency in question is an additional classificational criterion and $n$ could correlate with the character of neural processing.

### 2.6.3 Wake-up EEG

The question is whether this classification is consistent with the conventional decomposition into various bands and whether it allows to gain some real insights EEG. Consider first wake-up EEG [60].

1. The first implication is that each cyclotron frequency $f_c$ is accompanied by by two satellites $f_c \pm f_J$. For alpha band these satellites correspond to theta band and beta band identifiable as responses to control signals from magnetic body in alpha band. One can ask whether these bands as a whole correspond to the satellites of alpha band. This identification implies that both bands are present and makes sense for wake-up EEG but not as such for the EEG during first and second period of deep sleep during which theta band is present but higher bands are absent.

2. Sensorimotor rhythm in range (12-16) Hz is associated with physical stillness and body presence. The interpretation is as a low amplitude satellite of alpha rhythm with low amplitude control signals from the magnetic body so that rhythmicity is not lost and frequencies are clearly $f_c + f_J$.

3. Beta band is above 12 Hz and associated with active, busy or anxious thinking and active concentration and is chaotic and highly asynchronous. The natural interpretation is as large amplitude satellite of alpha band involving the activation of communications to the magnetic body and large control signals with $f_J^1 \gg f_c$. Hence the spectra would for a considerable part of period $1/f_c$ effectively consist of frequencies $f_\pm = f_J \pm f_J^1$, where $f_J^1$ varies in frequency range characterized by the amplitude of perturbation. There is no definite resonance frequency since $\omega_1^J$ can vary continuously. Globally the situation is different since the spectrum can in principle be decomposed to frequencies $f_J \pm nf_c$. These two descriptions correspond to time domain and genuine frequency domain.

   For sufficiently high harmonics of $f_c$ the chaoticity disappears and frequencies $f_J \pm nf_c$ become more manifest. The Josephson amplitudes of higher harmonics decrease as $1/nf_c$.

   Beta band is predicted to have a mirror image in theta band during cognitive activity. The frequencies in theta band are assigned with cognitive activities and memory recall. Note that also alpha band due to cyclotron frequencies should be present as well as the basic "drum beat" defined by $f_J$ for $f_J^1 \gg fc$.

4. Odd higher harmonics of cyclotron frequency are expected to be the most important ones and would have interpretation as control signals from magnetic body. Satellites would correspond to responses to magnetic body involving entire 160 km thick Josephson junction but certainly correlating strongly with what happens in brain (recall the analog of biological body with a receptor at cell membrane).

   For alpha band the third harmonics of most bosonic ions are in the range 28.2-34.2 Hz and roughly in gamma band above 30 Hz assignable with the control of cognitive activities from a flux quantum of Earth's magnetic field.

Fifth harmonics would be be in the range 37.5-57 Hz. The fermionic ion $Na^+$ would correspond to 65 Hz. During REM sleep EEG very similar to awake but 65 Hz resonance is present. One can ask whether fifth harmonics are present during REM sleep and serve as correlates for conscious visual imagery.

5. 40 Hz thalamocortical resonance band is very important EEG band. The upper satellite of the third harmonic of $Mn^{2+}$ is 37.9 Hz. The third harmonics of fermionic ions $^7Li^+$ and $Na^+$ correspond to 42.9 Hz and 39 Hz (Schumann resonance) and have no satellites as fermionic ions.

### 2.6.4 Satellites exist as mirror pairs!

The existence of the mirror satellites might be regarded as a killer prediction. Amazingly, narrow EEG bands which are mirror images of each other with respect to alpha band have been reported [38]. Besides alpha band at 11 Hz, Nunez mentions also narrow sub-bands at 3, 5 and 7 Hz at delta and theta range, as well as the bands at 13, 15 and 17 Hz in beta band [38]. All these frequencies are expressible in the form $f_c \pm f_J$, $f_J = 5$ Hz, which is one half of the frequency 10 Hz of the memetic code and by 14 per cent higher than 3.7 Hz predicted assuming $\lambda = 2^{11}$. The value of $\lambda$ deduced from these frequencies would be $\lambda = 1902$ and about 7 per cent smaller than $\lambda = 2^{11}$. This estimate cannot be taken too seriously since it is quite possible that the thickness of Josephson junction is not scaled up completely exactly.

The cyclotron frequencies associated with the bands are 8, 10, and 12 Hz. The cyclotron frequencies of bosonic ions $^{80}Se^{2-}$, $^{64}Zn^{2+}$, and $^{55}Mn^{2+}$ for a magnetic field strength $B_{end} = .2$ Gauss are 8.00, 9.90, and 12.00 Hz. The cyclotron frequencies of bosonic ions $^{59}Co^{2+}$ and $^{56}Fe^{2+}$ would be 10.52 Hz and 11.36 Hz and the satellites are at frequencies 5.52 Hz and 6.36 Hz and 15.52 and 16.36 Hz. All these frequencies belong to the bands reported by Nunez since their widths are 1-2 Hz. Thus the frequencies of all bosonic ions in alpha band and in their satellites belong to the bands reported by Nunez for values of $\lambda$ and $B$ very near to their nominal values used in calculations!

With these assumptions the frequencies $3f_c(Mn^{2+}) \pm f_J$ are 40.97 Hz and 30.97 Hz corresponding to 40 Hz band and the threshold of gamma band. That $f_c(O^{2-}) = 39.6$ Hz is also in this band suggests additional reason for why oxygen is so important for consciousness. $f_c(Mg^{2+}) = 26.3$ Hz is very near to Schumann resonance 26 Hz and its upper satellite corresponds to the threshold of gamma band.

What is also very remarkable that the 10 Hz magic frequency of the memetic code corresponding to the secondary p-adic length scale $L(2, 127)$ associated with Mersenne prime $M_{127}$ characterizing electron appears. It should be also noticed that $f_J = 5$ Hz frequency corresponds to cognitive theta appearing during tasks requiring mathematical skills.

### 2.6.5 Alpha band dominance during relaxed state

In a relaxed state beta band disappears and the spectral power in alpha band increases. This seems to be in conflict with the idea that beta band is a mere satellite. There are two mutually non-inclusive manners to understand this.

1. The first possibility is that cyclotron frequencies in alpha band are not actually present and only Schumann frequency 7.8 Hz and 10 Hz resonance frequency associated with the excitations of electric field in ionospheric cavity behaving like 2-dimensional waves on sphere.

2. Second possibility is that ionospheric Josephson junction is somehow closed so that only the cyclotron contribution of various ions is present. This might be caused by DNA level mechanism which simply prevents the flow of the Josephson currents flowing along magnetic flux sheets through DNA strands. This mechanism would be completely analogous to the closing of ionic channel associated with cell membrane protein.

### 2.6.6 EEG during sleep

The EEG during sleep [63] provides a testing ground for the proposed anatomy of EEG. Sleep consists of 90 + 90 minute periods of NREM and REM sleep. This period is also the period of brain hemisphere dominances during wake up and day dreaming occurs with the same period as REM sleep. During REM sleep the EEG is essentially similar to that during wake-up. These observations inspire the hunch that brain hemisphere dominance dictates whether REM or NREM is in question. This turns out to be a correct guess.

### EEG during stage 1

During stage 1 theta of deep sleep [63] waves in frequency range 4-8 Hz dominate and amplitudes increase when frequency is reduced. The control signals from magnetic body are expected to be weak so that $f_J^1 < f_J$ approximation should hold true implying that frequencies $f_J \pm f_c$ should dominate and EEG would look rhythmic rather than chaotic as indeed observed. The amplitudes behave as $1/\omega_c$ and thus increase with decreasing $\omega_c$. The fact that amplitudes increase with decreasing EEG frequency suggests that the frequencies they correspond to different cyclotron frequencies.

These facts does not conform with the general picture as such. If theta and beta bands are mere satellites of alpha band, both of them should be present during stage 1 sleep but this is not the case. The idea that cyclotron frequencies of heavier ions in $B_{end} = .2$ Gauss could replace those appearing during wake-up does not work. Theta band simply does not contain the cyclotron frequencies of biologically important ions for $B_{end} = .2$ Gauss. One can imagine two manners to resolve the difficulty.

*1. Two manners to quantize magnetic flux*

One way out of difficulty seems to be that the value of the magnetic field associated with active flux sheets is reduced by a factor of 1/2. This would mean that the most important range 7.5-15 Hz of cyclotron frequencies would be scaled down to 3.75-7.5 Hz which indeed corresponds to the theta band. If one excludes $Ca^{2+}$, the range for bosonic ion reduces from $7.5 - 11.4$ to $3.75 - 5.7$ Hz. The satellites correspond to the range $.05 - 8.7$ Hz and $7.45 - 9.4$ Hz plus $Ca^{2+}$ satellites at 3.8 Hz and 11.2 Hz. With $Ca^{2+}$ forming a possible exception, the resulting frequency ranges are consistent with empirical facts. Of course, it is quite possible that magnetic body does not generate cyclotron transitions at $Ca^{++}$ cyclotron frequency.

One can image several manners to resolve the problem but the most natural resolution of the puzzle came with the frustrating realization that $B_{end} = .2$ Gauss explaining the observations of Blackman and others is not equal to the Earth's magnetic field $B_E = .5$ Gauss. Although $B_{end}$ corresponds to $k = 169$, the value of Planck constant is $\hbar = 5\hbar_0$ and flux unit is $h_5 = 5h_0$. For $B_{end}$ $k = 169$ flux tubes carry two units of flux and for $B_{end}/2$ single unit so that the halved value of $B_{end}$ emerges very naturally.

The different values of field intensities might relate to the character of ions at the flux sheets in left and right hemisphere.

1. The quantization of magnetic flux reads as $Ze \int BdS = n\hbar$ and for Cooper pairs and bosonic ions with $Z = 2$ ($Z$ refers to the absolute value of charge) it gives magnetic field strength which is one half from that for fermionic singly charged ions. Both fermionic ions with $Z = 1$ and bosonic ions and Cooper pairs with $Z = 2$ are allowed in this case by the single valuedness of wave functions. For $Z = 2$ the quantization condition allows single valued wave functions for $Z = 2$ ions or Cooper pairs only.

2. Assume the quantization condition corresponds to $Z = 1$ for the left hemisphere and $Z = 2$ for the right hemisphere. The presence of fermionic ions implies additional cyclotron frequencies on left hemisphere and the presence of fermionic ions conforms with the old proposal that fermionic Fock states provide a realization of quantal version of Boolean algebra. This conforms with the view that left brain is more reductionistic and performs linear logic operations whereas right brain is more holistic.

3. As a consequence the cyclotron frequency scale in right hemisphere is reduced by a factor of 1/2 and during right hemisphere dominated NREM sleep alpha band would be scaled down to theta band.

4. The prediction is that, apart from the Schumann frequencies and neural noise, left hemisphere EEG spectrum consists of right hemisphere EEG specrum scaled up by a factor of 2 plus the contribution of fermionic ions and the Josephson satellites of these frequencies.

The assumption that the two quantization conditions correspond to just left and right hemispheres rather some other pair is of course un-necessarily strong and one can imagine also other correspondences.

*2. Exotic ions as a resolution of the problem?*

Second manner to achieve the scaling down of alpha band by a factor of 1/2 relies on the notion of exotic atomic nuclei. $Z^0$ ions coupling to $k = 113$ exotic weak bosons with $k_d = 2$ result if some color flux tubes bonding the nucleons of nuclei to nuclear string become weakly charged. This means that a color bond having quark and antiquark at its ends becomes $u\overline{d}$ type bond or its charge conjugate so that color bond becomes also em charged. There is evidence for this process. For instance, TGD explains the properties of tetraneuron assuming that alpha particle with two negatively charged color bonds is in question [F8].

Exotic ion is not chemically equivalent with an ion of same em charge since the valence of the system is anomalous. For instance, as far as electronic shell is considered, the ion could behave like noble gas atom. Electronic ionization could also compensate exotic ionization so that an electromagnetically neutral but weakly charged ion would result. For instance, doubly charged bosonic ions could have em neutral counterparts with two units of weak charge (unit defined as the weak charge of $u\overline{d}$ type color bond).

Since fermion number is not affected, singly charged exotic ion is boson for all nuclei with even neutron number, that is for the most stable nuclei. All biologically relevant ions might thus exist in bosonic states and form Bose-Einstein condensates. One can even wonder whether ions such as $Na^+, K^+$, and $Cl^-$ associated with cell are actually exotic ions and appear as Bose-Einstein condensates. For doubly charged bosonic ions, most of which are in alpha band, cyclotron frequencies of singly charged exotic counterparts would be halved. Also the Josephson frequency would be halved. For the first option this is not the case.

### EEG during stage 2

Sleep spindles appearing in the state 2 of deep sleep are sudden increases in EEG amplitude and frequency from theta band to 12-16 Hz [64]. The spindles .5-.1.5 seconds and appear with a period of about minute. In some sources frequency range 7-16 Hz is given as sleeping spindle range. The so called K-complexes are sudden increases in EEG amplitude but no change in frequency.

One interpretation is that sleep spindles correspond to the occasional wake-ups of the left hemisphere. Sleep spindles would thus correspond to the satellites of alpha band identifiable as responses of the corresponding Josephson junctions to occasional strong control signals at cyclotron frequencies in alpha band. K complexes could be interpreted as signals from magnetic body to left hemisphere but inducing no response. It might be that these sudden responses reflect the fact that the left brain is not fully asleep yet.

### EEG during stages 3 and 4

Most of EEG power during deep sleep stages 3 and 4 is in the range .75-4.5 Hz [63]. This implies that control signals at cyclotron transition frequencies of ions from the magnetic body cannot be appreciably present and the control signals at cyclotron frequencies of molecular ions, such as DNA with cyclotron frequencies below 1 Hz, should be responsible for the EEG. The small amplitude of control signal implies $1/f_c$ behavior and large amplitude as compared to the corresponding amplitudes at higher bands at weak amplitude limit.

Taking into account the fact that magnetic field strength is scaled down by factor of 1/2 this means that mass numbers of the ions in question must satisfied $A/Z \geq 150$ for $f_c \leq 1$ Hz. For DNA sequences with charge of 2 units per single base-pair one would have $A \geq 300$. The atomic weights for base pairs plus phosphate group and deoxyribose sugar are $327, 321, 291, 344$ corresponding to A, T, C, G. Harmonics would be present also now but their contributions are small if the amplitudes of the control signals are small.

### Transcendental states of consciousness and EEG

Transcendental states of consciousness are characterized by the presence of alpha and theta bands [65] (note that theta band is present also during childhood, youth and even early adolescence but usually disappears at older age). It is found that that theta and alpha bands are preserved also during deep sleep [66]. A possible interpretation is that the presence of alpha band signifies that left brain remains awake in a state of relaxed alertness involving weak signals from magnetic body. One could also argue that even deep sleep is a conscious state but that the presence of alpha band activity in left brain is necessary in order to have memories about this state.

### 2.6.7 Scaled up EEG periods at levels $k_d = 5, 6, 7$

It of considerable interest to find the scaled up EEG periods corresponding to frequencies $8, 10, 12$ Hz in alpha band and their satellites for levels $k_d = 5, 6, 7$ levels in order to see whether they might correspond to some important bio-rhytms. For $\lambda = 1902$ Josephson periods are given by $T_J = 7.35$ minutes, 9.02 days, and 43.6 years.

| | | | |
|---|---|---|---|
| $T_c/min$ | 4.59 | 3.66 | 3.06 |
| $T_+(1)/min$ | 12.25 | 7.35 | 5.25 |
| $T_+(3)/min$ | 1.93 | 1.47 | 1.19 |
| $T_+(5)/min$ | 1.05 | 0.82 | 0.67 |
| $T_-(1)/min$ | 2.83 | 2.45 | 2.16 |
| $T_-(2)/min$ | 1.27 | 1.05 | 0.90 |
| $T_-(3)/min$ | 0.82 | 0.67 | 0.57 |

Table 7. Periods $T_c$ and $T_\pm(n)$ corresponding to $f_c$ and $nf_c \pm f_J$, $n = 1, 3, 5$ for scaled up EEG at $k_d = 5$ level corresponding to alpha band frequencies 8, 10, 12 Hz of the ordinary EEG. The unit is one minute and Josephson period is 7.35 minutes.

| | | | |
|---|---|---|---|
| $T_c/day$ | 5.6 | 4.5 | 3.8 |
| $T_+(1)/day$ | 15.03 | 9.01 | 6.44 |
| $T_+(3)/day$ | 2.37 | 1.80 | 1.45 |
| $T_+(5)/day$ | 1.29 | 1.00 | 0.82 |
| $T_-(1)/day$ | 3.47 | 3.01 | 2.65 |
| $T_-(2)/day$ | 1.55 | 1.29 | 1.10 |
| $T_-(3)/day$ | 1.00 | 0.82 | 0.69 |

Table 8. Periods $T_c$ and $T_\pm(n)$ corresponding to $f_c$ and $nf_c \pm f_J$, $n = 1, 3, 5$ for scaled up EEG at $k_D = 6$ level corresponding to alpha band frequencies 8, 10, 12 Hz of the ordinary EEG. The unit is one day and Josephson period is 9.02 days. Note that 1 day (24 hours) appears as period.

| | | | |
|---|---|---|---|
| $T_c/y$ | 27.3 | 21.8 | 18.2 |
| $T_+(1)/y$ | 72.7 | 43.6 | 31.2 |
| $T_+(3)/y$ | 11.5 | 8.7 | 7.0 |
| $T_+(5)/y$ | 6.2 | 4.8 | 4.0 |
| $T_-(1)/y$ | 16.8 | 14.5 | 12.8 |
| $T_-(2)/y$ | 7.5 | 6.2 | 5.3 |
| $T_-(3)/y$ | 4.8 | 4.0 | 3.4 |

Table 9. Periods $T_c$ and $T_\pm(n)$ corresponding to $f_c$ and $nf_c \pm f_J$, $n = 1, 3, 5$ for scaled up EEG at $k_d = 7$ level corresponding to alpha band frequencies 8, 10, 12 Hz of the ordinary EEG. The unit is one year and Josephson period is 43.6 years.

### 2.6.8 Is $k_d = 3$ level responsible for kHz neuronal synchrony?

The time scale of nerve pulse emission is millisecond and synchronous emission of nerve pulses suggests the existence of a clock with frequency 1 kHz. Also memetic codeword for which single bit corresponds to 1027 Hz frequency requires a clock at $\sim 1$ kHz frequency.

The scaled up hierarchy of EEGs indeed predicts 1 kHz frequency band as a scaled up variant of 1 Hz cyclotron frequency associated with DNAs. Suppose that also magnetic flux tubes with area scaling as $S = \hbar^2$ and $B$ scaling as $B \propto 1/\hbar$ are present, at least for sufficiently large values of

$k_d$. For this hierarchy cyclotron frequencies would scale as $1/\hbar$ and for $k_d = 3$ 1 Hz DNA frequency in delta band would scale up to 2 kHz for $Z = 1$ magnetic flux quantization. For $Z = 2$ flux quantization scaled up DNA cyclotron band would be around 1 kHz and could serve as a drum beat making possible synchronized neuronal firing. Similar situation would be obtained for the cyclotron frequencies of singly charged exotic ions for which color bond inside nucleus has become color charged so that cyclotron frequency is typically in or below alpha band scaled down to 5 Hz.

### 2.6.9 Generalization of EEG to ZEG

The generalization of the model of EEG to ZEG (E in the middle of EEG could be of course replaced with appropriate letter such as K) is rather straightforward.

Also now there are three contributions: $Z^0$ Schumann frequencies, cyclotron frequencies, and the frequencies associated with Josephson junctions. The most conservative approach assumes that also $Z^0$ flux sheets characterized by $k_d$ traverse DNA (that is genes have wormhole contacts with these flux sheets). If these sheets possess the thickness of DNA double strand, the finite range $L_w(k_d)$ of $k = 113$ $Z^0$ quanta does not pose other restrictions than the requirement that the overall width of flux sheets is below $L_w(k_d)$.

For $k = 113$ weak bosons with $k_d = 2$ one has $L_w \simeq .2$ $\mu$m. For $k_d = 4$ which is thermally stable one would have $L_w \simeq .8$ m corresponding to the size scale of the human body, which is by a factor $2^{-22}$ smaller than the corresponding size in the electromagnetic case. $Z^0$ magnetic fields satisfy flux quantization condition implying that cyclotron frequency and energy are proportional to $Q_Z/Q_{Z,0}$, where a particle with charge $Q_{Z,0}$ defines flux quantization. Cyclotron frequencies would differ from their electromagnetic counterparts for $k_d = 2$ level only by factors $Q_Z/Q_{Z,0}$. The condition that $Z^0$ ions are em neutral would mean that $Z^0$ ions and bosonic ions are in one-one correspondence so that ZEG would be more or less identical with EEG as far as cyclotron frequencies are considered.

The model of Josephson junction hierarchy must be based on guesses. The simplest guess is that the cell membrane involves also a space-time sheet giving rise to $Z^0$ voltage, which is minimal in the sense that the energy of a singly charged $Z^0$ ion is at thermally marginally stable and thus also now $\simeq .08$ eV. The hierarchy of $Z^0$ Josephson junctions would result in an exactly the same manner as in the electromagnetic case and Josephson energies are same for all levels whereas frequencies scale down as $1/\hbar$.

Also the notion of Schumann resonance at same energy range as in em case could make sense. The finite range of weak force implies effectively the presence of conductive spherical surface analogous to ionosphere at radius $L_w$ preventing the penetration of $Z^0$ electric field through. Hence the system would possess effective $Z^0$ Schumann cavity and it could be possible to speak about cavity oscillations. Earth length scale would correspond to $k_d = 6$ level of dark matter hierarchy for $Z^0$ field which would mean that the Schumann energy would be very large in this length scale, about .64 MeV. $k_d = 4$ level ($L_w = .8$ m) would give Schumann energy which is of the same order of magnitude as in electromagnetic case.

With these assumptions the spectrum of ZEG for $k_d = 4$ level would be very much like the spectrum of EEG. An important difference would come from the fact that simplest exotic ions obtained by the generation of charged color bonds inside nuclei would be singly charged bosons and alpha band would be scaled down to 5 Hz for them. The mass number differs by one unit from that of ordinary ion and the resulting change of cyclotron frequency could be used as an experimental signature of exotic ion. Also Josephson energy would be one half from that of $Z = 2$ satellites so that alpha band its satellites would be suffer exact scaling by factor 1/2. For $k_d = 3$ and $Z^0$ magnetic field scaled up by $\lambda$, the 1 Hz lower bound dictated by thermal stability would correspond to kHz frequency for $Z = 2$ flux quantization. Scaled up delta band might be the "drum beat" making possible neuronal synchronization.

## 2.7 Appendix

The appendix discusses the generalization of the notion of imbedding space and provides tables of cyclotron and Larmor frequencies.

## 2.8 Appendix: A generalization of the notion of imbedding space

In the following the recent view about structure of imbedding space forced by the quantization of Planck constant is described. This view has developed much before the original version of this chapter was written.

The original idea was that the proposed modification of the imbedding space could explain naturally phenomena like quantum Hall effect involving fractionization of quantum numbers like spin and charge. This does not however seem to be the case. $G_a \times G_b$ implies just the opposite if these quantum numbers are assigned with the symmetries of the imbedding space. For instance, quantization unit for orbital angular momentum becomes $n_a$ where $Z_{n_a}$ is the maximal cyclic subgroup of $G_a$.

One can however imagine of obtaining fractionization at the level of imbedding space for space-time sheets, which are analogous to multi-sheeted Riemann surfaces (say Riemann surfaces associated with $z^{1/n}$ since the rotation by $2\pi$ understood as a homotopy of $M^4$ lifted to the space-time sheet is a non-closed curve. Continuity requirement indeed allows fractionization of the orbital quantum numbers and color in this kind of situation.

### 2.8.1 Both covering spaces and factor spaces are possible

The observation above stimulates the question whether it might be possible in some sense to replace $H$ or its factors by their multiple coverings.

1. This is certainly not possible for $M^4$, $CP_2$, or $H$ since their fundamental groups are trivial. On the other hand, the fixing of quantization axes implies a selection of the sub-space $H_4 = M^2 \times S^2 \subset M^4 \times CP_2$, where $S^2$ is a geodesic sphere of $CP_2$. $\hat{M}^4 = M^4 \backslash M^2$ and $\hat{CP}_2 = CP_2 \backslash S^2$ have fundamental group $Z$ since the codimension of the excluded sub-manifold is equal to two and homotopically the situation is like that for a punctured plane. The exclusion of these sub-manifolds defined by the choice of quantization axes could naturally give rise to the desired situation.

2. Zero energy ontology forces to modify this picture somewhat. In zero energy ontology causal diamonds ($CD$s) defined as the intersections of future and past directed light-cones are loci for zero energy states containing positive and negative energy parts of state at the two light-cone boundaries. The location of $CD$ in $M^4$ is arbitrary but p-adic length scale hypothesis suggests that the temporal distances between tips of $CD$ come as powers of 2 using $CP_2$ size as unit. Thus $M^4$ is replaces by $CD$ and $\hat{M}^4$ is replaced with $\hat{CD}$ defined in obvious manner.

3. $H_4$ represents a straight cosmic string inside $CD$. Quantum field theory phase corresponds to Jones inclusions with Jones index $\mathcal{M} : \mathcal{N} < 4$. Stringy phase would by previous arguments correspond to $\mathcal{M} : \mathcal{N} = 4$. Also these Jones inclusions are labeled by finite subgroups of $SO(3)$ and thus by $Z_n$ identified as a maximal Abelian subgroup.

   One can argue that cosmic strings are not allowed in QFT phase. This would encourage the replacement $\hat{CD} \times \hat{CP}_2$ implying that surfaces in $CD \times S^2$ and $(M^2 \cap CD) \times CP_2$ are not allowed. In particular, cosmic strings and $CP_2$ type extremals with $M^4$ projection in $M^2$ and thus light-like geodesic without zitterwebegung essential for massivation are forbidden. This brings in mind instability of Higgs=0 phase.

4. The covering spaces in question would correspond to the Cartesian products $\hat{CD}_{n_a} \times \hat{CP}_{2n_b}$ of the covering spaces of $\hat{CD}$ and $\hat{CP}_2$ by $Z_{n_a}$ and $Z_{n_b}$ with fundamental group is $Z_{n_a} \times Z_{n_b}$. One can also consider extension by replacing $M^2 \cap CD$ and $S^2$ with its orbit under $G_a$ (say tedrahedral, octahedral, or icosahedral group). The resulting space will be denoted by $\hat{CD} \hat{\times} G_a$ *resp.* $\hat{CP}_2 \hat{\times} G_b$.

5. One expects the discrete subgroups of $SU(2)$ emerge naturally in this framework if one allows the action of these groups on the singular sub-manifolds $M^2 \cap CD$ or $S^2$. This would replace the singular manifold with a set of its rotated copies in the case that the subgroups have genuinely 3-dimensional action (the subgroups which corresponds to exceptional groups in the ADE correspondence). For instance, in the case of $M^2 \cap CD$ the quantization axes for angular momentum

would be replaced by the set of quantization axes going through the vertices of tedrahedron, octahedron, or icosahedron. This would bring non-commutative homotopy groups into the picture in a natural manner.

6. Also the orbifolds $\hat{CD}/G_a \times \hat{CP_2}/G_b$ can be allowed as also the spaces $\hat{CD}/G_a \times (\hat{CP_2} \hat{\times} G_b)$ and $(\hat{CD} \hat{\times} G_a) \times \hat{CP_2}/G_b$. Hence the previous framework would generalize considerably by the allowance of both coset spaces and covering spaces.

There are several non-trivial questions related to the details of the gluing procedure and phase transition as motion of partonic 2-surface from one sector of the imbedding space to another one.

1. How the gluing of copies of imbedding space at $(M^2 \cap CD) \times CP_2$ takes place? It would seem that the covariant metric of $M^4$ factor proportional to $\hbar^2$ must be discontinuous at the singular manifold since only in this manner the idea about different scaling factor of $M^4$ metric can make sense. This is consistent with the identical vanishing of Chern-Simons action in $M^2 \times S^2$.

2. One might worry whether the phase transition changing Planck constant means an instantaneous change of the size of partonic 2-surface in $CD$ degrees of freedom. This is not the case. Light-likeness in $(M^2 \cap CD) \times S^2$ makes sense only for surfaces $X^1 \times D^2 \subset (M^2 \cap CD) \times S^2$, where $X^1$ is light-like geodesic. The requirement that the partonic 2-surface $X^2$ moving from one sector of $H$ to another one is light-like at $(M^2 \cap CD) \times S^2$ irrespective of the value of Planck constant requires that $X^2$ has single point of $(M^2 \cap CD)$ as $M^2$ projection. Hence no sudden change of the size $X^2$ occurs.

3. A natural question is whether the phase transition changing the value of Planck constant can occur purely classically or whether it is analogous to quantum tunneling. Classical non-vacuum extremals of Chern-Simons action have two-dimensional $CP_2$ projection to homologically non-trivial geodesic sphere $S^2_I$. The deformation of the entire $S^2_I$ to homologically trivial geodesic sphere $S^2_{II}$ is not possible so that only combinations of partonic 2-surfaces with vanishing total homology charge (Kähler magnetic charge) can in principle move from sector to another one, and this process involves fusion of these 2-surfaces such that $CP_2$ projection becomes single homologically trivial 2-surface. A piece of a non-trivial geodesic sphere $S^2_I$ of $CP_2$ can be deformed to that of $S^2_{II}$ using 2-dimensional homotopy flattening the piece of $S^2$ to curve. If this homotopy cannot be chosen to be light-like, the phase transitions changing Planck constant take place only via quantum tunnelling. Obviously the notions of light-like homotopies (cobordisms) and classical light-like homotopies (cobordisms) are very relevant for the understanding of phase transitions changing Planck constant.

### 2.8.2 Do factor spaces and coverings correspond to the two kinds of Jones inclusions?

What could be the interpretation of these two kinds of spaces?

1. Jones inclusions appear in two varieties corresponding to $\mathcal{M} : \mathcal{N} < 4$ and $\mathcal{M} : \mathcal{N} = 4$ and one can assign a hierarchy of subgroups of $SU(2)$ with both of them. In particular, their maximal Abelian subgroups $Z_n$ label these inclusions. The interpretation of $Z_n$ as invariance group is natural for $\mathcal{M} : \mathcal{N} < 4$ and it naturally corresponds to the coset spaces. For $\mathcal{M} : \mathcal{N} = 4$ the interpretation of $Z_n$ has remained open. Obviously the interpretation of $Z_n$ as the homology group defining covering would be natural.

2. $\mathcal{M} : \mathcal{N} = 4$ should correspond to the allowance of cosmic strings and other analogous objects. Does the introduction of the covering spaces bring in cosmic strings in some controlled manner? Formally the subgroup of $SU(2)$ defining the inclusion is $SU(2)$ would mean that states are $SU(2)$ singlets which is something non-physical. For covering spaces one would however obtain the degrees of freedom associated with the discrete fiber and the degrees of freedom in question would not disappear completely and would be characterized by the discrete subgroup of $SU(2)$.

   For anyons the non-trivial homotopy of plane brings in non-trivial connection with a flat curvature and the non-trivial dynamics of topological QFTs. Also now one might expect similar non-trivial contribution to appear in the spinor connection of $\hat{CD}\hat{\times}G_a$ and $\hat{CP}_2\hat{\times}G_b$. In conformal field theory models non-trivial monodromy would correspond to the presence of punctures in plane.

3. For factor spaces the unit for quantum numbers like orbital angular momentum is multiplied by $n_a$ *resp.* $n_b$ and for coverings it is divided by this number. These two kind of spaces are in a well defined sense obtained by multiplying and dividing the factors of $\hat{H}$ by $G_a$ *resp.* $G_b$ and multiplication and division are expected to relate to Jones inclusions with $\mathcal{M}:\mathcal{N}<4$ and $\mathcal{M}:\mathcal{N}=4$, which both are labeled by a subset of discrete subgroups of SU(2).

4. The discrete subgroups of $SU(2)$ with fixed quantization axes possess a well defined multiplication with product defined as the group generated by forming all possible products of group elements as elements of $SU(2)$. This product is commutative and all elements are idempotent and thus analogous to projectors. Trivial group $G_1$, two-element group $G_2$ consisting of reflection and identity, the cyclic groups $Z_p$, $p$ prime, and tedrahedral, octahedral, and icosahedral groups are the generators of this algebra.

By commutativity one can regard this algebra as an 11-dimensional module having natural numbers as coefficients ("rig"). The trivial group $G_1$, two-element group $G_2$¡ generated by reflection, and tedrahedral, octahedral, and icosahedral groups define 5 generating elements for this algebra. The products of groups other than trivial group define 10 units for this algebra so that there are 11 units altogether. The groups $Z_p$ generate a structure analogous to natural numbers acting as analog of coefficients of this structure. Clearly, one has effectively 11-dimensional commutative algebra in 1-1 correspondence with the 11-dimensional "half-lattice" $N^{11}$ ($N$ denotes natural numbers). Leaving away reflections, one obtains $N^7$. The projector representation suggests a connection with Jones inclusions. An interesting question concerns the possible Jones inclusions assignable to the subgroups containing infinitely manner elements. Reader has of course already asked whether dimensions 11, 7 and their difference 4 might relate somehow to the mathematical structures of M-theory with 7 compactified dimensions. One could introduce generalized configuration space spinor fields in the configuration space labelled by sectors of $H$ with given quantization axes. By introducing Fourier transform in $N^{11}$ one would formally obtain an infinite-component field in 11-D space.

The question how do the Planck constants associated with factors and coverings relate is far from trivial and I have considered several options.

1. If one assumes that $\hbar^2(X)$, $X=M^4$, $CP_2$ corresponds to the scaling of the covariant metric tensor $g_{ij}$ and performs an over-all scaling of metric allowed by Weyl invariance of Kähler action by dividing metric with $\hbar^2(CP_2)$, one obtains $r^2\equiv\hbar^2/\hbar_0^2\hbar^2(M^4)/\hbar^2(CP_2)$. This puts $M^4$ and $CP_2$ in a very symmetric role and allows much more flexibility in the identification of symmetries associated with large Planck constant phases.

2. Algebraist would argue that Planck constant must define a homomorphism respecting multiplication and division (when possible) by $G_i$. This requires $r(X)=\hbar(X)\hbar_0=n$ for covering and $r(X)=1/n$ for factor space or vice versa. This gives two options.

3. Option I: $r(X)=n$ for covering and $r(X)=1/n$ for factor space gives $r\equiv\hbar/\hbar_0=r(M^4)/r(CP_2)$. This gives $r=n_a/n_b$ for $\hat{H}/G_a\times G_b$ option and $r=n_b/n_a$ for $\hat{H}\hat{times}(G_a\times G_b)$ option with obvious formulas for hybrid cases.

4. Option II: $r(X)=1/n$ for covering and $r(X)=n$ for factor space gives $r=r(CP_2)/r(M^4)$. This gives $r=n_b/n_a$ for $\hat{H}/G_a\times G_b$ option and $r=n_a/n_b$ for $\hat{H}\hat{times}(G_a\times G_b)$ option with obvious formulas for the hybrid cases.

5. At quantum level the fractionization would come from the modification of fermionic anti-commutation (bosonic commutation) relations involving $\hbar$ at the right hand side so that particle number becomes a multiple of $1/n$ or $n$. If one postulates that the total number states is invariant in the transition, the increase in the number of sheets is compensated by the increase of the fundamental phase space volume proportional to $\hbar$. This would give $r(X)\rightarrow r(X)/n$ for factor space and $r(X)\rightarrow nr(X)$ for the covering space to compensate the $n$-fold reduction/increase of states. This would favor Option II.

6. The second manner to distinguish between these two options is to apply the theory to concrete physical situations. Since $G_a$ and $G_b$ act as symmetries in $CD$ and $CP_2$ degrees of freedom, one might of being able to distinguish between the two options if it is possible to distinguish between the action of $G$ as symmetry of quantum states associated with covering and factor space. Also the quantization of the orbital spin quantum number at single particle level as multiples of $n$ can be distinguished from that in multiples of $1/n$.

### 2.8.3 A simple model of fractional quantum Hall effect

The generalization of the imbedding space suggests that it could possible to understand fractional quantum Hall effect [35] at the level of basic quantum TGD. This section represents the first rough model of QHE constructed for a couple of years ago is discussed. Needless to emphasize, the model represents only the basic idea and involves ad hoc assumption about charge fractionization.

Recall that the formula for the quantized Hall conductance is given by

$$\begin{aligned} \sigma &= \nu \times \frac{e^2}{h} \ , \\ \nu &= \frac{n}{m} \ . \end{aligned} \tag{2.8.1}$$

Series of fractions in $\nu = 1/3, 2/5, 3/7, 4/9, 5/11, 6/13, 7/15..., 2/3, 3/5, 4/7, 5/9, 6/11, 7/13..., 5/3, 8/5, 11/7, 14/9...4$ $1/5, 2/9, 3/13..., 2/7, 3/11..., 1/7....$ with odd denominator have been observed as are also $\nu = 1/2$ and $\nu = 5/2$ states with even denominator [35].

The model of Laughlin [55] cannot explain all aspects of FQHE. The best existing model proposed originally by Jain is based on composite fermions resulting as bound states of electron and even number of magnetic flux quanta [36]. Electrons remain integer charged but due to the effective magnetic field electrons appear to have fractional charges. Composite fermion picture predicts all the observed fractions and also their relative intensities and the order in which they appear as the quality of sample improves.

The generalization of the notion of imbedding space suggests the possibility to interpret these states in terms of fractionized charge, spin, and electron number. There are four combinations of covering and factors spaces of $CP_2$ and three of them can lead to the increase of Planck constant. Besides this there are two options for the formula of Planck constant so that which the very meager theoretical background one can make only guesses. On the following just for fun consideration option I is considered although the conservation of number of states in the phase transition changing $\hbar$ favors option II.

1. The easiest manner to understand the observed fractions is by assuming that both $M^4$ and $CP_2$ correspond to covering spaces so that both spin and electric charge and fermion number are fractionized. This means that $e$ in electronic charge density is replaced with fractional charge. Quantized magnetic flux is proportional to $e$ and the question is whether also here fractional charge appears. Assume that this does not occur.

2. With this assumption the expression for the Planck constant becomes for Option II as $r = \hbar/\hbar_0 = n_a/n_b$ and charge and spin units are equal to $1/n_b$ and $1/n_a$ respectively. This gives $\nu = nn_a/n_b$. The values $m = 2, 3, 5, 7, ..$ are observed. Planck constant can have arbitrarily large values. There are general arguments stating that also spin is fractionized in FQHE.

3. The appearance of $\nu = 5/2$ has been observed [37]. The fractionized charge is $e/4$ in this case. Since $n_i > 3$ holds true if coverings are correlates for Jones inclusions, this requires to $n_b = 4$ and $n_a = 10$. $n_b$ predicting a correct fractionization of charge. The alternative option would be $n_b = 2$ that also $Z_2$ would appear as the fundamental group of the covering space. Filling fraction $1/2$ corresponds in the composite fermion model and also experimentally to the limit of zero magnetic field [36]. $n_b = 2$ is however inconsistent with the observed fractionization of electric charge and with the vision inspired by Jones inclusions.

4. A possible problematic aspect of the TGD based model is the experimental absence of even values of $n_b$ except $n_b = 2$ (Laughlin's model predicts only odd values of $n$). A possible explanation is

that by some symmetry condition possibly related to fermionic statistics (as in Laughlin model) $n_a/n_b$ must reduce to a rational with an odd denominator for $n_b > 2$. In other words, one has $n_a \propto 2^r$, where $2^r$ the largest power of 2 divisor of $n_b$.

5. Large values of $n_a$ emerge as $B$ increases. This can be understood from flux quantization. One has $e \int BdS = n\hbar(M^4) = nn_a\hbar_0$. By using actual fractional charge $e_F = e/n_b$ in the flux factor would give $e_F \int BdS = n(n_a/n_b)\hbar_0 = n\hbar$. The interpretation is that each of the $n_a$ sheets contributes one unit to the flux for $e$. Note that the value of magnetic field in given sheet is not affected so that the build-up of multiple covering seems to keep magnetic field strength below critical value.

6. The understanding of the thermal stability is not trivial. The original FQHE was observed in 80 mK temperature corresponding roughly to a thermal energy of $T \sim 10^{-5}$ eV. For graphene the effect is observed at room temperature. Cyclotron energy for electron is (from $f_e = 6 \times 10^5$ Hz at $B = .2$ Gauss) of order thermal energy at room temperature in a magnetic field varying in the range 1-10 Tesla. This raises the question why the original FQHE requires so low temperature. The magnetic energy of a flux tube of length $L$ is by flux quantization roughly $e^2B^2S \sim E_c(e)m_eL$ ($\hbar_0 = c = 1$) and exceeds cyclotron roughly by a factor $L/L_e$, $L_e$ electron Compton length so that thermal stability of magnetic flux quanta is not the explanation. A possible explanation is that since FQHE involves several values of Planck constant, it is quantum critical phenomenon and is characterized by a critical temperature. The differences of the energies associated with the phase with ordinary Planck constant and phases with different Planck constant would characterize the transition temperature.

As already noticed, it is possible to imagine several other options and the identification of charge unit is rather ad hoc. Therefore this model can be taken only as a warm-up exercise. In [F12] Quantum Hall effect and charge fractionization are discussed in detail and one ends up with a rather detailed view about the delicacies of the Kähler structure of generalized imbedding space.

**Phase transitions changing the value of Planck constant**

There are two basic kinds of phase transitions changing the value of Planck constant inducing a leakage between sectors of imbedding space. There are three cases to consider corresponding to

1. leakage in $M^4$ degrees of freedom changing $G_a$: the critical manifold is $R_+ \times CP_2$;

2. leakage in $CP_2$ degrees of freedom changing $G_b$: the critical manifold is $\delta M^4_+ \times S^2_{II}$;

3. leakage in both degrees of freedom changing both $G_a$ and $G_b$: the critical manifold is $R_+ \times S^2_{II}$. This is the non-generic case.

For transitions of type 2) and 3) $X^2$ must go through vacuum extremal in the classical picture about transition.

Covering space can also change to a factor space in both degrees of freedom or vice versa and in this case $G$ can remain unchanged as a group although its interpretation changes.

The phase transitions satisfy also strong group theoretical constraints. For the transition $G_1 \to G_2$ either $G_1 \subset G_2$ or $G_2 \subset G_1$ must hold true. For maximal cyclic subgroups $Z_n$ associated with quantization axes this means that $n_1$ must divide $n_2$ or vice versa. Hence a nice number theoretic view about transitions emerges.

One can classify the points of critical manifold according to the degree of criticality. Obviously the maximally critical points corresponds to fixed points of $G_i$ that its points $z = 0, \infty$ of the spheres $S^2_r$ and $S^2_{II}$. In the case of $\delta M^4_+$ the points $z = 0$ and $\infty$ correspond to the light-like rays $R_+$ in opposite directions. This ray would define the quantization direction of angular momentum. Quantum phase transitions changing the value of $M^4$ Planck constant could occur anywhere along this ray (partonic 2-surface would have 1-D projection along this ray). At the level of cosmology this would bring in a preferred direction. Light-cone dip, the counterpart of big bang, is the maximally quantum critical point since it remains invariant under entire group $SO(3, 1)$.

Interesting questions relate to the groups generated by finite discrete subgroups of $SO(3)$. As noticed the groups generated as products of groups leaving $R_+$ invariant and three genuinely 3-D groups are infinite discrete subgroups of SO(3) and could also define Jones inclusions. In this case orbifold is replaced with orbifold containing infinite number of rotated versions of $R_+$. These phases could be important in elementary particle length scales or in early cosmology.

As already explained, the original too restricted view about generalization of imbedding space led to the idea about p-adic fractal hierarchy of Josephson junctions. Although this vision can criticized as unrealistic I decided to keep the original section discussing this idea in detail.

Fractal hierarchy of Josephson junctions is not new in TGD framework. The development of quantitative models based on this notion has been however plagued by the absence of concrete idea about what these Josephson junctions look like. The dark matter hierarchy based on hierarchy of scaled up values of Planck constant when combined with the p-adic length scale hierarchy might allow to circumvent the problem.

An essential boost for the development of ideas have been the effects of ELF em fields in living matter explainable in terms of quantum cyclotron transitions in Earth's magnetic field. Especially the fact that these effects appear only in narrow temperature and amplitude windows has provided the key hints concerning the model for the hierarchy of Josephson junctions and EEGs. The discussion of these effects is left to a separate section.

### 2.8.4 Cyclotron frequencies and Larmor frequencies

The appendix emphasizes the difference between the endogenous magnetic field $B_{end}$ explaining the effects of ELF em fields on vertebrate brain and Earth's magnetic field $B_E$ and lists cyclotron and Larmor frequencies of some ions for $B_{end}$.

#### The relationship between the values of the endogenous magnetic field and the Earth's magnetic field

For years I erratically believed that the magnitude of the magnetic field assignable to the biological body is $B_E = .5$ Gauss, the nominal value of the Earth's magnetic field. Probably I had made the calculational error at very early stage when taking $Ca^{++}$ cyclotron frequency as a standard. I am grateful for Bulgarian physicist Rossen Kolarov for pointing to me that the precise magnitude of the magnetic field implying the observed 15 Hz cyclotron frequency for $Ca^{++}$ is .2 Gauss and thus slightly smaller than the minimum value .3 Gauss of $B_E$. This value must be assigned to the magnetic body carrying dark matter rather than to the flux quanta of the Earth's magnetic field. This field value corresponds roughly to the magnitude of $B_E$ at distance 1.4R, $R$ the radius of Earth.

Dark matter hierarchy leads to a detailed quantitative view about quantum biology with several testable predictions [M3]. The applications to living matter suggests that the basic hierarchy corresponds to a hierarchy of Planck constants coming as $\hbar(k) = \lambda^k(p)\hbar_0$, $\lambda \simeq 2^{11}$ for $p = 2^{127-1}$, $k = 0, 1, 2, ...$ [M3]. Also integer valued sub-harmonics and integer valued sub-harmonics of $\lambda$ might be possible. Each p-adic length scale corresponds to this kind of hierarchy. Number theoretical arguments suggest a general formula for the allowed values of $\lambda$ [A9] as $\lambda = n$ where $n$ characterizes the quantum phase $q = exp(i\pi/n)$ characterizing Jones inclusion [C6]. The values of $n$ for which quantum phase is expressible using only iterated square root operation are number theoretically preferred and correspond to integers $n$ expressible as $n = 2^k \prod_n F_{s_n}$, where $F_s = 2^{2^s} + 1$ is Fermat prime and each of them can appear only once. $n = 2^{11}$ obviously satisfies this condition. The lowest Fermat primes are $F_0 = 3, F_1 = 5, F_2 = 17$. The prediction is that also n-multiples of p-adic length scales are possible as preferred length scales. The unit of magnetic flux scales up as $h_0 \to h = nh_0$ in the transition increasing Planck constant: this is achieved by scalings $L(k) \to nL(k)$ and $B \to B/n$.

$B = .2$ Gauss would corresponds to a flux tube radius $L = \sqrt{5/2} \times L(169) \simeq 1.58L(169)$, which does not correspond to any p-adic length scale as such. $k = 168 = 2^3 \times 3 \times 7$ with $n = 5$ would predict the field strength correctly as $B_{end} = 2B_E/5$ and predict the radius of the flux tube to be $r = 18$ $\mu$m, size of a large neuron. However, $k = 169$ with flux $2h_5$ would be must more attractive option since it would give a direct connection with Earth's magnetic field. Furthermore, the model for EEG forces to assume that also a field $B_{end}/2$ must be assumed and this gives the minimal flux $h_5$. Note that $n = 5$ is the minimal value of $n$ making possible universal topological quantum computation with Beraha number $B_n = 4cos^2(\pi/n)$ equal to Golden Mean [E9].

An interesting working hypothesis is that $B_{end}$ is the dark companion of the the Earth's magnetic field and that the ratio $B_{end} = 2B_E/5$ holds true in the entire magnetosphere as a time average so that $B_{end}$ would define what might be called the dark magnetosphere of Earth.

### Table of cyclotron frequencies and magnetic frequencies

A detailed study of the cyclotron frequencies demonstrates that they indeed seem to correspond to important EEG frequencies. The cyclotron frequencies associated with other singly ionized atoms can be obtained by the formula

$$f = \frac{A}{20} \times f(Ca^{2+}) \qquad f(Ca^{2+}) \simeq 15\ Hz \ . \tag{2.8.2}$$

Here the strength of the endogenous magnetic field $B_{end}$ is assumed to be .2 Gauss $= 2 \times 10^{-5}$ Tesla. The

The following table lists cyclotron frequencies and their lowest multiples for some of the most important ions.

| Elementary particle | $f_1/Hz$ | J | $f_L/Hz$ |
|---|---|---|---|
| $e$ | $5.6 \times 10^5$ | 1/2 | $2.8 \times 10^5$ |
| $p$ | 300 | 1/2 | 419 |
| Bosonic ions | | | |
| $^6Li$ | 50.1 | 1 | 88.3 |
| $O^{2-}$ | 37.4 | 0 | 0 |
| $Mg^{++}$ | 25.0 | 0 | 0 |
| $Ca^{++}$ | 15.0 | 0 | 0 |
| $Mn^{2+}$ | 11.4 | 5/2 | 520 |
| $Fe^{2+}$ | 10.8 | 0 | 0 |
| $Co^{2+}$ | 10.0 | 7/2 | 695 |
| $Zn^{2+}$ | 9.4 | 0 | 0 |
| $Se^{2-}$ | 7.6 | 0 | 0 |
| Fermionic ions | | | |
| $^7Li^+$ | 42.9 | 3/2 | 489 |
| $N^+$ | 21.4 | 1 | 60.6 |
| $F^-$ | 15.8 | 1/2 | 395 |
| $Na^+$ | 13.0 | 3/2 | 333 |
| $Al^+$ | 11.1 | 5/2 | 546 |
| $Si^+$ | 10.7 | 0 | 0 |
| $P^+$ | 9.7 | 1/2 | 170 |
| $S^-$ | 9.4 | 0 | 0 |
| $Cl^-$ | 8.5 | 3/2 | 130 |
| $K^+$ | 7.5 | 3/2 | 58.5 |
| $Cr^-$ | 5.7 | 3/2 | 71.1 |
| $Cu^+$ | 4.8 | 3/2 | 333.9 |
| $Ag^+$ | 2.8 | 1/2 | 17 |
| $I^+$ | 2.4 | 5/2 | 420 |
| $Au^+$ | 1.5 | 3/2 | 21 |

Table 10. The first column gives cyclotron frequency in cycles per second for some ions in the endogenous magnetic field $B_{end} = 2B_E/5 = .2$ Gauss explaining the effects of ELF em fields on vertebrate brain ($B_E = .5$ Gauss denotes the nominal of the Earth's magnetic field). The remaining columns give spin or nuclear spin and Larmor frequency $f_L$.

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# Chapter 3

# Bio-Systems as Super-Conductors: Part III

## 3.1 Introduction

This chapter is devoted to further applications of the theory of high $T_c$ superconductors as quantum critical superconductors involving dark matter hierarchy and large values of $\hbar$. The theory is applied to explain the strange findings about ionic currents through cell membrane, exotic neutrino superconductivity and the notion of cognitive neutrino pair are discussed, and the possibility that superconductivity and Bose-Einstein condensates are involved with atmospheric phenomena is considered.

### 3.1.1 Strange behavior of cellular water and quantal ionic currents through cell membrane

The fact that cellular water does not leak out of cell in a centrifugal force suggests that some fraction of water inside cell is in different phase. One explanation is that the nuclei of water inside cell are in doubly dark phase whereas electrons are in singly dark phase (having Compton length of 5 nm and perhaps directly "visible" using day technology!) as indeed predicted by the model of high Tc superconductivity. This conceptual framework could explain various findings challenging the notions of ionic pumps.

The empirical findings challenging the notions of ionic pumps and channels, nicely summarized by G. Pollack in his book [46], provide a strong support for the notions of many-sheeted space-time and ionic super-conductivity.

1. The selectivity of the cell membrane implies that channels cannot be simple sieves and there must be complex information processing involved.

2. The needed number of pumps specialized to particular ions is astronomical and the first question is where to put all these channels and pumps. On the other hand, if the cell constructs the pump or channel specialized to a given molecule only when needed, how does it know what the pump looks like if it has never seen the molecule? The needed metabolic energy to achieve all the pumping and channelling is huge. Strangely enough, pumping does not stop when cell metabolism stops.

3. One can also wonder why the ionic currents through cell membrane look quantal and are same through cell membrane and silicon rubber membrane.

These observations suggest strongly the presence non-dissipative ionic currents and quantum self-organization. The TGD based explanation would be in terms of high $T_c$ electronic and possibly even ionic superconductivity associated with cell membrane made possible by the large $\hbar$ phase for nuclei and electrons in the interior of cell. It however seems that thermal stability conditions allow only protonic Cooper pairs in the model of ionic Cooper pairs based on direct generalization of the model of high $T_c$ electronic super conductivity. This does not however mean that quantal ionic currents would be absent. This empirical input also supports a view about homeostasis as a many-sheeted ionic flow equilibrium controlled by larger space-time sheets with the mediation of massless extremals (MEs) serving as space-time correlates for Bose-Einstein condensates of massless bosons (also of scaled down dark electro-weak bosons and gluons).

In the proposed picture one can understand how extremely low densities of ions and their supra currents can control much higher ion densities at the atomic space-time sheets. The liquid crystal nature of the bio-matter is crucial for the model. This vision allows also much better understanding of the effects of ELF em fields on bio-matter. Also the effects of homeopathic remedies and acupuncture known to crucially involve electromagnetic frequency signatures of chemicals can be understood if homeostasis is based on many-sheeted ionic flow equilibrium.

### 3.1.2 Dark $Z^0$ magnetic fields and cognition

Similar arguments as in the em case apply in the scale $L_w$=.2 $\mu$m for $Z^0$ magnetic transitions with scale about $10^4$ eV much above the thermal energy scale. The hierarchy of length scales is now $L_w$=.2 $\mu$m, .4 mm, .8 m,.... $L_w$=.4 mm, possibly characterizing mm sized cortical modules, corresponds roughly to a frequency scale 40/A Hz, A atomic weight. The thermal stability supports the earlier idea that $Z^0$ force, dark neutrino superconductivity, $\nu\overline{\nu}$ wormhole contacts, and ZEG relate to cognition which must be thermally insulated whereas electromagnetic interactions would relate to sensory perception which could be highly sensitive even to temperature differences.

#### How noble gases can act as anesthetes?

Chemically inert noble gases are known to act as anesthetes. Somehow these atoms affect neuronal membrane, probably reducing the nerve pulse activity. A possible explanation is in terms of anomalous weak isospin due to the charged color bonds inside nuclei of noble gas generated in the cellular environment. This bonds carry also em charge so that noble gas atom would behave like ion with nuclear charge Z+1 or Z-1. Also the long ranged color force and dark weak force with range $L_w$=.2 $\mu$m associated with noble gas nuclei in dark phase could be part of the solution of the mystery.

#### Dark neutrino super conductivity

Neutrinos play a key role in TGD based model for cognition and hearing [M6] and it is interesting to see whether this model survives the radically different interpretation of long ranged weak fields forcing to introduce large $\hbar$ variants of $k = 113$ weak bosons. The notion of cognitive neutrino pair generalizes elegantly to $\nu\overline{\nu}$ wormhole contact such that $\nu$ is dark neutrino coupling to exotic light weak bosons. The model for quantum critical electronic superconductivity discussed in previous chapter [J1] generalizes in a rather straightforward manner and together with its electronic counterpart correctly predicts and provides interpretation for the fundamental biological length scales.

A strong deviation from the previous picture is that one must however assume that the neutrinos which are most relevant for cognition correspond to $k = 127$ and mass of order .5 MeV. Quantum model of hearing, which is one of the quantitative victories of TGD inspired theory of consciousness, is not affected appreciably if one requires that the Gaussian Mersennes $k = 167, 163, 157$ label scaled down copies of charged leptons with $k = 113$ defining the mass scales of exotic weak bosons. Neutrino mass scale should be much lower than .5 eV mass of exotic electron (the metabolic energy quantum by the way) rather than .5 MeV mass scale.

The large neutrino mass scale could be understood as effective mass scale if the neutrino space-time sheets are connected by color magnetic flux tubes with $k = 127$ quarks at their ends in the same manner as nucleons form nuclear strings in TGD based model of nucleus [F8]. Also leptomesons, which have been identified as pion like bound states of color octet leptons and explain the anomalous production of electron pairs in the scattering of heavy nuclei just above Coulomb wall [F7], could be understood as exotic $k = 167$ lepton space-time sheets connected together by color bonds having $k = 127$ quarks at their ends. There would be quark-antiquark pair per lepton making possible color octet state.

### 3.1.3 Atmospheric phenomena and superconductivity

There is a considerable evidence that various electromagnetic time scales associated with the atmospheric phenomena correspond to those associated with brain functioning. If magnetic sensory canvas hypothesis holds true, this is just what is expected. In this section these phenomena are considered in more detail with the aim being to build as concrete as possible vision about the dynamics involving the dark matter Bose-Einstein condensates at super-conducting magnetic and $Z^0$ magnetic flux quanta.

Tornadoes and hurricanes provide the first example of self-organizing systems for which Bose-Einstein condensates of dark matter at magnetic and $Z^0$ magnetic flux quanta might be of relevance. Auroras represent a second phenomenon possibly involving supra currents of Cooper pairs and of exotic ions. Lightnings, sprites and elves might also involve higher levels of dark matter hierarchy. p-Adic length scale hypothesis and the hierarchy of Planck constants provide a strong grasp to these far from well-understood phenomena and allow to build rather detailed models for them as well as to gain concrete understanding about how dark matter hierarchy manifests itself in the electromagnetic phenomena at the level of atmosphere.

## 3.2 Empirical support for ionic super-conductivity as a fundamental control mechanism

The notions of ionic channels and pumps associated with cell membrane are central for the standard cell biology [40]. There are however puzzling observations challenging this dogma and suggesting that the currents between cell interior and exterior have quantum nature and are universal in the sense that they not depend on the cell membrane at all [36, 37, 45, 41, 42]. One of the pioneers in the field has been Gilbert Ling [36], who has devoted for more than three decades to the problem, developed ingenious experiments, and written several books about the topic. The introduction of the book [46]) gives an excellent layman summary about the paradoxical experimental results[1].

It was a pleasant surprise to find that these experimental findings give direct support for the role of supra currents and Josephson currents in biocontrol. In fact, the experimental data lead to an archetype model cell homeostastis as a flow equilibrium in which very small densities of super-conducting ions (also molecular ions) and ionic supra currents at cellular and other super-conducting space-time sheets dictate the corresponding densities at the atomic space-time sheets. $Z^0$ super-conductivity in principle allows to generalize the model also to the control of the densities of neural atoms and molecules at atomic space-time sheets.

### 3.2.1 Strange behavior of the intracellular water

The basic strange feature of cellular interior is related to its gelatinous nature and is in fact familiar for everyone. Although 80 percent of hamburger is water, it is extremely difficult to extract this water out. Ling [37] has demonstrated this at cellular level by using a centrifuge and cells for which cell membrane is cut open: centrifugal accelerations as high as 1000 g fail to induce the separation of the intracellular water.

The dipolar nature of biomolecules and induced polarization are basis prerequisites for the formation of gels. Ling raises the cohesion between water and protein molecules caused by electric dipole forces as a fundamental principle and calls this principle association-induction hypothesis [36]. This cohesion gives rise to liquid crystal [16] like structure of water implying among other things layered structures and internal electric fields orthogonal to the plane of the layers [36, 43, 44]. For instance, cell membranes can be understood as resulting from the self-organization of liquid crystals [I3]. The fundamental importance of electret nature of biomatter was also realized by Fröhlich [34] and led him to suggest that macroscopic quantum phases of electric dipoles might be possible. This concept, which is in central role in many theories of quantum consciousness, has not been established empirically.

[1] I am grateful for 'Wandsqueen' for sending me the relevant URL address and for Gene Johnson for very stimulating discussions.

### 3.2.2 Are channels and pumps really there?

Standard neurophysiology relies strongly on the concepts of what might be called hydro-electro-chemistry. The development of the theory has occurred through gradual improvements saving the existing theory.

The development began from the basic observation that cells are stable gelatinous entities not mixing with the surrounding water. This led to the hypothesis that cell membrane takes care that the contents of the cell do not mix with the cell exterior. It was however soon found that cell membrane allows some ions to flow through. The interaction between theory and experiment led gradually to the notions of ion channel and ion pump, which are still central for the standard paradigm of the cell [40]. Note that also 'electric pump' taking care that membrane potential is preserved, is needed.

These notions developed gradually during the period when cell was seen as a bag containing water and a mixture of various biochemicals. If cell biology would have started to develop during the latter half of this century and after the discovery of DNA, cell as a computer metaphor might have led to a quite different conceptualization for what happens in the vicinity of the cell membrane. Also the notion of liquid crystals [16] would have probably led to different ideas about how homeostasis between cell interior and exterior is realized [36, 43, 44].

For me it was quite a surprise to find that pump-channel paradigm is not at all so well-established as I had believed as an innocent and ignorant outsider. The first chapter of the book "Cells, Gels and the Engines of Life" of Gerald Pollack [46] provides a summary about the experimental paradoxes (the interested reader can find the first chapter of this book from web).

The standard theoretical picture about cell is based on the observation that cell exterior and interior are in a relative non-equilibrium. The measured concentrations of various atomic ions and organic molecules are in general different in the interior and exterior and cell membrane seems to behave like a semi-permeable membrane. There is also a very strong electric field over the cell membrane. In standard approach, which emerged around 1940, one can understand the situation by assuming that there are cell membrane pumps pumping ions from cell interior to exterior or vice versa and channels through which the ions can leak back. Quite a many candidates for proteins which seem to function like pump and channel proteins have been identified: even a pump protein for water [46]! This does not however prove that pumping and channelling is the main function of these proteins or that they have anything to do with how ionic and molecular concentrations in the interior and exterior of the cell are determined. It could quite well be that pump and channel proteins are receptors involved with the transfer of information rather than charges and only effectively act as pumps and channels.

There are several serious objections of principle against the vision of cell as a bag of water containing a mixture of chemicals. Even worse, the hypothesis seems to be in conflict with experimental data.

#### Selectivity problem

Cell membrane is extremely selective and this leads to an inflation in the complexity of channels and pumps. The problem might be christened as a dog-door problem: the door for dog allows also cat go through it. Channels cannot be simple sieves: it is known that channels which let some ions through do not let much smaller ions through. There must be more complicated criteria than geometric size for whether the channel lets the ion go through. Quite generally, channels must be highly selective and this seems to require complicated information processing to decide which ion goes through and which not. As a consequence, the models for channels inflate in their complexity.

The only reasonable way to circumvent the problem is to assume that there is kind of binary coding of various chemical compounds but it is difficult to see how this could be achieved in the framework of the standard chemistry. The notion of N-atom proposed in [J6] to give rise to the emergence of symbols at the level of biochemistry could however allow this kind of coding. Channels and pumps (or whatever these structures actually are) could be also generated by self-organization process when needed.

#### Inflation in the number of pumps and channels

Channels and pumps for atomic ions and channels and pumps for an astronomical number of organic molecules are needed. The first question is where to put all those channels and pumps? Of course, one could think that pumps and channels are constructed by the cell only when they are needed. But how does the cell know when a new pump is needed if the cell as never met the molecule in question: for instance, antibiotic or curare molecule?

To realize how weird the picture based on channels and pumps is, it is useful to imagine a hotel in which there is a door for every possible client letting only that client through but no one else. This strange hotel would have separate door for every five point five milliard humans. Alternatively, the building would be in a continual state of renovation, new doors being built and old being blocked.

There is however an TGD based objection against this slightly arrogant argument. In TGD framework cell is a self-organizing structure and it might be that there is some mechanism which forces the cell to produce these pumps and channels by self-organization. Perhaps the basic characteristic of quantum control in many-sheeted space-time is that it somehow forces this kind of miracles to occur.

#### Why pumping does not stop when metabolism stops?

One can also wonder how metabolism is able to provide the needed energy to this continual construction of pumps and channels and also do the pumping. For instance, sodium pump alone is estimated to take 45-50 per cent of the cell's metabolic energy supply. Ling has studied the viability of the notion of the ionic pump experimentally [36] by exposing cell to a coctail of metabolic poisons and depriving it from oxygen: this should stop the metabolic activities of the cell and stop also the pumping. Rather remarkably, nothing happened to the concentration gradients! Presumably this is the case also for the membrane potential so that also the notion of metabolically driven electrostatic pumps seems to fail. Of course, some metabolism is needed to keep the equilibrium but the mechanism does not seem to be a molecular mechanism and somehow manages to use extremely small amount of metabolic energy.

#### How it is possible that ionic currents through silicon rubber membrane are similar to those through cell membrane?

A crucial verification of the channel concept was thought to come in the experiment of Neher and Sakmann [39] (which led to a Nobel prize). The ingenious experimental arrangement was following. A patch of membrane is sucked from the cell and remains stuck on the micropipet orifice. A steady voltage is applied over the patch of the membrane and the resulting current is measured. It was found that the current consists of discrete pulses in consistency with the assumption that that a genuine quantum level current is in question. The observation was taken as a direct evidence for the postulate that the ionic currents through the cell membrane flow through ionic channels.

The later experiments of Fred Sachs [41] however yielded a complete surprise. Sachs found that when the patch of the cell membrane was replaced by a patch of silicon rubber, the discrete currents did not disappear: they remained essentially indistinguishable from cell membrane currents! Even more surprisingly, the silicon rubber membrane showed ion-selectivity features, which were essentially same as those of the cell membrane! Also the currents through synthetic polymer filters [42] were found to have essentially similar properties: as if ion selectivity, reversal potential, and ionic gating would not depend at all on the structure of the membrane and were more or less universal properties. Also experiments with pure lipid-layer membranes [45] containing no channel proteins demonstrated that the basic features – including step conductance changes, flickering, ion selectivity, and in-activation– characterized also cell membranes containing no ionic channels.

The in-escapable conclusion forced by these results seems to be that the existing 60-year old paradigm is somehow wrong. Ionic currents and the their properties seem to be universal and depend only on very weakly on the properties of the membrane.

### 3.2.3 Could the notion of the many-sheeted space-time solve the paradoxes?

The basic paradoxes are related to the universality of the ionic currents suggesting the absence of ionic channels and to the absence of metabolically driven chemical pumps assignable to cell membrane. Chemical pumps take care that the differences of the chemical potentials associated with the two sides of the cell membrane remain non-vanishing just like ordinary pump preserves a constant pressure difference. Also 'electrical pump' taking care that the potential difference between the cell exterior and interior is preserved is needed. The experiments suggest strongly that both chemical pumps and 'electrical pump', if present at all, need very low metabolic energy feed.

Many-sheeted space-time allows following interpretation for the puzzling findings.

1. What have been identified as pumps and channels are actually ionic receptors allowing the cell to measures various ionic currents flowing through membrane.

2. Pumps are not needed because the cell interior and exterior correspond to disjoint space-time sheets. The currents run only when join along boundaries contact (JAB) is formed and makes the current flow possible. The fact that the formation of JABs is quantal process explains the quantal nature of the currents. Channels are not needed because the currents run as supra currents (also the cyclotron states of bosonic ions define Bose-Einstein condensates) along cell membrane space-time sheet. The absence of dissipation would explain why so little metabolic energy feed is needed and why the ionic currents are not changed when the cell membrane is replaced by some other membrane. JABs could be formed between the space-time sheets representing lipid layers or between cell exterior/interior and cell membrane space-time sheet. The formation of JABs has also interpretation as a space-time correlate for the generation of quantum entanglement.

3. The universality of the currents suggests that the densities of current carriers are universal. The first interpretation would be in terms of a ordinary-dark-ordinary phase transition. Ordinary charge carriers at space-time sheets associated with cell interior and exterior would be transformed to dark matter particles at the cell membrane space-time sheet and flow through it as supra currents and then transform back to ordinary particles (reader is encouraged to visualize the different space-time sheets). This phase transition could give for the currents their quantal character instead of the formation of JABs. Of course, the formation of JABs might be prerequisite for this phase transition.

4. The ion densities in cell interior and exterior are determined by flow equilibrium conditions for currents traversing from super-conducting space-time sheets to non-super-conducting space-time sheets and back. Ion densities would be controlled by super-conducting ion densities by an amplification mechanism made possible by the electret nature of the liquid crystal state. The dissipation by the currents at the atomic space-time sheets associated with cell interior and exterior is very weak by the weakness of the electric fields involved and at cell membrane space-time sheet superconductivity means absence of dissipation.

#### Many-sheeted cell

TGD based model of nerve pulse and EEG relies on the notion of the many-sheeted space-time. There is entire hierarchy of space-time sheets so that one can assign to cell and its exterior atomic space-time sheets forming join-along boundaries condensate of units of size of about $10^{-10}$ meters, lipid layer *resp.* cell membrane space-time sheets with thickness of order $L(149) \simeq .5 \times 10^{-8}$ meters *resp.* $L(151) \simeq 10^{-8}$ meters, and cellular space-time sheets with size of order few microns. These space-time sheets are certainly not the only ones but the most important ones in the model of EEG and nerve pulse.

1. Water molecules at the atomic space-time sheet can form join along boundaries bond condensates and the strange properties of water inside the cell can be understood if these lumps in the cell interior have size larger than the join along boundaries bonds connecting atomic space-time sheet of cell interior to that of cell exterior. Liquid crystal structure indeed gives rise to layered crystal like structures of water.

2. Cell membrane space-time sheets have size of order cell membrane thickness and are assumed to be super-conducting. The lipid layers of the cell membrane define space-time sheets of thickness of about 50 Angstrom, which could act as parallel super-conductors connected by Josephson junctions.

3. Cellular space-time sheets have size of order cell size and are multi-ion super-conductors. Also they are connected to each other by join along boundaries bonds serving as Josephson junctions. Also charged organic molecules could form super-conductors and be transferred by the same mechanism between cell interior and exterior. In TGD framework also classical $Z^0$ fields are

present and $Z^0$ super-conductivity is possible and could make possible neutral supra currents and control of the densities of the neutral atoms and molecules.

Neuronal and cellular space-time sheets of size of order cell size are assumed to be parts of the magnetic flux tube like structures associated with Earth's magnetic field. Earth's magnetic field inside organisms could contain closed circuits and it is conceivable that the notion of magnetic circulation containing neural circuitry as a sub-circuitry makes sense. Large value of $\hbar$ makes possible high $T_c$ superconductivity. Only protonic Cooper pairs are possible at room temperature besides electronic and neutrino Cooper pairs using the proposed criterion super conductivity. Bose-Einstein condensates of bosonic ions at cyclotron states define also superconductors and at $k = 4$ level of dark matter hierarchy the cyclotron frequencies in Earth's magnetic field correspond to energies above thermal energy. These frequencies are in alpha band for most biologically relevant bosonic ions.

Electronic Josephson currents through cell membrane oscillate with a frequency which is given by the membrane potential $eV = 70\ meV$: this predicts that the emission of infrared photons as a signature of a living cell. Super currents transform to Ohmic currents when they enter to the atomic space-time sheets.

Also present are 'many-sheeted circuits' for which currents flow along super-conducting space-time sheets go to atomic space-time sheets where they flow as very weak Ohmic currents, and run back to super-conducting space-time sheets. The currents flowing in closed circuits traversing both cellular and atomic space-time sheets are in flow equilibrium. Because of the high value of the cell membrane electric field, the ionic currents flowing at cell membrane space-time sheets would give rise to high dissipation. The ohmic currents from the cell exterior to interior can however enter to the super-conducting cell membrane space-time sheet and back to the atomic space-time sheet of the cell interior and thus avoid the dissipation.

This picture suggests that the flow of particles between the cell interior and exterior takes mainly via the cell membrane space-time sheet. This would mean that $k = 169$ cell interior space-time sheet has permanent bridges to the $k = 151$ cell membrane space-time sheet, which in turn has only temporary bridges to the $k = 169$ cell exterior space-time sheets.

The character of the ionic currents through cell membrane is highly relevant for the model of the nerve pulse. The development of the model of nerve pulse [M2] has taken a long time and the original hypothesis about the decisive role of the ionic Josephson currents turned out to be wrong. The recent version of the model assumes that the reduction of charge entanglement between magnetic body and neuron interior made possible by charged $W$ MEs leads to a exotic ionization of the $Ca^{++}$ Bose-Einstein condensate. Exotic $Ca^{++,+}$ Bose-Einstein condensate reduces the membrane resting potential below the threshold for the generation of nerve pulse. The random generation of JABs makes possible flow of ionic currents and leads to the generation of nerve pulse. One cannot exclude the possibility that a portion of em or $Z^0$ ME drifting along the axon with the velocity of nerve pulse and connecting cell exterior and cell membrane space-time sheets defines the JAB: in the earlier version of the model $Z^0$ ME was responsible for the reduction of the membrane potential.

#### Faraday's law of induction in the many-sheeted space-time forces electrical non-equilibrium

Faraday's induction law in many-sheeted space-time gives strong constraints on the electric fields over the cell membrane region at various space-time sheets. Suppose that cellular space-time sheet and some other space-time sheets, say cellular and cell membrane space-time sheet, are in contact so that one can form a closed loops traversing along both space-time sheets. Faraday's law implies that the rotation of electric field around a closed loop traversing first from cell exterior to interior at cellular space-time sheet, going to the atomic space-time sheet and returning back to cell exterior and down to cellular space-time sheet must be equal to the time derivative of the magnetic flux through this loop. Since magnetic flux cannot grow indefinitely, the time average of this potential difference is vanishing. During the generation of nerve pulse the situation might change but only for a finite duration of time (of order millisecond).

Thus in electrostatic equilibrium there must be same exterior-interior potential difference over all space-time sheets in contact with cellular space-time sheets and the variation of potential difference at cellular space-time sheets induces automatically an opposite variation at other space-time sheets. This means that the supra currents at cellular space-time sheets can indeed control potential differences at other space-time sheets, in particular at atomic space-time sheets. Faraday's law in the many-sheeted space-time also implies that Ohmic currents at atomic space-time sheets cannot destroy the potential difference except for a finite period of time.

Faraday's law makes also possible a gauge interaction between dark and ordinary matter. The changes of dark matter charge densities induce changes of electric field patterns at dark matter space-time and once JABs are formed between dark matter space-time sheet and space-time sheets at lower level of dark matter hierarchy, closed many-sheeted circuits become possible and voltage differences along space-time sheet at different levels of dark matter hierarchy correspond to each other.

Massless extremals (MEs, topological light rays) serve as correlates for dark bosons. Besides neutral massless extremals (em and $Z^0$ MEs) TGD predicts also charged massless extremals obtained from their neutral counterparts by a mere color rotation (color and weak quantum numbers are not totally independent in TGD framework). The interpretation of the charged MEs has remained open hitherto. Charged $W$ MEs could induce long length scale charge entanglement of Bose-Einstein condensates by inducing exotic ionization of ionic nuclei. State function reduction could lead to a state containing a Bose-Einstein condensate in exotically ionized state.

In this manner the charge inside neuron and thus by Faraday's law membrane potential could be affected by magnetic body. The generation of nerve pulse could rely on the reduction of the resting potential below the critical value by this kind of mechanism inducing charge transfer between cell interior and exterior. The mechanism might apply even in the scale of magnetic body and make possible the control of central nervous system. Also remote mental interactions, in particular telekinesis, might rely on this mechanism.

### Flow equilibrium in many-sheeted space-time

The notion of many-sheeted space-time suggests that cell interior and exterior could be regarded as a system in 'many-sheeted flow equilibrium' so that the ion densities at atomic space-time sheets are determined by the ion densities at the super-conducting cellular space-time sheets and by the drift velocities by the basic formula $n_1/n_2 = v_2/v_1$ for flow equilibrium.

1. Cell exterior and interior understood as many-sheeted structures are in ionic flow equilibrium holding true for each ion type. The ionic currents run along circuits which traverse along super-conducting space-time sheets, enter into atomic space-time sheets and back to super-conducting space-time sheets.

2. To understand what is involved consider the simplest possible closed circuit connecting atomic and cellular space-time sheets. The ionic supercurrent $I_{i,s}$ flowing from a super-conducting space-time sheet to the atomic space-time sheet is transformed to Ohmic current $I_{i,O}$ in the atomic space-time sheet and in flow equilibrium one has

$$I_{i,s}(int) = I_{i,s} = I_{i,O}(ext) = I_i(membr) \ .$$

3. Ionic supra curent is sum of two terms.

$$I_{i,s} = I_{i,s|J} + I_{i,s|d} \ .$$

The first term is the oscillatory Josephson current associated with the Josephson junction connecting interior and exterior cellular space-time sheet. The second term is direct supra curent

$$I_{i,s|d} = \frac{1}{m_i} n_{i,s} \nabla\phi = \frac{n_{i,s} K_i}{m_i} \ ,$$

where $\phi$ is the phase of the super-conducting order parameter, and $m_i$ is the mass of the ion. $K_i$ is the quantized momentum like quantum number associated of super conducting loop (assuming for simplicity that current is constant).

4. Ionic Ohmic current is equal to

$$I_{i,O}(int) = \frac{n_i(int) q_i E_{int}}{k_i(int)} \ ,$$

$$I_{i,O}(ext) = \frac{n_i(ext) q_i E_{ext}}{k_i(ext)} \ .$$

Here $k_i$ is linear friction coefficient. Since cell exterior and interior are in different internal states, $k_i$ is different for cell interior and exterior. $E$ is the weak internal electric field made possible by liquid crystal property which is also different for the interior and exterior. Flow equilibrium conditions give for the ratio of the ion densities in interior and exterior

$$\frac{n_i(int)}{n_i(ext)} = \frac{v_i(ext)}{v_i(int)} = \frac{E_{ext}}{E_{int}} \frac{k_i(int)}{k_i(ext)} \quad .$$

Thus in flow equilibrium the ratio of the internal and external ion densities differs from unity and is determined by the ratio of the ionic drift velocities, which are different in cell interior and exterior.

5. The densities of the super-conducting ions at super-conducting space-time sheet determine the corresponding ion densities at the atomic space-time sheet

$$\frac{n_i(int)}{n_{i,s}} = \frac{v_{i,s}}{v_i(int)} = \frac{K_i k_i(int)}{m_i E_{int}} \quad ,$$

$$\frac{n_i(ext)}{n_{i,s}} = \frac{v_{i,s}}{v_i(ext)} = \frac{K_i k_i(ext)}{m_i E_{ext}} \quad .$$

Obviously, super-conducting ion densities control the ion densities at the atomic space-time sheets. Very weak electric fields $E_{ext}$ and $E_{int}$ and high values of friction coefficients $k_i$ make possible a large amplification of the super conducting densities to the non-super-conducting ionic densities at atomic space-time sheet. Thus the fact that liquid crystals allowin weak but stable electric fields orthogonal to the layer like structure is crucial for the mechanism.

6. Also flow equilibrium requires metabolism to keep the currents at the atomic space-time sheets flowing. There are two options.
i) Assuming that the current flows through cell membrane as an Ohmic current, the power dissipated in the circuit is equal to

$$P = I_i(int)(V_{int} + V_{memb} + V_{ext}) = I_{i,s}(V_{int} + V_{memb} + V_{ext}) \quad .$$

Since supercurrents and thus also Ohmic currents are weak and electric fields are weak in cell interior and exterior, also dissipation can be extremely low in these regions. The dominating and problematic term to the dissipation comes from the membrane potential which is very large.
ii) An alternative option is that the current flows flows through cell membrane region as a supercurrent by going from atomic to cell membrane space-time sheet and returning back to atomic space-time sheet. This gives

$$P = I_{i,s}(V_{int} + V_{ext}) \quad .$$

In this manner huge amount of metabolic energy would be saved and it is quite possible that this is the only sensical manner to understand the experimental results of Ling [36].

**Refinements and generalizations**

The proposed oversimplified model allows obviously refinements and variants. For instance, current circuits could run from exterior cellular space-time sheet to cell membrane space-time sheet and run only through the cell interior. In this case only the ionic concentrations in the cell interior would be controlled: this does not look a good idea. This option might be necessary in the case that cell exterior cannot be regarded as an electret carrying weak but stable electric field.

Several super-conducting space-time sheets are probably involved with the control and complex super-conducting circuits are certainly involved. The structure of the cell interior suggests a highly organized ohmic circuitry. In particular, cytoskeleton could be important carrier of currents and atomic space-times sheets of the microtubules could be in crucial role as carriers of the ohmic currents: there is indeed electric field along microtubule. The collagenous liquid crystalline networks [43, 44] are excellent candidates for the carriers of weak ohmic currents in the inter-cellular tissue. Fractality suggests that also structures like proteins, DNA and microtubules are in a similar flow equilibrium controlled by super-conducting ion densities at protein/DNA/microtubule space-time sheets and probably also larger space-time sheets.

Bioelectromagnetic research provides a lot of empirical evidence for the existence of the direct current ohmic circuits, mention only the pioneering work of Becker and the work of Nordenström [62, 54]. For instance, these direct currents are proposed to be crucial for the understanding of the effects of the acupuncture. The ancient acupuncture, which even now is not taken seriously by many skeptics, could indeed affect directly the densities and supercurrents of ions at super-conducting space-time sheets and, rather ironically, be an example of genuine quantum medicine.

### Explanation of the paradoxes in terms of many-sheeted space-time

The qualitative predictions of the flow equilibrium model conform with the experimental facts discussed above.

1. One can understand how a gelatinous lump of matter can be a stable structure if the interior of the cell is in a gelatinous state in length scales larger than the size of the Josephson junctions at atomic space-time sheet. This means that water inside cell consists of coherent lumps larger than the size of Josephson junction and cannot leak to the exterior. If the exterior of the cell forms single large space-time sheet or consists of sheets connected by Josephson junctions with size larger than the typical size for the coherent lumps of water in cell exterior, cell exterior behaves like ordinary mixture of water and chemicals.

2. The amplification mechanism of supra currents relying crucially on liquid crystal property implies that although liquid crystal pumps and metabolism are needed, the amount of metabolic energy can be extremely small. Absolutely essential is however that ohmic currents run through the super-conducting short circuit provided by the cell membrane space-time sheet.

3. The currents for various ions do not depend at all on the properties of the cell membrane but are determined by what happens on cellular and other super conducting space-time sheets. In flow equilibrium supra currents and Josephson currents are identical with currents through cell membrane at atomic space-time sheet. The observed quantal nature of the ionic currents supports their interpretation as faithful atomic level images of supra currents.

4. Since various ionic currents at the cellular space-time sheets dictate the ionic currents at the atomic space-time sheets, the selectivity of the cell membrane would seem to be only an apparent phenomenon. One must however be very cautious here. The self-organizing cell membrane might have the virtue of being co-operative and develop gradually structures which make it easier to establish the flow equilibrium. For large deviations from the flow equilibrium, ohmic currents are expected to flow through the atomic space-time sheet associated with the cell membrane since super-conducting currents become overcritical and super-conductivity is spoiled. Also the proteinic Josephson junctions between lipid layer space-time sheets might be crucial. Thus the notions of channel and pump proteins might make sense in the far from flow equilibrium regime where the currents though membrane region are dominantly ohmic.

To sum up, one could see super-conducting space-time sheets as controllers of the evolution of the cellular and other biological structures and the model of organism could be specified to some degree in terms of the densities and currents of the super-conducting particles at various space-time sheets besides the values quantized magnetic fluxes associated with various many-sheeted loops. Setting up the goal at controlling space-time sheets would force the atomic space-time sheets to self-organize so that the goal is achieved. This clearly provides a quantum mechanism of of volition. A fascinating challenge is to apply this vision systematically to understand morphogenesis and homeostasis.

Needless to say, the notion of many-sheeted current circuitry would have also revolutionary technological implications since all undesired dissipative effects could be minimized and currents at atomic space-time sheets would be used only for heating purposes! Of course, many-sheeted current circuitries would also make possible quantum computer technologies.

### Bio-control as a control of quantum numbers characterizing supracurrents

The magnetic quantum numbers $K_i$ which together with the densities of super-conducting ions characterize the densities of various ions at atomic space-time sheets. Thus magnetic quantum numbers associated with super-conducting circuits formed by magnetic flux tubes indeed characterize biological information as speculated already more than decade ago on basis of mathematical necessity. Direct ohmic currents and supra currents determine these quantum numbers only partially since in super-conducting circuit integer valued magnetic flux can flow without any induced current in the circuit. In presence of dissipation the currents in super-conducting circuit are minimal needed to guarantee quantized flux through the circuit.

In this picture biocontrol boils down to the changing of the various integers characterizing the phase increments over closed super conducting loops. If nerve pulse involves induction of supra curent compensating the deviation of the magnetic flux in circuit from integer multiple of flux quantum, this can be achieved. The coupling of super-conducting circuits with MEs makes it possible for MEs to affect the magnetic quantum numbers by time varying or constant magnetic fields.

1. If dissipation is slow, supra currents and thus also ionic concentrations can suffer a large change and the homeostatis of neuron changes for a period determined by the rate of dissipation for supra currents.

2. The induced a supra curent could also dissapate rapidly to minimal supra curent required by the quantization of the magnetic flux: the quantized part of the magnetic flux of external perturbation penetrates to super-conductor and is expected to affect the super-conducting part of the system. This does not of course occur permanently for oscillating em fields. The deviation of the external magnetic flux from a quantized value is coded to a small supercurrent. This mechanism combined with stochastic resonance possible for SQUID type circuits [19] makes it possible to 'measure' extremely weak magnetic fields of MEs by amplifying them to biological effects.

   MEs can also form junctions (possibly Josephson-) between two super-conducting circuits. In this case a constant electric field associated by ME defines the frequency of the induced Josephson current: the weaker the potential difference, the slower the oscillation period. This mechanism might explain why the effects of ELF em fields in living matter occur in intensity windows.

### The role of the cell membrane

What is the role of the cell membrane in TGD inspired picture about cell? Very much what it is found to be. Cell membrane recognizes various organic molecules, interacts with them, and possibly allows them to go through. A protein in the cell membrane might act as an effective channel or pump but this function would be only apparent in case of ions. Only if cell membrane space-time sheet has join along boundaries contacts with the cell interior, can ions and proteins enter cell interior through the membrane space-time sheet. One must also consider very seriously the possibility that cell membrane space-time sheet is a carrier of supra currents participating in the control of the physics at atomic space-time sheets.

This vision conforms with a computer-ageist view about cell membrane as an interface between computer and clients. Against the fact that tools (proteins) and symbols (DNA) emerge already at atomic length scale, it would indeed seem rather strange that cell would reduce to a bag of water containing mixture of chemicals. This view conforms also with fractality. Skin is the largest connected part of the nervous system and cell membrane could be also seen as the skin of neuron and thus a part of the nervous system of cell, specialized to receive signals from the external world.

In this vision cell is much more like a living, intelligent computer than a sack of ion-rich water, and cell membrane is its interface with the external world. Proteins and biomolecules are messages/messengers, and cell membrane allows them to attach to the receptor only if a number of conditions are satisfied.

In many cases it is not necessary for the messenger to continue its travel to the interior since electromagnetic and electromechanical communications with the cell nucleus are possible by liquid crystal property of cell structures. TGD suggests MEs ('massless extremals') and magnetic flux tubes carrying ionic super-conductors as a universal tool for these communications, and the simplest hypothesis is that the fractally scaled down versions of the communications in the cell length scale are realized also in the interior of the cell and inside cell nucleus, and even at the level of DNA. The interaction of MES and topologically quantized magnetic fields could solve many of the paradoxical features related with the phenomenon of pleiotropy discussed briefly in [J4]. In particular, electromagnetic passwords and commands analogous to computer language commands based on suitable frequency combinations or even amplitude modulated field patterns could be involved. For instance, in case of DNA SQUID type mechanism combined with stochastic resonance could make possible the activation of specified genes by using specific frequency combinations associated with MEs.

### 3.2.4 Water memory, homeopathy, and acupuncture

Further guidelines for TGD based view about biocontrol and coordination were provided by the empirical evidence for water memory and various effects involved with it [39, 40, 51, 47]. In [K5] a detailed mechanism of homeopathy and water memory based on the model of biocontrol in terms of many-sheeted ionic flow equilibrium is discussed.

*1. Transfer of homeopathic potency to non-atomic space-time sheets is not enough*

Many-sheeted ionic flow equilibrium suggests a possible mechanism of homeopathy: the extremely low densities of homeopathic remedies are at the controlling super-conducting space-time sheets where the control is. Thus homeopathy could be seen as a high precision medicine minimizing the amount of the remedy needed rather than some kind of magic treatment. This cannot be however the whole story. As already explained the study of homeopathic effects suggest an electromagnetic representation of the biomolecules based on frequencies [47] and it is possible achieve the healing effect by transferring mere frequencies instead of using homeopathic potency.

*2. Mechanisms of frequency imprinting and entraintment*

According to [47], the homeopathic remedies seem to be characterized by frequencies varying in the range containing at least the range $10^{-3} - 10^{9}$ Hz suggesting that electromagnetic fields at specific frequencies characterize the homeopathic remedy. These frequencies can be imprinted into water and also erased. Rather remarkably, the removal of Earth's magnetic field erases the imprinted frequencies.

One the other hand, the studies of acupuncture support the existence of certain highly coherent endogenous frequencies [47] at which em radiation has strong effects. The fact that these frequencies can entrain to exogenous frequencies suggests a mechanism of homeopathy based on entrainment. Effects are observed at pairs of high and low frequencies and the ratio of these frequencies is constant over all acupuncture meridians with a standard derivation of $\pm .15$ per cent. The first branch is at GHz range: in particular the frequencies 2.664 GHz, 1.42 GHz and 384 MHz have unexpected properties. The second branch of frequencies is in ELF range, in particular Schumann frequency 7.8 Hz accompanies 384 MHz.

Consider now the explanation of the observations of Smith and others in in TGD framework using the proposed model assigning to magnetic flux tubes parallel MEs making magnetic flux tube effectively a magnetic mirror.

1. The basic idea is that water forms representations for chemicals it contains in terms of transition frequencies of the chemical which become frequencies of MEs and structures of water generating these MEs by emission and absorption processes. Also representations of representations are possible. The molecule of a homeopathic potency is characterized by characteristic frequencies associated with its transitions as well as ELF frequencies. Of course, also transitions of a complex formed by molecule of the potency and water molecule could be involved.

   Water represents the transition frequencies of the potency molecule as transition frequencies of water molecules or of structures which correspond to space-time sheets of various sizes. This conforms with the fact that frequency imprinting disappears after thorough drying and returns when water is added and that also bulk water without any potency allows frequency imprinting. In the frequency range studied by Smith rotational transition frequencies of water and of the space-time sheets containing water in liquid crystal form provide a good candidate for a representational mechanism. ELF frequencies correspond now to the magnetic transitions of these space-time sheets behaving like point like objects in Earth's magnetic field.

2. The simplest assumption is that the ELF branch of the frequency spectrum corresponds to the magnetic transition frequencies in Earth's magnetic field whereas the high frequency branch corresponds to the characteristic frequencies $f = c/L$ of MEs parallel to the magnetic flux tubes. This assumption conforms with the crucial role of Earth's magnetic field in the erasure of the imprinted frequencies. Also the importance of 7.8 Hz Schumann frequency for the heart chakra [47] can be understood.

The singly ionized Ca, Ar, and K (all 7.5 Hz for $B = .5\times 10^{-4}$ Tesla) and Cl (8.5 Hz) have cyclotron transition frequencies near to Schumann frequency. For LC water blobs the ELF frequencies are below 1 Hz and the requirement that water blob has size smaller than radius of magnetic flux tube of Earth's magnetic field allows ELF frequencies down to $1/f \sim 1000$ years so that all biologically relevant length scales are covered. Quite interestingly, the frequency $f_h$ corresponding 1000 years is 20 Hz by the scaling law suggested by Smith and corresponds to the lower bound for audible frequencies and that also language involves subneuronal mimicry by LC water blobs. A fascinating possibility is that subneuronal LC water blobs could be responsible for all biorhytms and be involved also with our long term memories.

3. Frequency entrainment for both ELF and high frequency branches can be understood if both the thickness and length of the magnetic flux tubes are subject to a homeostatic control. The assumption that the total magnetic energy of the flux tube remains constant during the frequency entrainment together with the magnetic flux quantization implies that the ratio $S/L$ of the area $S$ of the magnetic flux tube to its length $L$ remains constant during entrainment. Thus the ratios $f_h/f_{ELF}$ of the magnetic transition frequencies to characteristic frequencies of MEs would be homeostatic invariants in agreement with the empirical findings. The value of the ratio is in good approximation $f_h/f_{ELF} = 2\times 10^{11}$.

4. The electromagnetic signature of the homeopathic potency corresponds to MEs stimulated by the electromagnetic transitions associated with the potency molecule. Since these frequencies are also transition frequencies for water molecules or space-time sheets containg water in liquid crystal form a resonant interaction is possible and em fields of MEs can be amplified/replicated by the transitions associated with these structures.

5. According to [47], coherence propagates with a light velocity whereas coherent domain of size $L$ diffuses with a velocity given by the scaling law $v \propto Lf$. In TGD the natural interpretation for the velocity of coherence propagation is as a signal velocity inside ME (possibly representing external em field). $v$ is in turn associated with the motion of ME transversal to some linear structure along it: this effect is not possible in Maxwell's theory since particle-field duality is not realized at the classical level. The velocities are reported to be of order few meters per second and of the same order of magnitude as nerve pulse conduction velocity and phase velocities for EEG waves. This relationship is of the same form as the scaling law which relates together the phase velocity of EEG wave (velocity of EEG ME in TGD framework) and the size $L$ of corresponding structure of brain or body. For instance, scaling law relates the size $L$ for brain structures and corresponding magnetic sensory canvas with much larger size $L_c = c/f$ [M4]. Scaling law would give $v/c = f_{ELF}/f_h$ and velocity of order mm/s for the motion of transversal MEs along magnetic flux tubes: this velocity is considerably smaller velocity than m/s reported in [47].

A detailed model for various homeopathic effects is discussed in [K5]. The model leads to a generalization of the view about many-sheeted DNA with magnetic mirrors transversal to DNA coding the electromagnetic structure of the organism and allows to understand introns as chemically passive but electromagnetically active genes. Magnetic mirrors provide also a recognition mechanism fundamental for the functioning of the bio-system: consider only the ability of aminoacids to find corresponding RNA triplets, the self assembly of tobacco mosaic virus and the functioning of the immune system. Magnetic mirrors can also serve as bridges between sender and receiver of intent in remote healing and viewing and these processes could be seen as scaled-up version of those occurring routinely endogenously.

## 3.3 Dark neutrino super conductivity

The new view about dark neutrino super conductivity differs completely in details from the earlier one. The reason is the new interpretation for classical long ranged weak gauge fields as space-time correlates for a hierarchy of exotic weak bosons with scaled down mass scale. The model of dark neutrino superconductivity will be constructed using various empirical guidelines about neutrinos to set quantitative constraints. The model itself is a direct generalization of the model for quantum critical electronic super conductor based on wormholy Cooper pairs generalized to the case of ORMEs so that electrons have large $\hbar$ and nuclei are doubly dark.

Also non-superconducting neutrinos might be important. The negativity of the neutrino energy in the $Z^0$ Coulombic fields created by nuclei possessing anomalous weak charge makes possible creation of neutrino-antineutrino pairs from vacuum by the splitting of $\nu\overline{\nu}$ type wormhole contacts with neutrino and antineutrino at causal horizons. Hence the $\nu\overline{\nu}$ wormhole contacts, in particular those of $k = 151$ neutrinos assignable to cell membranes, could be important. Cognitive neutrino pairs indeed play a key role in TGD based model for cognition. The decay of cognitive neutrino pairs to ordinary neutrino-antineutrino pairs followed by a possible transition to dark neutrino phase provides a possible mode of quantum control by creating and controlling the density of super-conducting dark neutrino Bose-Einstein condensates.

The special feature of the cognitive neutrino pairs is that they have nearly vanishing total energy and other quantum numbers. This makes them ideal candidates for realizing Boolean thoughts as sequences of cognitive neutrino pairs with the spin of cognitive antineutrino coding for the two values of the Boolean statement. Quantum model hearing [M6] relies on cognitive neutrino pairs and has been one of the quantitative victories of TGD inspired theory of consciousness and it is interesting to see whether it survives in the new vision.

### 3.3.1 The analogy between superconductors of type I and quantum critical superconductors

The original proposal was that bio-systems correspond to superconductors of type I near criticality. What makes super conductors of type I so interesting is that they allow the penetration of metastable magnetic field configurations destroying super-conductivity. Field configurations are cylindrically symmetric in the length scale $\lambda$ and their cross section has very complicated topology consisting of locally stripe like regions of width of order $\lambda << \xi$ [21]. In general, the cross section consists of several disjoint regions and each region is characterized by two integers in TGD [D7]. The magnetic flux obeys a generalized quantization condition of form $\oint(p - 2eA)dl = n2\pi$, where $v$ denotes the velocity field of Cooper pairs and magnetic flux can be smaller than its quantized value.

For superconductors of type I metastability makes the magnetic field structure near critical value of the magnetic field an ideal control tool since the topology of the cross section can be varied easily. This means that both memory dating and simple arithmetic operations are possible since the fusion of two disjoint regions corresponds to the addition of the integers $n_1$. This suggests that both the topology of the magnetized region and integers $n_1$ and/or $n_2$ code the content of the observation at various p-adic levels. In the absence of sensory input the magnetic field reduces to ground state configuration (no super-conducting regions) with related integers perhaps coding long term memories.

Quantum critical superconductors are naturally superconductors of type II but in this case the supra current carrying regions are associated with the boundaries of dynamical stripe like structures so that the situation remains more or less unchanged. The super-conducting regions are associated with the boundaries between regions possessing different value of $\hbar$ and stripes correspond to a larger value of $\hbar$. Wormholy Cooper pairs are at the boundary region of two phases.

The lipid layers of the cell membrane ($k = 149$) and the entire cell membrane itself ($k = 151$) as well as the endoplasma membranes filling the cell interior indeed resemble locally super-conducting regions of quantum critical super conductor since the thickness of the membrane is very small as compared to its typical radius of curvature. The join along boundaries bonds between cells (identified as the so called gap junctions [34]) could give rise to macroscopic super conductor. In nerve cells axons are long cylindrically symmetric configurations of this type.

In accordance with the magnetic metastability, the endoplasma membranes of the cell are known to be dynamical structures, which change their size and connectedness continually. An additional support for the role of the superconductivity in the cellular information processing comes from the empirical observation that strong magnetic fields have harmful consequences for the information processing of the cell. Above critical magnetic field vortices of radius $\xi$ inside which large $\hbar$ phase is transformed to ordinary one would be formed. Cell size gives a good estimate for the value of the coherence length $\xi$ of dark neutrino super-conductor identified as weak length scale.

### 3.3.2 Empirical guidelines

The empirical guidelines are following.

1. p-Adic mass calculations utilizing the information about neutrino mass squared differences support the view that neutrino Compton length scale is about $L(169)$ and neutrinos have mass of $\sim .2$ eV [F3]. There is evidence for other mass scales too, in particular $L(173)$. p-Adic mass calculations [F4] led to the conclusion that also hadronic quarks can correspond to several p-adic primes, even in the case of low mass hadrons. The TGD based model for nuclear physics assumes that color bonds having $k = 127$ quarks at their ends with MeV mass scale connect nucleons to nuclear strings. These findings encourage to ask whether also Gaussian Mersennes $k = 151, 157, 163, 167$ would define mass scales of neutrinos. The corresponding dark mass scales for $\hbar \to \hbar/v_0 \simeq 2^{11}\hbar$ correspond to $k_{eff} = 173, 179, 185, 189$ and span the length scale range 20 $\mu$m-.5 cm.

   The earlier model of neutrino superconductivity and cognitive neutrino pairs was based on $k = 151$ ordinary neutrinos having long ranged weak interactions. The new view about long range weak interaction requires much more massive neutrinos having dark Compton length around $L(151)$. Since both electron and nuclear exotic quarks [F8] correspond to Mersenne prime $M_{127}$, the natural guess is that also neutrinos can exist in $k = 127$ state with electron neutrinos having scaled up .55 MeV rather near to electron mass. A possible explanation for the special role of $M_{127}$ that it is largest Mersenne prime corresponding to a non-super-astrophysical length scale. One can also consider interpretation in terms of almost unbroken electro-weak symmetry for fermions. The corresponding dark length scale would be $L(k_{eff} = 149)$ and would correspond to the thickness of the lipid layer of cell membrane.

2. The model for the anomalies of water [F10] led to the conclusion that one fourth of hydrogen atoms of water are in dark matter phase with large value of $\hbar$ and that hydrogen atoms form linear super nuclei. This hypothesis allows to estimate the Coulombic $Z^0$ interaction energy of dark neutrinos with water molecules. The large density of anomalous $Z^0$ charge for doubly dark matter with $L_w \simeq n^3 \times .2\ \mu$m does not however require neutrino screening since color force can compensate the weak force as discussed in [F10]. The argument below shows that even in $k = 127$ neutrinos effective screening would require relativistic dark neutrinos since the density of dark neutrinos should be roughly one half of the density of water molecules for complete screening and too large by about three orders of magnitude.

3. The model for tritium beta decay anomaly gives the estimate $1/\mu m^3$ for the density of dark neutrinos in condensed matter. The density could of course be also higher in living matter. The requirement that dark neutrinos are non-relativistic implies strong bound on their density via Fermi momentum. One obtains

   $$E_F \ll m_\nu \ , \tag{3.3.1}$$

   which by using the expression for $E_F$ gives for effective dimensions $D = 1, 2, 3$ the bounds for $n_{\nu,D}$

   $$\begin{aligned} n_{\nu,1} &\ll \frac{1}{\sqrt{2}\pi}\frac{m_\nu}{\hbar} \ , \\ n_{\nu,2} &\ll \frac{1}{2\pi}\frac{m_\nu^2}{\hbar^2} \ , \\ n_{\nu,3} &\ll \frac{1}{6\pi^2}\frac{m_\nu^3}{\hbar^3} \ . \end{aligned} \tag{3.3.2}$$

   In large $\hbar$ phase the dark neutrino density is scaled down by a large factor. In 1-D case the 3-D density is obtained by dividing by the transversal area $S$ of the linear structure involved. The transversal size scale must at least be of the order of dark neutrino Compton lengths so that only numerical constants distinguish between the 3-D density in various effective dimensions.

Even for $k = 127$ the conditions guaranteing non-relativistic Fermi energy are non-trivial and read as

$$\begin{aligned}
n_{\nu,1} &\ll \sqrt{2}x\frac{1}{L(151)} \ , \\
n_{\nu,2} &\ll 2\pi x^2\frac{1}{L^2(151)} \ , \\
n_{\nu,3} &\ll \frac{8\pi}{6}x^3\frac{1}{L^3(151)} \ , \\
x &\simeq 11.3 \ .
\end{aligned} \tag{3.3.3}$$

The order of magnitude is few neutrinos per nm length scale which means that dark neutrino Cooper pairs with minimum size $L(151)$ have overlap which makes Bose-Einstein condensation possible. The upper bound for the density of Cooper pairs is considerably lower than the density of dark hydrogen nuclei if 1/4:th of hydrogen nuclei are in doubly dark phase: the ratio of 3-D densities is smaller than $(5.7, 8, 60) \times 10^{-4}$ for $D = 1, 2, 3$ if 1/4:th of hydrogen atoms are in dark phase and if all dark hydrogen atoms make a phase transition into a doubly dark phase in a given region. Therefore dark neutrinos cannot screen anomalous weak charge. Neutrino screening is not needed since long range color forces can compensate the repulsive weak force.

For $k \geq 151$ situation the conditions guaranteing non-relativistic Fermi momentum cannot be satisfied for dark neutrino density $\sim 1/\mu m^3$. Hence the conclusion seems to be that $k \geq 151$ dark neutrinos are most naturally relativistic.

4. $Z^0$ force is automatically vacuum screened above length scale $L_w$, which is about $3-6$ Angstroms for dark nuclear matter with $n = 3$ and $1.8 - 3.6$ $\mu$m for doubly dark case. In the latter case the screening condition does not pose condition on neutrino density. For $k \geq 151$ the condition implies that dark neutrinos are relativistic.

   $Z^0$ magnetic penetration length $\lambda_Z$ is obviously not longer than $L_w$. If there is active screening by supra currents one has $\lambda_Z < L_w$. This gives using $\lambda^2 = m_\nu/4\pi g_Z^2 n_c$

$$\begin{aligned}
n_{\nu,1} &> m_\nu L_w \times \frac{S}{4\pi g_Z^2 L_w^2}\frac{1}{L_w} \ , \\
n_{\nu,2} &> m_\nu L_w \times \frac{d}{4\pi g_Z^2 L_w}\frac{1}{L_w^2} \ , \\
n_{\nu,3} &> m_\nu L_w \times \frac{1}{4\pi g_Z^2 L_w^3}
\end{aligned} \tag{3.3.4}$$

   Here $S$ *resp.* $d$ is the transversal area *resp.* thickness of effectively 1-D *resp.* 2-D super conductor. Notice that this conditions does not involve $\hbar$ at all and it seems that the large value of $\hbar$ automatically implies that $L_w$ gives the magnetic penetration length. For $k = 151$ the 3-dimensional densities are in all cases of order few neutrinos per $L^3(151)$ so that the together with the conditions guaranteing non-relativistic Fermi energy these conditions force dark neutrino density to a rather narrow range. For $d = L(151)$ and $S = L(151)^2$ the lower bound for 3-D density is same in all cases and given by $n_{\nu,3} > .3/L(151)^3$ for $m(\nu_e) = .55$ MeV. The lower bound is by three orders of magnitude below the upper bound from the requirement that situation is non-relativistic. The upper bound for the 3-D density give the rough lower bound $\lambda > 10^{-3/2}L_w \simeq 6L(151) > \xi_T \simeq L(151)$, where $\xi_T$ is estimate for the transversal coherence length so that in the transversal direction type II superconductor would be in question. In longitudinal direction the coherence length $\xi_L = L_w > \lambda$ identified as a length of Cooper pair flux tube structure would mean type I super conductivity. The interpretation could be as follows. If axonal membrane is this kind of mixed superconductor, overcritical $Z^0$ magnetic field parallel to axon, would penetrate in flux quanta parallel to axon. For type I case transversal $Z^0$ magnetic field near criticality would penetrate into the axonal membrane as stripe like patterns with stripes of width $\lambda$.

The Compton length of neutrino gives lower bound for the thickness of the magnetic flux tube of the dark neutrino Cooper pairs.

1. $L(149)$ and $L(151)$ would correspond to lower bounds for thickness and length of the flux tubes for dark $k = 127$ neutrinos.In effectively 1-D case $k = 127$ with $S = L^2(149)$ neutrinos give for the neutrino density a lower bound which is of order one neutrino per $1/\mu m$. This would suggest that the lipid layers of cell membrane correspond to the pair of magnetic flux tubes defining the wormholy neutrino Cooper pairs.

2. One can also consider the possibility that the height of Cooper pairs is scaled up to $L(k_{eff} = 151 + 22) = L(173) = 20$ $\mu$m would give the length of the flux tube and axons between cell membranes are good candidates here. The vacuum screening of weak interaction above $L_w$ however strongly suggests $\xi < L_w$.

### 3.3.3 Dark neutrino superconductor as a quantum critical superconductor

The scarcity of the empirical guide lines forces the use of the model of quantum critical electronic superconductivity as the basic format. For $k = 127$ neutrinos the generalization of the wormholy model for electron Cooper pairs is not completely straightforward task since the finite range $L_w \simeq n^3 \times .2$ $\mu$m of exotic weak interactions causes delicacies.

#### The case of $k = 127$ neutrinos

The following arguments fix the generalization of the model for dark neutrino Cooper pairs in the case of $k = 127$ neutrinos.

1. Since the relevant length and mass scales of neutrinos and electrons are essentially identical, the dark neutrino Cooper pairs are expected to have similar sizes and are both associated with the boundaries between doubly dark and ordinary nuclear matter. In the case of cell cell interior and exterior would naturally correspond to these phases of matter. Of course, only partial darkness is possible: the model explaining the anomalies of water [F10] suggests that 1/4:th of hydrogen ions is in doubly dark phase in the cell interior and in dark phase in cell exterior.

2. The model of ORMEs as superconductors assumes that dark electrons have large $\hbar$ with $k_{eff} = 149$ and nuclei are in doubly dark phase with $k = 127$ dark quarks coupling to doubly dark $k = 113$ weak bosons possessing range of order $L_w \simeq n^3 \times .2$ $\mu$m. The wormholy Cooper pairs of dark electrons and neutrinos can be assumed to have same transversal size $L(149)$ as ordinary Cooper pairs.

3. The expression for the energy of Cooper pair has the general form $E = a/L^2 - b/L$ corresponding to kinetic energy and Coulombic interaction energy. The scaling up of $\hbar$ in the stability condition of for Cooper pairs discussed in [J1] amplifies the contribution of the kinetic energy by a factor $2^{22}$. This means that this factor also scales up the length of the Cooper pair to about 4 cm.

The situation is not quite this simple however. The most obvious implications of the finite range of the exotic weak force are $\lambda \simeq L_w$ and $\xi \leq L_w$, which is rather near to $L(167) = 2.5$ $\mu$m for $n = 3$. It simply does not make sense to talk about coherence and correlations above the weak length scale $L_w$. Therefore the energy of the Cooper pair is minimized subject to the constraint $L \leq L_w$ for the length of the Cooper pair which gives $L = L_w$. Situation remains the same even in the case of triply dark nuclear matter giving $L_w = n^3 \times .4$ mm.

Cell membranes and the dynamical endoplasma membranes within cell have interpretation as stripe like regions to which super-conducting dark electrons and neutrinos can be associated naturally. Macroscopic quantum coherence is often assigned to the ordered water in cell interior and the question is whether ordered water could correspond to doubly dark phase. One can also wonder whether the phase transitions between sol and gel phases associated with nerve pulse activity could correspond to transitions between dark and doubly dark phases. Since the transversal length scale of chromosomes and micro-tubules is also characterized by $L(151)$, it is natural to expect that dark electrons and neutrinos play key role in the dynamics of these structures.

**Is neutrino superconductivity possible for $k \geq 151$?**

For $k \geq 151$ the doubly dark coherence lengths are much longer than $L_w$ for doubly dark matter. One would however expect that the coherence length for Cooper pairs should be longer than the Compton length. Situation changes if dark nuclei correspond to triply dark nuclei with $L_w \simeq 3.6$ mm for $n = 3$ triply dark nuclei. The requirement that coherence length is longer than Compton length is satisfied up to $k = 157$ and for $k = 163, 167$ $L_w$ defines naturally the height of Cooper pair space-time sheet.

By the naive scaling the radius of the flux tube associated with neutrino Cooper pair would be $L(k+22)$, $k = 151, 157, 163, 167$. The naive scaling of $L(151)$ giving the height of the flux tube would give for the height of neutrino Cooper pair $L(k+44)$ which is longer than $L_w$ for triply dark matter. As in the previous case $L_w$ would be the upper bound for the height and would correspond to a maximal binding energy. These length scales would determine the transversal and longitudinal coherence lengths $\xi_T$ and $\xi_L$ of neutrino superconductor.

As already found, it is not possible to have non-relativistic Cooper pairs for reasonable values of dark neutrino density. Also stability condition assuming non-relativistic dark neutrinos leads to contradiction. Hence the energy of neutrino is difference of relativistic energy $E = 2\pi/L$ and $Z^0$ Coulombic interaction energy behaving in the same manner with respect to scalings. This implies that minimum energy is achieved for $L = L_w$. The scale of zero point kinetic energy would be $E = 2\pi/L_w \simeq E = 3.4$ K.

Unless ordinary and dark space-time sheets are thermally isolated, the BE condensate is thermally unstable for $k > 151$. For $k = 151$ dark neutrinos the critical temperature determined by $E_0 \sim 2\pi/L(151) \simeq 800$ K and gives critical temperature of order room temperature. Thermal isolation in reasonable time scales might be however possible since only de-coherence phase transition mediates interactions between ordinary matter and dark neutrinos.

The large values of these scales would mean that dark neutrino super-conductivity would relate to the control of smaller structures of size of order neutrino Compton length $\sim L(k)$ by structures of size $L(k+22)$. The de-coherence transition in which dark neutrino Cooper pairs decay to ordinary neutrinos would certainly be an essential aspect of this transition. The creation of ordinary neutrinos by the splitting of $\nu\overline{\nu}$ wormhole contacts (cognitive neutrino pairs) would be another facet of the quantum control.

### 3.3.4 Structure of brain and neutrino super conductivity

The structure of the brain affords evidence for the p-adic hierarchy of super-conductor structures associated with coherence lengths $\xi$ and suggests that sensory stimulus represents itself regions of larger $\hbar$ at various levels of the condensate containing cells activated by the sensory stimulus. Regions carrying magnetic fields could correspond to both the weak magnetic fields guaranteing effective one-dimensionality of the super conductor or magnetic fields associated with the defects of the super conductor.

Perhaps the entire organism could be regarded as a hierarchy of quantum critical super-conductors with super-conducting regions identifiable as boundaries between regions having different values of $\hbar$: the large the structure the larger the value of $\hbar$. The radius of curvature of cell membrane is so large that locally the magnetic field has constant direction.

In the absence of sensory input the condensate levels carry some preferred magnetic field configuration. The simplest possibility is the presence of constant magnetic or $Z^0$ magnetic field. The magnetic field of the flux tube containing the Bose-Einstein condensate of wormholy Cooper pairs does not destroy the super-conductivity based on spin 1 Cooper pairs. Topological field quanta are quite generally characterized by frequency type parameters $\omega_1, \omega_2$ and integers $n_1, n_2$ assignable to the increments of phases of $CP_2$ complex $CP_2$ coordinates around homologically nontrivial loops and analogous to angular momentum values [D7]. In particular, the integers $n_1$ could be carrier of biologically relevant information.

A fascinating possibility is that the Gaussian and ordinary Mersennes associated with $k = 113, 127, 151, 163, 167$ define the fundamental p-adic length scales and the large $\hbar$ satellites of these length scales could give rise fractal copies of the structures in these length scales scaled up by powers of $n/v_0 \simeq n \times 2^{11}$. In particular, the Mersennes $k = 127, 151, 157, 163, 167$ span 40 half octaves whereas the Mersennes $89, 107, 113, 127$ span 39 half octaves. Therefore one can wonder whether the biologically most relevant length scale range could contain a scaled down copy of elementary particle physics such that $k = 167, 163, 157$ correspond to three charged lepton generations.

Be as it may, the two lowest levels in the dark hierarchy cover the length scales associated with living organisms. Second fascinating possibility is that the twin primes $k, k+2$ might be of special biological relevance as the appearance of various twin structures in bio-matter would suggest. In the following the empirical evidence supporting these hypothesis is discussed.

### Structures in the cell length scale, miracle length scales, and twin primes

The miracle length scales defined by Gaussian Mersennes should make themselves manifest in cell length scales.

1. The two-layered structure of the cell membrane and of endoplasma membranes would naturally correspond to $k = 149$ and $k = 151$ p-adic levels. Membranes could be identified as regions between large $\hbar$ phase in the interior of cell and ordinary phase in the exterior of cell carrying wormholy Cooper pairs of electronic and neutrino type quantum critical superconductors and containing also cognitive neutrino pairs.

2. The interior of the cell contains structures, which might be identified with condensate levels $k = 163$ and $k = 167$, and might correspond to some higher levels in the information processing hierarchy of the cell. Cell nucleus with size in the range $5 - 10$ $\mu$m can accommodate all the miracle length scales. Biophotons [54] have energies in visible range and ultraviolet and visible wavelengths thus almost cover miracle length scales. For large $\hbar$ variants the wavelengths would be scaled up by powers of $n/v_0$ and these photons might be involved with quantum control of short length scales by longer length scales. The formation of Bose-Einstein type condensate of bio-photons could relate to the formation of gap junctions between cells.

3. The next level corresponds to a pair of length scales $L(167) = 2.5$ $\mu$m (lower bound for the cell size) and $L(169 = 13^2) = 5$ $\mu$m allowed if one generalizes length scale hypothesis so that it allows $k$ to be power of prime. The size of cell nucleus varies in the range 5-10 $\mu$ and one can wonder whether this length scale pair and corresponding Cooper pairs could relate to the twin structures formed by chromosomes and to the doubling of DNA during cell division.

4. Epithelial sheets consist of double cell layers and appear very frequently in multicellular bio-systems (skin, glands, sensory organs, etc.). It would be natural to interpret them as region in large $\hbar$ phases can be present. Eye provides an example of this kind of structure [34]: eye can be regarded as a composite structure consisting of single cell layer (rods and cones) and two-layered structure consisting of layers of bipolar cells and ganglion cells Great variety of super-conductors are possible at this length scale. These structures might involve doubly dark neutrino and electron super conductivity with transversal length scales $L(149 + 22) = L(171) = 10$ $\mu$m and $L(151 + 22) = L(173) = 20$ $\mu$m.

### Scaled up variants of cell membrane?

The information processing of the brain could involve dynamical membrane like structures inside the brain as dynamical units with electron and neutrino super-conductivity playing key role in the functioning of the structure. This would mean that the couplings between cells of the brain understood as neural net should have tendency to form dynamical two-dimensional surface like structures.

These higher level membranes could have functions analogous to those of ordinary cell membranes. Action potential between the cell layers and nerve pulse might be well defined concepts. These membranes could form cell like structures filled with dynamic "endoplasma" membranes. For instance, the twin primes $k = 179, 181$ could define generalized cell membrane like structure of thickness $L(181) \simeq 320$ $\mu$m.

Generalizing the ideas of TGD one might speculate that these membranes could act as Josephson junctions and communication between the structures should take place via counterparts of ordinary nerve pulses: also the existence of the counterpart of EEG is suggestive. Various parameters characterizing exotic nerve pulse and EEG should be related by simple scaling to those characterizing ordinary nerve pulse and EEG.

### Cortical structures and first level satellites of miracle length scales

The obvious place for the identification of large scale super conducting structures of is cortex. The relatively small thickness of the cortex (about 1 mm) implies that curvature effects do not mask the local cylindrical symmetry. Cortex is indeed known to possess columnar organization. For instance, in visual cortex there are two columnar structures with very complicated cross section perhaps identifiable as stipe like structures associated with quantum critical super-conductivity at higher level of dark matter hierarchy. These structures have also binary structure characteristic for the wormholy Cooper pairs.

*1. Field axis orientation columns*

The first columnar structure [34] in the visual cortex corresponds to the so called field axis orientation columns consisting of locally stripe like regions of cells (see Fig. 3.3.4), which preferentially react to the orientation of a bar of light in the visual field. The width of the stripes with fixed orientation is about $20-50$ $\mu$m [34].

The first large $\hbar$ satellite of $L(151)$ is indeed $L(173) = 20$ $\mu$m. A possible interpretation is that continued stimulus with fixed orientation creates at $k = 173$ level a cylindrical magnetic field configuration, which leaves only the regions reacting to this particular orientation in super conducting state. Doubly dark electronic and neutrino super conductors for which the length scales corresponding to $k = 171$ and 173 would appear naturally in the large $\hbar$ scaling of the cell membrane. It should be noticed that $k = 171$ corresponds to the upper bound 10 $\mu$m for the size of nucleus varying in the range 5-10 $\mu$m.

*Ocular dominance columns*

Ocular dominance regions consist of cells reacting appreciably to the stimulus from the second eye only, and form columnar structures [34] with complicated cross section and become visible via a continued stimulation of one eye only (see Fig. 3.3.4). The typical width of the stripe in the region is about $200-500$ $\mu$m.

The weak length scale of triply dark nuclear matter corresponds to $k_{eff} = n^3 \times 400$ $\mu$m so that $n = 1$ would make sense. The large $\hbar$ satellite of $L(157)$ is 160 $\mu$m.

The levels $k = 179$ and $k = 181$ forming a pair with $L(179) \simeq 160$ $\mu$m might be the relevant p-adic levels now. The ocular dominance columns associated with right and left eye alternate and the regions formed by right-left pairs of ocular dominance columns is a natural candidate for the double layered structure at level 179 involving Bose-Einstein condensate of wormholy Cooper pairs.

*3. Hyper columns*

The visual cortex contains also larger structures, "hyper columns" [34], which form basic units for the processing of visual information (and sensory information in general). These structures have roughly the size of order 1 mm, the thickness of the cortex. The large $\hbar$ satellite of $L(163)$ is 1.28 mm. $L(167)$ would give to large $\hbar$ satellite $L(167 + 22) = L(189) = .5$ cm. Also structures with this size scale could also appear in brain.

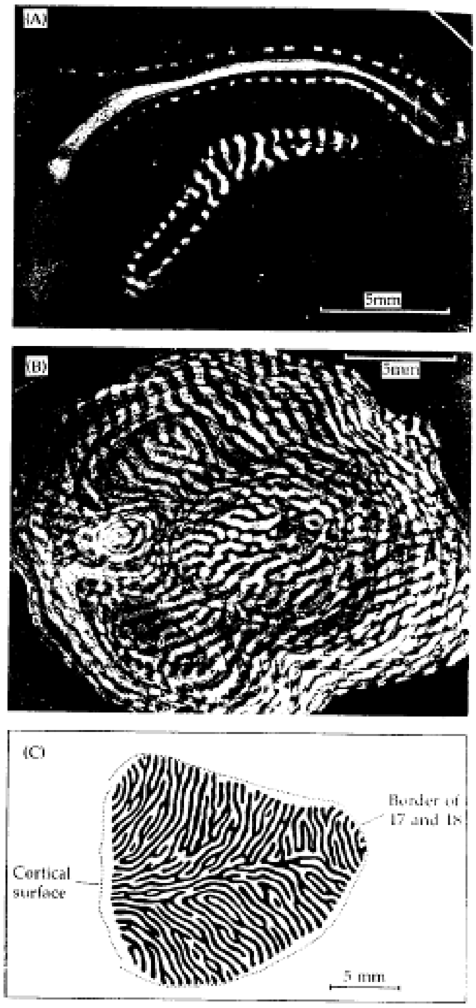
### Structures in the length scale of body and second level satellites of miracle length scales

In contrast to the prevailing view in neuroscience, in TGD framework entire body is seat of consciousness and brain only builds symbolic representations about sensory data. Also the idea about body as a passive receiver of commands from brain is given up and brain and body can be said to react to the desires of the magnetic body serving as a space-time correlate for the intentional me. Hence it makes sense to consider the possibility that also structures with scales larger than typical brain structures could be of importance for understanding conscious experience and functioning of living system.

The higher large $\hbar$ satellites of $k = 151, 157, 163, 167$ are $k = 195, 201, 207, 211$ and correspond to length scales 4 cm, 32 cm, 2.5 m, 10 m. k=163 and 167 could correspond to quantum critical super-conductivity in large sized organisms. These length scales could be also important for the structural organization of bio-systems. The fourth level in the hierarchy of dark nuclear matters would correspond to $L_w = n^4 \times .8$ m and might have relevance for information processing in the length scale of human body.

Double layered structures (both $k$ and $k+2$ primes) might appear in these length length scales.

1. For $k = 191, 193$ one has $L(191) \simeq 1$ cm.
2. $k = 197, 199$ is the largest doublet, which might be realized in bio-systems one has $L(197) \simeq 8$ cm. One cannot exclude the possibility that right and left brain hemispheres correspond to the condensation level $k = 197$ and whole brain to the condensation level $k = 199$.
3. For the next pair ($k = 227, 229$) (note the large gap in development) one has $L(227) \simeq 2500$ m, which is probably not realized in bio-systems at the level of organisms. One can of course ask whether biological organisms could form super organisms involving these higher levels.




4

OCULAR DOMINANCE COLUMNS IN MONKEY CORTEX demonstrated by injection of radioactive proline into one eye. (A) and (B) are autoradiographs photographed with dark field illumination in which the silver grains appear white. (A) This horizontal section first passes through the visual cortex at right angles to the surface displaying columns cut perpendicularly, then in the center horizontally through layer IV cutting columns tangentially. (B) Reconstruction made from numerous horizontal sections of layer IVC in another monkey in which the ipsilateral eye had been injected (no single horizontal section can encompass more than a part of layer IV of the cortex because of its curvature). Dorsal is above, medial to the right. In both (A) and (B), the ocular dominance columns appear as stripes of equal width supplied by one eye or the other. (C) Reconstruction of the pattern of ocular dominance columns over the entire exposed part of layer IVc. Scale 5 mm. (A and B from LeVay, unpublished, photos by courtesy of S. LeVay; C from LeVay, Hubel, and Wiesel, 1975.)

Figure 3.1:

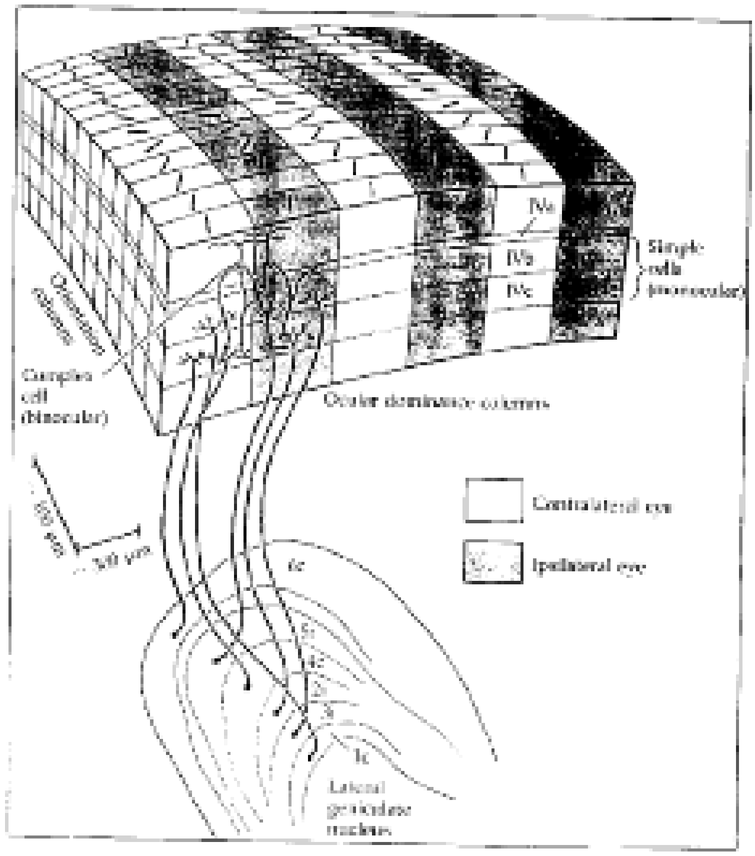
### 3.3.5 Cognitive neutrino pairs

The notion of cognitive neutrino pairs seems to survive the new interpretation of long range weak gauge fields although dramatic modifications of the model are necessary.

#### Cognitive neutrino pairs as $\nu\overline{\nu}$ wormhole contacts

Cognitive neutrino pairs can be identified as $\nu\overline{\nu}$ wormhole contacts. The throat carrying antineutrino quantum numbers would be at the space-time sheet carrying oxygen and ordinary hydrogen atoms so that $\overline{\nu}$ throat would experience only the ordinary weak force. The throat carrying neutrino quantum numbers would be at the space-time sheet of dark or doubly dark hydrogen ions. This would imply large negative weak interaction energy with the hydrogen ions which can be even larger than the mass of the neutrino. Hence the generation of cognitive neutrino pairs would be energetically favored and the splitting of the wormhole contacts could produce ordinary $k = 127$ antineutrinos and dark $k = 127$ neutrinos. The latter could in turn form Cooper pairs of dark neutrino super conductor.

The repulsive interaction between dark neutrinos and the weak screening caused by them implies that some maximum number of them can be generated (note that the compensation of weak force by




7 RELATION BETWEEN OCULAR DOMINANCE and orientation columns. Scheme in which the ocular dominance and orientation columns run at right angles to each other. An example of a complex cell is shown in an upper layer, receiving its inputs from two simple cells that lie in adjacent ocular dominance columns but share the same orientation columns. (From Hubel and Wiesel, 1972.)

Figure 3.2:

color force allows net weak charge). This means that cognitive neutrino pairs, besides serving in the role of bits arranged along linear structures defined by the stripes of doubly dark water ions, could also perform bio-control.

In a good approximation the mass of the cognitive antineutrino is obtained by scaling up the mass of ordinary $k = 169$ neutrino by a factor $2^{(169-127)/2} = 2^{21}$. Using the results of p-adic mass calculations [F3] this gives the estimates

$$\begin{aligned} m(\nu,127) &= \tfrac{L(169)}{L(127)} m(\nu_\mu,169) = 2^{21} m(\nu_\mu,169) \ , \\ m(\overline{\nu}_\mu,127) &= m(\overline{\nu}_\tau,127) \simeq 1.47\ MeV \ , \\ m(\overline{\nu}_e,127) &\simeq .55\ MeV \ . \end{aligned} \tag{3.3.5}$$

For $k = 127$ electron neutrinos mass is about .55 MeV.

The $Z^0$ Coulombic interaction energy of dark $k = 127$ neutrino with water molecule is obtained by integrating the Coulomb potential energies with hydrogen ions carrying anomalous $Z^0$ charge for a stripe stripe of length $L_w \simeq n^2 \times .2\ \mu$m containing doubly dark hydrogen ions. The expression for the interaction energy is given by

$$
\begin{aligned}
E &= \int_0^{L_w} V_Z(\nu, p) n dz dS \ , \\
V_Z &= \alpha_Z Q_Z(\nu) Q_Z(p) \frac{z - L_w}{S} \ , \\
n &\simeq \frac{1}{2} n_{H_2O} \simeq \frac{1}{2} \times \frac{1}{18a^3} \ , 
\end{aligned}
\tag{3.3.6}
$$

where $S$ is the transversal area of the stripe, $n_{H_2O}$ is the number density of water molecules, $Q_Z(p)$ is the anomalous $Z^0$ charge assignable to proton: twice the $Z^0$ charge of neutrino, and $a = 0.1$ nm is natural unit of length.

This gives

$$
\begin{aligned}
E &= \frac{1}{72} \alpha_Z Q_Z(\nu) Q_Z(p) (\frac{L_w}{a})^2 \times \frac{1}{a} \ , \\
\alpha_Z &= \frac{\alpha_{em}}{sin(\theta_W) cos(\theta_W)} \ , \ Q_Z(\nu) = \frac{1}{4} + sin^2(\theta_W) \ , \ Q_Z(p) = -2Q_Z(\nu) \ , \\
L_w &= n \times 2 \times 10^3 a \ .
\end{aligned}
\tag{3.3.7}
$$

For $n = 1$ one obtains the estimate $E = .76$ MeV which is smaller than the estimate $M_w = 2m_{\nu_e} = 1.1$ MeV for the mass of $\nu_e \overline{\nu_e}$ wormhole contact. For $\mu$ and $\tau$ neutrinos one would have $M_w = 2m_{\nu_\mu} = 2.9$ MeV. For $n = 3$ the formula gives 6.5 MeV. Therefore the generation of cognitive neutrino pairs should occur spontaneously for $n = 3$ and for electronic neutrinos perhaps also for $n = 1$.

One can also consider the possibility wormhole contacts for which throats correspond to $k = 151$ exotic neutrinos coupling to $W$ bosons with $L_w = n \times a$. Electron neutrino is estimated to have mass 138 eV. In this case the average binding energy would be

$$
E = \frac{n^3}{36} \alpha_Z Q_Z(\nu) Q_Z(p) \frac{1}{a} \ . \tag{3.3.8}
$$

$n = 1$ gives $E = .44$ eV, which happens to belong to the energy range metabolic energy quantum whereas $n = 3$ gives $E = 3.9$ eV. Spontaneously occurring generation of wormhole contacts is not favored in this case.

### Model for the generation of cognitive neutrino pairs

The generation of cognitive neutrino pairs is a purely TGD based phenomenon made possible by the large binding energy of $k = 127$ dark neutrinos in condensed matter which is much larger than neutrino rest mass. This makes possible a process in which neutrino-antineutrino pair having negative total energy and other quantum numbers is generated by the splitting of $\nu\overline{\nu}$ wormhole contact connecting the space-time sheet containing ordinary nuclei of water molecules and the space-time sheet containing doubly dark hydrogen ions. Antineutrino is assumed to correspond to the throat at the ordinary space-time sheet and neutrino to the throat at doubly dark space-time sheet. The splitting of the wormhole contact gives rise to neutrino antineutrino pair and dark neutrinos could in turn form Cooper pairs so that the generation of wormhole contacts could serve control purpose.

$\nu\overline{\nu}$ wormhole contact defines a cognitive neutrino pair in the sense that dark neutrino spin defines naturally a representation of bit. The spin of cognitive neutrino pairs can be flipped if the space-time sheet of dark neutrinos contains dynamical $Z^0$ magnetic field.

One can also consider the possibility that cell membrane represents double sheeted cognitive structure, 'wormhole magnetic field', glued to the outer boundary of cell, and that $Z^0$ magnetic field is generated by rotating $Z^0$ wormhole contacts [J5]. The conservation of $Z^0$ magnetic flux might however contradict the assumption that $Z^0$ fields are short ranged at the space-time sheet of ordinary atoms. The required magnetic field must be rather strong and cell membrane provides an excellent candidate for the regions at which cognitive neutrino pairs are created. The large value of $\hbar$ also increases the size of magnetic flux quantum by a factor $2^{11}$.

### Relativistic and non-relativistic cognitive neutrino pairs

There are two options concerning the modelling of cognitive neutrinos corresponding to relativistic and non-relativistic situations. At the relativistic limit the expressions for energies of the states

$$\begin{aligned} \omega(n+1,up) &= \sqrt{2n-\Delta g/2}\sqrt{Q_Z(\nu)g_ZB_Z} \ , \\ \omega(n,down) &= \sqrt{2n+\Delta g/2}\sqrt{Q_Z(\nu)g_ZB_Z} \ . \end{aligned} \tag{3.3.9}$$

where $\Delta g$ represents anomalous $Z^0$ magnetic moment of dark neutrino which is extremely small but crucial in the model of hearing [M6]. For the considerations to follow the value of $\Delta g$ does not matter.

For the second option cognitive neutrino is non-relativistic (classically this guarantees that cognitive antineutrino does not escape from the system) and the energies are given by

$$\begin{aligned} \omega(n+1,up) &= (n-\frac{\Delta g}{4})\omega_c \ , \\ \omega(n,down) &= (n+\frac{\Delta g}{4})\omega_c \ , \\ \omega_c &= \frac{Q_Z(\nu)g_ZB_Z}{m(\overline{\nu})} \ . \end{aligned} \tag{3.3.10}$$

The very low frequency associated with the transition $\omega(n+1,up) \leftrightarrow \omega(n,down) = \frac{\Delta g \omega_c}{2}$) codes for audible frequencies in the model of hearing [M6].

### Quantization of the $Z^0$ magnetic flux

Quantization of the $Z^0$ magnetic flux applied to the cylindrical shell defined by the axonal cell membrane gives the constraint

$$\begin{aligned} 2Q_Z(L)g_ZB_Z &= \frac{k\hbar}{dR} \ , \\ Q_Z(L) &= \frac{1}{4} - sin^2(\theta_W) \simeq .02 \ . \end{aligned} \tag{3.3.11}$$

$k=1$ is the minimum value of the integer $k$. $d \simeq L(151)$ denotes the thickness of the cell membrane and $R$ is the radius of the axon. Here the electronic $Z^0$ charge of $Q_Z(L)$ must be used. The requirement that flux quantization condition holds also true for the Cooper pairs of neutrinos implies the the ratio of corresponding $Z^0$ charges is integer: this gives

$$\frac{Q_Z(\nu)}{Q_Z(L)} = \frac{\frac{1}{4}+sin^2(\theta_W)}{\frac{1}{4}-sin^2(\theta_W)} = n \ . \tag{3.3.12}$$

This condition allows infinite number of solutions

$$sin^2(\theta_W) = \frac{k}{4k+1} \ , \ k = 0,1,2,\cdots \ . \tag{3.3.13}$$

varying in the range $(0,1/4)$. For $k=3$ one has

$$sin^2(\theta_W) = \frac{3}{13} \simeq .23072 \ . \tag{3.3.14}$$

It deserves to be noted that the solution is equivalent with the condition $4sin^2(\theta_W) = 24/26$: rather amusingly, the basic dimensions of bosonic string model appear in this expression. Not only amusingly, this value is consistent with the high precision value of Weinberg angle $sin^2(\theta_W) = .2294 \pm .001$ measured in 1994 by K. Abe and collaboration [27].

If $2Q_Z(L)$ as unit of $Z^0$ magnetic flux, the resulting unit of magnetic flux is by a factor 25 larger than when $2Q_Z(\nu)$ is used as unit. The weakest possible $Z^0$ magnetic field has strength of about $.5\times 10^{-4}$ Tesla (strength of Earth's magnetic field) for $2Q_Z(\nu)$ option whereas for $2Q_Z(L)$ option this field has strength of about $.25\times 10^{-2}$ Tesla.

The unit of quantization increases by a factor $\simeq 2^{11}$ if neutrino is in large $\hbar$ phase. This scales up the value of the magnetic transition energy scale $E=\hbar\omega_c$ by a factor $\simeq 2^{22}$. For electron neutrino with mass .55 MeV and $2Q_Z(\nu)$ as a unit this scale is predicted to be 90 K which is below room temperature. For $2Q_Z(L)$ as unit the scale is .45 eV which corresponds to the metabolic energy quantum.

**Does the quantum model of hearing survive the new interpretation of long ranged weak fields?**

Cyclotron frequency scales down by a factor 1/2 in the transition $(k=151\rightarrow 127,\hbar\rightarrow 2^{11}\hbar)$ for neutrinos so that the cyclotron frequency scale is preserved. This does not yet guarantee that the earlier quantum model for hearing relying crucially on the scale $\Delta g\times\omega_c$ survives. The proportionality $\Delta g\propto \alpha_Z m_\nu m_\tau/m_W^2$ [M6] with $\nu$, $\tau$ and $W$ referring now to the exotic counterparts of these particles means that $\Delta g$ does not automatically remain invariant in the transition from standard weak physics to exotic weak physics. The loss of quantum model for hearing would be highly regrettable since it has been one of the basic quantitative victories of TGD inspired theory of consciousness.

One might of course hope that the universality suggested by quantum criticality could imply the approximate invariance of $\Delta g$. The transition $k=89\rightarrow 113$ for $W$ $[L_w=L(k_{eff}=113+44)]$ means the scaling of $W$ mass by a factor $2^{-12}$. Taking into account that $\alpha_Z m_\nu/m_W^2$ gives a scaling factor $2^{-11+12+24}=2^{25}$, the invariance of $\Delta g$ requires $k_\tau=107+50=157$.

This lends support to the speculative idea that the exotic charged leptons $(e,\mu,\tau)$ could correspond to Gaussian Mersennes $(167,163,157)$ in analogy with the Mersenne hierarchy $(127,113,107)$ for the ordinary charged leptons. $k_{eff}=107+44=151$ corresponds to doubly dark hadronic space-time sheet and exotic QCD. As in the case of ordinary hadrons also quarks would correspond to these length scales with $k=167$ defining the counterpart of exotic $k=127$ quark. The $k=167$ exotic electron would have mass .5 eV: the miraculous metabolic energy unit pops up again and again.

What looks admittedly strange is that exotic neutrino mass scale would be higher than the mass scale of exotic charged leptons. Somehow it seems that the actual p-adic length scale of exotic neutrino must be longer than $L(167)$.

1. There exists experimental evidence for several scaled up variants of ordinary neutrinos but a convincing picture about the nature of the process changing neutrino mass scale is lacking. For instance, ordinary neutrinos emitted in weak interaction vertices could correspond to the p-adic length scale $M_{89}$ of weak bosons and have p-adic temperature $T_p=1/2$ implying that the neutrino corresponds effectively to the p-adic length $L(2\times 89=178)$ and mass scale $10^{-2}$ eV. The size of the space-time sheet of the emitted neutrino could be reduced in a process analogous to de-coherence. The increase of the p-adic prime in this process would force p-adic heating increasing the p-adic temperature of neutrino to $T_p=1$. The reduction of the size of an exotic neutrino [ characterized by even longer p-adic length scale than $L(k_{eff}=178)$] to $L(127)$ does not however look plausible.

2. The understanding of the mass scale could come from quite different direction. There is evidence for leptohadron physics for which colored excitations of charged leptons give rise to color bound states [F7]. Colored excitations of leptons could correspond to the presence of $k=127$ dark quark pairs inside leptons of leptopion making them color octets. This would be completely analogous to their appearance at the ends of color bonds connecting nucleons to nuclear strings in the model of atomic nucleus [F8]. An interesting possibility is that the $k=127$ quarks associated with the ends of the color bonds connecting neutrino space-time sheets increases the mass scale of much more lighter exotic neutrino to $k=127$. Also the electrons associated with lepto-pions could correspond to $k=167$ mass scale.

**$\nu\overline{\nu}$ wormhole contacts as a source of the $Z^0$ magnetic field?**

$Z^0$ magnetic field must be generated by some mechanism. In the case of wormholy Cooper pairs the magnetic flux could flow between homological magnetic monopoles at the ends of the flux tubes defining the Cooper pair. In recent case lipid layers of the cell membrane would carry the magnetic fluxes in question.

Second possibility is that the $Z^0$ current creating the $Z^0$ magnetic field is a surface current flowing at the boundaries of the space-time sheet of the lipid layer. The magnitude of the surface current measured using $g_Z$ as unit is from Maxwell equations

$$K = \frac{\hbar k}{Rd} . \tag{3.3.15}$$

$k$ is the integer appearing in the previous conditions for the quantization of magnetic flux and equals to $k = 1$ by previous argument.

$K$ could correspond to the surface currents of rotating $\nu\overline{\nu}$ wormhole contacts. The directions of rotation on the two sides of membrane should be opposite. In this case one has

$$K = n\beta\hbar = \frac{\hbar}{Rd} ,$$

where $n$ is surface density of neutrinos and $\beta$ is the rotation velocity of the wormhole contact behaving like neutrino at the dark neutrino space-time sheet. This gives

$$n_2 = \frac{\hbar}{Rd\beta} .$$

The value of the velocity should be small and this gives lower bound $n \gg \hbar/Rd$ for the surface density of wormhole contacts. The lower bound for the average density of cognitive antineutrinos in the axonal volume is

$$n_3 = \frac{2\hbar}{R^2 d} \sim 8 \times 10^2 \frac{\hbar}{L(169)^3}$$

for $R = L(169)$.

## 3.4 Atmospheric phenomena and super-conductivity

There is a lot of evidence that various electromagnetic time scales associated with the atmospheric phenomena correspond to those associated with brain functioning. If magnetic sensory canvas hypothesis holds true, this is just what is expected. In this section these phenomena are considered in more detail with the aim being to build as concrete as possible vision about the dynamics involving the dark matter Bose-Einstein condensates at super-conducting magnetic and $Z^0$ magnetic flux quanta.

### 3.4.1 Tornadoes as a macroscopic quantum phenomenon involving $Z^0$ super-conductivity?

Tornadoes represent a piece of not completely understood atmospheric physics. To mention just two questions which have received no satisfactory answer.

1. What makes possible the ability of tornado to preserve its structure and coherence?
2. What makes possible the coherent rotation of matter inside tornado?
3. How to understand various luminous phenomena associated with the tornadoes [58, 59, 60]?

Classical $Z^0$ forces and the vision about $Z^0$ magnetic flux tubes as $Z^0$ super-conductors suggests a new approach to the physics of tornados possibly providing also answers to these questions. The ideas about tornadoes have evolved in three steps: tornadoes as $Z^0$ magnetic spiral vortices, tornadoes as magnetic of $Z^0$ magnetic analogs of a rotating magnetic system known as Searl device, and tornado as a system corresponds to scaled up dark matter variant of cell like structure. These approaches, probably not mutually consistent in every detail, will be discussed in the following.

#### Tornadoes as $Z^0$ magnetic spiral vortices?

The basic idea is that tornadoes are a phenomenon involving complex many-sheeted space-time topology and classical $Z^0$ magnetic fields in an essential manner making tornadoes also macroscopic quantum systems in meteorological length and time scales.

1. A partial answer to the question relating to the stability and coherence is self-organization, which in fact implies in TGD context that tornado has 'self' and is conscious in some primitive sense. In standard physics context the ability of tornado to have a well defined macroscopic structure despite the locally chaotic nature of the hydrodynamic flow involved, is not easy to understand. In particular, self-organization does not as such explain the coherent rotation of the matter inside tornado.

2. In TGD framework the answer to the question relating to the rotation of matter inside tornado is that tornado corresponds to $Z^0$ magnetic flux tube or more generally a more complex structure consisting of $Z^0$ magnetic flux quanta, say flux walls.

   This implies that ions rotate with almost the same rotation velocity in same direction in the $Z^0$ magnetic field associated with the space-time sheet of the tornado. Although rotation velocities can have both signs, coherent motion in single direction can occur stably. $Z^0$ magnetic field is generated if all neutrinos do not co-rotate with the matter or if the screening of nuclear $Z^0$ charge by neutrinos is not complete. Conducting and super-conducting neutrinos are expected to be unable to follow the rotation of the nuclei whereas the neutrinos below Fermi surface should co-rotate with matter so that $Z^0$ magnetic field can be generated. Situation is completely analogous to that of an electric conductor.

3. The quantization of $Z^0$ magnetic field of tornado to flux tubes structures suggests strongly itself and classical orbits of $Z^0$ charges in average $Z^0$ magnetic field correspond to $Z^0$ magnetic flux tubes with helical shape. In case of tornado these flux tubes are expected to have spiral like structure implied by garden hose instability and provide an example of spiral waves which seem to be a very general phenomenon in excitable media. Just like the flux tubes of the magnetic field, also $Z^0$ magnetic flux tubes are expected to be super-conducting.

4. The mechanism for the breaking of the ordinary super-conductivity in case of the magnetic flux tubes is based on the idea that for curved flux tubes ionic current with an overcritical ion velocity leaks along join along boundaries bonds from the magnetic flux tubes to non-super-conducting space-time sheets. The reason is simply the inertia of the charged particle. This process implies the generation radiation in case of the ordinary electromagnetic ions. This process occurs in the reconnection of magnetic flux tubes and more generally, when the curvature of flux tube becomes very large so that the inertia of the particle drives it to a larger space-time sheet. The model applies also to $Z^0$ magnetic case and if the particles are ordinary em ions, the generation of radiation is expected also now. Of course, also the collisions of neural particles generate also radiation but not so much.

   This mechanism, besides providing a model for dissipation, might explain the luminous phenomena associated with tornadoes [58, 59, 60]. Tornadoes are expected to involve also ordinary magnetic fields and corresponding flux tube structures so that also they could give rise to luminous phenomena by the same mechanism as in the case of auroras.

5. In fact, the vortices of any hydrodynamic flow correspond to $Z^0$ magnetic vortices: in particular, the mechanism inducing transition from superfluidity to ordinary fluid flow is generation of $Z^0$ magnetic vortices at critical velocities which are much lower than those predicted by hydrodynamical arguments [D7]. The leakage mechanism of radial em or $Z^0$ supra currents from magnetic flux tubes might be involved with the dissipation and also with sono-luminescence.

#### Tornadoes as rotating magnetic and $Z^0$ magnetic systems

A useful analogy for the tornado is provided by rotating magnetic system known as Searl device [75]. This system starts to spontaneously accelerate at certain critical rotation frequency. The TGD inspired model for the system is discussed in [G2]. Spontaneous acceleration is accompanied by spontaneously occurring concentric cylindrical magnetic walls of thickness $\simeq .5$ cm with mutual distance of $\simeq .5$ m. Magnetic walls have thickness allowing the interpretation as scaled up counterparts of cell membrane for $k_d = 2$. Magnetic walls would contain dark matter Bose-Einstein condensates in cyclotron state carrying maximal magnetic field of $B = .05$ Tesla. Magnetic walls could serve as angular momentum and energy storages from which the system draws energy by time mirror mechanism which means sending of negative energy phase conjugate photons absorbed by the Bose-Einstein condensate.

The observed ionization of air in the vicinity of the rotating system is explained in terms of an Ohmic current generated by the radial vacuum electric field implied by the rotating magnetic field. Since the electric field corresponds to non-vanishing vacuum charge density, this current charges the rotating magnetic system. Current carriers drop from atomic space-time sheets to larger space-time sheets at the boundary of the system liberating their large zero point kinetic energy of order 1 keV. The resulting voltage allows in principle to use the system as an over-unity device by adding load to a wire connecting the system to ground. The model leads to the proposal that rotating magnetic flux quanta provide a fundamental mechanism leading to the generation of plasmoids, which can be regarded as primitive living systems [57].

The identification as a rotating magnetic system allows to interpret the luminous phenomena associated with tornadoes [58, 59, 60] in terms of a plasma resulting from the dropping of electrons of radial Ohmic currents to large space-time sheets. An analogous leakage to larger space-time sheets would be presumably associated with auroras. The angular momentum stored to dark Bose-Einstein condensates at the magnetic and $Z^0$ magnetic walls would provide angular momentum and energy for the tornado. As a matter fact, the formation of these Bose-Einstein condensates could force the rotation of tornado by angular momentum conservation.

#### Tornadoes as dark matter systems

The identification of tornadoes as large $\hbar$ systems is suggested by the ability to self-organize and preserve the self-organization pattern for relatively long periods of time. Dark matter would imply self organization and make the system living in a primitive sense.

There are several kinds of tornadoes [61]. For supercell tornadoes called twisters the width is usually below $d = 90$ m but can sometimes extend over 1.6 km. Wind velocity is typically $v = 160$ km/h= 44 m/s. This gives rough estimate for the angular velocity associated with tornado as $\omega = v/d$. The corresponding frequency is $f = 1/2\pi$ Hz.

Assume that dark variants of $k = 113$ weak bosons are responsible for long range weak fields possibly involved with the rotating system and that also rotating magnetic fields defining something very much analogous to the inner magnetosphere of Earth are involved. Denote by $k_d^{em}$ and $k_d^W = k_d^{em} + 2$ weak and em dark matter levels respectively and assume $\lambda = 2^{11}$.

1. For weak $k_d^W = 4 = k_d^{em} + 2$ the thickness of scaled up cell membrane like structure is $d_m = 2 + 2 = 4$ cm whereas $d = \lambda \times d_m = 80$ m corresponds to an upper limit for the size for super cell identified as a scaled up cell like structure in em case. $L_W = 2^{22} \times .2$ $\mu$m= .8 m defines the upper limit for the thickness of the weak magnetic walls. The appearance of $d_m$ as upper bound for with of twister supports the similarity of the dynamics of twisters and rotating magnetic systems.

2. For weak $k_d = 5$ level one has $L_w = 1.6$ km, which suggests that largest tornadoes correspond to $k_d^W = 5 = k_d^{em} + 2$ systems. The prediction would be that magnetic walls of thickness 40+40 m are present at this level. Hurricanes having much larger width could correspond to $k_d^W = 6 = k_{em} + 2$ level of dark matter hierarchy with $L_W(5) = 3355$ km and $d_m(4) = 168 = 84 + 84$ km. This wall structure should reflect itself in the visible properties of tornadoes and hurricanes.

Consider now this picture more quantitatively in case of tornadoes.

1. Both em and $Z^0$ magnetic fields can be considered as being associated with the vortex and by previous argument would correspond to $k_d^{em} = 2$ and $k_d^W = 4$. A natural guess would be that magnetic flux quanta correspond to walls except in the central region where magnetic or $Z^0$ flux tube could exist as in the case of rotating magnetic systems.

2. In electromagnetic case only the cyclotron energies of electron Cooper pairs are stable and this only if the magnetic field at magnetic walls of thickness 4 cm is of the same maximal magnitude

$B = 2^{10}B_E = .05$ Tesla as for rotating magnetic system. Cyclotron energy for electron is $E_c = 10$ eV for $k_d = 2$. For proton Cooper pair $E_c$ would be below 11 meV and below the thermal stability limit of .086 eV at room temperature.

3. Exotic neutrinos with $k = 127$ and having same mass scale as electrons are necessary if one wants to preserve the model for cognitive neutrino-antineutrino pairs [M6]. Note that these neutrinos do not contribute to the decay width of ordinary intermediate gauge bosons since they do not couple to them. The long range weak interaction mediated by dark $k = 113$ weak bosons essentially massless below the length scale $L_W$ would make possible the formation of neutrino Cooper pairs by a mechanism similar to that applying in the case of electrons. Neutrino Cooper pairs could generate the $Z^0$ magnetic field inside $Z^0$ magnetic wall. The field would be given by $B_Z = 2K_Z$, where $K_Z$ is the magnitude of oppositely directed neutrino Cooper pair surface currents at 2 cm thick boundaries of say .5 m thick $Z^0$ magnetic wall (this would conform with 2 cm+ 2 cm decomposition of boundary layer analogous to the decomposition of cell membrane to lipid layers).

   Second possibility is provided by exotic $O_2$ and $N_2$ ions for which with atomic nuclei possess some charged color bonds making them both em and $Z^0$ ions. Exotic ions could form Bose-Einstein condensates in the $Z^0$ magnetic field created by surface supra currents of neutrino Cooper pairs. Weak length scale $L_w(k_d = 4) = .8$ m gives upper bound for the thickness of the $Z^0$ magnetic walls. This suggest that the distance $d = .5$ m between magnetic walls in Searl device could correspond to the thickness of $Z^0$ magnetic wall (parity breaking provides evidence for the presence of also $Z^0$ fields in the system).

   For the thickness $d_W = .5$ m of $Z^0$ magnetic walls and for $g_Z B_Z = eB_E = .5$ Gauss $k_d = 4$ flux quantization condition is satisfied for the distances $R > 1$ m from the center of vortex. For neutrino Cooper pairs the order of magnitude for cyclotron energies is 44.6 keV and still considerably smaller than $k = 127$ neutrino mass. The order of magnitude for the exotic ion cyclotron energies is from flux quantization $E_c = (Z/A) \times E_p(k_d = 4) \simeq (Z/A) \times 21.8$ eV, where $Z$ is the anomalous em charge of exotic ion and $A$ its mass number. ($A = 24$ for $O_2$ and $A = 28$ for $N_2$) so that thermal stability is achieved at room temperature.

4. The rough estimate of the angular momentum, call it $L$, from the basic data and from the classical formula for cyclotron orbits, call it $L_c$, gives some grasp about the angular momentum storage idea. For $Z^0$ magnetic case the estimate for angular momentum using $L = MvR$ with $v = 40$ m/s, $R = 50$ m, and $M = Am_p$, is by a factor $(A/Z) \times (v/\omega_p R) \sim (A/Z) \times 2.7 \times 10^{-3}$ smaller that the classical estimate $L_c = M\omega R^2$, $\omega = ZeB/Am_p$, for $B = .5$ Gauss. For neutrino Cooper pairs $L$ is $2.6 \times 10^{-6}$ smaller than $L_c$. For electronic Cooper pairs $L$ would be by a factor $\sim 1.3 \times 10^{-9}$ smaller than $L_c$ so that quite impressive amount of angular momentum and also energy could be stored to cyclotron states (note however that for each value of principal quantum number $n$ also state with $L_z = 0$ is possible.

### 3.4.2 Auroras as an astrophysical quantum phenomenon?

Auroras are perhaps the most magnificent electromagnetic phenomenon in the atmosphere. The mechanism generating the auroras is not completely understood. What is however known that auroras involve the motion of ions along flux lines of Earth's magnetic field acting effectively as current wires. This suggest the that the ionic currents could be supra currents running along the flux tubes of the magnetic field of Earth or its dark counterpart $B_{end} = 2B_E/5$ suggest to exist on basis of findings about the effects of ELF em fields on vertebrate brain [M3]. Hence auroras could be a directly visible macroscopic quantum phenomenon! In the following a model of auroras based on this vision and explaining the latest findings about them is developed.

#### Basic facts, ideas and puzzles related to auroras

Auroras occur at heights of 56-970 km along a circle surrounding the magnetic North (South) pole [28]. Magnetic storms accompany auroras and auroras are especially intense during sunspot maxima. Protons and electrons of the solar wind are known to flow along magnetic flux lines acting effectively as current wires. Some mechanism accelerates electrons and protons during their travel to the pole region where they collide with the ions (mainly oxygen and nitrogen) of the ionosphere and generate visible light. The spectral lines correspond to ionic transitions and each color corresponds to a particular ion dominating at a particular height.

A brief summary of the basic ideas and problems related to the auroras is in order before representing TGD based model.

1. The reconnection of solar magnetic field lines carried by solar wind with the field lines of Earth's magnetic field was proposed by James Dungey as a mechanism explaining the energetics of the auroras. There is indeed increasing empirical support for the view that the reconnection of the magnetic field lines of Sun and Earth accompanies auroras [33, 30, 31]. What would happen would be that the reconnected nearby opposite fields lines form a tightly bent U-shaped structure which straightens and acts as a catapult giving recoil energy to the plasma ions flinging in the direction of Earth. The highly energetic protons and electrons of the solar wind would flow towards Earth and collide with the ions of atmosphere and generate the auroras in this manner. The detailed understanding of the reconnection mechanism is lacking and here TGD suggests microscopic topological description relying on magnetic flux tubes.

2. The problem of the reconnection mechanism is how the solar and earthly magnetic flux lines running in opposite directions and carrying opposite currents know of each other and can change their direction so that the lines can meet. In TGD framework the reconnection of the magnetic flux tubes could be seen as a process changing space-time topology. At the point of reconnection magnetic field becomes zero in Maxwell's theory and it is thought that the charged particles must be able to leave the flux lines by some unknown mechanism so that demagnetization occurs. TGD in turn suggests that inertial effects force ions flow to larger space-time sheets along join along boundaries bonds.

3. An electric field parallel to the magnetic flux lines has been postulated as the mechanism of acceleration: empirical evidence for the existence of this electric field has been found quite recently [32]. Two U shaped potential regions with positive *resp.* negative charges have been found at heights 5000-8000 km *resp.* 1500-3000 km. It is convenient to christen lower U shaped region as $\cap$ and the upper one as $\cup$. The negatively charged region feeds electrons to the aurora region and positively charged region sucks them back. There is however no consensus about how this kind of electric field is generated and how it could be stable.

#### TGD based model for auroras

There are several poorly understood aspects related to the modelling of auroras. TGD approach provides new views to these problems. The following vision is perhaps the most plausible option discovered hitherto.

1. The electronic and protonic currents in the ionosphere of Earth would flow as supra currents for $k_d = 4$ level of dark matter hierarchy. If the flux tubes of solar wind and of magnetotail have $k_d = 5$, the flux tubes inside and outside ionosphere would be roughly of the same transversal area. For this option electron Cooper pairs and bosonic ions up to atomic number $A \leq 16Z$ can form Bose-Einstein condensates $k_d = 5$ flux tubes.

2. The reconnection of field lines generalizes to reconnection of magnetic flux tubes. The large inertia of ions in reconnection process from solar wind flux tube can induce their leakage and subsequent transfer to the upper magnetic flux tube in reconnection process. This would accumulate negative charge to the lower and positive charge to the upper U shaped flux tube.

3. The rapid straightening of the lower U shaped flux tube behaving like rubber band provides the mechanism of acceleration and brings ions of solar wind to the ionosphere where the collision with the flux tubes of inner magnetosphere induces the collision of electrons and ions and generates auroras. The liberation of cyclotron energy of electrons in cyclotron transitions of Bose-Einstein condensate of Cooper pairs of electrons and protons, and possibly even of exotic $O^+$ ions makes possible ionization and electronic excitations of ions involved.

*1. Could em currents flow along magnetic flux quanta of solar and Earth's magnetic field as supra currents?*

The question is under what conditions the statement that charged particles move along the flux lines of Earth's magnetic field without appreciable dissipation translates in TGD framework to supra currents flowing along the flux tubes of Earth's magnetic field.

1. Consider first the flux tubes of solar wind. The solar wind is made of Hydrogen (95%) and Helium (4%) and Carbon, Nitrogen, Oxygen, Neon, Magnesium, Silicon and Iron ($\simeq 1\%$). The magnetic field has strength $\sim 10$ nT. Electron Cooper pairs at $k_d = 4$ level of dark matter hierarchy would have cyclotron energy $E_c = 8$ eV which is below the temperature $T \simeq 15$ eV of solar wind near Earth but proton Cooper pions and ion Coopers would not satisfy it. For $k_d = 5$ $E_c(e) = 16$ keV implies that electronic Cooper pairs satisfy the stability condition. Protonic cyclotron energy would be 8 eV and below the thermal stability limit.

2. Consider next flux tubes in magnetotail. In magnetotail the field strength of Earth's magnetic field is around 30 nT in the lobes of the inner magnetosphere at the night side of Earth and temperature is around .5 eV (metabolic energy quantum again) so that critical cyclotron energy is $E_{cr} = 2.88 \times T = 1.44$ eV. Proton's cyclotron energy would be 12 meV for $k_d = 4$ so that Cooper pairs would not be possible in magnetotail. For electron the cyclotron energy would be 24 eV. An interesting question is whether Bose-Einstein condensates of exotic $O^+$ ions could be present near polar regions where field is stronger. What is known that cyclotron resonance frequencies of $O^+$ and $H^+$ ions appear in the frequency spectrum of electric fields in the aurora regions [25]. This however requires only $k_d = 4$ since magnetic field is much stronger and near to $B_E = .5$ Gauss.

   For $k_d = 5$ the value of electron cyclotron energy in magnetotail would be 48 keV and 10 percent of electron rest mass. Also ions with mass number $A \leq 16Z$ would have cyclotron energies above the thermal threshold. What is interesting and perhaps of significance is that $O^+$ exotic ion would be the heaviest possible ion forming Bose-Einstein condensates and also the dominating one besides proton.

   The transversal areas of magnetic flux quanta inside ionosphere ($B_{iono} \sim .5$ Gauss and in magnetotail $B_{tail} \sim 30$ nT are very nearly the same if ionosphere corresponds to $k_d = 4$ and magnetotail to $k_d = 5$ (the ratio of the nominal values is $B_{iono}/B_{tail} = 1667 \sim \lambda$).

*2. Radii of flux quanta*

The gyroradius $p_T/ZeB$, where $p_T$ is momentum transversal to $B$, of proton *resp.* electron of solar wind in the magnetotail is about 700 km *resp.* 20 km whereas the radii of the magnetic flux tubes would be in the range in 10-100 micrometers for ordinary value of $\hbar$ and minimal magnetic flux.

For $k_d = 5$ level of dark matter hierarchy the radius of tubular flux tube scaling as $\hbar^{1/2}$ is $R_n = \sqrt{n} \times R_1$, where $R_1(B_{wind} = 10\ nT) = 6$ km and $R_n(B_{tail} = 30\ nT) = 10$ km. If the radius is required to be above the electronic gyroradius for both wind and magnetotail, one must have $n \geq 11$ for $B_{wind}$ and $n \geq 4$ for $B_{tail}$. Flux tube radii are very nearly identical for minimal values of $n$. These observations favor $k_d = 5$ option.

That the gyroradii of ions are larger than the radius of the flux tube for $k_d = 5$ implies that the ions leak out from solar flux tube in the reconnection process. This turns out to be essential for how the negatively and positively charged regions are generated in the reconnection process.

*3. Reconnection mechanism*

In TGD framework one can understand how reconnection can occur. The helical structure of the flux tubes implies that they can be in transversal direction to the average magnetic field and this means that flux tubes can meet each other in U-shaped manner. Thus the process of reconnection would be a genuine quantal and topological transition for which the flux quantization would be essential.

It seems natural to expect that the location of the reconnection region is determined from the requirement that the flux tubes of solar wind and Earth's magnetic field have same thickness so that also local magnetic fields have the same strength from flux quantization. In Maxwell's theory this corresponds to the fact that the two magnetic fields sum up to zero. The reconnection process should be also energetically favored.

*4. Acceleration mechanism*

One can regard Earth's magnetic field as a collection of magnetic flux tubes containing matter and analogous to rubber strings. For instance, the rotation of the magnetic flux tubes could be essential prerequisite for the stability of curved flux tubes. Also the idea about catapult action meaning that the reconnected U shaped magnetic flux tube in East-West plane, briefly $\cap$, rapidly straightens and becomes a flux tube in ionosphere and collides with flux tubes of ionosphere looks natural. $k_d = 5 \rightarrow k_d = 4$ phase transition would naturally accompany this process.

The collision of flux tubes would in turn induce the collision of ions and electrons inside them and generate auroras. For $k_d = 5$ the high energy scale $E_c = 48$ keV of the cyclotron energy states of electrons would induce ionization of atoms in the magnetic flux tubes and induce generation of visible light in atomic transitions of ions and also generation of X rays and perhaps even gamma rays. Even when the phase transition to $k_d = 4$ state occurs inside ionosphere, the cyclotron energy scale is 24 eV and cyclotron photons are in UV region. Analogous collision of flux tubes could explain generation of X and gamma rays associated with lightnings.

*5. Formation of return current and generation of stronge voltage between reconnection region and aurora region*

This picture allows also to understand why a return current from aurora region to $\cup$ is formed and what might cause the strong voltage of about $10^4$ Volts between the top of $\cap$ and ionosphere.

The formation of the return current of electrons suggests the presence of closed electric field lines so that electric field would not be conservative. These closed field lines would correspond to closed structures formed from magnetic flux tubes carrying electric field. This means that there must be time varying magnetic flux through the surface , call it $X^2$, orthogonal to Earth's surface and extending from the aurora region in ionosphere to $\cup$. This is the case if the highly curve $\cap$ contracts (recall the rubber band analogy) to a relatively straight flux tube inside ionosphere in magnetic East-West direction. The change of the magnetic flux through $X^2$ would be the magnetic flux carried by this flux tube. Of course, several flux tubes might be involved.

The generalization of the flux quantization condition to time domain reads as

$$2e \int_0^T V dT = n\hbar(k_d) \ ,$$

where $T$ is the time during which flux tube traverses the boundary of ionosphere. The condition follows from Faraday's induction law and magnetic flux quantization, and relates the change of flux to the time and nonconservative voltage around flux loop. If $n$ refers to the flux of single flux tube of Earth's magnetic field in which case it would have radius $R_n = \sqrt{n} \times 10$ km, $n \geq 4$ by the requirement that electron gyroradius is smaller than $R_n$. Alternatively, one could have $m$ flux tubes with minimal radius $R_{tail} = 20$ km corresponding to $n_{min} = 4$ flux quanta giving $n = 4m$.

This condition allows to estimate the value of $T$ using the estimate $V = 10^4$ V [26] for the voltage between recombination region and auroral region. For $n = 4m$ for $B_{tail}$ $k_d = 5$ gives $T = m \times 97$ s for the time during which the flux tube traverses the boundary of the ionosphere. In [32] 200 s time scale is associated with the straightening process on basis of experimental data. This would support the idea about quantal process and $m = 2$ is favored if the estimate is taken completely seriously. This would mean radius 28 km safely above the electronic gyroradius 20 km. For $k_d = 5$ the radius of the flux tube would be $R = \sqrt{m}R_0$, $R_0 = 20$ km so that the velocity of straightening flux tube would be $v \sim 2\sqrt{m}R_0/T = .4\sqrt{m}$ km/s.

*7. Generation of regions of positive and negative charge*

The proposed reconnection mechanism provides also insights to the mechanism leading to the generation of negative charge to the top of $\cap$ at height 1500-3000 km above Earth and positive charge to the bottom of $\cup$ at $5000 - 8000$ km above Earth [32]. The formation of these regions can be indeed understood: due to the small inertia of electron Cooper pairs of solar wind and the fact that the electronic gyroradius 20 km is smaller than the radius of flux tube of Earth's magnetic field in magnetotail for $k_d = 5$, electrons are not expected to leak out of the flux tube in the reconnection process. Ions are however much more massive and their gyroradius (700 km for proton) is much larger than 20 km so that they are expected to leak out in the reconnection process and end up to $\cap$ thus providing it with a positive charge.

**Auroras, meteors, and consciousness?**

There are claims that auroras generate audible sounds [28]. These sounds have not been detected by acoustic means. Magnetic sensory canvas hypothesis could explain this. The magnetic storms accompanying auroras should affect also our auditory canvases. In particular, Schumann resonances which could correspond either MEs parallel to the magnetic flux tubes or oscillations of the magnetic flux tubes, are excited. Higher Schumann resonances are in the audible range and could directly give rise to extrasensory perception of sounds. The TGD based model of hearing relies heavily on classical $Z^0$ fields and auditory canvas could be be actually $Z^0$ magnetic. Since all classical fields are expressible in terms of $CP_2$ coordinates, magnetic storms are expected to be accompanied by their $Z^0$ magnetic counterparts.

There is also some other evidence for the sensory canvas hypothesis. Since 16th century it is known that also meteors produce audible sounds. What is mysterious that there is no time lag due to the propagation through the atmosphere. The explanation is that it is very low frequency em waves which propagate to Earth and generate sounds by interacting with the objects at the surface of Earth. Joined by the International Leonid Watch - Croatia (ILWC) project, a group of scientists presented the first instrumental detection of elusive electrophonic meteor sounds. In November 1998, the researchers from the Croatian Physical Society and the University of Kentucky organized an expedition to Mongolia to observe the anticipated Leonid meteor shower and shed some light on the phenomenon [29]. The complete data analysis revealed two electrophonic (electronically detected) sounds that provided several important clues about the nature of this longstanding astronomical mystery. It became clear that sounds were created when the meteors were crossing night-time ionosphere. The existing theories cannot however completely explain the phenomenon. The energy of meteor does not seem to be high enough to invoke the electric fields needed to explain the electronically recorded sounds, and strangely enough, the frequencies are much lower than expected, in the region 20-40 Hz.

Magnetic mirrors as carriers of the electromagnetic perturbations might allow a better understanding of the phenomenon. Perhaps the audible sounds, in contrast to the electronically recorded ones which seem to be of much lower frequency, are in fact generated by the direct perturbations of magnetic or $Z^0$ magnetic auditory canvas: this would explain why there is no lag due to the propagation through atmosphere. Electronically recorded sounds could be induced by the em perturbations propagating along magnetic mirrors at Schumann frequencies and the mirrors might act as resonators amplifying the em fields (electrophonic sounds had frequency spectrum in the region of lowest Schumann frequencies). Notice that magnetic mirrors of length shorter than Earth's circumference would give rise to higher resonance frequencies than Schumann frequencies.

There are also reports that seeing auroras can cause a loss of consciousness. This effect might not be only due to the depth of the aesthetic experience. The effects of magnetic storms on patients of mental hospitals are also well documented. If our sensory representations are indeed realized at magnetic flux tubes structures associated with Earth's magnetic field, one is led to ask whether the dissipative processes associated with auroras destroying ionic supra currents might indeed affect directly our consciousness, inducing even a loss of consciousness.

The magnetic flux tube structures associated with the sensory canvas could also experience the pressure of the solar wind and change their shape during night time. Also this might correlate with the fact that we usually sleep during night time and daytime consciousness differs from nighttime consciousness.

### 3.4.3 Lightnings, sprites, elves, and the hypothesis of magnetic sensory canvas

In 1920s, the Scottish physicist C. T. R. Wilson predicted the existence of brief flashes of light high above large thunderstoms [21]. Almost 70 years later, Bernard Vonnegut of SUNY Albany realized that this prediction could be tested by studying the videos of Earth's upper atmosphere recorded by space shuttle astronauts. William Boeck and Otha Vaughan from NASA decided to look for the evidence and they indeed found it. Also John Winkler and his colleagues had serendipitously observed a flash in moonless night time skies over Minnesota in 1989. These findings inspired two field programs (led by Walter Lyons and Davis Sentman respectively) to study the new phenomena and it soon became clear that the flashes are in fact a common phenomenon in the mesosphere.

Sentman and Lyons found two broad classes of flashes [18, 20]: sprites and elves. These short lived luminous phenomena are associated with large thunder storms called mesoscale convective systems often covering entire states in the Great Plains of the US in summertime. These migratory regions contain often regions of active convection adjacent to the regions of weaker stratiform convection. Ground flashes with a negative polarity (Earth surface corresponds to the negative electrode) dominate in the active convection regions whereas the less frequent but more energetic flashes with positive polarity (Earth surface corresponds to positive electrode) predominate in the stratiform regions. The great majority of sprites and elves are initiated by ground flashes of the latter type. Elves and very low frequency perturbations from electromagnetically pulsed sources are centered above vertical channels to ground whereas sprites lie above horizontally extensive spider lightnings in the lower portion of the stratiform cloud.

My own interest on these phenomena was stimulated by the article [22] according to which neither the origin of the blue light accompanying sprites nor the fast rate for the development of sprites are well-understood. The obvious strategy is to find whether the notion of many-sheeted space-time could provide an improved understanding of these phenomena.

The notion of many-sheeted space-time is crucial for TGD based model of brain involving in an essential manner also the notion of the magnetic sensory canvas: the magnetic flux tube structures involved can have size comparable to Earth's size. An interesting question is whether one could somehow relate the notion of sensory magnetic canvas to the electromagnetic phenomena occurring in the atmosphere. Rather encouragingly, the basic dynamical time scales of lightnings, sprites and elves correspond to those associated with brain. This inspires some speculations about how magnetic bodies and atmospheric electromagnetic phenomena might relate.

#### Lightnings

A good summary about basic facts concerning lightnings [64], sprites and elves can be found in Wikipedia [24]. Lightnings are classified to positive and negative lightnings depending on whether the electron current is from ground to cloud or vice versa. The following brief summary gives a rough account of what happens in case of negative lightning for which electron current flows to ground.

*An initial discharge, (or path of ionised air), called a "stepped leader", starts from the cloud and proceeds generally downward in a number of quick jumps, typical length 50 meters, but taking a relatively long time (200 milliseconds) to reach the ground. This initial phase involves a small current and is almost invisible compared to the later effects. When the downward leader is quite close, a small discharge comes up from a grounded (usually tall) object because of the intensified electric field.*

*Once the ground discharge meets the stepped leader, the circuit is closed, and the main stroke follows with much higher current. The main stroke travels at about 0.1 c and has high current for .1 m or so. It may persist for longer periods with lower current.*

*In addition, lightning often contains a number of restrikes, separated by a much larger amount of time, 30 milliseconds being a typical value. This rapid restrike effect was probably known in antiquity, and the "strobe light" effect is often quite noticeable.*

*Positive lightning does not generally fit the above pattern.*

Positive lightnings are rare but more energetic. The typical voltages, electric fields, and durations of strikes involved with positive *resp.* negative lightnings are 1 GV, $10^5$ V/m and 1 ms *resp.* .1 GV, $10^4$ V/m and .1 ms. During positive lighting there is a huge amount of VLF and ELF radiations which implies that lightning induces effects in ionospheric scale.

The notions of leader emerging from cloud and streamer emerging from ground and meeting before the strike are well established. The development of leader means that air becomes conductive in a stepwise manner by ionization. Stepped leaders are associated with negative lightnings and dart leaders with positive lightnings. Lightnings are accompanied by X ray bursts with duration $< .1$ ms. wit X ray energies up to few hundred keV. The bursts are presumably generated during stepped leader and dart leader phase. Also gamma ray bursts have been observed.

Runaway breakdown is a generally accepted mechanism in the theory for the formation of lightnings. It is assumed that cosmic ray strikes atmospheric molecular and releases extremely energetic electrons having enhanced free path length of tens of centimeters. Electrons are accelerated in the electric field of storm and ionize further molecules and initiate the runaway breakdown at higher which then proceeds downwards. Conductive path with a length of typically 50 m is created. There are however some problems. The rate for the strikes by cosmic rays having sufficient energy is 50/km$^2$

and too low to explain the number of lightnings during thunderstorm. Also the measured X ray burst intensity is only 5 per cent of the predicted value.

### Sprites

Sprites come in several varieties and these complex structures have been dubbed with descriptive names like carrots, angles, jellyfish and A-bombs. The simplest sprites are so called C sprites which have transversal size of order 200 m and height of order 10 km and form structures resembling Fourth of July fireworks. The vertical extension of sprites can be as high as 60 km and there lower end is typically at the height of 30 km (for illustrations of sprites and elves see [22]).

In Wikipedia [64] sprites are characterized as follows.

*Sprites are now well-documented electrical discharges that occur high above the cumulonimbus cloud of an active thunderstorm. They appear as luminous reddish-orange, neon-like flashes, last longer than normal lower stratospheric discharges (typically around 17 milliseconds), and are usually spawned by discharges of positive lightning between the cloud and the ground.*

*Sprites can occur up to 50 km from the location of the lightning strike, and with a time delay of up to 100 milliseconds. Sprites usually occur in clusters of two or more simultaneous vertical discharges, typically extending from 65 to 75 km above the earth, with or without less intense filaments reaching above and below. Sprites are preceded by a sprite halo that forms because of heating and ionisation less than 1 millisecond before the sprite.*

The structure of sprite resembles that of a botanic tree consisting of roots (negative end), trunk and branches (positive end). This bi-directional structure of the sprite suggests two separate processes: the first process proceeds upwards and is followed by a second process proceeding downwards. The blue color of the lower part of the sprite (roots) is known to be due to the transitions of $N_2^+$ ions whereas the red color of the upper part is due to the transitions of $N_2$ molecules.

Wilson's theory suggests that the process associated with trunk and branches of the tree corresponds to a dielectric breakdown induced by the ionization of molecules by electrons flowing upwards in the electric field generated by the spider lightning. The dipole field associated with the lightning behaves as $1/z^3$ as function of height from the pancake like electronic reservoir located at the thunder cloud at height of order 10 km. Since the dielectric strength (the critical electric field causing the ionization of molecules) is proportional to the density of the molecules, which decreases exponentially with height, the dielectric breakdown is predicted to begin from higher heights above thunder cloud and cause a cascade like electron current.

The expression for the drift velocity of electron in an external electric field is obtained from the condition

$$\frac{m_e v^2}{2} = eEl \quad , \quad l = \frac{1}{n\sigma} \quad . \tag{3.4.1}$$

Here $\sigma$ denotes the total scattering cross section for the scattering of electrons on molecules and $l$ denotes the length of the average free path of electron. The condition simply states that the kinetic energy gained in the field between two interactions equals to the work done by the electric field on electron.

Ionization becomes possible when the kinetic energy is above the ionization energy $E_{ion}$ of the molecules of the atmosphere. This condition determines the critical value of the electric field as

$$eE_{cr} = 2E_{ion}n\sigma \quad . \tag{3.4.2}$$

The critical value of the electric field is proportional to the density $n$ of the molecules decreasing exponentially with height. The values of the dipole moment $p$ characterizing the electric fields generated by lightnings range from 10 to more than $10^3$ coulomb kilometers (for the convenience of the reader we notice that one coulomb corresponds roughly to $10^{19}$ electronic charges). Assuming the distance scale $z \sim 40$ km, dipole moment $p \sim 10^3$ Ckm, and collision cross section $\sigma \sim Angstrom^2$, one finds that the critical drift velocity is of the same order of magnitude as the observed velocity .1 c for the generation of sprite. In [22] it has been stated that the predicted critical drift velocity tends to be too small.

The negative end of the sprite (roots) accompanied by blue light suggests that the $N_2^+$ ions created in the electronic ionization run downwards in this region. The mechanism leading to the the transitions of $N_2^+$ ions generating blue light is most naturally the collisions of $N_2^+$ ions with $N_2$ molecules. This assumption conforms with the basic facts about sprite formation and structure: the intensity of the blue light is comparable to that of red light, the blue end of the sprite develops later than the red end, the blue emission is at the lower end of the sprite, and the branching of the lower end proceeds downwards. Note that the critical velocity for the ionization of $N_2$ molecules by collisions with $N_2^+$ molecules is proportional to $1/\sqrt{M(N_2)n}$ and thus considerably smaller than in case of electron for given values of $n$ and $E$. This together with the larger density of $N_2$ molecules implies that the lower part of the sprite is generated more slowly.

A priori also sprites for which thunder cloud carries positive charge are possible. Only two cases of sprites associated of this kind have been found, and according to [22] this asymmetry is not yet well-understood. A possible explanation is following. When cloud is negatively charged, the pancake like electronic reservoir located at the thunderstorm provides the seed electrons initiating the ionization cascade providing new current carrying electrons. When the cloud is positively charged, the electrons would propagate downwards from upper part of atmosphere to the direction in which drift velocity decreases. There are however no seed electrons now. There is however a reservoir of positive $N_2^+$ ions in thunder cloud and they might be able to generate the dielectric breakdown. It is quite possible that the typical seed density is simply too low for this in most cases. These infrequent sprites should have blue or pink-blue upper end ($N_2^+ - N_2$ collisions can also excite $N_2$ molecules) and should develop with much more slower rate.

If the collisions with the electrons were responsible for the transitions of $N_2^+$ ions (as believed in [22]), the intensity of the blue light would be by several orders of magnitude weaker from the fact that the density of $N_2^+$ ions is of the same order as that of electrons from the requirement of overall charge neutrality, and from the fact that the density of $N_2$ ions is much higher than that of electrons (there are roughly 1 electron per 10 billion $N_2$ molecules [22] at the upper portion of the sprite).

#### Elves

In Wikipedia [64] elves are characterize in the following manner.

*Elves often appear as a dim, flattened, expanding glow around 400 km (250 miles) in diameter that lasts for, typically, just one millisecond [7]. They occur in the ionosphere 100 km (60 miles) above the ground over thunderstorms. Their colour was a puzzle for some time, but is now believed to be a red hue. Elves were first recorded on another shuttle mission, this time recorded off French Guiana on October 7, 1990. Elves is a frivolous acronym for Emissions of Light and Very Low Frequency Perturbations From Electromagnetic Pulse Sources. This refers to the process by which the light is generated; the excitation of nitrogen molecules due to electron collisions (the electrons having been energized by the electromagnetic pulse caused by a positive lightning bolt).*

Elves are thus a phenomenon occurring above ionosphere rather whereas sprites are ionospheric phenomena. This allows to understand why they occur for positive lightings (electrons flow from ground to cloud).

In case of elves the ionization mechanism differs from that for sprites. The radiation from the lightning decays with distance as $1/z$ and this guarantees that the threshold for the breakdown is exceeded as long as lightning current is sufficiently large. The observations show that there is a time lapse of order 10 ms between the lightning and the generation of elve: this lapse is consistent with the propagation of radiation with light velocity. Observations show that peak currents of 70 A or greater are required.

Electronic plasma frequency defined as

$$f_p^2 = \frac{n_e e^2}{m_e} \tag{3.4.3}$$

plays an important role in understanding the electromagnetic phenomena in atmosphere. Plasma frequency defines the cutoff frequency for waves which can propagate inside sprite: what this means is that frequencies lower than $f_p$ are reflected. The observations about reflections of em waves on sprites show that $f_p$ is in the range $2-25$ kHz which means that the density of electrons is in the range $10^4$ to $10^6$ $cm^{-3}$, somewhat more dilute than in aurora borealis and slightly above the electron concentration in the daytime E region of the ionosphere. VF and ELF em waves can propagate in the 80-90 km thick wave guide below ionosphere and sprite activity generates ELF waves, which are especially strong at Schumann resonance frequencies and serve as a global signature for them.

### Dark matter hierarchy, lightnings, sprites, and elves

What is known about sprites and elves might be marginally understood in the framework of standard physics. The model for the leaders based on runaway breakdown induced by cosmic rays is however inconsistent with all empirical facts and $k_d = 4$ Bose-Einstein condensates at the flux tubes of Earth's magnetic field provide an alternative model. This inspires the question whether dark matter hierarchy could manifests itself somehow in these phenomena. The first thing one can do is to look whether the time and length scales involved could be assigned with the basic scales of the dark matter hierarchy.

*1. Time scales*

Millisecond time scale seems to govern the dynamics of both lightnings, sprites and elves. The net time for the formation of stepped leader is about 200 ms and since length scale involved is 10 km this means that generation of single step corresponds to millisecond time scale. Also the time scales of strikes are in millisecond scale: for instance, sprite halos appears 1 millisecond before sprire, sprite typically last about 17 milliseconds, and elves last for 1 millisecond.

The appearance of millisecond time scale for the main strike and appearance of re-strikes brings strongly in mind nerve pulse generation and nerve pulse sequences having similar time scales. Moreover, delta band of EEG resembles corresponding region of sferics and intense VLF and ELF radiation accompanies positive lightnings. The question is whether the similarity of time scales is a mere accident and whether lightnings could be regarded as sequences of scaled up nerve pulse like discharges involving kHz synchrony.

Taking this idea seriously, one can ask whether one could understand the emergence of 1 kHz frequency as a drum beat analogous to say 1 Hz cyclotron frequencies assignable to DNA in living matter and near to the thermal threshold for $k_d = 4$ cyclotron energies. Tornadoes involve luminous phenomena and thunderstorms. The model of tornadoes involves magnetic walls with Earth's magnetic field strength scaled up to .05 Tesla and naturally resulting from $Z = 2$ flux quantization with flux quantum area scaled down as $1/\lambda^2$ in the transition $k_d = 4 \rightarrow 3$. This transition would scale up 1 Hz delta frequency to 1 kHz frequency. Hence kHz band of spherics could indeed play the role of drum beat in the generation of lightnings as atmospheric "nerve pulses".

*2. Length scales*

1. The length scales for the formation of leader seem to correspond to $k_d = 2$. Enhanced electron mean free path of few centimeters would correspond to a scaled up cell membrane thickness 4=2+2 cm and the length 50 m of single step in leader to the scaled up maximal size scale of cell 80 m at this level.

2. The distances between sprites and lightning system are below 50 km. The maximal size of $k_d = 3$ variant of scaled up cell nucleus ($L(169)$) is about 40 km. Hence sprites could make thunderstorm a $k_d = 3$ phenomenon whereas elves would extend it to $k_d = 4$ phenomenon.

3. The generation of lightning could proceed from $k_d = 2$ level to higher levels of dark matter hierarchy. This kind of hierarchical development could explain the sprites and elves as well as strong ELF and VLF is associated with positive lightnings as being to the fact that electron current proceeds upwards and can thus excite $k_d = 3$ ionospheric excitations (sprites) and $k_d = 4$ excitations (elves) above ionosphere.

*3. Dark matter hierarchy and generation of leaders*

Dark matter hierarchy suggests a new kind of mechanism initiating the development of leaders. The dissipation-free acceleration of cyclotron electron Cooper pairs and of ions at the flux tubes in strong electric field and transfer to the atomic space-time sheets could provide a mechanism generating the typically 50 meter long steps of step leaders. The energy of .5 MeV, which corresponds to electron rest mass, would be reached in a free acceleration of proton or electron Cooper pair in an electric field of $E = 10^4$ V/m associated with negative lightnings over distance 50 meters. This corresponds to electron rest mass so that also the generation of gamma rays could be understood. For dart leaders the same energy would be reached during 5 meter long free acceleration, which raises the question whether dart leaders are step leaders with shorter length of the basic step.

Note that 80 m length scales corresponds to the maximal size of the fractally scaled up cell structure for $k_d = 2$ and that $k_d = 2$ dark matter level was already associated with tornadoes often accompanied by thunder storms.

Electronic cyclotron energy scale for $k_d = 4$ level of dark matter hierarchy is about $E_c = 33$ keV. Therefore cyclotron photons emitted in the collisions of electron Cooper pairs at the magnetic flux tubes of Earth could be involved with the generation of highly energetic electrons which in turn induce runaway breakdown. This energy is perhaps too small to explain the energies of highest X rays and of gamma rays.

*4. $k_d = 4$ dark matter and the formation of sprites and elves*

The too low drift velocity of electrons drifting to the trunk and branches of sprite from electron reservoir at the bottom of the cloud is a possible problem in the model for the formation of sprites. Almost dissipation free upwards directed acceleration of Cooper pairs of electrons at $k_d = 4$ magnetic flux tubes would allow much higher drift velocities since the free path of electron Cooper pair would be longer. This would reduce the critical value of the electric field and make the process faster.

The density of $N_2$ molecules is about $10^3/\mu m^3$ at the upper part of the sprite and one can consider the possibility that at least part of these molecules reside at the magnetic flux tubes of the dark counterpart $B_{end}$ of the Earth's magnetic field $B_E$ which is hypothesized to have the value $B_{end} = 2B_E/5$ on basis of the model explaining the effects of ELF em fields on vertebrate brain (see the appendix of [J2] and [M3]). One can even raise the question whether singly charged exotic $N_2^+$ ions (behaving like neutral atoms electronically) could be present and define cyclotron condensates. The downwards directed dissipation-free acceleration of $N_2^+$ exotic ions scattering from ordinary $N_2^+$ ions could induce the transitions of $N_2^+$ ions responsible for the blue color in the lower part of sprite.

In the case of elves the ionization mechanism is believed to involve radiation from lightning energizing electrons in turn exciting $N_2$ molecules. The effect would be stronger if Bose-Einstein condensate of exotic $N_2^+$ ions is excited coherently by the collisions with energized electronic Cooper pairs.

### Atmospheric electromagnetic phenomena and consciousness

The hypothesis about magnetic sensory canvas should be related to experimental reality somehow. The electromagnetic phenomena (such as lightnings, auroras sprites, elves) in the atmospheric waveguide are indeed rather promising in this respect.

1. If the magnetic sensory canvas hypothesis holds true one has the right to expect that brain functioning and these electromagnetic phenomena should possess common time scales. Amazingly, the frequency spectra as well as typical durations for the lightnings, sprites and elves correspond to those associated with brain. The typical duration of lightning is about .1 seconds which is the fundamental time scale of sensory consciousness and defines the duration of the memetic code word. Sprites are generated during one millisecond and typically last 10-100 milliseconds. The spectrum of the spherics associated with the activity of lightnings is in the range 0-25 kHz: this follows from the fact that waves in this frequency range are reflected from ionosphere and propagate in the waveguide defined by the atmosphere. It is perhaps not an accident that this frequency range corresponds to the range of frequencies audible for human brain.

   It is also known that hippocampus, which is crucial for long term memories, contains highly ordered magnetite particles (private communication) and responds in complex ways to magnetic perturbations having frequencies in ELF range and amplitudes in picoTesla range. Perhaps it is not an accident that the amplitudes for the perturbations of Earth's magnetic field are also in picoTesla range in theta and alpha range of EEG frequencies. Also alpha waves generate a peak in MEG with amplitude of order picoTesla: presumably this peak corresponds to the lowest Schumann frequency. Also eyes generate static magnetic fields with strength of order 10 picoTesla. In consistency with the observations of Blackmann and others about the intensity and frequency windows for ELF em fields, these findings encourage to think that brain is indeed sensitive to the perturbations of Earth's magnetic field (note however that the electric fields in these experiments are typically of order $1 - 10$ V/m [44] and roughly two orders of magnitude higher). This would mean also a sensitivity to the perturbations of the magnetic flux tube structures defining the hierarchy of magnetic bodies. These perturbation might directly affect conscious experience (not necessarily at our level of hierarchy) giving rise to effective extrasensory perceptions and the effects at the level of brain would represent a reaction to this kind of conscious experience.

2. There should be also interaction between brain and the electromagnetic phenomena in the atmosphere and Schumann resonances which characterize the perturbations of Earth's magnetic field should be of special importance. Lightnings, sprites and elves indeed excite Schumann resonances known to affect strongly human consciousness [56]. Furthermore, the shape of the frequency spectrum for sferics at delta frequencies resembles delta band of EEG [46]. The generation of Schumann resonances might mean also a direct interaction with the magnetic sensory canvas and one cannot exclude the possibility that atmospheric phenomena could have role in signalling at the higher levels of self hierarchy. Perhaps the peak in MEG at alpha range results from this kind of interaction.

   There are typically few sprites per minute and they generate strong Schumann resonances. One can wonder whether sprites and/or the assocaited spider lightnings could have correlates at the level of EEG and neurophysiology and perhaps even affect conscious experience, say by causing changes in mood. It should be possible to check whether the EEGs of persons possibly located at different parts of globe display simultaneous correlates for sprites and lightnings.

3. One could go even further and try to test the fractality hypothesis. The ratio of length scales associated with pairs cell membrane-cell, cortex-brain and atmospheric waveguide-Earth are of same order of magnitude. This observation and Mother Gaia hypothesis encourages to consider the possibility that the atmosphere could in some sense be a scaled-up version of cortex, which in turn would be scaled-up version of the cell membrane. For instance, the transversal size of order 200 m of the smallest sprites (so called C sprites) would correspond to the micron length scale in brain length scale and thus the size of smallest neurons whereas this length scale corresponds to nanometer (DNA size scale) at neuronal level. The height of C sprites which is about 10 km corresponds to the length of about 50 microns which in turn reminds of the lengths of cortical neurons.

4. The geometric appearance of sprites brings in mind the geometry of neurons and one can even play with the thought that sprites and lightnings are associated with pre-existing electric flux tube structures in atmosphere so that lightnings, sprites and elves could be phenomena comparable to nerve pulse activity and graded potentials in brain. The geometric structures associated with sprites resembles the axonal and dendritic geometries for cortical neurons.

5. The most fascinating possibility is that sprites and elves are parts of magnetic bodies made temporarily visible. If so, then one could also consider the possibility that magnetic bodies form a self hierarchy analogous to that formed by monocellulars and increasingly complex multicellulars with cell being replaced with brain/physical body of organism. Various organisms would obviously form the lowest level of this self hierarchy and various levels of collective consciousness would be the electromagnetic analog of the multicellular life.

**What auroras, tornadoes, ball lightnings, and cold fusion might have in common?**

If the density of the ions inside magnetic flux tubes is constant, garden hose instability for magnetic field suggests itself strongly. Similar instability might be associated with the flux quanta of the $Z^0$ magnetic field if they contain $Z^0$ ions. This kind of instability of $Z^0$ magnetic field giving rise to spiral helices is the basic assumption in the TGD based model of tornadoes. This suggests that $Z^0$ superconductivity and, since rotating systems probably involve also magnetic fields, phenomena analogous to auroras could be involved also now.

It is indeed well known that luminous phenomena resembling those accompanying ball lightnings [64] are associated also with tornadoes [58, 59, 60]). Edward Lewis introduces the notion of plasmoid to explain a wide range of phenomena including ball lightnings and tornadoes. He assigns plasmons even with cold fusion (the damage resulting to Palladium target in cold fusion resembles the traces caused by ball lightnings, [62]) and super-conductivity (sic!). Although Lewis obviously over-generalizes the notion of plasmoid, one cannot deny that the concept has a strong theoretical appeal in it.

The findings of Lewis inspire some further ideas about the physics of many-sheeted space-time.

1. The runaway mechanism for ions from the magnetic flux tubes could provide a general mechanism behind luminous phenomena like auroras, lightnings, ball lightnings, sprites and tornadoes. Plasmoids would result when supra current becomes overcritical. The un-identified source of energy in these phenomena might be the energy associated with the supra currents.

2. The break-down of the super-conductivity could be understood in terms of a supra current leakage to non-super-conducting space-time sheets caused by the inertia of the current carriers. The critical temperature could be determined as the temperature below which the join along boundaries bonds between super-conducting and non-conducting space-time sheets are not formed. The temperature of super-conducting space-time sheets could be much more lower than this temperature but this is not necessary if high $\hbar$ dark matter is in question.

3. The Trojan horse mechanism of cold fusion [F8] involves the notion many-sheeted space-time in an essential manner. Perhaps the supra currents running at the magnetic flux tube space-time sheets not containing the nuclear Coulombic fields provide the means to circumvent the Coulomb barrier.

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# Part II

# TOPOLOGICAL LIGHT RAYS AND WORMHOLE MAGNETIC FIELDS

# Chapter 4

# Quantum Antenna Hypothesis

## 4.1 Introduction

One of the basic problems faced by the quantum theories of consciousness is to understand how macroscopic quantum coherence in the brain is realized. Bose-Einstein condensates and coherent states are believed to be crucial in this respect but the great problem is how macroscopic quantum phases could be realized in the wetty, noisy and hot enviroment provided by brain. In TGD framework the notion of many-sheeted space-time provides a solution to this basic problem. Furthermore, the notion of self as a subsystem able to remain p-adically un-entangled is consistent with the fact that macroscopic quantum phases behave like quantum particles. The general views about macroscopic quantum phases predicted by TGD and about their role with regards to consciousness is described in previous chapters. This chapter is devoted to coherent and Bose-Einstein condensed photons which are crucial in the quantum models of brain consciousness relaying on microtubules and seem to be associated with linear structures also in TGD framework. These linear structures include not only microtubules but also axons, DNA and proteins and most of the considerations to follow are quite general and by no means restricted to microtubules.

### 4.1.1 Massless extremals and quantum antenna hypothesis

The purpose of this chapter is a more detailed formulation of the quantum antenna hypothesis stating that microtubules generate a macroscopic coherent state of photons. The so called massless extremals are a very general class of zero action non-vacuum extremals of both the Kähler action and the effective action and differentiate clearly between TGD and standard gauge theories, in particular QED. Massless extremals describe the propagation of massless gauge fields in single preferred direction. The polarization for given values of transversal coordinates has a fixed direction. Linear superposition is not possible.

Topological field quantization assigns to each quantum notion its classical counterpart and a very attractive identification of the massless extremals is as the classical counterparts of massless classical quanta such as photons and gravitons. Even the classical counterparts of the virtual particles make sense: in particular, negative energy photons represented by annihilation part of the free photon field seem to have geometric representation as negative energy massless extremals.

Massless extremals (ME) of the effective action can indeed generate coherent states of photons and gravitons.

1. ME:s are characterised by light like vacuum Kähler current $J_K$ (this is purely TGD:eish feature!). In general but not always this implies light-like em current $J_{em}$ and the standard coupling to the quantized photon field generates a coherent state of photons.

2. The geometry of the 3-surface in question is most naturally cylindrical and microtubules (as also DNA, proteins, etc..) indeed possess this kind of geometry. There are sharp resonances at frequencies $\omega = n2\pi/L$, where $L$ is the length of the cylindrical 3-surface (say a space-time sheet associated with a microtubule). The BE condensates for the resonance frequency photons provide means of communication for the neuron society and could orchestrate microtubules to

form a single macroscopic quantum system. One could also consider the possibility that nerve pulse patters are coded to vacuum currents and in turn coded to patterns of coherent photons. In fact, the model of memetic code leads to the identification of nerve pulse/no nerve pulse as Boolean statement true/false. The coding of the nerve pulse patterns to the patterns of vacuum currents of axonal microtubules could occur naturally. The vacuum currents associated with the radial neuronal microtubules could communicate nerve pulse patterns to cell nucleus and the effects of the anesthetics on neuronal microtubules could mean the cutting of this communication line.

A necessary condition for the macroscopic quantum coherence is the phase locking of the vacuum currents associated with different microtubules. Join along boundaries bonds connecting the massless extremals to a larger space-time sheet serving as a common pacemaker could make possible the phase locking.

### 4.1.2 Evidence

This picture suggests that microtubules could act as senders and receivers of a coherent light and that visual consciousness should be closely related with the microtubules in accordance with the general philosophy already described. There is indeed some experimental support for identifying the coherent states of photons as associated with vision. It is known that some monocellulars possess elementary vision based on the microtubules [35]. The length distribution of the microtubules in the rods and cones of the eye is concentrated in the region of the visible wavelengths. Insects are known to perceive certain chemical compounds (such as pheromones) by the maser like emission of infrared light by these chemical compounds [50]. Also human nose contains so called vomeronasal organ which seems to give rise to an additional unconscious sense of odors with social and sexual meaning. Interesting hypothesis is that also this vision is based on infrared vision.

There is quite unexpected connection with the phenomenon of sonoluminescence suggesting that liquids contain structures of size of order microtubule diameter and that the highly synchronized light flash emitted in the sonoluminescence results from the condensation of water vapor to liquid involving generation of $k = 149$ space-time sheets from $k = 151$ space-time sheets by p-changing phase transition and subsequent creation of light-like vacuum currents at almost empty $k = 151$ space-time sheets leading to the emission of the flash of coherent light.

An additional support for the quantum antenna hypothesis comes from the quite recently observed anomalous dissociation of water molecules to hydrogen and oxygen in room temperature in presence of catalyst and stirring of the liquid. Usually the reaction is driven by thermal photons at temperature of order 3300 K. A possible explanation is that the $Z^0$ magnetic flux tubes created by the rotating nuclear $Z^0$ charge are accompanied by space-time sheets carrying light like vacuum currents generating coherent photons, which in turn drive the dissociation reaction.

Biefeld-Brown effect is one of the oldest poorly understood anomalous effects [56, 57, 58]. What happens is that charged capacitor gains center of mass momentum in the direction orthogonal to the plane of the capacitor plates. Antigravity effect caused by the redistribution of gravitational and/or $Z^0$ fluxes of the capacitor between various space-time sheets could explain some aspects of the effect. The generation of negative energy space-time sheet with net momentum associated with classical em fields could be also involved with the effect. So called "massless extremals" are optimal candidates for this purpose. This mechanism might be applied by bio-systems to generate coherent motions.

### 4.1.3 Quantum antenna hypothesis and brain consciousness

The identification of macroscopic quantum phases possibly serving as quantum correlates of some qualia does not yet help much in understanding brain consciousness. Brain as a neuron society, brain as a music instrument or even entire orchestra and the notion of neural window are metaphors which have served as guidelines in the attempts to guess the general architecture of brain consciousness and might help also the reader to better understand the considerations to follow.

#### Brain as a neuron society metaphor

The brain as a society of conscious neurons metaphor has surprisingly nontrivial consequences. In particular, a plausible and testable hypothesis for the physical correlates of the sensory qualia becomes possible.

1. Brain as a society of conscious neurons metaphor suggests that our sensory qualia must have a reduction to the neuronal level. For instance, this could mean that our sensory experiences correspond to the sensory experiences associated with the large coherently firing neuron gap junction connected neuron groups in brain.

2. Conscious neurons must be able to communicate their conscious experiences to their fellow neurons. The simplest manner to achieve this is to regenerate the original sensory experience to be communicated by sending a message which creates the stimulus resembling the stimulus giving rise to the original sensory experience.

An attractive idea is that the massless extremals (MEs) associated with the microtubules and other linear structures are for the neuron society what radio receivers and stations are for us. Perhaps the idea about the information society at neuronal level does not look so far fetched if one recalls that a communication based on the genetic code takes place already at DNA-protein level. Furthermore, if Nature has invented a communication by means of a coherent light, it probably has invented also the use of several bandwidths by using several microtubule lengths so that very sophisticated communication systems could exists in brain.

Brain as a society of neurons hypothesis has close relationship to other hypothesis with very similar content. Global workspace hypothesis [21] states essentially that mass media type communication available for large numbers of neurons plays crucial role in the functioning of conscious brain: coherent light is ideal for this purpose. Also brain as hologram idea [25, 30], which is abstracted to neuronal window idea in TGD framework, states that some kind of mass media type communication occurs.

### The notion of neural window

The idea of neural window suggests that secondary sensory organs see either the classical em field or the coherent light generated by the mind-like space-time sheets representing the objects of the perceptive field, which can be associated with the primary sensory organ or with the secondary sensory organs in thalamus and cortex. This secondary vision, which could make possible imagination in or all sensory modalities, would be made possible by the coherent photons suffered Bose-Einstein condensation on space-time sheets associated with microtubules or with axons (several space-time sheets might be involved) and serving as wave guides. Massless extremals allow to translate the notion of neural window to the notion of quantum hologram.

### Music metaphor

Music metaphor which states that each neuron gives rise to characteristic sensory experience like string of piano gives rise to single note, gives strong constraint on the neuronal window idea. The massless extremal associated with axon corresponds to definite axon dependent frequency. In fact, in the proposed model for the quantum correlates of the sensory qualia [K3] sensory qualia are characterized by some frequency of BE condensed photons besides a pattern of cyclotron frequencies.

A related catching metaphor is to regard groups of parallel axonal microtubules as an orchestra producing light instead of sound with various frequencies. The interior containing the light-like em current would be the instrument and the note produced by single tubule would be a superposition of the frequencies $n\omega_0$, $\omega_0 = 2\pi/L$. The Fourier spectrum of the massless extremal would define the characteristics of the instrument. Of course, in long time scales microtubule could vary its length and achieve more impressive performances than single note samba. A good candidate for the player is the microtubule surface controlling the amplitude of the quantum photon field emitted by the interior by modulating the light-like current in the interior.

### Brain as an associative net

The previous metaphors are consistent with the basic view about brain is as associative net such that conscious associations at neural level correspond to conscious experiences of presynaptic neurons associated with the experience of the postsynaptic neuron. The experiences of given neuron is always the same and only its intensity varies so that brain is indeed like a music instrument or orchestra.

The intensity of experience is coded by the pattern of nerve pulses. The hypothesis about memetic code states following things. Nerve pulse/no nerve pulse corresponds to true/false Boolean statement; the codons of the memetic code consist of 126 bits and have total duration of order .1 seconds, the duration of our cognitive subself; single bit corresponds to a duration of order one millisecond, the duration of nerve pulse; codons are represented by temporal sequences of cognitive neutrino pairs to which nerve pulse sequences are coded; cognitive neutrino pairs are in turn coded to conscious experiences in many-to-one manner by a unique code analogous to that coding mRNA sequences to polypeptides.

### 4.1.4 Relationship of TGD approach with microtubular approach

The role of the microtubules (for a nice introduction see [28]) is believed to be also important for brain consciousness. In TGD framework however microtubules are only one, rather low-lying, although certainly important, level of the self-hierarchy and microtubular consciousness is not expected to correspond to our consciousness directly. In fact, the identification of our subselves (mental images) as 'ELF selves' having as their geometrical correlates topological field quanta of em field with size of Earth, supported by various experimental data about the effects of ELF (extremely low frequency) em fields on brain and correlating our subselves with certain EEG frequencies, could not be philosophically farther from the reductionistic identification of microtubules as seat of our consciousness proposed by Penrose and Hameroff [27].

Fröhlich condensates [34] and microtubular Bose-Einstein condensates of photons have been proposed as the relevant macroscopic quantum phases in the microtubular theory of consciousness. Also in TGD framework macroscopic quantum phases are crucial and serve as quantum correlates of sensory qualia. The basic problem of these theories is how to preserve macroscopic quantum coherence over a time interval of order .1 seconds characterizing our consciousness. In In TGD framework the wake-up time of the microtubular selves (time which they are able to stay p-adically unentangled) of about $10^{-16}$ seconds typically, is not a problem since microtubular selves are not our immediate subselves.

The notion of many-sheeted space-time allows TGD counterparts of both Fröhlich condensates and microtubular photon BE condensates as condensatse associated not only with microtubules.

1. Wormhole contacts are unavoidable element of the many-sheeted space-time concept. Wormhole contacts behave in many respects like charged particles and are described by a complex order parameter and it makes sense to speak about wormhole super conductivity. The connection with Fröhlich's condensate comes as follows. Electric fields penetrate from one space-time sheet to another via wormhole contacts carrying quantized fluxes. Thus the normal component of electric field is essentially the density of wormhole charge given by the modulus squared for the order parameter of the wormhole BE condensate. Vacuum polarization of the space-time sheet amounts to the generation of wormhole BE condensates of opposite gauge flux on the two sides of the polarized space-time sheet. In a well defined sense wormhole contact order parameter is square root of the order parameter of Fröhlich condensate.

2. Living matter behaves as liquid crystal and the electret nature of liquid crystals is crucial for many-sheeted ionic flow equilibrium since the weak but coherent electric fields make possible ohmic currents at atomic space-time sheets transforming to supra currents at superconducting space-time sheets.

3. Vacuum gauge fields with non-vanishing gauge currents are a generic phenomenon in TGD and not possible in standard theories. These c-number currents automatically generate quantum coherent states of photons and gravitons via their coupling to the corresponding quantized boson fields. Massless extremals are ideal in this respect since the generation of coherent photons by the light-like vacuum current occurs resonant like manner. Very importantly, massless extremals allow BE condensates of photons in the direction of the light-like vacuum current. This means that massless extremals can serve both as receiving and sending quantum antennae.

### 4.1.5 MEs and information molecules

The notion of information molecule is central for the understanding of biological control. There are however several difficult questions related to the notion of information molecule. TGD inspired view about biocontrol and coordination suggests a general answer to these questions and leads to a general model of biological control based on both MEs and information molecules with massless extremals (MEs) serving as actual information carriers initiating self-organization processes whereas information molecules are in the role analogous to that of computer password.

### 4.1.6 MEs and quantum holography

One can generalize the original solution ansatz for MEs by introducing what might be called local light cone coordinates for $M^4_+$. Boundary conditions for MEs are satisfied if the boundaries of MEs are light-like 3-surfaces, and thus have the same miraculous conformal properties as the boundary of the future light cone. In fact, the light-likeness of the boundaries of $M^4$ like space-time sheets provide a universal manner to satisfy boundary conditions for field equations.

The superconformal and supercanonical symmetries can be used to generalize the construction of the configuration space geometry to take into account the classical non-determinism of Kähler action. Quantum holography in the sense of the quantum information theory allows to interpret MEs both as receiving and sending quantum antennae as well as dynamical holograms with light-like vacuum currents defining the counterpart of the diffraction grating, and making possible the teleportation of quantum em fields. The superconformal and supercanonical symmetries, which commute with Poincare symmetries apart from quantum gravitational effects, makes the boundaries of MEs natural seats of supercanonical representations, and since these states are genuine quantum gravitational states defined by statefunctionals in the 'world of worlds', they are expected to be crucial for understanding higher level consciousness.

MEs induce super currents in superconducting magnetic circuits by magnetic induction mechanism, serve as Josephson junctions between magnetic flux tubes, and induce magnetic quantum phase transitions. MEs can generate reference waves or their phase conjugates (time reversals) acting on lower level MEs serving as dynamical holograms. The induced coherent light pattern would act as a control command or its time reversed version. Conjugate reference waves could provide an extremely simple basic mechanism of healing by time reversal allowing the living matter to fight against second law. MEs could read DNA strand to the light-like vacuum current by drifting along it and thus code DNA strand/conjugate strand to a hologram or its phase conjugate in turn acting as a control command or its time reversal. Thus living matter could be regarded as a symbiosis in which MEs control superconducting magnetic flux tubes controlling ordinary matter at atomic space-time sheets via many-sheeted ionic flow equilibrium. DNA would represent the ROM of this system.

### 4.1.7 MEs and the notion of conscious hologram

The notion of conscious hologram is the last step in the development of ideas related to bioholograms. The basic challenge is to generalize the notion of the ordinary hologram to that of a *conscious* hologram, about which bio-holograms would be examples. The notion of quantum gravitational hologram is defined at the level of geometric, purely physical existence whereas conscious holograms exist at the level of subjective existence defined by the sequence of quantum jumps and giving rise to the self hierarchy. Of course, these two notions of hologram must be closely related.

The notion of conscious hologram combines the saint and sinner aspects of consciousness to single concept: macrotemporal quantum coherence due to the generation of bound state entanglement and giving rise to co-operation on one hand, and the dissipative self-organization giving rise to Darwinian selection and competition on the other hand.

In nutshell, the notion of conscious hologram follows from the topological field quantization. Classical fields and matter form a Feynmann diagram like structure consisting of lines representing matter (say charged particles) and bosons (say photons). The matter lines are replaced by space-time sheets representing matter (elementary particles, atoms, molecules,...), and virtual bosons are replaced by topological light rays ("mass-less extremals", MEs). Also magnetic flux tubes appear and together with MEs they serve as correlates for bound state quantum entanglement.

The classical fields associated with MEs interfere only at the nodes, where they meet, and one has a hologram like structure with nodes interpreted as the points of a hologram. Thus one avoids the loss of information caused by the interference of all signals everywhere. This aspect is crucial for understanding the role of em fields in living matter and brain. The MEs corresponding to 'real photons' are like laser beams entering the hologram and possibly reflected from it. What is new that the nodes can be connected by 'virtual photon' MEs also analogous to laser beams. Hence also 'self-holograms' with no laser beam from external world are possible (brain without sensory input).

The hologram has a fractal structure: there are space-time sheets at space-time sheets and high frequency MEs propagating effectively as mass-less particles inside low frequency MEs serving as quantum entangling bridges of even astrophysical length. The particle like high frequency MEs induce 'bridges' between magnetic flux tubes and atomic space-time sheets at the receiving end. This makes possible the leakage of supra currents from magnetic flux tubes to atomic space-time sheets analogous to the exposure of film producing hologram. The leakage induces dissipation, self-organization, and primitive metabolism as a cyclic flow of ionic currents between the two space-time sheets, and thus a Darwinian selection of the self-organization patterns results. Under certain conditions the leakage followed by dropping back to the larger space-time sheet can also give rise to a many-sheeted laser. The low frequency MEs are responsible for the bound state entanglement, macroscopic quantum coherence and co-operation whereas high frequency MEs are responsible for self-organization and competion.

The 3-D vision associated with ordinary holograms generalizes to stereo consciousness resulting in the fusion of mental images associated with the points of conscious hologram [K4].

### 4.1.8 Negative energy MEs and bio-control

Negative energy MEs correspond to space-time sheets with a reversed time orientation. These MEs serve as correlates for bound state entanglement. Low frequency negative energy MEs can contain inside them high frequency MEs propagating along them like negative energy particles. The possibility to quantum jump to a higher energy state by generating negative energy ME gives rise to the pay now-let others pay mechanism of metabolism. This quantum credit card mechanism makes the functioning of the living system extremely flexible. The fact that ELF MEs play an important role in living matter forces to consider the possibility of remote metabolism and the transfer of metabolic energy even in the length scale of Earth (7.8 Hz frequency corresponds to Earth's circumference). The small energy dissipation related to 'our' consciousness could perhaps help to solve 'brain's energy crisis' [23] raised by the puzzling observation that the human brain plus body as a whole does not use more energy than smaller brained mammals with a similar body size.

Negative energy MEs are optimal for the realization of intentions. First p-adic ME transformed to a negative energy ME is generated and serves as a geometric correlate of intention. Then quantum jumps of a real system to a higher energy state occurs and in this quantum jumps p-adic ME is transformed to a negative energy ME to take care of the conservation laws.

Right and left brain hemispheres could have different arrows of the geometric time at appropriate p-adic time scales. For instance, negative energy MEs would make possible quantum communications to the direction of the geometric past. The model of non-episodal memory call would involve quantum communication of the question to the geometric past (time-like entanglement and sharing of mental images), and a classical (dissipative) communication of the answer to the geometric future. Negative-positive energy dichotomy could be be realized in an extremely wide range of time scales and to explain, besides the basic mechanism of long term memory, also precisely targeted realization of intentions, sensory-motor dichotomy, and biocycles as dissipation-healing cycles.

### 4.1.9 MEs and dark matter hierarchy

This chapter has been written much before the emergence of the idea about dark matter hierarchy serving as the source of the long ranged electro-weak and color gauge fields implied by classical. I have left the chapter as such despite the deep insights provided by this vision (for the discussion of this vision see for instance [C6, F6, F10, J1, J2, J6]). Some comments are however in order.

The levels of the dark matter hierarchy are labelled by the value of Planck constant expressible in terms of generalized Beraha numbers $B_q = 4cos^2(\pi/q)$ , $q = m/n$, by the spectrum of complex conformal weights expressible in terms of subsets of zeros of Riemann Zeta, a rational characterizing the effective q-adic topology with which the p-adic topologies corresponding to the primes appearing as factors of the numerator and denominator of the rational number $q = m/n$ are consistent, and an algebraic extension of p-adic number field in question. It is clear that the visible matter is in this framework only a tip of an iceberg. A good metaphor for TGD Universe is as an inverted Mandelbrot fractal for which the introduction of longer length scale resolution meaning bird's eye of view makes visible new large scale structures in every new zoom without limit.

An attractive hypothesis is that particle is characterized either by the integer $m$ or $n$ (nothing to do with $q$ above) depending on whether it corresponds to a positive or negative energy particle, that two positive (negative) energy particles can have direct interactions if the integers $m$ ($n$) associated with them have common prime factors, and that these primes characterize the elementary particles exchanged in the interactions.

As a rule of thumb one can say that the values of $\hbar$ coming as $\lambda^k\hbar$, $\lambda = nv_0$ $v_0 \simeq 2^{11}$ define dark matter hierarchies such that higher level particles decay to lower level particles by de-coherence phase transition reducing the value of $\hbar$ by $1/\lambda$. This hierarchy means for a given particle a hierarchy of zoomed up Compton lengths and times making possible macroscopic quantum coherence by the overlap criterion of space-time sheets having sizes of order Compton length.

The criterion for the phase transition to larger $\hbar$ phase at the lowest level is that the interaction strength $\alpha Q^2$ for particles of charge $Q$ and gauge coupling strength $\alpha$ satisfies $\alpha Q^2 \geq 1$ and implies the increase of $\hbar$ by $\hbar \rightarrow Q^2\alpha\hbar/v_0$ implying the reduction of the interaction strength as $Q^2\alpha \rightarrow v_0$.

MEs can be regarded as space-time correlates for a hierarchy of gauge bosons characterized by different values of Planck constant and the de-coherence phase transition would naturally correspond to the decay of MEs to smaller space-time sheets. The ordinary laser light cannot be regarded as a large $\hbar$ phase, which de-coheres to ordinary photons before the interaction with ordinary matter. Very general consistency arguments lead to the conclusion that dark matter and dark MEs must correspond to $\lambda^k$-fold ($k > 0$) coverings of $M^4$ locally ($\hbar(k) = \lambda^k\hbar_0$, $\lambda \simeq 2^{11}$) whereas ordinary laser light would correspond to $k = 0$.

## 4.2 Massless extremals

The so called massless extremals are very general solution of field equations associated with the minimization of Kähler action parameterized by several arbitrary functions. The purely TGD:eish feature of the massless extremals is the presence of light-like currents generating coherent states of photons and gravitons. These features suggest that massless extremals might have important role in bio-systems.

### 4.2.1 Massless extremals as general solutions of field equations

Let $k = (k^0, k^3, 0, 0)$ be a light like vector of $M^4$ and $u = u(m^1, m^2)$ arbitrary function of the Minkowski coordinates $m^1$ and $m^2$ in the plane orthogonal to the direction of the 3-vector $(k^3, 0, 0)$ associated with $k$. The surfaces defined by the map

$$s^k = f^k(k \cdot m, u) \ , \tag{4.2.1}$$

where $f^k$ and $u$ are arbitrary functions define massless extremals. They describe the propagation of massless fields in the direction of $k$: the fields are periodic with a period $\lambda = 2\pi/k$ so that only $k$ and its integer multiples are possible wavevectors. The polarization associated with various induced gauge fields depends on the position in $(m^1, m^2)$-plane and is in the direction of the gradient of $u$. Field equations involve tensor contractions of the energy momentum tensor and gauge current but these are proportional to $kk$ and $k$ respectively and vanish by the light-likeness of $k$. Linear superposition holds true only in a restricted sense since both the propagation direction and the polarization direction in each $(m^1, m^2) = const$ plane is fixed.

What is remarkable that these solutions are not solutions of the ordinary Maxwell equations in vacuum: Kähler current density $J_K$ is in general non-vanishing(!) and proportional to the light like four-momentum $k$. As a consequence, also a light-like electromagnetic current is in general (but not necessarily) present. The interpretation of the em current $J$ as charged elementary particle current is impossible and the correct interpretation as a vacuum current associated with the induced gauge fields. The finite length of the microtubule plus the requirement that the total vacuum charge vanishes, implies that the Fourier decompositions of the massless fields contain only integer multiples of the basic four-momentum $k$. The direct detection of the light-like vacuum current inside a microtubule would provide strong support for TGD.

The physical importance of these extremals is suggested by the fact they are in certain sense elementary particle like objects: in fact, the original interpretation was as a model for the exterior space-time of a topologically condensed massless particle. The solution set is also very general involving several arbitrary functions. Although the minimization of the Kähler action favors the formation of Kähler electric fields, massless extremals might well appear as space-time sheets of the effective space-time. These space-time sheets should not contain ordinary charges since their presence implies a transition to the Maxwell phase described in an excellent approximation by the ordinary Maxwell electrodynamics.

Rather remarkably, massless extremals are also solutions of the field equations associated with the low energy effective action. This holds true in the absence of the topologically condensed matter, phenomenologically described using external currents. For instance, the term

$$(T^{\alpha\beta}_{\#} - \frac{1}{16\pi G}G^{\alpha\beta})D_\beta\partial_\alpha h^k \ ,$$

where # refers to the topologically condensed matter, reduces to

$$\frac{1}{16\pi G}G^{\alpha\beta}D_\beta\partial_\alpha h^k \ ,$$

and vanishes identically because Einstein tensor is light like so that contraction with the second fundamental form vanishes. The vanishing of these terms in presence of matter is not possible since the gauge currents and energy momentum tensor associated with the topologically condensed matter are not light-like. Thus massless extremals correspond to vacuum space-time sheets with respect to the ordinary matter. Massless extremals can however interact with the ordinary matter via # contacts.

The fact that vacuum em current and vacuum Einstein tensor do not in general vanish, implies that massless extremals serve as sources of coherent photons and gravitons. It is not very economonical to maintain BE condensates all the time. In 'dormant' states microtubules could correspond to ME:s with vanishing em fields but non-vanishing $Z^0$ fields or even vacuum extremals of the effective action with one-dimensional $CP_2$ projection and having vanishing classical gauge fields. Massless extremals can also reduce to vacuum extremals of the Kähler action in the case that the $CP_2$ projection is, in general two-dimensional, Legendre manifold of $CP_2$. Also in this case massless extremals are however non-vacuum extremals of the effective action.

### 4.2.2 About the electro-weak and color fields associated with massless extremals

Space-time sheets carrying em fields carry usually also $Z^0$ and $W$ fields and it is not possible to speak about em or $Z^0$ type MEs. It is however possible to speak about neutral and $W$ MEs. The $CP_2$ projection of ME is 2-dimensional and in a special case it reduces to a geodesic sphere. There are two kinds of geodesic spheres in $CP_2$.

1. For space-time sheets for which $CP_2$ projection is $r = \infty$ homologically non-trivial geodesic sphere of $CP_2$ one has

   $$\gamma = (\frac{3}{4} - \frac{sin^2(\theta_W)}{2})Z^0 \simeq \frac{5Z^0}{8} \ .$$

   The induced $W$ fields vanish in this case and they vanish also for all geodesic sphere obtained by $SU(3)$ rotation.

2. For homologically trivial geodesic sphere a standard representative is obtained by using for the phase angles of standard complex $CP_2$ coordinates constant values. In this case induced em, $Z^0$, and Kähler fields vanish but induced $W$ fields are non-vanishing. This holds also for surfaces obtained by color rotation. Hence one can say that for non-vacuum extremals with 2-D $CP_2$ projection color rotations and weak symmetries commute.

The MEs corresponding to these two geodesic spheres could be called neutral and $W$ MEs and they carry color fields for which the color group $SU(3)$ reduces to some of its $U(1)$ subgroups. Quite generally, the holonomy algebra of color group is Abelian since the induced color field is of the form $g^A_{\alpha\beta} \propto H^A J_{\alpha\beta}$, where $H^A$ denotes color Hamiltonian.

Neutral MEs are excellent candidates for mediating EEG type communications from the biological body to the magnetic body whereas charge entanglement induced by $W$ MEs would be ideal for the realization of motor actions of the magnetic body by generating first superposition of exotically ionized states of atomic nuclei entangling magnetic and biological body [M3]. State function reduction would lead to an exotically ionized state accompanied by dark plasma oscillation pattern. By Faraday law this pattern would induce electric fields at the space-time sheets containing ordinary matter which in turn would generate ohmic currents leading to various physiological effects.

MEs are excellent candidates for the space-time correlates of laser beams. Dark matter hierarchy implies that also MEs can be classified by the level of the dark matter hierarchy involved. A very general argument leads to the conclusion that dark space-time sheets, in particular MEs, at the $k^{th}$ level of the dark matter hierarchy correspond to space-time sheets defining $\lambda^k$-fold coverings of $M^4$ (recall that one has $\hbar(k) = \lambda^k \hbar_0$ and $\lambda \simeq 2^{11}$) [C6, M3]. $k = 0$ MEs would correspond to the ordinary laser light.

### 4.2.3 How massless extremals generate coherent states of photons?

ME:s can be in 'dormant' or active state according to whether the em current associated with the ME is vanishing or not. In active state ME:s generate Bose Einstein condensate type state for ordinary photons. This means in TGD context the emission of (topological) vapor phase photons ($CP_2$ type extremals), which can condense on other condensate levels. ME:s generate gravitonic BE condensate and the possible biological role of this condensate will be discussed later.

Assuming that the coupling of quantized photon field to the massless extremal is given by regarding the massless extremal as a classical background field one obtains QED with a light like source $J^\alpha$:

$$\begin{aligned} D_\beta F^{\alpha\beta} &= eJ^\alpha \ , \\ J^\alpha &= Jk^\alpha \ . \end{aligned} \tag{4.2.2}$$

The system is equivalent with an infinite number of harmonic oscillators each driven by a harmonic external force and a basic exercise in the quantum mechanics shows that the solutions of the field equations give the new oscillator operators as sums of free oscillator operators plus c-number term, which is essentially the Fourier component of the light like current in the direction of the polarization.

In the limit that ME has infinite duration and is a cylindrical structure of finite length $L$ (that is microtubule) one has for $J \propto sin(k_z(t-z))$

$$\begin{aligned} a^\dagger(p) &\rightarrow a^\dagger(p) + g(p) \ , \\ g(p) &= \sum_n \delta(p^0, k_n^0) K(p, k_n) J(k_n^z, p_T) \ , \\ K(p,k) &= \epsilon(p)\cdot k \frac{1}{i(p_z - k_z)}(exp(ip_z L) - 1) \ , \\ k_n &= nk_0 = \frac{n2\pi}{L}(1,1,0,0) \ . \end{aligned} \tag{4.2.3}$$

Here $p$ denotes the momentum of the photon and $k$ the 4-momentum associated with the Fourier component of a light-like current. $\epsilon(p)$ denotes the polarization of the photon. $J(k_n^z, p_T)$ is essentially the 3-dimensional Fourier transform of the scalar function $J$. The infrared behavior of $J(k_z, p_T)$ as a function of the transversal momentum $p_T$ can be deduced from the fact that the transverse dimension of the microtubule is small (about 25 nm) as compared to $1/p_T$ so that the Fourier component is in good approximation independent of $p_T$.

For the frequencies present in the Fourier decomposition of the massless extremal, the ordinary oscillator vacuum is transformed to a coherent state in the corresponding Fourier mode of the quantized photon field. The essential point is that the wave vectors of the radiation field and massless extremal are nonorthogonal. The radiation pattern resembles the ordinary antenna pattern associated with an oscillating current $J(t) = exp(i\omega t)$ in that the intensity of radiation vanishes at angles $\theta = \pi/2$ and $\theta = 0$. For $J \propto sin(k_z(z-t))$ $|K|^2$ has maxima for $\theta = 48.6$ degrees and 131.4 degrees. For an ordinary dipole with $J = sin(\omega t)$, $\omega = 2\pi/L$ the radiation pattern is concentrated at angles $\theta \geq 40$ degrees with maximum and 69.3 degrees and 110.7 degrees.

A more complicated situation corresponds to a group of several massless extremals (say microtubules). If massless extremals are parallel and have same length the previous expression generalizes with superposition of terms

$$g(p) \quad \rightarrow \quad \sum_n exp(i\phi_n)exp(ip_z z_n)exp(ip_T \cdot x_T)g_n(p) \quad . \tag{4.2.4}$$

The phase $\phi_n$ is the phase difference between $n$:th light like current with respect to some reference current. If the positions of microtubules and/or phases of the individual light like currents are suitably chosen then various terms interfere constructively and macroscopic quantum coherence is obtained at resonant frequencies. Suffice it so say that the needed timing is extremely accurate: less than $10^{-12}$ seconds! Since $p_z$ is small rather larger transversal distances are allowed by the requirement of constructive interference. In a more general situation also the orientations of microtubules can vary in certain limits. Note that light-like energy momentum generates also gravitonic BE condensates at preferred frequencies.

### 4.2.4 Massless extremal is accompanied by a Bose-Einstein condensate of parallel photons

The interaction Lagrangian describing the interaction of photon field with the light-like vacuum current does not couple to the photons collinear with the vacuum current (light-like wave vector has vanishing length squared). Therefore the ground states of the system are degenerate since one can add to any coherent state generated by the vacuum current any number of photons collinear with the vacuum current and topologically condensed inside the massless extremal. This means Bose-Einstein condensation in collinear degrees of freedom.

Collinear Bose-Einstein condensates of photons are crucial for the model of the quantum correlates of the sensory qualia. Sensory quale is characterized partially by the BE condensate of photons associated with the massless extremal parallel to the axon. The existence of the BE condensate makes possible induced emission. For instance, Josephson currents generate photons with frequencies which are multiples of the Josephson frequency. If the potential difference in Josephson junction equals to a multiple of the cyclotron frequency of some super conducting ion, the current flows resonantly in the sense that Josephson current serves as a harmonic perturbation generating quantum jumps and gives rise to a large dissipative current and also quantum jumps in either super conductor. Since the emission rate for photons by the current is proportional to $N^2$, where $N$ is the number of photons already in the state, the presence of the BE condensate of photons with this frequency amplifies the emission rate. This kind of resonance mechanism is assumed in the model of sensory experience since it elegantly explains why given neuron corresponds to single quale. Since the potential difference over the Josephson junction can correspond to only single cyclotron frequency, the dominance of single quale is unavoidable even when all macroscopic quantum phases are present.

The existing BE condensate increases the probability of topological condensation of coherent photons generated by other massless extremals to the massless extremal. This mechanism could provide inter-neuronal communication mechanism and realize the metaphor about brain as a society of neutrons, the notion of neuronal window idea and also give a more precise content to the music metaphor. In particular, neurons far away from each other could communicate using wavelengths in a narrow wave length range by this mechanism.

The wave vectors of the photons are multiples of $k = \pi/L$. This means that the length of the massless extremal correlates with the maximal allowed wavelength. For ELF photons associated with EEG frequencies of order 10 Hz the length of massless extremal is of order Earth's circumference. This suggests that more general massless extremals with a topology of torus instead of linear topology could characterize the topological field quanta of ELF fields. It is however impossible to say, whether the field equations allow more general solutions resembling massless extremals.

### 4.2.5 MEs and exotic representations of p-adic Super Virasoro

The exotic representations of p-adic Super Canonical and Super Virasoro algebras forming excellent candidate for a hierarchy of lifeforms are associated with MEs [M2, K3]. For these representations mass squared of the particle is proportional to Virasoro generator $L_0$ having integer valued mass spectrum. When the value of the p-adic mass squared is power of $p$: $M^2 \propto p^n$, $n = 1, 2, ..$, the real counterpart of the mass squared is extremely small since it is proportional to $1/p^n$ in this case. These states are generated by a subalgebra of Super Canonical Algebra in case of MEs since the conformal weight of the vacuum state vanishes (for ordinary elementary particles conformal weight of the vacuum is negative integer). Thus very special representations of p-adic Super Virasoro algebra are in question.

The degeneracy of states (number of states with same mass very small squared) is enormous for the physically interesting values of p-adic prime $p$. This means that these states provide huge negentropy resources. Thus exotic Super Virasoro representations be interpreted as quantum level articulation for the statement that TGD Universe is quantum critical quantum spin glass. Exotic Super Virasoro representations clearly provide an excellent candidate for an infinite hierarchy of life forms. These lifeforms are labelled by three integers (k,m,n): physically interesting primes correspond to $p \simeq 2^{k^m}$, whereas $k$ prime and $m$ are integers, and the power $n$ appearing in $M^2 \propto p^n$. It is these lifeforms which make mind-like space-time sheets living creatures and these lifeforms emerge already in elementary particle length scales and become increasingly complex when the p-adic length scale increases. Life can be regarded as a symbiosis of these lifeforms. These lifeforms ('mind') interact with each other and ordinary matter via the classical gauge fields associated with MEs. A natural hypothesis is that the quantum phase transitions of the macroscopic quantum phases for the particles of the exotic Super Virasoro representations formed in classical fields of MEs (mind-like space-time sheets) give rise to some (but not all) qualia.

## 4.3 Microtubules as quantum antennae

### 4.3.1 Linear structures as quantum antennae

The many-sheeted space-time concept of TGD indeed allows almost vacuum space-time sheets and these space-time sheets might be crucial for the understanding of the bio-systems. For instance, the weak interaction of these space-time sheets with the ordinary space-time sheets containing matter could provide representations of the external world in the physical properties of the almost vacuum space-time sheets. In particular, mind-like space-time sheets having finite time duration could generate coherent light and coherent light might make communication possible between mind-like space-time sheets and realize the idea of neuronal window discussed briefly in introduction [H7]. The mind-like space-time sheets associated with various linear structures are especially natural candidates for massless extremals serving as quantum antennae. Bio-systems are full of linear structures and the mind-like space-time sheets associated with microtubules, DNA and protein molecules are the most obvious candidates for quantum antennae.

### 4.3.2 Are microtubules accompanied by massless extremals?

The interior of the microtubule is by its cylindrical symmetry an ideal place for ME:s whereas the axonal cell membranes must correspond to 'Maxwell phase', where ordinary Maxwell equations are satisfied in a good approximation but also a separate space-time sheet is possible candidate for a massless extremal. The function $u(x, y)$ appearing in the general solution is most naturally $u(x, y) = \sqrt{x^2 + y^2}$ for microtubules implying radial polarization. The explanation of the macroscopic quantum coherence in the brain would provide crucial support for the TGD based world picture since massless sources and vacuum currents are not possible in the ordinary QED.

There is analogy with the super radiance phenomenon [49]: in this case however the photons radiated by the microtubule waveguide have momenta parallel to the microtubule so that the mechanism leading to the formation of the macroscopic BE condensate remains to be understood. The theories associating coherent photons with the microtubules typically assume that the coherent photons reside inside the microtubules: this leads to problems since Uncertainty Principle; the direct study of Maxwell equations also suggest that photons should have very large transversal momenta corresponding to the transversal dimension of the microtubule of order $10^{-8}$ meters. In TGD this difficulty is avoided since only the *sources* of the coherent photons are restricted into the interior of microtubules whereas the photons can exists in vapor phase and condense on various space-time sheets of the topological condensate.

The necessary condition for the formation of the coherent states in the presence of the matter is that ME condensate level does not contain ordinary gauge charges. If ME corresponds to a larger space-time sheet 'below' the space-time sheet containing the ordered water, this requires that the gauge charges of the condensed matter do not flow to the interior of the ME space-time sheet. This is achieved if the condensed particles combine by join along boundaries bonds together to form a net like structure so that gauge fluxes can run along the join along boundaries bonds to the boundary of the ME region, where they can flow down to the ME condensate level. Ordered water is a good candidate for this join along boundaries condensate. Microtubules are known to be surrounded by ordered water and also the interior contains ordered water. The axial electric polarization of the microtubular surface suggests that there is a longitudinal electric gauge flux at the condensate level of the ordered water running to/from the ME condensate level at the ends of the microtubule. The wave lengths appearing in the Fourier expansion of $J$ are of form $L/n$, $L$ being microtubule length.

In the active mode microtubule acts as a quantum antenna creating quantum coherent light unlike the ordinary antenna, which creates incoherent light. Also waveguide mode is possible for the topologically condensed photons but antenna mode is crucial for the generation of the macroscopic coherent states. The following argument suggests that he dielectric properties of the microtubule surface can change the antenna pattern somewhat. The dipoles of the microtubule are known to be parallel to the axis of the microtubule. The interaction energy of a dipole $p$ with the radiation field is proportional to the quantity $p \cdot E = pEcos(\theta)$ so that the effect of the dielectric is largest, when the wave vector of the photon is orthogonal to the axis of the microtubule. As a consequence, the dipole pattern should concentrate in the forward direction.

The em current in the interior transforms ordinary QED vacuum to a coherent state in the resonating Fourier modes of the photon field. In ME mode the resonance energies come as multiples of $E_0 = 2\pi/L$ and wavelength $L/n$, where $L$ is the length of the microtubule whereas in VE mode the spectrum is continuous. Biophotons [52] with energy of order one eV might be regarded as evidence for BE states associated with the shortest microtubules (such as centriole and basal bodies). The average length of the neuronal microtubules is about $10^{-5}$ $m$ and corresponding IR radiation is more energetic than thermal IR radiation with a wavelength of order $10^{-4}$ $m$.

In the ME mode the resonances at energies $E_n = nE_0$, $E_0 = 2\pi/L$, provide ideal communication channels. Microtubules with different lengths provide independent communication channels so that very effective communication in principle becomes possible. This process could orchestrate axonal microtubules as well as the microtubules belonging to different neurons to form a larger macroscopic quantum state. An optimal performance is obtained if the microtubules belonging to same group are parallel and their lengths are quantized with a common multiple. The microtubules of the neighboring neurons indeed tend to be parallel. Axonal microbutules are also parallel whereas the microtubules inside the ordinary cells are in radial configurations. The grey matter in brain has a columnar structure so that axonal microtubules tend to be in the direction of the columns: this should favor the formation of a quantum resonance between different microtubules. Furthermore, the model of [50], described in Tuscon II, for the microtubule interactions predicts that the microtubules of even far away neurons are parallel. The average length of the neuronal microtubules is about $10^{-5}$ $m$ and it is known that the response of 3T3 cells to weak IR radiation is maximum at this wavelength. Neurons could be able to tune their microtubules to the desired infrared stations by controlling their orientation and length. The upper bound about $10^{-4}$ meters for the length of the axonal microtubules can be understood: for the longer microtubules the thermal IR radiation becomes important and makes communication impossible. In long axons this problem is avoided by joining shorter microtubules in series via Microtubule Associated Proteins (MAPs).

Since the time scale for the change of the tubulin polarization is of order $10^{-10}$ seconds and the period of the IR radiation is of order $10^{-13}$ seconds, amplitude modulated IR transmissions are possible. The mechanism of the amplitude modulation could be simply a change of the microtubule interior gauge field from active to dormant ME mode. Amplitude becomes vanishing if this field becomes ordinary sourcefree em field or $Z^0$ field. IR transmissions could be based on some kind of binary code resembling genetic code. There is indeed concrete proposal of Koruga for this code motivated by the geometric structure of the microtubule surface. [37, 28]. One possibility is that the propagating modes of dipole and conformational oscillations perform elementary AM modulations. These modes could correspond to elementary language expressions at the level of the microtubules.

Microtubules can also absorb photons coming from an external source at resonance energies. If Bose-Einstein condensate of $N$ photons in some mode is present, the absorption probability is amplified roughly by the factor $N^2$ as shown in appendix. This suggests that microtubules containing BE condensate of photons in some mode are able to 'see' in some elementary sense. Of course, receiving antenna containing the BE condensate need not be microtubule. Centrioles (T shaped pair of microtubules inside animal cells) could provide cell with infrared eye and there is experimental evidence for this in the case of monocellular organisms [35]. Also the radial microtubules could have elementary sense of vision. Note that all eucaryotic cells have radial structure of microtubules in their cytosceleton.

### 4.3.3 How macroscopic quantum coherence is generated?

The big problem is the creation of constructive interference between the coherent states associated with different microtubules. The problem looks exceedingly difficult: microtubules should be able to tune up the frequency and phase associated with light like current inside microtubule with those of other microtubules contributing to the coherent state. Frequency tuning, or equivalently length tuning, involves time scales smaller than $10^{-13}$ seconds in case of infrared light associated with longest microtubules. The simplest solution to come into mind is that there exist some pacemaker keeping the microtubules in rhythm. One can imagine several mechanisms important for the tuning, each involving the special properties of the TGD:eish space-time crucially.

#### Topological field quantization

TGD:eish space-time surface decomposes into regions characterized by vacuum quantum numbers, which are frequencies and integers related to the time and angle dependences of the phase angles associated with the two complex $CP_2$ coordinates. Typically one has $\Phi = \omega t + Fourier\ expansion$ so that space-time surface vibrates with frequency $\omega$. This vibration is an ideal candidate for a pacemaker for the physical systems inside a given space-time region. In fact, the vacuum quantum numbers characterize partially also the order parameter of a super conductor. Vacuum frequencies could also be special frequencies for the Maxwell fields.

The increased understanding about topological field quanta as classical and quantum coherence regions of em field is consistent with and generalizes this view. When topological field quanta are joined by join along boundaries bond generated in quantum jump they fuse to form a larger region of classical and quantum coherence. This suggests a general mechanism for how various axons/microtubules can generate phase coherent em fields. What is needed is that there is larger space-time sheet connected by join along boundaries bonds to the massless extremals associated with various axons/microtubules. This larger space-time sheet is most naturally the geometrical counterpart of higher level self so that consciousness is what creates synchrony rather than vice versa!

A further important aspect in the generation of synchrony is self-organization. The subsystems of self quantum self-organize and end up to asymptotic self-organization patterns selected by dissipation. These patterns are simple and typically involve spatially repeating patterns and synchronous oscillations (Benard flow is simple example of this). It is consciousness which implies synchrony and coherence whereas in standard approaches to quantum consciousness synchrony and coherence are believed to be prerequisites for consciousness.

#### Phase locking for the system of Josephson junctions

Japanese physicist Yoshiki Kuramato from the University of Kioto has shown that the solutions of the differential equations describing Josephson junctions tend to a state in which there is single collective oscillation frequency. A.T. Winfree from the University of Arizona has shown that a phase transition to single collective oscillation frequency analogous to the freezing of liquid occurs in this kind of system.

The solutions of the differential equations describing Josephson junctions model quantum self-organization and synchronization can be interpreted as an instance of the selection of asymptotic self-organization patterns selected by dissipation and occurring always in quantum self-organization.

Of course, the quantum jumps can occur only provided the system of Josephson junction belongs to a system having self so that consciousness is again prerequisite for synchrony rather than vice versa! In any case, the fact that entire brain is hierarchy of space-time sheets such that the space-time sheets at various levels are connected by Josephson junctions makes this result rather encouraging.

**Gap junctions and MAPs**

As noticed, the formation of the join along bonds is the basic prerequisite for the formation of the macroscopic quantum systems. The so called gap junctions can be regarded as join along boundaries bonds between the cell membranes (understood as 3-surfaces in TGD picture) of the neighboring cells. They could have a key role in synchronous firing of neuron groups. Gap junctions could also force the vacuum quantum numbers of the neighboring cell membranes to be identical as well as provide the bridges for the propagation of the Maxwell type fields between neighboring cells. It is known that the coherently firing neuron groups in brain possibly responsible for the generation of sensory experience are gap junction connected. It is not however obvious whether gap junctions have anything to do with the synchronizing of the vacuum currents: the difference between the time scales involved is indeed huge. Also Microtubule Associated Proteins could act as join along boundaries bonds guaranteing quantum coherence between microtubules inside same cell.

### 4.3.4 Are nerve pulse patterns coded into vacuum currents and coherent light?

It has turned out that TGD based model for memetic code leads to the same interpretation of nerve pulse patterns as suggested by neuroscience. Nerve pulse/no nerve pulse corresponds to true/false Boolean statement or 1/0 value of binary digit. Fundamental coding of nerve pulse patterns is the coding into temporal sequences of cognitive neutrino pairs associated with cell membrane such that the spin of the cognitive antineurino codes for true/false (1/0). Of course, bits could code also for binary digits in the binary expansion and code for the intensity of the primitive sensory experience associated with the neuron. It is natural to ask whether nerve pulse patters could be also coded to some other representations. Light-like currents are indeed optimal in this respect.

The dependence of the light-like current on the longitudinal coordinate of massless extremal is arbitrary and therefore light-like current provides ideal tool of classical communication of information with light velocity as well as coding of this information to coherent light received by other massless extremals. The first bio-application to come into mind is that the instantaneous nerve pulse patterns propagating along the axon could be coded into the pattern of the vacuum current. The velocity of propagation for the nerve pulse pattern is extremely small as compared to light velocity but this is not a problem if the coding takes place in the region where nerve pulses are generated. What happens is that same temporal pattern of pulses propagates with different velocities. This coding in turn implies coding of nerve pulses to coherent states of photons and in principle the communication of nerve pulse pattern to other neurons.

The relationship between memetic and genetic code is that between two hierarchy levels of a computer program. This suggests that nerve pulse patterns representing memetic codons could serve as transcription factors at gene level. This requires the communication of nerve pulse patters to nucleus. Even more, communication mechanism must treat different presynaptic inputs as different inputs. Modulation of the vacuum current could make possible communication of the nerve pulse patterns to the cell nucleus along the massless extremals associated with the radial microtubules which in case of neurons have direct contact with the cell membrane. The fact, that some anesthetics seem to affect microtubules and that some brain diseases involve changes of microtubules could also be explained as a breaking of the cell membrane-nucleus communication link. That this kind of communication link might exist is suggested bythe fact that ELF em fields have direct efect on genetic expression [29].

## 4.4 Masless extremals and information molecules

The notion of information molecule is central for the understanding of biological control. There are however several rarely asked questions related to the notion of information molecule: in particular, the phenomenon of pleiotropy is not easy to understand on basis of pure chemistry [24]. TGD inspired view about biocontrol and coordination suggests a general answer to these questions and leads to a general model of biological control based on both MEs and information molecules with massless extremals (MEs) serving as actual information carriers and information molecules having a a role analogous to that of computer passwords.

### 4.4.1 Questions about information molecules

Central nervous system (CNS), endocrine system and immune system are three basic systems involved with bio-control and -communication. The work of Candace Pert and other neuroscientists has led to a general notion of information molecule described in popular manner by Candace Pert [26]. Neural transmitters and modulators associated with CNS are only special cases of information molecules. Also neuropeptides and various hormones are involved. It has become clear that emotions are closely related with the activity of information molecules and that both brain, endocrine system and immune system communicate intensively with each other. One could regard even brain as a big gland. Of course, one could also consider various glands and organs as mini-brains.

The interactions of the information molecules involve the formation of receptor-information molecule complex either at cell surface or in the cell plasma inside cell. Receptor-information molecule complex inside cell can move to genome and induce gene transcription. In case that the complex is formed at the surface of cell, second messenger action is involved. One can also speak about N:th messenger action. There are many poorly understood aspects related to the mechanisms of information molecule action [24].

1. There are only few second messenger pathways and relatively few receptors but large number of different functions. This phenomenon is known as pleiotropy or multi-functionality. For instance, given second messenger causes different effects depending on the hormone that activated it (the phenomenon is somewhat analogous to the phenomenon in which message can be understood in several manners depending on the state of receiver). At purely chemical level the problem is how second messenger knows what hormone activated it? In steroid action the complex formed by information molecule and receptor in turn activates some gene. Now the question is: How the activated RNA polymerase knows which gene has to be activated? Pleiotropy appears also at level of hormones. Same hormone can have multiple effects and the border between hormone, neuropeptide or even neurotransmitter is unclear. For instance, hormone which by definition transmits long distance communications, can have effects in nearby cells and thus acts like a neuropeptide. How hormone knows what function it must perform? Also drugs and treatments can have different effects and side effects.

2. There is also functional redundancy: the same function is performed by several second messenger molecules. For instance, glucagon, growth hormone, adrenaline and corticosteroids elevate clucose levels. This suggests that there is deeper level of communication involved and that second messenger molecules are more like computer passwords than subprogram calls. Now the question is: What these subprogram calls do correspond physically?

3. Biological functions can be initiated also in nonchemical manner. The phenomena of healing by touch and the effects of meditation and biofeedback are examples of biological self-organization processes are initiated in nonchemical manner. Even other treatments like massage, acupuncture or meditation can decrease or inhibit pain. These observations suggest that chemical level is not the deepest level involved with biological functions and the question is: What is this deeper control level?

Simple lock and key mechanism cannot provide answer to the questions raised above. Rather, computer password might provide better metaphor for the second messenger action whereas receptor-information molecule complex would effectively generate subprogram call perhaps carried by the second messanger molecule or possibly broadcasted. It seems that information molecules act more like signs or symbols rather than being purely chemical agents. These symbols are interpreted by cell level intelligences and the interpretation depends on context.

### 4.4.2 A model of biological self-organization based on quantum antenna hypothesis

The view that self hierarchy is present already at molecular level and realized in terms of MEs provides rather straightforward interpretation of pleiotropy and redundancy. The phenomenon of pleiotropy suggests there is nonchemical communication between receptor-peptide complex and cell nucleus. The most natural TGD inspired candidate for the communication is wake-up of genome subself by general wake-up mechanism in which classical em field associated with ME induces quantum jumps leading to quantum phase transition which could correspond to the transcription process. The almost-determinism of the transcription process would be due to the Darwinian selection caused by dissipative effects.

These considerations suggest that information molecule-receptor complex could generate ME carrying classical gauge fields and vacuum current. Vacuum current is excellent candidate for coding the information and can lead to a generation of coherent light.

1. The first possibility is broadcasting. The ME associated with information molecule receptor-complex acts as active quantum antenna and activated structure, say genome, serves as a passive quantum antenna receiving the coherent light. Classical fields and/or coherent light would induce quantum jumps serving as seeds of quantum phase transitions leading to a wake-up of conscious and self-organizing subself inside receiver.

2. Alternatively, second messenger molecule could carry the information carrying ME with itself as a genuine message inducing the self-organization process in, say, genome.

A natural hypothesis is that the states of the exotic Super Virasoro representations define the macroscopic quantum phases in question: the reason is that these representations are present in all length scales. The information molecule-receptor pair corresponds to a definite frequency, or more generally, combination of frequencies, coding the corresponding function. For instance, genes might be coded to harmonics of Super Virasoro frequencies associated with various p-adic length scales. All information molecule-receptor combinations initiate some function determined by these frequencies and pleiotropy emerges as a basic prediction of the model. Second messenger pathway is like a password to computer, universal key, together with the frequency or even entire ME specifying the function in question: this initiates the desired self-organization process waking-up proper subself.

These ideas suggest the following general framework for understanding biological self-organization.

1. Biological programs consist of self-organization patterns generated by classical gauge fields associated with MEs at specific resonance frequencies inducing quantum jumps leading to quantum phase transitions. These resonance frequencies serve as names of the genetic subprograms. Messenger molecules in turn serve in the role of computer passwords.

2. Self-organization processes are associated with MEs and generated by special frequencies, which could be harmonics of the fundamental frequencies associated with various exotic Super Virasoro representations. For instance, combinations of harmonics of various Super Virasoro transition frequencies could define 'name of gene'. The fact that these frequencies are constants of Nature means that the model is immediately testable. Of course, also other transition frequencies, in particular, magnetic and $Z^0$ magnetic transition frequencies, could be important.

3. The ability of a biological system to act effectively like a deterministic computer is due to the Darwinian selection of the asymptotic patterns of self-organization caused by dissipation in systems which are feeded by energy.

4. The four-dimensionality of this self-organization process is also important element. The frequency of ME defines time scale $T = 1/f$ which defines the duration of biological chronon. With this interval of geometric time entire 4-dimensional space-time surface changes in self-organization process.

## 4.5 Evidence for quantum antenna hypothesis

In the following some evidence for quantum MEs and quantum antenna hypothesis is discussed. It must be emphasized that there is also other evidence discussed in other chapters of the book (for instance, see the chapters [K3, M2, M4, M5].

### 4.5.1 TGD inspired model for sonoluminescence

Sonoluminescence [46] is a peculiar phenomenon, which might provide an application for the hydrodynamical hierarchy. The radiation pressure of a resonant sound field in a liquid can trap a small gas bubble at a velocity node. At a sufficiently high sound intensity the pulsations of the bubble are large enough to prevent its contents from dissolving in the surrounding liquid. For an air bubble in water, a still further increase in intensity causes the phenomenon of sonoluminence above certain threshold for the sound intensity. What happens is that the minimum and maximum radii of the bubble decrease at the threshold and picosecond flash of broad band light extending well into ultraviolet is emitted. Rather remarkably, the emitted frequencies are emitted simultaneously during very short time shorter than 50 picoseconds, which suggests that the mechanism involves formation of coherent states of photons. The transition is very sensitive to external parameters such as temperature and sound field amplitude. In the following only the rough hydrodynamical characteristics of the phenomenon are considered from the point of view of p-adic length scale hypothesis. Also an attempt to understand the mechanism behind quantum coherence in terms of light-like vacuum currents associated with massless extremals is made.

#### Sonoluminescence and hydrodynamic hierarchy

A plausible explanation for the sonoluminescence is in terms of the heating caused by shock waves launched from the boundary of the adiabatically contracting bubble [46]. The temperature jump across a strong shock is proportional to the square of Mach number and increases with decreasing bubble radius. After the reflection from the miminum radius $R_s(min)$ the outgoing shock moves into the gas previously heated by the incoming shock and the increase of the temperature after focusing is approximately given by $T/T_0 = M^4$, where M is Mach number at focusing and $T_0 \sim 300\ K$ is the temperature of the ambient liquid. The observed spectrum of sonoluminescence is explained as a brehmstrahlung radiation emitted by plasma at minimum temperature $T \sim 10^5\ K$.

The model reproduces nicely the time development of the bubble and sonoluminescence spectrum and explains sensitivity to the external parameters [46]. The problem is to understand how the length scales are generated and explain the jumpwise transition to sonoluminescence and the decrease of the bubble readius at sonoluminescence: ordinary hydrodynamics predicts continuous increase of the bubble radius. The length scales are the ambient radius $R_0$ (radius of the bubble, when gas is in pressure of 1 atm) and the minimum radius $R_s(min)$ of the shock wave determining the temperature reached in shock wave heating. Zero radius is certainly not reached since since shock front is susceptible to instabilities.

Since p-adic length scale hypothesis introduces a hierarchy of hydrodynamics with each hydrodynamics characterised by a p-adic cutoff length scale there are good hopes of achieving a better understanding of these length scales in TGD. The change in bubble size in turn could be understood as a change in the 'primary' condensation level of the bubble.

1. The bubble of air is characterized by its primary condensation level $k$. The minimum size of the bubble at level $k$ must be larger than the p-adic length scale $L(k)$. This suggests that the transition to photoluminesence corresponds to the change in the primary condensation level of the air bubble. In the absence of photoluminesence the level can be assumed to be $k = 163$ with $L(163) \sim .76\ \mu m$ in accordance with the fact that the minimum bubble radius is above $L(163)$. After the transition the primary condensation level of the air bubble is $k = 157$ with $L(157) \sim .07\ \mu m$. In the transition the minimum radius of the bubble decreases below $L(163)$ but should not decrease below $L(157)$: this hypothesis is consistent with the experimental data [46].

2. The particles of hydrodynamics at level $k$ have minimum size $L(k_{prev})$. For $k = 163$ one has $k_{prev} = 157$ and for $k = 157$ $k_{prev} = 151$ with $L(151) \sim 11.8\ nm$. It is natural to assume that the

minimum size of the particle at level $k$ gives also the minimum radius for the spherical shock wave since hydrodynamic approximation fails below this length scale. This means that the minimum radius of the shock wave decreases from $R_s(min,163) = L(157)$ to $R_s(min,157) = L(151)$ in the transition to sonoluminescence. The resulting minimum radius is 11 $nm$ and much smaller than the radius .1 $\mu\ m$ needed to explain the observed radiation if it is emitted by plasma.

A quantitative estimate goes along lines described in [46].

1. The radius of the spherical shock is given by

$$R_s = At^{\alpha} \ , \tag{4.5.1}$$

where $t$ is the time to the moment of focusing and $\alpha$ depends on the equation of state (for water one has $\alpha \sim .7$).

2. The collapse rate of the adiabatically compressing bubble obeys

$$\frac{dR}{dt} = c_0(\frac{2}{3\gamma}\frac{\rho_0}{\rho}(\frac{R_m}{R_0})^3)^{1/2} \ , \tag{4.5.2}$$

where $c_0$ is the sound velocity in gas, $\gamma$ is the heat capacity ratio and $\rho_0/\rho$ is the ratio of densities of the ambient gas and the liquid.

3. Assuming that the shock is moving with velocity $c_0$ of sound in gas, when the radius of the bubble is equal to the ambient radius $R_0$ one obtains from previous equations for the Mach number $M$ and for the radius of the shock wave

$$\begin{aligned} M &= \frac{\frac{dR_s}{dt}}{c_0} = (t_0/t)^{\alpha-1} \ , \\ R_s &= R_0(t/t_0)^{\alpha} \ , \\ t_0 &= \frac{\alpha R_0}{c_0} \ . \end{aligned} \tag{4.5.3}$$

where $t_0$ is the time that elapses between the moment, when the bubble radius is $R_0$ and the instant, when the shock would focus to zero radius in the ideal case. For $R_0 = L(167)$ (order of magnitude is this) and for $R_s(min) = L(151)$ one obtains $R_0/R_s(min) = 256$ and $M \simeq 10.8$ at the minimum shock radius.

4. The increase of the temperature immediately after the focusing is approximately given by

$$\frac{T}{T_0} \simeq M^4 = (\frac{R_0}{R_s})^{\frac{4(1-\alpha)}{\alpha}} \simeq 1.3 \cdot 10^4 \ . \tag{4.5.4}$$

For $T_0 = 300\ K$ this gives $T \simeq 4 \cdot 10^6\ K$: the temperature is far below the temperature needed for fusion.

In principle the further increase of the temperature can lead to further transitions. The next transition would correspond to the transition $k = 157 \to k = 151$ with the minimum size of particle changing as $L(k_{prev}) \to L(149)$. The next transition corresponds to the transition to $k = 149$ and $L(k_{prev}) \to L(141)$. The values of the temperatures reached depend on the ratio of the ambient size $R_0$ of the bubble and the minimum radius of the shock wave. The fact that $R_0$ is expected to be of the order of $L(k_{next})$ suggests that the temperatures achieved are not sufficiently high for nuclear fusion to take place.

### The model of sonoluminescence by Buzzacchi, del Giudice and Preparata

The coherence of the light generated in sonoluminescence looks rather mysterious from the view point of standard physics. There is very interesting paper of Buzzacchi, del Giudice and Preparata about sonoluminescence with title '*Sonoluminescence Unveiled?*' [46]. The study of this paper revealed that the physical picture behind microtubule as quantum antenna hypothesis leads to a model for sonoluminescence and that sonoluminescence could be interpreted as a direct evidence for light-like vacuum currents generating coherent photons in TGD. Needless to say, vacuum currents are a purely TGD:eish phenomenon and implied by the induced gauge field concept deriving from the hypothesis that space-time is 4-dimensional surface in certain 8-dimensional space.

The assumptions of the work of Buzzacchi, del Giudice and Preparata [46] are following.

1. The energy of the coherent radiation created in sonoluminescence results from the latent heat 0.26 eV per molecule for gas to liquid phase transition occurring at the final stage of the bubble collapse. In [46] the latent heat is used to deduce the width $\Gamma$ of the energy spectrum of photons.

2. When shock wave is formed during the collapse of bubble (collapse velocity becomes supersonic), a front of layers with distance that between water molecules is formed. The average distance of molecules in tangential direction are much larger but gets smaller during the collapse of bubble. One can say that there is vapor layer looking like water in radial direction but in transversal directions the layer is much less dense. When the radius of the buble reaches certain critical value (so that density is about 1/3 of the density of liquid phase), condensation in the transversal directions to liquid occurs. Note that this means that there is preferred direction suggesting cylindrical symmetry for the condensing regions.

3. The phase transition is assumed to occur in coherent regions with size of order $\lambda \simeq 500$ Angstroms, which is not far from the diameter of microtubules. In these regions there is a coherent planewave electromagnetic field with frequency $\omega = 2\pi/\lambda$ and the decay of this field produces the highly synchronized light flash of duration of less than $10^{-11}$ seconds.

4. The physical origin of the coherent regions is somewhat mysterious in standard physics but authors propose that QED is enough to explain the mystery. Authors identify the source of coherent light as resulting from the transitions between two different molecular energy states with energy difference $\Delta E \simeq 12$ eV. One could criticize this assumption as ad hoc. In any case, classical current must be defined as expectation value, which vanishes unless the two energy eigen states get mixed by interactions.

### TGD inspired model for sonoluminescence

Consider now the TGD based modification of this model based on the same assumptions 1), 2), 3) about the origin of the coherent light as related to the liquid-gas phase transition but with different identification for the mechanism producing the coherent light. The model is based on the idea that bubble collapse might involve the sequential formation of several new space-time sheets with p-adic primes $p \simeq 2^k$, $k = 163, 157, 151, 149$ characterizing their typical sizes. The importance of the many-sheeted space-time concept was realized already in the previous rough model of the phenomenon just suggesting the identification of the basic scales of the problem in terms of the p-adic length scale hypothesis but involved no model for the generation of coherent light.

*a) Light like vacuum currents generate coherent light*

What is known is that the light flash emitted is *coherent* light. All frequencies are emitted simultaneously. The temporal widths of various frequencies do not depend on the nature of the gas. Thus the spectrum is certainly not genuine black body spectrum and the production mechanism must involve macroscopic quantum coherence. In TGD there indeed exists a unique mechanism leading to the generation of coherent light and is based on so called 'massless extremals' carrying light-like *vacuum currents* generating coherent light in a resonant like manner. Clearly, this mechanism predicts no dependence of the spectrum on the chemical nature of the gas in bubble. Of course, the gas can affect the spectrum by absorbing some frequencies and this indeed seems to occur. It is also known that the presence of noble gases is favorable for sonoluminescence: this is perhaps understandable from the fact that presence of noble gases (no absorption) reduces the effect of other gases by reducing their densities. In TGD inspired theory of bio-systems as macroscopic quantum systems massless extremals correspond to almost empty space-time sheets associated with microtubules and possibly also other linear bio-structures and create coherent photons (perhaps biophotons of Popp [52]).

*b) Vapor-liquid phase transition in regions of microtubular size occurs*

Following [46], it will be assumed shockwave formation leads to the formation of vapor layers with the mutual distance $a \simeq 3.2$ Angstroms equal to the average distance between liquid molecules and that condensation to liquid occurs when the transversal distance between the molecules of the layer becomes smaller than some critical distance $a < a_T < a_0$, where $a_0 \simeq 3.2 \times 10^{-7}$ meters is the transversal distance of the molecules when shockwave is generated. In the model of [46] $a_T \simeq \sqrt{3}a$ holds true: in TGD based model p-adic argument gives $a_T = 2a$. In TGD framework the formation of liquid phase is assumed to mean the formation of new cylindrical space-time sheets of size of order 500 Angstroms, when the transversal distance between $H_20$ molecules becomes critical (3 times the distance in liquid phase). At these space-time sheets water molecules are condensed into liquid phase. The length scale 500 Angstroms is suggested by [46] and in TGD framework the justification for this length scale is that it corresponds to the diameter of microtubules: these cylindrical structures could serve as templates for the formation of microtubules). Rather flat cylinders with radius equal to height are in question: of course, one can consider also cubic geometry.

*c) p-Adic length scale hypothesis*

p-Adic length scale hypothesis makes this picture more quantitative. Before the phase transition vapor phase is join along boundaries condensate of $k = 151$ space-time sheets glued to $k = 157$ sheets. Note that $L(151) \simeq 10^{-8}$ meters corresponds to the thickness of the cell membrane: now however the sheets are larger having size of order 500 Angstroms. Gas-to liquid phase transition is identified as a phase transition changing the value of the p-adic prime $p$: most naturally $k = 151 \rightarrow k = 149$. This implies $a_T = 2a_0$ rather than $\sqrt{3}a_0$ as in the model of [46]. Therefore the critical density is $\rho^* = \rho(liquid)/4$ instead of $\rho(liquid)/3$ of [46]. Using the relationship

$$a_T(t) = a_0\frac{R(t)}{R_0} \quad , \tag{4.5.5}$$

where $R_0 \simeq 4.5\mu m$ is the radius of the bubble when contraction velocity becomes supersonic one obtains for the transversal distance $a_T^*$ at criticality:

$$a_T^* \simeq 2a = a_0 R^*/R_0$$

giving $R^* \simeq .9\ \mu m$ to be compared with $R^* \simeq .8\ \mu m$ of [46].

One can estimate the thickness of the condensing shell from the requirement that the number of molecules in the shell with inner and outer radii $R^*$ and $R_0$ at time $t_0$ is same as the number of molecules in the thin liquid shell at time when condensation to liquid has occurred. This gives for the thickness $T$ of the liquid shell

$$T \simeq \frac{R_0^2}{R^{*2}}\frac{a^3}{a_0^3}(1 - \frac{R^{*3}}{R_0^3})R_0 \quad , \tag{4.5.6}$$

giving $T \simeq 10^{-7}$ meters which is *two*(!) times the size of the coherence domain as suggested by the transversal size of microtubules.

*d) Topological details of the phase transition process*

Consider next the topological details of the process. The transversal size of $k = 151$ sheets is (most naturally) halved in the phase transition and the join along boundaries bonds connecting $k = 151$ sheets to each other are probably split. According to the basic rules of p-adic TGD, space-time sheets with different p-adic prime $p$ can have only wormhole contacts as stable contacts. This means that, for a p-changing phase transition to take place, the bonds connecting $k = 151$ sheets belonging to different sides of the shock front must be split, probably immediately after the formation of the shock wave. The inward flow of the newly formed $k = 149$ sheets slows down whereas the flow of $k = 151$ sheets behind them continues: the molecules condensed on them cannot however follow the flow since they collide with the liquid phase. Therefore these sheets become thus almost vacuum space-time sheets and the $k = 149$ sheets containing liquid phase topologically condense on them. At this stage the vacuum currents are generated on these almost empty $k = 151$ sheets.

*e) Generation of coherent light*

In the last stage of the process vacuum currents are generated on the almost empty $k = 151$ sheets and they generate the coherent light giving rise to the flash. The experience with microtubules as quantum antennae hypothesis suggests that massless extremals carrying classical light-like vacuum currents flowing in radial direction are in question. The vacuum current, possible *only* in TGD context, generates coherent photons and the flux of coherent photons from the system creates the coherent flash of photons. The frequency spectrum for the current associated with the massless extremals comes in multiples of the basic frequency $\pi/L$, $L$ being the length of the cylinder, which is roughly equal to the thickness of $H_2O$ layer condensing to liquid (this length is expected to have some distribution). The dependence of the vacuum current on transversal and longitudinal coordinate, which is not specified by the field equations for the vacuum extremals, in principle determines the energy spectrum. The model for the sonoluminescence should be able to predict the form of the vacuum current but this requires a model for the coupling between the parameters of the vacuum current and ordinary matter.

The model of [46] suggests that only the lowest frequency $\omega_0 = 2\pi/L$ is effectively present. The spectrum of [46] is of form

$$\begin{aligned}
\frac{1}{V}\frac{dE}{d\omega} &= \frac{3\omega_0^3}{16\pi^3}|c_1|^2|F(\omega)|^2\frac{\omega^2}{(\omega-\omega_0)^2+\Gamma^2/4} \ , \\
|c_1|^2 &\simeq 1.8 \ , \\
F(\omega) &= exp(-1.4\frac{\omega^2}{\omega_0^2}) \ . \qquad (4.5.7)
\end{aligned}$$

It is of considerable interest to verify that a spectrum, which is product of a form factor and resonance factor, results also now. The presence of the form factor $F(\omega)$ reflects the dependence of the vacuum current on transversal coordinate, which for cylindrical geometry is radial coordinate. The dependence on the transversal coordinate is left completely open by the field equations and the unknown coupling of the vacuum current with matter should determine it. The resonance factor has a purely kinematical origin: the energy spectrum for photons has form $1/(\omega-\omega_0)^2$ resulting from the fact that matrix element for photon emission involves the overlap integral $\int exp[i(\omega-\omega_0)t]dt$ over a finite time-interval. One must take dissipation into account so that the real spectrum is proportional to $1/\left[(\omega-\omega_0)^2+\Gamma^2/4\right]$. The resonance width is of order $\Gamma \simeq 18$ eV and in [46] it is determined by the requirement that total energy output equal to the latent heat .28 eV per molecule.

The order of magnitude for the duration of the flash can be estimated from the radial contraction velocity $dR/dt(t_0) \simeq 1.5\times10^3 m/s = 10^{-5}c/2$ of the bubble at the moment $t_0$ when the phase transition begins (according to [46]) and from the length $l \leq 500$ Angstroms, which the empty $k = 151$ sheets must travel before $k = 149$ sheets can condense on them. This gives the estimate $t(flash) \simeq 3\times10^{-11}$ seconds which is less than the experimental upper bound $t(flash) < 5\times10^{-11}$ seconds,

To summarize: sonoluminescence could provide a direct verification for the concept of massless extremal and light-like vacuum currents. Gas-liquid phase transitions could quite generally involve the formation of massless extremals. Perhaps massless extremals of microtubular size are always present in liquid phase but carry very weak vacuum currents and bio-systems are perhaps able to amplify them. One could perhaps understand all phase transitions as formation of new space-time sheets involving p-changing phase transition.

### 4.5.2 Stirred and shaken

Japanese chemist Kazamuri Dozen and his colleagues have observed mysterious splitting of water into hydrogen and oxygen at room temperature using a simple catalyst (copper oxide in powder form) and by stirring the liquid [20]. The quicker the container is stirred the more hydrogen and oxygen are produced. Usually the dissociation occurs at temperature of about 3000 C and is driven by light: the photon density of thermal radiation has maximum at $E \sim 4T$ giving the estimate $E \sim 1.32$ eV: which gives an estimate for the energy of O–H bond possibly lowered by the presence of a catalyst. Notice that the photons in question correspond to visible light. Domen believes that direct transformation of the kinetic energy of the liquid motion to chemical energy must take place: standard wisdom allows only the transformation *kinetic energy → thermal energy → chemical energy*. There is no idea about the underlying mechanism. According to [20] already 1980 analogous direct transformation of acoustic energy to chemical energy was discovered and gave rise to the field of sonochemistry. An attractive possibility is that liquid motion somehow generates coherent light which in turn drives the reaction. Similar mechanism might be at work in sonochemistry. Since sonoluminescence involves the transformation of mechanical energy into coherent light, quantum antenna hypothesis is an obvious guide line in the attempt to identify the mechanism.

The simplest TGD based mechanism explaining the anomalous splitting of hydrogen is following.

1. Stirring creates linear cylindrical vortex like structures, which are accompanied by space-time sheets carrying light like vacuum currents. The splitting to oxygen and hydrogen is driven by the coherent light emitted by the vacuum currents associated with cylindrical structures of length $L$. The energies for the photons of the coherent light come as multiples of $E_0 = \pi/L$ (or of $E_1 = 2\pi/L$ if periodic boundary conditions are assumed). For $E = E_0 \sim 1.32$ eV this gives the estimate $L \sim .47 \cdot 10^{-6}$ meters. This length scale is not too far from the p-adic length scale $L(163) \sim .64 \cdot 10^{-6}$ meters assuming that $L(151)$ corresponds to cell membrane thickness $L(151) \simeq 10^{-8}$ meters.

2. The rotational motion creates classical $Z^0$ magnetic fields (purely TGD:eish effect) realized as $Z^0$ magnetic flux tubes and a natural expectation is that these flux tubes are accompanied by cylindrical space-time sheets carrying light like vacuum currents. Since quarks feed their $Z^0$ gauge fluxes to the space-time sheets having typically twice the cell size, the naive expectation for the length of the cylindrical structures in question would be of order $L(169) \sim 5 \cdot 10^{-6}$ meters, which is however almost by one order of magnitude too large. This of course does not exclude the possibility that $Z^0$ magnetic flux tubes are in question. The generation of $Z^0$ magnetic flux tubes was suggested already many years ago to explain the observed loss of the super fluidity at much smaller critical rotational velocity than predicted by standard physics [D7].

3. A possible function of the catalyst powder is to lower the O–H bonding energy, so that it is nearer to the energy of the photons of the coherent light.

What is interesting from the point of view of consciousness theorizing is that in gel-phase vigorous streaming of intracellular liquid occurs. Furthermore, the coherent photons causing dissociation would correspond to visible light. Therefore one can wonder whether the generation of light-like vacuum current emitting coherent biophotons [52] could be one function of the streaming. A possible test for this hypothesis is to look for an additional sink of metabolic energy inside cell.

### 4.5.3 Evidence for quantum antenna hypothesis in living systems

It is known that some monocellulars possess elementary vision based on the microtubules [35]. The emergence of the multicellulars during the Cambrian explosion was preceded by the appearance of the microtubules. If the emergence of the microtubules meant the emergence of the visual consciousness in the length scale of the cell, then the formation of the multicellulars as cell societies can be understood as a natural consequence. The length distribution of the microtubules in the rods and cones of the eye is concentrated in the region of the visible wavelengths. The coherent light in question could be identifiable as bio-photons of Popp [52].

A further piece of evidence comes from the work of Callahan about the sense of smell of insects [50]. Many insects, such as moths and ants, are known to be attracted by light, say candles and electric lamps and Callahan took as his challenge to understand what is involved. Callahan discovered that insect's olfaction is not based on chemistry but to a maser like emission of infrared light generated by various molecules such as pheromones, scent molecules and many other biomolecules. Thus insects would see rather than chemically perceive the sources of the infrared light. The sensillae of the insects serve as receiving antennas and amplify the incoming infrared radiation. Callahan also observed that the oscillation of insect antennae induce maser like emission from scent/etc. molecules by creating an oscillating emf. Thus sensory experiencing seems to involve active participation from the part of insect. The results of Callahan suggest that coherent light could be important also in our neuronal sensory experiencing.

Quite remarkably, pheromones are known to mediate sexual and social signals also in case of many mammals. For instance, certain chemical messages from female mouse can make male mouse to mate immediately while certain chemical messages from other males make him aggressive. Many mammals, for instance rodents, are known to possess vomeronasal organs, small cigar like sacks containing neurons and having length of order few millimeters [33], giving rise to an accessory olfactory system, which is known to have much more primitive structure and to work in different way than the ordinary olfactory system. It is also known that this systems bypasses cerebral cortex in rodents. There is evidence that even humans have the ability to sniff certain chemicals mediating social and sexual signals without being aware of it and there is already now an entire perfume industry based on this evidence. The chemicals giving rise to sexual attraction are probably pheromones. The fact that pheromones mediate sexual signals in case of both insects and mammals, is hardly an accident and suggests that the sensory mechanism must be the same and be based on the infrared emissions by pheromones. If the response is at neuronal level and if the cortex is not involved, one could understand why these messages are not experienced consciously. One could test this hypothesis by finding whether coherent infrared radiation at frequencies emitted by pheromones can affect the behavior of higher mammals including humans.

There is a further peculiar co-incidence: the cascade of transduction events occurring in the absorption of photon in retina is repeated in a remarkably similar way in olfactory receptor cells, which respond to odors whereas the receptor cells that respond to sound use a very different system [33]. Could this mean that also the experience of odor primarily involves the detection of (also) infrared light so that humans would not basically differ from insects or that olfactory system has evolved from the receptor neurons originally sensing infrared light? This would conform with the idea that the Kähler field generated in ear corresponds to classical $Z^0$ field, which does not generate coherent photons but couples with neutrinos. One must however notice that the resemblances between visual and linguistic imagery suggest that some part of ear generates cognitive representation based on coherent light and experienced by the secondary sensory organs in the thalamus.

In CASYS'2000 conference Peter Marcer reviewed the work done by him in collaboration with Russian group [45] providing experimental evidence for the hypothesis that DNA acts as receiving and sending quantum antenna. What was observed that irradiation of DNA with visible laser light induced emission of coherent light with both visible and radio frequencies. The emitted radiation was also modulated in time scale of about .01 seconds. The modulation could be due to propagation of soliton sequences propagating along Josephson junction formed by the strands of DNA or due to nonpropagating spatially constant Josephson current: both cases are mathematically equivalent with gravitational pendulum

### 4.5.4 Biefeld-Brown effect

Biefeld-Brown effect was invented as early as 1926 and is one of the oldest poorly understood electromagnetic anomalies [56, 57, 58]. The basic experiments are following.

1. Capacitor is balanced on beam balance and then charged. If the positive pole of the capacitor points upwards, the condenser moves up. If it points down the condenser moves down.

2. Capacitor is placed in free suspension such that the normal orthogonal to the plane of capacitor plates is horizontal and then charged. Capacitor is found to exhibit a horizontal thrust in the direction of the positive plate.

   Thus it seems that when capacitor is provided with large charge, a force acting on capacitor in direction normal to the plane of the capacitor is observed. The motion takes place to the direction of the positively charged plate. The larger the surface area $A$ of the capacitor, the shorter the distance $d$ between the plates, the larger the mass $M$ between the capacitor plates, the higher the relative dielectric constant $\epsilon$ of the dielectric, the larger the voltage $V$ used, the larger is the size the effect. This behavior can be understood if the size of the effect is proportional to the total electric energy $E_e = \epsilon\frac{AV^2}{d}$ between capacitor plates. It is difficult to understand this effect in standard physics framework.

Consider first experiment 1) in which the normal of the capacitor plane is in vertical direction. This experiment could be understood in the general conceptual framework described in the chapter [G2]. Capacitor generates some net gravitational flux. This flux is in general fed to several space-time sheets, although most of it goes to the "standard" sheet at which the gravitational field of Earth resides. One could understand the result of the experiment a) in terms of a redistribution of these gravitational fluxes. When the positive plate points upwards/downwards the flux $\phi_{gr}(Earth)$ fed to the "standard" space-time sheet is reduced/increased. Therefore the effective weight of the capacitor decreases/increases. The dependence of $\phi_{gr}(Earth)$ on the relative orientation of the gravitational field and electric field is not surprising from TGD point of view since classical gravitational and electric fields are very closely related in TGD framework. If classical $Z^0$ electric force contributes to the effective gravitational force significantly, then similar mechanism in case of $Z^0$ electric flux could contribute significantly to the change of the effective weight of the capacitor.

It seems that this mechanism cannot explain the result of the second experiment in which capacitor moves to horizontal direction. Rather it seems that two effects must be involved. there must be some mechanism giving for the capacitor momentum in the direction of the electric field. The TGD based general mechanism of energy production relying on the generation of space-time sheets with negative time orientation and carrying negative energies could explain this aspect of Biefeld-Brown effect.

1. Suppose that the charging of capacitor involves generation of space-time sheet with negative time orientation. The energy density associated with classical fields at this space-time sheet is negative. Energy conservation requires that capacitor receives compensating energy which in case of Biefeld-Brown effect is partially realized as kinetic energy associated with center of mass motion.

2. The classical gauge fields associated with the negative energy space-time sheet can carry also momentum and compensating momentum must be developed at the space-time sheet of the capacitor. Therefore condenser is forced to move. The momentum density of em field is proportional to the cross product $E \times B$ of the electric and magnetic fields. This momentum density gives rise to a net field momentum in the direction orthogonal to the plane of condenser plates if $E$ and $B$ are in directions parallel to the plates. This resembles somewhat the situation encountered in the case of Hall effect.

A working hypothesis worth of studying is that the negative energy space-time sheet associated with the capacitor corresponds to a massless extremal with $E$ and $B$ fields propagating from positive to negative plate (field momentum is in this direction).

1. Momentum conservation implies that the space-time sheet of the capacitor generates opposite momentum so that capacitor must move in the direction normal to the plane of the plates. What remains to be understood why the direction of motion is towards the positively charged plate. The light-likeness of 4-momentum gain together with the presence of Fourier components with single direction of wave vector means that momentum gain per energy gain is maximal. Therefore generation of negative energy "massless extremals" is optimal mechanism of propulsion. Massless extremals can have also net angular momentum since polarized Fourier components carry spin. Therefore capacitor can gain internal angular momentum in some form.

2. Assuming that the entire momentum of the classical field on negative energy space-time sheet is compensated by the momentum gain of capacitor, one obtains for the total energy gain

$$E_t = M\beta \ ,$$

where $M$ is total mass of the capacitor and $\beta$ is its velocity (the units $\hbar = 1$, $c = 1$ are used). This means quite large energy gain. For instance, for $M = .01$ kg and $\beta = 10^{-12}$, one has $E_t \sim 10^2$ Joule. The energy $\Delta E$, which is not realized as kinetic energy, is given by

$$\Delta E = M\beta(1 - \frac{\beta}{2}) \ .$$

Obviously, only a small fraction of the energy is realized as kinetic energy of the capacitor.

The ratio of the energy to thermal energy is given by

$$\frac{E_t}{E_{th}} \sim A\frac{m_p\beta}{T} \quad ,$$

where $A$ denotes atomic number. This ratio is much smaller than one for $\beta \ll T/Am_p$. In room temperature this gives $\beta \ll 10^{-11}/A$. An estimate for the magnitude of the electric field is obtained from $E_t = P$. Expressing everything in terms of integrals of energy and momentum densities, one obtains $EB \sim \rho\beta$. Since $E = B$ holds true for massless extremals, one has $B \sim \sqrt{\rho\beta}$. In condensed matter densities one has $\rho \sim Am_p/a^3$, where $a$ is Bohr radius. This gives $B \sim \sqrt{10^5 A\beta}/a^2$. $B$ is roughly about one $\sqrt{A}$ Tesla for $\beta \sim 10^{-12}$. Very strong electric and magnetic fields are clearly involved.

The proposed mechanism might also make possible to understand how living systems are able to generate coherent motions.

1. The ability of bio-systems (70 per cent of water!) to generate coherent motions is complete mystery from the point of view of standard physics describing bio-system as a soup of randomly moving atoms and molecules. The generation of massless extremals provides an optimal mechanism for coherent motion. Negative energies are not absolutely essential for generating coherent motions. However, if massless extremals have positive energies, the efficiency of energy usage is however very low, approximately $\beta/2$, where $\beta$ is the velocity generated: something like $10^{-8}$ if velocity is of order one meter per second. It could quite well be that massless extremal is created only for the period of time that motion lasts: this in accordance with the idea that classical counterparts of virtual particles are in question. Since the surplus energy generated on the material space-time sheet is partially dissipated during this time interval, this mechanism requires that metabolism feeds energy to the system to compensate this loss. Thus there is no contradiction with the general wisdom about the necessity of metabolic energy feed.

2. Brown observed that capacitors had definite effects on plants and animals. This is not surprising if TGD picture about bio-systems is correct. Coherent light is generated and this coherent light can affect the communications of neuronal society.

3. If bio-systems can generate negative energy massless extremals, a very efficient generation of metabolic energy from vacuum becomes possible. There is a lot of anecdotal evidence about the ability of yogis and mystics to survive without eating [32]. The explanation often proposed by yogis themselves [32] is that the energy of light replaces the usual sources of the metabolic energy. Standard science sceptics of course "know" and ridicule all this but, against the background of new physics predicted by TGD, I cannot avoid asking myself whether there might be some seed of truth behind these claims.

## 4.6 Quantum holography and MEs

The idea about hologrammic brain, advocated by Karl Pribram [25] and other pioneers, has several very attractive features, one of them being the robustness of the information storage due to the nonlocality of the representation. The notion of the classical hologram does not however seem to be enough as such. It is difficult to imagine how static holograms could be realized in brain. How to store simultaneously memories over entire life cycle into the same hologram at given time value is also a problem. This problem is common to all theories identifying subjective, experienced time with the geometric time of physicist: the unavoidable prediction is that brain state at given value of time must code also information about brain states at earlier times.

Peter Marcer and Walter Schempp have been advocating the notion of quantum holography as crucial for the understanding of consciousness and biocontrol [46]. Motivated by certain experimental findings Peter Gariaev and collaborators have proposed the notion wave DNA based on the idea that coherent electromagnetic fields and DNA holograms are crucial for the biocontrol [45].

Inspired by the talks of Peter Marcer in CASYS2000 and CASYS2001 conferences [52, 45], I decided to take a fresh look on how quantum holography might be realized in TGD framework, where superconducting magnetic flux tubes and massless extremals (MEs) provide an exact Bohr orbit representation of em fields and play a key role in quantum control and coordination of biomatter at atomic space-time sheets. It soon became clear that MEs are indeed tailor-made for quantum holography and teleportation in the sense as it is defined in quantum information theory [17]. Quantum holography conceptualization inspires much more detailed views about how bio-systems process information and how this information becomes conscious.

Also a profound connection with the notion of holography as it is defined in quantum gravity and string models emerges [17], and allows to deepen the vision about what the Universe predicted by quantum TGD looks like. One can also refine the formulation of quantum TGD to take properly into account the classical non-determinism of Kähler action. In particular, the intuition that the super-canonical and superconformal symmetries of light cone boundary $\delta M^4_+ \times CP_2$, which are cosmological symmetries, generalize to approximate macroscopic symmetries acting on the light-like boundaries of the space-time sheets inside future light cone and are broken by quantum gravity, can be justified more rigorously. A rather concrete demonstration for the power of quantum holography thinking was the realization that the general ansatz for MEs should generalize followed by the observation that it indeed does so!

### 4.6.1 Quantum holography in the sense of quantum gravity theories

In string theory context quantum holography is more or less synonymous with Maldacena conjecture [18] which (very roughly) states that string theory in Anti-de-Sitter space AdS is equivalent with a conformal field theory at the boundary of AdS. In purely quantum gravitational context [17], quantum holography principle states that quantum gravitational interactions at high energy limit in AdS can be described using a topological field theory reducing to a conformal (and nongravitational) field theory defined at the *time-like* boundary of the AdS. Thus the time-like boundary plays the role of a dynamical hologram containing all information about correlation functions of $d+1$ dimensional theory. This reduction also conforms with the fact that blackhole entropy is proportional to the horizon area rather than the volume inside horizon.

Holography principle reduces to general coordinate invariance in TGD but there are overall important delicacies involved.

1. If the action principle assigning space-time surface to a given 3-surface at light cone boundary were completely deterministic, four-dimensional general coordinate invariance would reduce the construction of the configuration geometry for the space of 3-surfaces in $M^4_+ \times CP_2$ to the construction of the geometry at the boundary of the configuration space consisting of 3-surfaces in $\delta M^4_+ \times CP_2$ (moment of big bang). Also the quantum theory would reduce to the boundary of the future light cone.

2. The classical non-determinism of Kähler action however implies that quantum holography in this strong form fails. This is indeed as it should be. The classical non-determinism (determinism in generalized sense is achieved by generalizing the notion of 3-surface by allowing unions of space-like 3-surfaces with time-like separations) is absolutely crucial for the ordinary elementary particle physics. Indeed, the quaternion-conformal symmetries responsible for the ordinary elementary particle quantum numbers act in degrees of freedom which do not contribute at all to the configuration space metric line element at all. Classical determinism would also mean that time would be lost in TGD as it is lost in GRT. Classical non-determinism is also absolutely essential for quantum consciousness and makes possible conscious experiences with contents localized into finite time interval despite the fact that quantum jumps occur between entire quantum histories.

3. Forgetting for a moment the effects of the classical non-determinism, cosmological light cone boundary $\delta M^4_+ \times CP_2$ takes the role of a quantum hologram. An important difference to AdS case is that the time-like direction of AdS boundary is replaced with light-like direction implying the metric two-dimensionality of the light cone boundary. This makes possible infinite-dimensional group of conformal symmetries in case of 4-dimensional Minkowski space. Thus the theory is much more structured than in AdS case and there is a direct connection with 2-dimensional critical systems expected on basis of quantum criticality of the TGD Universe.

4. The educated guess is that the cosmological supercanonical and superconformal symmetries associated with the light cone boundary generalize to approximate symmetries for the sub-light cones of the cosmological light cone broken presumably only by quantum gravitational interactions. As a matter fact, not only sub-light cone boundaries but all light-like 3-dimensional boundaries inside future light cone, in particular the boundaries of massless extremals (MEs), can take the role of the cosmological light cone and define approximate supercanonical symmetries. Hence it seems that the construction of the configuration space geometry taking into account the delicacies caused by the classical non-determinism could be achieved by generalizing the construction at $\delta M^4_+ \times CP_2$ to apply also at the light-like boundaries created after big bang.

5. The generalized supercanonical symmetries commute with Poincare symmetries apart from the effects due to quantum gravitation. Therefore the states inside supercanonical representations decompose into gigantic multiplets of almost degenerate states ideal for representing biologically relevant information. MEs are especially interesting carriers of supercanonical representations.

In the following this picture is discussed in more detail.

### 4.6.2 Generalization of the solution ansatz defining massless extremals (MEs)

The solution ansatz for MEs has developed gradually to an increasingly general form and the following formulation is the most general one achieved hitherto. Rather remarkably, it rather closely resembles the solution ansatz for the $CP_2$ type extremals and has direct interpretation in terms of geometric optics. Equally remarkable is that the latest generalization based on the introduction of the local light cone coordinates was inspired by quantum holography principle.

The solution ansatz for MEs has developed gradually to an increasingly general form and the following formulation is the most general one achieved hitherto. Rather remarkably, it rather closely resembles the solution ansatz for the $CP_2$ type extremals and has direct interpretation in terms of geometric optics. Equally remarkable is that the latest generalization based on the introduction of the local light cone coordinates was inspired by quantum holography principle.

#### Local light cone coordinates

The solution involves a decomposition of $M^4_+$ tangent space localizing the decomposition of Minkowski space to an orthogonal direct sum $M^2 \oplus E^2$ defined by light-like wave vector and polarization vector orthogonal to it. This decomposition defines what might be called local light cone coordinates.

1. Denote by $m^i$ the linear Minkowski coordinates of $M^4$. Let $(S_+, S_-, E_1, E_2)$ denote local coordinates of $M^4_+$ defining a *local* decomposition of the tangent space $M^4$ of $M^4_+$ into a direct *orthogonal* sum $M^4 = M^2 \oplus E_2$ of spaces $M^2$ and $E^2$. This decomposition has interpretation in terms of the longitudinal and transversal degrees of freedom defined by local light-like four-velocities $v_\pm = \nabla S_\pm$ and polarization vectors $\epsilon_i = \nabla E_i$ assignable to light ray.

2. In accordance with this physical picture, $S_+$ and $S_-$ define light-like curves and thus satisfy the equation:

$$(\nabla S_\pm)^2 = 0 \quad .$$

   The gradients of $S_\pm$ are obviously analogous to local light like velocities $v = (1, \overline{v})$ and $\tilde{v} = (1, -\overline{v})$. These equations are also obtained in geometric optics from Hamilton Jacobi equation by replacing photon's four-velocity with the gradient $\nabla S$: this is consistent with the interpretation of MEs as Bohr orbits of em field.

3. With these assumptions the coordinates $(S_\pm, E_i)$ define local light cone coordinates with the metric element having the form

$$ds^2 = g_{S_+S_-} dS_+ dS_- + g_{11} dE_1^2 + g_{22} dE_2^2 \quad .$$

Conformal transformations of $M^4_+$ leave the general form of this decomposition invariant. The task is to find all possible local light cone coordinates defining one-parameter families 2-surfaces defined by the condition $S_i = constant$, $i = +$ *or* $= -$, dual to each other and expanding with light velocity.

### A conformally invariant family of local light cone coordinates

The simplest solutions to the equations defining local light cone coordinates are of form $S_\pm = k \cdot m$ giving as a special case $S_\pm = m^0 \pm m^3$. For more general solutions of from

$$S_\pm = m^0 \pm f(m^1, m^2, m^3) \ , \ (\nabla_3 f)^2 = 1 \ ,$$

where $f$ is an otherwise arbitrary function, this relationship reads as

$$S_+ + S_- = 2m^0 \ .$$

This condition defines a natural rest frame. One can integrate $f$ from its initial data at some two-dimensional $f = constant$ surface and solution describes curvilinear light rays emanating from this surface and orthogonal to it. The flow velocity field $\overline{v} = \nabla f$ is irrotational so that closed flow lines are not possible in a connected region of space and the condition $\overline{v}^2 = 1$ excludes also closed flow line configuration with singularity at origin such as $v = 1/\rho$ rotational flow around axis.

One can identify $E^2$ as a local tangent space spanned by polarization vectors and orthogonal to the flow lines of the velocity field $\overline{v} = \nabla f(m^1, m^2, m^3)$. Since the metric tensor of any 3-dimensional space allows always diagonalization in suitable coordinates, one can always find coordinates $(E_1, E_2)$ such that $(f, E_1, E_2)$ form orthogonal coordinates for $m^0 = constant$ hyperplane. Obviously one can select the coordinates $E_1$ and $E_2$ in infinitely many manners.

### Closer inspection of the conditions defining local light cone coordinates

Whether the conformal transforms of the local light cone coordinates $\{S_\pm = m^0 \pm f(m^1, m^2, m^3), E_i\}$ define the only possible compositions $M^2 \oplus E^2$ with the required properties, remains an open question. The best that one might hope is that any function $S_+$ defining a family of light-like curves defines a local decomposition $M^4 = M^2 \oplus E^2$ with required properties.

1. Suppose that $S_+$ and $S_-$ define light-like vector fields which are not orthogonal (proportional to each other). Suppose that the polarization vector fields $\epsilon_i = \nabla E_i$ tangential to local $E^2$ satisfy the conditions $\epsilon_i \cdot \nabla S_+ = 0$. One can formally integrate the functions $E_i$ from these condition since the initial values of $E_i$ are given at $m^0 = constant$ slice.

2. The solution to the condition $\nabla S_+ \cdot \epsilon_i = 0$ is determined only modulo the replacement

$$\epsilon_i \rightarrow \hat{\epsilon}_i = \epsilon_i + k \nabla S_+ \ ,$$

where $k$ is any function. With the choice

$$k = -\frac{\nabla E_i \cdot \nabla S_-}{\nabla S_+ \cdot \nabla S_-}$$

one can satisfy also the condition $\hat{\epsilon}_i \cdot \nabla S_- = 0$.

3. The requirement that also $\hat{\epsilon}_i$ is gradient is satisfied if the integrability condition

$$k = k(S_+)$$

is satisfied: in this case $\hat{\epsilon}_i$ is obtained by a gauge transformation from $\epsilon_i$. The integrability condition can be regarded as an additional, and obviously very strong, condition for $S_-$ once $S_+$ and $E_i$ are known.

4. The problem boils down to that of finding local momentum and polarization directions defined by the functions $S_+$, $S_-$ and $E_1$ and $E_2$ satisfying the orthogonality and integrability conditions

$$(\nabla S_+)^2 = (\nabla S_-)^2 = 0 \ , \quad \nabla S_+ \cdot \nabla S_- \neq 0 \ ,$$

$$\nabla S_+ \cdot \nabla E_i = 0 \ , \qquad \frac{\nabla E_i \cdot \nabla S_-}{\nabla S_+ \cdot \nabla S_-} = k_i(S_+) \ .$$

The number of integrability conditions is 3+3 (all derivatives of $k_i$ except the one with respect to $S_+$ vanish): thus it seems that there are not much hopes of finding a solution unless some discrete symmetry relating $S_+$ and $S_-$ eliminates the integrability conditions altogether.

A generalization of the spatial reflection $f \rightarrow -f$ working for the separable Hamilton Jacobi function $S_\pm = m^0 \pm f$ ansatz could relate $S_+$ and $S_-$ to each other and trivialize the integrability conditions. The symmetry transformation of $M^4_+$ must perform the permutation $S_+ \leftrightarrow S_-$, preserve the light-likeness property, map $E^2$ to $E^2$, and multiply the inner products between $M^2$ and $E^2$ vectors by a mere conformal factor. This encourages the conjecture that all solutions are obtained by conformal transformations from the solutions $S_\pm = m^0 \pm f$.

### General solution ansatz for MEs for given choice of local light cone coordinates

Consider now the general solution ansatz assuming that a local wave-vector-polarization decomposition of $M^4_+$ tangent space has been found.

1. Let $E(S_+, E_1, E_2)$ be an arbitrary function of its arguments: the gradient $\nabla E$ defines at each point of $E^2$ an $S_+$-dependent (and thus time dependent) polarization direction orthogonal to the direction of local wave vector defined by $\nabla S_+$. Polarization vector depends on $E^2$ position only.

2. The most general MEs correspond to the solution family of the field equations having the general form

$$s^k = f^k(S_+, E) \ ,$$

where $s^k$ denotes $CP_2$ coordinates and $f^k$ is an arbitrary function of $S_+$ and $E$. The solution represents a wave propagating with light velocity and having definite $S_+$ dependent polarization in the direction of $\nabla E$. By replacing $S_+$ with $S_-$ one obtains a dual solution. Field equations are satisfied because energy momentum tensor and Kähler current are light-like so that all tensor contractions involved with the field equations vanish: the orthogonality of $M^2$ and $E^2$ is essential for the light-likeness of energy momentum tensor and Kähler current.

3. The simplest solutions of the form $S_\pm = m^0 \pm m^3$, $(E_1, E_2) = (m^1, m^2)$ and correspond to a cylindrical MEs representing waves propagating in the direction of the cylinder axis with light velocity and having polarization which depends on point $(E^1, E^2)$ and $S_+$ (and thus time). For these solutions four-momentum is light-like: for more general solutions this cannot be the case. Polarization is in general case time dependent so that both linearly and circularly polarized waves are possible. If $m^3$ varies in a finite range of length $L$, then 'free' solution represents geometrically a cylinder of length $L$ moving with a light velocity. Of course, ends could be also anchored to the emitting or absorbing space-time surfaces.

4. For the general solution the cylinder is replaced by a three-dimensional family of light like curves and in this case the rectilinear motion of the ends of the cylinder is replaced with a curvilinear motion with light velocity unless the ends are anchored to emitting/absorbing space-time surfaces. The non-rotational character of the velocity flow suggests that the freely moving particle like 3-surface defined by ME cannot remain in a infinite spatial volume. The most general ansatz for MEs should be useful in the intermediate and nearby regions of a radiating object whereas in the far away region radiation solution is excepted to decompose to cylindrical ray like MEs for which the function $f(m^1, m^2, m^2)$ is a linear linear function of $m^i$.

### 4.6.3 Quantum holography in non-cosmological length scales

Quantum holography principle naturally generalizes to an approximate principle expected to hold true also in non-cosmological length and time scales.

1. The most general ansatz for MEs (inspired by the quantum holographic thinking) relies on the introduction of the notion of local light cone coordinates $S_+, S_-, E_1, E_2$. The gradients $\nabla S_+$ and $\nabla S_-$ define two light-like directions just like Hamilton Jacobi functions define the direction of propagation of wave in geometric optics. The two polarization vector fields $\nabla E_1$ and $\nabla E_2$ are orthogonal to the direction of propagation defined by either $S_+$ or $S_-$. Since also $E_1$ and $E_2$ can be chosen to be orthogonal, the metric of $M^4_+$ can be written locally as $ds^2 = g_{+-}dS_+dS_- + g_{11}dE_1^2 + g_{22}dE_2^2$. In the earlier ansatz $S_+$ and $S_-$ where restricted to the variables $k \cdot m$ and $\tilde{k} \cdot m$, where $k$ and $\tilde{k}$ correspond to light-like momentum and its mirror image and $m$ denotes linear $M^4$ coordinates: these MEs describe cylindrical structures with constant direction of wave propagation expected to be most important in regions faraway from the source of radiation.

2. Boundary conditions are satisfied if the 3-dimensional boundaries of MEs have one light-like direction ($S_+$ or $S_-$ is constant). This means that the boundary of ME has metric dimension $d = 2$ and is characterized by an infinite-dimensional supercanonical and superconformal symmetries just like the boundary of the imbedding space $M^4_+ \times CP_2$: The boundaries are like moments for mini big bangs (in TGD based fractal cosmology big bang is actually replaced with what might be called a silent whisper amplified to not necessarily so big bang). Quantum holography would mean that effectively 2-dimensional conformal field theory at the boundary of $M^4_+$ region determined by ME determines what happens in the interior at QFT limit when space-time surface is not regarded as a dynamical object.

3. These observations inspire the conjecture that boundary conditions for $M^4$ like space-time sheets fixed by the absolute minimization of Kähler action quite generally require that space-time boundaries correspond to light-like 3-surfaces with metric dimension equal to $d = 2$. Quantum holography principle would state that the dynamics related to the metric of the configuration space, that is genuine quantum gravitation, would reduce to the boundaries of space-time sheets. The dynamics in zero modes and quaternion conformal degrees of freedom crucial for elementary particle physics would not however allow this kind of reduction. This would be consistent with the fractality which is expected to be a basic characteristic of the quantum critical Universe predicted by TGD. The approximate supercanonical and conformal symmetries would be associated with the light-like boundaries of the space-time sheets. Supercanonical invariance would be broken only by quantum gravitational effects at the level of the configuration space by the fact that the boundaries of space-time surfaces are actually dynamical rather than fixed. The cosmological light cone boundary would be however non-dynamical and this would guarantee the exactness of the cosmological supercanonical invariance.

### 4.6.4 Supercanonical representations, quantum holography, and consciousness

Supercanonical representations are genuine quantum gravitational states since they correspond to functionals in the space of 3-surfaces (the world of worlds) and thus correspond to higher abstraction level than ordinary elementary particles. This has motivated the assignment of the so called non-geometric qualia (colors, tactile senses,...) to the quantum phase transitions associated with the supercanonical states [K3].

MEs are natural carriers of supercanonical representations obtained by multiplying ordinary physical states by configuration space Hamiltonians (functions of $CP_2$ coordinates and coordinates $E_1, E_2$ and $S_+$ or $S_-$ which can obviously be arranged into irreducible representations of the color group $SU(3)$) and define an excellent candidate for a hierarchy of higher level life forms. The intuitive belief that quantum gravitation is crucial for higher level consciousness can be indeed justified in this framework: the 'worlds about worlds' aspect of higher level consciousness is what requires genuine quantum gravitational states.

The boundary of ME having one light-like direction gives rise to conformal quantum hologram representing quantum correlation functions for quantum field theory defined in the interior of ME. This 3-dimensional dynamical quantum hologram should code for conscious information about external world. This information could be determined by coherent light and gravitons scattered from the outer boundaries of other space-time sheets and could provide a quantum representation for the geometry of the boundaries of the other space-time sheets.

The standard manner to see the evolution of organism is as an initial value problem with data given at time=constant space-like section of Minkowski space. This view is definitely wrong in TGD framework, where the classical non-determinism of Kähler action is absolutely essential for the understanding of bio-systems and consciousness. Rather, one should see the problem as a boundary value problem with data given at light-like surfaces bounding MEs analogous to light cone boundary identifiable as the moment of big bang. This view conforms nicely with the active intentional aspects of the biological evolution: system can decide what it will be and life is more like a narrative with definite goals than random Brownian zigzag curve. The life cycle of the organism is specified by posing some requirements which it must satisfy in the form of boundary conditions and organism does it best to satisfy them.

### 4.6.5 Quantum holography and quantum information theory

Sokolov and collaborators [17] have proposed a model of quantum holographic teleportation in which the *classical* photocurrents from the sender to receiver take the role of a dynamical hologram. The connection with MEs is obvious.

1. MEs are carriers of classical light-like vacuum currents (one of the basic differences between TGD and Maxwell theory). This suggests that MEs could be interpreted also as *classical* holograms, which are *dynamical* as in quantum information theory. Light-like current would be like a dynamical (four-dimensional) diffraction grating. Light-like vacuum currents and vacuum Einstein tensor generate also coherent states of photons and gravitons and MEs serve as templates for the topological condensation of photons and gravitons to the Bose-Einstein condensate of photons collinear with ME. The Bose-Einstein condensation of collinear photons (or their generalizations to 'configuration space photons') should affect the vacuum current by adding to the reference current what might be called evoked response. This condensation process could generate conscious experience and higher level qualia. Thus it would seem that MEs have a triple role as receiving and sending quantum antennae as well as classical holograms.

2. The proposal of [17] generalizes to the case of MEs provided one can device a method of coding quantum states of photon field to the vacuum currents. The high efficiency photodetector matrix is in which each pixel gives rise to a photocurrent [17], is replaced with ME or set of parallel MEs. The neural window hypothesis [H4] states that neuronal axons are accompanied by parallel MEs carrying information between sensory organs and brain and various parts of brain. This is only a less standard manner to say that ME represents classical dynamical hologram. The possibility of local light cone coordinates allows also MEs which define curved deformations of the simplest cylindrical MEs.

   The concrete realization of holographic teleportation proposed in [17] brings strongly in mind the architecture of the visual pathways. Thus one can wonder whether brain is performing internal teleportation of photonic quantum states with spike patterns being directly coded to the pattern of the vacuum currents flowing along MEs. If spike patterns code the dynamical hologram, a surprisingly close relationship with Pribram's views about hologrammic brain results. Nerve pulse patterns could be seen as specifying the necessary classical aspects of the quantum teleportation (in TGD classical physics is essential part of quantum physics, rather than some effective theory).

3. Vacuum current at a 3-dimensional time-like section of ME as a function function of time defines a dynamical 3-dimensional hologram. This is consistent with the fact that our visual experience is two-dimensional: the information is always about outer boundaries of the objects of the perceptive field. The values of the vacuum current at a given point are non-deterministic which means that vacuum current is ideal for coding information. Classical data also propagate without

dispersion with light velocity obeying the laws of geometric optics and MEs imply channelling so that MEs are tailor-made for classical information transfer.

4. Space-time sheets can have both positive and negative time orientations and the sign of energy depends on time orientation in TGD framework. This means that classical communication can occur both in the direction of the geometric future and past: this is essential for the classical model of the long term memories as a question communicated to the geometric past followed by answer. The dynamical nature of the holograms means that there is no need to combine 2- or 3-dimensional holograms associated with several moments of geometric time to single hologram. To remember is to perceive an object located in the geometric past. Of course, fractality might make possible temporally scaled down versions of the geometric past but the principle would remain the same.

5. Quantum hologram view suggests that the supercanonical representations at the light-like boundaries of MEs characterized by gigantic almost-degeneracies are the real carriers of biological information. According to the general theory of qualia [K3], this information would become conscious since elementary qualia would correspond to quantum jumps for which increments of the quantum numbers correspond to the quantum numbers labelling supercanonical generators in the complement of Cartan algebra. In this view superconducting magnetic flux tubes could perhaps be seen as intermediate level in the control circuitry controlled by MEs and controlling atomic level.

6. This picture leaves open whether there is a level controlling the thicknesses of the magnetic flux tubes and thus also magnetic transition frequency scales, and what this level might be. The entrainment of the endogenous frequencies to exogenous frequencies explains water memory and the effects of homeopathic remedies [47] [J2], and could make possible also endogenous NMR spectroscopy and chemical senses. The key to the puzzle might be a purely mathematical problem: how the boundary conditions at the boundaries of the magnetic flux tubes can be satisfied? It might be that the induced metric must become degenerate at the boundaries ($\sqrt{g} = 0$) implying a degeneracy of the induced metric at the boundary of the magnetic space-time sheet. This need not however mean that the $M^4_+$ projection of the boundary is a light-like surface: the projection could well be completely static. This supports the view that the boundaries do not carry supercanonical representations, which are associated with the imbedding space projection of the boundary rather than the boundary itself. One can imagine that ME with the same transversal section as magnetic flux tube is glued to the magnetic flux tube along this section: this kind of gluing results in a singular 4-surface analogous to the vertex region of Feynman diagram and some kind of smoothing-out procedure is needed. The smoothed-out vertex region would make possible for ME to control magnetic flux tube thickness by varying its own transversal thickness.

### 4.6.6 MEs and qualia

The properties of supercanonical representations suggests strongly that our non-geometric qualia (colors, odors,..) are associated with the supercanonical phase transitions assignable with the light-like boundaries of MEs. If so, qualia would be parameterized by the quantum number increments in the transition. The simplest qualia are in one-one correspondence with superalgebra generators which correspond to Hamiltonians labelled by spin and color quantum numbers. The notion of 'configuration space photon' defined as a ME carrying photonic Fock state and characterized by a Hamiltonian labelled by color and spin quantum numbers suggests itself. Sensory input could give rise to configuration space photons BE condensing on larger MEs. Thus photons could be genuinely colored ('qualed')!

Also magnetic quantum phase transitions give rise to qualia but it is quite possible that these qualia are not our qualia but primitive chemical qualia in much shorter length scales, say cell length scale. Magnetic qualia can however have higher level counterparts. For instance, MEs could make possible endogenous NMR and generalizations of it, and the coherent light emitted in the magnetic quantum phase transitions could BE condense on MEs and give rise to our chemical qualia.

Zero modes associated with the light-like boundaries of MEs correspond to purely geometric information about space-time surfaces and the increments of zero modes are expected to code for the purely geometric qualia (position, velocity, etc..).

Long term memories do not differ radically from ordinary qualia, the only difference being that the object of the perceptive field is in the geometric past. The light-like boundaries of ME defining the geometric correlates of selves realize this vision concretely.

### 4.6.7 Connection with the notion of wave-DNA

Peter Gariaev and his group have observed several interesting effects related to the interaction of DNA and coherent light [45]. There is evidence that the irradiation of DNA with polarized coherent light at visible wavelengths generates a radio wave response with the same polarization. Also the modulation of photon polarization by the molecules of DNA preparation is claimed to occur. There are also indications that the resulting radio waves have strange biological effects. For instance, a dramatic increase in the growth rate of potatoes irradiated by the radio waves is claimed in [45].

#### The notion of wave-DNA

These observations have led Gariaev group to propose that DNA is accompanied by a series of dynamical laser mirrors somehow storing a sequence dynamical holograms. For instance, there could be one hologram for each nucleotide pair. These effects could be indeed understood as resulting from the reading of DNA hologram by applying laser wave at a correct frequency and inducing the generation of coherent light at radio frequencies. Wave DNA hypothesis would provide a reason why for the biophotons of Popp [54].

Visible-to-radio frequency transmutation suggests that the interaction of visible photons with DNA involves the coupling of radio wave-modulated em gauge potential at visible frequencies to Dirac spinor. This coupling indeed induces a fermionic em current containing also radio frequency Fourier components in turn emitting photons at radio frequencies. The observed correlation between the polarization of the laser beam at visible frequencies with the polarization of the radio waves could be understood as reflecting the entanglement of coherent photons at these wavelengths. Note that the reduction of this entanglement in quantum jump would correspond to generation of ME self in TGD framework.

#### DNA MEs as counterparts of wave DNA

In standard physics framework a possible objection against this scenario is that the wavelengths of the visible photons are almost one micrometer and much longer than the transversal DNA length scale. In TGD framework the laser mirrors associated with DNA could be single or double sheeted MEs orthogonal to DNA. Since these MEs represent space-time sheets, their length could quite well be measured in multiples of visible light wavelength. Note that the thickness of chromosomes is of order $E-7$ meters, not far from visible wavelengths.

DNA MEs would be analogous the ELF MEs assumed to drift along cortex and scan and control the state of various brain regions [K3]. The variation of the magnetic field along DNA would induce the drifting force. Of course, DNA MEs need not drift. DNA MEs could be like pages of a book [45] with each page storing its own independent dynamical hologram realized as a light-like classical vacuum current. The local polarization direction of the classical em field inside ME varies continuously and depends on the light-like coordinate $S_+$ (on $S_-$ for dual ME). This means that a dynamical orientation field in plane can be represented by single ME. The local polarization of the coherent light is indeed proposed to be carrier of bio-information in [45].

DNA ME would describe a sawtooth like zigzag curve in space-time. At the turning points it would be glued to other space-time sheets representing matter: vacuum current and information content would be determined by what happens at these two-dimensional regions.

Quantum gravitational hologram principle says that the quantum information about the development of the organism is stored by the supercanonical representations which can be thought of as localized to the light-like boundaries of MEs. The immense almost degeneracies of supercanonical states would indeed mean huge information storage capacities and almost infinite adaptivity already at DNA level. The information stored by the genome would be only a tiny part of the information and comparable to the read-only-memory burnt into the hardware of computer.

#### DNA solitons and phantom DNA effect as evidence for superconducting DNA space-time sheets

According to [45] there is also evidence for electro-acoustic soliton sequences propagating along DNA and inducing a local opening of DNA double strand. In TGD framework these soliton sequences could be seen as scaled-down versions of nerve pulse patterns. They would be induced from the Sine-Gordon soliton sequencies (the simplest soliton sequences are equivalent with a rotational motion of gravitational pendulum propagating with sub- or superluminal phase velocity). The solitons would be associated with electron (most naturally) Josephson currents running between DNA strand space-time sheets connected by Josephson junctions idealizable with a continuous Josephson junction. In accordance with homeostasis as an ionic flow equilibrium idea, stochastic resonance could induce acoustic solitons at atomic space-time sheets involving the local opening of DNA. MEs, in particular DNA MEs, could serve as ultimate quantum controllers inducing electron super currents at various space-time sheets associated with DNA and thus affecting the ionic flow equilibrium at the atomic space-time sheets.

MEs and superconducting magnetic flux tubes associated with DNAs could also explain the phantom DNA effect [48]. Some of the magnetic flux tubes would be left to chamber after removal of DNA and provide a representation of quantum control level of DNA. The intensity of the radiation generated in phantom DNA effect would give an estimate for the density of ions at the superconducting magnetic flux tube space-time sheets. Water memory would be also based on similar structures.

### 4.6.8 p-Adic cognition and the existence of double-sheeted MEs and wormhole magnetic fields

By the inherent non-determinism of the p-adic differential equations, p-adic space-time sheets represent a natural candidate for the geometric correlates of imagination. The transformation of thought into action corresponds in p-adic-to-real phase transition in this conceptual framework. TGD predicts that space-time sheets with negative time orientation carry negative energies. Thus conservation laws allow p-adic–real transitions for pairs of space-time sheets having opposite energies and momenta. Presumably it is also easier to satisfy the boundary conditions at the ends of the double sheeted structures of finite length.

In particular, the MEs associated with cognition should be double sheeted structures with vanishing net energy. In this case the classical fields could be precise time reversals (phase conjugates) of each other. The analogy with DNA double sheet is obvious. Also DNA MEs could be double sheeted and represent cognitive structures at molecular level.

The double sheeted MEs could represent dynamical holograms associated with long term memory: negative energy ME would represent a question communicated to the geometric past and positive energy ME would represent the answer of self woken up in geometric past and by self-organization generating the answer. To remember would be to make a quantum jump generating this kind of double sheeted ME. Subjectively this would be completely instantaneous process and could involve the generation of entanglement between self geometrically now and self in in geometric past and its reduction in quantum jump. Communication/long term memory could be seen as a four-dimensional quantum measurement.

MEs are not the only double-sheeted cognitive structures one can imagine. The so called wormhole magnetic fields are formed by pairs of space-time sheets carrying opposite magnetic fields and are analogous to double sheeted MEs and DNA double strands. Magnetic space-time sheets are connected by extremely tiny wormhole contacts. The wormhole throats of the wormhole contact carry opposite classical em charges and rotating wormhole contacts induce opposite magnetic fields at two flux tube space-time sheets. Bio-systems might be able to generate both double sheeted MEs and wormhole magnetic fields at will by p-adic-real phase transitions since energetic constraints would not pose any restrictions. The p-adic versions of wormhole magnetic fields would serve as cognitive representations for Earth's magnetic field and the magnetic circulation associated with body could involve also wormhole magnetic fields. Quite generally, TGD Universe might be mimicking itself by constructing double-sheeted zero energy copies of single sheeted structures representing matter. This process might be an essential aspect of water memory and homeopathy [J5].

### 4.6.9 Connection with quantum holography involved with NMR

A highly abstract and refined form of quantum holography appears also in the mathematical formulation of NMR spectroscpy by Walter Schempp [19]. In this formulation coherent photon states are identified as states in the irreducible unitary representations of the Heisenberg group generated by a bosonic oscillator operator, its conjugate and identity operator. The vision about homeostasis as many-sheeted ionic flow equilibrium encourages the idea that endogenous NMR and its generalizations to arbitrary magnetic transitions make possible chemical senses.

1. The ultracold magnetic flux tubes carrying superconducting ions and molecules are ideal for NMR. The contact with ME perturbs the magnetic field inside a magnetic flux tube by superposing to it a rotating transversal component. The perturbations of Earth's magnetic field have frequencies in EEG range (by purely geometric arguments). More generally, the inverse of the geometric size scale for the flux tubes defines the minimum frequency for the perturbations. The temperature is extremely low so that the ratio $N_+/N_- = exp(-\Delta E/kT)$ of ions with different spin directions in magnetic field associated with magnetic flux tube (of say Earth's magnetic field) deviates strongly from unity. This makes possible to avoid the immense reduction of NMR signal intensity (proportional to $exp(-\Delta E/kT) - 1$) occurring in the ordinary NMR spectroscopy. If magnetic quantum transitions occur coherently for the superconducting BE condensate, the rate for quantum transition is proportional to the square of the number of superconducting ions and this gives an additional amplification factor. The rate for the BE condensation of the coherent light generated in the magnetic quantum phase transition is also amplified by the presence of the collinear BE condensed photons at MEs acting as receiving quantum antennae.

2. If the magnetic flux tube thickness varies along the flux tube, the strength of the magnetic field and magnetic transition frequency scale vary too. In this kind of situation the interaction produces NMR spectroscopy for superconducting ions at superconducting magnetic flux tubes. The resonance frequency spectrum place-code various ionic concentrations in the sense that each ion would give to a conscious resonance located at a particular position of the magnetic flux tube. This would be one example about the coding of abstract geometric data (now ionic concentrations) to magnetic field strength to position along magnetic flux tube.

3. Magnetic phase transitions could represent some kind of primitive chemical qualia, much more primitive than the qualia associated with the transitions of genuinely quantum gravitational super-canonical states at MEs (non-trivial functionals in the world of worlds, space of 3-surfaces). The magnetic qualia need not be conscious to us since the characteristic length scale given by the magnetic length is cell length scale in the case of endogenous magnetic field $B_{end} = .2$ Gauss which has same order of magnitude as Earth's magnetic field with nominal value $B_E = .5$ Gauss. The value of $B_{end}$ comes from the explanation for the effects of ELF em fields on vertebrate in terms of cyclotron transitions. The BE condensation of the coherent light emitted in the magnetic phase transitions on MEs could however lead to higher level variants of the chemical qualia.

4. In the many-sheeted ionic flow equilibrium superconducting ion densities are related to the ionic densities at the atomic space-time sheets. This means that the information about ionic densities at the atomic space-time sheets could be coded into vacuum currents and MEs could contain holographic representation of the biochemical state of the organism. The possibility of $Z^0$ magnetic flux tubes would also make possible to code information about the densities of neural atoms and molecules to $Z^0$ MEs. Unless massless exotic variants of $Z^0$ bosons are possible, higher level variants of $Z^0$ type chemical qualia are not possible.

### 4.6.10 Summary

It seems that the vision about quantum control and experiencing is becoming rather concrete and beautiful overall pattern is emerging. At least following anomalous from standard physics point of view pieces fit together.

1. The paradoxical results related to the ionic channels and pumps [46] give very strong support for ionic flow equilibrium in many-sheeted space-time.

2. Water memory and homeopathy fits with this picture. The results of Cyril Smith [47] about homeopathic effects at various frequencies as well as the findings of Benveniste [39, 40] and recent findings of a collaboration involving four laboratories about water memory [51] support this view. The observed effects of ELF em fields on biomatter [44] are also consistent with the assumption that ELF em fields affect directly the control circuitry at superconducting space-time sheets. The biophotons of Popp [54] should also be mentioned as also the puzzles related to the interaction of biomolecules (hormones, second messengers) with cell nucleus (pleiotropy) suggesting that non-chemical communication mechanisms are involved.

3. A common answer to the questions 'Why liquid crystals?', 'Why electrets?', 'Why DC currents of Becker [62]?', 'Why collagen networks?', is that otherwise the many-sheeted control circuitry is not possible.

4. The healing of bone fractures by electric currents discovered by Becker [62] could also be a manner to re-establish super current patterns leading to many-sheeted ionic flow equilibrium and healing. Note the possible applications in nanotechnology: the generation of an appropriate supra current pattern could force ionic flow equilibrium leading to the healing of fractures in electromechanical systems.

5. The recent empirical findings [31] provide strong support for the belief that NDE experiences and thus consciousness are possible even when brain is clinically dead and it is interesting to ponder what this might mean in TGD framework. Both MEs and magnetic flux tube structures form a fractal hierarchy. Rather interestingly, the magnetic fields associated with eyes have cyclotron time scale varying from hour to year roughly. This is necessary for higher abstraction levels of consciousness since they involve subjective memories in time scale much longer than the .1 seconds of sensory experience. Flux tubes are of thickness of order millimeter in this case: the size scale of iris!

   Very rough estimates suggest that the magnetic crystals contained by brain (say those in pineal gland) could generate fields in the range $10^{-2} - 1$ fT, flux tube thickness would be in the range $1 - 10$ cm and cyclotron time scale would vary from years to hundred years (life summary during NDE). This provokes several questions. Could these magnetic flux tubes connect near relatives, like umbilic cords (meeting of relatives during NDEs)? Could they give rise to tunnel experience involved with NDEs: magnetic flux tube self experiencing fractal hierarchy of sub-flux tubes as mental images (my own 'tunnel like' visual experiences after sitting and writing resemble incompressible fluid flow, $\nabla \cdot B = 0$)? Is this magnetic consciousness what remains after physical death: are our bodies sensory and motor organs of huge fractal magnetic circuitry ('light being') living in symbiosis with MEs?

## 4.7 Appendix: A model for the topological condensation of coherent vapor phase photons

In ordinary QED classical gauge fields can have only ordinary charged particles as their sources. In TGD genuine vacuum currents are possible. The coupling of the quantum field to the classical em field with a non-vanishing vacuum source implies the generation of a coherent state of photons such that each Fourier component present in the classical gauge current gives rise to an eigen state of the corresponding photonic annihilation operator. In case of light-like vacuum currents allowed by TGD, the coherent state is generated in resonant-like manner so that light-like vacuum current acts as an ideal quantum antenna.

If one introduces a second space-time sheet, which contains BE condensate of photons for some modes of the photon field, a stimulated topological condensation of both coherent vapor phase photons and transfer of coherent condensed photons from other space-time sheets to this space-time sheet occurs. This effect makes possible the the action of the second space-time sheet as an optimal receiving antenna. In the following calculation the consideration is restricted to the stimulated condensation of vapor phase photons.

In biological context microtubules could server both as senders and receivers of coherent photons. According to the proposed identification of coherent photons as the quantum correlate of vision, the microtubules contain BE condensate of photons in some some modes would have the ability to see in some primitive manner.

### 4.7.1 The action

The simplest model for the situation is based on Maxwell action for electromagnetic field regarded as an induced field obtained from superposition of the classical emf in $CP_2$ degrees of freedom and second quantized free emf in $M^4_+ \times CP_2$ having only $M^4$ components and depending on $M^4_+$ coordinates only and having decomposition into vapor phase and condensate parts ($\hbar = 1$ and $c = 1$ will defined the units used in the following).

$$
\begin{aligned}
F_{\mu\nu} &= F_{\mu\nu}(cl) + F_{\mu\nu}(qu) \ , \\
F_{\mu\nu}(cl) &= F_{kl}(cl)\partial_\mu s^k \partial_\nu s^l \ , \\
F_{\mu\nu}(qu) &= F_{kl}(qu)\partial_\mu m^k \partial_\nu m^l \ , \\
F_{kl}(qu) &= \partial_l A_k(qu) - \partial_k A_l(qu) \ , \\
A_k(qu) &= A_k(qu,v) + A_k(qu,c) \ .
\end{aligned} \tag{4.7.1}
$$

$F_{kl}(qu)$ satisfies empty space Maxwell equations. $m^k$ and $s^k$ refer to $M^4_+$ and $CP_2$ coordinates and $v$ and $c$ refer to vapor phase and condensate.

Maxwell action density can be transformed to a sum of a total divergence reducing to mere boundary term, to be neglected, plus free part and two interaction terms in the following manner:

$$
\begin{aligned}
\frac{L}{\sqrt{g}} &= \sum_i L(free,i) + L_1(int) + L_2(int) \ , \\
L(free,i) &= \frac{1}{4} F_{\mu\nu}(qu,i) F^{\mu\nu}(qu,i) \ , \ i = c,v \ . \\
L_1(int) &= \frac{1}{2} j^\mu(cl) \sum_i A_\mu(qu,i) \ , \\
L_2(int) &= \frac{1}{2} \sum_i J^\mu(qu,i) A_{mu}(cl) \ , \\
J^\mu(qu,i) &= F^\mu_k(i) M^{k\nu}_\nu + F_k^{\ \nu}(i) M^{k\mu}_\nu \ , \ i = c,v \\
M^k_{\alpha\beta} &= D_\beta \partial_\alpha m^k \ .
\end{aligned} \tag{4.7.2}
$$

$L(free,i)$ denotes the free action for the classical emf and vapor phase and condensed quantum emfs and defines photon propagators. Standard propagator is obtained, when Minkowski coordinates are used for space-time surface.

$L_1(int)$ corresponds to the action of the vapor phase and condensed quantum emf with the vacuum current and leads to generation of coherent state of photons both in vapor phase and condensate.

$L_2(int)$ is non-vanishing only, when the $M^4_+$ part of the second fundamental form $M^k_{\alpha\beta}$ for 4-surface is non-vanishing: in this case the em current associated with $A_{mu}(qu)$ is non-vanishing despite the fact that it vanishes for $A_k(qu)$! This term describes the external curvature of the 4-surface as opposed to the internal curvature described by the curvature tensor. In general case, the external curvature can be large even when the gravitational field vanishes. It must be however emphasized that this term is proportional to the metric of $CP_2$ and, in case of the massless extremals, this term is significant only if the dependence of $CP_2$ coordinates on the transversal coordinates of $M^4_+$ is strong: this in turn requires huge value for the light-like Einstein tensor. This term will be neglected in the sequel.

The representation

$$
\begin{aligned}
&A_+(k,\lambda) = \sqrt{\tfrac{2\pi}{\omega_k}} a^\dagger(k,\lambda) \ , \\
&\left[a(k_1,\lambda_1), a^\dagger(k_2,\lambda_2)\right] = \delta^3(k_1 - k_2)\delta_{\lambda_1,\lambda_2} \ ,
\end{aligned} \tag{4.7.3}
$$

for which the density of states factor for photon states is $dN = d^3k$, will be used in the sequel.

### 4.7.2 Coherent state is generated in resonant-like manner for light-like vacuum currents

The presence of the vacuum current leads to the generation of coherent state of photons both in vapor phase and condensate. Coherent states states are eigen states of the photonic annihilation operators and in the estimates for the rate of topological condensation, one in a good approximation one can replace $A_\mu(qu,i)$, $i = cond, vap$, with the classical photon field $A_\mu(coh,i)$ having classical vacuum current as its source and serving as order parameters for the coherent state. The Fourier component of a vector potential describing the eigenvalue of the annihilation operator part of the photon field is for given momentum $k$ and polarization direction $\lambda$ given by

$$\begin{aligned} A^\mu(coh,v|\lambda,k) &= \sum_n c(k,k_n)\frac{\lambda_\mu J^\mu(k_n)\lambda^\mu}{k_n^2} \ , \\ exp(-ik\cdot m) &= \sum_n c(k,k_n)exp(-ik_n\cdot m) \ . \end{aligned} \tag{4.7.4}$$

$c(k,k_n)$ is the Fourier component of the planewave $exp(-ik\cdot m)$ expressed using discrete planewave basis for the space-time sheet containing the vacuum current. $m$ denotes Minkowski coordinates.

If the classical vacuum current is associated with a 'massless extremal', em current is light-like and this implies resonance for those frequencies for which photon wave vector corresponds to the wave vectors appearing in the vacuum current. The resonance is smoothed out by the finite spatial size of the space-time sheet containing the light-like vacuum current. At the limit of an infinitely large spatial size for the space-time sheet, one obtains infinitely large amplitude since one has $k_n^2 = k^2 = 0$ at this limit.

### 4.7.3 Stimulated topological condensation

The presence of the coherent state of photons implies the possibility of the topological condensation of photons. If the device contains $N(k,\lambda)$ photons in the the state $(k,\lambda)$, stimulated topological condensation, completely analogous to the stimulated emission, occurs and the condensation rate is proportional to $(N(k,\lambda)+1)^2$.

Assume that there exists a coherent state generated by quantum antenna of possibly astrophysical dimension and associate label '1' with this space-time sheet. Assume also a second space-time sheet and associate with it label '2'. In the lowest order the matrix element for the topological condensation of single photon can be obtained as the matrix element of the creation operator part of the interaction term of the action

$$\begin{aligned} &iS_+ = \tfrac{i}{2}\int_{V_2} dV_2 j^\mu_\perp(coh,1)A_{\mu,+}(cond,2) \\ &= \tfrac{i}{2}\sum_{\lambda_2}\int d^3k_2 X(k_2,\lambda_2)a^\dagger(k_2,\lambda_2) \ , \\ &X(k_2,\lambda_2) = \sqrt{\tfrac{2\pi}{\omega_{k_2}}}\sum_{\lambda_1}\int d^3k_1 Y(k_1,\lambda_1,k_2,\lambda_2) \ , \\ &Y(k_1,\lambda_1,k_2,\lambda_2) = j(coh,1|k_1,\lambda_1)c(k_1,k_2)e_{\lambda_1}\cdot e_{\lambda_2} \ , \\ &c(k_1,k_2) = \int_{V_2} dV_2 exp\left[i(k_1-k_2)\cdot m\right] \ , \end{aligned} \tag{4.7.5}$$

between the initial and final states. $j^\mu(coh,1)$ is just the transversal part of the classical vacuum current creating the coherent state. The latter expression is obtained by using Fourier expansions for $j$ and $A_+$ (, which denotes the creation operator part of the free photon field projected to the space-time surface representing the device: Minkowski coordinates are used for both source regions and device).

In case that the region $V_1$ is box of length $L$ in the direction of the vacuum current, the explicit calculation, writing the light-like vacuum current as $j^\mu = Jp^\mu$, $p^0 = p^z = 1$, leads to the following expression for the Fourier component $j(coh,1|k_1,\lambda_1)$:

$$
\begin{array}{l}
j(coh,1|k,\omega_k,\lambda) = j^{\mu}(coh,1|k,\omega_k)e^{\lambda}_{\mu} \ , \\
= \sum_n \frac{exp(ik_zL)-1}{ik_z} J(\omega_n,k_T) p\cdot e^{\lambda}\delta(k^0-\omega_n) \ , \\
\omega_n = \frac{n\pi}{L} \ .
\end{array} \tag{4.7.6}
$$

Delta-function expresses the fact that only discrete frequencies are allowed for the vacuum current and one can write the condensation amplitude as a sum $iS_+ = i\sum_n iS_{+,n}$ over the allowed frequencies $\omega_n$. $k_T$ refers to the transversal part of the wave vector orthogonal to the light-like vacuum current.

From this expression one can deduce the probability for the topological condensation of photon $(k,\lambda)$ to a state containing $N(k,\lambda)$ photons as

$$
|S(k,\lambda)|^2 = |\sum_n S_{+,n}|^2 (N(k,\lambda)+1)^2 \ , \tag{4.7.7}
$$

Clearly, $(N(k,\lambda)+1)^2$ factor corresponds to the induced condensation. By a standard trick one can eliminate the square of the delta-function by replacing the condensation probability with condensation rate $R(k,\lambda)$ obtained by dividing condensation probability with $T\rightarrow\infty$ eliminating one deltafunction. Furthermore, one can calculate the transition rate to a set of final states by multiplying the expression thus obtained with the density of states factor $dN = d^3k$, which after the elimination of the second delta function effectively reduces to $\omega_n^2 d\Omega$. In this manner one obtains for the differential condensation rate a a rather neat expression in terms of the vacuum current

$$
\begin{array}{l}
\frac{dR(k,\lambda,n)}{d\Omega} = \frac{\pi}{2}\omega_n L^2 |M(k,\lambda|^2 (N(k,\lambda)+1)^2 \ , \\
M(k,\lambda) = i\sum_{\lambda_1}\int d^3k_1 J(\omega_n,k_T^1) c(k^1,k) X(k_1,\lambda_1) \ , \\
X(k_1,\lambda_1) = \frac{exp(ik_z^1L)-1}{ik_z^1L} p\cdot e_{\lambda_1} e_{\lambda_1}\cdot e_{\lambda} \ .
\end{array} \tag{4.7.8}
$$

From this expression it is clear that resonance indeed occurs and at the limit $L\rightarrow\infty$ the rate for condensation diverges as $L^2$. In this expression the overlap integral $c(k_1,k_2)$ carries information about the geometry of the space-time sheet associated with the 'device' whereas $J(\omega_n,k_T)$ characterizes the vacuum current and the remaining factor $X$ is a purely 'kinematic' factor.

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# Chapter 5

# Wormhole Magnetic Fields

## 5.1 Introduction

Topological field quantization has turned out to be fundamental for the understanding of quantum TGD and TGD inspired theory of consciousness. What makes topological field quantization so important is that it provides very precise classical representation for the quantum aspects of the theory. Even virtual particles have geometric counterparts and as a special case correspond to mind-like space-time sheets providing cognitive representations for the material space-time sheets. In TGD the sign of the classical energy correlates with the time orientation of the space-time sheet and this makes possible pairs of space-time sheets of finite duration having vanishing total energy. This suggest an astonishingly simple mechanism for the formation of cognitive representations: direct mimicry in which classical fields in some region of the material space-time sheet are realized at the two mind-like space-time sheets of opposite time orientation! This realization would make physicist's universe analogous to the computer scientist's universe filled with computers emulating each other. Concerning the understanding of how intelligent consciousness is realized, the implications would be highly nontrivial.

The fact that em fields oscillating with multiples of the cyclotron frequencies of various charged particles in Earth's magnetic fields have effects on living matter [58] could indeed mean that biomatter mimics Earth's magnetic field by forming double sheeted structures, wormhole magnetic fields, with magnetic field strength equal to that of Earth's magnetic field. This observation could serve as a good motivation for the modelling of wormhole magnetic fields. This was not the original motivation for studying wormhole magnetic fields. Rather, it was the modelling of homeopathy in terms mind-like space-time sheets, which led to the discovery of the astonishing possibility of a direct mimicry performed by mind-like space-time sheets. Note that also more abstract cognitive representations are possible. In particular, various oscillation frequencies of material space-time sheets could be transferred to mind-like space-time sheets and the counterparts of FM and AM modulation would provide obvious cognitive representations.

Topological field quantization originates from the fact that given classical gauge field configuration does not allow global representation as an induced gauge field but space-time splits into separate regions, topological field quanta. Typically, magnetic field reduces to a bundle of disjoint *flux tubes* flowing along field lines of classical field, which in TGD context are cylindrical regions of 3-space with outer boundaries. There is no doubt about the fundamental importance of topological field quanta for biosystems if TGD is correct and the natural working hypothesis is that topologically quantized classical gauge field configurations belong to the basic tools of biocontrol and that the vacuum quantum numbers characterizing topological field quanta (for the definition of vacuum quantum numbers see the Appendix) carry bio-information.

It has also become clear, that the closely related concepts of *many-sheeted space-time* and *charged wormhole* play crucial role in biosystems. Wormholes feed gauge fluxes from a smaller sheet of 3-space to a larger one and are located near the boundary of the smaller 3-space sheet and have size of order $CP_2$ length of order $10^4$ Planck lengths as do also ordinary elementary particles. Not only electromagnetic but also $Z^0$ wormholes are possible in TGD since long range classical $Z^0$ fields are unavoidable in TGD context. Wormhole throat can have also magnetic charge. Furthermore, the topology of the wormhole throat, being characterized by the genus of the 2-surface in question, gives rise to a degeneracy analogous to the family replication of elementary fermions.

Wormhole concept leads naturally to the concept of *wormhole flux tube*, which by assumption contains no ordinary matter inside it and is forced by Maxwell equations to be a *hollow cylinder*. Maxwell's equations require rotating charge carrier densities with opposite total charges on the inner and outer boundaries of this cylinder. Since ordinary charges are excluded, the only possibility is that these charge carries are charged wormholes. Since the wormhole behaves like a gauge charge $\pm Q$ on the two space-time sheets respectively, there is return flux on the second space-time sheet. Wormhole flux tubes need not be closed unlike ordinary flux tubes: at the end point magnetic flux just flows from 'upper' space-time sheet to the 'lower' space-time sheet via magnetic wormhole behaving as magnetic charge $\pm Q_m$ on the two space-time sheets respectively. Charged wormhole flux tubes can form arbitrary complicated net like structures. Since wormholes form *BE condensate* and behave as super conductor, the classical field is transformed in TGD context to a macroscopic quantum system, *wormhole magnetic field*. It has become clear that electronic and neutrino superconductivity might play fundamental role in biosystems: it might be even possible to identify the quantum correlates of sensory qualia as coherent photons and gravitons, wormhole BE condensate and BE condensates of electronic and neutrino Cooper pairs. What is important is that wormhole magnetic fields seem to provide a topological representation for the defects of fermionic super conductors.

Quantum antenna hypothesis states that the lightlike vacuum currents associated with microtubules, and possibly also other linear structures, serve as sources of quantum coherent photon fields [J4], in particular of bio-photons. The phenomenon of sonoluminescence has an explanation in terms of light-like vacuum currents underlying the quantum antenna hypothesis and that microtubular diameter provides a natural intrinsic length scale of hydrodynamics of water. One of the many challenges is to understand how wormholes and coherent photons interact. In this chapter a model for this interaction is proposed. The model leads to possible explanations of *Comorosan effect* [33, 34] and *phantom DNA effect* [82, 53]. Also the effect of homeopathy could reduce to that of mind-like space-time sheets associated with the drug if these mind-like space-time sheets mimic directly the classical gauge field structure of the drug.

The concept of wormhole magnetic field is proposed as a possible explanation for claimed psychokinetic effects (PK). Topologically quantized wormhole magnetic field, being a macroscopic quantum system, can give rise to PK effect via *magnetic levitation*, if external object is wormhole super conductor and if the density of charged wormholes on its boundary is sufficiently high to generate Meissner effect. This same structure could enlarge DNA and other basic structures to macroscopic quantum systems with size much larger than the basic object consisting of ordinary matter. One could even imagine that the structure of DNA sequences could be coded into the structure of the topologically quantized magnetic field created by it.

An alternative model of psychokinesis is based on the possibility of space-time sheets having negative time orientation and carrying therefore negative classical energy. It is not clear whether the space-time sheets associated with the wormhole magnetic fields could have opposite time orientations. This kind of mechanism of energy production might explain claimed poltergeist type effects involving spontaneous gain of kinetic energy. Many-sheeted space-time concept makes possible also psychokinesis based on levitation: what is needed that subsystem is able to topologically condense to a sufficiently large space-time sheet carrying very weak gravitational fields.

## 5.2 Basic conceptual framework

The notions of topological condensate and p-adic length scale hierarchy are in a central role in TGD and for a long time it seemed that the physical interpretation of these notions is relatively straightforward. The evolution of number theoretical ideas however forced to suspect that the implications for physics might be much deeper and involve not only a solution to the mysteries of dark matter but also force to bring basic notions of TGD inspired theory of consciousness. At this moment the proper interpretation of the mathematical structures involving typically infinite hierarchies generalizing considerably the mathematical framework of standard physics is far from established so that it is better to represent just questions with some plausible looking answers.

### 5.2.1 Basic concepts

It is good to discuss the basic notions before discussing the definition of gauge charges and gauge fluxes.

#### $CP_2$ type vacuum extremals

$CP_2$ type extremals behave like elementary particles (in particular, light-likeness of $M^4$ projection gives rise to Virasoro conditions). $CP_2$ type vacuum extremals have however vanishing four-momentum although they carry classical color charges. This raises the question how they can gain elementary particle quantum numbers.

In topological condensation of $CP_2$ type vacuum extremal a light-like causal horizon is created. Number theoretical considerations strongly suggest that the horizon carries elementary particle numbers and can be identified as a parton. The quantum numbers or parton would serve as sources of the classical gauge fields created by the causal horizon.

In topological evaporation $CP_2$ type vacuum extremal carrying only classical color charges is created. This would suggest that the scattering of $CP_2$ type vacuum extremals defines a topological quantum field theory resulting as a limit of quantum gravitation ($CP_2$ is gravitational instanton) and that $CP_2$ type extremals define the counterparts of vacuum lines appearing in the formulation of generalized Feynman diagrams.

#### # contacts as parton pairs

The earlier view about # contacts as passive mediators of classical gauge and gravitational fluxes is not quite correct. The basic modification is due to the fact that one can assign parton or parton pair to the # contact so that it becomes a particle like entity. This means that an entire p-adic hierarchy of new physics is predicted.

1. Formally # contact can be constructed by drilling small spherical holes $S^2$ in the 3-surfaces involved and connecting the spherical boundaries by a tube $S^2 \times D^1$. For instance, $CP_2$ type extremal can be glued to space-time sheet with Minkowskian signature or space-time sheets with Minkowskian signature can be connected by # contact having Euclidian signature of the induced metric. Also more general contacts are possible since $S^2$ can be replaced with a 2-surface of arbitrary genus and family replication phenomenon can be interpreted in terms of the genus.

   The # contact connecting two space-time sheets with Minkowskian signature of metric is accompanied by two "elementary particle horizons", which are light-like 3-surfaces at which the induced 4-metric becomes degenerate. Since these surfaces are causal horizons, it is not clear whether # contacts can mediate classical gauge interactions. If there is an electric gauge flux associated with elementary particle horizon it tends to be either infinite by the degeneracy of the induced metric. It is not clear whether boundary conditions allow to have finite gauge fluxes of electric type. A similar difficulty is encountered when one tries to assign gravitational flux to the # contact: in this case even the existence of flux in non-singular case is far from obvious. Hence the naive extrapolation of Newtonian picture might not be quite correct.

2. Number theoretical considerations suggests that the two light-like horizons associated with # contacts connecting space-time sheets act as dynamical units analogous to shock waves or light fronts carrying quantum numbers so that the identification as partons is natural. Quantum holography would suggest itself in the sense that the quantum numbers associated with causal horizons would determine the long range fields inside space-time sheets involved.

3. # contacts can be modelled in terms of $CP_2$ type extremals topologically condensed simultaneously to the two space-time sheets involved. The topological condensation of $CP_2$ type extremal creates only single parton and this encourages the interpretation as elementary particle. The gauge currents for $CP_2$ type vacuum extremals have a vanishing covariant divergence so that there are no conserved charges besides Kähler charge. Hence electro-weak gauge charges are not conserved classically in the region between causal horizons whereas color gauge charges are. This could explain the vacuum screening of electro-weak charges at space-time level. This is required since for the known solutions of field equations other than $CP_2$ type extremals vacuum screening does not occur.

4. In the special case space-time sheets have opposite time orientations and the causal horizons carry opposite quantum numbers (with four-momentum included) the # contact would serve the passive role of flux mediator and one could assign to the contact generalized gauge fluxes as quantum numbers associated with the causal horizons. This is the case if the contact is created from vacuum in topological condensation so that the quantum numbers associated with the horizons define naturally generalized gauge fluxes. Kind of generalized quantum dipoles living in two space-times simultaneously would be in question. # contacts in the ground state for space-time sheets with opposite time orientation can be also seen as zero energy parton-antiparton pairs bound together by a piece of $CP_2$ type extremal.

5. When space-time sheets have same time orientation, the two-parton state associated with the # contact has non-vanishing energy and it is not clear whether it can be stable.

### $\#_B$ contacts as bound parton pairs

Besides # contacts also join along boundaries bonds (JABs, $\#_B$ contacts) are possible. They can connect outer boundaries of space-time sheets or the boundaries of small holes associated with the interiors of two space-time sheets which can have Minkowskian signature of metric and can mediate classical gauge fluxes and are excellent candidates for mediators of gauge interactions between space-time sheet glued to a larger space-time sheet by topological sum contacts and join along boundaries contacts. The size scale of the causal horizons associated with parton pairs can be arbitrary whereas the size scale of # contacts is given by $CP_2$ radius.

The existence of the holes for real space-time surfaces is a natural consequence of the induced gauge field concept: for sufficiently strong gauge fields the imbeddability of gauge field as an induced gauge field fails and hole in space-time appears as a consequence. The holes connected by $\#_B$ contacts obey field equations, and a good guess is that they are light-like 3-surfaces and carry parton quantum numbers. This would mean that both # and $\#_B$ contacts allow a fundamental description in terms of pair of partons.

Magnetic flux tubes provide a representative example of $\#_B$ contact. Instead of $\#_B$ contact also more descriptive terms such as join along boundaries bond (JAB), color bond, and magnetic flux tube are used. $\#_B$ contacts serve also as a space-time correlate for bound state formation and one can even consider the possibility that entanglement might have braiding of bonds defined by # contacts as a space-time correlate [E9].

It seems difficult to exclude join along boundaries contacts between between holes associated with the two space-time sheets at different levels of p-adic hierarchy. If these contacts are possible, a transfer of conserved gauge fluxes would be possible between the two space-time sheets and one could speak about interaction in conventional sense.

### Topological condensation and evaporation

Topological condensation corresponds to a formation of # or $\#_B$ contacts between space-time sheets. Topological evaporation means the splitting of # or $\#_B$ contacts. In the case of elementary particles the process changes almost nothing since the causal horizon carrying parton quantum numbers does not disappear. The evaporated $CP_2$ type vacuum extremal having interpretation as a gravitational instanton can carry only color quantum numbers.

As # contact splits partons are created at the two space-time sheets involved. This process can obviously generate from vacuum space-time sheets carrying particles with opposite signs of energies and other quantum numbers. Positive energy matter and negative energy anti-matter could be thus created by the formation of # contacts with zero net quantum numbers which then split to produce pair of positive and negative energy particles at different space-time sheets having opposite time orientations. This mechanism would allow a creation of positive energy matter and negative energy antimatter with an automatic separation of matter and antimatter at space-time sheets having different time orientation. This might resolve elegantly the puzzle posed by matter-antimatter asymmetry.

The creation of # contact leads to an appearance of radial gauge field in condensate and this seems to be impossible at the limit of infinitely large space-time sheet since it involves a radical instantaneous change in field line topology. The finite size of the space-time sheet can however resolve the difficulty.

If all quantum numbers of elementary particle are expressible as gauge fluxes, the quantum numbers of topologically evaporated particles should vanish. In the case of color quantum numbers and Poincare quantum numbers there is no obvious reason why this should be the case. Despite this the cancellation of the interior quantum numbers by those at boundaries or light-like causal determinants could occur and would conform with the effective 2-dimensionality stating that quantum states are characterized by partonic boundary states associated with causal determinants. This could be also seen as a holographic duality of interior and boundary degrees of freedom [A2].

### 5.2.2 Gauge charges and gauge fluxes

The concepts of mass and gauge charge in TGD has been a source of a chronic headache. There are several questions waiting for a definite answer. How to define gauge charge? What is the microscopic physics behind the gauge charges necessarily accompanying long range gravitational fields? Are these gauge charges quantized in elementary particle level? Can one associate to elementary particles classical electro-weak gauge charges equal to its quantized value or are all electro-weak charges screened at intermediate boson length scale? Is the generation of the vacuum gauge charges, allowed in principle by the induced gauge field concept, possible in macroscopic length scales? What happens to the gauge charges in topological evaporation? Should Equivalence Principle be modified in order to understand the fact that Robertson-Walker metrics are inertial but not gravitational vacua.

#### How to define the notion of gauge charge?

In TGD gauge fields are not primary dynamical variables but induced from the spinor connection of $CP_2$. There are two manners to define gauge charges.

1. In purely group theoretical approach one can associate non-vanishing gauge charge to a 3-surface of finite size and quantization of the gauge charge follows automatically. This definition should work at Planck length scales, when particles are described as 3-surfaces of $CP_2$ size and classical space-time mediating long range interactions make no sense. Gauge interactions are mediated by gauge boson exchange, which in TGD has topological description in terms of $CP_2$ type extremals [C2].

2. Second definition of gauge charge is as a gauge flux over a closed surface. In this case quantization is not obvious nor perhaps even possible at classical level except perhaps for Abelian charges. For a closed 3-surface gauge charge vanishes and one might well argue that this is the case for finite 3-surface with boundary since the boundary conditions might well generate gauge charge near the boundary cancelling the gauge charge created by particles condensed on 3-surface. This would mean that at low energies (photon wavelength large than size of the 3-surfaces) the 3-surfaces in vapor phase look like neutral particles. Only at high energies the evaporated particles would behave as ordinary elementary particles. Furthermore, particle leaves in topological evaporation its gauge charge in the condensate.

   The alternative possibility that the long range $\frac{1}{r^2}$ gauge field associated with particle disappears in the evaporation, looks topologically impossible at the limit when larger space-time sheet has infinite size: only the simultaneous evaporation of opposite gauge charges might be possible in this manner at this limit. Topological evaporation provides a possible mechanism for the generation of vacuum gauge charges, which is one basic difference between TGD and standard gauge theories.

There is a strong temptation to draw a definite conclusion but it is better to be satisfied with a simplifying working hypothesis that gauge charges are in long length scales definable as gauge fluxes and vanish for macroscopic 3-surfaces of finite size in vapor phase. This would mean that the topological evaporation of say electron as an electromagnetically charged particle would not be possible except at $CP_2$ length scale: in the evaporation from secondary condensation level electron would leave its gauge charges in the condensate. Vapor phase particle still looks electromagnetically charged in length scales smaller than the size of the particle surface if the neutralizing charge density is near (or at) the boundary of the surface and gauge and gravitational interactions are mediated by the exchange of $CP_2$ type extremals.

**In what sense could # contacts feed gauge fluxes?**

One can associate with the # throats magnetic gauge charges $\pm Q_i$ defined as gauge flux running to or from the throat. The magnetic charges are of opposite sign and equal magnitude on the two space-time sheets involved. For Kähler form the value of magnetic flux is quantized and non-vanishing only if the the $t = constant$ section of causal horizon corresponds to a non-trivial homology equivalence class in $CP_2$ so that # contact can be regarded as a homological magnetic monopole. In this case # contacts can be regarded as extremely small magnetic dipoles formed by tightly bound # throats possessing opposite magnetic gauge charges. # contacts couple to the difference of the classical gauge fields associated with the two space-time sheets and matter-# contact and # contact-# contact interaction energies are in general non-vanishing.

Electric gauge fluxes through # throat evaluated at the light-like elementary particle horizon $X_l^3$ tend to be either zero or infinite. The reason is that without appropriate boundary conditions the normal component of electric $F^{tn}\sqrt{(g_4)}/g^2$ either diverges or is infinite since $g^{tt}$ diverges by the effective three-dimensionality of the induced metric at $X_l^3$. In the gravitational case an additional difficulty is caused by the fact that it is not at all clear whether the notion of gravitational flux is well defined. It is however possible to assign gravitational mass to a given space-time sheets as will be found in the section about space-time description of charge renormalization.

The simplest conclusion would be that the notions of gauge and gravitational fluxes through # contacts do not make sense and that # contacts mediate interactions in a more subtle manner. For instance, for a space-time sheet topologically condensed at a larger space-time sheet the larger space-time sheet would characterize the basic coupling constants appearing in the S-matrix associated with the topologically condensed space-time sheets. In particular, the value of $\hbar$ would characterize the relation between the two space-time sheets. A stronger hypothesis would be that the value of $\hbar$ is coded partially by the Jones inclusion between the state spaces involved. The larger space-time sheet would correspond to dark matter from the point of view of smaller space-time sheet [C6, F10].

One can however try to find loopholes in the argument.

1. It might be possible to pose the finiteness of $F^{tn}\sqrt{g_4}/g^2$ as a boundary condition. The variation principle determining space-time surfaces implies that space-time surfaces are analogous to Bohr orbits so that there are also hopes that gauge fluxes are quantized.

2. Another way out of this difficulty could be based on the basic idea behind renormalization in TGD framework. Gauge coupling strengths are allowed to depend on space-time point so that the gauge currents are conserved. Gauge coupling strengths $g^2/4\pi$ could become infinite at causal horizon. The infinite values of gauge couplings at causal horizons might be a TGD counterpart for the infinite values of bare gauge couplings in quantum field theories. There are however several objections against this idea. The values of coupling constants should depend on space-time sheet only so that the situation is not improved by this trick in $CP_2$ length scale. Dependence of $g^2$ on space-time point means also that in the general case the definition of gauge charge as gauge flux is lost so that gauge charges do not reduce to fluxes.

It seems that the notion of a finite electric gauge flux through the causal horizon need not make sense as such. Same applies to the notion of gravitational gauge flux. The notion of gauge flux seems however to have a natural quantal generalization. The creation of a # contact between two space-time sheets creates two causal horizons identifiable as partons and carrying conserved charges assignable with the states created using the fermionic oscillator operators associated with the second quantized induced spinor field. These charges must be of opposite sign so that electric gauge fluxes through causal horizons are replaced by quantal gauge charges. For opposite time orientations also four-momenta cancel each other. The particle states can of course transform by interactions with matter at the two-space-time sheets so that the resulting contact is not a zero energy state always.

This suggests that for gauge fluxes at the horizon are identifiable as opposite quantized gauge charges of the partons involved. If the the net gauge charges of # contact do not vanish, it can be said to possess net gauge charge and does not serve as a passive flux mediator anymore. The possibly screened classical gauge fields in the region faraway from the contact define the classical correlates for gauge fluxes. A similar treatment applies to gravitational flux in the case that the time orientations are opposite and gravitational flux is identifiable as gravitational mass at the causal horizon.

Internal consistency would mildly suggest that # contacts are possible only between space-time sheets of opposite time orientation so that gauge fluxes between space-time sheets of same time orientation would flow along $\#_B$ bonds.

#### Are the gauge fluxes through # and $\#_B$ contacts quantized?

There are good reasons (the absolute minimization of the Kähler action plus maximization of the Kähler function) to expect that the gauge fluxes through # (if well-defined) and $\#_B$ contacts are quantized. The most natural guess would be that the unit of electric electromagnetic flux for $\#_B$ contact is 1/3 since this makes it possible for the electromagnetic gauge flux of quarks to flow to larger space-time sheets. Anyons could however mean more general quantization rules [E9]. The quantization of electromagnetic gauge flux could serve as a unique experimental signature for # and $\#_B$ contacts and their currents. The contacts can carry also magnetic fluxes. In the case of $\#_B$ contacts the flux quantization would be dynamical and analogous to that appearing in super conductors.

#### Hierarchy of gauge and gravitational interactions

The observed elementary particles are identified as $CP_2$ type extremals topologically condensed at space-time sheets with Minkowski signature of induced metric with elementary particle horizon being responsible for the parton aspect. This suggests that at $CP_2$ length scale gauge and gravitational interactions correspond to the exchanges of $CP_2$ type extremals with light-like $M^4$ projection with branching of $CP_2$ type extremal serving as the basic vertex as discussed in [C2]. The gravitational and gauge interactions between the partons assignable to the two causal horizons associated with # contact would be mediated by the # contact, which can be regarded as a gravitational instanton and the interaction with other particles at space-time sheets via classical gravitational fields.

Gauge fluxes flowing through the $\#_B$ contacts would mediate higher level gauge and interactions between space-time sheets rather than directly between $CP_2$ type extremals. The hierarchy of flux tubes defining string like objects strongly suggests a p-adic hierarchy of "strong gravities" with gravitational constant of order $G \sim L_p^2$, and these strong gravities might correspond to gravitational fluxes mediated by the flux tubes.

### 5.2.3 The relationship between inertial gravitational masses

It took quite a long time to accept the obvious fact that the relationship between inertial and gravitational masses cannot be quite the same as in General Relativity.

#### Modification of the Equivalence Principle?

The findings of [D3] combined with the basic facts about imbeddings of Robertson-Walker cosmologies [D5] force the conclusion that inertial mass density vanishes in cosmological length scales. This is possible if the sign of inertial energy depends on time orientation of the space-time sheet. This forces a modification of Equivalence Principle. The modified Equivalence Principle states that gravitational energy corresponds to the absolute value of inertial energy. Since inertial energy can have both signs, this means that gravitational mass is not conserved and is non-vanishing even for vacuum extremals. This differences is dual for the two time times: the experienced time identifiable as a sequence of quantum jumps and geometric time.

More generally, all conserved (that is Noether-) charges of the Universe vanish identically and their densities vanish in cosmological length scales. The simplest generalization of the Equivalence Principle would be that gravitational four-momentum equals to the absolute value of inertial four-momentum and is thus not conserved in general. Gravitational mass density does not vanish for vacuum extremals and, as will be found, one can deduce the renormalization of gravitational constant at given space-time sheet from the requirement that gravitational mass is conserved inside given space-time sheet. The conservation law holds only true inside given space-time sheet.

An interesting question is whether inertial-gravitational duality generalizes to the case of color gauge charges so that color gauge fluxes would correspond to "gravitational" color charges and the charges defined by the conserved currents associated with color isometries would define "inertial" color charges. Since induced color fields are proportional to color Hamiltonians multiplied by Kähler form they vanish identically for vacuum extremals in accordance with "gravitational" color confinement.

**Gravitational mass is necessarily accompanied by non-vanishing gauge charges**

The experience from the study of the extremals of the Kähler action [D1] suggests that for non-vacuum extremals at astrophysical scales Kähler charge doesn't depend on the properties of the condensate and is apart from numerical constant equal to the gravitational mass of the system using Planck mass as unit:

$$Q_K = \epsilon_1 \frac{M_{gr}}{m_{proton}} . \tag{5.2.1}$$

The condition $\frac{\epsilon_1}{\sqrt{\alpha_K}} < 10^{-19}$ must hold true in astrophysical length scales since the long range gauge force implied by the Kähler charge must be weaker than gravitational interaction at astrophysical length scales. It is not clear whether the 'anomalous' Kähler charge can correspond to a mere $Z^0$ gauge or em charge or more general combination of weak charges.

Also for the imbedding of Schwartschild and Reissner-Nordström metrics as vacuum extremals non-vanishing gravitational mass implies that some electro-weak gauge charges are non-vanishing [D1]. For vacuum extremals with $sin^2(\theta_W) = 0$ em field indeed vanishes whereas $Z^0$ gauge field is non-vanishing.

If one assumes that the weak charges are screened completely in electro-weak length scale, the anomalous charge can be only electromagnetic if it corresponds to ordinary elementary particles. This however need not be consistent with field equations. Perhaps the most natural interpretation for the "anomalous" gauge charges is due to the elementary charges associated with dark matter. Since weak charges are expected to be screened in the p-adic length scale characterizing weak boson mass scale, the implication is that scaled down copies of weak bosons with arbitrarily small mass scales and arbitrarily long range of interaction are predicted. Also long ranged classical color gauge fields are unavoidable which forces to conclude that also a hierarchy of scaled down copies of gluons exists.

One can hope that photon and perhaps also $Z^0$ and color gauge charges in Cartan algebra could be quantized classically at elementary particle length scale ($p \leq M_{127}$, say) and electromagnetic gauge charge in all length scales apart from small renormalization effects. One of the reasons is that classical electromagnetic fields make an essential part in the description of, say, hydrogen atom.

The study of the extremals of Kähler action and of the imbeddings of spherically symmetric metrics [D3, D1] shows that the imbeddings are characterized by frequency type vacuum quantum numbers, which allow to fix these charges to pre-determined values. The minimization of Kähler action for a space-time surface containing a given 3-surface leads to the quantization of the vacuum parameters and hopefully to charge quantization. This motivates the hypothesis that the electromagnetic charges associated with the classical gauge fields of topologically condensed elementary particles are equal to their quantized counterparts. The discussion of dark matter leads to the conclusion that electro-weak and color gauge charges of dark matter can be non-vanishing [J6, F10].

### 5.2.4 Can one regard # *resp.* $\#_B$ contacts as particles *resp.* string like objects?

#-contacts have obvious particle like aspects identifiable as either partons or parton pairs. $\#_B$ contacts in turn behave like string like objects. Using the terminology of M-theory, $\#_B$ contacts connecting the boundaries of space-time sheets could be also seen as string like objects connecting two branes. Again the ends holes at the ends of $\#_B$ contacts carry well defined gauge charges.

**# contacts as particles and $\#_B$ contacts as string like objects?**

The fact that # contacts correspond to parton pairs raises the hope that it is possible to apply p-adic thermodynamics to calculate the masses of # contact and perhaps even the masses of the partons. If this the case, one has an order of magnitude estimate for the first order contribution to the mass of the parton as $m \sim 1/L(p_i)$, $i = 1, 2$. It can of course happen that the first order contribution vanishes: in this case an additional factor $1/\sqrt{p_i}$ appears in the estimate and makes the mass extremely small.

For # contacts connecting space-time sheets with opposite time orientations the vanishing of the net four-momentum requires $p_1 = p_2$. According to the number theoretic considerations below it is possible to assign several p-adic primes to a given space-time sheet and the largest among them, call it $p_{max}$, determines the p-adic mass scale. The milder condition is that $p_{max}$ is same for the two space-time sheets.

There are some motivations for the working hypothesis that # contacts and the ends of $\#_B$ contacts feeding the gauge fluxes to the lower condensate levels or vice versa tend to be located near the boundaries of space-time sheets. For gauge charges which are not screened by vacuum charges (em and color charges) the imbedding of the gauge fields created by the interior gauge charges becomes impossible near the boundaries and the only possible manner to satisfy boundary conditions is that gauge fluxes flow to the larger space-time sheet and space-time surface becomes a vacuum extremal of the Kähler action near the boundary.

For gauge bosons the density of boundary $\#_B$ contacts should be very small in length scales, where matter is essentially neutral. For gravitational $\#_B$ contacts the situation is different. One might well argue that there is some upper bound for the gravitational flux associated with single # or $\#_B$ contact (or equivalently the gravitational mass associated with causal horizon) given by Planck mass or $CP_2$ mass so that the number of gravitational contacts is proportional to the mass of the system.

The TGD based explanation for Podkletnov effect [29] is based on the assumption that magnetically charged # contacts are carries of gravitational flux equal to Planck mass and predicts effect with correct order of magnitude. The model generalizes also to the case of $\#_B$ contacts. The lower bound for the gravitational flux quantum must be rather small: the mass $1/L(p)$ determined by the p-adic prime associated with the larger space-time sheet is a first guess for the unit of flux.

#### Could # and $\#_B$ contacts form Bose-Einstein condensates?

The description as # contact as a parton pair suggests that it is possible to assign to # contacts inertial mass, say of order $1/L(p)$, they should be describable using d'Alembert type equation for a scalar field. # contacts couple dynamically to the geometry of the space-time since the induced metric defines the d'Alembertian. There is a mass gap and hence # contacts could form a Bose-Einstein (BE) condensate to the ground state. If # contacts are located near the boundary of the space-time surface, the d'Alembert equation would be 3-dimensional. One can also ask whether # contacts define a particular form of dark matter having only gravitational interactions with the ordinary matter.

Also the probability amplitudes for the positions of the ends of $\#_B$ contacts located at the boundary of the space-time sheet could be described using an order parameter satisfying d'Alembert equation with some mass parameter and whether the notion of Bose-Einstein condensate makes sense also now. The model for atomic nucleus assigns to the ends of the $\#_B$ contact realized as a color magnetic flux tube quark and anti-quark with mass scale given by $k = 127$ (MeV scale) [F8].

This inspires the question whether # and $\#_B$ contacts could be essential for understanding bio-systems as macroscopic quantum systems [I3]. The BE condensate associated with the # contacts behaves in many respects like super conductor: for instance, the concept of Josephson junction generalizes. As a matter fact, it seems that $\#_B$ contacts, join along boundaries, or magnetic flux tubes could indeed be a key element of not only living matter but even nuclear matter and condensed matter in TGD Universe.

### 5.2.5 TGD based description of external fields

The description of a system in external field provides a nontrivial challenge for TGD since the system corresponds now to a p-adic space-time sheet $k_1$ condensed on background 3-surface $k_2 > k_1$. The problem is to understand how external fields penetrate into the smaller space-time sheet and also how the gauge fluxes inside the smaller space-time sheet flow to the external space-time sheet. One should also understand how the penetrating magnetic or electric field manages to preserve its value (if it does so). A good example is provided by the description of system, such as atom or nucleus, in external magnetic or electric field. There are several mechanisms of field penetration:

#### Induction mechanism

In the case of induction fields are mediated from level $k_1$ to levels $k_2 \neq k_1$. The external field at given level $k_1$ acts on # and $\#_B$ throats (both accompanied by a pair of partons) connecting levels

$k_2$ and $k_1$. The motion of # and $\#_B$ contacts, induced by the gauge and gravitational couplings of partons involved to classical gauge and gravitational fields, creates gauge currents serving as sources of classical gauge field at the space-time sheets involved. This mechanism involves "dark" partons not predicted by standard model.

A good example is provided by the rotation of charged # throats induced by a constant magnetic field, which in turn creates constant magnetic field inside a cylindrical condensate space-time sheet. A second example is the polarization of the charge density associated with the # throats in the external electric field, which in turn creates a constant electric field inside the smaller space-time sheet.

One can in principle formulate general field equations governing the penetration of a classical gauge field from a given condensate level to other levels. The simplified description is based on the introduction of series of fields associated with various condensate levels as analogs of $H$ and $B$ and $D$ and $E$ fields in the ordinary description of the external fields. The simplest assumption is that the fields are linearly related. A general conclusion is that due to the delicacies of the induced field concept, the fields on higher levels appear in the form of flux quanta and typically the field strengths at the higher condensate levels are stronger so that the penetration of field from lower levels to the higher ones means a decomposition into separate flux tubes.

The description of magnetization in terms of the effective field theory of Weiss introduces effective field $H$, which is un-physically strong: a possible explanation as a field consisting of flux quanta at higher condensate levels. A general order of magnitude estimate for field strength of magnetic flux quantum at condensate level $k$ is as $1/L^2(k)$.

### Penetration of magnetic fluxes via # contacts

At least magnetic gauge flux can flow from level $p_1$ to level $p_2$ via # contacts. These surfaces are of the form $X^2 \times D^1$, where $X^2$ is a closed 2-surface. The simplest topology for $X^2$ is that of sphere $S^2$. This leads to the first nontrivial result. If a nontrivial magnetic flux flows through the contact, it is quantized. The reason is that magnetic flux is necessarily over a closed surface.

The concept of induced gauge field implies that magnetic flux is nontrivial only if the surface $X^2$ is homologically nontrivial: $CP_2$ indeed allows homologically nontrivial sphere. Ordinary magnetic field can be decomposed into co-homologically trivial term plus a term proportional to Kähler form and the flux of ordinary magnetic field comes only from the part of the magnetic field proportional to the Kähler form and the magnetic flux is an integer multiple of some basic flux.

The proposed mechanism predicts that magnetic flux can change only in multiples of basic flux quantum. In super conductors this kind of behavior has been observed. Dipole magnetic fields can be transported via several # contacts: the minimum is one for ingoing and one for return flux so that magnetic dipoles are actual finite sized dipoles on the condensed surface. Also the transfer of magnetic dipole field of, say neutron inside nucleus, to lower condensate level leads to similar magnetic dipole structure on condensate level. For this mechanism the topological condensation of elementary particle, say charged lepton space-time sheet, would involve at least two # contacts and the magnetic moment is proportional to the distance between these contacts. The requirement that the magnetic dipole formed by the # contacts gives the magnetic moment of the particle gives an estimate for the distance $d$ between # throats: by flux quantization the general order of magnitude is given by $d \sim \frac{\alpha_{em} 2\pi}{m}$.

### Penetration of electric gauge fluxes via # contacts

For # contact for the opposite gauge charges of partons define the value of generalized gauge electric flux between the two space-time sheets. In this case it is also possible to interpret the partons as sources of the fields at the two space-time sheets. If the # contacts are near the boundary of the smaller space-time sheet the interpretation as a flow of gauge flux to a larger space-time sheet is perfectly sensible. The partons near the boundary can be also seen as generators of a gauge field compensating the gauge fluxes from interior.

The distance between partons can be much larger than p-adic cutoff length $L(k)$ and a proper spatial distribution guarantees homogeneity of the magnetic or electric field in the interior. The distances of the magnetic monopoles are however large in this kind of situation and it is an open problem whether this kind of mechanism is consistent with experimental facts.

An estimate for the electric gauge flux $Q_{em}$ flowing through the # contact is obtained as $n \sim \frac{E}{QL(k)}$: $Q \sim EL^2(k)$, which is of same order of magnitude as electric gauge flux over surface of are $L^2(k)$. In magnetic case the estimate gives $Q_M \sim BL^2(k)$: the quantization of $Q_M$ is consistent with homogeneity requirement only provided the condition $B > \frac{\Phi_0}{L^2(k)}$, where $\Phi_0$ is elementary flux quantum, holds true. This means that flux quantization effects cannot be avoided in weak magnetic fields. The second consequence is that too weak magnetic field cannot penetrate at all to the condensed surface: this is certainly the case if the total magnetic flux is smaller than elementary flux quantum. A good example is provided by the penetration of magnetic field into cylindrical super conductor through the end of the cylinder. Unless the field is strong enough the penetrating magnetic field decomposes into vortex like flux tubes or does not penetrate at all.

The penetration of flux via dipoles formed by # contacts from level to a second level in the interior of condensed surface implies phenomena analogous to the generation of polarization (magnetization) in dielectric (magnetic) materials. The conventional description in terms of fields $H, B, M$ and $D, E, P$ has nice topological interpretation (which does not mean that the mechanism is actually at work in condensed matter length scales). Magnetization $M$ (polarization $P$) can be regarded as the density of fictitious magnetic (electric) dipoles in the conventional theory: the proposed topological picture suggests that these quantities essentially as densities for # contact pairs. The densities of $M$ and $P$ are of opposite sign on the condensed surface and condensate. $B = H - M$ corresponds to the magnetic field at condensing surface level reduced by the density $-M$ of # contact dipoles in the interior. $H$ denotes the external field at condensate level outside the condensing surface, $M$ $(-M)$ is the magnetic field created by the # contact dipoles at condensate (condensed) level. Similar interpretation can be given for $D, E, P$ fields. The penetrating field is homogenous only above length scales larger than the distance between # throats of dipoles: $p$-adic cutoff scale $L(k)$ gives natural upper bound for this distance: if this is the case and the density of the contacts is at least of order $n \sim \frac{1}{L^3(k)}$ the penetrating field can be said to be constant also inside the condensed surface.

In condensed matter systems the generation of ordinary polarization and magnetization fields might be related to the permanent # contacts of atomic surfaces with, say, $k = 139$ level. The field created by the neutral atom contains only dipole and higher multipoles components and therefore at least two # contacts per atom is necessary in gas phase, where join along boundaries contacts between atoms are absent. In the absence of external field these dipoles tend to have random directions. In external field # throats behave like opposite charges and their motion in external field generates dipole field. The expression of the polarization field is proportional to the density of these static dipole pairs in static limit. # contacts make possible the penetration of external field to atom, where it generates atomic transitions and leads to the emission of dipole type radiation field, which gives rise to the frequency dependent part of dielectric constant.

**Penetration via $\#_B$ contacts**

The field can also through $\#_B$ contacts through the boundary of the condensed surface or through the small holes in its interior. The quantization of electric charge quantization would reduce to the quantization of electric gauge flux in $\#_B$ contacts. If there are partons at the ends of contact they affect the gauge gauge flux.

The penetration via $\#_B$ contacts necessitates the existence of join along boundaries bonds starting from the boundary of the condensed system and ending to the boundary component of a hole in the background surface. The field flux flows simply along the 3-dimensional stripe $X^2 \times D^1$: since $X^2$ has boundary no flux quantization is necessary. This mechanism guarantees automatically the homogeneity of the penetrating field inside the condensed system.

An important application for the theory of external fields is provided by bio-systems in which the penetration of classical electromagnetic fields between different space-time sheets should play central role: what makes the situation so interesting is that the order parameter describing the # and $\#_B$ Bose-Einstein condensates carries also phase information besides the information about the strength of the normal component of the penetrating field.

### 5.2.6 Number theoretical considerations

Number theoretical considerations allow to develop more quantitative vision about the how p-adic length scale hypothesis relates to the ideas just described.

### How to define the notion of elementary particle?

p-Adic length scale hierarchy forces to reconsider carefully also the notion of elementary particle. p-Adic mass calculations led to the idea that particle can be characterized uniquely by single p-adic prime characterizing its mass squared. It however turned out that the situation is probably not so simple.

The work with modelling dark matter suggests that particle could be characterized by a collection of p-adic primes to which one can assign weak, color, em, gravitational interactions, and possibly also other interactions. It would also seem that only the space-time sheets containing common primes in this collection can interact. This leads to the notions of relative and partial darkness. An entire hierarchy of weak and color physics such that weak bosons and gluons of given physics are characterized by a given p-adic prime $p$ and also the fermions of this physics contain space-time sheet characterized by same p-adic prime, say $M_{89}$ as in case of weak interactions. In this picture the decay widths of weak bosons do not pose limitations on the number of light particles if weak interactions for them are characterized by p-adic prime $p \neq M_{89}$. Same applies to color interactions.

The p-adic prime characterizing the mass of the particle would perhaps correspond to the largest p-adic prime associated with the particle. Graviton which corresponds to infinitely long ranged interactions, could correspond to the same p-adic prime or collection of them common to all particles. This might apply also to photons. Infinite range might mean that the join along boundaries bonds mediating these interactions can be arbitrarily long but their transversal sizes are characterized by the p-adic length scale in question.

The natural question is what this collection of p-adic primes characterizing particle means? The hint about the correct answer comes from the number theoretical vision, which suggests that at fundamental level the branching of boundary components to two or more components, completely analogous to the branching of line in Feynman diagram, defines vertices [C2, E3].

1. If space-time sheets correspond holographically to multi-p p-adic topology such that largest $p$ determines the mass scale, the description of particle reactions in terms of branchings indeed makes sense. This picture allows also to understand the existence of different scaled up copies of QCD and weak physics. Multi-p p-adicity could number theoretically correspond to q-adic topology for $q = m/n$ a rational number consistent with p-adic topologies associated with prime factors of $m$ and $n$ ($1/p$-adic topology is homeomorphic with p-adic topology).

2. One could also imagine that different p-adic primes in the collection correspond to different space-time sheets condensed at a larger space-time sheet or boundary components of a given space-time sheet. If the boundary topologies for gauge bosons are completely mixed, as the model of hadrons forces to conclude, this picture is consistent with the topological explanation of the family replication phenomenon and the fact that only charged weak currents involve mixing of quark families. The problem is how to understand the existence of different copies of say QCD. The second difficult question is why the branching leads always to an emission of gauge boson characterized by a particular p-adic prime, say $M_{89}$, if this p-adic prime does not somehow characterize also the particle itself.

### What effective p-adic topology really means?

The need to characterize elementary particle p-adically leads to the question what p-adic effective topology really means. p-Adic mass calculations leave actually a lot of room concerning the answer to this question.

1. The naivest option is that each space-time sheet corresponds to single p-adic prime. A more general possibility is that the boundary components of space-time sheet correspond to different p-adic primes. This view is not favored by the view that each particle corresponds to a collection of p-adic primes each characterizing one particular interaction that the particle in question participates.

2. A more abstract possibility is that a given space-time sheet or boundary component can correspond to several p-adic primes. Indeed, a power series in powers of given integer $n$ gives rise to a well-defined power series with respect to all prime factors of $n$ and effective multi-p-adicity could emerge at the level of field equations in this manner.

One could say that space-time sheet or boundary component corresponds to several p-adic primes through its effective p-adic topology in a hologram like manner. This option is the most flexible one as far as physical interpretation is considered. It is also supported by the number theoretical considerations predicting the value of gravitational coupling constant [E3].

An attractive hypothesis is that only space-time sheets characterized by integers $n_i$ having common prime factors can be connected by join along boundaries bonds and can interact by particle exchanges and that each prime $p$ in the decomposition corresponds to a particular interaction mediated by an elementary boson characterized by this prime.

The physics of quarks and hadrons provides an immediate test for this interpretation. The surprising and poorly understood conclusion from the p-adic mass calculations was that the p-adic primes characterizing light quarks u,d,s satisfy $k_q < 107$, where $k = 107$ characterizes hadronic space-time sheet [F4].

1. The interpretation of $k = 107$ space-time sheet as a hadronic space-time sheet implies that quarks topologically condense at this space-time sheet so that $k = 107$ cannot belong to the collection of primes characterizing quark.

2. Quark space-time sheets must satisfy $k_q < 107$ unless $\hbar$ is large for the hadronic space-time sheet so that one has $k_{eff} = 107 + 22 = 129$. This predicts two kinds of hadrons. Low energy hadrons consists of u, d, and s quarks with $k_q < 107$ so that hadronic space-time sheet must correspond to $k_{eff} = 129$ and large value of $\hbar$. One can speak of confined phase. This allows also $k = 127$ light variants of quarks appearing in the model of atomic nucleus [F8]. The hadrons consisting of c,t,b and the p-adically scaled up variants of u,d,s having $k_q > 107$, $\hbar$ has its ordinary value in accordance with the idea about asymptotic freedom and the view that the states in question correspond to short-lived resonances.

### Do infinite primes code for q-adic effective space-time topologies?

Besides the hierarchy of space-time sheets, TGD predicts, or at least suggests, several hierarchies such as the hierarchy of infinite primes [E3], hierarchy of Jones inclusions [C6], hierarchy of dark matters with increasing values of $\hbar$ [F10, J6], the hierarchy of extensions of given p-adic number field, and the hierarchy of selves and quantum jumps with increasing duration with respect to geometric time. There are good reasons to expect that these hierarchies are closely related.

*1. Some facts about infinite primes*

The hierarchy of infinite primes can be interpreted in terms of an infinite hierarchy of second quantized super-symmetric arithmetic quantum field theories allowing a generalization to quaternionic or perhaps even octonionic context [E3]. Infinite primes, integers, and rationals have decomposition to primes of lower level.

Infinite prime has fermionic and bosonic parts having no common primes. Fermionic part is finite and corresponds to an integer containing and bosonic part is an integer multiplying the product of all primes with fermionic prime divided away. The infinite prime at the first level of hierarchy corresponds in a well defined sense a rational number $q = m/n$ defined by bosonic and fermionic integers $m$ and $n$ having no common prime factors.

*2. Do infinite primes code for effective q-adic space-time topologies?*

The most obvious question concerns the space-time interpretation of this rational number. Also the question arises about the possible relation with the integers characterizing space-time sheets having interpretation in terms of multi-p-adicity. On can assign to any rational number $q = m/n$ so called q-adic topology. This topology is not consistent with number field property like p-adic topologies. Hence the rational number $q$ assignable to infinite prime could correspond to an effective q-adic topology.

If this interpretation is correct, arithmetic fermion and boson numbers could be coded into effective q-adic topology of the space-time sheets characterizing the non-determinism of Kähler action in the relevant length scale range. For instance, the power series of $q > 1$ in positive powers with integer coefficients in the range $[0, q)$ define q-adically converging series, which also converges with respect to the prime factors of $m$ and can be regarded as a p-adic power series. The power series of $q$ in negative powers define in similar converging series with respect to the prime factors of $n$.

I have proposed earlier that the integers defining infinite rationals and thus also the integers $m$ and $n$ characterizing finite rational could correspond at space-time level to particles with positive *resp.* negative time orientation with positive *resp.* negative energies. Phase conjugate laser beams would represent one example of negative energy states. With this interpretation super-symmetry exchanging the roles of $m$ and $n$ and thus the role of fermionic and bosonic lower level primes would correspond to a time reversal.

1. The first interpretation is that there is single q-adic space-time sheet and that positive and negative energy states correspond to primes associated with $m$ and $n$ respectively. Positive (negative) energy space-time sheets would thus correspond to p-adicity ($1/p$-adicity) for the field modes describing the states.

2. Second interpretation is that particle (in extremely general sense that entire universe can be regarded as a particle) corresponds to a pair of positive and negative energy space-time sheets labelled by $m$ and $n$ characterizing the p-adic topologies consistent with $m-$ and $n$-adicities. This looks natural since Universe has necessary vanishing net quantum numbers. Unless one allows the non-uniqueness due to $m/n = mr/nr$, positive and negative energy space-time sheets can be connected only by # contacts so that positive and negative energy space-time sheets cannot interact via the formation of $\#_B$ contacts and would be therefore dark matter with respect to each other.

   Positive energy particles and negative energy antiparticles would also have different mass scales. If the rate for the creation of # contacts and their CP conjugates are slightly different, say due to the presence of electric components of gauge fields, matter antimatter asymmetry could be generated primordially.

These interpretations generalize to higher levels of the hierarchy. There is a homomorphism from infinite rationals to finite rationals. One can assign to a product of infinite primes the product of the corresponding rationals at the lower level and to a sum of products of infinite primes the sum of the corresponding rationals at the lower level and continue the process until one ends up with a finite rational. Same applies to infinite rationals. The resulting rational $q = m/n$ is finite and defines q-adic effective topology, which is consistent with all the effective p-adic topologies corresponding to the primes appearing in factorizations of $m$ and $n$. This homomorphism is of course not 1-1.

If this picture is correct, effective p-adic topologies would appear at all levels but would be dictated by the infinite-p p-adic topology which itself could refine infinite-P p-adic topology [E3] coding information too subtle to be catched by ordinary physical measurements.

Obviously, one could assign to each elementary particle infinite prime, integer, or even rational to this a rational number $q = m/n$. $q$ would associate with the particle q-adic topology consistent with a collection of p-adic topologies corresponding to the prime factors of $m$ and $n$ and characterizing the interactions that the particle can participate directly. In a very precise sense particles would represent both infinite and finite numbers.

**Under what conditions space-time sheets can be connected by $\#_B$ contact?**

Assume that particles are characterized by a p-adic prime determining it mass scale plus p-adic primes characterizing the gauge bosons to which they couple and assume that $\#_B$ contacts mediate gauge interactions. The question is what kind of space-time sheets can be connected by $\#_B$ contacts.

1. The first working hypothesis that comes in mind is that the p-adic primes associated with the two space-time sheets connected by $\#_B$ contact must be identical. This would require that particle is many-sheeted structure with no other than gravitational interactions between various sheets. The problem of the multi-sheeted option is that the characterization of events like electron-positron annihilation to a weak boson looks rather clumsy.

2. If the notion of multi-p p-adicity is accepted, space-time sheets are characterized by integers and the largest prime dividing the integer might characterize the mass of the particle. In this case a common prime factor $p$ for the integers characterizing the two space-time sheets could be enough for the possibility of $\#_B$ contact and this contact would be characterized by this prime. If no common prime factors exist, only # contacts could connect the space-time sheets.

This option conforms with the number theoretical vision. This option would predict that the transition to large $\hbar$ phase occurs simultaneously for all interactions.

### What about the integer characterizing graviton?

If one accepts the hypothesis that graviton couples to both visible and dark matter, graviton should be characterized by an integer dividing the integers characterizing all particles. This leaves two options.

*Option I: gravitational constant characterizes graviton number theoretically*

The argument leading to an expression for gravitational constant in terms of $CP_2$ length scale led to the proposal that the product of primes $p \leq 23$ are common to all particles and one interpretation was in terms of multi-fractality. If so, graviton would be characterized by a product of some or all primes $p \leq 23$ and would thus correspond to a very small p-adic length scale. This might be also the case for photon although it would seem that photon cannot couple to dark matter always. $p = 23$ might characterize the transversal size of the massless extremal associated with the space-time sheet of graviton.

*Option II: graviton behaves as a unit with respect to multiplication*

One can also argue that if the largest prime assignable to a particle characterizes the size of the particle space-time sheet it does not make sense to assign any finite prime to a massless particle like graviton. Perhaps graviton corresponds to simplest possible infinite prime $P = X \pm 1$, $X$ the product of all primes.

As found, one can assign to any infinite prime, integer, and rational a rational number $q = m/n$ to which one can assign a $q$-adic topology as effective space-time topology and as a special case effective p-adic topologies corresponding to prime factors of $m$ and $n$.

In the case of $P = X \pm 1$ the rational number would be equal to $\pm 1$. Graviton could thus correspond to $p = 1$-adic effective topology. The "prime" $p = 1$ indeed appears as a factor of any integer so that graviton would couple to any particle. Formally the 1-adic norm of any number would be 1 or 0 which would suggest that a discrete topology is in question.

The following observations help in attempts to interpret this.

1. $CP_2$ type extremals having interpretation as gravitational instantons are non-deterministic in the sense that $M^4$ projection is random light-like curve. This condition implies Virasoro conditions which suggests interpretation in terms topological quantum theory limit of gravitation involving vanishing four-momenta but non-vanishing color charges. This theory would represent gravitation at the ultimate $CP_2$ length scale limit without the effects of topological condensation. In longer length scales a hierarchy of effective theories of gravitation corresponds to the coupling of space-time sheets by join along boundaries bonds would emerge and could give rise to "strong gravities" with strong gravitational constant proportional to $L_p^2$. It is quite possible that the M-theory based vision about duality between gravitation and gauge interactions applies to electro-weak interactions and in these "strong gravities".

2. p-Adic length scale hypothesis $p \simeq 2^k$, $k$ integer, implies that $L_k \propto \sqrt{k}$ corresponds to the size scale of causal horizon associated with # contact. For $p = 1$ $k$ would be zero and the causal horizon would contract to a point which would leave only generalized Feynman diagrams consisting of $CP_2$ type vacuum extremals moving along random light-like orbits and obeying Virasoro conditions so that interpretation as a kind of topological gravity suggests itself.

3. $p = 1$ effective topology can make marginally sense for vacuum extremals with vanishing Kähler form and carrying only gravitational charges. The induced Kähler form vanishes identically by the mere assumption that $X^4$, be it continuous or discontinuous, belongs to $M^4 \times Y^2$, $Y^2$ a Lagrange sub-manifold of $CP_2$.

Why topological graviton, or whatever the particle represented by $CP_2$ type vacuum extremals should be called, should correspond to the weakest possible notion of continuity? The most plausible answer is that discrete topology is *consistent* with any other topology, in particular with any p-adic topology. This would express the fact that $CP_2$ type extremals can couple to any p-adic prime. The vacuum property of $CP_2$ type extremals implies that the splitting off of $CP_2$ type extremal leaves the physical state invariant and means effectively multiplying integer by $p = 1$.

It seems that Option I suggested by the deduction of the value of gravitational constant looks more plausible as far as the interpretation of gravitation is considered. This does not however mean that $CP_2$ type vacuum extremals carrying color quantum numbers could not describe gravitational interactions in $CP_2$ length scale.

## 5.3 Model for topologically quantized magnetic field

### 5.3.1 Topological field quantization

Topological field quantization [D7] implies that various notions of quantum field theory have rather precise classical analogies. Topological field quantization provides the correspondence between the abstract Fock space description of elementary particles and the description of the elementary particles as concrete geometric objects detected in the laboratory. In standard quantum field theory this kind of correspondence is lacking since classical fields are regarded as a phenomenological concept only. Topological field quanta define regions of coherence for the classical fields and classical coherence is the prerequisite of the quantum coherence.

The energies and other classical charges of the topological field quanta are quantized by the absolute minimization of the Kähler action making classical space-time surfaces the counterparts of the Bohr orbits. Feynman diagrams become classical space-time surfaces with lines thickened to 4-manifolds. For instance, "massless extremals" representing topologically quantized classical radiation fields are the classical counterparts of gravitinos and photons. Topologically quantized non-radiative nearby fields give rise to various geometric structures such as magnetic and electric flux tubes.

The virtual particles of quantum field theory have also classical counterparts. In particular, the virtual particles of quantum field theory can have negative energies: this is true also for the TGD counterparts of the virtual particles. The fundamental difference between TGD and GRT is that in TGD the sign of energy depends on the time orientation of the space-time sheet: this is due to the fact that in TGD energy current is vector field rather than part of tensor field. Therefore space-time sheets with negative energies are possible. This could have quite dramatic technological consequences: consider only the possibility of generating energy from vacuum and classical signalling backwards in time along negative energy space-time sheets [J4, K1]. Also bio-systems might have invented negative energy space-time sheets: in fact, so called "massless extremals" provide an ideal manner to generate coherent motions as recoil effects caused by the creation of negative energy massless extremals [I4, I5]. An interesting possibility is that quantum entanglement has the formation of the join along boundaries bonds as its geometric correlate.

The crucial question is of course 'How to make this idea quantitative?'. An attractive possibility is that topological field quanta identified as material or mind-like space-time sheets could be regarded as counterparts of oscillator operators of free fields in quantum field theory. This would mean that one could make order of magnitude estimates for the probabilities for the presence of various numbers of both material and mind-like space-time sheets using quantum field theoretical intuition. The coefficient of a particular state in the expansion of the creation operators of the outgoing interacting quantum fields in terms of the creation and annihilation operators of free quantum fields could provide an estimate for the probability that a particular configuration containing topological field quanta with positive and negative energies results in quantum jump between quantum histories. Since mind-like space-time sheets are correlates for virtual particles, this would also mean a deep connection between quantum field theory and cognition.

Topological field quanta could serve as templates for the formation of the bio-structures. Thus topologically quantized classical electromagnetic fields could be equally important for the functioning of the living systems as the structures formed by the visible bio-matter and the visible part of bio-system might represent only a dip of an ice berg.

Topological field quantization of magnetic field means that given classical magnetic field is replaced with a bundle of flux tubes flowing along the field lines of classical magnetic field. In TGD context magnetic flux tubes are really what they look, that is cylindrical 3-surfaces with *boundary.* The boundary of the flux tube must by Maxwell equations contain rotating em or $Z^0$ charges creating the magnetic field in the interior (just like an induction coil creates an axial magnetic field inside it). The concept of topological field quantum generalizes also to the case of classical fields generated by wormholes.

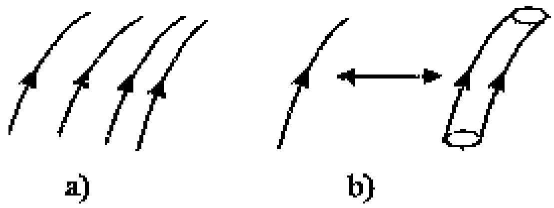


Figure 5.1: Topological field quantization for magnetic field replaces flux lines with flux tubes having outer boundary as 3-surfaces.

In case of wormhole super conductivity 'charge carriers' are wormholes. Wormhole looking like charge $+Q$ on the 'upper' sheet looks like charge $-Q$ on the 'lower' sheet; when looked from the wider perspective (imbedding space), wormhole behaves as a dipole with extremely small dipole strength. The currents associated with wormholes are of opposite sign on the two space-time sheets and magnetic flux tube consists of two fluxes: the flux on the 'upper' space-time sheet and return flux on the 'lower' space-time sheet. Closed wormhole flux tube can be visualized as two circles above each other and having Planck distance; the circles carry opposite magnetic fluxes. This visualization turns out to be useful later.

### 5.3.2 Do mind-like space-time sheets perform simple mimicry?

Mind-like space-time sheets are quantum correlates of selves and are made possible by the classical non-determinism of the Kähler action and their defining property is finite temporal extension. mind-like space-time sheets are absolutely crucial for TGD inspired theory of consciousness since their presence is what makes possible conscious experiences with contents localized in a finite time interval, which characterized by the duration of the mind-like space-time sheet: without mind-like space-time sheets the contents of conscious experiences would not be temporally localized. Topological field quantization suggests the identification of the mind-like space-time sheets as classical counterparts of virtual particles, in particular, virtual photons. This suggests that some (not all) mind-like space-time sheets could be topological correlates of the internal (photon) lines of Feynman diagram and thus have naturally finite time duration.

Rather remarkably, TGD based notion of energy correlates the sign of energy with time orientation and allows mind-like space-time sheets to have also negative energy. Also wormhole-magnetic fields could be analogous to virtual particle pairs with vanishing total energy if the space-time sheets associated with the wormhole magnetic field have opposite time orientation. Mind-like space-time sheets provide cognitive representations and the simplest representation is direct mimicry. Hence one cannot exclude the possibility that wormhole magnetic fields form cognitive representations of the surrounding world in an extremely concrete manner: the magnetic field strength is the same as the field strength of the 'real' magnetic field. This could hold true quite generally: pairs of space-time sheets with opposite time orientation could form cognitive representations of the external world such that the field strengths are same as those of the external world.

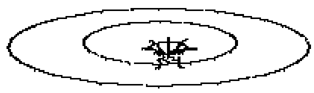

Figure 5.2: Two-dimensional visualization of wormhole

A concrete manner to achieve this mimicry is to glue mind-like space-time sheet pairs on the boundaries of the material space-time sheets by connecting the material space-time sheet by join along boundaries bond to the mind-like space-time sheet with a positive time orientation. This would mean that universe would be mimicking itself at classical level and in very concrete manner: note that this mimicry would resemble the emulation of Turing machines performed by Turing machines. In particular, the effect of em radiation on living matter at cyclotron frequencies of ions in Earth's magnetic field (or modulated by these frequencies) [58] could be due to the fact that some ions 'drop' (or rather, flow along join along boundaries bonds) to the space-time sheets of wormhole magnetic fields providing cognitive representation for Earth's magnetic field.

An interesting possibility is that cell membranes correspond to $Z^0$ wormhole magnetic fields glued to the boundaries of the cellular space-time sheets, or rather, are between and glued to the boundaries of cellular and extracellular space-time sheets characterized by same p-adic prime. The model for hearing and cognition is consistent with but does not require this assumption [K3, L1, M6].

### 5.3.3 Model for wormhole flux tube as a hollow cylinder

In the absence of ordinary matter the electric part of gauge field is sourceless in the interior of the flux tube and one must assume the geometry of a *hollow cylinder* for the flux tube to avoid singularities. The wormhole charge densities on the inner and outer boundaries of the cylinder are of opposite sign and sourceless radial electric field is created in the interior of the cylinder. Rotational motion of the wormholes creates axial magnetic fluxes of opposite sign on the two space-time sheets. Clearly, the magnetic flux runs along the cylinder; goes to 'lower' space-time sheet via magnetic wormhole, and returns along the 'lower' space-time sheet (see Fig. 5.3.3). It is perhaps needless to add that hollow cylindrical structures are very frequent in bio-systems: representative examples are provided by microtubules and axons.

### 5.3.4 Wormhole flux tubes need not be closed in ordinary sense

The wormhole flux tube can apparently have an end unlike ordinary magnetic flux tube. At the end point the magnetic flux from the 'upper' sheet flows to the 'lower' sheet through *magnetic* wormhole, which looks like a magnetic monopole, when viewed from either sheet of 3-space. From imbedding space perspective, one has extremely weak magnetic dipole, with monopoles located at Planck distance. Note that magnetic flux lines are closed as they should be.

The simplest expectation is that also wormhole flux tubes run along the closed field lines of the average classical magnetic field associated with the wormhole flux tube configuration. Wormhole flux tube structures can however form topologically much more complicated structures since one can

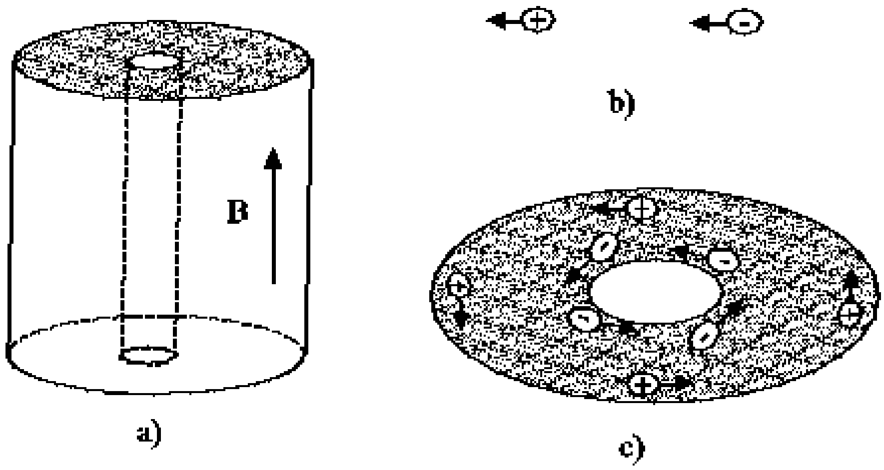


Figure 5.3: a) Wormhole flux tube consists of two hollow cylinders on parallel space-time sheets connected by wormholes. b) Negatively and positively charged rotating wormholes. c) Wormhole supra currents of opposite sign flow on the inner and outer surfaces of the cylinder and create magnetic fields.

construct also branched flux tubes by gluing two flux tubes together such that contact point contains magnetic wormhole.

### 5.3.5 Wormhole flux tubes form a macroscopic quantum system

Since wormholes populate the boundaries of the flux tubes and since they form BE condensate, the entire exotic magnetic field configuration can be regarded as a macroscopic quantum system. Thus, according to TGD inspired theory of consciousness, flux tube configurations should be indeed controllable by quantum jumps and quantum mechanical free will becomes possible in the entire region covered by the exotic magnetic field configuration. One might even say, that wormhole condensate makes classical field a potential conscious being. This suggests that wormhole magnetic fields are crucial for the understanding the behavior of bio-systems as systems possessing free will.

The simplest possibility is that only the fluxes of the magnetic fluxes inside flux tubes are controlled by free will. As a consequence, psychokinetic effects on objects, which are wormhole super conductors, are in principle possible via a voluntary control of Meissner force (levitation). As found in [D7], magnetic fluxes associated with flux tubes are in general quantized so that control occurs in discrete steps.

### 5.3.6 The interaction of coherent light with wormhole flux tubes

To understand Comorosan effect and phantom DNA effect to be considered in next section, one must construct a model for the interaction of wormholes with laser light. Needless to say, this interaction is fundamental for the TGD based description of bio-systems as macroscopic quantum systems.

1. Wormholes have coupling to the *difference* $\Delta A$ of the quantized gauge potentials describing photons (Planck size 3-surfaces) of topologically condensed coherent light on the two space-time sheets of the wormhole flux tube. This is due to the fact that wormhole behaves as a pair of two opposite charges on the two parallel space-time sheets connected by it.

2. The absorption of laser light can induce topology change for a closed wormhole flux tube. It is useful to visualize wormhole flux tubes as two one-dimensional closed circles above each other (within distance of Planck length). Clearly, the circles span in the initial situation *annulus*. The absorption of laser light can induce a pinching process in which the two circles are deformed so that they touch each other momentarily. At the moment of touching the circles are cut and the ends can recombine in two different manners to form a single circle. Either the upper and lower ends of circle on the same side recombine to give single circle which spans *annulus with cut*. Or the upper and lower ends belonging to different sides recombine to form a circle with a twist of $\pi$, which spans a *twisted annulus*, known as Möbius strip, which is non-orientable, single-sided surface. The model for Comorosan and phantom DNA effects relies on the process *annulus* $\rightarrow$ *twisted annulus*.

### 5.3.7 Quantum antenna hypothesis and wormholes

Quantum antenna hypothesis states that microtubules create a coherent state of photons (in particular bio-photons) and possibly also of gravitons. If the proposed model for the interaction between wormholes and coherent light is correct, then the presence of quantum coherent light in bio-system is necessary for the generation of currents in wormhole flux tube structures associated with DNA.

These currents correspond to phase gradients and the integer valued quantum numbers characterizing the phase increments around closed loops have been proposed to provide a coding of biological information and a model of memory [I3]. Although the model was constructed assuming that bio-system is ordinary super conductor, it works also for wormhole super conductor option. Note also, that the previous model fixes also the interaction between coherent photons and wormholes associated with the lipid layers of cell membrane, which is only one example of hollow cylinder like configurations frequent in bio-systems. An interesting possibility is that bio-system uses the twisted and untwisted configurations of closed flux tubes to store binary data.

Combining these ideas with the suggested identification for the quantum correlates of the sensory qualia, a definite picture of bio-system as a macroscopic quantum in which both wormholes and wormhole magnetic fields, coherent light electronic and neutrino Cooper pairs have essential roles, seems to emerge. [To be honest, this is actually quite an old discovery: the basic concepts of Hindu yoga are prana channels (wormhole flux tubes) and light (coherent photons)!].

### 5.3.8 Phantom DNA effect, Comorosan effect, DNA as a conductor, ORMEs: four peculiar effects with a common explanation

The concept of closed wormhole flux tube provides explanation for Comorosan effect and phantom DNA effect as also the conductivity of DNA [19] described in [J1, J2, J3]. The irradiation of bio-matter using visible laser light with certain preferred frequencies is crucial for *all* these effects. The interpretation is that irradiation transfers electron from one space-time sheet to another one (and creates automatically wormhole) and since the energy of electron is quantized, the preferred frequencies correspond to energy differences of electron on the two space-time sheets associated with the wormhole flux tube. This in turn provides support for the exotic atom concept providing explanation for the properties of ORMEs [102].

# 5.4 Comorosan effect, phantom DNA effect and homeopathy

## 5.4.1 Comorosan effect

The first model for Comorosan effect was based on super conductivity and the formation of Josephson junctions between interacting organic molecules assumed to contain closed super conducting current loops. The model reproduced the basic formula of Comorosan effect but *not all* aspects related to the interaction of laser light with organic molecule were understood. Wormhole super conductivity leads to much more precise model for this interaction and wormhole super conductivity is strongly favored over ordinary the super conductivity as an explanation of the effect.

### The effect

Comorosan effect [33, 34] demonstrates rather peculiar looking facts about the interaction of organic molecules with visible laser light at wavelength $\lambda = 546\ nm$. As a result of irradiation molecules seem to undergo a transition $S \rightarrow S^*$. $S^*$ state has anomalously long lifetime and stability in solution. $S \rightarrow S^*$ transition has been detected through the interaction of $S^*$ molecules with different biological macromolecules, like enzymes and cellular receptors.

The typical result in the enzyme-substrate interaction is represented by the enhancement of the enzymic rate, when the respective enzyme substrate is previously irradiated for certain sharply defined times. These *efficient (irradiation) times* are enzyme dependent and can also depend on the biological origin of the enzyme. They are always of the following type $t_i = i{*}5$ sec, where $i$ is certain integer. The general formula for the effective times is $t_k = t_m + (k-1)\tau_n$, $k = 1, 2, .., 6$, where $t_m$ is the minimum radiation time inducing the first effect and $\tau_n$ is the period between two consecutive effects [33, 34]. $t_m = m_E t_1$ and $\tau_n = n_E t_1$ are multiples of the basic time scale $t_1 = 5\ sec$: $t_k = (m_E{+}(k{-}1)n_E)t_1$. The integers $m_E$ and $n_E$ can be regarded as enzyme characteristics, depending however on the biological origin of the enzyme.

Consider the specific enzymic interaction $E + S \leftrightarrow ES \leftrightarrow E + P$, where E stands for enzyme, S for substrate and P interaction product. Assume that substrate S is subject to a sequence of distinct irradiations lasting for times $t_a, t_b, ...$. The following rules are found to hold true.
1) The irradiations of the substrate performed after an irradiation with efficient time have no effect on the enzyme-substrate interaction.
2) Any arbitrary irradiation of the substrate with irradiation time less than sixth efficient time $t_6$ performed prior to any other efficient time, is irrelevant for the enzyme-substrate interaction.
3) Any arbitrary irradiation of the substrate lasting more than the sixth efficient time $t_6$ and performed prior to an efficient time precludes all other subsequent effects in enzyme-substrate interaction.

The work of Comorosan demonstrates that all irradiation times have nontrivial effect on organic molecules but that for effective times something very special must occur. One must understand what this 'very special' is, derive Comorosan formula from a physical model and find physical interpretation for the integers $m_E$ and $n_E$ appearing in the formula as well as explain the special role of $t > t_6$ irradiation times.

### Model for the interaction of laser light with organic molecule

The model reproduces the basic formula of Comorosan effect but there were also some not so well understood aspects.

1. Effect occurs for *preferred frequencies* only. This can be understood if the process the interaction of laser light with wormhole flux tube involves transfer of electron from one condensate level to another one and thus a change of energy level. The transfer of electron leads to a creation of a wormhole.

2. The *intensity of laser light does not matter.* What is needed is that the intensity is above certain threshold. The original explanation in terms of saturation of effect (for large intensities of laser light the effect of laser light on organic molecules does not depend on the intensity) has turned to be unsatisfactory. It seems that laser light just initiates some process which itself does not depend on the laser light.

3. The assumption that laser light stimulates the increase of a phase angle increment type variable defined over a loop, which is effectively cut in process, explains the preferred radiation times. What happens is that the phase increment increases linearly with time and for preferred radiation times the increase of phase angle is multiple of $2\pi$ so that the loop can close back again. The experience with super conductivity suggests the identification of the phase angle gradient as quantized momentum: the problem is to identify the carrier of this momentum.

An elegant explanation for these aspects of Comorosan effect results if one assumes that wormhole super conductivity is in question and that laser light induces a transformation of a closed wormhole tube spanning an *annulus* to that spanning a *twisted annulus*. Since the characteristic time scale is defined by the frequency of laser light, the process in question occurs very rapidly as compared to the time scale of order 5 seconds of the laser irradiaton. What is important is that the reverse process in which a twisted annulus transforms to an untwisted annulus cannot occur if the wormholes possess momentum $k$ which is not multiple of $2\pi/L$ (by the quantization of momentum propagating in closed loop) and the wave length of laser length is large compared to the size of the loop.

The twisted annulus configuration leads to the acceleration of the wormholes and generation of longitudinal wormholes currents. If the initial, annulus type configuration of the flux tube contains constant wormhole charge density, then for the twisted annulus the charge density is of constant magnitude and of opposite sign on the different sides of each kink since the twist interchanges the 'upper' and 'lower' space-time sheets. Half of the structure corresponds to positive, and half of the structure to negative wormhole charge density (see Fig. 5.4.1).

One must assume that both kinks contain *additional wormhole charges of opposite sign* generated from vacuum, when the twisted annulus configuration is created in the interaction with the laser light. The creation of a twisted annulus is necessary in order to get a pair of opposite charges with large distance along the flux tube. These wormhole charges serve as sources of additional electric fields. Most of the electric flux flows in the radial direction of the flux tube but a small fraction $E_L = \epsilon E_{max}$ of the maximal flux $E_{max} = e/2S$, where $S$ is the transverse area of the tube, is assumed to flow along the flux tube surface. $E_L$ has constant magnitude and is of opposite sign on the 'upper' and 'lower' space-time sheets.

$E_L$ accelerates the wormholes. The acceleration is of opposite sign at the opposite sides of the kinks and leads to the flow of the wormholes to the kink, where they must annihilate topologically. Newton's equation for the wormhole in external field gives wormhole momentum $k(t)$ as a function of time

$$\begin{aligned}
\frac{dk}{dt} &= \epsilon 2eE \ , \\
E &= \frac{e}{2S} sign(x) \ . \\
sign(x) &= \left\{ \begin{array}{ll} -1, & x<0 \ , \\ +1, & x>0 \end{array} \right.
\end{aligned} \tag{5.4.1}$$

Here $|x|$ measures the distance from the twist. The factor 2 in Coulomb force comes from the identical contributions of the two space-time sheets to the Coulomb force. The momentum of wormhole as function of time can also be obtained from the quantization condition

$$k - 2eA_L = 0 \ , \tag{5.4.2}$$

stating that wormhole order parameter is covariantly constant in the longitudinal direction. Since $A_L = E_L t$ holds true, one obtains same result as from Newton's equation.

Wormhole momentum increases linearly as a function of time since constant force is in question apart from the effect caused by the gradually decreasing density of wormholes caused by wormhole pair annihilation in kinks; this effect is however completely negligible since the time scale is so slow. In an excellent approximation the momentum gained by the wormholes in time $t$ is

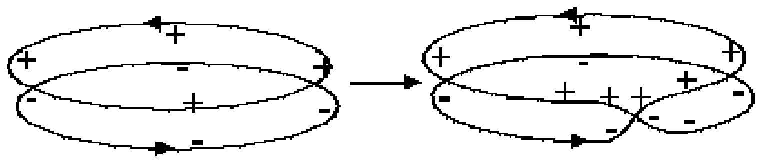

Figure 5.4: The interaction with laser light is assumed to induce the transformation of annulus configuration of wormhole flux tube to twisted annulus and creation of at least one wormhole pair with opposite charges. The members of wormhole pair go to separate kinks and create small longitudinal electric field.

$$\begin{aligned} k(t) &= \epsilon \frac{e^2}{S} t = \frac{2\pi}{L}\frac{t}{t_0} \ , \\ t_0 &= \frac{1}{\alpha}\frac{1}{2\epsilon}\frac{S}{L} \ , \\ \alpha &= \frac{e^2}{4\pi} \ . \end{aligned} \tag{5.4.3}$$

Here $t_0$ is the time during which $k$ achieves a value allowing the transitions back to the untwisted flux tube configuration. In agreement with the experimental data, the time scale $t_0$ is does not depend on the intensity of irradiation; $t_0$ should be of the order of 5 seconds. $L$ should be considerably smaller than the wavelength of the visible light in case of Comorosan effect. For $\sqrt{S}$ and $L$ of order $10^{-9}$ and $10^{-8}$ meters respectively one obtains the estimate $\epsilon \sim 10^{-16}$ so that the longitudinal fraction of electric gauge flux is extremely small.

For $t = t_n = nt_0$ wormholes have gained momentum $k = n2\pi/L$, for which the return to the ordinary closed untwisted flux tube configuration is possible. Laser light stimulates automatically transitions to the untwisted configuration. If laser light stimulation is not continued after $t_n$, a certain fraction of molecules is left to the closed untwisted loop state with wormhole momentum $k = n2\pi/L$. It is the presence of these loops carrying wormhole super current, which explains the change in the interactions of with organic molecules if interaction involves the formation of Josephson junctions between interacting molecules. If the stimulation is continued, also the closed untwisted loops suffer a re-transition to the twisted state and the momentum $k$ continues to increase and the effect remains small. If stimulation ceases at such moment of time that $k$ fails badly to satisfy the quantization condition the loops remain in twisted configuration and transitions to untwisted configuration are rare.

### The explanation for Comorosan formula

It is assumed that organic molecules are wormhole super conductors containing closed wormhole flux tubes. The explanation as such does not differentiate between ordinary and wormhole super conductors.

If wormhole order parameter is proportional to a spatially non-constant phase factor then the flux tubes of the wormhole magnetic field carry longitudinal wormhole supra currents proportional to the gradient of the phase factor. The increment of the phase factor around any closed loop is $n2\pi$, $n$ integer, and the momentum associated with the wormhole is proportional to $n$. These supra currents are created with the interaction of the wormhole flux tubes with laser light by a mechanism already considered.

Assume that enzyme contains a loop carrying wormhole supra current characterized by an enzyme specific integer $m_E$ and created by the previously described interaction with the laser light. Assume that the substrate contains a similar loop, characterized by integer $n_S$. Assume further that in the enzyme-substrate interaction $n_E$ Josephson junctions between the identical loops are formed and that the Josephson junctions are evenly spaced in $\Phi$ and there are either $n_E = 2s+1$ or $n_E = 2s$ junctions corresponding to ODD and and EVEN receptors defined by Comorosan [34]. Assume that the directions of the wormhole supra currents are same. The phase difference between the ends of the Josephson junction gives phase factor $exp(i(N_E - N_S)\Phi_n)$ to the current flowing through n:th junction and destructive inteference in general occurs for the sum of Josephson currents. If the junctions are identical Josephson current is proportional to quantity U defined as a sum of phase factors

$$\begin{aligned} U &= \sum_{k=0,..,n_E} exp((m_E - n_S)\frac{i2\pi}{n_E}) \\ n_E &= 2s+1 \ (ODD\ receptor) \\ n_E &= 2s \ (EVEN\ receptor) \end{aligned} \tag{5.4.4}$$

All phase factors are trivial and constructive interference occurs, when the condition

$$n_S = m_E + (k-1)n_E, \ k = 1, 2, ... \tag{5.4.5}$$

is satisfied. This is just the condition for for Comorosan effect to occur. Therefore, if the occurrence of constructive interference leads to enhanced enzymatic effect, that is 'reading' of the substrate state in terminology of Comorosan, the model reproduces the experimental results of Comorosan for $k \leq 6$ and gives interpretation for $m_E$ as angular momentum like quantum number associated with super current and $n_E$ as the number of Josepshon junctions.

Note that Comorosan defines UP-type receptors as a receptor which read only ODD states with $t_k$ odd multiple of $t_1$ [34]. These correspond to odd value of $m_E$ and even value of $n_E$. DOWN-type receptors read only DOWN-type states with $t_k$ even multiple of $t_1$: these correspond to even values of $m_E$ and $n_E$.UP-DOWN receptors correspond to odd values of $m_E$ and $n_E$.

The model reproduces the basic experimental regularity observed by Comorosan with single exception. Comorosan has observed no effect for $t_{rad} > t_6$: according to the model the effect should be observed for all odd values of $k$ and depend on $k_1 = k \ mod \ n_E$ only so that $k$ and $k + n_E$ ought to lead to same effect. The problem looks difficult since $t_6$ is enzyme dependent parameter. The only manner to explain this observation seems to be following. Assume that substrate contains several loops $L_i$, one loop for each enzyme type $E_i$ studied and that each loop is radiation detector in the sense already described. Assume that $E_i$-loop ceases to respond to irradiation, when the value of $\Delta\Phi$ exceeds the critical limit corresponding to $n_{cr}(E) = m_E + 5n_E$. One explanation for this behavior is that the supra current exceeds critical value and wormhole super conductivity is lost. The shorter the loop the smaller the critical value of $n_{cr}(E)$ is expected to be.

This model suggest that organic molecules are able to store memories into the integer valued vacuum quantum numbers associated with their supra current loops and that the interaction with coherent light, bio-photons perhaps, provides a mechanism of memory storage. The enzyme-substrate interactions in turn code this information to chemical form.

#### What is the origin of the 5 second time scale?

The time scale $\tau = 5$ seconds associated with the Comorosan effect has remained a teasing mystery for almost a decade. In particular, p-adic length scale hypothesis does not explain the time scale, and it does not correspond to any obvious time scale associated with magnetic transitions.

Only the model for quantum dark matter [D6] inspired by the fascinating findings that planetary orbits obey Bohr rules analogous to those for hydrogen atom but with a huge value of Planck constant equal to $\hbar_{gr} = GMm\hbar/v$, where $v/c$ is a harmonic or sub-harmonic of $v_0/c = 4.8233 \times 10^{-4}$, led to a progress in the understanding of the time scale $\tau$.

The idea about astro-quantal dark matter as a fundamental bio-controller by its gigantic value of Planck constant, inspires the guess that $\tau$ could relate to a quantal dark matter structure topologically condensed around a magnetic flux tube around a planetary Bohr orbit of radius $R$ via the correspondence $\tau = R/c$. As observed by Nottale [92], $n = 1$ orbit for $v_0 \rightarrow 3v_0$ corresponds in a good approximation to the solar radius and thus to a time scale of 2.18 seconds. Since Earth's orbit corresponds to the principal quantum number $n = 5$, $n = 1$ orbit corresponds for $v_0 \rightarrow 2v_0$ to $\tau = AU/(4 \times 25) = 4.992$ seconds: here $R = AU$ is the astronomical unit equal to the average distance of Earth from Sun. The deviation from $\tau_C$ is only one per cent and of the same order of magnitude as the variation of the radius for the orbit due to orbital eccentricity $(a - b)/a = .0167$ [29].

An alternative explanation emerged with the discovery of dark matter hierarchy based on the scaled up values of $M^4$ and $CP_2$ Planck constants given as $\hbar(M^4) = n_a\hbar_0$ and $\hbar(CP_2) = n_a\hbar_0$, $n_i > 2$ [A9]. Typical quantum times and lengths, say Compton length and time, scale as $n_a$. The integers $n_i$ have number theoretically preferred values which correspond to n-polygons constructible using only ruler and compass. These integers are given as $n = 2^k \prod_s F_s$, where each Fermat prime $F_s$ can appear only once in the product. $F_s$ has the form $F_s = 2^{2^s} + 1$. The known Fermat primes are $3, 5, 17, 257$, and $2^{16} + 1$. If one scales the fundamental biological time scale $T_2(127 = .1$ s by $n_F = 3 \times 17$ one obtains the time scale $T = 5.1$ s.

### 5.4.2 Phantom DNA effect

The phenomenon of phantom DNA [82, 53] suggests that physical vacuum can have some additional structure with no obvious identification in the standard physics context. What is studied, is the scattering of the laser light on chamber, which is either empty or contains DNA. The autocorrelation function for scattered laser light is measured. This means in practise a linear array of detectors, which measure the number of scattered photons during certain time interval. There are three subsequent stages in the experiment.

1. Scattering chamber is empty. In this case autocorrelation function is random. The numbers of photons detected by various detectors are essentially random.

2. One adds the DNA in the chamber and finds that autocorrelation function is decaying exponential, which oscillates. This is due to the scattering of laser light on DNA.

3. One removes the DNA and instead of random autocorrelation finds that autocorrelation function exhibits exponential decay and oscillations also now! The numbers of photons detected are many orders of magnitude smaller but it is clear that something in the structure of vacuum, call it *phantom DNA*, serves as an effective scatterer of the laser light. For phantom DNA effect to occur it is essential that DNA in chamber is illuminated with laser light before its removal. The effect is long lasting, phantom DNA is detected even after period of months!

#### Is the mechanism explaining Comorosan effect behind phantom DNA effect?

The mechanism explaining Comorosan effect could explain also phantom DNA effect. Assume that the presence of DNA creates wormhole magnetic field, that is a net of wormhole flux tubes. This configuration is indeed vacuum configuration from the point of view of standard physics since the only 'particles' are wormholes on the boundaries of the flux tubes. Laser light transforms closed untwisted flux tubes to twisted ones and accelerates wormholes so that they get net momentum.

When DNA is removed from the chamber, part of the wormhole magnetic field remains in chamber. If the chamber is now irradiated with laser light, the *wormhole supra currents* created in the irradiation of DNA interact with the laser light. Before the irradiation these currents vanish so that there is no effect. More quantitative argument goes as follows. Coupling is just the standard coupling of charged scalar field to the difference of topologically condensed coherent photon fields so that the interaction term is of the general form $\bar{\Psi}\Delta A\nabla\Psi$. In Fourier basis the couplings are of the form $e(k_i+k_f)A(k_i-k_f)$. If $A$ is slowly varying, one has in good approximation $k_i = k_f$ for the allowed transitions, and transition matrix element is proportional to $k$. Thus the value of momentum $k$ and thus coupling is appreciable *only* if DNA is irradiated before its removal.

The transfer of electron between the space-time sheets must be *crucial* for the process acceleration process. Otherwise, the irradiation of mere wormhole flux tube structure, 'phantom DNA', would accelerate the wormholes creating supra currents and would eventually lead to stimulated emission.

#### Other explanations

With the development of the model for the bio-system as a macroscopic quantum system are also other possible explanations of the phantom DNA effect have emerged.

1. Perhaps the simplest explanation would be that a small fraction of DNA molecules drops to the magnetic flux tubes of Earth's magnetic field and scatters the coherent light.

2. The hypothesis that liquid crystal water blobs can mimic the electromagnetic body of the DNA molecule in the sense that some parts of the electromagnetic spectrum represented by MEs are more or less identical with that of DNA, could explain the phantom DNA effect in terms of the liquid crystal blobs remaining when DNA is removed. The explanation would be same as for the effect of the homeopathic remedies. The explanation requires that LC water blobs are able to mimic the electromagnetic spectrum of DNA at visible frequencies. This is not at all obvious since water is transparent for visible light and thus does not have intense spectral lines in the visible frequency range.

### 5.4.3 Mind-like space-time sheets, mimicry and homeopathy

Homeopathy resembles phantom DNA effect in the sense that the repeated dilution of some drugs seems to give rise to a concentration of a 'phantom drug' affecting the patient in some nonchemical manner. Standard science refuses to take homeopathy seriously. As often is the case with the paranormal phenomena, the refusal is based on very simple argument: standard science does not allow this kind of effect. TGD however framework allows room for homeopathy and homeopathy provides evidence for the notion of mind-like space-time sheet absolutely crucial for TGD based theory of consciousness as also for the general hypothesis that magnetic and $Z^0$ transition frequencies are quantum correlates of consciousness.

In TGD inspired theory of consciousness mind-like space-time sheets, which by definition have finite time duration, are geometric correlates of selves. TGD inspired theory of consciousness predicts that self hierarchy starts already from the elementary particle level and that the typical duration of self is given by the p-adic time scale $T_p = l \times L_p/c$, $l \simeq 10^4$ Planck lengths. For elementary particle selves the duration of wake-up time is of order Compton time and extremely short in human standards but extremely long when using the average duration of single quantum jump of order $l/c$ as standard: elementary particle performs roughly $\sqrt{p}$ quantum jumps during its wake-up period and the values of p-adic prime are huge (electron has $p = 2^{127} - 1$).

If this scenario is correct, mind-like space-time sheets should accompany all forms of matter. Against this background it would not be too surprising that given drug would be characterized, not only by its chemistry, but also by the mind-like space-time sheets associated with its subselves. When the drug is dissolved into water, it can happen that mind-like space-time sheets associated with the drug lose their original owner and become (potential) subselves of the solvent. If this really happens, a concentration of mind-like space-time sheets associated with the 'drug selves', remains into the solution, even when the drug is diluted to practically zero concentration. Water need not be a mere passive receiver of the mind-like space-time sheets of the drug but can also generate new mind-like space-time sheets mimicking the mind-like space-time sheets of drug. The effect of the drug on living organism involves self-organization and therefore also consciousness at some level. Thus is would not be surprising if 'drug selves' were the effective component of some drugs and that the chemistry would only determine what 'drug selves' and their effects are. This is indeed expected, since mind-like space-time sheets provide cognitive representations for the properties of the material space-time sheets associated with the drug.

One can imagine several options for how mind-like space-time sheets represent the relevant properties of drug. If cognitive space-time sheets perform direct mimicry of the material space-time sheets this scenario becomes even more plausible since mind-like space-time sheet and drug space-time sheets would not differ much in their electromagnetic properties. For instance, disease could involve the inability of some subselves of the organism to stay awake and self-organize: brisk new drug selves could simply replace these sleepish subselves and initiate the self-organization processes again! Note that direct mimicry might be involved also with the phantom DNA effect. The wormhole magnetic fields (or massless extremals) associated with DNA could mimic the classical fields associated with DNA molecule. TGD based concept of space-time allows in principle non-vanishing vacuum currents so that also the smoothed out charge distribution of DNA might be mimicked. If this indeed occurs, the interaction of the coherent light with DNA could resemble to some degree to its interaction with real DNA.

'Direct mimicry' understood as a generation of a copy about classical fields associated with the material space-time sheet (note that the sheet is 4-dimensional!) might be too strong a requirement. A more abstract mimicry is restricted on regeneration of dominating frequencies associated with the classical fields: this could be enough since it is resonance frequencies rather than amplitudes which are crucial for quantum control and coordination. The effects of ELF modulated em fields on living matter [45, 58] suggest that also amplitude modulation could be involved with the formation of the cognitive representations. mind-like space-time sheets associated with water could simply mimic the drug in frequency domain by reproducing the frequencies generated by the drug molecules or corresponding mind-like space-time sheets. That this might be the case is supported by the following arguments.

1. There are well documented effects related to the ability of water to absorb and transmit frequencies [59]. The ability of water to absorb and transmit frequencies could rely on the generation of mind-like space-time sheets oscillating with the same frequency as stimulus. Water would form cognitive representation for the stimulus, mimic it.

2. The hypothesis that magnetic and $Z^0$ magnetic transitions frequencies are basic correlates of consciousness[K3] suggests that the effects of at least some drugs are quantum control effects and basically frequency mediated and that chemical effects are only secondary. If the effect of a drug indeed relies on its ability to generate an oscillation (say ELF em field) with some frequency and if this oscillation is generated by mind-like space-time sheets associated with water, then the mechanism of homeopathy could be understood.

Rather interestingly, subject persons allergic to a particular substance exposed to the substance and frequency at the same time develop after a short association period an allergic response to the frequency alone [59]. A patient who has developed allergic response to certain frequency has also allergic response to water treated by the same frequency. Thus the water in human body together with central nervous system seems to have cognitive abilities, in particular ability to form associations. This suggests the possibility of associative medicine: the effect of drug is conditioned with frequency: in this manner the undesired side effects of the chemical drug could be circumvented.

## 5.5 Subcellular control and wormhole flux tubes

### 5.5.1 Intracellular bio-control and memory

Wormhole magnetic fields could provide a tool of quantum bio-control below cell length scales. For instance, cell nucleus could control from distance the motion of cell organelles using magnetic and $Z^0$ magnetic fields generated by wormholes. In [I3] it is suggested that the winding numbers associated with closed wormhole flux tubes, which actually correspond to quantized momenta for wormhole supra currents, might provide a memory, which is very stable against perturbations. It must be however emphasized that the TGD based model of long term memory does not require any memory storage since memories are essentially re-experienced episodes of geometric past. Wormhole supra currents, and the entire zoo of various supra-currents predicted by quantum TGD, might however form cognitive representations and an important brain function would be the construction of this kind of representations as caricatures of the conscious experience.

### 5.5.2 Coding of genetic information to topologically quantized fields?

The mechanisms behind ontegeny leading from single cell do an adult individual are poorly known. The wormhole flux tubes represent spatial extension of bio-system to a larger quantum system via magnetic fields so that long distance control via topologically quantized magnetic field becomes possible. As suggested in [J1, J2, J3], either the flux tubes of ordinary or wormhole magnetic field could serve as templates of bio-structures: more specifically, wormhole flux tubes could provide topological representation for defects of various bio-super conductors.

Various bio-structures are expected to be surrounded by a characteristic flux tube network extending over a spatial region considerably larger than structure itself and bio-structure could control the fluxes inside the individual flux tubes. The field configuration would somehow control the ontogeny. By the previous considerations also the coherent photons created by microtubules and possibly other linear structures, could control the state of magnetic flux tubes. Note that also ordinary super conductivity with topologically quantized wormhole flux tubes representing defects might be involved. In this case the wormhole magnetic field cancels the penetrating field in the larger space-time sheet and recreates it in the smaller space-time sheet.

One can wonder how the genetic information is coded into extended spatial structures and to what extend wormholes flux tubes and various related structures represent something genuinely new. The p-adic hierarchy of space-time sheets certainly breaks naive reductionistic philosophy so that that the dynamics wormhole flux tubes and related structures is probably not completely determined by the genetic code. The idea about the flux tubes of magnetic field as templates for bio-structures does not support (or at least, does not require it) the idea about the coding of the magnetic structure to DNA and flux tube structure could be a result of self-organization process and topological field quantization. For instance, in case of DNA the structure of the topologically quantized wormhole magnetic field surrounding DNA (with quantized magnetic flux) can depend only on the general properties of the DNA sequence since only few topological quantum numbers are involved and it indeed seems that these quantum numbers are determined by the dynamics at larger length scales in accordance with Slaving Principle. On the other hand, the structure of the wormhole magnetic fields in length scales shorter than DNA could be determined completely by the structure of DNA sequence.

### 5.5.3 Are magnetic and wormhole magnetic fields involved with the control of gene expression?

The development of organism is a complicated self-organization process during which gene expression is controlled by the feedback from long length scales. The mechanism of this 'biofeedback' is poorly understood. It is not even known whether it is really chemical. In fact, it is known that besides the chemical transcription factors (proteins) controlling gene expression, there are nonchemical transcription factors called silencers and enhancers, whose action mechanism is not known [39, L2]. Magnetic and wormhole magnetic fields could indeed be involved with the control of gene expression performed by growing organism using Josephson currents.

1. As suggested in [I4, I5], magnetic and perhaps also wormhole magnetic fields could be involved with the gene expression via Josephson currents and make possible biological alarm clocks

'waking-up' gene self and initiating gene expression. Complicated circuits, involving pattern recognizers, comparison circuits and novelty detectors could serve as building bricks of logical circuits conditioning the gene expression to begin only when certain conditions are satisfied.

2. The realization of the alarm clock would be following. Ions and electrons form in the magnetic fields or wormhole magnetic fields bound states characterized by cyclotron frequencies. When the potential difference between the space-time sheets representing two weakly couple super conductors connected by the join boundaries bonds representing Josephson junctions equals to a magnetic transition frequency of a charge carrier in either superconductor, quantum jumps occur and 'wakes-up' the 'clock self' and initiate thus self-organization process.

3. One can imagine that the genetic alarm clock is formed by Josephson junction formed by one of the many space-time sheets associated with the many-sheeted DNA and the space-time sheet of the growing organ [L2]. The size of the space-time sheet correlates with the vacuum frequency $\omega_1$ of the space-time sheet (there are two frequency type vacuum quantum numbers denoted by $\omega_1$ and $\omega_2$ [Appendix] and a natural assumption is that the difference of the frequencies $\omega_1$ associated with the gene space-time sheet and organ's space-time sheet corresponds to the electromagnetic potential difference over Josephson junction: $\Delta\omega_1 = ZeV$. When this difference equals to the energy difference for the states localized in either super conductor, the superconductor 'wake up'. Thus a precise timing for the wake-up results and the initiation of the gene expression correlates in a precise manner with the size of the organ. This is something highly nontrivial: chemical transcription factors are concentrations and it is very difficult to imagine how concentrations, which carry purely local information, could code precise information about the size of the organ and even use it to control purposes.

4. If the states are cyclotron states confined in (wormhole) magnetic fields, the energy difference is in general case difference for multiples of the corresponding cyclotron frequencies. This flow of charge would eventually lead to the 'wake-up' of the gene and initiate the self-organization process leading to gene expression.

### 5.5.4 Wormhole flux tubes as templates of bio-structures

One aspect of control of ontogeny is that part of a flux tube structure could serve as a template in the sense that bio-matter gathers around flux tubes during ontogeny. According the considerations of [J1, J2, J3], magnetic or wormhole magnetic fields could provide general representation for the defects of super conductors. Microtubules, axons and very many other basic bio-structures are indeed *hollow* cylinders identifiable as defects of super conductors of type II (electronic super conductors). It is also known that macroscopic cylindrical bio-structures such as legs are characterized by winding numbers (for rather peculiar consequences, see [49]): this suggests that wormhole condensates associated with the boundaries of bio-sub-structures of all sizes play important role in bio-control. The stripe like structures (cell membranes, epithelial sheets, larger bi-layered structures of brain) could in turn correspond to defects of super conductors of type I (neutrino super conductors):

Ordinary atom could topologically condense on the interior of the flux tubes and topological condensation could become stable if one or more valence electrons is dropped on the 'lower' space-time sheet of the flux tube. The resulting atom would be 'exotic atom' with chemical properties those of atom having $Z$ smaller by one unit (electronic alchemy!). As a matter of fact, the potential importance of the wormhole concept became clear from the attempt to explain the peculiar properties of so called ORMEs [102] in terms of the concept of exotic atom [J1, J2, J3]

The formation of exotic atoms might have been the basic step from the ordinary chemical evolution to bio-evolution. The process would be amplified by the presence of wormholes on the magnetic flux tube just like the formation of BE condensate is catalyzed by the presence of already existing seed of BE condensate (condensation probability is proportional to $N^2$, where $N$ is the number of bosons in ground state). The possibility that Na, K, Ca ions in cell could be really exotic atoms with $s$ wave valence electron(s) dropped on the lower space-time sheet, is not excluded.

## 5.6 TGD inspired models for psychokinesis

The reality of psychokinesis (PK) as of also other psi phenomenona is subject of a continuous debate and it seems that opinions are not always based on rational arguments. I am personally neither believer nor non-believer of psi phenomena but regard it as important (and also entertaining) to try to find rational testable models for psi rather than ridiculing or mystifying it. Indeeed, in the following a TGD inspired model of psychokinesis is considered.

The basic philosophy of the model is following. PK is not just some isolated exotic phenomenon but only a special case of the voluntary control of bodily motions, which we all routinely perform. The only difference is that the range of voluntary control extends over the boundaries of the body in case of PK. This leads to an important conclusion: PK phenomena must involve classical long range fields, which give for bio-systems spatial extension larger than what is visible (that is hands with which to grasp on external object!). According to TGD inspired theory of consciousness, cell and even DNA can be conscious and perform choices. Thus the model should also provide understanding about small scale bio-control such as the (voluntary!) control of the motion of cell organelles performed by cell nucleus. A related problem is how genetic code is transformed into spatial structures during ontogeny, and the idea that each DNA sequence corresponds to a characteristic classical field configuration, is attractive. Thus the model in question is not meant to be an ad hoc solution of a particular problem called PK but a general solution of several basic problems in biology.

### 5.6.1 Wormhole magnetic fields and psychokinesis

The model for psychokinesis is fixed to rather high degree by the following arguments.

#### PK as a special case of voluntary action

Our subjective experience tells that our bodily motions are controlled by our free will. Only the fact, that we are so familiar with this PK in the scale of our own body, makes us believe that nothing peculiar is involved. This suggests that PK-able persons differ from ordinary people in that they can perform PK also in length scales larger than their own body. PK is probably possible and probably occurs also below cell length scales, say in the control of motions of cellular organelles by nucleus. Also DNA and microtubules could perform PK. The only logical conclusion is that PK, as well as voluntary control of motion, involves long range classical fields effectively giving for PK-able system hands with which to grasp on the external object.

#### Quantum entanglement and PK

Quantum entanglement plays basic role in TGD inspired theory of consciousness and this is especially so for TGD inspired model of psi phenomena such as telepathy [H9]. Therefore it is assumed that PK mechanism involves quantum entanglement of some part of brain B with some part S of body such that S has ability to generate some classical field, which affects the material object. The field depends sensitively on quantum state of S so that the control becomes possible via B-S entanglement and quantum jumps reducing the entanglement. The most promising classical fields are magnetic fields (ordinary or $Z^0$-).

p-Adic considerations might exclude the possibility of PK in many cases. Suppose that, as strongly suggested by QFT limit of TGD, the space-time sheets indeed have effective p-adic topology characterized by p-adic prime. The tensor product for p-adic state spaces with different p-adic primes $p_1$ and $p_2$ gives rise to $R_p$ valued state space, where $p$ is the p-adic prime associated with the entire system. There are some reasons to believe that $p_1 \neq p_2$ quantum entanglement is rare phenomenon: if true this implies the decomposition of the space-time into separate space-time sheets labelled by primes and behaving more or less classically with respect to each other: this is certainly in accordance with the everyday intuition. An immediate consequence is that subsystems of brain can get quantum entangled mostly with subsystems having same $p$. Furthermore, the space-time sheet for the object of PK should be such that magnetic field created by PK is on the space-time sheet at which it the object has suffered topological condensation.

### Bio-systems and classical $Z^0$ fields

Bio-matter must be in special position as far as PK is considered and thus cell length scale should be somehow in special role in the possible explanation of PK. Indeed, TGD predicts that the prime $p \simeq 2^{169}$ corresponds to the primary condensation level of neutrinos (on basis of data from latest neutrino mass experiments [F3]. The corresponding p-adic length scale corresponds to cell size. This p-adic condensation level is also the p-adic condensation level at which nuclei must feed their $Z^0$ charges, where they in turn are screened by neutrinos (this requirement is necessitated by the stability of condensed matter against *classical* long range $Z^0$ force, which is a purely TGD:eish phenomenon). In this manner one also avoids the large parity breaking effects caused by classical $Z^0$ fields, if present in atomic length scales.

Thus *neutrinos* and *classical* $Z^0$ force correspond to the new TGD-based physics emerging at cell length scale. TGD neutrinos are predicted to be super-conducting and classical $Z^0$ magnetic fields break the super conductivity: an attractive possibility is that cell membranes and endoplasma membranes correspond to the defects in the resulting superconductor of type I. The explanation of chirality selection [F10] in terms of $Z^0$ magnetic fields and neutrinos and of tritium beta decay anomaly [F8] provide strong support for this picture. The additional important piece of new physics important for bio-systems is related to *wormhole contacts*. For instance, wormhole contacts are created when electrons of ordinary atom drops from atomic space-time sheet to a larger space-time sheet parallel to it. This process leads to so called exotic atom [J1, J2, J3] explaining the peculiar properties of so called ORMEs [102]. In fact, the dropping of electron on larger space-time sheet might have been a (perhaps even the!) crucial step in transforming chemical evolution to bio-evolution. Also the penetration of classical electric and magnetic fields from a space-time sheet to another one requires the presence of charged wormholes and classical em fields are known to be very important in bio-systems.

### Magnetic levitation as a basic mechanism of PK

The simplest possibility is PK effect is based on magnetic levitation. Both classical magnetic and $Z^0$ magnetic fields can give rise to the effect. This requires that all objects which can be moved by PK, must be diamagnetic and repel from their interior external magnetic fields by generating currents on their boundaries. If they behave like superconductors (in some sense) this is indeed the case.

Wormholes feed the gauge flux from a smaller p-adic space time sheet to a larger one and the throats of the wormhole look like classical charges of opposite sign coupling to the difference of classical fields associated with the two space-time sheets. When looked from imbedding space context, they can be regarded as extremely weak dipoles and their coupling to vapor phase photons is extremely weak, which explains why they have not been observed via radiation. Wormhole Bose-Einstein condensates are a purely TGD-based phenomenon. $Z^0$ wormholes have classical $Z0$ interaction with atomic nuclei screened by neutrinos and this in turn couples them to phonons and electromagnetic interactions indirectly. If $Z^0$ are in thermal equilibrium with ordinary matter then wormhole Bose-Einstein condensates are possible in the length scales below $L = 1/T$ ($T$ is temperature, in room temperature $L$ is about $10^{-5} - 10^{-4}$ meters).

Wormholes BE-condensate behaves in many respects like super conductor. Thus wormhole superconductivity is a possible candidate for a mechanism behind PK. What is required is that the density of wormholes on the boundary of the object is high enough so that surface currents can cancel external magnetic field and magnetic levitation becomes possible. Charged wormholes provide also a mechanism of electronic bio-super conductivity and also this might be involved in PK as it possibly appears in bio-control.

### Topological field quantization could make possible precise quantum control of magnetic fields

Bio-system must has an ability to create and control in precise manner magnetic fields. The only manner to achieve this is to construct magnetic field from magnetic flux tubes with *quantized magnetic fluxes*. Actually, the decomposition into flux tubes with quantized magnetic fluxes occurs *automatically* for any magnetic field in TGD [D7]. This is due to the induced gauge field concept: the imbedding of classical gauge field as induced gauge field in general fails outside some region and 3-surface with boundary is generated (in [D7] these regions were christened as topological field quanta). Since wormholes form a Bose-Einstein condensate on the boundaries of flux tubes, topological field quantization actually makes the classical magnetic field quantum object and potential conscious being if TGD inspired theory of consciousness is correct! Control of the magnetic field occurs via the control of the order parameter describing the state of the wormhole condensate.

PK mechanism could be at work below cell length scale for ordinary magnetic fields and it is tempting to speculate that this kind of PK is one of the basic mechanisms of intracellular control. For instance, cell nucleus could control from distance the motion of cell organelles using magnetic and $Z^0$ magnetic fields generated by wormholes. Also microtubules and perhaps even DNA could apply PK mechanism for control purposes. In longer length scales, much above the cell length scale, $Z^0$ type wormhole magnetic fields might be important.

### Order of magnitude estimates

One can imagine several mechanisms for the penetration of the magnetic and wormhole magnetic fields. If the size of the object is small as compared to the thickness of the flux tube, the wormhole magnetic field at either sheet can penetrate (or try to penetrate in present case!) to the space-time sheet of an object topologically condensed at the space-time sheet of the flux tube. When the size of the object is larger than the thickness of the magnetic flux tube, situation is more complicated: a similar microscopic mechanism could however be at work also in this case since the object contains hierarchy of smaller space-time sheets topologically condensed on it. The following discussion neglects these complications and treats the (wormhole) magnetic field as ordinary classical fields: intuitively the idealization of the flux tube structure with ordinary classical magnetic field seems natural.

The energy for creating and changing magnetic or wormhole magnetic fields must come from the metabolism. Dissipation effects are expected to be small since wormholes behave as a super conductor. Super conductivity (perfect diagmagnetism) is not necessary, also nonperfect diamagnets can levitate. In case of super conducting object the strength of the magnetic field must be smaller than the critical field destroying the super conductivity; this condition is a crucial limitation for PK based on super conductivity.

A rough order of magnitude estimate for the needed magnetic field strengths is obtained in the following manner. Meissner force is the gradient of the magnetic field energy regarded as a function of the position of the object located in the field. For simplicity, assume that (wormhole) magnetic field depends linearly on the coordinate $z$ in the direction of gravitational field

$$B = B_0(1+\frac{z}{h}) \ , \tag{5.6.1}$$

where $h$ is the characteristic scale of variation for the wormhole magnetic field.

The Meissner force experienced by an object having size much smaller than scale $h$, so that the magnetic field is essentially constant in the volume of the object, is from a rough order of magnitude estimate

$$\begin{aligned} F &\sim -\frac{dE_{magn}}{dz} \ , \\ E_{magn}(z) &\simeq \frac{1}{2}B^2V = \frac{B_0^2V}{2}(1+\frac{z}{h})^2 \ , \end{aligned} \tag{5.6.2}$$

where $E_{magn}$ is the magnetic field energy contained in the volume $V$ of the object. For the lifting of an object with mass $m$ in the gravitational field, this force must have a magnitude larger than the gravitational force $F = mg$, where $g$ is gravitational acceleration. This gives an order of magnitude estimate for the minimum magnetic field $B_0$ making the lifting of the object possible:

$$B_0 \sim \sqrt{\rho g h} \ , \tag{5.6.3}$$

where $\rho$ is the density of the object. Note that in the approximation that magnetic field is essentially constant in the volume of the object, the estimate does not depend on the size or form of the object. More generally, the gradient of $B$ is roughly the gravitational force divided by the average magnetic field $B_0$: $\frac{dB}{dz} \sim \frac{\rho g}{B_0}$.

An order of magnitude estimate is obtained by putting $\rho \sim 10^3\ kg/m^3$ (density of water roughly) and $h \sim 10^{-2}\ meters$ (object could be a sheet considerably thinner than one centimeter). In this case magnetic field $B_0$ of order $10^{-5}\ Tesla$ is needed.

Consider first ordinary super conductivity and ordinary magnetic fields (assuming object to be super conductor). Hudson claims that the critical magnetic fields for ORME superconductivity are of the order of Earth's magnetic field, about $10^{-7}\ Tesla$. The claim concerns ordinary magnetic field, not wormhole magnetic fields, and thus electronic superconductivity should be in question. If the claim gives general order of magnitude then the needed magnetic field would destroy the electronic super conductivity. By reducing the thickness of the object to the cell length scale of order $10^{-6}\ meters$, one finds that the needed magnetic field is of order $10^{-7}\ Tesla$ so that the effect might be possible below cell length scales and cell nucleus might control the motion of cell organelles by PK based on the ordinary magnetic fields and electronic super conductivity.

Second case corresponds to wormhole super conductivity (object must be wormhole super conductor). Since wormhole magnetic fields are new physics, one can make only order of magnitude guesses. 'Ordinary' wormhole magnetic fields can exist in arbitrarily short p-adic length scales and there is no obvious upper bound for the critical wormhole magnetic field in this case. Since $Z^0$ classical fields appear only in the p-adic length scales not smaller than the cell length scale, p-adic length scale hypothesis suggests that the critical wormhole magnetic field is in this case *at most* of the order $1/L(cell)^2$ in units ($\hbar = c = 1$). This gives $B_0 \leq 10^{-4}\ Tesla$. This would be enough in the previous example with a sheet like object having the density of water and thickness below one centimeter. Note that thin sheets are ideal objects for the experimental verification of the effect.

### 5.6.2 Alternative models of psychokinesis

The manner TGD solves the energy problem of GRT is simple: energy momentum tensor is replaced by a vector field so that the energy defined as an integral over 3-space is coordinate independent scalar quantity. Vector field nature however implies that the sign of the energy depends on the time orientation of the space-time sheet and one can quite well consider the possibility that the time orientation of the space-time sheet is not always same as the natural time orientation of the future lightcone. This would make possible negative energies and "buy now, pay later" type mechanism of energy production by the generation of negative energy space-time sheets of possibly finite time duration. One can even consider the possibility that entire universe is generated from vacuum and has vanishing total quantum numbers.

In [D3] this mechanism is discussed as an explanation for certain peculiar looking claims about energy production occurring with efficiency larger than one. (the N-machine of DePalma [24] and the space energy generator of Tewari [28]). The model also explains why the rotation of a system consisting of a conductor disk rigidly attached to a cylindrical magnet generates potential difference between the axis and rim of the conducting disk. This effect, observed already by Faraday, has no satisfactory explanation in ordinary electrodynamics. In TGD framework the explanation is simple: the mere rotation of the 3-surface generates the radial electric field automatically. The divergence of the electric field associated with the Faraday disk is nonvanishing and gives rise to vacuum charge density and this in turn implies the necessity of second space-time sheet with opposite charge density and possibly opposite time orientation.

One can consider the possibility that mind-like space-time sheets could have negative time orientation so that pairs of space-time sheets with opposite time orientations could be the basic characteristic of living matter. In fact, only this option makes possible the realization of Boolean mind relying on electron positron pairs. Note that also wormhole magnetic fields could correspond to pairs of space-time sheets having opposite time orientation. If this picture is correct, psychokinetic effects could occur spontaneously in living systems when mind-like space-time sheets with negative time orientation are generated and material space-time sheet receives compensating positive energy. This mechanism would make possible "poltergeist" effects involving generation of kinetic energy from "nowhere" and would make possible to affect the physical world by mere thought! There also legends about the magic feats of the trained yogis. Sceptics have of course strong opinions concerning these stories: I would be happy if I could share with the sceptics their access to deeper knowledge making life so simple. I do no even know whether we might be affecting everydaily that part of the physical world which we identify as our physical body by this mechanism!

TGD suggest also a third mechanism of PK. Space-time sheets form a hierarchy. Our space-time sheet is usually glued to the space-time sheet of Earth so that we feel the gravitational force of Earth. One could however consider the possibility that 'our' space-time sheet could in some manner get glued to a larger space-time sheet at which Earth's gravitational field is not felt appreciabely. This would make possible levitation. This kind of effect would also make the apparent fusion of solid bodies and an effect that might be called "Houdini effect". The occurrence of this effect in atomic length scales makes possible to bypass Coulomb walls and has been suggested as a mechanism of cold fusion in [F8].

### 5.6.3 Experimental tests

The basic concept is topological field quantization implying the decomposition of magnetic field to flux tubes. This indeed occurs in super conductors. Actually, it might be that this phenomenon can be demonstrated using just child's toy magnet! The ferrite powder on table indeed concentrates on lines in the vicinity of magnet. I do not know whether this phenomenon has a more mundane explanation or is it really a direct manifestation of topological field quantization.

The simplest experimental proof for the wormhole flux tube idea is to make them visible! One could achieve the situation in which atoms are condensed on wormhole flux tubes and form exotic atoms so that also electronic alchemy occurs: one can hardly imagine more dramatic proof of the concept! A second possibility is the interaction of laser light with wormhole flux tubes if the proposed explanation of phantom DNA effect is correct. The recent progress in understanding of high $T_c$ superconductivity [J1, J2] gives indeed very strong indirect support for the notion of wormhole contact as parton-antiparton pair as well as for the notion of dark matter as large $\hbar$ phase of ordinary matter.

There are two possible realizations for PK in the proposed model. Either in terms of ordinary topologically quantized magnetic field and super conductivity or in terms of wormhole super conductivity and corresponding magnetic fields, which always appear on *two* space-time sheets simultaneously and thus forming twin structures. The essential requirement is that magnetic field is on the space-time sheet at which the object has suffered topological condensation. Also the restrictions from p-adic quantum entanglement and from many-sheetedness of the space-time could be decisive and explain why the phenomenon is so rare.

The basic concept is topological field quantization implying the decomposition of the magnetic field to flux tubes. This indeed occurs in super conductors. It might be that this phenomenon can be demonstrated by child's toy magnet! The ferrite powder on table indeed concentrates on lines in the vicinity of magnet. I do not really know whether this phenomenon has a more mundane explanation or is it really a direct manifestation of topological field quantization.

If PK-able persons can control also ordinary magnetic fields created by ordinary charges then one can consider an experiment in which PK-able person tries to affect the state of an ordinary super conductor.

The simplest experimental proof for the wormhole flux tube idea is to make them visible. One could achieve the situation in which atoms are condensed on wormhole flux tubes and form exotic atoms so that also electronic alchemy occurs: one can hardly imagine more dramatic proof of the concept! A second possibility is the interaction of laser light with wormhole flux tubes if the proposed explanation of phantom DNA effect is correct.

Also an experiment in which PK-able person tries to affect the motion of ORMEs [102] (material possible containing exotic atoms predicted by TGD), could be considered. Actually, peculiar levitation effects have been claimed and also the proposed interpretations have been based on some kind of magnetic levitation and super conductivity. The original explanation was in terms of electronic super conductivity but on the light of recent results wormhole super conductivity seems to be a more plausible explanation. PK effect could be involved also with the claimed fluctuations in the weight of the ORMEs [102]. PK effect might lead to an fluctuations in the high precision measurements of the value of gravitational constant. An interesting possibility is whether also ORMEs exhibit phantom ORME effect analogous to phantom DNA effect [53] having explanation in terms of wormhole super conductivity.

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# Part III

# DARK MATTER AND LIVING MATTER

# Chapter 6

# Dark Nuclear Physics and Condensed Matter

## 6.1 Introduction

The unavoidable presence of classical long ranged weak (and also color) gauge fields in TGD Universe has been a continual source of worries for more than two decades. The basic question has been whether electro-weak charges of elementary particles are screened in electro-weak length scale or not. The TGD based view about dark matter assumes that weak charges are indeed screened for ordinary matter in electro-weak length scale but that dark electro-weak bosons correspond to much longer symmetry breaking length scale.

The large value of $\hbar$ in dark matter phase implies that Compton lengths and -times are scaled up. In particular, the sizes of nucleons and nuclei become of order atom size so that dark nuclear physics would have direct relevance for condensed matter physics. It becomes impossible to make a reductionistic separation between nuclear physics and condensed matter physics and chemistry anymore. This view forces a profound re-consideration of the earlier ideas in nuclear and condensed physics context. It however seems that most of the earlier ideas related to the classical $Z^0$ force and inspired by anomaly considerations survive in a modified form.

In its original form this chapter was an attempt to concretize and develop ideas related to dark matter by using some experimental inputs with emphasis on the predicted interaction between the new nuclear physics and condensed matter. As the vision about dark matter became more coherent and the nuclear string model developed in its recent form, it became necessary to update the chapter and throw away the obsolete material. I dare hope that the recent representation is more focused than the earlier one.

### 6.1.1 Evidence for long range weak forces and new nuclear physics

There is a lot of experimental evidence for long range electro-weak forces, dark matter, and exotic nuclear physics giving valuable guidelines in the attempts to build a coherent theoretical scenario.

#### Cold fusion

Cold fusion [43] is a phenomenon involving new nuclear physics and the known selection rules give strong constraints when one tries to understand the character of dark nuclear matter. The simplest model for cold fusion found hitherto is based on the nuclear string model [F9] and will be taken as the basis of the considerations of this chapter. Also comparisons with the earlier variant of model of cold fusion [F8] will be made in the section about cold fusion.

#### Large parity breaking effects

Large parity breaking effects in living matter indicate the presence of long ranged weak forces, and the reported nuclear transmutations in living matter [69, 70] suggest that new nuclear physics plays a role also now. For instance, the Gaussian Mersennes $(1+i)^k-1$ for $k = 113, 151, 157163, 167$ could correspond to weak length scales and four biologically important length scales in the range 10 nm-25 $\mu$m, which seem to relate directly to the coiling hierarchy of DNA double strands. Quantum criticality of living matter against phase transitions between different values of Planck constant suggests that zeros of Riemann Zeta can appear as conformal weights of particles in living matter.

### Anomalies of the physics of water

The physics of water involves a large number of anomalies and life depends in an essential manner on them. As many as 41 anomalies are discussed in the excellent web page "Water Structure and Behavior" of M. Chaplin [36]. The fact that the physics of heavy water differs much more from that of ordinary water as one might expect on basis of different masses of water molecules suggests that dark nuclear physics is involved.

1. The finding that one hydrogen atom per two water molecules remain effectively invisible in neutron and electron interactions in attosecond time scale [36, 37] suggests that water is partially dark. These findings have been questioned in [38] and thought to be erroneous in [39]. If the findings are real, dark matter phase made of super-nuclei consisting of protons connected by dark color bonds could explain them as perhaps also the clustering of water molecules predicting magic numbers of water molecules in clusters. If so, dark nuclear physics could be an essential part of condensed matter physics and biochemistry. For instance, the condensate of dark protons might be essential for understanding the properties of bio-molecules and even the physical origin of van der Waals radius of atom in van der Waals equation of state.

2. The observation that the binding energy of dark color bond for $n = 2^{11} = 1/v_0$ of the scaling of $\hbar$ corresponds to the bond energy .5 eV of hydrogen bond raises the fascinating possibility that hydrogen bonds is accompanied by a color bond between proton and oxygen nucleus. Also more general chemical bonds might be accompanied by color bonds so that dark color physics might be an essential part of molecular physics. Color bonds might be also responsible for the formation of liquid phase and thus solid state. Dark weak bonds between nuclei could be involved and might be responsible for the repulsive core of van der Waals force and be part of molecular physics too. There is evidence for two kinds of hydrogen bonds [80, 79]: a possible identification is in terms of p-adic scaling of hydrogen bonds by a factor 2. This kind of doubling is predicted by nuclear string model [F9].

3. Tedrahedral water clusters consisting of 14 water molecules would contain 8 dark protons which corresponds to a magic number for a dark nucleus consisting of protons. Icosahedral water clusters in turn consist of 20 tedrahedral clusters. This raises the question whether fractally scaled up super-nuclei could be in question. If one accepts the vision about dark matter hierarchy based in Jones inclusions to be discussed briefly later, tedrahedral and icosahedral structures of water could correspond directly to the unique genuinely 3-dimensional $G_a = E_6$ and $E_8$ coverings of $CP_2$ with $n_a = 3$ and $n_a = 5$ assignable to dark electrons. Icosahedral structures are also very abundant in living matter, mention only viruses.

### Exotic chemistries

Exotic chemistries [48] in which clusters of atoms of given given type mimic the chemistry of another element. These systems behave as if nuclei would form a jellium (constant charge density) defining a harmonic oscillator potential for electrons. Magic numbers correspond to full electron shells analogous to noble gas elements. It is difficult to understand why the constant charge density approximation works so well. If nuclear protons are in large $\hbar(M^4)$ phase with $n_F = 3 \times 2^{11}$, the electromagnetic sizes of nuclei would be about 2.4 Angstroms and the approximation would be natural.

As a matter, fact nuclear string model predicts that the nuclei can have as many as $3A$ exotic charge states obtained by giving neutral color bond charge $\pm 1$: this would give rise to quite different kind of alchemy [F9] revealing itself in cold fusion.

### Free energy anomalies

The anomalies reported by free energy researchers such as over unity energy production in devices involving repeated formation and dissociation of $H_2$ molecules based on the original discovery of

Nobelist Irwing Langmuir [72] (see for instance [73]) suggest that part of $H$ atoms might end up to dark matter phase liberating additional energy. The "mono-atomic" elements of Hudson suggest also dark nuclear physics [102]. There is even evidence for macroscopic transitions to dark phase [98, 99, 78].

#### Tritium beta decay anomaly and findings of Shnoll

Tritium beta decay anomaly [18, 19, 28, 29] suggests exotic nuclear physics related to weak interactions and that dark anti-neutrino density at the orbit of Earth around Sung oscillating with one year period is involved. This kind of remnant of dark matter would be consistent with the model for the formation of planets from dark matter. The evidence for the variation of the rates of nuclear and chemical processes correlating with astrophysical periods [74] could be understood in terms of weak fields created by dark matter and affect by astrophysical phenomena.

### 6.1.2 Dark rules

I have done a considerable amount of trials and errors in order to identify the basic rules allowing to understand what it means to be dark matter is and what happens in the phase transition to dark matter. It is good to try to summarize the basic rules of p-adic and dark physics allowing to avoid obvious contradictions.

#### The notion of field body

The notion of "field body" implied by topological field quantization is essential. There would be em, $Z0$, $W$, gluonic, and gravitonic field bodies, each characterized by its one prime. The motivation for considering the possibility of separate field bodies seriously is that the notion of induced gauge field means that all induced gauge fields are expressible in terms of four $CP_2$ coordinates so that only single component of a gauge potential allows a representation as and independent field quantity. Perhaps also separate magnetic and electric field bodies for each interaction and identifiable as flux quanta must be considered. This kind of separation requires that the fermionic content of the flux quantum (say fermion and anti-fermion at the ends of color flux tube) is such that it conforms with the quantum numbers of the corresponding boson.

What is interesting that the conceptual separation of interactions to various types would have a direct correlate at the level of space-time topology. From a different perspective inspired by the general vision that many-sheeted space-time provides symbolic representations of quantum physics, the very fact that we make this conceptual separation of fundamental interactions could reflect the topological separation at space-time level.

The p-adic mass calculations for quarks encourage to think that the p-adic length scale characterizing the mass of particle is associated with its electromagnetic body and in the case of neutrinos with its $Z^0$ body. $Z^0$ body can contribute also to the mass of charged particles but the contribution would be small. It is also possible that these field bodies are purely magnetic for color and weak interactions. Color flux tubes would have exotic fermion and anti-fermion at their ends and define colored variants of pions. This would apply not only in the case of nuclear strings but also to molecules and larger structures so that scaled variants of elementary particles and standard model would appear in all length scales as indeed implied by the fact that classical electro-weak and color fields are unavoidable in TGD framework.

One can also go further and distinguish between magnetic field body of free particle for which flux quanta start and return to the particle and "relative field" bodies associated with pairs of particles. Very complex structures emerge and should be essential for the understanding the space-time correlates of various interactions. In a well-defined sense they would define space-time correlate for the conceptual analysis of the interactions into separate parts. In order to minimize confusion it should be emphasized that the notion of field body used in this chapter relates to those space-time correlates of interactions, which are more or less *static* and related to the formation of *bound states*.

#### What dark variant of elementary particle means

It is not at all clear what the notion of dark variant of elementary particle or of larger structures could mean.

*1. Are only field bodies dark?*

One variety of dark particle is obtained by making some of the field bodies dark by increasing the value of Planck constant. This hypothesis could be replaced with the stronger assumption that elementary particles are maximally quantum critical systems so that they are same irrespective of the value of the Planck constant. Elementary particles would be represented by partonic 2-surfaces, which belong to the universal orbifold singularities remaining invariant by all groups $G_a \times G_b$ for a given choice of quantization axes. If $G_a \times G_b$ is assumed to leave invariant the choice of the quantization axes, it must be of the form $Z_{n_a} \times Z_{n_b} \subset SO(3) \times SU(3)$. Partonic 2-surface would belong to $M^2 \times CP_2/U(1) \times U(1)$, where $M^2$ is spanned by the quantization axis of angular momentum and the time axis defining the rest system.

A different manner to say this is that the $CP_2$ type extremal representing particle would suffer multiple topological condensation on its field bodies so that there would be no separate "particle space-time sheet".

Darkness would be restricted to particle interactions. The value of the Planck constant would be assigned to a particular interaction between systems rather than system itself. This conforms with the original finding that gravitational Planck constant satisfies $\hbar = GM_1M_2/v_0$, $v_0 \simeq 2^{-11}$. Since each interaction can give rise to a hierarchy dark phases, a rich variety of partially dark phases is predicted. The standard assumption that dark matter is visible only via gravitational interactions would mean that gravitational field body would not be dark for this particular dark matter.

Complex combinations of dark field bodies become possible and the dream is that one could understand various phases of matter in terms of these combinations. All phase transitions, including the familiar liquid-gas and solid-liquid phase transitions, could have a unified description in terms of dark phase transition for an appropriate field body. At mathematical level Jones inclusions would provide this description.

The book metaphor for the interactions at space-time level is very useful in this framework. Elementary particles correspond to ordinary value of Planck constant analogous to the ordinary sheets of a book and the field bodies mediating their interactions are the same space-time sheet or at dark sheets of the book.

*2. Can also elementary particles be dark?*

Also dark elementary particles themselves rather than only the flux quanta could correspond to dark space-time sheet defining multiple coverings of $H/G_a \times G_b$. This would mean giving up the maximal quantum criticality hypothesis in the case of elementary particles. These sheets would be exact copies of each other. If single sheet of the covering contains topologically condensed space-time sheet, also other sheets contain its exact copy.

The question is whether these copies of space-time sheet defining classical identical systems can carry different fermionic quantum numbers or only identical fermionic quantum numbers so that the dark particle would be exotic many-fermion system allowing an apparent violation of statistics ($N$ fermions in the same state).

Even if one allows varying number of fermions in the same state with respect to a basic copy of sheet, one ends up with the notion of $N$-atom in which nuclei would be ordinary but electrons would reside at the sheets of the covering. The question is whether symbolic representations essential for understanding of living matter could emerge already at molecular level via the formation of $N$-atoms.

### Criterion for the transition to dark phase

The criterion $\alpha Q_1 Q_2 > 1$ for the transition to dark matter phase relates always to the interaction between two systems and the interpretation is that when the field strength characterizing the interaction becomes too strong, the interaction is mediated by dark space-time sheets which define $n = n(G_a) \times n(G_b)$-fold covering of $M^4 \times CP_2/G_a \times G_b$. The sharing of flux between different space-time sheets reduces the field strength associated with single sheet below the critical value.

### 6.1.3 Implications

**Dark variants of nuclear physics**

One can imagine endless variety of dark variants of ordinary nuclei and every piece of data is well-come in attempts to avoid a complete inflation of speculative ideas. The book metaphor for the extended imbedding space is useful in the attempts to imagine various exotic phases of matter. For the minimal option atomic nuclei would be ordinary whereas field bodies could be dark and analogous to $n$-sheeted Riemann surfaces. One can imagine that the nuclei are at the "standard" page of the book and color bonds at different page with different p-adic length scale or having different Planck constant $\hbar_{eff}$. This would give two hierarchies of nuclei with increasing size.

Color magnetic body of the structure would become a key element in understanding the nuclear binding energies, giant dipole resonances, and nuclear decays. Also other field bodies are in a key role and there seems to be a field body for every basic interaction (classical gauge fields are induced from spinor connection and only four independent field variables are involved so that this is indeed required).

Nothing prevents from generalizing the nuclear string picture so that color bonds could bind also atoms to molecules and molecules to larger structures analogous to nuclei. Even hydrogen bond might be interpreted in this manner. Molecular physics could be seen as a scaled up variant of nuclear physics in a well-defined sense. The exotic features would relate to the hierarchy of various field bodies, including color bonds, electric and weak bonds. These field bodies would play key role also in biology and replaced molecular randomness with coherence in much longer length scale.

In the attempt to make this vision quantitative the starting point is nuclear string model [F9] and the model of cold fusion based on it forcing also to conclude the scaled variants of electro-weak bosons are involved. The model of cold fusion requires the presence of a variant electro-weak interactions for which weak bosons are effectively massless below the atomic length scale. $k = 113$ p-adically scaled up variant of ordinary weak bosons which is dark and corresponds to $\hbar = n\hbar_0$, $n = 2^{11}$, is a natural option. For ordinary nuclei weak bosons could be ordinary.

Anomalies of water could be understood if one assumes that color bonds can become dark with $n = k2^{11}$, $k = 1, 3$ and if super-nuclei formed by connecting different nuclei by the color bonds are possible. Tetrahedral and icosahedral water clusters could be seen as magic super-nuclei in this framework. Color bonds could connect either proton nuclei or water molecules.

**Could the notion of dark atom make sense?**

One can also imagine several variants of dark atom. Book metaphor suggest one variant of dark atom.

1. Nuclei and electrons could be ordinary but classical electromagnetic interactions are mediated via dark space-time sheet "along different page of the book". The value of Planck constant would be scaled so that one would obtain a hierarchy of scaled variants of hydrogen atom. The findings of Mills [73] find an explanation in terms of a reduced Planck constant. An alternative explanation is based on the notion of quantum-hydrogen atom obtained as q-deformation of the ordinary hydrogen atom.

2. A more exotic variant if atom is obtained by assuming ordinary nuclei but dark, not totally quantum critical, electrons. Dark space-time surface is analogous to n-sheeted Riemann surface and if one assumes that each sheet could carry electron, one ends up with the notion of $N$-atom.

**Implications of the partial darkness of condensed matter**

The model for partially dark condensed matter deriving from nuclear physics allows to understand the low compressibility of the condensed matter as being due to the repulsive weak force between exotic quarks, explains large parity breaking effects in living matter, and suggests a profound modification of the notion of chemical bond having most important implications for bio-chemistry and understanding of bio-chemical evolution.

## 6.2 General ideas about dark matter

In the sequel general ideas about the role of dark matter in condensed matter physics are described.

### 6.2.1 Quantum criticality, hierarchy of dark matters, and dynamical $\hbar$

Quantum criticality is the basic characteristic of TGD Universe and quantum critical superconductors provide an excellent test bed to develop the ideas related to quantum criticality into a more concrete form.

#### Quantization of Planck constants and the generalization of the notion of imbedding space

The recent geometric interpretation for the quantization of Planck constants is based on Jones inclusions of hyper-finite factors of type $II_1$ [A9].

1. Different values of Planck constant correspond to imbedding space metrics involving scalings of $M^4$ *resp.* $CP_2$ parts of the metric deduced from the requirement that distances scale as $\hbar(M^4)$ *resp.* $\hbar(M^4)$. Denoting the Planck constants by $\hbar(M^4) = n_a\hbar_0$ and $\hbar(CP_2) = n_b\hbar_0$, one has that covariant metric of $M^4$ is proportional to $n_b^2$ and covariant metric of $CP_2$ to $n_a^2$. In Kähler action only the effective Planck constant $\hbar_{eff}/\hbar_0 = \hbar(M^4)/\hbar(CP_2)$ appears and by quantum classical correspondence same is true for Schödinger equation. Elementary particle mass spectrum is also invariant. Same applies to gravitational constant. The alternative assumption that $M^4$ Planck constant is proportional to $n_b$ would imply invariance of Schrödinger equation but would not allow to explain Bohr quantization of planetary orbits and would to certain degree trivialize the theory.

2. $M^4$ and $CP_2$ Planck constants do not fully characterize a given sector $M^4_\pm \times CP_2$. Rather, the scaling factors of Planck constant given by the integer $n$ characterizing the quantum phase $q = exp(i\pi/n)$ corresponds to the order of the maximal cyclic subgroup for the group $G \subset SU(2)$ characterizing the Jones inclusion $\mathcal{N} \subset \mathcal{M}$ of hyper-finite factors realized as subalgebras of the Clifford algebra of the "world of the classical worlds". This means that subfactor $\mathcal{N}$ gives rise to $G$-invariant configuration space spinors having interpretation as $G$-invariant fermionic states.

3. $G_b \subset SU(2) \subset SU(3)$ defines a covering of $M^4_+$ by $CP_2$ points and $G_a \subset SU(2) \subset SL(2,C)$ covering of $CP_2$ by $M^4_+$ points with fixed points defining orbifold singularities. Different sectors are glued together along $CP_2$ if $G_b$ is same for them and along $M^4_+$ if $G_a$ is same for them. The degrees of freedom lost by $G$-invariance in fermionic degrees of freedom are gained back since the discrete degrees of freedom provided by covering allow many-particle states formed from single particle states realized in $G$ group algebra. Among other things these many-particle states make possible the notion of N-atom.

4. Phases with different values of scalings of $M^4$ and $CP_2$ Planck constants behave like dark matter with respect to each other in the sense that they do not have direct interactions except at criticality corresponding to a leakage between different sectors of imbedding space glued together along $M^4$ or $CP_2$ factors. In large $\hbar(M^4)$ phases various quantum time and length scales are scaled up which means macroscopic and macro-temporal quantum coherence. In particular, quantum energies associated with classical frequencies are scaled up by a factor $n_a/n_b$ which is of special relevance for cyclotron energies and phonon energies (superconductivity). For large $\hbar(CP_2)$ the value of $\hbar_{eff}$ is small: this leads to interesting physics: in particular the binding energy scale of hydrogen atom increases by the factor $n_b/n_a^2$.

#### A further generalization of the notion of imbedding space?

The original idea was that the proposed modification of the imbedding space could explain naturally phenomena like quantum Hall effect involving fractionization of quantum numbers like spin and charge. This does not however seem to be the case. $G_a \times G_b$ implies just the opposite if these quantum numbers are assigned with the symmetries of the imbedding space. For instance, quantization unit for orbital angular momentum becomes $n_a$ where $Z_{n_a}$ is the maximal cyclic subgroup of $G_a$.

One can however imagine of obtaining fractionization at the level of imbedding space for space-time sheets, which are analogous to multi-sheeted Riemann surfaces (say Riemann surfaces associated with $z^{1/n}$ since the rotation by $2\pi$ understood as a homotopy of $M^4$ lifted to the space-time sheet is a non-closed curve. Continuity requirement indeed allows fractionization of the orbital quantum numbers and color in this kind of situation.

*1. Both covering spaces and factor spaces are possible*

The observation above stimulates the question whether it might be possible in some sense to replace $H$ or its factors by their multiple coverings.

1. This is certainly not possible for $M^4$, $CP_2$, or $H$ since their fundamental groups are trivial. On the other hand, the fixing of quantization axes implies a selection of the sub-space $H_4 = M^2 \times S^2 \subset M^4 \times CP_2$, where $S^2$ is a geodesic sphere of $CP_2$. $\hat{M}^4 = M^4 \backslash M^2$ and $\hat{CP_2} = CP_2 \backslash S^2$ have fundamental group $Z$ since the codimension of the excluded sub-manifold is equal to two and homotopically the situation is like that for a punctured plane. The exclusion of these sub-manifolds defined by the choice of quantization axes could naturally give rise to the desired situation.

2. Zero energy ontology forces to modify this picture somewhat. In zero energy ontology causal diamonds ($CD$s) defined as the intersections of future and past directed light-cones are loci for zero energy states containing positive and negative energy parts of state at the two light-cone boundaries. The location of $CD$ in $M^4$ is arbitrary but p-adic length scale hypothesis suggests that the temporal distances between tips of $CD$ come as powers of 2 using $CP_2$ size as unit. Thus $M^4$ is replaces by $CD$ and $\hat{M}^4$ is replaced with $\hat{CD}$ defined in obvious manner.

3. $H_4$ represents a straight cosmic string inside $CD$. Quantum field theory phase corresponds to Jones inclusions with Jones index $\mathcal{M} : \mathcal{N} < 4$. Stringy phase would by previous arguments correspond to $\mathcal{M} : \mathcal{N} = 4$. Also these Jones inclusions are labeled by finite subgroups of $SO(3)$ and thus by $Z_n$ identified as a maximal Abelian subgroup.

   One can argue that cosmic strings are not allowed in QFT phase. This would encourage the replacement $\hat{CD} \times \hat{CP_2}$ implying that surfaces in $CD \times S^2$ and $(M^2 \cap CD) \times CP_2$ are not allowed. In particular, cosmic strings and $CP_2$ type extremals with $M^4$ projection in $M^2$ and thus light-like geodesic without zitterwebegung essential for massivation are forbidden. This brings in mind instability of Higgs=0 phase.

4. The covering spaces in question would correspond to the Cartesian products $\hat{CD}_{n_a} \times \hat{CP}_{2n_b}$ of the covering spaces of $\hat{CD}$ and $\hat{CP_2}$ by $Z_{n_a}$ and $Z_{n_b}$ with fundamental group is $Z_{n_a} \times Z_{n_b}$. One can also consider extension by replacing $M^2 \cap CD$ and $S^2$ with its orbit under $G_a$ (say tedrahedral, octahedral, or icosahedral group). The resulting space will be denoted by $\hat{CD} \hat{\times} G_a$ *resp.* $\hat{CP_2} \hat{\times} G_b$.

5. One expects the discrete subgroups of $SU(2)$ emerge naturally in this framework if one allows the action of these groups on the singular sub-manifolds $M^2 \cap CD$ or $S^2$. This would replace the singular manifold with a set of its rotated copies in the case that the subgroups have genuinely 3-dimensional action (the subgroups which corresponds to exceptional groups in the ADE correspondence). For instance, in the case of $M^2 \cap CD$ the quantization axes for angular momentum would be replaced by the set of quantization axes going through the vertices of tedrahedron, octahedron, or icosahedron. This would bring non-commutative homotopy groups into the picture in a natural manner.

6. Also the orbifolds $\hat{CD}/G_a \times \hat{CP_2}/G_b$ can be allowed as also the spaces $\hat{CD}/G_a \times (\hat{CP_2} \hat{\times} G_b)$ and $(\hat{CD} \hat{\times} G_a) \times \hat{CP_2}/G_b$. Hence the previous framework would generalize considerably by the allowance of both coset spaces and covering spaces.

There are several non-trivial questions related to the details of the gluing procedure and phase transition as motion of partonic 2-surface from one sector of the imbedding space to another one.

1. How the gluing of copies of imbedding space at $(M^2 \cap CD) \times CP_2$ takes place? It would seem that the covariant metric of $M^4$ factor proportional to $\hbar^2$ must be discontinuous at the singular manifold since only in this manner the idea about different scaling factor of $M^4$ metric can make sense. This is consistent with the identical vanishing of Chern-Simons action in $M^2 \times S^2$.

2. One might worry whether the phase transition changing Planck constant means an instantaneous change of the size of partonic 2-surface in $CD$ degrees of freedom. This is not the case. Light-likeness in $(M^2 \cap CD) \times S^2$ makes sense only for surfaces $X^1 \times D^2 \subset (M^2 \cap CD) \times S^2$, where $X^1$

is light-like geodesic. The requirement that the partonic 2-surface $X^2$ moving from one sector of $H$ to another one is light-like at $(M^2 \cap CD) \times S^2$ irrespective of the value of Planck constant requires that $X^2$ has single point of $(M^2 \cap CD)$ as $M^2$ projection. Hence no sudden change of the size $X^2$ occurs.

3. A natural question is whether the phase transition changing the value of Planck constant can occur purely classically or whether it is analogous to quantum tunneling. Classical non-vacuum extremals of Chern-Simons action have two-dimensional $CP_2$ projection to homologically non-trivial geodesic sphere $S^2_I$. The deformation of the entire $S^2_I$ to homologically trivial geodesic sphere $S^2_{II}$ is not possible so that only combinations of partonic 2-surfaces with vanishing total homology charge (Kähler magnetic charge) can in principle move from sector to another one, and this process involves fusion of these 2-surfaces such that $CP_2$ projection becomes single homologically trivial 2-surface. A piece of a non-trivial geodesic sphere $S^2_I$ of $CP_2$ can be deformed to that of $S^2_{II}$ using 2-dimensional homotopy flattening the piece of $S^2$ to curve. If this homotopy cannot be chosen to be light-like, the phase transitions changing Planck constant take place only via quantum tunnelling. Obviously the notions of light-like homotopies (cobordisms) and classical light-like homotopies (cobordisms) are very relevant for the understanding of phase transitions changing Planck constant.

*2. Do factor spaces and coverings correspond to the two kinds of Jones inclusions?*

What could be the interpretation of these two kinds of spaces?

1. Jones inclusions appear in two varieties corresponding to $\mathcal{M} : \mathcal{N} < 4$ and $\mathcal{M} : \mathcal{N} = 4$ and one can assign a hierarchy of subgroups of $SU(2)$ with both of them. In particular, their maximal Abelian subgroups $Z_n$ label these inclusions. The interpretation of $Z_n$ as invariance group is natural for $\mathcal{M} : \mathcal{N} < 4$ and it naturally corresponds to the coset spaces. For $\mathcal{M} : \mathcal{N} = 4$ the interpretation of $Z_n$ has remained open. Obviously the interpretation of $Z_n$ as the homology group defining covering would be natural.

2. $\mathcal{M} : \mathcal{N} = 4$ should correspond to the allowance of cosmic strings and other analogous objects. Does the introduction of the covering spaces bring in cosmic strings in some controlled manner? Formally the subgroup of $SU(2)$ defining the inclusion is $SU(2)$ would mean that states are $SU(2)$ singlets which is something non-physical. For covering spaces one would however obtain the degrees of freedom associated with the discrete fiber and the degrees of freedom in question would not disappear completely and would be characterized by the discrete subgroup of $SU(2)$.

   For anyons the non-trivial homotopy of plane brings in non-trivial connection with a flat curvature and the non-trivial dynamics of topological QFTs. Also now one might expect similar non-trivial contribution to appear in the spinor connection of $\hat{CD}\hat{\times}G_a$ and $\hat{CP}_2\hat{\times}G_b$. In conformal field theory models non-trivial monodromy would correspond to the presence of punctures in plane.

3. For factor spaces the unit for quantum numbers like orbital angular momentum is multiplied by $n_a$ *resp.* $n_b$ and for coverings it is divided by this number. These two kind of spaces are in a well defined sense obtained by multiplying and dividing the factors of $\hat{H}$ by $G_a$ *resp.* $G_b$ and multiplication and division are expected to relate to Jones inclusions with $\mathcal{M} : \mathcal{N} < 4$ and $\mathcal{M} : \mathcal{N} = 4$, which both are labeled by a subset of discrete subgroups of SU(2).

4. The discrete subgroups of $SU(2)$ with fixed quantization axes possess a well defined multiplication with product defined as the group generated by forming all possible products of group elements as elements of $SU(2)$. This product is commutative and all elements are idempotent and thus analogous to projectors. Trivial group $G_1$, two-element group $G_2$ consisting of reflection and identity, the cyclic groups $Z_p$, $p$ prime, and tedrahedral, octahedral, and icosahedral groups are the generators of this algebra.

By commutativity one can regard this algebra as an 11-dimensional module having natural numbers as coefficients ("rig"). The trivial group $G_1$, two-element group $G_2$¡ generated by reflection, and tedrahedral, octahedral, and icosahedral groups define 5 generating elements for this algebra. The products of groups other than trivial group define 10 units for this algebra so that there are 11 units altogether. The groups $Z_p$ generate a structure analogous to natural numbers acting as analog of coefficients of this structure. Clearly, one has effectively 11-dimensional commutative algebra in 1-1 correspondence with the 11-dimensional "half-lattice" $N^{11}$ ($N$ denotes natural numbers). Leaving away reflections, one obtains $N^7$. The projector representation suggests a connection with Jones inclusions. An interesting question concerns the possible Jones inclusions assignable to the subgroups containing infinitely manner elements. Reader has of course already asked whether dimensions 11, 7 and their difference 4 might relate somehow to the mathematical structures of M-theory with 7 compactified dimensions. One could introduce generalized configuration space spinor fields in the configuration space labelled by sectors of $H$ with given quantization axes. By introducing Fourier transform in $N^{11}$ one would formally obtain an infinite-component field in 11-D space.

The question how do the Planck constants associated with factors and coverings relate is far from trivial and I have considered several options.

1. If one assumes that $\hbar^2(X)$, $X = M^4$, $CP_2$ corresponds to the scaling of the covariant metric tensor $g_{ij}$ and performs an over-all scaling of metric allowed by Weyl invariance of Kähler action by dividing metric with $\hbar^2(CP_2)$, one obtains $r^2 \equiv \hbar^2/\hbar_0^2\hbar^2(M^4)/\hbar^2(CP_2)$. This puts $M^4$ and $CP_2$ in a very symmetric role and allows much more flexibility in the identification of symmetries associated with large Planck constant phases.

2. Algebraist would argue that Planck constant must define a homomorphism respecting multiplication and division (when possible) by $G_i$. This requires $r(X) = \hbar(X)\hbar_0 = n$ for covering and $r(X) = 1/n$ for factor space or vice versa. This gives two options.

3. Option I: $r(X) = n$ for covering and $r(X) = 1/n$ for factor space gives $r \equiv \hbar/\hbar_0 = r(M^4)/r(CP_2)$. This gives $r = n_a/n_b$ for $\hat{H}/G_a \times G_b$ option and $r = n_b/n_a$ for $\hat{H}t\hat{imes}(G_a \times G_b)$ option with obvious formulas for hybrid cases.

4. Option II: $r(X) = 1/n$ for covering and $r(X) = n$ for factor space gives $r = r(CP_2)/r(M^4)$. This gives $r = n_b/n_a$ for $\hat{H}/G_a \times G_b$ option and $r = n_a/n_b$ for $\hat{H}t\hat{imes}(G_a \times G_b)$ option with obvious formulas for the hybrid cases.

5. At quantum level the fractionization would come from the modification of fermionic anti-commutation (bosonic commutation) relations involving $\hbar$ at the right hand side so that particle number becomes a multiple of $1/n$ or $n$. If one postulates that the total number states is invariant in the transition, the increase in the number of sheets is compensated by the increase of the fundamental phase space volume proportional to $\hbar$. This would give $r(X) \rightarrow r(X)/n$ for factor space and $r(X) \rightarrow nr(X)$ for the covering space to compensate the $n$-fold reduction/increase of states. This would favor Option II.

6. The second manner to distinguish between these two options is to apply the theory to concrete physical situations. Since $G_a$ and $G_b$ act as symmetries in $CD$ and $CP_2$ degrees of freedom, one might of being able to distinguish between the two options if it is possible to distinguish between the action of $G$ as symmetry of quantum states associated with covering and factor space. Also the quantization of the orbital spin quantum number at single particle level as multiples of $n$ can be distinguished from that in multiples of $1/n$.

*3. A simple model of fractional quantum Hall effect*

The generalization of the imbedding space suggests that it could possible to understand fractional quantum Hall effect [35] at the level of basic quantum TGD. This section represents the first rough model of QHE constructed for a couple of years ago is discussed. Needless to emphasize, the model represents only the basic idea and involves ad hoc assumption about charge fractionization.

Recall that the formula for the quantized Hall conductance is given by

$$\begin{aligned} \sigma &= \nu \times \frac{e^2}{h} ~, \\ \nu &= \frac{n}{m} ~. \end{aligned} \tag{6.2.1}$$

Series of fractions in $\nu = 1/3, 2/5, 3/7, 4/9, 5/11, 6/13, 7/15..., 2/3, 3/5, 4/7, 5/9, 6/11, 7/13..., 5/3, 8/5, 11/7, 14/9...4/3, 7/5, 10$ $1/5, 2/9, 3/13..., 2/7, 3/11..., 1/7....$ with odd denominator have been observed as are also $\nu = 1/2$ and $\nu = 5/2$ states with even denominator [35].

The model of Laughlin [55] cannot explain all aspects of FQHE. The best existing model proposed originally by Jain is based on composite fermions resulting as bound states of electron and even number of magnetic flux quanta [36]. Electrons remain integer charged but due to the effective magnetic field electrons appear to have fractional charges. Composite fermion picture predicts all the observed fractions and also their relative intensities and the order in which they appear as the quality of sample improves.

The generalization of the notion of imbedding space suggests the possibility to interpret these states in terms of fractionized charge, spin, and electron number. There are four combinations of covering and factors spaces of $CP_2$ and three of them can lead to the increase of Planck constant. Besides this there are two options for the formula of Planck constant so that which the very meager theoretical background one can make only guesses. On the following just for fun consideration option I is considered although the conservation of number of states in the phase transition changing $\hbar$ favors option II.

1. The easiest manner to understand the observed fractions is by assuming that both $M^4$ and $CP_2$ correspond to covering spaces so that both spin and electric charge and fermion number are fractionized. This means that $e$ in electronic charge density is replaced with fractional charge. Quantized magnetic flux is proportional to $e$ and the question is whether also here fractional charge appears. Assume that this does not occur.

2. With this assumption the expression for the Planck constant becomes for Option II as $r = \hbar/\hbar_0 = n_a/n_b$ and charge and spin units are equal to $1/n_b$ and $1/n_a$ respectively. This gives $\nu = nn_a/n_b$. The values $m = 2, 3, 5, 7, ..$ are observed. Planck constant can have arbitrarily large values. There are general arguments stating that also spin is fractionized in FQHE.

3. The appearance of $\nu = 5/2$ has been observed [37]. The fractionized charge is $e/4$ in this case. Since $n_i > 3$ holds true if coverings are correlates for Jones inclusions, this requires to $n_b = 4$ and $n_a = 10$. $n_b$ predicting a correct fractionization of charge. The alternative option would be $n_b = 2$ that also $Z_2$ would appear as the fundamental group of the covering space. Filling fraction 1/2 corresponds in the composite fermion model and also experimentally to the limit of zero magnetic field [36]. $n_b = 2$ is however inconsistent with the observed fractionization of electric charge and with the vision inspired by Jones inclusions.

4. A possible problematic aspect of the TGD based model is the experimental absence of even values of $n_b$ except $n_b = 2$ (Laughlin's model predicts only odd values of $n$). A possible explanation is that by some symmetry condition possibly related to fermionic statistics (as in Laughlin model) $n_a/n_b$ must reduce to a rational with an odd denominator for $n_b > 2$. In other words, one has $n_a \propto 2^r$, where $2^r$ the largest power of 2 divisor of $n_b$.

5. Large values of $n_a$ emerge as $B$ increases. This can be understood from flux quantization. One has $e\int BdS = n\hbar(M^4) = nn_a\hbar_0$. By using actual fractional charge $e_F = e/n_b$ in the flux factor would give $e_F \int BdS = n(n_a/n_b)\hbar_0 = n\hbar$. The interpretation is that each of the $n_a$ sheets contributes one unit to the flux for $e$. Note that the value of magnetic field in given sheet is not affected so that the build-up of multiple covering seems to keep magnetic field strength below critical value.

6. The understanding of the thermal stability is not trivial. The original FQHE was observed in 80 mK temperature corresponding roughly to a thermal energy of $T \sim 10^{-5}$ eV. For graphene the effect is observed at room temperature. Cyclotron energy for electron is (from $f_e = 6 \times 10^5$ Hz at $B = .2$ Gauss) of order thermal energy at room temperature in a magnetic field varying in the range 1-10 Tesla. This raises the question why the original FQHE requires so low temperature. The magnetic energy of a flux tube of length $L$ is by flux quantization roughly $e^2B^2S \sim E_c(e)m_eL$ ($\hbar_0 = c = 1$) and exceeds cyclotron roughly by a factor $L/L_e$, $L_e$ electron Compton length so that thermal stability of magnetic flux quanta is not the explanation. A possible explanation is that since FQHE involves several values of Planck constant, it is quantum critical phenomenon and is characterized by a critical temperature. The differences of

the energies associated with the phase with ordinary Planck constant and phases with different Planck constant would characterize the transition temperature.

As already noticed, it is possible to imagine several other options and the identification of charge unit is rather ad hoc. Therefore this model can be taken only as a warm-up exercise. In [F12] Quantum Hall effect and charge fractionization are discussed in detail and one ends up with a rather detailed view about the delicacies of the Kähler structure of generalized imbedding space.

### 6.2.2 How the scaling of $\hbar$ affects physics and how to detect dark matter?

It is relatively easy to deduce the basic implications of the scaling of $\hbar$.

1. If the rate for the process is non-vanishing classically, it is not affected in the lowest order. For instance, scattering cross sections for say electron-electron scattering and $e^+e^-$ annihilation are not affected in the lowest order since the increase of Compton length compensates for the reduction of $\alpha_{em}$. Photon-photon scattering cross section, which vanishes classically and is proportional to $\alpha_{em}^4\hbar^2/E^2$, scales down as $1/\hbar^2$.

2. Higher order corrections coming as powers of the gauge coupling strength $\alpha$ are reduced since $\alpha = g^2/4\pi\hbar$ is reduced. Since one has $\hbar_s/\hbar = \alpha Q_1Q_2/v_0$, $\alpha Q_1Q_2$ is effectively replaced with a universal coupling strength $v_0$. In the case of QCD the paradoxical sounding implication is that $\alpha_s$ would become very small.

3. The binding energy scale $E \propto \alpha_{em}^2 m_e$ of atoms scales as $1/\hbar^2$. This would suggest that a partially dark matter for which protons have a large value of $\hbar(M^4)$ does not interact appreciably with the ordinary light. Multiple coverings defined by $G_a$ and $G_b$ imply fractionization of various quantum numbers as $q \to q/n_a$ for $CP_2$ quantum numbers and as $n \to q/n_b$ for spin. One prediction is N-atom for which the $N = N(G_b)$ sheets of covering of $M^4_+$ can carry up to $N$ electrons with identical quantum numbers. In this case Planck constant is scaled down by $n_a/n_b$ so that the scale of hydrogen atom binding energy increases by $k^2 = (n_b/n_a)^2$. Mills reports this kind of scalings for $k = 2, 3, ..., 10$ [73]. Dark positive charges are however required to stabilize the electronic charge but the example of atomic nuclei suggests that N-atoms can be stable.

### 6.2.3 General view about dark matter hierarchy and interactions between relatively dark matters

The identification of the precise criterion characterizing dark matter phase is far from obvious. TGD actually suggests an infinite number of phases which are dark relative to each other in some sense and can transform to each other only via a phase transition which might be called de-coherence or its reversal and which should be also characterized precisely.

A possible solution of the problem comes from the general construction recipe for S-matrix. Fundamental vertices correspond to partonic 2-surfaces representing intersections of incoming and outgoing light-like partonic 3-surfaces.

1. If the characterization of the interaction vertices involves all points of partonic 2-surfaces, they must correspond to definite value of Planck constants and more precisely, definite groups $G_a$ and $G_b$ characterizing dark matter hierarchy. Particles of different $G_b$ phases could not appear in the same vertex since the partons in question would correspond to vacuum extremals. Hence the phase transition changing the particles to each other analogous could not be described by a vertex and would be analogous to a de-coherence.

   The phase transition could occur at the incoming or outgoing particle lines. At space-time level the phase transition would mean essentially a leakage between different sectors of imbedding space and means that partonic 2-surface at leakage point has $CP_2$ projection reducing to the orbifold point invariant under G or alternatively, its $M^4_\pm$ projection corresponds to the tip of $M^4_\pm$. Relative darkness would certainly mean different groups $G_a$ and $G_b$. Note that $\hbar(M^4)$ *resp.* $\hbar(CP_2)$ can be same for different groups $G_a$ *resp.* $G_b$ and that only the ratio of $\hbar(M^4)/\hbar(M^4)$ appears in the Kähler action.

2. One can represent a criticism against the idea that relatively dark matters cannot appear at the same interaction vertex. The point is that the construction of S-matrix for transitions transforming partonic 2-surfaces in different number fields involves only the rational (algebraic) points in the intersection of the 2-surfaces in question. This idea applies also to the case in which particles correspond to different values of Planck constant. What is only needed that all the common points correspond to the orbifold point in $M^4$ or $CP_2$ degrees of freedom and are thus intermediate between two sectors of imbedding space. In this picture phase transitions would occur through vertices and S-matrix would characterize their probabilities. It seems that this option is the correct one.

If the matrix elements for real-real transitions involve all or at least a circle of the partonic 2-surface as stringy considerations suggest [C2], then one would have clear distinction between quantum phase transitions and ordinary quantum transitions. Note however that one could understand the weakness of the quantal interactions between relatively dark matters solely from the fact that the $CP_2$ type extremals providing space-time correlates for particle propagators must in this case go through an intermediate state with at most point-like $CP_2$ projection.

At quantum level the phase transition is possible only at quantum criticality and number theoretic considerations lead to the hypothesis that super-canonical conformal weights for partons reduce to zeros of Riemann Zeta in this situation. In the general case the imaginary parts of conformal weights would be linear combinations $y = \sum_k n_k y_k$ of imaginary parts of zeros $1/2 + iy_k$ of $\zeta$ with integer coefficients.

#### What does one mean with dark variants of elementary particle?

It is not at all clear what one means with the dark variant of elementary particle. In this respect p-adic mass calculations provide a valuable hint. According to the p-adic mass calculations [F4], $k = 113$ characterizes electromagnetic size of u and d quarks, of nucleons, and nuclei. $k = 107$ characterizes the QCD size of hadrons. This is somewhat paradoxical situation since one would expect that quark space-time sheets would be smaller than hadronic space-time sheets.

The simplest resolution of the problem suggested by the basic characteristics of electro-weak symmetry breaking is that $k = 113$ characterizes the size of the electro-magnetic field body of the quark and that the prime characterizing p-adic mass scale labels the em field body of the particle. One can assign mass also the $Z^0$ body but this would be much smaller as the small scale of neutrino masses suggests. This size scale correspond to a length scale of order 10 $\mu$m, which conforms with the expectation that classical $Z^0$ force is important in biological length scales. The size of $Z^0$ body of neutrino could relate directly to the chirality selection in living matter. An interesting question is whether the $Z^0$ field bodies of also other elementary fermions are of this size.

If this picture is correct then dark variant of elementary particle would differ from ordinary only in the sense that its field body would be dark. This conforms with the general working hypothesis is that only field bodies can be dark.

#### Are particles characterized by different p-adic primes relatively dark?

Each particle is characterized by a collection of p-adic primes corresponding to the partonic 2-surfaces associate with the particle like 3-surface. Number theoretical vision supports the notion of multi-p p-adicity and the idea that elementary particles correspond to infinite primes, integers, or perhaps even rationals [E3, F6]. To infinite primes, integers, and rationals it is possible to associate a finite rational $q = m/n$ by a homomorphism. This would suggest generalization of p-adicity with q-adicity (q-adic topology does not correspond to number field) but this does not seem to be a promising idea.

The crucial observation is that one can decompose the infinite prime, call it $P$, to finite and infinite parts and distinguish between bosonic and fermionic finite primes of which infinite prime can be said to consist of [C6, E3, H8]. The interpretation is that bosonic and fermionic finite primes in the *infinite* part of $P$ code for p-adic topologies of light-like partonic 3-surfaces associated with a given *real* space-time sheet whereas the primes in the *finite* part of $P$ code for p-adic lightlike partonic 3-surfaces.

This raises two options.

1. Two space-time sheets characterized by rationals having common prime factors can be connected by a $\#_B$ contact and can interact by the exchange of particles characterized by divisors of $m$ or $n$ since in this case partonic 2-surface with same p-adic or effective p-adic topology can be found. This is the only possible interaction between them.

2. The number theoretic vision about the construction of S-matrix however allows to construct S-matrix also in the case that partons belong to different number fields and one ends up with a very elegant description involving only finite number of points of partonic 2-surfaces belonging to their intersection consisting of rational (algebraic points of imbedding space), which by algebraic universality could apply also to diagonal transitions. Also now the interactions mediated between propagators connecting partons with different effective p-adic topologies might be very slow so that this would give rise to relative darkness.

### Interpretation of super-canonical conformal weights

Super-canonical conformal weights [B3, C1] are in general complex and define a new kind, perhaps even conserved, quantum number which could be called scaling momentum. There are strong number theoretic reasons to believe that the conformal weights are expressible in terms of zeros of Riemann Zeta.

*1. Generalization of the notion of super-canonical conformal weight, p-adicization, and number theoretical universality of Riemann Zeta*

It has clear that super-canonical conformal weights could actually depend on the $CP_2$ of the partonic 2-surface via the formula $\Delta = \zeta^{-1}(z)$, where $z$ is the complex coordinate of the projection of the point of partonic to the geodesic sphere of $CP_2$ transforming linearly under $U(2) \subset SU(3)$. Note that $\Delta$ has infinite number of branches corresponding to the zeros of $\zeta$, and the region of partonic 2-surface given branch generalizes the notion of constant conformal weight. Several branches can be associated with a given partonic 2-surface.

In the most general case $\Delta$ could be sum of $\delta M^4_\pm$ and $CP_2$ parts where $M^4_+$ part is of same form but now argument corresponds to the standard projective complex coordinate of $S^2$. Also now orbifold points would be introduced and the interpretation would be in terms of a selection of the quantization direction of angular momentum occurring already at the level of configuration space of 3-surfaces.

Suppose that one accepts the hypothesis of the number theoretical universality of $\zeta$ stating that the zeros $s_k = 1/2 + iy_k$ of $\zeta$ have the property that the factors $1/(1+p^{s_k}$ are algebraic numbers for all zeros of zeta [C1, E8]. This is guaranteed if $p^{iy_k}$ is algebraic number for any value of $p$ and $y_k$. Under this assumption, p-adicization requires that the intersections of partonic 2-surfaces belonging to different number fields must correspond to points which are linear combinations of zeros of $\zeta$ with integer coefficients. Zeros of Riemann Zeta in turn correspond to orbifold points which are common to the sectors of the imbedding space characterized by different groups $G_b$ and thus possessing different values of $\hbar(M^4)$ in general.

This means that a collection of super-canonical conformal weights can be associated with the intersection points of real parton surface with a given effective p-adic topology and that each value of conformal weight defines a number theoretic braid. Same applies to the intersections of partonic space-time sheets with different p-adic topologies. The sum of these conformal weights associated with the interaction points can be said to define the net super-canonical conformal weight of the particle. Obviously super-canonical conformal weights do not define quantum number in the standard sense of the word. In particular, the new effective quantum number does not allow an effective violation of Fermi statistics.

What is important that conformal weights associated with the quantum critical partonic 2-surface must correspond to zeros or infinite values of Riemann Zeta for quantum critical points since these points correspond to north and south poles of $\zeta$ remaining invariant under $G_b$.

*2. Is conformal confinement needed?*

The first guess was that the net value of super-canonical conformal weight is real for physical states. This would give rise to the notion of conformal confinement. It was thought that a particular kind of dark matter would correspond to a conformally confined matter with particles having complex conformal weights such that the net conformal weight is real. The proposed identification of the net super-canonical conformal weight does not support this identification.

It has also become clear that there is no strong physical reason to require the reality of conformal weights at single particle level [C1]: in zero energy ontology the reality of the net conformal weight for zero energy states is predicted in any case since all conserved quantum numbers vanish for them. Furthermore, the conjugation of the conformal weight has interpretation as generalization of phase conjugation of photons in laser physics. This means that time orientation becomes an inherent characteristic of a particle so that positive energy particles propagating in the direction of the geometric future can be distinguished from negative energy particles propagating to the direction of the geometric past.

#### Hierarchy of infinite primes and dark matter hierarchy

In previous consideration only the simplest infinite primes at the lowest level of hierarchy were considered. Simple infinite primes allow a symmetry changing the sign of the finite part of infinite prime. A possible interpretation in terms of phase conjugation. One can consider also more complex infinite primes at this level and a possible interpretation in terms of bound states of several particles. One can also consider infinite integers and rationals: the interpretation would be as many particle states. Rationals might correspond to states containing particles and antiparticles. At the higher levels of the hierarchy infinite primes of previous take the role of finite primes at the previous level and physically these states correspond to higher level bound states of the particles of the previous level.

Thus TGD predicts an entire hierarchy of dark matters such that the many particle states at previous level become particles at the next level. This hierarchy would provide a concrete physical identification for the hierarchy of infinite primes identifiable in terms of a repeated second quantization of an arithmetic super-symmetric QFT [E3] including both free many-particle states and their bound states. The finite primes about which infinite prime is in a well defined sense a composite of would correspond to the particles in the state forming a unit of dark matter. Particles belonging to different levels of this hierarchy would obviously correspond to different levels of dark matter hierarchy but their interactions must reduce to the fundamental partonic vertices.

### 6.2.4 How dark matter and visible matter interact?

The hypothesis that the value of $\hbar$ is dynamical, quantized and becomes large at the verge of a transition to a non-perturbative phase in the ordinary sense of the word has fascinating implications. In particular, dark matter, would correspond to a large value of $\hbar$ and could be responsible for the properties of the living matter. In order to test the idea experimentally, a more concrete model for the interaction of ordinary matter and dark matter must be developed and here of course experimental input and the consistency with the earlier quantum model of living matter is of considerable help.

#### How dark photons transform to ordinary photons?

The transitions of dark atoms naturally correspond to coherent transitions of the entire dark electron BE condensate and thus generate $N_{cr}$ dark photons and behave thus like laser beams. Dark photons do not interact directly with the visible matter. An open question is whether even ordinary laser beams could be identified as beams of dark photons: the multiple covering property at the level of imbedding space and the fact that MEs are possible in all sectors suggests that this is not the case. Note that the transition from dark to ordinary photons implies the scaling of wave length and thus also of coherence length by a factor $n_b/n_a$.

Dark $\leftrightarrow$ visible transition should have also a space-time correlate. The so called topological light rays or MEs ("massless extremals") represent a crucial deviation of TGD from Maxwell's ED and have all the properties characterizing macroscopic classical coherence. Therefore MEs are excellent candidates for the space-time correlate of BE condensate of dark photons.

MEs carry in general a superposition of harmonics of some basic frequency determined by the length of ME. A natural expectation is that the frequency of classical field corresponds to the generalized de Broglie frequency of dark photon and is thus $\hbar/\hbar_s$ times lower than for ordinary photons. In completely analogous manner de Broglie wave length is scaled up by $k = \hbar_s/\hbar$. Classically the decay of dark photons to visible photons would mean that an oscillation with frequency $f$ inside topological light ray transforms to an oscillation of frequency $f/k$ such that the intensity of the oscillation is scaled up by a factor $k$. Furthermore, the ME in question could naturally decompose into $1 < N_{cr} \leq 137$

ordinary photons in the case that dark atoms are in question. Of course also MEs could decay to lower level MEs and this has an interpretation in terms of hierarchy of dark matters to be discussed next.

**About the criterion for the transition increasing the value of Planck constant**

An attractive assumption is that the transition to dark matter phase occurs when the interaction strength satisfies the criticality condition $Q_1Q_2\alpha \simeq 1$. A special case corresponds to self interaction with $Q_1 = Q_2$. This condition applies only to gauge interactions so that particles can be characterized by gauge charges. A more general characterization would be that transition occurs when perturbation theory ceases to converge. The criterion cannot be applied to phenomenological QFT description of strong force in terms of, say, pion exchange.

Some examples are in order to test this view.

1. Transition from perturbative phase in QCD to hadronic phase is the most obvious application. The identification of valence quarks and gluons as dark matter would predict for them QCD size ($k = 107$ space-time sheet) of about electron Compton length. This does not change the QCD cross sections in the lowest order perturbation theory but makes them excellent predictions. It also provides completely new view about how color force determines the nuclear strong force indeed manifesting itself as long ranged harmonic oscillator potential, the long range of which becomes manifest in the case of neutron halos of size of $2.5 \times 10^{-14}$ m [61]. One can also understand tetraneutron in this framework. This criterion applies also in QCD plasma and explains the formation of liquid like color glass condensate detected in RHIC [67]. A possible interpretation for QCD size would be as a length of the cylindrical magnetic walls defining the magnetic body associated with u and d type valence quarks, nucleons, and nuclei. There is no need to assume that conformal weights are complex in this phase.

2. QCD size of quark must be distinguished from the electromagnetic size of quark associated with $k = 113$ space-time sheets of $u$ and $d$ quarks and assignable to the height of the magnetic body and defining the length scale of join along boundaries contacts feeding quark charges to $k = 113$ space-time sheets.

3. In the case of atomic nuclei the criterion would naturally apply to the electromagnetic interaction energy of two nucleon clusters inside nucleus or to to self energy ($Q^2\alpha_{em} = 1$). Quite generally, the size of the electromagnetic $k = 113$ space-time sheet would increase by a $n_F = 2^k \prod_s F_s$, where $F_s$ are different Fermat primes (the known ones being $3, 5, 17, 257, 2^{16}+1$), in the transition to large $\hbar$ phase. Especially interesting values of $n_F$ seem to be of form $n_F = 2^{k11}$ and possibly also $n_F = 2^{k11} \prod_s F_s$. Similar criterion would apply in the plasma phase. Note that many free energy anomalies involve the formation of cold plasma [G2].

   The criterion would give in the case of single nucleus and plasma $Z \geq 12$ if the charges are within single space-time sheet. This is consistent with cold fusion involving Palladium nuclei [43]. Since $u$ and $d$ quarks have $k = 113$, they both and thus both neutrons and protons could make a transition to large $\hbar$ phase. This is consistent with the selection rules of cold fusion since the production of $^3He$ involves a phase transition pnp$_d$ $\rightarrow$ pnp and the contraction of $p_d$ to $p$ is made un-probable by the Coulomb wall whereas the transition nnp$_d$ $\rightarrow$nnp producing tritium does not suffer from this restriction.

Strong and weak physics of nuclei would not be affected in the phase transition. Electromagnetic perturbative physics of nuclei would not be affected in the process in the lowest order in $\hbar$ (classical approximation) but the height of the Coulomb wall would be reduced by a factor $1/n_F$ by the increase in the electromagnetic size of the nucleus. Also Pd nuclei could make the transition and Pd nuclei could catalyze the transition in the case the deuterium nuclei.

### 6.2.5 Could one demonstrate the existence of large Planck constant photons using ordinary camera or even bare eyes?

If ordinary light sources generate also dark photons with same energy but with scaled up wavelength, this might have effects detectable with camera and even with bare eyes. In the following I consider in a rather light-hearted and speculative spirit two possible effects of this kind appearing in both visual perception and in photos. For crackpotters I want to make clear that I love to play with ideas to see whether they work or not, and that I am ready to accept some convincing mundane explanation of these effects and I would be happy to hear about this kind of explanations. I was not able to find any such explanation from Wikipedia using words like camera, digital camera, lense, aberrations [51].

**Why light from an intense light source seems to decompose into rays?**

If one also assumes that ordinary radiation fields decompose in TGD Universe into topological light rays ("massless extremals", MEs) even stronger predictions follow. If Planck constant equals to $\hbar = q \times \hbar_0$, $q = n_a/n_b$, MEs should possess $Z_{n_a}$ as an exact discrete symmetry group acting as rotations along the direction of propagation for the induced gauge fields inside ME.

The structure of MEs should somewhat realize this symmetry and one possibility is that MEs has a wheel like structure decomposing into radial spokes with angular distance $\Delta\phi = 2\pi/n_a$ related by the symmetries in question. This brings strongly in mind phenomenon which everyone can observe anytime: the light from a bright source decomposes into radial rays as if one were seeing the profile of the light rays emitted in a plane orthogonal to the line connecting eye and the light source. The effect is especially strong if eyes are stirred. It would seem that focusing makes the effect stronger.

Could this apparent decomposition to light rays reflect directly the structure of dark MEs and could one deduce the value of $n_a$ by just counting the number of rays in camera picture, where the phenomenon turned to be also visible? Note that the size of these wheel like MEs would be macroscopic and diffractive effects do not seem to be involved. The simplest assumption is that most of photons giving rise to the wheel like appearance are transformed to ordinary photons before their detection.

The discussions about this led to a little experimentation with camera at the summer cottage of my friend Samppa Pentikäinen, quite a magician in technical affairs. When I mentioned the decomposition of light from an intense light source to rays at the level of visual percept and wondered whether the same occurs also in camera, Samppa decided to take photos with a digital camera directed to Sun. The effect occurred also in this case and might correspond to decomposition to MEs with various values of $n_a$ but with same quantization axis so that the effect is not smoothed out.

What was interesting was the presence of some stronger almost vertical "rays" located symmetrically near the vertical axis of the camera. In old-fashioned cameras the shutter mechanism determining the exposure time is based on the opening of the first shutter followed by closing a second shutter after the exposure time so that every point of sensor receives input for equally long time. The area of the region determining input is bounded by a vertical line. If macroscopic MEs are involved, the contribution of vertical rays is either nothing or all unlike that of other rays and this might somehow explain why their contribution is enhanced. The shutter mechanism is un-necessary in digital cameras since the time for the reset of sensors is what matters. Something in the geometry of the camera or in the reset mechanism must select vertical direction in a preferred position. For instance, the outer "aperture" of the camera had the geometry of a flattened square.

**Anomalous diffraction of dark photons**

Second prediction is the possibility of diffractive effects in length scales where they should not occur. A good example is the diffraction of light coming from a small aperture of radius $d$. The diffraction pattern is determined by the Bessel function

$$J_1(x) \ \ , \ \ x = kdsin(\theta) \ \ , \ \ k = 2\pi/\lambda .$$

There is a strong light spot in the center and light rings around whose radii increase in size as the distance of the screen from the aperture increases. Dark rings correspond to the zeros of $J_1(x)$ at $x = x_n$ and the following scaling law for the nodes holds true

$$sin(\theta_n) = x_n \frac{\lambda}{2\pi d} per .$$

For very small wavelengths the central spot is almost point-like and contains most light intensity.

If photons of visible light correspond to large Planck constant $\hbar = q \times \hbar_0$ transformed to ordinary photons in the detector (say camera film or eye), their wavelength is scaled by $q$, and one has

$$sin(\theta_n) \to q \times sin(\theta_n)$$

The size of the diffraction pattern for visible light is scaled up by $q$.

This effect might make it possible to detect dark photons with energies of visible photons and possibly present in the ordinary light.

1. What is needed is an intense light source and Sun is an excellent candidate in this respect. Dark photon beam is also needed and n dark photons with a given visible wavelength $\lambda$ could result when dark photon with $\hbar = n \times q \times \hbar_0$ decays to n dark photons with same wavelength but smaller Planck constant $\hbar = q \times \hbar_0$. If this beam enters the camera or eye one has a beam of $n$ dark photons which forms a diffraction pattern producing camera picture in the de-coherence to ordinary photons.

2. In the case of an aperture with a geometry of a circular hole, the first dark ring for ordinary visible photons would be at $sin(\theta) \simeq (\pi/36)\lambda/d$. For a distance of $r = 2$ cm between the sensor plane ("film") and effective circular hole this would mean radius of $R \simeq rsin(\theta) \simeq 1.7$ micrometers for micron wave length. The actual size of spots is of order $R \simeq 1$ mm so that the value of $q$ would be around 1000: $q = 2^{10}$ and $q = 2^{11}$ belong to the favored values for $q$.

3. One can imagine also an alternative situation. If photons responsible for the spot arrive along single ME, the transversal thickness R of ME is smaller than the radius of hole, say of of order of wavelength, ME itself effectively defines the hole with radius R and the value of $sin(\theta_n)$ does not depend on the value of $d$ for $d > R$. Even ordinary photons arriving along MEs of this kind could give rise to an anomalous diffraction pattern. Note that the transversal thickness of ME need not be fixed however. It however seems that MEs are now macroscopic.

4. A similar effect results as one looks at an intense light source: bright spots appear in the visual field as one closes the eyes. If there is some more mundane explanation (I do not doubt this!), it must apply in both cases and explain also why the spots have precisely defined color rather than being white.

5. The only mention about effects of diffractive aberration effects are colored rings around say disk like objects analogous to colors around shadow of say disk like object. The radii of these diffraction rings in this case scale like wavelengths and distance from the object.

6. Wikipedia contains an article from which one learns that the effect in question is known as lens flares [52]. The article states that flares typically manifest as several starbursts, circles, and rings across the picture and result in internal reflection and scattering from material inhomogenities in lens (such as multiple surfaces). The shape of the flares also depends on the shape of aperture. These features conform at least qualitatively with what one would expect from a diffraction if Planck constant is large enough for photons with energy of visible photon.

   The article [53] defines flares in more restrictive manner: lense flares result when *non-image* forming light enters the lens and subsequently hits the camera's film or digital sensor and produces typically polygonal shape with sides which depend on the shape of lense diaphgram. The identification as a flare applies also to the apparent decomposition to rays and this dependence indeed fits with the observations.

The experimentation of Samppa using digital camera demonstrated the appearance of colored spots in the pictures. If I have understood correctly, the sensors defining the pixels of the picture are in the focal plane and the diffraction for large Planck constant might explain the phenomenon. Since I did not have the idea about diffractive mechanism in mind, I did not check whether fainter colored rings might surround the bright spot.

1. In any case, the readily testable prediction is that zooming to bright light source by reducing the size of the aperture should increase the size and number of the colored spots. As a matter fact, experimentation demonstrated that focusing brought in large number of these spots but we did not check whether the size was increased.

2. Standard explanation predicts that the bright spots are present also with weaker illumination but with so weak intensity that they are not detected by eye. The positions of spots should also depend only on the illumination and camera. The explanation in terms of beams of large Planck constant photons predicts this if the flux of dark photons from any light source is constant.

### 6.2.6 Dark matter and exotic color and electro-weak interactions

The presence of classical electro-weak and color gauge fields in all length scales is an unavoidable prediction of TGD and the interpretation in terms of hierarchy of dark matters in some sense is also more or less unavoidable.

#### Does dark matter provide a correct interpretation of long ranged classical electro-weak gauge fields?

For two decades one of the basic interpretational challenges of TGD has been to understand how the un-avoidable presence of long range classical electro-weak gauge fields can be consistent with the small parity breaking effects in atomic and nuclear length scales. Also classical color gauge fields are predicted, and I have proposed that color qualia correspond to increments of color quantum numbers [K3]. The proposed model for screening cannot banish the unpleasant feeling that the screening cannot be complete enough to eliminate large parity breaking effects in atomic length scales so that one one must keep mind open for alternatives.

p-Adic length scale hypothesis suggests the possibility that both electro-weak gauge bosons and gluons can appear as effectively massless particles in several length scales and there indeed exists evidence that neutrinos appear in several scaled variants [75] (for TGD based model see [F3]).

This inspires the working hypothesis that long range classical electro-weak gauge and gluon fields are correlates for light or massless dark electro-weak gauge bosons and gluons.

1. In this kind of scenario ordinary quarks and leptons could be essentially identical with their standard counterparts with electro-weak charges screened in electro-weak length scale so that the problems related to the smallness of atomic parity breaking would be trivially resolved.

2. In condensed matter blobs of size larger than neutrino Compton length (about 5 $\mu$m if $k = 169$ determines the p-adic length scale of condensed matter neutrinos) the situation could be different. Also the presence of dark matter phases with sizes and neutrino Compton lengths corresponding to the length scales $L(k)$, $k = 151, 157, 163, 167$ in the range 10 nm-2.5 $\mu$m are suggested by the number theoretic considerations (these values of $k$ correspond to so called Gaussian Mersennes [K2]). Only a fraction of the condensed matter consisting of regions of size $L(k)$ need to be in the dark phase.

3. Dark quarks and leptons would have masses essentially identical to their standard model counterparts. Only the electro-weak boson masses which are determined by a different mechanism than the dominating contribution to fermion masses [F2, F3] would be small or vanishing.

4. The large parity breaking effects in living matter would be due to the presence of dark nuclei and leptons. Later the idea that super-fluidity corresponds to $Z^0$ super-conductivity will be discussed: it might be that also super-fluid phase corresponds to dark neutron phase.

The basic prediction of TGD based model of dark matter as a phase with a large value of Planck constant is the scaling up of various quantal length and time scales. A simple quantitative model for condensed matter with large value of $\hbar$ predicts that $\hbar$ is by a factor $\sim 2^{11}$ determined by the ratio of $CP_2$ length to Planck length larger than in ordinary phase meaning that the size of dark neutrons would be of order atomic size. In this kind of situation single order parameter would characterize the behavior of dark neutrinos and neutrons and the proposed model could apply as such also in this case.

Dark photon many particle states behave like laser beams decaying to ordinary photons by decoherence meaning a transformation of dark photons to ordinary ones. Also dark electro-weak bosons and gluons would be massless or have small masses determined by the p-adic length scale in question. The decay products of dark electro-weak gauge bosons would be ordinary electro-weak bosons decaying rapidly via virtual electro-weak gauge boson states to ordinary leptons. Topological light rays ("massless extremals") for which all classical gauge fields are massless are natural space-time correlates for the dark boson laser beams. Obviously this means that the basic difference between the chemistries of living and non-living matter would be the absence of electro-weak symmetry breaking in living matter (which does not mean that elementary fermions would be massless).

In super-canonical conformal weights are non-vanishing and can vary then Fermi statistics allows neutrinos to have same energy if their conformal weights are different so that a kind "fermionic Bose-Einstein condensate" would be in question. If both nuclear neutrons and neutrinos are in dark phase, it is possible to achieve a rather complete local cancellation of $Z^0$ charge density.

The model for neutrino screening was developed years before the ideas about the identification of the dark matter emerged. The generalization of the discussion to the case of dark matter option should be rather trivial and is left to the reader as well as generalization of the discussion of the effects of long range $Z^0$ force on bio-chemistry.

### Criterion for the presence of exotic electro-weak bosons and gluons

Classical gauge fields directly are space-time correlates of quantum states. The gauge fields associated with massless extremals ("topological light rays") decompose to free part and a part having non-vanishing divergence giving rise to a light-like Abelian gauge current. Free part would correspond to Bose-Einstein condensates and current would define a coherent state of dark photons.

The dimension $D$ of the $CP_2$ projection of the space-time sheet serves as a criterion for the presence of long ranged classical electro-weak and gluon fields. $D$ also classifies the (possibly asymptotic) solutions of field equations [D1].

1. For $D = 2$ induced gauge fields are Abelian and induced Kähler form vanishes for vacuum extremals: in this case classical em and $Z^0$ fields are proportional to each other. The non-vanishing Kähler field implies that induced gluon fields are non-vanishing in general. This raises the question whether long ranged color fields and by quantum classical correspondence also long ranged QCD accompany non-vacuum extremals in all length scales. This makes one wonder whether color confinement is possible at all and whether scaled down variants of QCD appear in all length scales.

   The possibility to add constants to color Hamiltonians appearing in the expression of the classical color gauge fields allows to have vanishing color charges in the case of an arbitrary space-time sheet. The requirement that color quantum numbers of the generator vanish allows to add the constant only to the Hamiltonians of color hyper charge and isospin so that for $D = 2$ extremals color charges can be made vanishing. This might allow to understand how color confinement is consistent with long ranged induced Kähler field.

2. For $D \geq 3$ all classical long ranged electro-weak fields and non-Abelian color fields are present. This condition is satisfied when electric and magnetic fields are not orthogonal and the instanton density $A \wedge J$ for induced Kähler form is non-vanishing. The rather strong conclusion is that in length scales in which exotic electro-weak bosons are not present, one has $D = 2$ and gauge fields are Abelian and correspond trivially to fixed points of renormalization group realized as a hydrodynamic flow at space-time sheets [C3].

Quantum classical correspondence suggests the existence of electro-weak gauge bosons with mass scale determined by the size of the space-time sheets carrying classical long range electro-weak fields. This would mean the existence of new kind of gauge bosons.

The obvious objection is that the existence of these gauge bosons would be reflected in the decay widths of intermediate gauge bosons. The remedy of the problem is based on the notion of space-time democracy suggested strongly by the fact that the interactions between space-time sheets possessing different p-adic topologies proceed with very slow rates simply because the number of common rational (algebraic) points of partonic 2-surfaces appearing in the vertex is small.

For light exotic electro-weak bosons also the corresponding leptons and quarks would possess a large weak space-time sheet but lack the ordinary weak partonic 2-surface so that there would be no direct coupling to electro-weak gauge bosons. These space-time sheets are dark in weak sense but need not have a large value of $\hbar$. This picture implies the notion of partial darkness since any space-time sheets with different ordinary of Gaussian primes are dark with respect to each other.

**Do Gaussian Mersennes define a hierarchy of dark electro-weak physics?**

Gaussian Mersennes are defined as Gaussian primes of form $g_n = (1+i)^n - 1$, where $n$ must be prime. They have norm squared $g\overline{g} = 2^n - 1$. The list of the first Gaussian Mersennes corresponds to the following values of $n$.

2, 3, 5, 7, 11, 19, 29, 47, 73, 79, 113, 151, 157, 163, 167, 239, 241, 283, 353, 367, 379, 457, 997, 1367, 3041, 10141, 14699, 27529, 49207, 77291, 85237, 106693, 160423 and 203789.

The Gaussian primes $k = 113, 151, 157, 163, 167$ correspond to length scales which are of most obvious interest but in TGD framework one cannot exclude the twin prime $239, 241$ corresponds to length scales $L(k) \simeq 160$ km and 320 km. Also larger primes could be of relevant for bio-systems and consciousness. Also the secondary and higher length scales associated with $k < 113$ could be of importance and their are several length scales of this kind in the range of biologically interesting length scales. Physics and biology inspired considerations suggests that particular Gaussian primes correspond to a particular kind of exotic matter, possibly also to large $\hbar$ phase.

$k = 113$ corresponds to the electromagnetic length scale of $u$ and $d$ quarks and nuclear p-adic length scale. For dark matter these length scales are scaled up by a factor $\sim 2^{11}n$, where $n$ is an integer. For $k = 113$ one obtains atomic length scale .8 A for $n = 1$. $k = 151, 153, 163, 167$ correspond to biologically important p-adic length scales varying in the range 10 nm-2.5 $\mu$m with the scaled up length scales varying in the range 2 $\mu$m- 5 mm.

On basis of biological considerations (large parity breaking in living matter) there is a temptation to assign to these length scales a scaled down copy of electro-weak physics and perhaps also of color physics. The mechanism giving rise to these states would be a phase transition transforming the ordinary $k = 89$ Mersenne of weak space-time sheets to a Gaussian Mersenne and thus increasing its size dramatically.

If given space-time sheet couples considerably only to space-time sheets characterized by same prime or Gaussian prime, the bosons of these physics do not couple directly to ordinary particles, and one avoids consistency problems due to the presence of new light particles (consider only the decay widths of intermediate gauge bosons [F5]) even in the case that the loss of asymptotic freedom is not assumed.

A question arises about the interpretation of structures of the predicted size. The strong interaction size of u and $d$ quarks, hadrons, and nuclei is smaller than $L(k = 113) \simeq 2 \times 10^{-4}$ m for even heaviest nuclei if one accepts the formula $R \sim A^{1/3} \times 1.5 \times 10^{-15}$ m. A natural interpretation for this length scale would be as the size of the field body/magnetic body of system defined by its topologically quantized gauge fields/magnetic parts of gauge fields. The (possibly dark) p-adic length scale characterizes also the lengths of join along boundaries bonds feeding gauge fluxes from elementary particle to the space-time sheet in question. The delocalization due these join along boundaries bonds in p-adic length scale in question would determine the scale of the contribution to the mass squared of the system as predicted by p-adic thermodynamics.

### 6.2.7 Anti-matter and dark matter

The usual view about matter anti-matter asymmetry is that during early cosmology matter-antimatter asymmetry characterized by the relative density difference of order $r = 10^{-9}$ was somehow generated and that the observed matter corresponds to what remained in the annihilation of quarks and leptons to bosons. A possible mechanism inducing the CP asymmetry is based on the CP breaking phase of CKM matrix.

The TGD based view about energy [D3, D5] forces the conclusion that all conserved quantum numbers including the conserved inertial energy have vanishing densities in cosmological length scales. Therefore fermion numbers associated with matter and antimatter must compensate each other. Therefore the standard option is definitely excluded in TGD framework.

An early TGD based scenario explains matter antimatter asymmetry by assuming that antimatter is in vapor phase. This requires that matter and antimatter have slightly different topological evaporation rates with the relative difference of rates characterized by the parameter $r$. A more general scenario assumes that matter and antimatter reside at different space-time sheets. The reader can easily guess the next step. The strict non-observability of antimatter finds an elegant explanation if anti-matter is dark matter.

## 6.3 Dark variants of nuclear physics

The book metaphor for the extended imbedding space can be utilized as a guideline as one tries to imagine various exotic phases of matter. Atomic nuclei are assumed to be ordinary (in the sense of nuclear string model!) and only field bodies can be dark. They are analogous to $n$-sheeted Riemann surfaces. Nuclei can be visualized as residing at the "standard" pages of the book and dark color-/weak-/em- bonds are at different pages with different p-adic length scale or having different Planck constant $\hbar_{eff}$. This would give two hierarchies of nuclei with increasing size.

### 6.3.1 Constraints from the nuclear string model

In the case of exotic nuclei nuclear string model [F9] is a safe starting point. In this model nucleons are connected by color flux tubes having exotic light fermion and antifermion at their ends. Whether fermion is quark or colored excitation of lepton remains open question at this stage. The mass of the exotic fermion is much smaller than 1 MeV (p-adic temperature $T = 1/n < 1$). This model predicts large number of exotic states since color bonds, which can be regarded as colored pions, can have em charges (1,-1,0). In particular, neutral variant of deuterium is predicted and this leads to a model of cold fusion explaining its basic selection rules. The earlier model for cold fusion discussed in [F8], which served as a constraint in the earlier speculations, is not so simple than the model of [F9] .

What is important that the model requires that weak bosons for which Compton length is of order atomic size are involved. Weak bosons would behave as massless particles below the Compton and the rates for the exchanges of weak bosons would be high in the length scales considered. Weak bosons would correspond to scaled up variants of the ordinary weak bosons: scaling could be p-adic in which mass scale is reduced and weak interaction rates even above Compton length would be scaled up as $1/M_W^4$. The scaling could result also from the scaling of Planck constant in which case masses of weak bosons nor weak interaction rates in the lowest order would not be affected. If only dark scaling is involved, weak interactions would be still extremely weak above dark Compton length of weak bosons. Of course, both scalings can be imagined.

The scale of the color binding energy is $E_s = .2$ MeV for ordinary $^4He$ strings [D4]. $k = 151, 157, 163, 167$ define Gaussian Mersennes $G_k^{=}(1+i)^k - 1$ and excellent candidates for biologically important p-adic length scales. If $M_{127}$ is scaled up to Gaussian Mersenne $G_{167}$, one obtains cell-nucleus sized (5 $\mu$m) exotic nuclei and the unit of color binding energy is still .2 eV. For p-adic length scale of order 100 $\mu$m (size of large neuron) the energy scale is still around thermal energy at room temperature.

In the case of dark color bonds it is not quite clear how the unit $E_s$ of the color binding energy scales. If color Coulombic energy is in question, one expects $1/\hbar^2$ scaling. Rather remarkably, this scaling predicts that the unit for the energy of $A < 4$ color bond scales down to .5 eV which is the energy of hydrogen bond so that hydrogen bonds, and also other molecular bonds, might involve color bonds between proton and oxygen.

### 6.3.2 Constraints from the anomalous behavior of water

$H_{1.5}O$ behavior of water with respect to neutron and electron scattering is observed in attosecond time scale which corresponds to 3 Angstrom length scale, defining an excellent candidate for the size scale of exotic nuclei and Compton length of exotic weak interactions.

#### What happens to the invisible protons?

A possible explanation for the findings is that one fourth of protons forms neutral multi-proton states connected by possibly negatively charged color bonds of length differing sufficiently from the length of ordinary O-H bond. Although the protons are ordinary, neutron diffraction reflecting the crystal like order of water in atomic length scales would not see these poly-proton super-nuclei if they form separate closed strings.

1. For the ordinary nuclei the p-adic length scale associated with the color bonds between $^4He$ corresponds to $M_{127}$, and one can imagine exotic nuclear strings obtained by connecting two ordinary nuclei with color bonds. If second exotic nucleus is neutral (the model of cold fusion assumes that $D$ nucleus is neutral) this could work since the Coulomb wall is absent. If the

exotic nuclei have opposite em charges, the situation improves further. New super-dense phases of condensed matter would be predicted.

If one fourth of hydrogen nuclei of water combine to form possibly neutral nuclear strings with average distance of nuclei of order $L(127)$, they are not visible in diffraction at atomic length scale because the natural length scale is shortened by a factor of order 32 but could be revealed in neutron diffraction at higher momentum exchanges. The transition between this kind of phase and ordinary nuclei would be rather dramatic event and the exchanges of exotic weak bosons with Compton lengths of order atomic size induce the formation of this kind of nuclei (this exchange is assumed in the model of cold fusion).

2. If dark color magnetic bonds are allowed, a natural distance between the building blocks of super-nuclei is given by the size scale of the color magnetic body. The size scales of dark color magnetic bodies associated with nuclear strings consisting of $^4He$, $^4He$ and $A \leq 3$ color magnetic bodies would be $L(127+22=149) = 5$ nm, $L(118+22=140) = 2.2$ Angstrom, and $L(116+22=138) = 1.1$ Angstrom. The first scale equals to the thickness of lipid layer of cell membrane which suggests a direct connection with biology. The latter two scales correspond to molecular length scales and it is not clear why the protons of dark nuclear strings of this kind would not be observed in electron and neutron scattering. This would leave only nuclear strings formed from $^4He$ nuclei into consideration.

   The crucial parameter is the the unit $E_s$ of the color binding energy. Since this parameter should correspond to color Coulombic potential it could transform like the binding energy of hydrogen atom and therefore scale as $1/hbar^2$. This would mean that $E_s = 2.2$ MeV deduced from the deuteron binding energy would scale down to .5 eV for $n = 2^{11}$. This is the energy of hydrogen bond so that hydrogen bonds might have interpretation as color bonds between nuclei. Nuclear color bonds could serve as prerequisites for the formation of bond at level of valence electrons also in the case of other bonds.

   For $^4He$ color bonds one would obtain $E_s = .05$ for so that the invisible protons could also belong to dark $^4He$ nuclear strings. The predicted $E_s = .05$ eV is very near to the energy associated with the membrane potential at the threshold for the generation of nerve pulse.

3. The third option is that color bonds have $n = 3 \times 2^{11}$ instead of $n = 2^{11}$. The color bond would be 9 times longer and probably also the distance between color bonded protons would be longer. In this case one would have $E_s = .056$ eV which is also near to the value of action potential.

The transition between the dark and ordinary nuclei would be favored by the minimization of Coulomb energy and energy differences would be small because of darkness. The transitions in which ordinary proton becomes dark and fuses to super-nuclear string or vice versa could be the basic control mechanism of bio-catalysis. Metabolic energy quantum .5 eV should relate to this transition.

Magic nuclei could have fractally scaled up variants in molecular length scale and tedrahedral and icosahedral water clusters could correspond to $A = 8$ and $A = 20$ magic nuclei with color bonds connecting nucleons belonging to different dark nuclei.

**About the identification of the exotic weak physics?**

The model of cold fusion requires exotic weak physics with the range of weak interaction of order atomic radius.

1. One can consider the possibility of $k = 113$ dark weak physics with $n = 2^{11}$. Weak Compton length for $k = 113$ dark weak bosons would be about 1.5 Angstrom. Above $L(135)$ weak bosons would have the mass scale $2^{-12}m_W \sim 25$ MeV and weak rates would be scaled up by $2^{48}$. In [F9] it is proposed that isospin dependent strong force is nothing but a scaled variant of electro-weak force appearing as several fractally scaled up variants. Bohr radius would represent a critical transition length scale and exotic weak force could have dramatic implications for the behavior of the condensed matter in high pressures when exotic weak force would become visible.

2. Also exotic weak bosons corresponding to the ordinary value of Planck constant and to the atomic length scale $k = 137$ could be present. In this case the weak mass scale would be $2^{-24}m_W \sim 6$ eV and Compton length would be 3 Angstroms. New eV scale weak physics possibly relevant

for molecular physics would be predicted. The transitions between nuclear strings and ordinary nuclei would involve nuclear energies so that this option is not favored as an explanation of $H_{1.5}O$ anomaly.

To sum up, it would seem that the variant of ordinary nuclear physics obtained by making color bonds and weak bonds dark is the most promising approach to the $H_{1.5}O$ anomaly and cold fusion. Exotic weak bosons with Compton wave length of atomic size and the most natural assumption is that they are dark $k = 113$ weak bosons. One variant of exotic atoms is as atoms for which electromagnetic interaction between ordinary nuclei and ordinary electrons is mediated along dark topological field quanta.

### 6.3.3 Exotic chemistries and electromagnetic nuclear darkness

The extremely hostile and highly un-intellectual attitude of skeptics stimulates fear in anyone possessing amygdala, and I am not an exception. Therefore it was a very pleasant surprise to receive an email telling about an article published in April 16, 2005 issue of New Scientist [48]. The article gives a popular summary about the work of the research group of Walter Knight with Na atom clusters [49] and of the research group of Welford Castleman with Al atom clusters [50].

The article tells that during last two decades a growing evidence for a new kind of chemistry have been emerging. Groups of atoms seem to be able to mimic the chemical behavior of single atom. For instance, clusters of 8, 20, 40, 58 or 92 sodium atoms mimic the behavior of noble gas atoms [49]. By using oxygen to strip away electrons one by one from clusters of Al atoms it is possible to make the cluster to mimic entire series of atoms [50]. For aluminium cluster-ions made of 13, 23 and 37 atoms plus an extra electron are chemically inert.

One can imagine two explanations for the findings.

1. The nuclei are dark in the sense that the sizes of nuclear space-time sheets are scaled up implying the smoothing out of the nuclear charge.

2. Only electrons are dark in the sense of having scaled up Compton lengths so that the size of multi-electron bound states is not smaller than electron Compton length and electrons "see" multi-nuclear charge distribution.

If darkness and Compton length is assigned with the em field body, it becomes a property of interaction, and it seems impossible to distinguish between options 1) and 2).

#### What one means with dark nuclei and electrons?

Can the idea about dark nuclei and electrons be consistent with the minimalist picture in which only field bodies are dark? Doesn't the darkness of nucleus or electron mean that also multi-electron states with $n$ electrons are possible?

The proper re-interpretation of the notion Compton length would allow a consistency with the minimalist scenario. If the p-adic prime labelling the particle actually labels its electromagnetic body as p-adic mass calculations for quark masses encourage to believe, Compton length corresponds to the size scale of the electromagnetic field body and the models discussed below would be consistent with the minimal scenario. Electrons indeed "see" the external charge distribution by their electromagnetic field body and field body also carries this distribution since $CP_2$ extremals do not carry it. One could also defend this interpretation by saying that electrons is operationally only what can be observed about it through various interactions and therefore Compton length (various Compton length like parameters) must be assigned with its field body (bodies).

Also maximal quantum criticality implies that darkness is restricted to field bodies but does not exclude the possibility that elementary particle like structures can possess non-minimal quantum criticality and thus possess multi-sheeted character.

#### Option I: nuclei are electromagnetically dark

The general vision about nuclear dark matter suggests that the system consists of super-nuclei analogous to ordinary nuclei such that electrons are ordinary and do not screen the Coulomb potentials of atomic nuclei.

The simplest possibility is that the electromagnetic field bodies of nuclei or quarks become dark implying delocalization of nuclear charge. The valence electrons would form a kind of mini-conductor with electrons delocalized in the volume of the cluster. The electronic analog of the nuclear shell model predicts that full electron shells define stable configurations analogous to magic nuclei. The model explains the numbers of atoms in chemically inert Al and Ca clusters and generalizes the notion of valence to the level of cluster so that the cluster would behave like single super-atom.

The electromagnetic $k = 113$ space-time sheets (em field bodies) of quarks could have scaled up size $nL(113)/v_0 = n2^{11} \times 2 \times 10^{-14}$ m, $n = 1, 2, 3$. One would have atomic size 1 Angstrom for $n = 1$. A suggestive interpretation is that the electric charge of nuclei or valence quarks assignable to their field bodies is delocalized quantum mechanically to atomic length scale. Electrons would in a good approximation experience quantum mechanically the nuclear charges as a constant background, jellium, whose effect is indeed modellable using harmonic oscillator potential.

One can test the proposed criterion for the phase transition to darkness. The unscreened electromagnetic interaction energy between a block of partially ionized nuclei with a net em charge $Z$ with $Z$ electrons would define the relevant parameter as $r \equiv Z^2\alpha$. For the total charge $Z \geq 12$ the condition $r \geq 1$ is satisfied. For a full shell with 8 electrons this condition is not satisfied.

#### Option II: Electrons are electro-magnetically dark

Since the energy spectrum of harmonic oscillator potential is invariant under the scaling of $\hbar$ accompanied by the opposite scaling of the oscillator frequency $\omega$, one must consider also the em bodies of electrons are in large $\hbar$ phase (one can of course ask whether they could be observed in this phase!). The rule would be that the size of the bound states is larger than the scaled up electron Compton length.

The Compton wavelength of electrons would be scaled up by a factor $n2^{11}$, $n = 1, 3, 5$, where $n$ is product of different Fermat primes, and correspond to $\sim n \times 5$ nm. The atomic cluster of this size would contain roughly $n \times 10^4(a_0/a)^3$ atoms where $a$ is atomic volume and $a_0 = 1$ Angstrom is the natural unit.

The shell model of nucleus is in TGD framework a phenomenological description justified by nuclear string model with string tension responsible for the oscillator potential. This leads to ask whether the electrons of jellium actually form analogs of nuclear strings with electrons connected by color bonds.

## 6.4 Has dark matter been observed?

In this section two examples about anomalies perhaps having interpretation in terms of quantized Planck constant are discussed. The first anomaly belongs to the realm of particle physics and hence does not quite fit the title of the chapter. Second anomaly relates to nuclear physics.

### 6.4.1 Optical rotation of a laser beam in a magnetic field

The group of G. Cantatore has reported an optical rotation of a laser beam in a magnetic field [87]. The experimental arrangement involves a magnetic field of strength $B = 5$ Tesla. Laser beam travels 22000 times forth and back in a direction orthogonal to the magnetic field travelling 1 m during each pass through the magnet. The wavelength of the laser light is 1064 nm. A rotation of $(3.9 \pm .5) \times 10^{-12}$ rad/pass is observed.

A possible interpretation for the rotation would be that the component of photon having polarization parallel to the magnetic field mixes with QCD axion, one of the many candidates for dark matter. The mass of the axion would be about 1 meV. Mixing would imply a reduction of the corresponding polarization component and thus in the generic case induce a rotation of the polarization direction. Note that the laser beam could partially transform to axions, travel through a non-transparent wall, and appear again as ordinary photons.

The disturbing finding is that the rate for the rotation is by a factor $2.8 \times 10^4$ higher than predicted. This would have catastrophic astrophysical implications since stars would rapidly lose their energy via axion radiation.

TGD predicts the existence of a hierarchy of QCD type physics based on the predicted hierarchy of scaled up variants of quarks and also those of color excited leptons. The fact that these states are not seen in the decay widths of intermediate gauge bosons can be understood if the particles in question are dark matter with non-standard value of Planck constant and hence residing at different page of the book like structure formed by the imbedding space. I have discussed in detail the general model in case of leptohadrons consisting of colored excitation of ordinary lepton and explaining quite an impressive bundle of anomalies [F7]. Since leptopion has quantum numbers of axion and similar couplings, it is natural to propose that the claimed axion like particle -if it indeed exists- is a pion like state consisting either exotic light quarks or leptons.

### Could the optical rotation be caused by a pion of a scaled down copy of ordinary QCD

The motivation for introducing axion was the large CP breaking predicted by the standard QCD. No experimental evidence has been found has been found for this breaking. The idea is to introduce a new broken U(1) gauge symmetry such that is arranged to cancel the CP violating terms predicted by QCD. Because axions interact very weakly with the ordinary matter they have been also identified as candidates for dark matter particles.

In TGD framework there is special reason to expect large CP violation analogous to that in QCD although one cannot completely exclude it. Axions are however definitely excluded. TGD predicts a hierarchy of scaled up variants of QCD and entire standard model plus their dark variants corresponding to some preferred p-adic length scales, and these scaled up variants play a key role in TGD based view about nuclear strong force [F8, F9], in the explanation of the anomalous production of $e^+e^-$ pairs in heavy nucleus collisions near Coulomb wall [F7], high $T_c$ superconductivity [J1, J2, J3] and also in the TGD based model of living matter [M3]. Therefore a natural question is whether the particle in question could be a pion of some scaled down variant of QCD having similar coupling to electromagnetic field. Also dark variants of this pion could be considered.

What raises optimism is that the Compton length of the scaled down quarks is of the same order as cyclotron wavelength of electron in the magnetic field in question. For the ordinary value of Planck constant this option however predicts quite too high mixing rate. This suggests that dark matter has been indeed observed in the sense that the pion corresponds to a large value of Planck constant. Here the encouraging observation is that the ratio $\lambda_c/\lambda$ of wavelength of cyclotron photon and laser photon is $n = 2^{11}$, which corresponds to the lowest level of the biological dark matter hierarchy with levels characterized the value $\hbar(M^4_\pm) = 2^{11k}\hbar_0$, $k = 1, 2, ....$

The most plausible model is following.

1. Suppose that the photon transforms first to a dark cyclotron photon associated with electron at the lowest $n = 2^{11}$ level of the biological dark matter hierarchy. Suppose that the coupling of laser photon to dark photon can be modelled as a coefficient of the usual amplitude apart from a numerical factor of order one equal to $\alpha_{em}(n) \propto 1/n$.

2. Suppose that the coupling $g_{\pi NN}$ for the scaled down hadrons is proportional to $\alpha_s^4(n) \propto 1/n^4$ as suggested by a simple model for what happens for the nucleon and pion at quark level in the emission of pion.

Under these assumptions one can understand why only an exotic pion with mass of 1 meV couples to laser photons with wavelength $\lambda = 1$ $\mu$m in magnetic field $B = 5$ Tesla. The general prediction is that $\lambda_c/\lambda$ must correspond to preferred values of $n$ characterizing Fermat polygons constructible using only ruler and compass, and that the rate for the rotation of polarization depends on photon frequency and magnetic field strength in a manner not explained by the model based on the photon-axion mixing.

### Scaled up variant of PCAC

Consider first briefly the scaled up variant of partially conserved axial current hypothesis (PCAC).

1. The mass of the particle would be around 1 meV. If a scaled down ordinary pion is in question, the mass ratio $m_\pi/m_A \simeq 140 \times 10^9 \sim 2^{37}$ suggests that the space-time sheet associated with gluons of this QCD is related by p-adic scale in question corresponds to $k = 107 + 2 \times 37 = 181$, which is prime and corresponds to p-adic length scale $L(181) = .327$ mm. The predicted pion mass from exact scaling would be 1.1 meV. This pion does not couple to ordinary quarks and therefore this coupling does not affect astrophysics at the level of visible matter. The parameter $\Lambda_{QCD,181}$ would be obtained by the scaling $\Lambda_{QCD}(181) = 2^{-37}\Lambda_{QCD}(107)$.

2. The interaction of pion and photons is fixed completely by the anomaly of axial current [19]

$$\langle 0|A^j_\mu(x)|\pi^k\rangle = i\delta^{jk}p_\mu f_\pi exp^{-ip\cdot x} \quad . \tag{6.4.1}$$

Here $f_\pi \simeq 93$ MeV characterizes the matrix element of axial current between vacuum and single-pion state and thus the decay rate of pion.

The form of the interaction is exactly the same as in the case of axion and given by the interaction Lagrangian

$$\begin{aligned} L &= k_{em}\pi F\wedge F \quad , \\ k_{em} &= \frac{e^2}{32\pi^2 f_\pi} \quad . \end{aligned} \tag{6.4.2}$$

The detailed arguments leading to the expression for $k_{em}$ can be found in [19].

3. Axial current anomaly implies that the divergence of the axial current is proportional to the pion field. Writing the most general form for the matrix element of the axial current between nucleon states, this gives a relationship between pion-nucleon coupling $g_{\pi NN}$ and pion decay rate $f_\pi$:

$$\begin{aligned} \frac{g_A(0)}{f_\pi} &= \frac{g_{\pi NN}}{m_N} \quad , \\ g_A(0) &= \frac{G_A}{G_V} \quad . \end{aligned} \tag{6.4.3}$$

One has $m_N = .94$ GeV, $g^2_{\pi NN}/4\pi = 14.6$. $g_A(0) = G_A/G_V = 1.22$ is the ratio of axial and vectorial weak couplings for the fermion at zero momentum transfer. Te relationship follows from the conservation of axial current between nucleon and states that the coefficient of the term $q^\mu\overline{u}\gamma_5 u$ in the axial current matrix element between two nucleon states has a pole corresponding to the exchange of approximately massless pion. This formula generalizes trivially for the scaled up variants of QCD. The photon-axion mixing rate is proportional to $1/m_N$, where $m_N$ is the mass of the exotic nucleon.

### Comparison with the axion model

Let us compare the predictions of this model with the predictions of the axion model.

1. Axion-photon interaction Lagrangian has exactly the same form as $\pi^0\gamma\gamma$ interaction Lagrangian. The parameter $f_a$ for the axion satisfies the condition

$$f_a \simeq \frac{\Lambda^2_{QCD}}{m_a} \quad . \tag{6.4.4}$$

Here one has $m_a \simeq 1$ meV and $\Lambda_{QCD} \simeq .2$ GeV.

2. From the fact that the rate is by a factor $r = 2.8\times 10^4$ higher than the rate expected for QCD axion with mass $m_a \simeq 1$ meV one can deduce that the mass scale of the exotic $u$ and $d$ quarks. The condition that the two decay rates differ by the factor $R = 2.8\times 10^4$ reads as

$$\frac{g_{A,e}(0)}{g_{\pi_e N_e N_e}} \times m_{N_e} = \frac{1}{\sqrt{R}} \frac{\Lambda^2_{QCD}}{m_a} , \qquad (6.4.5)$$

where the right hand side refers to the exotic nucleon and pion. The parameter $g_{A,e}$ can be assumed to be near to one.

Suppose first that exotic pion is not dark and that $g_{\pi_e N_e N_e} = g_{\pi NN}$ holds true. The small mass of axion implies that the right hand side is about $2.4 \times 10^5$ GeV so that $m_{N_e}$ should be by a factor about $3.2 \times 10^6 \sim 2^{22}$ larger than $m_N$ and corresponding quarks would roughly correspond to $k \sim 73$. This is in in contradiction with what one would expect. Basically the large decay constant of exotic pion $\propto 1/m_N$ is in conflict with the very small decay constant of axion proportional to $\propto m_a/\Lambda^2$.

Consider now various options which could cure the problem.

Option I: The first dark matter option option is that one has $\hbar = n\hbar_0$ and $g_{\pi_e N_e N_e}$ is by a factor $1/n^k \simeq 2^{-60} \simeq 10^{-18}$ smaller than $g_{\pi NN}$. The factor comes from the overall reduction factor $3.2 \times 10^6 \sim 2^{22}$ of $1/f_\pi$ and from the fact that nucleon mass scale should be reduced roughly by a factor $\sim 2^{-37}$ (just like pion mass scale).

This could be understood if the pion exchange involves the emission of $k$ virtual gluons implying $g_{\pi_e N_e N_e} \propto \alpha_s^k \propto 1/n^k$. One virtual gluon would decay to pion and two additional exchanges are necessary since all three valence quarks of nucleon must interact: hence $k = 3$ is the minimal option. One can also argue that the quarks resulting in the decay of virtual gluon must exchange at least one gluon to become a pion. This would give $1/n^4$ behavior giving the estimate $n = 2^{15}$ assuming $g_{\pi_e N_e N_e} = g\alpha_s^4$, with $g$ having no dependence on $\alpha_s$. The higher powers of $\alpha_s$ in the expansion of $g_{\pi NN}$ are important for ordinary hadrons physics but small for its dark variants so that the estimate is just a rough order of magnitude estimate if even that.

Option II: One can consider also the possibility that the space-time sheet of the magnetic field is dark so that the disappearance of photons from the laser beam involves a transformation to a dark photon followed by a transformation to a dark neutral pion in the magnetic field used. This would mean that the amplitude for the process would involve an additional dimensionless factor $g_{\gamma\gamma_d} \propto \alpha_{em} \propto 1/\hbar$. This would predict $n \simeq 2^{53}$ and values of this order of magnitude are possible in the model of living matter [M3]. The smallness of this amplitude could explain the discrepancy. This option is however not very plausible.

Option III: The third option would be a combination of the first two so that the vertex would contain the factor $g_{\gamma\gamma_d} g_{\pi_e N_e N_e} = \alpha_{em} g_{\pi NN} n^{-1-k}$. For $k = 4$ one would have $n^5 \sim 2^{53}$ suggesting $n = 2^{11}$ corresponding to the lowest level in the hierarchy of preferred scaling factors $n = 2^{k11}$ of $\hbar = n\hbar_0$ in living matter. If laser photons are dark photons themselves then $g_{\pi NN} = k\alpha_s^5$ would give the same prediction. Note that the presence of higher powers of $\alpha_s$ in the expansion of $g_{\pi NN}$ could affect these conclusions.

**Transformation of laser photons to dark cyclotron photons to exotic pions as the basic mechanism**

The cyclotron wave length of electron in a magnetic field of 5 Tesla equals to $\lambda_c = 2$ mm and one has $\lambda_c/\lambda = 2^{11}$. This intriguing finding suggests that $\lambda_c$ corresponds to the wavelength of dark variant of laser photon at $k = 1$ level of this hierarchy. One can therefore ask whether the basic mechanism is the transformation of the laser photon to a dark cyclotron photon with $\hbar = 2^{11}\hbar_0$ and its mixing with the $k = 181$ exotic pion.

This would predict that the effect is sensitive to the ratio $\lambda_c/\lambda$ which should be near $n = 2^{11}$, or to a more general preferred value of $n$. The preferred values for the scaling factors $n$ of $\hbar$ correspond to n-polygons constructible using ruler and compass. The values of $n$ in question are given by $n_F = 2^k \prod_i F_{s_i}$, where the Fermat primes $F_s = 2^{2^s} + 1$ appearing in the product are distinct. The lowest Fermat primes are $3, 5, 17, 257, 2^{16} + 1$. In the model of living matter the especially favored values of $\hbar$ come as powers $2^{k11}$.

*Can one understand the mass scale of the exotic pion?*

The model predicts preferred values for the ratio $\lambda_c/\lambda$ and the experiments correspond to the lowest value of this ratio for biological dark matter hierarchy. In order to be taken seriously the model should also tell why just the scaled up variant of QCD with $m_\pi \simeq 1$ meV is involved.

Also this could relate somehow to the properties of the magnetic field. The frequency associated with the cyclotron photons emitted by electron in the magnetic field is $f = eB/m_e$ and for $B = 5$ Tesla the corresponding wave length is $\lambda_c = 2$ mm to be compared with $L(181) = .327$ mm. As already noticed, $\lambda_c = 2^{11}\lambda$, where $2^{11}\lambda$ is the wavelength of the dark variant of laser photon. Hence it is natural to assume that $\lambda_c$ corresponds to an characteristic p-adic length scale for the exotic QCD in question.

The p-adic length scale $L(113)$ of u and d quarks is related by a factor 8 to gluon length scale $L(107)$. This would predict that exotic u and d quark correspond to $L(187) = 2.6$ mm to be compared with $\lambda_c = 2$ mm. Hence the latter scale might relate to the p-adic length scales characterizing the Compton lengths of exotic u and d quarks. The prediction would be that the mixing rate depends on magnetic field changing in a discontinuous manner for critical values of the magnetic field.

*Summary*

To sum up, the assumption that laser photons couple to a dark variant of an exotic pion at the first level of the biological dark matter hierarchy explains the rotation of the polarization direction if one accepts the proposed proportionality $g_{\pi NN} \propto \alpha_s^4 \propto 1/\hbar^4$ and that the transformation of the ordinary laser photon to dark photon can be modelled by a coefficient $k\alpha_{em} \propto 1/\hbar$. The model explains also why dark variants of other exotic pions are not produced.

### 6.4.2 Do nuclear reaction rates depend on environment?

Claus Rolfs and his group have found experimental evidence for the dependence of the rates of nuclear reactions on the condensed matter environment [90]. For instance, the rates for the reactions $^{50}$V(p,n)$^{50}$Cr and $^{176}$Lu(p,n) are fastest in conductors. The model explaining the findings has been tested for elements covering a large portion of the periodic table.

#### Debye screening of nuclear charge by electrons as an explanation for the findings

The proposed theoretical explanation [90]is that conduction electrons screen the nuclear charge or equivalently that incoming proton gets additional acceleration in the attractive Coulomb field of electrons so that the effective collision energy increases so that reaction rates below Coulomb wall increase since the thickness of the Coulomb barrier is reduced.

The resulting Debye radius

$$R_D = 69\sqrt{\frac{T}{n_{eff}\rho_a}} , \tag{6.4.6}$$

where $\rho_a$ is the density of atoms per cubic meter and $T$ is measured in Kelvins. $R_D$ is of order .01 Angstroms for $T = 373$ K for $n_{eff} = 1$, $a = 10^{-10}$ m. The theoretical model [88, 89] predicts that the cross section below Coulomb barrier for $X(p, n)$ collisions is enhanced by the factor

$$f(E) = \frac{E}{E+U_e} exp(\frac{\pi\eta U_e}{E}) . \tag{6.4.7}$$

$E$ is center of mass energy and $\eta$ so called Sommerfeld parameter and

$$U_e \equiv U_D = 2.09 \times 10^{-11}(Z(Z+1))^{1/2} \times (\frac{n_{eff}\rho_a}{T})^{1/2}\ eV \tag{6.4.8}$$

is the screening energy defined as the Coulomb interaction energy of electron cloud responsible for Debye screening and projectile nucleus. The idea is that at $R_D$ nuclear charge is nearly completely screened so that the energy of projectile is $E+U_e$ at this radius which means effectively higher collision energy.

The experimental findings from the study of 52 metals support the expression for the screening factor across the periodic table.

1. The linear dependence of $U_e$ on $Z$ and $T^{-1/2}$ dependence on temperature conforms with the prediction. Also the predicted dependence on energy has been tested [90].

2. The value of the effective number $n_{eff}$ of screening electrons deduced from the experimental data is consistent with $n_{eff}(Hall)$ deduced from quantum Hall effect.

The model suggests that also the decay rates of nuclei, say beta and alpha decay rates, could be affected by electron screening. There is already preliminary evidence for the reduction of beta decay rate of $^{22}$Na $\beta$ decay rate in Pd [91], metal which is utilized also in cold fusion experiments. This might have quite far reaching technological implications. For instance, the artificial reduction of half-lives of the radioactive nuclei could allow an effective treatment of radio-active wastes. An interesting question is whether screening effect could explain cold fusion [43] and sono-fusion [47]: I have proposed a different model for cold fusion based on large $\hbar$ in [F8].

### Could quantization of Planck constant explain why Debye model works?

The basic objection against the Debye model is that the thermodynamical treatment of electrons as classical particles below the atomic radius is in conflict with the basic assumptions of atomic physics. On the other hand, it is not trivial to invent models reproducing the predictions of the Debye model so that it makes sense to ask whether the quantization of Planck constant predicted by TGD could explain why Debye model works.

TGD predicts that Planck constant is quantized in integer multiples: $\hbar = n\hbar_0$, where $\hbar_0$ is the minimal value of Planck constant identified tentatively as the ordinary Planck constant. The preferred values for the scaling factors $n$ of $\hbar$ correspond to n-polygons constructible using ruler and compass. The values of $n$ in question are given by $n_F = 2^k \prod_i F_{s_i}$, where the Fermat primes $F_s = 2^{2^s} + 1$ appearing in the product are distinct. The lowest Fermat primes are $3, 5, 17, 257, 2^{16} + 1$. In the model of living matter the especially favored values of $\hbar$ come as powers $2^{k11}$ [M3, J6].

It is not quite obvious that ordinary nuclear physics and atomic physics should correspond to the minimum value $\hbar_0$ of Planck constant. The predictions for the favored values of $n$ are not affected if one has $\hbar(stand) = 2^k\hbar_0$, $k \geq 0$. The non-perturbative character of strong force suggests that the Planck constant for nuclear physics is not actually the minimal one [F8]. As a matter fact, TGD based model for nucleus implies that its "color magnetic body" has size of order electron Compton length. Also valence quarks inside hadrons have been proposed to correspond to non-minimal value of Planck constant since color confinement is definitely a non-perturbative effect. Since the lowest order classical predictions for the scattering cross sections in perturbative phase do not depend on the value of the Planck constant one can consider the testing of this issue is not trivial in the case of nuclear physics where perturbative approach does not really work.

Suppose that one has $n = n_0 = 2^{k_0} > 1$ for nuclei so that their quantum sizes are of order electron Compton length or perhaps even larger. One could even consider the possibility that both nuclei and atomic electrons correspond to $n = n_0$, and that conduction electrons can make a transition to a state with $n_1 < n_0$. This transition could actually explain how the electron conductivity is reduced to a finite value. In this state electrons would have Compton length scaled down by a factor $n_0/n_1$.

For instance, if one has $n_0 = 2^{11k_0}$ as suggested by the model for quantum biology [M3] and by the TGD based explanation of the claimed detection of dark matter [87], the Compton length $L_e = 2.4 \times 10^{-12}$ m for electron would reduce in the transition $k_0 \rightarrow k_0 - 1$ to $L_e = 2^{-11}L_e \simeq 1.17$ fm, which is rather near to the proton Compton length since one has $m_p/m_e \simeq .94 \times 2^{11}$. It is not too difficult to believe that electrons in this state could behave like classical particles with respect to their interaction with nuclei and atoms so that Debye model would work.

The basic objection against this model is that anyonic atoms should allow more states that ordinary atoms since very space-time sheet can carry up to $n$ electrons with identical quantum numbers in conventional sense. This should have been seen.

### Electron screening and Trojan horse mechanism

An alternative mechanism is based on Trojan horse mechanism suggested as a basic mechanism of cold fusion [F8]. The idea is that projectile nucleus enters the region of the target nucleus along a larger space-time sheet and in this manner avoids the Coulomb wall. The nuclear reaction itself occurs conventionally. In conductors the space-time sheet of conduction electrons is a natural candidate for the larger space-time sheet.

At conduction electron space-time sheet there is a constant charged density consisting of $n_{eff}$ electrons in the atomic volume $V = 1/n_a$. This creates harmonic oscillator potential in which incoming proton accelerates towards origin. The interaction energy at radius $r$ is given by

$$V(r) = \alpha n_{eff}\frac{r^2}{2a^3} \ , \tag{6.4.9}$$

where $a$ is atomic radius.

The proton ends up to this space-time sheet by a thermal kick compensating the harmonic oscillator energy. This occurs below with a high probability below radius $R$ for which the thermal energy $E = T/2$ of electron corresponds to the energy in the harmonic oscillator potential. This gives the condition

$$R = \sqrt{\frac{Ta}{n_{eff}\alpha}a} \ . \tag{6.4.10}$$

This condition is exactly of the same form as the condition given by Debye model for electron screening but has a completely different physical interpretation.

Since the proton need not travel through the nuclear Coulomb potential, it effectively gains the energy

$$E_e = Z\frac{\alpha}{R} = \frac{Z\alpha^{3/2}}{a}\sqrt{\frac{n_{eff}}{Ta}} \ . \tag{6.4.11}$$

which would be otherwise lost in the repulsive nuclear Coulomb potential. Note that the contribution of the thermal energy to $E_e$ is neglected. The dependence on the parameters involved is exactly the same as in the case of Debye model. For $T = 373$ K in the $^{176}Lu$ experiment and $n_{eff}(Lu) = 2.2\pm1.2$, and $a = a_0 = .52\times10^{-10}$ m (Bohr radius of hydrogen as estimate for atomic radius), one has $E_e = 28.0$ keV to be compared with $U_e = 21 \pm 6$ keV of [90] ($a = 10^{-10}$m corresponds to $1.24 \times 10^4$ eV and 1 K to $10^{-4}$ eV). A slightly larger atomic radius allows to achieve consistency. The value of $\hbar$ does not play any role in this model since the considerations are purely classical.

An interesting question is what the model says about the decay rates of nuclei in conductors. For instance, if the proton from the decaying nucleus can enter directly to the space-time sheet of the conduction electrons, the Coulomb wall corresponds to the Coulomb interaction energy of proton with conduction electrons at atomic radius and is equal to $\alpha n_{eff}/a$ so that the decay rate should be enhanced.

## 6.5 Water and new physics

In this section the previous ideas are applied in an attempt to understand the very special properties of water.

### 6.5.1 The 41 anomalies of water

The following list of 41 anomalies of water taken from [36] should convince the reader about the very special nature of water. The detailed descriptions of the anomalies can be found in [36]. As a matter fact, the number of anomalies has now grown to 63.

1. Water has unusually high melting point.
2. Water has unusually high boiling point.
3. Water has unusually high critical point.
4. Water has unusually high surface tension and can bounce.
5. Water has unusually high viscosity.
6. Water has unusually high heat of vaporization.

7. Water shrinks on melting.
8. Water has a high density that increases on heating (up to 3.984°C).
9. The number of nearest neighbors increases on melting.
10. The number of nearest neighbors increases with temperature.
11. Pressure reduces its melting point (13.35 MPa gives a melting point of -1°C)
12. Pressure reduces the temperature of maximum density.
13. $D_2O$ and $T_2O$ differ from $H_2O$ in their physical properties much more than might be expected from their increased mass; e.g. they have increasing temperatures of maximum density (11.185°C and 13.4°C respectively).
14. Water shows an unusually large viscosity increase but diffusion decrease as the temperature is lowered.
15. Water's viscosity decreases with pressure (at temperatures below 33°C).
16. Water has unusually low compressibility.
17. The compressibility drops as temperature increases down to a minimum at about 46.5°C. Below this temperature, water is easier to compress as the temperature is lowered.
18. Water has a low coefficient of expansion (thermal expansivity).
19. Water's thermal expansivity reduces increasingly (becoming negative) at low temperatures.
20. The speed of sound increases with temperature (up to a maximum at 73°C).
21. Water has over twice the specific heat capacity of ice or steam.
22. The specific heat capacity ($C_P$ and $C_V$) is unusually high.
23. Specific heat capacity; $C_P$ has a minimum.
24. NMR spin-lattice relaxation time is very small at low temperatures.
25. Solutes have varying effects on properties such as density and viscosity.
26. None of its solutions even approach thermodynamic ideality; even $D_2O$ in $H_2O$ is not ideal.
27. X-ray diffraction shows an unusually detailed structure.
28. Supercooled water has two phases and a second critical point at about -91°C.
29. Liquid water may be supercooled, in tiny droplets, down to about -70°C. It may also be produced from glassy amorphous ice between -123°C and - 149°C and may coexist with cubic ice up to -63°C.
30. Solid water exists in a wider variety of stable (and metastable) crystal and amorphous structures than other materials.
31. Hot water may freeze faster than cold water; the Mpemba effect.
32. The refractive index of water has a maximum value at just below 0°C.
33. The solubilities of non-polar gases in water decrease with temperature to a minimum and then rise.
34. At low temperatures, the self-diffusion of water increases as the density and pressure increase.
35. The thermal conductivity of water is high and rises to a maximum at about 130°C.
36. Proton and hydroxide ion mobilities are anomalously fast in an electric field.
37. The heat of fusion of water with temperature exhibits a maximum at -17°C.
38. The dielectric constant is high and behaves anomalously with temperature.
39. Under high pressure water molecules move further away from each other with increasing pressure.
40. The electrical conductivity of water rises to a maximum at about 230°C and then falls.
41. Warm water vibrates longer than cold water.

### 6.5.2 The model

Networks of directed hydrogen bonds $H-O-H\cdots OH_2$ with positively charged $H$ acting as a binding unit between negatively charged O (donor) and $OH_2$ (acceptor) bonds explaining clustering of water molecules can be used to explain qualitatively many of the anomalies at least qualitatively [36].

The anomaly giving evidence for anomalous nuclear physics is that the physical properties $D_2O$ and $T_2O$ differ much more from $H_2O$ than one might expect on basis of increased masses of water molecules. This suggests that dark protons of various sizes are responsible for the anomalies. That heavy water in large concentrations acts as a poison is consistent with the view that the macroscopic quantum phase of dark protons is responsible for the special biological role of water.

What proton darkness could mean? One fourth of protons of water are not seen in neither electron nor neutron scattering in atto-second time scale which translates n 3 Angstrom wavelength scale suggesting that in both cases diffraction scattering is in question. Both nuclear strong interactions and magnetic scattering contribute to the diffraction which is sensitive to the intra-atomic distances. The minimal conclusion is that the protons form a separate phase with inter-proton distance sufficiently different from that between water molecules and are therefore not seen in neutron and electron diffraction in the atto-second time scale at which protons of water molecule are visible. The stronger conclusion is that they are dark with respect to nuclear strong interactions.

The previous considerations inspired by the model of nuclei as nuclear strings suggests possible explanations.

1. Hydrogen atoms form analogs of nuclear strings connected by color bonds.

2. Nuclear protons form super-nuclei connected by dark color bonds or belong to such super-nuclei (possibly consisting of $^4He$ nuclei). If color bonds are negatively charged, closed nuclear strings of this kind are neutral and not visible in electron scattering: this assumption is however unnecessarily strong for invisibility in diffractive scattering in atto-second time scale.

### Model for super-nuclei formed from dark protons

Dark protons could form super nuclei with nucleons connected by dark color bonds with $\hbar = k2^{11}\hbar_0$. The large distance between protons would eliminate isospin dependent strong force so that multi-proton states are indeed possible. The interpretation would be that nuclear size scale is zoomed up to $k2^{11}L(113) = kL(135) \sim .49k$ Angstrom, where $n$ is Fermat integer: $k = 1, 3, 5$ are the smallest candidates. Dark color bonds could also connect different nuclei.

The predictions of the model for bond energy depend on the transformation properties of $E_s$ under the scaling of $\hbar$. The interpretation of $E_s$ as color Coulombic potential energy $\alpha_s/r$ suggests that $E_s$ behaves under scaling like the binding energy of hydrogen atom ($1/\hbar^2$ scaling).

1. For $k = 1$ $E_s$ would be about .5 eV and same as the energy of hydrogen bond. This energy is same as the universal metabolic energy quantum so that the basic metabolic processes might involve transitions dark-ordinary transition for protons. This would however suggest that the length of color bond is same as that of hydrogen bond so that the protons in question would not be invisible in diffraction in atto-second time scale. The interpretation of color bonds between atoms as hydrogen bonds is much more attractive.

2. For $k = 3$ one would have $E_s \rightarrow E_s/k^2 = .056$ eV which is the nominal value for the energy associated with the cell membrane potential at the threshold for nerve pulse generation and just above the thermal energy at room temperature. There is a temptation to assign the invisible protons suggested by the $H_{1.5}O$ formula [37] with $k = 3$ hydrogen bonds. The length of hydrogen bond is 1.6-2 Angstrom. If hydrogen bond length scales as $E_s$ as the harmonic oscillator picture suggests, the distance would scale as $k^2$ and would be 9 times longer for $k = 3$ bond. This would explain the invisibility of corresponding hydrogen atoms in electron and neutron diffraction.

### Hydrogen bonds as color bonds between nuclei?

The original hypothesis was that there are two kinds of hydrogen bonds: dark and "ordinary". The finding that the energy of dark nuclear color bond with $n = 2^{11}$ equals to the energy of typical hydrogen bond suggests that all hydrogen bonds are associated with color bonds between nuclei. Color bond would bind the proton to electronegative nucleus and this would lead to to the formation of hydrogen bond at the level of valence electrons as hydrogen donates its electron to the electronegative atom. The electronic contribution would explain the variation of the bond energy.

If hydrogen bonds connect H-atom to O-atom to acceptor nucleus, if $E_s$ for p-O bond is same as for p-n color bond, and if color bonds are dark with $n = k2^{11}$, where $k$ is Fermat integer, the bond energy is $E_s = 2.2MeV/n^2$. For $k = 1$ single bond is predicted to have bond energy $E_s = .5$ eV whereas the bond energy for n-bond structure energy would be $n^2$ times larger. The alternative hypothesis would be that hydrogen bonds are dark color bonds between atoms having $k = 118$ and $n = 2^{11}$.

Nuclear color bonds would serve as a prerequisite for the formation of electronic parts of hydrogen bonds and could be associated also with other molecular bonds so that dark nuclear physics might be essential part of molecular physics. Dark color bonds could be also charged which brings in additional exotic effects. The long range order of hydrogen bonded liquids could due to the ordinary hydrogen bonds. An interesting question is whether nuclear color bonds could be responsible for the long range order of all liquids. If so dark nuclear physics would be also crucial for the understanding of the condensed matter.

In the case of water the presence of $k = 3$ bonds between dark protons would bring in additional long range order in length scale of order 10 Angstrom characteristic for DNA transversal scale: also hydrogen bonds play a crucial role in DNA double strand. Two kinds of bond networks could allow to understand why water is so different from other molecular liquids containing also hydrogen atoms and the long range order of water molecule clusters would reflect basically the long range order of two kinds of dark nuclei.

### Two kinds of hydrogen bonds

There is experimental evidence for two different hydrogen bonds but, contrary to the original belief, this does not relate to $H_{1.5}O$ anomaly. Li and Ross represent experimental evidence for two kinds of hydrogen bonds in ice in an article published in Nature 1993 [80], and there is a popular article "Wacky Water" in New Scientist about this finding [79]. The ratio of the force constants associated with the bonds is 1:2 which suggests that binding energies scale as 2:1. This finding excludes the possibility that all hydrogen bonds are ordinary for ice. The interpretation would that these bonds correspond to two different p-adic length scales differing by scale factor 2. $A \leq 4$ nucleons indeed correspond to p-adic length scales $L(k_{eff} = 116)$ and $L(k_{eff} = 118)$. Obviously these bonds cannot be identified as the two variants of color bond discussed above. A possible interpretation for tedrahedral and icosahedral water clusters would be as magic super-nuclei and the prediction would be that binding energy behaves as $n^2E_s$ rather than being just the sum of the binding energies of hydrogen bonds $(nE_s)$.

The possibility to divide the bonds to two kinds of bonds in an arbitrary manner brings in a large ground state degeneracy given by $D = 16!/(8!)^2$ unless additional symmetries are assumed and give for the system spin glass like character and explain large number of different amorphous phases for ice [36]. This degeneracy would also make possible information storage and provide water with memory.

It is interesting to compare this model with the model for hexagonal ice which assumes four hydrogen bonds per water molecule: for two of them the molecule acts as a donor and for two of them as an acceptor. Each water molecule in the vertices of a tedrahedron containing 14 hydrogen atoms has a hydrogen bond to a water molecule in the interior, each of which have 3 hydrogen bonds to molecules at the middle points of the edges of the tedrahedron. This makes 16 hydrogen bonds altogether. If all of them are of first type with bonding energy $E_s = .5$ eV and if the bond network is connected one would obtain total bond energy equal to $n^2E_s = 258 \times .5$ eV rather than only $nE_s = 16 \times .5$ eV. Bonds of second type would have no role in the model.

### Tedrahedral and icosahedral clusters of water molecules and dark color bonds

Water molecules form both tedrahedral and icosahedral clusters. $^4He$ corresponds to tedrahedral symmetry so that tedrahedral cluster could be the condensed matter counterpart of $^4He$. It the nuclear string model nuclear strings consist of maximum number of $^4He$ nuclei themselves closed strings in shorter length scale.

The p-adic length scales associated with $^4He$ nuclei and nuclear string are $k = 116$ and $k = 127$ The color bond between $^4He$ units has $E_s = .2$ MeV and $n = 2^{11}$ would give by scaling $E_s = .05$ eV which is the already familiar energy associated with cell membrane potential at the threshold for nerve pulse generation. This energy is in a good approximation associated also with $n = 3 \times 2^{11}$ color bonds so that the invisible hydrogen bonds might closely relate to the formation of icosahedral clusters. The binding energy associated with a string formed by $n$ tedrahedral clusters would be $n^2E_s$. This observation raises the question whether the neural firing is accompanied by the re-organization of strings formed by the tedrahedral clusters and possibly responsible for a representation of information and water memory.

The icosahedral model [36] for water clusters assumes that 20 tedrahedral clusters, each of them containing 14 molecules, combine to form icosahedral clusters containing 280 water molecules. Concerning the explanation of anomalies, the key observation is that icosahedral clusters have a smaller volume per water molecule than tedrahedral clusters but cannot form a lattice structure. Note that the number 20 for the dark magic dark nuclei forming the icosahedron is also a magic number.

**Tedrahedral and icosahedral clusters and dark electrons**

An additional dark insight to tedrahedral and icosahedral structures is based on the observation that dark matter phases correspond to large values of $n_a/n_b$ and there large value of $M^4$ Planck constant. This means $N(G_a)$-fold covering of $CP_2$ with the order of maximal cyclic subgroup of $G_a$ being $n_a$. For tedrahedron and dodecahedron one has $n_a = 3$ and $n_a = 5$ respectively so that the increase of Planck constant would be relatively small and would correspond to Fermat polygon in both cases. These two groups are the only subgroups of $SO(3)$ which correspond to genuinely 3-dimensional symmetries. Of course, $n_a = 3$ and $n_a = 5$ have nothing to do with $n_a = 2^{11}$ but it is quite possible that also these dark matter levels are involved and could be assigned with dark electrons rather than dark color bonds between nuclei.

Synaptic contacts contain clathrin molecules which are truncated icosahedrons and form lattice structures and are speculated to be involved with quantum computation like activities possibly performed by microtubules. Many viruses have the shape of icosahedron. One can ask whether these structures could be formed around templates formed by dark matter corresponding to 120-fold covering of $CP_2$ points by $M^4$ points and having $\hbar(CP_2) = 5\hbar_0$ perhaps corresponding color confined light dark quarks. Of course, a similar covering of $M^4$ points by $CP_2$ could be involved.

It should be noticed that single nucleotide in DNA double strands corresponds to a twist of $2\pi/10$ per single DNA triplet so that 10 DNA strands corresponding to length $L(151) = 10$ nm (cell membrane thickness) correspond to $3 \times 2\pi$ twist. This could be perhaps interpreted as evidence for group $C_{10}$ perhaps making possible quantum computation at the level of DNA.

### 6.5.3 Comments on 41 anomalies

Some clarifying general comments about the anomalies are in order. Quite generally, it seems that it is the presence of new degrees of freedom, the presence of icosahedral clusters, and macroscopic quantum coherence of dark matter, which are responsible for the peculiar properties of water.

*1. Anomalies relating to the presence of icosahedral clusters*

Icosahedral water clusters have a better packing ratio than tedrahedral lattice and thus correspond to a larger density. They also minimize energy but cannot cannot form a lattice [36].

1. This explains the unusually high melting point, boiling point, critical point, surface tension, viscosity, heat of vaporization, shrinking on melting, high density increasing on heating, increase of the number of nearest neighbors in melting and with temperature. It is also possible to understand why X-ray diffraction shows an unusually detailed structure.

   The presence of icosahedral clusters allows to understand why liquid water can be super-cooled, and why the distances of water molecules increase under high pressure. The spin glass degeneracy implied by dark and ordinary hydrogen bonds could explain why ice has many glassy amorphous phases. The two phases of super-cooled water could correspond to the binary degree of freedom brought in by two different hydrogen bonds. For the first phase both hydrogen atoms of a given water molecule would be either dark or ordinary. For the second phase the first hydrogen atom would be dark and second one ordinary.

   Since icosahedral clusters have lower energy than a piece of ice of same size, they tend to super-cool and this slows down the transition to the solid phase. The reason why hot water cools faster would be that the number of icosahedral clusters is smaller: if cooling is carried with a sufficient efficiency icosahedral clusters do not form.

2. Pressure can be visualized as a particle bombardment of water clusters tending to reduce their volume. The collisions with particles can induce local transitions of hexagonal lattice to icosahedral structures with a smaller specific volume and energy and induce local melting. This would explain the low compressibility of water and why pressure reduces melting point and the temperature of maximum density and viscosity.

3. The increase of temperature is expected to reduce the number of icosahedral clusters so that the effect of pressure on these clusters is not so large. This explains the increase of compressibility with temperature below 46.5°C. The fact that the collapse of icosahedral clusters opposes the usual thermal expansion is consistent with the low thermal expansivity as well as the change of sign of expansivity near melting point. Since the square of sound velocity is inversely proportional to compressibility and density, also the increase of speed of sound with temperature can be understood.

*2. The presence of dark degrees of freedom and spin glass degeneracy*

The presence of dark degrees of freedom and the degeneracy of dark nucleus ground states could explain the high specific heat capacity of water. The reduction of dark matter degrees of freedom for ice and steam would explain why water has over twice the specific heat capacity of ice or steam. The possibility to relax by dissipating energy to the dark matter degrees of freedom would explain the short spin-lattice relaxation time. The fact that cold water has more degrees of freedom explains why warm water vibrates longer than cold water.

Also the high thermal and electric conductivity of water could be understood. The so called Grotthuss mechanism [36, 30] explaining $OH_-$ and $H_+$ mobilities (related closely to conductivities) is based on hopping of electron of $OH_-$ and $H_+$ in the network formed by hydrogen bonds and generalizes to the recent case. The reduction of conductivity with temperature would be due to the storage of the transferred energy/capture of charge carriers to the water molecule clusters.

*3. Macroscopic quantum coherence*

The high value of dielectric constant could derive from the fact that dark nuclei and super-nuclei are quantum coherent in a rather long length scale. For curl free electric fields potential difference must be same along space-time sheets of matter and dark matter. The synchronous quantum coherent collective motion of dark protons (and possible dark electrons) in an oscillating external electric field generates dark photon laser beams (it is not clear yet whether these dark laser beams are actually ordinary laser beams) de-cohering to ordinary photons and yield a large dynamical polarization. As the temperature is lowered the effect becomes stronger.

### 6.5.4 Burning salt water by radio-waves and large Planck constant

This morning (Tuesday, 14 August 2007) my friend Samuli Penttinen send an email telling about strange discovery [104] by engineer John Kanzius: salt water in the test tube radiated by radiowaves at harmonics of a frequency f=13.56 MHz burns. Temperatures about 1500 K, which correspond to .15 eV energy have been reported. You can radiate also hand but nothing happens. The original discovery of Kanzius was the finding that radio waves could be used to cure cancer by destroying the cancer cells. The proposal is that this effect might provide new energy source by liberating chemical energy in an exceptionally effective manner. The power is about 200 W so that the power used could explain the effect if it is absorbed in resonance like manner by salt water.

The energies of photons involved are very small, multiples of $5.6 \times 10^{-8}$ eV and their effect should be very small since it is difficult to imagine what resonant molecular transition could cause the effect. This leads to the question whether the radio wave beam could contain a considerable fraction of dark photons for which Planck constant is larger so that the energy of photons is much larger. The underlying mechanism would be phase transition of dark photons with large Planck constant to ordinary photons with shorter wavelength coupling resonantly to some molecular degrees of freedom and inducing the heating. Microwave oven of course comes in mind immediately.

1. The fact that the effects occur at harmonics of the fundamental frequency suggests that rotational states of molecules are in question as in microwave heating. Since the presence of salt seems to be essential, the first candidate for the molecule in question is NaCl but also HCl can be considered and also water molecules. NaCl makes sense if NaCl and $Na^+$ and $Cl^-$ are in equilibrium. The formula for the rotational energies [49] is

$$E(l) = E_0 \times (l(l+1) \ \ , \ \ E_0 = \hbar_0^2/2\mu R^2 \ \ , \ \ \mu = m_1 m_2/(m_1 + m_2) \ \ .$$

Here $R$ is molecular radius which by definition is deduced from the rotational energy spectrum. The energy inducing the transition $l \rightarrow l+1$ is $\Delta E(l) = 2E_0 \times (l+1)$.

2. By going to Wikipedia [50], one can find molecular radii of hetero-nuclear molecules such as $NaCl$ and homonuclear di-atomic molecules such as $H_2$. Using $E_0(H_2) = 8.0 \times 10^{-3}$ eV one obtains by scaling

$$E_0(NaCl) = (\mu(H_2/\mu(NaCl)) \times (R(H_2)/R(NaCl)^2 \ .$$

The atomic weights are $A(H) = 1, A(Na) = 23, A(Cl) = 35$.

3. A little calculation gives $f(NaCl) = 2E_0/h = 14.08$ GHz. The ratio to the radio wave frequency is $f(NaCl)/f = 1.0386 \times 10^3$ to be compared with the $\hbar/\hbar_0 = 2^{10} = 1.024 \times 10^3$. The discrepancy is 1 per cent.

   Thus dark radio wave photons could induce a rotational microwave heating of the sample and the effect could be seen as an additional dramatic support for the hierarchy of Planck constants.

4. One can consider also the possibility that energy is feeded to the rotational degrees of freedom of water molecules as in microwave oven and salt has some other function. Both mechanisms could be involved of course. The microwave frequency used in microwave ovens is 2.45 GHz giving for the Planck constant the estimate 180.67 equal to 180 with error of .4 per cent. The values of Planck constants for $(\hat{M}^4/G_a) \times \hat{CP}_2 \hat{\times} G_b$ option (factor space of $M^4$ and covering space of $CP_2$ maximizing Planck constant for given $G_a$ and $G_b$) are given by $\hbar/\hbar_0 = n_a n_b$. $n_a n_b = 4 \times 9 \times 5 = 180$ can result from the number theoretically simple values of quantum phases $exp(i2\pi/n_i)$ corresponding to polygons constructible using only ruler and compass. For instance, one could have $n_a = 2 \times 3$ and $n_b = 2 \times 3 \times 5$. This option gives a slightly better agreement than NaCl option.

There are several questions to be answered.

1. Does this effect occur also for solutions of other molecules and other solutes than water? This can be tested since the rotational spectra are readily calculable from data which can be found at net.

2. Are the radio wave photons dark or does water - which is very special kind of liquid - induce the transformation of ordinary radio wave photons to dark photons by fusing $2^{10}$ radio wave massless extremals (MEs) to single ME. Does this transformation occur for all frequencies? This kind of transformation might play a key role in transforming ordinary EEG photons to dark photons and partially explain the special role of water in living systems.

3. Why the radiation does not induce spontaneous combustion of living matter which contains salt. And why cancer cells seem to burn: is salt concentration higher inside them? As a matter fact, there are reports about [105]. One might hope that there is a mechanism inhibiting this since otherwise military would be soon developing new horror weapons unless it is doing this already now. Is it that most of salt is ionized to $Na^+$ and $Cl^-$ ions so that spontaneous combustion can be avoided? And how this relates to the sensation of spontaneous burning [106] - a very painful sensation that some part of body is burning?

4. Is the energy heating solely due to rotational excitations? It might be that also a "dropping" of ions to larger space-time sheets is induced by the process and liberates zero point kinetic energy. The dropping of proton from k=137 (k=139) atomic space-time sheet liberates about .5 eV (0.125 eV). The measured temperature corresponds to the energy .15 eV. This dropping is an essential element of remote metabolism and provides universal metabolic energy quanta. It is also involved with TGD based models of "free energy" phenomena. No perpetuum mobile is predicted since there must be a mechanism driving the dropped ions back to the original space-time sheets.

Recall that one of the empirical motivations for the hierarchy of Planck constants came from the observed quantum like effects of ELF em fields at EEG frequencies on vertebrate brain and also from the correlation of EEG with brain function and contents of consciousness difficult to understand since the energies of EEG photons are ridiculously small and should be masked by thermal noise.

In TGD based model of EEG (actually fractal hierarchy of EEGs) the values $\hbar/\hbar_0 = 2^{k11}$, $k = 1, 2, 3, ...$, of Planck constant are in a preferred role. More generally, powers of two of a given value of Planck constant are preferred, which is also in accordance with p-adic length scale hypothesis.

## 6.6 Connection with mono-atomic elements, cold fusion, and sonofusion?

Anomalies are treasures for a theoretician and during years I have been using quite a bundle of reported anomalies challenging the standard physics as a test bed for the TGD vision about physics. The so called mono-atomic elements, cold fusion, and sonofusion represent examples of this kind of anomalies not taken seriously by most standard physicists. In the following the possibility that dark matter as large $\hbar$ phase could allow to understand these anomalies.

Of course, I hear the angry voice of the skeptic reader blaming me for a complete lack of source criticism and the skeptic reader is right. I however want to tell him that I am not a soldier in troops of either skeptics or new-agers. My attitude is "let us for a moment assume that these findings are real..." and look for the consequences in this particular theoretical framework.

### 6.6.1 Mono-atomic elements as dark matter and high $T_c$ super-conductors?

The ideas related to many-sheeted space-time began to develop for a decade ago. The stimulation came from a contact by Barry Carter who told me about so called mono-atomic elements, typically transition metals (precious metals), including Gold. According to the reports these elements, which are also called ORMEs ("orbitally rearranged monoatomic elements") or ORMUS, have following properties.

1. ORMEs were discovered and patented by David Hudson [102] are peculiar elements belonging to platinum group (platinum, palladium, rhodium, iridium, ruthenium and osmium) and to transition elements (gold, silver, copper, cobalt and nickel).

2. Instead of behaving as metals with valence bonds, ORMEs have ceramic like behavior. Their density is claimed to be much lower than the density of the metallic form.

3. They are chemically inert and poor conductors of heat and electricity. The chemical inertness of these elements have made their chemical identification very difficult.

4. One signature is the infra red line with energy of order .05 $eV$. There is no text book explanation for this behavior. Hudson also reports that these elements became visible in emission spectroscopy in which elements are posed in strong electric field after time which was 6 times longer than usually.

The pioneering observations of David Hudson [102] - if taken seriously - suggest an interpretation as an exotic super-conductor at room temperature having extremely low critical magnetic fields of order of magnetic field of Earth, which of course is in conflict with the standard wisdom about super-conductivity. After a decade and with an impulse coming from a different contact related to ORMEs, I decided to take a fresh look on Hudson's description for how he discovered ORMEs [102] with dark matter in my mind. From experience I can tell that the model to be proposed is probably not the final one but it is certainly the simplest one.

There are of course endless variety of models one can imagine and one must somehow constrain the choices. The key constraints used are following.

1. Only valence electrons determining the chemical properties appear in dark state and the model must be consistent with the general model of the enhanced conductivity of DNA assumed to be caused by large $\hbar$ valence electrons with $r = \hbar/\hbar_0 = n$, $n = 5, 6$ assignable with aromatic rings. $r = 6$ for valence electrons would explain the report of Hudson about anomalous emission spectroscopy.

2. This model cannot explain all data. If ORMEs are assumed to represent very simple form of living matter also the presence electrons having $\hbar/\hbar_0 = 2^{k11}$, $k = 1$, can be considered and would be associated with high $T_c$ super-conductors whose model predicts structures with thickness of cell membrane. This would explain the claims about very low critical magnetic fields destroying the claimed superconductivity.

Below I reproduce Hudson's own description here in a somewhat shortened form and emphasize that must not forget professional skepticism concerning the claimed findings.

**Basic findings of Hudson**

Hudson was recovering gold and silver from old mining sources. Hudson had learned that something strange was going on with his samples. In molten lead the gold and silver recovered but when "I held the lead down, I had nothing". Hudson tells that mining community refers to this as "ghost-gold", a non-assayable, non-identifiable form of gold.

Then Hudson decided to study the strange samples using emission spectroscopy. The sample is put between carbon electrodes and arc between them ionizes elements in the sample so that they radiate at specific frequencies serving as their signatures. The analysis lasts 10-15 seconds since for longer times lower electrode is burned away. The sample was identified as Iron, Silicon, and Aluminum. Hudson spent years to eliminate Fe, Si, and Al. Also other methods such as Cummings Microscopy, Diffraction Microscopy, and Fluorescent Microscopy were applied and the final conclusion was that there was nothing left in the sample in spectroscopic sense.

After this Hudson returned to emission spectroscopy but lengthened the time of exposure to electric field by surrounding the lower Carbon electrode with Argon gas so that it could not burn. This allowed to reach exposure times up to 300 s. The sample was silent up to 90 s after which emission lines of Palladium (Pd) appeared; after 110 seconds Platinum (Pt); at 130 seconds Ruthenium (Ru); at about 140-150 seconds Rhodium; at 190 seconds Iridium; and at 220 seconds Osmium appeared. This is known as fractional vaporization.

Hudson reports the boiling temperatures for the metals in the sample having in mind the idea that the emission begins when the temperature of the sample reaches boiling temperature inspired by the observation that elements become visible in the order which is same as that for boiling temperatures.

The boiling temperatures for the elements appearing in the sample are given by the following table.

| Element | $Ca$ | $Fe$ | $Si$ | $Al$ | $Pd$ | $Rh$ |
|---|---|---|---|---|---|---|
| $T_B/^oC$ | 1420 | 1535 | 2355 | 2327 | >2200 | 2500 |
| Element | $Ru$ | $Pt$ | $Ir$ | $Os$ | $Ag$ | $Au$ |
| $T_B/^oC$ | 4150 | 4300 | $> 4800$ | $> 5300$ | 1950 | 2600 |

Table 2. Boiling temperatures of elements appearing in the samples of Hudson.

Hudson experimented also with commercially available samples of precious metals and found that the lines appear within 15 seconds, then follows a silence until lines re-appear after 90 seconds. Note that the ratio of these time scales is 6. The presence of some exotic form of these metals suggests itself: Hudson talks about mono-atomic elements.

Hudson studied specifically what he calls mono-atomic gold and claims that it does not possess metallic properties. Hudson reports that the weight of mono-atomic gold, which appears as a white powder, is 4/9 of the weight of metallic gold. Mono-atomic gold is claimed to behave like super-conductor.

Hudson does not give a convincing justification for why his elements should be mono-atomic so that in following this attribute will be used just because it represents established convention. Hudson also claims that the nuclei of mono-atomic elements are in a high spin state. I do not understand the motivations for this statement.

**Claims of Hudson about ORMEs as super conductors**

The claims of Hudson that ORMES are super conductors [102] are in conflict with the conventional wisdom about super conductors.

1. The first claim is that ORMEs are super conductors with gap energy about $\Delta = .05$ eV and identifies photons with this energy resulting from the formation of Cooper pairs. This energy happens to correspond one of the absorption lines in high $T_c$ superconductors.

2. ORMEs are claimed to be super conductors of type II with critical fields $H_{c1}$ and $H_{c2}$ of order of Earth's magnetic field having the nominal value $.5 \times 10^{-4}$ Tesla [102]. The estimates for the critical parameters for the ordinary super conductors suggests for electronic super conductors critical fields, which are about .1 Tesla and thus by a factor $\sim 2^{11}$ larger than the critical fields claimed by Hudson.

3. It is claimed that ORME particles can levitate even in Earth's magnetic field. The latter claim looks at first completely nonsensical. The point is that the force giving rise to the levitation is roughly the gradient of the would-be magnetic energy in the volume of levitating super conductor. The gradient of average magnetic field of Earth is of order $B/R$, $R$ the radius of Earth and thus extremely small so that genuine levitation cannot be in question.

### Minimal model

Consider now a possible TGD inspired model for these findings assuming for definiteness that the basic Hudson's claims are literally true.

*1. In what sense mono-atomic elements could be dark matter?*

The simplest option suggested by the applicability of emission spectroscopy and chemical inertness is that mono-atomic elements correspond to ordinary atoms for which valence electrons are dark electrons with large $\hbar/\hbar_0 = n_a/n_b$. Suppose that the emission spectroscopy measures the energies of dark photons from the transitions of dark electrons transforming to ordinary photons before the detection by de-coherence increasing the frequency by the factor $r = \hbar/\hbar_0$. The size of dark electrons and temporal duration of basic processes would be zoomed up by $r$.

Since the time scale after which emission begins is scaled up by a factor 6, there is a temptation to conclude that $r = n_a/n_b = 6$ holds true. Note that $n = 6$ corresponds to Fermat polygon and is thus preferred number theoretically in TGD based model for preferred values of $\hbar$ [A9]. The simplest possibility is that the group $G_b$ is trivial group and $G_a = A_6$ or $D_6$ so that ring like structures containing six dark atoms are suggestive.

This brings in mind the model explaining the anomalous conductivity of DNA by large $\hbar$ valence electrons of aromatic rings of DNA. The zooming up of spatial sizes might make possible exotic effects and perhaps even a formation of atomic Bose-Einstein condensates of Cooper pairs. Note however that in case of DNA $r = 6$ not gives only rise to conductivity but not super-conductivity and that $r = 6$ cannot explain the claimed very low critical magnetic field destroying the super-conductivity.

*2. Loss of weight*

The claimed loss of weight by a factor $p \simeq 4/9$ is a very significant hint if taken seriously. The proposed model implies that the density of the partially dark phase is different from that of the ordinary phase but is not quantitative enough to predict the value of $p$. The most plausible reason for the loss of weight would be the reduction of density induced by the replacement of ordinary chemistry with $\hbar/\hbar_0 = n_a/n_b = 6$ chemistry for which the Compton length of valence electrons would increase by this factor.

*3. Is super-conductivity possible?*

The overlap criterion is favorable for super-conductivity since electron Compton lengths would be scaled up by factor $n_a = 6, n_b = 1$. For $\hbar/\hbar_0 = n_a = 6$ Fermi energy would be scaled up by $n_a^2 = 36$ and if the same occurs for the gap energy, $T_c$ would increase by a factor 36 from that predicted by the standard BCS theory. Scaled up conventional super-conductor having $T_c \sim 10$ K would be in question (conventional super-conductors have critical temperatures below 20 K). 20 K upper bound for the critical temperature of these superconductors would allow 660 K critical temperature for their dark variants!

For large enough values of $n_a$ the formation of Cooper pairs could be favored by the thermal instability of valence electrons. The binding energies would behave as $E = (n_b/n_a)^2 Z_{eff}^2 E_0/n^2$, where $Z_{eff}$ is the screened nuclear charge seen by valence electrons, $n$ the principal quantum number for the valence electron, and $E_0$ the ground state energy of hydrogen atom. This gives binding energy smaller than thermal energy at room temperature for $n_a/n_b > (Z_{eff}/n)\sqrt{2E_0/3T_{room}} \simeq 17.4 \times (Z_{eff}/n)$. For $n = 5$ and $Z_{eff} < 1.7$ this would give thermal instability for $n_a = 6$.

Interestingly, the reported .05 eV infrared line corresponds to the energy assignable to cell membrane voltage at criticality against nerve pulse generation, which suggests a possible connection with high $T_c$ superconductors for which also this line appears and is identified in terms of Josephson energy. .05 eV line appears also in high $T_c$ superconductors. This interpretation does not exclude the interpretation as gap energy. The gap energy of the corresponding BCS super-conductor would be scaled down by $1/n_a^2$ and would correspond to 14 K temperature for $n_a = 6$.

Also high $T_c$ super-conductivity could involve the transformation of nuclei at the stripes containing the holes to dark matter and the formation of Cooper pairs could be due to the thermal instability of valence electrons of Cu atoms (having $n = 4$). The rough extrapolation for the critical temperature for cuprate superconductor would be $T_c(Cu) = (n_{Cu}/n_{Rh})^2T_c(Rh) = (25/36)T_c(Rh)$. For $T_c(Rh) = 300$ K this would give $T_c(Cu) = 192$ K: accoding to Wikipedia cuprate perovskite has the highest known critical temperature which is 138 K. Note that quantum criticality suggests the possibility of several values of $(n_a, n_b)$ so that several kinds of super-conductivities might be present.

#### ORMEs as partially dark matter, high $T_c$ super conductors, and high $T_c$ super-fluids

The appearance of .05 eV photon line suggest that same phenomena could be associated with ORMEs and high $T_c$ super-conductors. The strongest conclusion would be that ORMEs are $T_c$ super-conductors and that the only difference is that $Cu$ having single valence electron is replaced by a heavier atom with single valence electron. In the following I shall discuss this option rather independently from the minimal model.

*1. ORME super-conductivity as quantum critical high $T_c$ superconductivity*

ORMEs are claimed to be high $T_c$ superconductors and the identification as quantum critical superconductors seems to make sense.

1. According to the model of high $T_c$ superconductors as quantum critical systems, the properties of Cooper pairs should be more or less universal so that the observed absorption lines discussed in the section about high $T_c$ superconductors should characterize also ORMEs. Indeed, the reported 50 meV photon line corresponds to a poorly understood absorption line in the case of high $T_c$ cuprate super conductors having in TGD framework an interpretation as a transition in which exotic Cooper pair is excited to a higher energy state. Also Copper is a transition metal and is one of the most important trace elements in living systems [48]. Thus the Cooper pairs could be identical in both cases. ORMEs are claimed to be superconductors of type II and quantum critical superconductors are predicted to be of type II under rather general conditions.

2. The claimed extremely low value of $H_c$ is also consistent with the high $T_c$ superconductivity. The supra currents in the interior of flux tubes of radius of order $L_w = .2$ $\mu$m are BCS type supra currents with large $\hbar$ so that $T_c$ is by a factor $2^{11}$ higher than expected and $H_c$ is reduced by a factor $2^{-11/2}$. This indeed predicts correct order of magnitude for the critical magnetic field.

3. $r = \hbar/\hbar_0 = 2^{11}$ is considerably higher that $r = 6$ suggested by the minimum model explaining emission spectroscopic results of Hudson. Of course, several values of $\hbar$ are possible and the values $r \in \{5, 6, 2^{k11}\}$ are indeed assumed in TGD inspired model of living matter and generalize EEG [M3]. Thus internal consistency would be achieved if ORMEs are regarded as a very simple form of living matter.

4. The electronic configurations of Cu and Gold are chemically similar. Gold has electronic configuration $[Xe, 4f^{14}5d^{10}]6s$ with one valence electron in $s$ state whereas Copper corresponds to $3d^{10}4s$ ground state configuration with one valence electron. This encourages to think that the doping by holes needed to achieve superconductivity induces the dropping of these electrons to $k = 151$ space-time sheets and gives rise to exotic Cooper pairs. Also this model assumes the phase transition of some fraction of Cu nuclei to large $\hbar$ phase and that exotic Cooper pairs appear at the boundary of ordinary and large $\hbar$ phase.

More generally, elements having one electron in $s$ state plus full electronic shells are good candidates for doped high $T_c$ superconductors. Both Cu and Au atoms are bosons. More generally, if the atom in question is boson, the formation of atomic Bose-Einstein condensates at Cooper pair space-time sheets is favored. Thus elements with odd value of $A$ and $Z$ possessing full shells plus single $s$ wave valence electron are of special interest. The six stable elements satisfying these conditions are $^5$Li, $^{39}$K, $^{63}$Cu, $^{85}$Rb, $^{133}$Cs, and $^{197}$Au.

*2. "Levitation" and loss of weight*

The model of high $T_c$ superconductivity predicts that some fraction of Cu atoms drops to the flux tube with radius $L_w = .2\ \mu$m and behaves as a dark matter. This is expected to occur also in the case of other transition metals such as Gold. The atomic nuclei at this space-time sheet have high charges and make phase transition to large $\hbar$ phase and form Bose-Einstein condensate and superfluid behavior results. Electrons in turn form large $\hbar$ variant of BCS type superconductor. These flux tubes are predicted to be negatively charged because of the Bose-Einstein condensate of exotic Cooper pairs at the boundaries of the flux tubes having thickness $L(151)$. The average charge density equals to the doping fraction times the density of Copper atoms.

The first explanation would be in terms of super-fluid behavior completely analogous to the ability of ordinary superfluids to defy gravity. Second explanation is based on the electric field of Earth which causes an upwards directed force on negatively charged BE condensate of exotic Cooper pairs and this force could explain both the apparent levitation and partial loss of weight. The criterion for levitation is $F_e = 2eE/x \geq F_{gr} = Am_pg$, where $g \simeq 10$ m$^2$/s is gravitational acceleration at the surface of Earth, $A$ is the atomic weight and $m_p$ proton mass, $E$ the strength of electric field, and $x$ is the number of atoms at the space-time sheet of a given Cooper pair. The condition gives $E \geq 5 \times 10{-}10Ax$ V/m to be compared with the strength $E = 10^2 - 10^4$ V/m of the Earths' electric field.

An objection against the explanation for the effective loss of weight is that it depends on the strength of electric field which varies in a wide range whereas Hudson claims that the reduction factor is constant and equal to 4/9. A more mundane explanation would be in terms of a lower density of dark Gold. This explanation is quite plausible since there is no atomic lattice structure since nuclei and electrons form their own large $\hbar$ phases.

*4. The effects on biological systems*

Some monoatomic elements such as White Gold are claimed to have beneficial effects on living systems [102]. 5 per cent of brain tissue of pig by dry matter weight is claimed to be Rhodium and Iridium. Cancer cells are claimed to be transformed to healthy ones in presence of ORMEs. The model for high $T_c$ super conductivity predicts that the flux tubes along which interior and boundary supra currents flow has same structure as neuronal axons. Even the basic length scales are very precisely the same. On basis of above considerations ORMEs are reasonable candidates for high $T_c$ superconductors and perhaps even super fluids.

The common mechanism for high $T_c$, ORME- and bio- super-conductivities could explain the biological effects of ORMEs.

1. In unhealthy state superconductivity might fail at the level of cell membrane, at the level of DNA or in some longer length scales and would mean that cancer cells are not anymore able to communicate. A possible reason for a lost super conductivity or anomalously weak super conductivity is that the fraction of ORME atoms is for some reason too small in unhealthy tissue.

2. The presence of ORMEs could enhance the electronic bio- superconductivity which for some reason is not fully intact. For instance, if the lipid layers of cell membrane are, not only wormhole-, but also electronic super conductors and cancer involves the loss of electronic super-conductivity then the effect of ORMEs would be to increase the number density of Cooper pairs and make the cell membrane super conductor again. Similar mechanism might work at DNA level if DNA:s are super conductors in "active" state.

*5. Is ORME super-conductivity associated with the magnetic flux tubes of dark magnetic field $B_d = 0.2$ Gauss?*

The general model for the ionic super-conductivity in living matter, which has developed gradually during the last few years and will be discussed in detail later, is based on the assumption that super-conducting particles reside at the super-conducting magnetic flux tubes of Earth's magnetic field with nominal value $B_E = .5$ Gauss. It later became clear that the explanation of ELF em fields on vertebrate brain requires $B_d = .2$ Gauss rather than $B_E$ as was erratically assumed in the original model. The interpretation was as dark magnetic field $B_d = .2$ Gauss.

The predicted radius $L_w = .2$ $\mu$m is consistent with the radius of neuronal axons. For $\hbar \rightarrow n\times 2^{11}\hbar$, $n = 3$, the radius is 1.2 $\mu$m and still smaller than the radius $d$ of flux tube of $B_E$ of order $d = 5$ $\mu$m and scales up as $d \rightarrow \sqrt{B_d/B_E}\sqrt{r}d = \sqrt{5r/2}d$ in the replacement $\hbar/\hbar_0 \rightarrow r$, $B_E \rightarrow B_d$. Consistency is achieved even for $r = 1$ and for $r = 6$ the radius corresponds to the size of large neuron. The most natural interpretation would be that these flux tubes topologically condense at the flux tubes of $B_d$ or $B_E$. Both bosonic ions and the Cooper pairs of electrons or of fermionic ions can act as charge carriers so that actually a whole zoo of super-conductors is predicted. There is even some support for the view that even molecules and macromolecules can drop to the magnetic flux tubes [K6].

#### Consciousness related claims

If mono-atomic elements represent dark or partially dark matter with suggested properties, the claimed finding by Hudson that 5 per cent of brain tissue of pig by dry matter weight is Rhodium and Iridium might be understood.

In order to not induce un-necessary negative reactions in materialistic readers, I have purposefully left out Hudson's references to alchemy and Biblical stories. These references admittedly begin to make sense for an open minded reader if dark matter serves as a kind of elixir of life or philosopher's stone. If there exists an infinite hierarchy of conscious entities, it would not be difficult to accept that alchemists (Newton being one of them) would have had precognition about the existence of dark matter and its significance for life.

#### Possible implications

The existence of exotic atoms could have far reaching consequences for the understanding of bio-systems. If Hudson's claims about super-conductor like behavior are correct, the formation of exotic atoms in bio-systems could provide the needed mechanism of electronic super-conductivity. One could even argue that the formation of exotic atoms is the magic step transforming chemical evolution to biological evolution.

Equally exciting are the technological prospects. If the concept works it could be possible to manufacture exotic atoms and build room temperature super conductors and perhaps even artificial life some day. It is very probable that the process of dropping electron to the larger space-time sheet requires energy and external energy feed is necessary for the creation of artificial life. Otherwise the Earth and other planets probably have developed silicon based life for long time ago. Ca, K and Na ions have central position in the electrochemistry of cell membranes. They could actually correspond to exotic ions obtained by dropping some valence electrons from $k = 137$ atomic space-time sheet to larger space-time sheets. For instance, the $k = 149$ space-time sheet of lipid layers could be in question.

The status of ORMEs is far from certain and their explanation in terms of exotic atomic concept need not be correct. The fact is however that TGD predicts exotic atoms: if they are not observed TGD approach faces the challenge of finding a good explanation for their non-observability.

### 6.6.2 Connection with cold fusion?

The basic prediction of TGD is a hierarchy of fractally scaled variants of non-asymptotically free QCD like theories and that color dynamics is fundamental even for our sensory qualia (visual colors identified as increments of color quantum numbers in quantum jump). The model for ORMEs suggest that exotic protons obey QCD like theory in the size scale of atom. If this identification is correct, QCD like dynamics might be studied some day experimentally in atomic or even macroscopic length scales of order cell size and there would be no need for ultra expensive accelerators! The fact that Palladium is one of the "mono-atomic" elements used also in cold fusion experiments as a target material [41, 42] obviously puts bells ringing.

### What makes possible cold fusion?

I have proposed that cold fusion might be based on Trojan horse mechanism in which incoming and target nuclei feed their em gauge fluxes to different space-time sheets so that electromagnetic Coulomb wall disappears [F8]. If part of Palladium nuclei are "partially dark", this is achieved. Another mechanism could be the de-localization of protons to a larger volume than nuclear volume induced by the increase of $\hbar_{eff}$ meaning that reaction environment would differ dramatically from that appearing in the usual nuclear reactions and the standard objections against cold fusion would not apply anymore [F8]: this delocalization could correspond to the darkness of electromagnetic field bodies of protons.

A third proposal is perhaps the most elegant and relies on the nuclear string model [F9] predicting a large number of exotic nuclei obtained by allowing the color bonds connecting nucleons to have all possible em charges $1, 0, 1$. Many ordinary heavy nuclei would be exotic in the sense that some protons would correspond to protons plus negatively charged color bonds. The exchange of an exotic weak boson between $D$ and $Pd$ nuclei transforming $D$ nuclei to exotic neutral $D$ nuclei would occur. The range of the exotic weak interaction correspond to atomic length scale meaning that it behaves as massless particle below this length scale. For instance, $W$ boson could be $n = 2^{11}$ dark variant of $k = 113$ weak boson but also other options are possible.

### How standard objections against cold fusion can be circumvented?

The following arguments against cold fusion are from an excellent review article by Storms [43].

1. Coulomb wall requires an application of higher energy. Now electromagnetic Coulomb wall disappears in both models.

2. If a nuclear reaction should occur, the immediate release of energy can not be communicated to the lattice in the time available. In the recent case the time scale is however multiplied by the factor $r = n_a$ and the situation obviously changes. For $n_a = 2^{11}$ the time scale corresponding to MeV energy becomes that corresponding to keV energy which is atomic time scale.

3. When such an energy is released under normal conditions, energetic particles are emitted along with various kinds of radiation, only a few of which are seen by various CANR (Chemically Assisted Nuclear Reactions) studies. In addition, gamma emission must accompany helium, and production of neutrons and tritium, in equal amounts, must result from any fusion reaction. None of these conditions is observed during the claimed CANR effect, no matter how carefully or how often they have been sought. The large value of $\hbar(M^4)$ implying large Compton lengths for protons making possible geometric coupling of gamma rays to condensed matter would imply that gamma rays do not leave the system. If only protons form the quantum coherent state then fusion reactions do not involve the protons of the cathode at all and production of $^3He$ and thus of neutrons in the fusion of $D$ and exotic $D$.

4. The claimed nuclear transmutation reactions (reported to occur also in living matter [44]) are very difficult to understand in standard nuclear physics framework.

   i) The model of [F8] allows them since protons of different nuclei can re-arrange in many different manners when the dark matter state decays back to normal.

   ii) Nuclear string model [F9] allows transmutations too. For instance, neutral exotic tritium produced in the reactions can fuse with $Pd$ and other nuclei.

5. Many attempts to calculate fusion rates based on conventional models fail to support the claimed rates within PdD (Palladium-Deuterium). The atoms are simply too far apart. This objections also fails for obvious reasons.

### Mechanisms of cold fusion

One can deduce a more detailed model for cold fusion from observations, which are discussed systematically in [43] and in the references discussed therein.

1. A critical phenomenon is in question. The average $D/Pd$ ratio must be in the interval $(.85, .90)$. The current must be over-critical and must flow a time longer than a critical time. The effect occurs in a small fraction of samples. $D$ at the surface of the cathode is found to be important and activity tends to concentrate in patches. The generation of fractures leads to the loss of the anomalous energy production. Even the shaking of the sample can have the same effect. The addition of even a small amount of $H_2O$ to the electrolyte (protons to the cathode) stops the anomalous energy production.

   i) These findings are consistent the view that patches correspond to a macroscopic quantum phase involving delocalized nuclear protons. The added ordinary protons and fractures could serve as a seed for a phase transition leading to the ordinary phase [F8].

   ii) An alternative interpretation is in terms of the formation of neutral exotic $D$ and exotic $Pd$ via exchange of exotic, possibly dark, $W$ bosons massless below atomic length scale [F9].

2. When $D_2O$ is used as an electrolyte, the process occurs when $PdD$ acts as a cathode but does not seem to occur when it is used as anode. This suggests that the basic reaction is between the ordinary deuterium $D = pn$ of electrolyte with the exotic nucleus of the cathode. Denote by $\hat{p}$ the exotic proton and by $\hat{D} = n\hat{p}$ exotic deuterium at the cathode.

   For ordinary nuclei fusions to tritium and $^3He$ occur with approximately identical rates. The first reaction produces neutron and $^3He$ via $D+D \rightarrow n+^3He$, whereas second reaction produces proton and tritium by $3H$ via $D + D \rightarrow p +^3 H$. The prediction is that one neutron per each tritium nucleus should be produced. Tritium can be observed by its beta decay to $^3He$ and the ratio of neutron flux is several orders of magnitude smaller than tritium flux as found for instance by Tadahiko Mizuno and his collaborators (Mizuno describes the experimental process leading to this discovery in his book [45]). Hence the reaction producing $^3He$ cannot occur significantly in cold fusion which means a conflict with the basic predictions of the standard nuclear physics.

   i) The explanation discussed in [F8] is that the proton in the target deuterium $\hat{D}$ is in the exotic state with large Compton length and the production of $^3He$ occurs very slowly since $\hat{p}$ and $p$ correspond to different space-time sheets. Since neutrons and the proton of the $D$ from the electrolyte are in the ordinary state, Coulomb barrier is absent and tritium production can occur. The mechanism also explains why the cold fusion producing $^3He$ and neutrons does not occur using water instead of heavy water.

   ii) Nuclear string model [F9] model predicts that only neutral exotic tritium is produced considerably when incoming deuterium interacts with neutral exotic deuterium in the target.

3. The production of $^4He$ has been reported although the characteristic gamma rays have not been detected.

   i) $^4He$ can be produced in reactions such as $D + \hat{D} \rightarrow^4 He$ in the model of [F8].

   ii) Nuclear string model [F8] does not allow direct production of $^4He$ in D-D collisions.

4. Also more complex reactions between $D$ and $Pd$ for which protons are in exotic state can occur. These can lead to the reactions transforming the nuclear charge of $Pd$ and thus to nuclear transmutations.

   Both model explain nuclear transmutations. In nuclear string model [F8] the resulting exotic tritium can fuse with $Pd$ and other nuclei and produce nuclear transmutations.

   The reported occurrence of nuclear transmutation such as $^{23}Na +^{16} O \rightarrow^{39} K$ in living matter [44] allowing growing cells to regenerate elements K, Mg, Ca, or Fe, could be understood in nuclear string model if also neutral exotic charge states are possible for nuclei in living matter. The experimental signature for the exotic ions would be cyclotron energy spectrum containing besides the standard lines also lines with ions with anomalous mass number. This could be seen as a splitting of lines. For instance, exotic variants of ions such $Na^+$, $K^+$, $Cl^-$, $Ca^{++}$ with anomalous mass numbers should exist. It would be easy to mis-interpret the situation unless the actual strength of the magnetic field is not checked.

5. Gamma rays, which should be produced in most nuclear reactions such as $^4He$ production to guarantee momentum conservation are not observed.

   i) The explanation of the model of [F8] is that the recoil momentum goes to the macroscopic quantum phase and eventually heats the electrolyte system. This provides obviously the mechanism by which the liberated nuclear energy is transferred to the electrolyte difficult to imagine in standard nuclear physics framework.

   ii) In nuclear string model [F9] $^4He$ is not produced at all.

6. Both models explain why neutrons are not produced in amounts consistent with the anomalous energy production. The addition of water to the electrolyte is however reported to induce neutron bursts.

   i) In the model of [F8] a possible mechanism is the production of neutrons in the phase transition $\hat{p} \rightarrow p$. $\hat{D} \rightarrow p+n$ could occur as the proton contracts back to the ordinary size in such a manner that it misses the neutron. This however requires energy of 2.23 MeV if the rest masses of $\hat{D}$ and $D$ are same. Also $\hat{D} + \hat{D} \rightarrow n +^3 He$ could be induced by the phase transition to ordinary matter when $\hat{p}$ transformed to $p$ does not combine with its previous neutron partner to form $D$ but recombines with $\hat{D}$ to form $^3\hat{He} \rightarrow^3 He$ so that a free neutron is left.

   ii) Nuclear string model [F9] would suggest that the collisions of protons of water with exotic $D$ produce neutron and ordinary $D$. This requires the transformation of negatively charged color bond between p and n of target D to a neutral color bond between incoming p and neutron of target.

### 6.6.3 Connection with sono-luminescence and sono-fusion?

Sono-luminescence [46] is a poorly understood phenomenon in which the compression of bubbles in liquid leads to very intense emission of photons and generation of temperatures which are so high that even nuclear fusion might become possible. Sono-fusion [47] is a second closely related poorly understood phenomenon. I have discussed a TGD inspired model for sono-luminescence in terms of p-adic length scale hypothesis.

In bubble compression the density of matter inside bubble might become so high that the Compton lengths associated with possibly existing conformally confined phases inside nuclei could start to overlap and a delocalized phase of protons and/or neutrons could form and em and $Z^0$ Coulomb walls could disappear. Cold fusion would occur and the energy produced would explain the achieved high temperatures and sono-luminescence. Thus the causal relation would be reversed from what it is usually believed to be. The same anomalies are predicted as in the case of cold fusion also now.

Bubble compression brings in mind "mini crunch" occurring also in RHIC experiments, and p-adic fractality suggests that analogy might be rather precise in that magnetic flux tubes structure carrying Bose-Einstein condensate of protons, electrons and photons might form. The intense radiation of photons might be an analog of thermal radiation from an evaporating black hole. The relevant p-adic scale is probably not smaller than 100 nm, and this would give Hagedorn temperature which is around $T_H \sim 10$ eV for ordinary Planck constant and much smaller than fusion temperature. For $\hbar_s$ the Hagedorn temperature would be scaled up to $T_H \sim rT_H$, $r = \hbar_s/\hbar$. For $r = 10^5$ temperatures allowing nuclear fusion would be achieved.

## 6.7 Dark atomic physics

Dark matter might be relevant also for atomic physics and in the sequel some speculations along these lines are represented. Previous considerations assumed that only field bodies can be dark. The notion of N-atom discussed below is based on more general view about dark matter not requiring that elementary particles are maximally quantum critical in the sense that elementary particle like partonic 2-surfaces remain invariant under the cyclic groups $G_a \times G_b$ leaving invariant the choice of the quantization axes. Therefore the sheets of space-time surface associated with the sheets of the multiple coverings $H \rightarrow H/G_a \times G_b$ do not co-incide and can carry fermionic quantum numbers. The minimum option is that fermion states possibly associated with different sheets are identical so that an apparent failure of Fermi statistics would result. The additional degree of freedom would correspond to an element of group algebra of $G_a \times G_b$ for a given many-fermion state. The more general option allowing different fermion quantum numbers is not consistent with quantum classical correspondence in its strongest form.

### 6.7.1 From naive formulas to conceptualization

I have spent a considerable amount of time on various sidetracks in attempts to understand what the quantization of Planck constant does really mean. As usual, the understanding has emerged by unconscious processing rather than by a direct attack.

#### Naive approach based on formulas

The whole business started from the naive generalization of various formulas for quantized energies by replacing Planck constant with is scaled value. It seems that this approach does not lead to wrong predictions, and is indeed fully supported by the basic applications of the theory. Mention only the quantization of cyclotron energies crucial for the biological applications, the quantization of hydrogen atom, etc... The necessity for conceptualization emerges when one asks what else the theory predicts besides the simple zoomed up versions of various systems.

#### The geometric view about the quantization of Planck constant

After the naive approach based on simple substitutions came the attempt to conceptualize by visualizing geometrically what dark atoms could look like, and the description in terms of $N(G_a)\times N(G_b)$-fold covering $H \rightarrow H/G_a \times G_b$ emerged.

Especially confusing was the question whether one should assign Planck constant to particles or to their interactions or both. It is now clear that one can assign Planck constant to both the "personal" field bodies assignable to particles and to their interactions ("relative" or interaction field bodies), and that each interaction can correspond to both kinds of field bodies. Planck constant for the relative field bodies depends on the quantum numbers of both particles as it does in the case of gravitation. The Planck constant assignable to the particle's "personal" field body makes possible generalizations like the notion of N-atom.

Each sheet of the "personal" field body corresponds to one particular Compton length characterizing one particular interaction and electromagnetic interaction would define the ordinary Compton length. The original picture was that topological condensation of $CP_2$ type vacuum extremal occurs at space-time sheet with size of Compton length identified usually with particle. In the new picture this space-time sheet can be identified as electromagnetic field body.

Elementary particles have light-like partonic 3-surfaces as space-time correlates. If these 3-surfaces are fully quantum critical, they belong to the intersection of all spaces $H/G_a \times G_b$ with fixed quantization axes. This space is just the 4-D subspace $M^2 \times S^2 \subset M^4 \times CP_2$, where $S^2$ is geodesic sphere of $CP_2$. Partonic 2-surfaces are in general non-critical and one can assign to them a definite value of Planck constant.

There are two geodesic spheres in $CP_2$. Which one should choose or are both possible?

1. For the homologically non-trivial one corresponding to cosmic strings, the isometry group is $SU(2) \subset SU(3)$. The homologically trivial one $S^2$ corresponds to vacuum extremals and has isometry group $SO(3) \subset SU(3)$. The natural question is which one should choose. At quantum criticality the value of Planck constant is undetermined. The vacuum extremal would be a natural choice from the point of view of quantum criticality since in this case the value of Planck constant does not matter at all and one would obtain a direct connection with the vacuum degeneracy. One can of course ask whether all surfaces $M^2 \times Y^2$, $Y^2$ Lagrangian submanifold of $CP_2$ should be allowed: the answer seems to be "No" since in the generic case $SO(3)$ does not act as $H$-isometries of $Y^2$.

2. The choice of the homologically non-trivial geodesic sphere as a quantum critical sub-manifold would conform with the previous guess that $\mathcal{M} : \mathcal{N} = 4$ corresponds to cosmic strings. It is however questionable whether the ill-definedness of the Planck constant is consistent with the non-vacuum extremal property of cosmic strings unless one assumes that for partonic 3-surfaces $X^3 \subset M^2 \times S^2$ the effective degrees of freedom reduce to mere topological ones.

### Fractionization of quantum numbers and the hierarchy of Planck constants

The original generalization of the notion of imbedding space to a union of the factor spaces $\hat{H}/G_a \times G_b$ discussed in the section "General ideas about dark matter" does not allow charge fractionization whereas the covering spaces $\hat{H}\hat{\times}(G_a \times G_b)$ allow a fractionization in a natural manner. Also hybrid cases are obtained corresponding $(\hat{M}^4\hat{\times}G_a) \times (\hat{CP}_2/G_b)$ and $(\hat{M}^4/G_a) \times (\hat{CP}_2\hat{\times}G_b)$. The simplest assumption is that Planck constant is a homomorphism from the lattice like structure of groups with product of groups defined to be the group generated by the groups.

*1. $\hat{H}/G_a \times G_b$ option*

The safest and indeed natural assumption motivated by Jones inclusions is that physical states in sector $H/G_a \times G_b$ are $G_a \times G_b$ invariant meaning a discrete analog of color confinement. This alone excludes fractionization and actually implies just the opposite of it.

1. For states with vanishing fermionic quantum numbers $G_a \times G_b$ invariance means that wave functions live in the base space $H/G_a \times G_b$. For instance, $L_z$ would be a multiple of $n_a$ defining the order of maximal cyclic subgroup of $G_a$. Analogous conclusion would hold true for color quantum numbers.

2. Just as in the case of ordinary spin fermionic quantum numbers (spin, electro-weak spin) necessarily correspond to the covering group of the isometry group since a state with a half-odd integer spin does not remain invariant under the subgroups of the rotation group. In particular, states with odd fermion number cannot be $G_a \times G_b$ invariant. For even fermion numbers it is possible to have many-particle states for which individual particles transform non-trivially under orbital $G_a \times G_b$ if total $G_a \times G_b$ quantum numbers in spin like degrees of freedom compensate for the orbital quantum numbers (for instance, total spin is multiple of $n_a$). Hence the group algebra of $G_a \times G_b$ would characterize the states in orbital degrees of freedom as indeed assumed. The earlier picture would be correct apart from the lacking assumption about overall $G_a \times G_b$ invariance.

3. The construction of these states could be carried out just like the construction of ordinary $G_a \times G_b$ invariant states in $H$ so that the mathematical treatment of the situation involves no mystics elements. Since $G_a \times G_b$ is actually assigned with a sector $M^4_\pm \times CP_2$ with fixed quantization axes and preferred point of $H$, one has center of mass degrees of freedom for the position of tip of $M^4_\pm$ and a preferred point of $CP_2$. This gives new degrees of freedom and one would have a rich spectrum of N-electrons, N-nucleons, N-atoms, etc.... behaving effectively as elementary particles. For example, one interesting question is whether 2-electrons could be interpreted as Cooper pairs of particular kind This would require either $s_z = 0, l_z = 0$ or $s_z = 1, l_z = mn_a - 1$, $m = 0, 1, 2...$ For instance, for $n_a = 3$ (the minimal value of $n_a$) one could have $s_z = l, l_z = 2$ with $J_z = 3$. One can also ask whether some high spin nuclei could correspond to N-nuclei.

4. This picture is quite predictive. For instance, in the case of gravitational interactions it would mean that the spin angular momentum of an astrophysical system is a multiple of "personal" gravitational Planck constant $GM^2/v_0$. The value of $v_0$ could be deduced from this condition and is expected to be a negative power of 2. In the same manner the relative angular momentum of planet-Sun system would be a multiple of $GMm/v_0$ using the gravitational Planck constant as a unit. This is a strong prediction but reduces to the Bohr quantization rule for circular orbits.

*2. $\hat{H}\hat{\times}(G_a \times G_b)$ option*

For this option the units of orbital angular momentum and color hyper charge and isospin are naturally scaled down by the factor $n_i$. In the case of spin and electro-weak spin this kind of scaling would require a covering group of Abelian Cartan group. Since the first homotopy group of SU(2) vanishes there are no coverings of $SU(2)$ in the ordinary sense of the word but quantum version of $SU(2)$ is an excellent candidate for the counterpart of the covering. Also quantum variants of other Lie groups are highly suggestive on basis of ADE correspondence.

There does not seem to be any absolute need for assuming $G_a \times G_b$ singletness. If so, there would be asymmetry between coverings and factor spaces bringing in mind confined and de-confined phases.

Since coverings *resp.* factor spaces are labelled by $N^{11}$-valued lattice momenta *resp.* their negatives, this asymmetry would be analogous to time reversal asymmetry. Note however that all components of lattice momenta are either positive or negative and that this fits nicely with the interpretation of p-adic integers as naturals and "super-naturals". An intriguing question is whether there might be some connection with M-theory and its 4-D compactifications (dropping reflection group one obtains 7-D lattice).

*3. Implications of the new picture*

This picture has several important implications.

1. There is a symmetry between $CP_2$ and $M^4$ so that for a given value of Planck constant one obtains factor space with divisor group $G_a \times G_b$ and covering space with homotopy group $G_b \times G_a$. For large values of Planck constant the large $Z_n$ symmetry acts in $M^4$ factor *resp.* $CP_2$ factor for these two options. Therefore the large $Z_n$ symmetry in $M^4$ degrees of freedom, which can be challenged in some of the applications, could be replaced with large $Z^n$ symmetry in $CP_2$ degrees of freedom emerging rather naturally.

2. For a large value of Planck constant it is possible to obtain a relatively small dark matter symmetry group in $M^4$ factor and also the small genuinely 3-dimensional symmetry groups (tedrahedral, octahedral, icosahedral groups) can act in $M^4$ factor as symmetries of dark matter. Hence the groups appearing as symmetries of molecular physics (aromatic rings, DNA,...) could be identified as symmetries of dark electron pairs. These symmetries appear also in longer length scales (snow flakes and even astrophysical structures). In earlier picture one had to assume symmetry breaking at the level of visible matter.

3. The notion of N-atom generalizes. The original model predicted large electronic charges suggesting instability plus large $Z_n$ symmetry in $M^4$ degrees of freedom (identified as a symmetry of field body). For instance, in the case of DNA double helix this kind of large rotational symmetry is questionable. Same applies to astrophysical systems with a gigantic value of gravitational Planck constant. The change of the roles of $M^4$ and $CP_2$ and charge fractionization would resolve these problems. This would provide a support for the idea that the electronic or protonic hot spots of catalyst and substrate correspond to fractional charges summing up to a unit charge. This framework could provide a proper realization for the original vision that symbolic level of dynamics and sex emerge already at the molecular level with sequences of catalyst sites representing "words" and their conjugates (opposite molecular sexes).

### 6.7.2 Dark atoms and dark cyclotron states

The development of the notion of dark atom involves many side tracks which make me blush. The first naive guess was that dark atom would be obtained by simply replacing Planck constant with its scaled counterpart in the basic formulas and interpreting the results geometrically. After some obligatory twists and turns it became clear that this assumption is indeed the most plausible one. The main source of confusion has been the lack of precise view about what the hierarchy of Planck constants means at the level of imbedding space at space-time.

#### The assumptions of the model of dark atom

Let us briefly summarize the basic assumptions of the model.

1. The quantized values of effective Planck constant appearing in Schrödinger equation are in the set $\hbar_{eff}/\hbar_0 \in \{n_a/n_b, n_b/n_a, n_a n_b, 1/(n_a n_b)$ corresponding to the sectors $\hat{H}/G_a \times G_b$, $\hat{H}\hat{\times}(G_a \times G_b)$, $\hat{M}^4/G_a \times (\hat{CP}_2\hat{\times})G_b$, and $(\hat{M}^4\hat{\times}G_a) \times \hat{CP}_2/G_b$. Note that one can consider the replacement of the right hand side of the formula for Planck constant by its inverse, and at this stage one must just keep mind open for the options.

2. In the case of covering spaces the units of quantum numbers are replaced by $1/n_a$ and $1/n_b$, $n_i$ the order of maximal cyclic subgroup. Both fermion number, spin, color, and electro-weak quantum numbers can fractionize. For factor spaces units are inverses of these and in this case states are $G_a \times G_b$ singlets: hence N-atoms with dark electrons in general involve many-electron

states with even number of electrons. Simplest situation corresponds to spin singlet electron pair and one cannot exclude the possibility that valence electrons are dark electrons.

3. It is assumed that the quantum critical sub-manifolds $M^2 \times S^2$ correspond to homologically trivial geodesic sphere. Note that although quantum critical parton orbits are vacuum extremals, induced electric and $Z^0$ fields are non-vanishing in general. This is a very important point since it makes possible electric and magnetic fluxes between different sectors of the generalized imbedding space $H$. For instance, nucleus and electrons can belong to different sectors of $H$. A helpful visualization is provided by a book with pages glued together along $M^2 \times S^2$. Both electric and magnetic flux are assumed to be conserved as it flows from a sector to another one: therefore dark electron in the covering experiences the electric charge of nucleus as scaled down by a factor $1/N(G_b)$ giving the number of sectors.

4. In the case of factor spaces 3-surface is invariant under $G_i$ so that one has $N(G_i)$ strict copies of the particle: $G_i$ invariance selects states with $l_z = nn_a$ and forces many electron states in order to satisfy quantization conditions in the case of spin. Here one can consider the possibility that single particle states transform according to irreducible representations of $G_i$ although the entire state is $G_i$ invariant.

5. In the case of covering spaces there is no need to assume that partonic 3-surface consists of $N(G_i)$ identical copies. In this case the states are naturally classified by the representations of $G_a \times G_b$ identifiable as elements of the corresponding group algebra. Apparently one has a modified statistics since $N(G_a) \times N(G_b)$ states correspond to the same state in the ordinary sense of the word. It can happen that the action of $G_i$ in $H$ has some isotropy subgroup. In fact, the action of $D_{2n}$ in $M^2$ and $S^2$ reduces to the action of the corresponding cyclic group $Z_n$ so that has $N(G_i) = n_i$.

6. One can consider quite a number of variants for the dark atom. Even nucleus could be dark (either fractionally charged or $N$-nucleus with charge $N(G_b)$). Second interesting possibility is atom with ordinary nucleus and dark electrons. It is also possible that only valence electrons are dark and correspond to one of the allowed varieties.

**Thermal stability**

The energy scale of hydrogen atom is proportional to $1/\hbar^2$. Depending on the sector of $H$ and on the values of $n_a$ and $n_b$ the scale of energy can increase or be reduced. Also charge fractionization in case of covering spaces of $\hat{CP_2}$ reduces the energy scale. By the conservation of electric flux this takes place for both proton and electron so that the energy scale receives a factor $1/N(G_b)^2$. For large values of Planck constant the energy scale is reduced and thermal stability poses upper limit on the value of Planck constant if dark matter is assumed to be in thermal equilibrium with ordinary matter.

The following table lists the four possible options.

$$\begin{array}{cccc} I & II & III & IV \\ \hat{H}\hat{\times}G_a \times G_b & \hat{H}/(G_a \times G_b) & (\hat{H}/G_a)\hat{\times}G_b & (\hat{H}/G_b)\hat{\times}G_a \end{array}$$

One can also consider two options for the formula of Planck constant.

1. For $\hbar/\hbar_0 = n_a/n_b$ in case of option I and $G_b = Z_n$ thermal stability condition boils down to the condition

$$\begin{array}{ll} I: & Z \geq \frac{n_b^3}{n_a} \times x \ , \\ II: & Z \geq \frac{n_a}{n_b} \times x \ , \\ III: & Z \geq n_a n_b^3 \times x \ , \\ IV: & Z \geq \frac{1}{n_a n_b} \times x \ . \end{array} \quad x \equiv \sqrt{\frac{E_{th}}{E_1}} \ . \tag{6.7.1}$$

Here $E_{th}$ denotes thermal energy. Note that option III maximizes Planck constant for given $G_a \times G_b$ and is therefore especially interesting. Option IV minimizes in turn minimizes it.

By replacing the formula for Planck constant with its inverse ($\hbar/\hbar_0 = n_b/n_a$ for option I) one obtains the conditions

$$\begin{array}{ll} I: & Z \geq n_b^2 n_a \times x \ , \\ II: & Z \geq \frac{n_b}{n_a^2} \times x \ , \\ III: & Z \geq \frac{n_b^2}{n_a} \times x \ , \\ IV: & Z \geq n_a n_b \times x \ . \end{array} \quad x \equiv \sqrt{\frac{E_{th}}{E_1}} \ . \tag{6.7.2}$$

Recall that the preferred values of $n_a$ and $n_b$ correspond to the number theoretically simple quantum phases $exp(i2\pi/n_i)$ expressible using only square root function and rational functions applied on rationals. $n_i$ are given as products $2^k \times \prod_i F_i$, where $F_i$ are distinct Fermat primes.

2. The original proposal for the hierarchy of Planck constants coming as $\hbar/\hbar_0 = \lambda = 2^{11k}$ does not allow stable hydrogen atom at room temperature. This is not a problem since this hierarchy is associated with cyclotron energies.

3. For option I with $n_a = 1$ and $n_b \in \{3, 5, 6, 12\}$ one would have $Z \geq z \in \{1, 6, 10, 81\}$. Carbon atom would satisfy the condition fors $(n_b = 5, n_a = 1)$ and $(n_b = 6, n_a = 2)$.

4. For option II with $n_b = 1$ one obtains $Z \geq n_a$ for $E_{th} \sim E_1$. What is intriguing that aromatic carbon 5- and 6-cycles, which are abundant in biology and correspond to factor space option, would satisfy this condition for $E_{th} \sim E_1$. For $n > 6$-cycles the condition would not be satisfied. Could this condition state something non-trivial about pre-biotic evolution at high temperatures?

5. For option III with $n_b = 3$ meaning charge fractionization and $n_a$-fold cyclic symmetry one obtains $Z \geq n_a \times 1.3$ at room temperature. For $n_b = 3$ 5-cycles with $\hbar/\hbar_0 = 15$ and 6-cycles with $\hbar/\hbar_0 = 18$ would be stable below room temperature but not higher cycles. This estimate is of course very rough since the energy scale $E_1$ for possibly dark delocalized free electron pairs appearing in n-cycles need not be exactly equal to $E_1$.

6. If one replaces the right hand side by its inverse in the expression of Planck constant the factor space option would favor the thermal stability for large values of $n_a$ and n-cycles with large $n$ so that this option does not look reasonable.

**Is the fractionization of principal quantum number possible?**

One can also consider the fractionization $n \rightarrow n/n_b$ of the principal quantum number of hydrogen analogous to that occurring for angular momentum. If one assumes that fractionization occurs only for isometry charges this option is excluded. This argument might quite well be enough to exclude this kind of fractionization.

Since s-wave states correspond to orbits which represent radial motion between two extremes, one could consider the possibility of periodic radial orbits which run to maximal radius, back to the maximum radius at the opposite side and close after $N_b$ loops of this kind, where $N_b$ is the order of maximal cyclic subgroup of $G_b$. This would be direct a counterpart for a rotational orbit which closes only after $N_b$ full $2\pi$ rotations.

One can consider the occurrence of this phenomenon also in the case of ordinary imbedding space. At least inn this case the interpretation in terms of a transition to chaos might be appropriate. In case of generalized imbedding space one could speak about transition to chaos by period $N_b$-folding and suggest fractionization of the radial quantum number to $n/N_b$. Similar fractionization could makes sense for all orbits which are not precisely circular. This fractionization would increase the energy scale by a factor $n_b^2$.

In empty space fractional diagonal quantum number would mean that ordinary hydrogen atom wave functions diverge at spatial infinity. This kind of scaling is consistent with finiteness inside dark sector if the copies of sheet fuse together at at 3-surface belonging to the quantum critical manifold $M^2 \times S^2$.

### Possible experimental implications

An interesting possibility is the formation of stable hydrogen bonds as a fusion of N-hydrogen atoms with $N-k$ and $k$ electrons to give rise to a full shell of electrons possessing an exceptional stability.

1. In the case of factor space the state would be analogous to full Fermi sea or full atomic or nuclear shells. The large value of electric charge might make the state unstable. The resulting state would be invariant under $G_a \times G_b$.

2. For covering space option the total quantum numbers for the resulting state would be those of electron. The degeneracy of states is $N(G_a) \times N(G_b)$-fold corresponding to the group algebra of $G_a \times G_b$. This would mean that the full shell for states with given energy $E_n$ would have total energy $n_a n_b E_n$.

Consider next the possible experimental implications of N-atom concept.

1. Valence electrons could transform to dark electrons in one of the four possible senses.

   i) For covering space option fractal electrons could result. Fractal electron and its conjugate would combine to form a particle with quantum numbers of electrons but with larger mass. Catalytic sites are one possible candidate for fractal electrons and catalyst activity could be understood as a strong tendency of fractal electron and its conjugate to fuse to form an ordinary electron. The anomalously high mass would be the tell-tale signature of these exotic electrons. The effective mass of electron in condensed matter is known to vary in wide limits and to exceed electron mass even by a factor of order hundred: is this really a mere standard physics effect?

   ii) For factor space option full electron shells would be the most stable states and would have have rather high fermion number but vanishing spin. Spin singlet electron pairs would define stable $G_a \times G_b$ singlets. These states might behave like Cooper pairs.

   iii) If the value of Planck constant is smaller than its standard value, the molecular bonds containing dark electrons could be stable at anomalously high temperatures. Note that the dependence of the bond energy on Planck constant need not be non-perturbative as it is for atoms. For instance, a naive application of the formulas for vibrational and rotational energies assuming that the parameters of Hamiltonian (such as vibrational energy scale) do not depend on Planck constant would suggest that large Planck constant implies thermal stability in this kind of situations.

   iv) Both fermionic a $(Na^+, K^+, Cl^-)$ and bosonic $(Ca^{++}, Mg^{++})$ ions are very important in biology. Optimist would interpret this as a support for the plasmoids as predecessors of biological life. These ions are formed in some manner and the simplest manner would be transformation of valence electrons to dark electrons and subsequence delocalization.

2. The recently discovered evidence [75] that Sun has a solid surface consisting mostly of calcium-ferrite is inconsistent with the fact that photosphere has temperature 5800 K (iron melts at 1811 K and calcium-aluminium ferrite in the range 1670-1720 K at normal pressure). Metallic bonds responsible for the solid state are due to the interaction of delocalized conduction electrons with metal atoms. If the valence electrons giving rise to conduction bands have a reduced value of Planck constant, the energy scale of the valence bands would become higher and raise the melting temperature. The reduction of Planck constant seems necessary by the non-perturbative dependence of atomic binding energies on $\hbar$.

3. The claims of Mills [73] about the scaling up of the binding energy of the hydrogen ground state by a square $k^2$ $(k = 2, 3, 4, 5, 6, 7, 10)$ of an integer in plasma state are a challenge for the theory. The simplest explanation is that the Planck constant is reduced by factor $1/k$.

Before I had realized that $\hbar_{eff}$ satisfies the formula $\hbar_{eff}/\hbar_0 = n_a/n_b$, the presence of $k = 2$ state in spectrum was a difficult problem and I ended up with the idea that the quantum variant of Laguerre polynomials associated with quantized radial motion could explain $n = 1/2$ and also other fractional states. Later it will be found that this approach indeed predicts these quantum numbers approximately! This raises the question whether these states might appear as metastable intermediate states for hydrogen atom in the phase having $\hbar_{eff}/\hbar_0 = 1$ and $n_a = n_b > 1$. These states would be unstable against the phase transition leading to $n_b > kn_a$, $k = 2, 3, .....$

Living matter could perhaps be understood in terms of quantum deformations of the ordinary matter, which would be characterized by the quantum phases $q = exp(i2\pi/N)$. Hence quantum groups, which have for long time suspected to have significance in elementary particle physics, might explain the mystery of living matter and predict an entire hierarchy of new forms of matter.

As demonstrated in [N4], the notion of $N$-atom leads to an elegant model for the lock and key mechanism of bio-catalysis as well as the understanding of the DNA replication based on the spontaneous decay and completion of fermionic $N < N(G)$-particles to $N = N(G)$-particles. Optimal candidates for the $N$-particles are $N$-hydrogen atoms associated with bio-molecules appearing as letters in the "pieces of text" labelling the molecules. Lock and key would correspond to conjugate names in the sense that $N_1$ and $N_2$ for the letters in the name and its conjugate satisfy $N_1 + N_2 = N = N(G)$: as the molecules combine, a full fermion shell represented is formed.

### 6.7.3 Dark cyclotron states

Dark cyclotron states have been scaled spectrum $E_n = (n_a/n_b)E_n$ and for large values of $n_a$ one can have energies above thermal threshold. The crucial observation is that the flux of ordinary magnetic field cannot divide into $N(G)$ dark fluxes since magnetic fluxes necessarily vanish at orbifold surfaces. Hence dark magnetic field would carry total flux which is $N(G)$ times higher than the flux of ordinary magnetic field of same intensity. Fermionic analogs of Bose-Einstein condensates are possible so that each cyclotron energy $E_n = n\hbar_0\omega$ would be replaced with spectrum extending from $(n_a/n_b)E_n$ to $(n_a/n_b)N(G_b)E_n$ in the case of fractionization.

### 6.7.4 Could q-Laguerre equation relate to the claimed fractionation of the principal quantum number for hydrogen atom?

In the following a semiclassical model based on dark matter and hierarchy of Planck constants is developed for the fractionized principal quantum number $n$ claimed by Mills [73] to have at least the values $n = 1/k$, $k = 2, 3, 4, 5, 6, 7, 10$. This model can explain the claimed fractionization of the principal quantum number $n$ for hydrogen atom [73] in terms of single electron transitions for all cases. The original model could not cope with $n = 1/2$: the basic reason is that Jones inclusions are characterized by quantum phases $q = exp(i\pi/n)$, $n > 2$. Since quantum deformation of the standard quantum mechanism is involved, this motivated an attempt to understand the claimed fractionization in terms of q-analog of hydrogen atom. The safest interpretation for them would be as states which can exist in ordinary imbedding space (and also in other branches). The natural guess would be that they can occur as intermediate states in the phase transition changing $n_b/n_a = 1$ to $k = 2, 3, ...$

The Laguerre polynomials appearing in the solution of Schrödinger equation for hydrogen atom possess quantum variant, so called q-Laguerre polynomials [17], and one might hope that they would allow to realize this semiclassical picture at the level of solutions of appropriately modified Schrödinger equation and perhaps also resolve the difficulty associated with $n = 1/2$. Unfortunately, the polynomials discussed in [17] correspond to $0 < q \leq 1$ rather than complex values of $q = exp(i\pi/m)$ on circle and the extrapolation of the formulas for energy eigenvalues gives complex energies.

#### q-Laquerre equation for $q = exp(i\pi/m)$

The most obvious modification of the Laguerre equation for $S$-wave sates (which are the most interesting by semiclassical argument) in the complex case is based on the replacement

$$\begin{aligned} \partial_x &\rightarrow \frac{1}{2}(\partial_x^{q)} + \partial_x^{\overline{q})}) \\ \partial_x^{q)} f &= \frac{f(qx) - f(x)}{(q-1)x} \ , \\ q &= exp(i\pi/m) \end{aligned} \tag{6.7.3}$$

to guarantee hermiticity. When applied to the Laguerre equation

$$x\frac{d^2L_n}{dx^2} + (1-x)\frac{dL_n}{dx} = nL_n \ , \tag{6.7.4}$$

and expanding $L_n$ into Taylor series

$$L_n(x) \ = \ \sum_{n\geq 0} l_n x^n \ , \tag{6.7.5}$$

one obtains difference equation

$$\begin{aligned}
a_{n+1}l_{n+1} \ &+ \ b_n l_n = 0 \ , \\
a_{n+1} \ &= \ \frac{1}{4R_1^2}\left[R_{2n+1} - R_{2n} + 2R_{n+1}R_1 + 3R_1)\right] + \frac{1}{2R_1}\left[R_{n+1} + R_1\right] \\
b_n \ &= \ \frac{R_n}{2R_1} - n^{q)} + \frac{1}{2} \ , \\
R_n \ &= \ 2cos\left[(n-1)\pi/m\right] - 2cos\left[n\pi/m\right] \ .
\end{aligned} \tag{6.7.6}$$

Here $n^{q)}$ is the fractionized principal quantum number determining the energy of the q-hydrogen atom. One cannot pose the difference equation on $l_0$ since this together with the absence of negative powers of $x$ would imply the vanishing of the entire solution. This is natural since for first order difference equations lowest term in the series should be chosen freely.

### Polynomial solutions of q-Laquerre equation

The condition that the solution reduces to a polynomial reads as

$$b_n \ = \ 0 \tag{6.7.7}$$

and gives

$$n^{q)} \ = \ \frac{1}{2} + \frac{R_n}{2R_1} \ , \tag{6.7.8}$$

For $n = 1$ one has $n^{q)} = 1$ so that the ground state energy is not affected. At the limit $N \rightarrow \infty$ one obtains $n^{q)} \rightarrow n$ so that spectrum reduces to that for hydrogen atom. The periodicity $R_{n+2Nk} = R_n$ reflects the corresponding periodicity of the difference equation which suggests that only the values $n \leq 2m - 1$ belong to the spectrum. Spectrum is actually symmetric with respect to the middle point $[N/2]$ which suggests that only $n < [m/2]$ corresponds to the physical spectrum. An analogous phenomenon occurs for representations of quantum groups [**?**]. When $m$ increases the spectrum approaches integer valued spectrum and one has $n > 1$ so that no fractionization in the desired sense occurs for polynomial solutions.

### Non-polynomial solutions of q-Laquerre equation

One might hope that non-polynomial solutions associated with some fractional values of $n^{q)}$ near to those claimed by Mills might be possible. Since the coefficients $a_n$ and $b_n$ are periodic, one can express the solution ansatz as

$$\begin{aligned}
L_n(x) \ &= \ P_a^{2m)}(x)\sum_k a^k x^{2mk} = P_a^{2m)}(x)\frac{1}{1-ax^{2m}} \ , \\
P_a^{2m)}(x) \ &= \ \sum_{k=0}^{2m-1} l_k x^k \ , \\
a \ &= \ \frac{l_{2m}}{l_0} \ ,
\end{aligned} \tag{6.7.9}$$

This solution behaves as $1/x$ asymptotically but has pole at $x_\infty = (1/a)^{1/2m}$ for $a > 0$.

The expression for $l_{2m}/l_0 = a$ is

$$a = \prod_{k=1}^{2m} \frac{b_{2m-k}}{a_{2m-k+1}} \quad . \tag{6.7.10}$$

This can be written more explicitly as

$$\begin{aligned} a &= (2R_1)^{2m} \prod_{k=1}^{2m} X_k \ , \\ X_k &= \frac{R_{2m-k} + (-2n^{q)} + 1)R_1}{R_{4m-2k+1} - R_{4m-2k} + 4R_{2m-k+1}R_1 + 2R_1^2 + 3R_1} \ , \\ R_n &= 2cos\,[(n-1)\pi/m] - 2cos\,[n\pi/m] \quad . \end{aligned} \tag{6.7.11}$$

This formula is a specialization of a more general formula for $n = 2m$ and resulting ratios $l_n/l_0$ can be used to construct $P_a^{2m)}$ with normalization $P_a^{2m)}(0) = 1$.

**Results of numerical calculations**

Numerical calculations demonstrate following.

1. For odd values of $m$ one has $a < 0$ so that a a continuous spectrum of energies seems to result without any further conditions.

2. For even values of $m$ $a$ has a positive sign so that a pole results.

For even value of $m$ it could happen that the polynomial $P_a^{2m)}(x)$ has a compensating zero at $x_\infty$ so that the solution would become square integrable. The condition for reads explicitly

$$P_a^{2m)}\left( (\frac{1}{a})^{\frac{1}{2m}} \right) = 0 \quad . \tag{6.7.12}$$

If $P_a^{2m)}(x)$ has zeros there are hopes of finding energy eigen values satisfying the required conditions. Laguerre polynomials and also q-Laguerre polynomials must posses maximal number of real zeros by their orthogonality implied by the hermiticity of the difference equation defining them. This suggests that also $P_a^{2m)}(x)$ possesses them if $a$ does not deviate too much from zero. Numerical calculations demonstrate that this is the case for $n^{q)} < 1$.

For ordinary Laguerre polynomials the naive estimate for the position of the most distant zero in the units used is larger than $n$ but not too much so. The naive expectation is that $L_{2m}$ has largest zero somewhat above $x = 2m$ and that same holds true a small deformation of $L_{2m}$ considered now since the value of the parameter $a$ is indeed very small for $n^{q)} < 1$. The ratio $x_\infty/2m$ is below .2 for $m \leq 10$ so that this argument gives good hopes about zeros of desired kind.

One can check directly whether $x_\infty$ is near to zero for the experimentally suggested candidates for $n^{q)}$. The table below summarizes the results of numerical calculations.

1. The table gives the exact eigenvalues $1/n_{q)}$ with a 4-decimal accuracy and corresponding approximations $1/n^{q)}_{\simeq} = k$ for $k = 3, ..., 10$. For a given value of $m$ only single eigenvalue $n^{q)} < 1$ exists. If the observed anomalous spectral lines correspond to single electron transitions, the values of $m$ for them must be different. The value of $m$ for which $n^{q)} \simeq 1/k$ approximation is optimal is given with boldface. The value of $k$ increases as $m$ increases. The lowest value of $m$ allowing the desired kind of zero of $P^{2m)}$ is $m = 18$ and for $k \in \{3, 10\}$ the allowed values are in range $18, .., 38$.

2. $n^{q)} = 1/2$ does not appear as an approximate eigenvalue so that for even values of $m$ quantum calculation produces same disappointing result as the classical argument. Below it will be however found that $n^{q)} = 1/2$ is a universal eigenvalue for odd values of $m$.

| m | $1/n^{q)}_{\simeq}$ | $1/n^{q)}$ | m | $1/n^{q)}_{\simeq}$ | $1/n^{q)}$ |
|---|---|---|---|---|---|
| **18** | **3** | 2.7568 | 30 | 8 | 7.5762 |
| **20** | **4** | 3.6748 | **32** | **8** | 8.3086 |
| 22 | 5 | 4.5103 | **34** | **9** | 9.0342 |
| **24** | **5** | 5.3062 | **36** | **10** | 9.7529 |
| **26** | **6** | 6.0781 | 38 | 10 | 10.4668 |
| **28** | **7** | 6.8330 | | | |

Table 1. The table gives the approximations $1/n^{q})_{\simeq} = 1/k$ and corresponding exact values $1/n^{q})$ in the range $k = 3, ..., 10$ for which $P_a^{2m)}(x_\infty)$ is nearest to zero. The corresponding values of $m = 2k$ vary in the range, $k = 18, ..., 38$. For odd values of $m$ the value of the parameter $a$ is negative so that there is no pole. Boldface marks for the best approximation by $1/n^{q)}_{\simeq} = k$.

**How to obtain $n^{q)} = 1/2$ state?**

For odd values of $m$ the quantization recipe fails and physical intuition tells that there must be some manner to carry out quantization also now. The following observations give a hunch about be the desired condition.

1. For the representations of quantum groups only the first $m$ spins are realized [**?**]. This suggests that there should exist a symmetry relating the coefficients $l_n$ and $l_{n+m}$ and implying $n^{q)} = 1/2$ for odd values of $m$. This symmetry would remove also the double degeneracy associated with the almost integer eigenvalues of $n^{q)}$. Also other fractional states are expected on basis of physical intuition.

2. For $n^{q)} = 1/2$ the recursion formula for the coefficients $l_n$ involves only the coefficients $R_m$.

3. The coefficients $R_k$ have symmetries $R_k = R_{k+2m}$ and $R_{k+m} = -R_m$.

There is indeed this kind of symmetry. From the formula

$$\begin{aligned} \frac{l_n}{l_0} &= (2R_1)^n \prod_{k=1}^{n} X_k \ , \\ X_k &= \frac{R_{n-k} + (-2n^{q)} + 1)R_1}{[R_{2n-2k+1} - R_{n-2k} + 4R_{n-k+1}R_1 + 2R_1^2 + 3R_1} \end{aligned} \tag{6.7.13}$$

one finds that for $n^{q)} = 1/2$ the formula giving $l_{n+m}$ in terms of $l_n$ changes sign when $n$ increases by one unit

$$\begin{aligned} A_{n+1} &= (-1)^m A_n \ , \\ A_n &= \prod_{k=1}^{m} \frac{b_{n+m-k}}{a_{n+m-k+1}} = \prod_{k=1}^{m} (2R_1)^m \prod_{k=1}^{m} X_{k+n} \ . \end{aligned} \tag{6.7.14}$$

The change of sign is essentially due to the symmetries $a_{n+m} = -a_n$ and $b_{n+m} = b_n$. This means that the action of translations on $A_n$ in the space of indices $n$ are represented by group $Z_2$.

This symmetry implies $a = l_{2m}/l_0 = -(l_m)(l_0)^2$ so that for $n^{q)} = 1/2$ the polynomial in question has a special form

$$\begin{aligned} P_a^{2m)} &= P_a^{m)}(1-Ax^m) \ , \\ A &= A_0 \ . \end{aligned} \tag{6.7.15}$$

The relationship $a=-A^2$ implies that the solution reduces to a form containing the product of $m^{th}$ (rather than $(2m)^{th}$) order polynomial with a geometric series in $x^m$ (rather than $x^{2m}$):

$$L_{1/2}(x) = \frac{P_a^{m)}(x)}{1+Ax^m} \ . \tag{6.7.16}$$

Hence the $n$ first terms indeed determine the solution completely. For even values of $m$ one obtains similar result for $n^{q)}=1/2$ but now $A$ is negative so that the solution is excluded. This result also motivates the hypothesis that for the counterparts of ordinary solutions of Laguerre equation sum (even $m$) or difference (odd $m$) of solutions corresponding to $n$ and $2m-n$ must be formed to remove the non-physical degeneracy.

This argument does not exclude the possibility that there are also other fractional values of $n$ allowing this kind of symmetry. The condition for symmetry would read as

$$\begin{aligned} \prod_{k=1}^{m}(R_k+\epsilon R_1) &= \prod_{k=1}^{m}(R_k-\epsilon R_1) \ , \\ \epsilon &= (2n^{q)}-1 \ . \end{aligned} \tag{6.7.17}$$

The condition states that the odd part of the polynomial in question vanishes. Both $\epsilon$ and $-\epsilon$ solutions so that $n^{q)}$ and $1-n^{q)}$ are solutions. If one requires that the condition holds true for all values of $m$ then the comparison of constant terms in these polynomials allows to conclude that $\epsilon=0$ is the only universal solution. Since $\epsilon$ is free parameter, it is clear that the $m$:th order polynomial in question has at most $m$ solutions which could correspond to other fractionized eigenvalues expected to be present on basis of physical intuition.

This picture generalizes also to the case of even $n$ so that also now solutions of the form of Eq. 6.7.16 are possible. In this case the condition is

$$\prod_{k=1}^{m}(R_k+\epsilon R_1) = -\prod_{k=1}^{m}(R_k-\epsilon R_1) \ . \tag{6.7.18}$$

Obviously $\epsilon=0$ and thus $n=1/2$ fails to be a solution to the eigenvalue equation in this case. Also now one has the spectral symmetry $n_\pm = 1/2\pm\epsilon$.

The symmetry $R_n=(-1)^mR_{n+m-1}=(-1)^mR_{n-m-1}=(-1)^mR_{m-n+1}$ can be applied to show that the polynomials associated with $\epsilon$ and $-\epsilon$ contain both the terms $R_n-\epsilon$ and $R_n+\epsilon$ as factors except for odd $m$ for $n=(m+1)/2$. Hence the values of $n$ can be written for even values of $m$ as

$$n^{q)}(n) = \frac{1}{2}\pm\frac{R_n}{2R_1} \ , \ n=1,...,\frac{m}{2} \ , \tag{6.7.19}$$

and for odd values of $m$ as

$$\begin{aligned} n_\pm^{q)}(n) &= \frac{1}{2}\pm\frac{R_n}{2R_1} \ , \ n=1,...,\frac{m+1}{2}-1 \ , \\ n^{q)} &= 1/2 \ . \end{aligned} \tag{6.7.20}$$

Plus sign obviously corresponds to the solutions which reduce to polynomials and to $n^{q)}\simeq n$ for large $m$. The explicit expression for $n^{q)}$ reads as

$$n_{\pm}^{q)}(n) = \frac{1}{2} \pm \frac{(sin^2(\pi(n-1)/2m) - sin^2(\pi n/2m))}{2sin^2(\pi/2m)} . \quad (6.7.21)$$

At the limit of large $m$ one has

$$n_{+}^{q)}(n) \simeq n , \ n_{-}^{q)}(n) \simeq 1-n . \quad (6.7.22)$$

so that the fractionization $n \simeq 1/k$ claimed by Mills is not obtained at this limit. The minimum for $|n^{q)}|$ satisfies $|n^{q)}| < 1$ and its smallest value $|n^{q)}| = .7071$ corresponds to $m = 4$. Thus these zeros cannot correspond to $n^{q)} \simeq 1/k$ yielded by the numerical computation for even values of $m$ based on the requirement that the zero of $P^{2m)}$ cancels the pole of the geometric series.

**Some comments**

Some closing comments are in order.

1. An open question is whether there are also zeros $|n^{q)}| > 1$ satisfying $P_a^{2m)}((1/a)^{1/2m}) = 0$ for even values of $m$.

2. The treatment above is not completely general since only s-waves are discussed. The generalization is however a rather trivial replacement $(1-x)d/dx \rightarrow (l+1-x)d/dx$ in the Laguerre equation to get associated Laguerre equation. This modifies only the formula for $a_{n+1}$ in the recursion for $l_n$ so that expression for $n^{q)}$, which depends on $b_n$:s only, is not affected. Also the product of numerators in the formula for the parameter $a = l_{2m}/l_0$ remains invariant so that the general spectrum has the spectral symmetry $n^{q)} \rightarrow 1 - n^{q)}$. The only change to the spectrum occurs for even values of $m$ and is due to the dependence of $x_\infty = (1/a)^{1/2m}$ on $l$ and can be understood in the semiclassical picture. It might happen that the value of $l$ is modified to its $q$ counterpart corresponding to q-Legendre functions.

3. The model could partially explain the findings of Mills and $n^{q)} \simeq 1/k$ for $k > 2$ also fixes the value of corresponding $m$ to a very high degree so that one would have direct experimental contact with generalized imbedding space, spectrum of Planck constants, and dark matter. The fact that the fractionization is only approximately correct suggests that the states in question could be possible for all sectors of imbedding space appear as intermediate states into sectors in which the spectrum of hydrogen atom is scaled by $n_b/n_a = k = 2, 3, .....$

4. The obvious question is whether q-counterparts of angular momentum eigenstates ($idf_m/d\phi = mf_m$) are needed and whether they make sense. The basic idea of construction is that the phase transition changing $\hbar$ does not involve any other modifications except fractionization of angular momentum eigenvalues and momentum eigenvalues having purely geometric origin. One can however ask whether it is possible to identify q-plane waves as ordinary plane waves. Using the definition $L_z = 1/2(\partial_u^q + \partial_{\overline{u}}^{\overline{q}})$, $u = exp(i\phi)$, one obtains $f_n = exp(in\phi)$ and eigenvalues as $n^{q)} = R_n/R_1 \rightarrow n$ for $m \rightarrow \infty$. Similar construction applies in the case of momentum components.

## 6.8 Dark matter, long ranged weak force, condensed matter, and chemistry

The challenge of understanding the effects of dark weak force in condensed matter and chemistry is not easy since so many options are available. The guidelines to be used are maximal conservatism, nuclear string model and model for the cold fusion, the general criterion for the transition to dark phase, and intriguing hints that dark weak force could play important role not only in biochemistry but also in ordinary condensed matter physics contrasted with the fact that isotopic independence is not visible in the physics of condensed matter and in chemistry.

### 6.8.1 What is the most conservative option explaining chiral selection?

Long ranged exotic weak interactions should produce parity breaking responsible for the chiral selection. The first thing that comes in mind is that ordinary quarks or nucleons suffer a phase transition in which the p-adic prime characterizing weak space-time sheets increases, perhaps to one of the Gaussian Mersennes $k = 113, 151, ...$

There are objections against this idea.

1. The criterion $\alpha_w Q_1 Q_2 \simeq 1$ for the transition to dark phase does not apply at weak space-time sheets so that ordinary quarks should not perform this transition.

2. If ordinary nucleons make the transition to the dark weak phase with $k \leq 113$, very strong $Z^0$ Coulombic interaction results and isotopic dependence of chiral symmetry breaking is predicted.

3. Repulsive weak interaction would provide a nice explanation for the hard core of the interaction potential in van der Waals equation for liquid phase. Isotopic dependence is again the problem.

Nuclear string model [F9] suggests a maximally conservative model for chiral selection consistent with these objections.

1. Assume that nucleons are not affected at all in the transition and that nothing happens in the transition even at the level of exotic quarks so that they must have weak space-time sheets with size at least of order atom size.

2. The weak space-time sheet of exotic quarks associated with $k = 127$ color bonds cannot correspond to $k = 89$ since this would be seen in the decay width of the ordinary electro-weak gauge bosons. The model of cold fusion requires a phase transition transforming $D$ to its neutral variants and this phase transition can only occur via the exchange of exotic $W$ bosons with the range of weak interactions of order atomic distance (at least). Dark variants of $k = 113$ $W$ bosons with $n = 2^{11}$ defines one option.

3. It would be nice to have weakly charged nuclei. Weak charges should not be however too large. This is achieved if some of the color bonds containing exotic quark and anti-quark at their ends carry net em charge and thus also weak charge. This hypothesis allows to understand tetraneutron as an alpha particle containing two negatively charged color bonds and predicts entire spectroscopy of exotic nuclei containing charged color bonds [F8, F9]. Cold fusion could be understood in terms of absence of Coulomb wall in the collision of ordinary proton with neutral variant of deuteron [F9].

4. Instead of ordinary neutrinos transformed to dark neutrinos in weak sense, neutrino species associated with with weak space-time sheets would be present and participate in the weak screening together with exotic $W^+$ bosons and possible exotic counterparts of electrons. The Gaussian Mersennes associated with $k = 151, 157, 163, 167$ define good candidates for the space-time sheets of exotic leptons. There is experimental evidence that neutrinos appear in several mass scales [F3].

5. Also higher levels of darkness would be allowed by the standard criterion applied to say molecules. Also a hierarchy of colored dark matters could emerge as nuclei get net color charge and combine to form molecules which are color singlets.

Consider now the implications of this picture.

1. The repulsive weak interaction between exotic of quarks of color bonds with net em and weak charge could explain the hard core of the interaction potential in van der Waals equation without isotope dependence.

2. Bio-control could occur by the variation of weak screening using $W^+$ bosons and exotic neutrinos. The resulting parity breaking effects would be large below the length scale $L_w$. Chiral selection would not have isotope dependence.

### 6.8.2 Questions related to ordinary condensed matter and chemistry

Consider first some questions related to ordinary condensed matter and chemistry.

*1. Could electromagnetic darkness relate to the properties condensed matter?*

The purely electromagnetic dark phase for $k = 113$ space-time sheets without dark weak bosons implies that atomic nuclei possess field bodies of atomic size, and one can wonder how this might relate to the basic properties of condensed matter. For instance, the linking of magnetic flux tubes of field bodies of different nuclei might have some role in quantum information processing, if the general vision of [E9] about topological quantum computation in terms of linking of magnetic flux tubes is taken seriously.

*2. Does repulsive weak force relate to the stability of condensed matter?*

The Coulomb repulsion of electrons could be enough to explain van der Waals equation of state. One can still wonder whether the dark weak force effective below the length scale $L_w(dark)$ could have something to do with the repulsive core in van der Waals equation of state and with the sizes of atoms in condensed matter.

The low compressibility of condensed matter indeed suggests that repulsive $Z^0$ force between constituent molecules is present or at least appears when one tries to compress condensed matter. The long ranged weak interactions between exotic quarks associated with color bonds of condensed matter nuclei would explain this without predicting non-trivial isotopic effects in van der Waals equation. The most conservative option is that compression induces a phase transition to a phase in which nuclei contain charged color bonds and generates strong $Z^0$ repulsion in the length scale of atomic radius. The fact that the density of water is reduced above freezing point when pressure is increased or temperature reduced might have explanation in terms of this mechanism.

The orthodox physicist would presumably argue that the mere electromagnetic interactions allow to understand the value of the atomic radius. The following argument challenges this belief in the case of heavy atoms.

The size of atom in the absence of the classical dark weak forces can be estimated from the expression of the radius of the orbital $n$ given by $r_n = n^2a$, where $a = a_0/Z$ is the radius of the lowest electronic orbital, and from the fact that a given orbital contains $2n^2$ electrons. In a reasonable approximation one has $Z = 2n_{max}^3/3$ and $n_{max} = (3Z/2)^{1/3}$. In this approximation the radius of the largest orbital identifiable as the atomic radius $r_Z$ is

$$r_Z = (\frac{3}{2})^{2/3}\frac{a_0}{Z^{1/3}} \ . \tag{6.8.1}$$

Indeed, at distances above this radius the atom looks more or less neutral since electrons screen the nuclear charge completely. This gives an estimate for the density of the condensed phase consisting of atoms with nuclear charge $Z$.

$$\rho = \frac{4}{9}AZ \times \frac{m_p}{a_0^3} \ . \tag{6.8.2}$$

In case of iron ($A = 55, Z = 26$) one would have $\rho \simeq 635$ kg/dm$^3$: the value is roughly 100 times higher actual value $\rho = 7.8$ kg/m$^3$ at room temperature!

Thus the radii of heavy atoms seem to be too large in the standard physics framework. The transition to a phase in which charged color bonds are present is expected to be especially probable in the case of heavy nuclei and a generation of repulsive $Z^0$ force might explain the radii.

*3. Could the repulsive weak core relate to the stability of chemical compounds?*

Could the long ranged repulsive weak force relate the typical lengths of chemical bonds? Could it even make possible valence quark approximation? Since the generation of weakly charged color bonds and even color bonds connecting different atomic nuclei does not involve isotopic dependence, one must consider the possibility that these forces might be involved even with the physics of chemical bonds.

For instance, the generation of a chemical bond might involve formation of state containing a component in which the two nuclei have generated color bonds with opposite charges creating additional attractive force. One can also consider the possibility that nuclei generate anomalous electromagnetic charge of same sign so that a repulsive weak force between atoms results. This would give rise to a hard sphere behavior essential for the notion of valence.

At least at classical level one can question the hard sphere behavior of atoms assumed implicitly in the models of molecules based on molecular orbitals and allowing to treat full electronic shells as rigid structures so that only valence electrons are dynamical and give rise to shared orbitals. One can argue that purely electromagnetic atoms/molecules do not behave like hard spheres and that all electrons should be treated like valence electrons moving in the combined Coulomb field of the two nuclei whose distance is not fixed by the molecular size.

Since electrons are very light, one could classically regard the electronic cloud as a perfectly conducting rapidly deformable shell. When atoms approach each other the electronic charge density arranges in such a manner that it minimizes the Coulombic interaction energy between nuclei by preventing the penetration of the nuclear electric field of the other atom through the electronic shell. There the encounter of atoms would be more like a collision of point nuclei surrounded by highly deformable smooth electron mattresses than that of hard spheres.

What could go wrong with this argument? Fermi statistic might change the situation and make closed electronic shells to behave like rigid charged spheres.

### 6.8.3 Dark-to-visible phase transition as a general mechanism of bio-control

Dark-to-visible phase transition reduces the de-Broglie wave lengths by a factor $1/n = 2^{-11}/k$ for the favored value of the scaling factor of $\hbar$ (also other values of scaling factor are of course possible). This would essentially code patterns in dark length scale to patterns of visible matter in much shorter length scale and make possible long length scales to control short length scales in a coherent manner. This phase transition could occur separately on em, weak, and color space-time sheets. For instance, the dark phase of hydrogen ions in the case of proton need not involve dark weak phase.

The hierarchy of dark matters defines naturally a control hierarchy ordered with respect to time and length scales. Dark electrons would be functional at the lowest level of the control hierarchy whereas dark neutrinos would naturally appear at the higher levels.

The strange properties of water could be understood to a great extent if a fraction of protons has made a transition large $\hbar$ phase in electromagnetic sector (as discussed, this could actually mean that the em bodies of protons have large $\hbar$). This does not require anything anomalous in the weak and colored sectors.

The criterion for the transition is that a system consisting of sub-systems with charges $Z_1$ and $Z_2$ makes a transition to dark matter phase reads as $\alpha_{em} Z_1 Z_2 \simeq 1$.

Option I: If this criterion applies to self interactions as such, it would give in the case of atomic nuclei $Z_{cr} = 12$ (Mg).

Option II: If full nuclear shells are non-interacting, as one expects on basis of Fermi statistics, the criterion could be interpreted as stating that only nuclei having $Z = 2 + 6 + 12 = 20$ (the self interaction of the full third shell would induce the transition) can make this transition [F8]. That Ca ions ($Z = 20$) satisfy this condition would conform with the fact that play a unique role in bio-chemistry and neurophysiology.

Option III: If the criterion does not apply to self interactions and only full shells interact, the condition would be that the nucleus contains nucleon clusters with charge $Z_1 = Z_2 = 20$ giving $Z_{cr} = 40$ if the critical interaction is between separate $Z = 12$ shells. TGD inspired view about nuclear physics [F8] based on dark valence quarks and $k = 127$ exotic quarks with ordinary value of $\hbar$ at the ends of long color bonds responsible for nuclear strong force suggests that nuclei could be regarded as collections of linked and knotted nuclear strings and that the linking of magic nuclei produces new especially stable nuclei.

Cold fusion with Pd catalyst [42] having $Z = 46$ could involve local transitions of Pd catalyst to $k = 113$ dark matter phase and perhaps also the transition $k = 89 \rightarrow 113$.

For option III trace elements with $Z \geq 40$ should play a key role in living matter inducing phase transitions of lighter nuclei to dark phase as the model for cold fusion suggests. There is some support for this interpretation.

1. DNA is insulator but the implantation of Rh atoms in DNA strands is known to make it super-conductor [99], perhaps even super-conductor. Dark electrons obviously define a good candidate for the current carriers.

2. The so called mono-atomic elements [102] claimed by Hudson to possess very special physical properties have explanation in terms of dark matter phase transition [J6] and have $Z \geq 44$. Interestingly, Hudson claims that mono-atomic elements have not only very special biological effects but also affect consciousness, and that 5 per cent of brain tissue of pig by dry matter weight is Rhodium ($Z = 45$) and Iridium ($Z = 77$).

### 6.8.4 Long ranged weak forces in chemistry and condensed matter physics

According to the model of water, one fourth of hydrogen ions would be in dark phase such that $k = 113$ space-time sheet has transformed to large $\hbar$ phase and would have size of order atomic radius. This would suggests that that the atomic size could be understood in terms of large $\hbar$ associated with $k = 113$ electromagnetic space-time sheet. Weak interactions in this phase could be normal. Quantum classical correspondence forces however to consider the possibility for which also long range weak force is present-

#### Exotic nuclear quarks as sources of long ranged weak force

One can a consider a copy of weak physics for which weak space-time sheets of particles have $k > 89$, say $k = 113$. This would imply strong parity breaking effects in $k = 113$ length scale. If this transition is followed by a transition of $k = 113$ space-time sheet to dark matter phase with large value of $\hbar$, the length scale $L_w(dark) = n2^{11}L(113)$ in which strong parity breaking effects occur corresponds to atomic length scale. This kind of phase could explain chiral selection in living matter and dark weak boson condensates and dark quarks and leptons might play a fundamental role in bio-control.

The criterion for the transition to the large $\hbar$ phase does not suggest that this transition could happen to ordinary quarks and leptons. Also the fact the absence of non-trivial isotopic dependence in chemistry and condensed matter supports the conservative view "once vacuum screened-always vacuum screened".

The TGD based model of atomic nuclei however involves besides dark valence quarks color bonds having $k = 127$ quarks at their ends and their weak space-time sheets cannot correspond to $k = 89$ since this would be reflected in the decay widths of weak bosons. One possibility is that the weak space-time sheet corresponds to $k = 113$, possibly with large $\hbar$.

TGD based identification of tetra-neutron is as an alpha particle containing two negatively charged color bonds [F8]. Since there is no reason to expect that tetra-neutron would be a rare exception, one expects that ordinary nuclei of condensed matter can make transition to a phase in which some color bonds are em charged and thus carry also weak charges creating long ranged weak forces and parity breaking without the un-acceptable isotopic independence. The unavoidable long ranged weak and color fields associated with non-vacuum extremals suggest even more radical possibility. The nuclear strings associated with neighboring condensed matter nuclei could fuse to single nuclear string so that nuclei would be color and weakly charged and could carry fractional em charges.

Below $L_w(dark)$ atoms whose nuclear color bonds carry net weak charges would look like $Z^0$ ions and condensed matter in this phase would be kind of $Z^0$ plasma. The weak forces could be screened by vacuum charges above the length scale $L_w(dark)$ just as they are screened usually. Dark weak bosons would have mass obtained by scaling down the intermediate gauge boson masses by a factor $2^{-12}$ for $k = 113$. An essential point is that the $Z^0$ charge density of nuclei would be constant below $L_w$ rather than that corresponding to $Z^0$ charges with nuclear size. This makes $Z^0$ screening by particles much more easier and the question is not whether to achieve precise enough screening in say nuclear length scale but in what scale it is possible to vary the degree of screening.

#### Could long ranged weak forces be key players in bio-catalysis?

Bio-catalysis involves chiral selection in an essential manner which suggests that weak force is involved. This inspires the question about the underlying mechanisms controlling the assembly and de-assembly of bio-molecules.

*1. Bio-catalysis and phase transition to a phase containing charged color bonds?*

The considerations related to van der Waals equation and the fact that color bonds could be unstable against beta decay via the emission of light $W$ boson nucleon suggest that nuclei could tend to develop color bonds with the same sign of $Z^0$ charges. Anomalous em charges could vanish if the transition involves an emission of a dark W boson charging color bond transforming to ordinary weak boson by de-coherence and absorbed by nucleon. This kind of transition could proceed spontaneously as a two-nucleon process if the nuclei are close enough as in the situation when liquid is compressed.

If so, the resulting weak forces tend to de-stabilize these molecules. The range $L_w \simeq 2.56L(89)$ gives for this force a scale about $2.56 \times L(k_{eff} = 133) \simeq 1.3n$ Angstrom if scaled directly from the Compton length of intermediate gauge boson assuming the scaling $\hbar \rightarrow n\hbar/v_0$. $n = 3$ gives the length scale of the typical chemical bond in DNA.

The molecules need not become un-stable in the phase transition to the phase containing charged color bonds. The phase transition could only reduce the binding energies of the chemical bonds and facilitate chemical reactions serving thus as a catalyst.

Dark molecules of form $AH_n$, where $A$ is arbitrary atom and $H_n$ refers to $n$ hydrogen atoms be in the role of biological hardware since they are not affected appreciably by this kind of phase transition. The basic molecules of life are indeed molecules of type $CH_n, OH_n, NH_n$, which could of course be also partially dark.

*2. The variation of the strength of the $Z^0$ force as a control mechanism*

The variation of the strength of the repulsive $Z^0$ force could be achieved by varying the density of screening particles. To be effective this tool should allow sharp enough length scale resolution and the resolution is determined by the p-adic length scale of the screening particle. The situation is dramatically improved by the fact that the $Z^0$ charge density to be screened is constant below $L_w$. Hence a constant $Z^0$ charge density of screening charges is enough to achieve a complete screening. The control of the degree of $Z^0$ ionization rather than control of $Z^0$ charge density would be in question.

*3. What distinguishes between ordinary condensed matter and living matter?*

If weakly charged color bonds appear already in ordinary condensed matter and give rise to the repulsive core in van der Waals equation of state, one can wonder what is the real distinction between living matter and ordinary condensed matter. The difference might relate to the value of $n$ for the transition $\hbar \rightarrow n\hbar/v_0$ for electromagnetic space-time sheets. $n = 1$ could correspond to ordinary condensed matter with $L_w$ in the range of 1-2 Angstrom and $n = 3$ to living matter with $L_w$ in the range 3-6 Angstrom. Water could differ from other condensed matter systems in that it would have $n = 3$ for one fourth of hydrogen ions.

A second question relates to the identification of the weak space-time sheet of exotic quarks. Can one assume that the weak space-times sheet of exotic quarks and em space-time sheet of valence quarks in dark em phase both correspond to $k = 113$ with large $\hbar$? This hypothesis can be defended: below $L_w$ dark electro-weak symmetry is not broken so that em and weak interactions should take place at the same space-time sheet.

### 6.8.5 $Z^0$ force and van der Waals equation of state for condensed matter

Most physicists probably think that van der Waals equation of state represents those aspects of condensed matter physics which have been thoroughly understood for long time ago. Approximate isotopic independence of the basic parameters of the state equation provides support for this belief. Isotopic independence does not however exclude the role of long ranged weak forces if they are associated with exotic $k = 127$ quarks appearing in the TGD based model of nucleus [F8]. The decay widths of weak bosons require that exotic weak bosons correspond to some other p-adic length scale than $k = 89$, say $k_{eff} = 113 + 24 = 137$ for large $\hbar$ or $k = 151$ for ordinary $\hbar$. The presence of em charged color bonds in ordinary nuclei would provide them with anomalous em and weak charges and bring in long ranged weak force.

One can imagine various scenarios for how dark weak forces might enter condensed matter physics.

1. It might be energetically favorable for the ordinary condensed matter nuclei to be in a phase containing charged color bonds. By the charge independence of strong interactions this would

not considerably affect the nuclear physical properties of condensed matter nuclei. The hard core of the interaction potential in van der Waals equation could be seen as a signature of dark weak force.

2. The nuclei could be ordinary in the ordinary liquid phase (water forming a possible exception) so that long ranged weak forces need not be present. The low compressibility of the liquid phase could however be due to a phase transition of nuclei inducing charged color bonds by exotic weak decays of exotic quarks. This would induce a repulsive weak force felt in the length scale $L_w$ of order $3-6$ Angstrom for $k=113$ and $\hbar \rightarrow n\hbar/v_0$, $n=3$. The dark weak force becoming visible only when liquid is compressed would explain the hard core term in van der Waals equation. The energy provided by the compression would feed in the energy making possible the phase transition not occurring spontaneously. Sono-luminescence [46] could represent a situation in which the phase transition occurs.

   The phase transition generating charged color bonds could be induced by the direct contact of the nuclear em field bodies of exotic quarks and anti-quarks with size associated with any nucleus having $A>1$ and having field em field body with size $L \sim nL(113)/v_0$ of order atomic radius (this point is discussed in detail in the model of nuclei based on color bonds [F8]).

Both options predict isotopic independence of compressibility and essentially standard nuclear physics. The explanation for the anomalous behavior of water above its freezing point, in particular the reduction of density as the temperature is lowered or pressure increases, could be basically due to the appearance of additional color bonds in oxygen nuclei during compression.

These considerations raise the question how weak forces reveal their implicit presence in the basic argumentation leading to van der Waals equation of state. In the sequel the deduction of van der Waals discussed in more detail to make more explicit the origin of the hard core term.

*1. Van der Waals equation of state*

Van der Waals equation of state provides the simplest thermodynamical model for gas-liquid phase transition. The equation can be derived from thermodynamics using the following assumptions.

1. The partition function $Z_N$ for a condensed matter system consisting of $N$ identical particles codes the thermodynamical information and can be deduced once the Hamiltonian of the system is known.

2. It is assumed that the Hamiltonian separates into a sum of single particle Hamiltonians $H = \sum H_i = T + U = \sum T_i + \sum U_i$. Single particle Hamiltonian consists of a sum of the kinetic energy $T_i$, the energy associated with internal degrees of freedom (such as rotational degrees of freedom of the molecule), and the potential energy $U_i = \sum_{j\neq i} u_{ij}$.

3. The potential energy $u_{ij}$ is assumed to depend on the relative coordinate $\overline{r}_i - \overline{r}_j$ only and to be large and positive at short distances and vanish rapidly at large distances. Also spherical symmetry can be assumed in a good approximation. Above $2r_0$, $r_0$ molecular radius, $u$ is assumed to be small and negative and in this manner generate an attractive force, which can be assumed to be of electromagnetic origin.

Consider now the approximate deduction of the equation of state.

1. The partition function factors into a product of the partition function $Z_N^{id}$ of ideal gas and a term defined by the potential energy terms in the Hamiltonian of the whole system.

$$\begin{aligned} Z &= Z_N^{id}(T) \times Q_N(T,V) \ , \\ Q_N(T,V) &= \frac{1}{V^N}\int \prod_i dV_i exp(-U/T) \ . \end{aligned} \tag{6.8.3}$$

2. The standard manner to derive an approximate form of the partition function, free energy and pressure in turn providing the equation of state is based on the so called virial expansion using the

elementary multiplicative properties of the exponential function $exp(-U/T) = \prod_{i,j} exp(-u_{ij}/T)$ appearing in $Q_N$. In the lowest non-trivial order one has

$$\begin{aligned} Q_N(T,V) &\simeq \frac{N^2}{V} I_2 \ , \\ I_2 &= \int dV \lambda(\overline{r}) \ , \\ \lambda(\overline{r}) &= exp(-u_{12}(\overline{r})/T) - 1 \ . \end{aligned} \quad (6.8.4)$$

The integrand in this expression is in a good approximation equal to $-1$ inside the sphere of radius $2r_0$ defined by the minimal distance between the molecules of radius $r_0$ and positive outside this sphere and approaches zero rapidly.

3. Quite generally, one can write $Q_N$ as

$$\begin{aligned} Q_N(T,V) &\simeq 1 + N \times \frac{n}{2} \times I_2 \simeq (1 + \frac{nI_2}{2})^N \ , \\ n &= \frac{N}{V} \ . \end{aligned} \quad (6.8.5)$$

The improved approximation is dictated by the fact that free energy must be an extensive quantity. For the free energy $F = -Tln(Z)$ one obtains an approximate expression

$$F = NF^{id} - NTnI_2 \ . \quad (6.8.6)$$

For the pressure $P = -(\partial F/\partial V)_{T,N}$ one obtains

$$P = nT(1 - nI_2/2 + \cdots) \ . \quad (6.8.7)$$

4. The value of $I_2$ can be calculated approximately by dividing the integration region to two parts. The first part corresponds to a sphere of radius $2r_0$ ($r_0$ is the radius of molecule) inside which $\lambda_{12} = -1$ could be interpreted in terms of the approximate vanishing of the exponential of the interaction potential behaving like $1/r$. The second part corresponds to the exterior of the sphere of radius $2r_0$, where $\lambda$ is assumed to have positive but small values so that the exponential can be approximated by the first two terms of the Taylor series with respect to $u_{12}$ This gives

$$I_2 \simeq \ -\tfrac{4\pi}{3}(2r_0)^3 + \tfrac{4\pi}{T}\int drr^2 u_{12}(r) \equiv 2b - 2a/T \ . \quad (6.8.8)$$

Note that $a > 0$ implied by $u_{12} \leq 0$ holds true.

5. The resulting equation of state is

$$P + n^2 a = nT(1 + nb) \ . \quad (6.8.9)$$

This equation is second order in $n$ and does not give the characteristic cusp catastrophe associated with the van der Waals equation.

6. The approximation

$$1 + nb \simeq \frac{1}{1 - nb} \tag{6.8.10}$$

holding true for $nb << 1$ and then extrapolating to a region where this condition does not hold true. This gives the van der Waals equation of state

$$(P + n^2 a)(1 - nb) = nT \tag{6.8.11}$$

allowing a simple description of gas-to liquid phase transition requiring that at least third power of $n$ appears in the equation of state. The equation allows an attractive physical interpretation. $P_{in} \equiv n^2 a$ can be identified as internal pressure mainly due to the attractive van der Waals force and 1-nb tells the fraction of free volume so that $P_{tot} V_{free} = NT$ holds true.

This trick is believed to take into account the neglected higher order terms in the virial expansion. The proper justification comes from the catastrophe theory [18]. The virial expansion gives all orders in $n$ to the right hand side of Eq. 6.8.9 and by the general theorems of catastrophe theory cusp catastrophe is the singularity associated with a state equation with two control variables $a$ and $b$. What the cusp catastrophe means is that three values of $n$ satisfy the equation of state for given values of $P$ and $T$. Two of these values correspond to stable phases, liquid and gas, the lower and upper sheets of the cusp, whereas the intermediate sheet of the cusp corresponds to an unstable phase.

In TGD framework $a$ could be interpreted as characterizing purely electromagnetic interactions above the critical radius $r_0$ and and $b$ both em and long ranged interactions below $r_0$. The emergence of repulsive $Z^0$ interactions below the critical radius $r_0$ would serve as a physical definition for $r_0$. The fraction of free volume $1 - nb$ would differ from unity because repulsive dark weak forces enter in play when the number density $n$ tends to become larger than $1/b$.

In a very optimistic mood one might provocatively claim that the classical $Z^0$ Coulombic force allows to understand why the hard core approximation behind van der Waals equation works and that the setting on of dark weak force provides a precise first principle definition for the notion of the molecular radius. The criticality implied by the $Z^0$ Coulombic force would reflect itself as the criticality of the liquid-gas phase transition. Obviously the parameter $b$ contains very little information about the details of the $Z^0$ Coulombic interaction energy besides the fact that the phase transition charging some color bonds weakly occurs when molecules are at distance $r < r_0$. The calculation of the value of the parameter $a$ should reduce to standard electromagnetic interactions between molecules.

### 6.8.6 $Z^0$ force and chemical evolution

Although long ranged weak forces manages to hide themselves very effectively, they leave some tell tale traces about its presence. The most spectacular effect is chiral selection which is extremely difficult to understand in the standard model. Also the mysterious ability of noble gases to act as anesthetes [92] could be understood as being due to dark weak forces. If a phase transition charging some color bonds of the noble gas nuclei increasing or reducing $Z$ occurs, noble gas atoms behave chemically as ions. A discussion (somewhat obsolete now) of the mechanism can be found in [M2].

Classical $Z^0$ force might also make itself visible by delicate chemical effects due to the fact that the classical $Z^0$ charge of the hydrogen atom vanishes. Since the exotic $Z^0$ charges of proton and electron necessarily vanish by the absence of color bonds the prediction is that proton and electron are in a completely exceptional role in chemistry, and in biochemistry in particular. Certainly this is the case: consider only the role of proton and electron in biochemistry (say in metabolic cycles and in polymerization). Furthermore, $Z^0$ force seems to be the key player in the biochemical evolution in TGD Universe: molecular stability could be controlled by the possibility to generate charged color bonds and by the screening of long ranged weak forces.

Enzymatic action, known to involve chiral selection, can be based on the control of the strength of the classical $Z^0$ force by varying the densities of the Bose-Einstein condensates responsible for the $Z^0$

screening. Metabolism involves basically the chopping of the nutrient molecules to pieces and their re-assembly. The chopping into pieces could be partially achieved by weakening the screening of the classical $Z^0$ force locally. The sizes of the enzymes and ribozymes are rather large and vary in the range 10-20 nm. This is not easily understood in the standard chemistry context but is what one expects if $k = 151$ weak bosons are involved.

An interesting hypothesis is that chemical evolution has proceeded via a sequence of phase transitions producing dark weak bosons corresponding to Gaussian Mersennes $G_k = (1+i)^k - 1$, $k = 113, 151, ...$ as $k = 89 \rightarrow 113$ followed by $k = 113 \rightarrow 151 \rightarrow 157 \rightarrow 163 \rightarrow 167 \rightarrow ....$

### 6.8.7 Parity breaking effects at molecular level

The observed parity breaking effects at molecular level are large: a natural unit for molecular dipole moments is one Debye: $e10^{-10}\ m \sim eL(137)$. This scale compares favorably with the $k = 113$ weak length scale $L_w = nx$ Angstrom, $x \in [1,2]$, $n = 1,2,3$. The larger the value of $n$, the larger the scale of parity breaking. The breaking of the mirror symmetry appears at geometric level and this kind of symmetry breaking does not require large parity breaking at the level of physics laws. The parity breaking however takes place in a much deeper manner: only second chirality of two mirror image molecules appears in Nature and an unsolved problem is to understand this selection of the molecular chirality.

The axial part of weak forces, in particular $Z^0$ force, suggests a first principle explanation for the molecular parity breaking. A phase transition generating dark weak force below length scale $L_w$ would induce axial force implying different energies for mirror images of molecule.

#### Mechanism of parity breaking

One can imagine two mechanisms of chiral selection. For the first mechanism the classical $Z^0$ interactions between the atoms of the molecule lead to a chiral selection. If equilibrium positions correspond to the minima of $Z^0$ Coulomb energy, the parity breaking effect, being proportional to the gradient of $Z^0$ scalar potential, however vanishes. Of course, the net force involves both electromagnetic and $Z^0$ contributions so that the equilibrium positions do not actually correspond to the minima of $Z^0$ Coulomb potential. Proton is an exception because of its small vectorial $Z^0$ charge and by the fact that it is the only nucleus not containing color bonds (assuming that self bonding does not occur).

Second mechanism is based on the presence of an external $Z^0$ electric field and to the fact that the energies of a chiral molecule and its mirror image in an external $Z^0$ electric field are different. In this case the parity breaking contributions of the individual atoms of the molecule to the energy are in general non-vanishing and lead to chiral selection. The presence of classical $Z^0$ electric fields in bio-matter would not be surprising since bio-matter is also ordinary electret. Spontaneous $Z^0$ electric polarization might be an essential element of chiral selection and lead to energy minimization. This kind of phase transition might be induced by a rather small external perturbation such as bombarding of a system containing both chiralities with neutrinos or electrons.

#### Detailed form of the parity breaking interaction

Consider first in more detail the form of parity breaking interaction.

1. In molecular physics the minimization of the energy for electronic configurations selects the ground state configuration for atoms in the molecule (this is essentially due to the small mass ratio $m_e/m_p$).

2. The parity breaking force is proportional to the axial part of weak isospin, which is of same magnitude for all particles involved. Axial force is proportional to the gradient of $Z^0$ scalar potential created by exotic quarks in color bonds. Axial force is also inversely proportional to the mass of the particle involved.

   The mass scale of exotic quarks is determined by $k = 127$. The hypothesis that lepto-hadrons are bound states of colored excitations of leptons predicts also $k = 127$ for their mass scale and colored electrons would have essentially the same mass as electrons. One can make only guesses about the p-adic mass scale of exotic (possibly dark) neutrinos and electrons. The maximally non-imaginative hypothesis is that the scales are same as for ordinary leptons. In this case the mass would by a factor of about $10^{-6}$ smaller for dark $k = 169$ neutrinos with mass about .1 eV than for exotic quarks with mass $\sim$ .1 MeV if p-adically scaled down from that of ordinary quarks [F8]. Therefore the presence of dark neutrinos could induce the dominating parity breaking effects. For this option the $Z^0$ binding energy would be much larger than neutrino mass for reasonable values of nuclear $Z^0$ charge, which would favor the $Z^0$ screening by neutrinos.

3. The parity breaking $Z^0$ interaction energies of exotic $k = 127$ quark and anti-quark at the ends of color bond are of same sign in three cases corresponding to pion type color singlet bonds $q^{\uparrow}\overline{q}^{\downarrow}$ and em and color charged bonds $u^{\uparrow}\overline{d}^{\uparrow}$ and $d^{\uparrow}\overline{u}^{\uparrow}$. Thus the parity breaking interaction does not require the presence of color charged bonds and is in principle present for all nuclei but can of course cancel in good approximation if the net spins of $k = 127$ quarks and anti-quarks do not cancel separately.

4. For Fermi sea of dark neutrinos the parity breaking effects on energy are proportional to spin and sum up to zero if the number of neutrinos is even. Note however that complete screening is not required.

Consider now a more quantitative estimate.

1. The axial part of the $Z^0$ force acting on neutrinos is given by

$$V_{NPC} \simeq \pm\alpha_Z Q_Z^A(\nu)Q_Z^V(\nu)\frac{1}{m(\nu)}\bar{S}\cdot\nabla V_Z(\bar{r}) \ . \tag{6.8.12}$$

2. The order of magnitude for the energy difference of a configuration and its mirror image is obtained as the difference of axial interaction energies for configurations related by reflection. Consider a particle with $Z^0$ charge $Q_{Z,1}$ and mass $m$ experiencing the axial $Z^0$ field created by a nucleus with anomalous $Z^0$ charge $Q_{Z,2}$. In this case the contribution to energy difference has order of magnitude

$$|\Delta E| \sim \frac{\alpha_Z(Q_{Z,1}Q_{Z,2}}{4mL^2} \ , \tag{6.8.13}$$

where $L \leq L_w$ is the typical distance between nucleus and the particle involved.

3. Consider now various options for the parity breaking assuming first $k = 113$ dark weak matter so that $L$ is of order of size of atom.

i) For $k = 169$ neutrino one would have $\Delta E \sim 1$ MeV, which does not sound reasonable. If partial neutrino screening is present for $k = 113$ at all, it must involve spin pairing. As already found, neutrino screening cannot be ideal for $k = 113$ since the Fermi energy would be rather high. Partial screening favored by the negative energies of dark neutrinos cannot be however excluded since single neutrino could be shared between several constituents of, say, linear molecule. For $k = 151$ for neutrino and electron one would have $\Delta E \sim 2$ keV.

ii) For an exotic electron with ordinary mass but $k = 113$ weak space-time sheet the order of magnitude is $\Delta E \sim 2$ eV, which corresponds to visible frequencies. For exotic quarks with mass $m \sim .1$ MeV one would have $\Delta E \sim 10$ eV. For both cases it would not be chiral selection which would thermally unstable but the dark weak phase itself, and the selection would be absolute in the temperature range were dark weak phase is possible.

iv) For dark $W^+(113)$ bosons having mass $\sim$ 25 MeV one would have $\Delta E \sim 10^{-2}$ eV, which corresponds to the scale of room temperature. Unfortunately, the large mass and short lifetime of $W^+(113)$ do not favor this idea.

4. Consider now $k = 151$ weak bosons. The difficulties of $W^+(113)$ option are circumvented in the case of $W(151)$ with mass of $\sim 50$ eV since leptonic decays become impossible. The generation of $W^+(151)$ BE condensate is also energetically favorable due to the large $Z^0$ binding energy. $L(151)$ corresponds to the thickness of the cell membrane and to a minimal length of DNA double strand giving rise to an integer multiple of $2\pi$ twist with integer number (10) of DNA triplets. Note however that the large $\hbar$ length scale would be $L \sim nL(151 + 22 = 173) \simeq n \times 20$ $\mu$m. The decay of the BE condensate of dark $W(151)$ bosons (with large value of $\hbar$) to non-dark $W(151)$ bosons could allowing the control of $k = 151$ length scale by $k = 173$ length scale.

   In this case one would have $\Delta E \sim 5$ keV so that chiral selection would be highly stable. This option could be realized for linear bio-molecules. Hence the Bose-Einstein condensate of screening $k = 151$ $W^+$ bosons possessing net spin must be considered as a candidate for a mechanism inducing chiral selection of bio-polymers. The positive charge of the $W^+$ condensate could relate to the negative charge characterizing bio-polymers.

   If the order parameter of $W^+$ condensate around the molecule is spherically symmetric, the average interaction energy vanishes so that $W$ bosons should possess also orbital angular momentum: the simplest option is that net angular momentum vanishes. The geometric breaking of spherical and reflection symmetries of the molecule would naturally induce the needed asymmetry of the order parameter.

### 6.8.8 Hydrogen bond revisited

Hydrogen bond is fundamental for the physics of water and believed to relate to its anomalous expansion at freezing point and anomalous contraction in heating above freezing point. Hydrogen bond plays also a key role in the living matter. Against this background it is perhaps somewhat surprising how poorly understood the physics of the hydrogen bond is.

The special role of hydrogen bond is consistent with the suggested role of dark $Z^0$ force. Hydrogen bond is believed to reflect ordinary Coulomb interaction between hydrogen bound to molecule and lost its electron partially to the molecule and electronegative atom (N, O, Cl,...) which has captured partially the electron of the atom with which its bonds, say C, and which therefore looks like having positive charge. Hydrogen bonds are in a key role in the binding of DNA strands, in the generation of geometric structure of proteins and RNA molecules, and also the molecular motors are constructed from their building blocks by hydrogen bonds. The reason why could be very simple: hydrogen bonds unlike valence and ionic bonds are relatively immune to the bio-control based on the variation of the classical $Z^0$ force by varying the $Z^0$ screening.

An interesting question is whether the hydrogen bonded state A+B of atoms A and B could be in a superposition of states with A and B in the ordinary state and a state in which A/B contains positively/negatively charged color bond changing the charge numbers A and B and effectively creating ionic bond.

If the hydrogen bond corresponds to a non-vacuum extremal in necessarily carries color gauge flux. Quantum classical correspondence together with the picture about nuclei as nuclear strings with nucleons connected by long color bonds forces to ask whether the nuclear strings of hydrogen bonded atoms fuse to form single nuclear string containing long straight section connecting the nuclei. Hydrogen bonded nuclei would become both colored and weakly charged in this kind of situation and would posses also a fractional electromagnetic charge not explainable in terms of fractional quantum Hall effect. In this kind of situation the first guess is that the exotic quark pairs associated with the color bond could play the role of valence electrons and characterize both the binding energy and parity breaking possibly associated with the bond.

## 6.9 Long ranged weak and color forces, phonons, and sensory qualia

Phase conjugate electromagnetic waves [43, 44] correspond in TGD framework negative energy topological light rays representing signals propagating to the geometric future [G3]. Phase conjugation is known to make sense even for sound waves [44]. Since phase conjugation means time reversal and negative energies in TGD framework, the only possible conclusion seems to be that classical sound waves and photons must correspond to their own space-time sheets. Depending on the time orientation of these space-time sheets, sound waves or their phase conjugates result in the interaction of these space-time sheets with matter.

If condensed matter is partially dark in the sense that nuclei tend to combine to form super-nuclei, the question arises whether dark weak force and dark nuclear strong force are involved with the sound waves besides em forces. Topological light rays ("massless extremals", briefly MEs) carrying classical gauge fields corresponding to an Abelian subgroup of the gauge group, be it color or electro-weak gauge group, and drifting quantum jump by quantum jump in the direction of sound wave define candidates for the space-time correlates of sound waves. Also the deformations of warped imbeddings of $M^4$ to $M^4 \times CP_2$ with maximal signal velocity reduced to sound velocity using $M^4$ as standard define candidate for the space-time sheets associated with sound waves.

In plasma phase classical electric field can cause plasma waves as longitudinal oscillations of charge density. Also the notion of $Z^0$ plasma wave makes sense if nuclei carry anomalous $Z^0$ charges due to charged color bonds. Entire dark hierarchy of these waves is possible. Even the counterparts of QCD plasma waves are possible.

### 6.9.1 Slowly varying periodic external force as the inducer of sound waves

The basic idea is that an external force, which is constant in the length scale of atomic nuclei or molecules sets them in a harmonic motion around equilibrium point. This slowly varying force is associated with the space-time sheet serving as the space-time correlate of phonon.

The basic fact about quantum physics of harmonic oscillator is that the resulting new ground state represents a *coherent* state having interpretation as a classical state of harmonic oscillator. If the external force depends periodically on time and spatial coordinates the intensity of the parameter characterizing coherent state varies in oscillatory manner and classical sound wave results as a consequence.

### 6.9.2 About space-time correlates of sound waves

$Z^0$ MEs ("massless extremals") represent transversal classical $Z^0$ fields propagating with light velocity. These transversal fields are candidates for the external force generating the coherent states giving rise to sound waves. There are however two problems.

1. How it is possible that sound velocity $v$ is below light velocity?

2. How the Lorentz force orthogonal to the direction of propagation of classical fields inside ME can give rise to longitudinal sound waves.

One can imagine two solutions to these problems.

Option I: The first solution to both problems could be as follows. Let $Z^0$ ME represent a wave moving in z-direction with light velocity and let sound wave propagate in the direction of x-axis with sound velocity $v_s$. Assume that $Z^0$ electric field of linearly polarized ME is in x-direction, and thus defines a longitudinal force field inducing the coherent state. Also $Z^0$ magnetic field is present but for non-relativistic particles it is by a factor $v/c$ weaker than $Z^0$ electric force and can be thus neglected.

$Z^0$ ME suffers in each quantum jump a shift consisting of a shift in z-direction and a shift in x-direction. The shift in the z-direction causes an effective reduction of the phase velocity of the field pattern inside ME. The shift in the x-direction means that the $Z^0$ electric field of ME moves is in x-direction and causes a longitudinal force. The velocity of the shifting motion in the x-direction must be sound velocity.

The classical force field is in a correct phase if $Z^0$ ME shifts in z-direction with such an average velocity that the phase $\omega t - kz$ along ME at point $(t, x, y, z)$ changes to $\omega t - kz + \omega\Delta t - k_1\Delta x$ in the shift $x \rightarrow x + \Delta x$ of the position of ME resulting in quantum jump sequence corresponding to $t \rightarrow t + \Delta t$. This requires $\Delta z = (k_1/k)\Delta x$ giving $dz/dx = c/v_s$. Hence the rays $x = v_s t$ of constant phase for sound wave correspond to the rays of constant phase $z = ct$ along ME.

In the case of transversal sound oscillations possible in solid state $Z^0$ MEs shift in each quantum jump in z-direction in such a manner that effective phase velocity becomes sound velocity. $Z^0$ MEs generate oscillating transverse electric field inducing a coherent state of phonons. I have already earlier proposed that nerve pulse propagation corresponds to a propagation of $Z^0$ ME in an analogous manner [M2].

Option II: By quantum classical correspondence one might argue that sound propagation should have a direct space-time correlate. There exists an infinite variety of vacuum extremals with $D = 1$-dimensional $CP_2$ projection having a flat induced metric. These extremals correspond to warped imbeddings $m^0 = t, s^k = s^k(t)$ of $M^4$ with the induced metric $g_{tt} = 1 - R^2 s_{kl}\partial_t s^k \partial_t s^l$, $g_{ij} = -\delta_{ij}$. The maximal signal velocity using the canonical imbedding of $M^4$ as a reference is reduced to $c_\# = \sqrt{g_{tt}}$.

$D = 2$ vacuum deformations for this kind of space-time sheets exist but the great question mark are there non-vacuum deformations which correspond to solutions of field equations. Do they represent waves propagating with $c_\#$? This could be the case since the field equations for these deformations contain a term proportional to linearized d'Alembert equation in the background metric. Could phonon space-time sheets correspond to deformations of vacuum extremals of this kind analogous to MEs with $c_\#$ identifiable as sound velocity? Could phonons correspond to 3-D light-like surfaces representing wave fronts inside deformed vacuum extremals of this kind? Could the drifting of MEs have this kind of space-time sheets as a space-time correlate?

### 6.9.3 A more detailed description of classical sound waves in terms of $Z^0$ force

The proposed rough model is the simplest description in the case of condensed matter as long as the positions of particles vary slowly in the time scale of the oscillations associated with the sound wave.

A modified description applies when harmonic forces are between neighboring atoms. In this case the modification of standard wave equation would introduce a term representing external force to the wave equation. In one-dimensional case of one-dimensional periodic lattice with lattice constant $a$, elastic constant $k$ for the elastic force between nearest neighbors, and atom mass $m$, one would have in the continuum approximation

$$\begin{aligned} (\partial_t^2 - v_s^2\nabla^2)A &= \frac{Q_Z E_Z}{ma} \ , \\ v_s^2 &= \frac{ka^2}{m} \ . \end{aligned} \tag{6.9.1}$$

Here $a$ denotes lattice constant.

Temporally slowing varying $Z^0$ force to an harmonic external force yielding coherent states of the quantized system. Velocity resonance results when the external $Z^0$ field pattern has effective phase velocity equal to sound velocity $E_Z = f(u_+)$, $u_\pm = x \pm v_s t$. Writing the equations in the form

$$\partial_+\partial_- A = \frac{Q_Z f(u_+)}{ma} \ , \tag{6.9.2}$$

one finds that the general solution is of form

$$A = A_+(u_+) + A_-(u_-) + u_+\frac{Q_Z}{ma}\int du_- f(u_-) \ . \tag{6.9.3}$$

$A_+$ and $A_-$ are arbitrary functions of their argument. In the absence of dissipative effects the amplitude increases without bound.

The quantization of the model is straightforward since a one-dimensional "massless" field coupled to an external source is in question with sound velocity taking the role of light velocity. The resulting asymptotic ground state is a product of coherent states for the frequencies present in the external force term. In quantum field theory this kind of state is interpreted as a maximally classical state and thus classical sound wave.

The intensity of the sound wave would be proportional to the modulus squared of the order parameter of the coherent state proportional to the Fourier transform of the classical $Z^0$ force. The standard classical model for sound waves would thus be only apparently correct. In TGD framework the screened dark $Z^0$ force gives a contribution also to the elastic forces between atoms and explains the strong repulsive potential below atomic distances implying incompressibility of condensed matter and needed in van der Waals equation of state.

Also in the hydrodynamics dark $Z^0$ force would take the role of an external force. Although the quantization of the Euler's equations is far from being a trivial task and perhaps not even sensible, the proposed picture is expected to be the same also in this case for small oscillations for which wave equation holds true. In TGD framework incompressible hydrodynamic flow is interpreted from the beginning in terms of dark $Z^0$ magnetic force [D1], and this should make possible a first principle quantization of sound waves in the case of liquid and gas phases.

1. The hydrodynamic flow occurs along the flux tubes of $Z^0$ magnetic field and it is quite possible that $Z^0$ superconductivity equivalent with super-fluidity along flux tube occurs in sufficiently short length scales. The presence of $Z^0$ magnetic flux tubes parallel to the flow lines is what makes possible to apply hydrodynamic description. The incompressibility inside $Z^0$ magnetic flux tubes is due to the fact that $Z^0$ magnetic field has a vanishing divergence. Alfwen waves, identifiable as transverse oscillations of magnetic flux tubes and propagating with light velocity along the flow lines should have $Z^0$ counterparts and might have detectable effects on the hydrodynamic flow.

2. The Beltrami condition $\nabla \times v = \alpha v$ guarantees that a coordinate varying along flow lines is globally defined and means that super-conducting order parameter defined along the flow lines can be continued to a function defined everywhere so that there is $Z^0$ superconductivity also in the global sense. The complex patterns of flow reduce to the generalized Beltrami property of the topologically quantized flow. Also in the case of gas phase one expects incompressibility inside the flux tubes at least.

### 6.9.4 Does the physics of sound provide an operational definition of the dark $Z^0$ force?

The somewhat surprising conclusion supported by the existence of phase conjugate sound waves is that coherent sound waves could be a direct manifestation of the dark $Z^0$ force directly determining the amplitude of the sound wave understood as a coherent state. Therefore the problem of defining the notion of dark $Z^0$ force operationally would become trivial.

The hypothesis would predict that sound intensity for a given strength of the dark $Z^0$ field proportional to amplitude squared is proportional to $(N/k)^2$, where $N$ is the anomalous color charge of the oscillating nucleus, and $k$ elastic constant for the harmonic oscillations around the equilibrium position of (say) atom.

### 6.9.5 Weak plasma waves and the physics of living matter

In plasma phase electromagnetic MEs, and even more so scalar wave pulses, can generate plasma waves accompanied by longitudinal electric fields. In the case of scalar wave pulses the mechanism is simple: the longitudinal electric field of the scalar wave pulse kicks electrons so that a gradient of electron density results and oscillation starts at plasma frequency $\omega_p = e\sqrt{n/m_e}$ in the case of electron. The frequencies of transversal plasma waves are above the plasma frequency.

The notion of weak plasma frequency makes sense if condensed matter can be regarded as $Z^0$ plasma below the weak length scale $L_w$ with nuclei carrying anomalous weak isospin $I_{3,L}$. Let $I_{3,L}$ be equal to $N$ using neutron's isospin $I_{3,L} = 1/2$ as a unit so that single charged color bond corresponds to $N = \pm 2$.

For a hydrodynamic flow of water of density $\rho = 1$ kg/dm$^3$ giving $18n(H_2O) \simeq 10^{30}/m^3$ and $m(H_2O) = 18m_p$, $W$ and $Z^0$ plasma frequencies are given by

$$\begin{aligned}
\omega_p(W) &= g_W N\sqrt{n/m} \ , \\
\omega_p(Z^0) &= g_Z N\sqrt{\tfrac{1}{2} - sin^2(\theta_W)}\sqrt{n/m} = \sqrt{\tfrac{\frac{1}{2}-sin^2(\theta_W)}{sin^2(\theta_W)}} \times \omega_p(W) \ , \\
g_W^2 &= e^2 tan(\theta_W) \ , \quad g_Z^2 = \tfrac{e^2}{sin(\theta_W)cos(\theta_W)} \ , \quad sin^2(\theta_w) \simeq .23 \ .
\end{aligned} \tag{6.9.4}$$

For $N = 2$ corresponding to single color bond $Z^0$ plasma frequency corresponds to an energy $E \simeq .062$ eV. Note that $\omega_p(W) = 1.08\omega_p(Z^0)$ is very near to $\omega_p(Z^0)$. The two plasma frequencies are identical for $p = 1/4$.

$\omega_p(W)$ is very nearly the frequency associated with the resting potential 0.065 eV of the cell membrane [M2]. Although this result could be a sheer co-incidence, it supports the idea that $Z^0$ plasma vacuum-screened in atomic length scale has a fundamental role in living matter. Of course, entire hierarchy of weak plasmas are possible and more or less forced by the fact that vacuum weak fields appear in all length scales. Weak scalar wave pulses would be an ideal tool for generating plasma oscillations whereas weak MEs would generate sound and transversal plasma waves.

### 6.9.6 Sensory qualia and dark forces

The TGD based model of sensory qualia relies on universality hypothesis stating that the increments of various quantum numbers in quantum jump define qualia at fundamental level in all p-adic length scales. The hierarchy of dark matters would allows to realize similar qualia in all length and time scales.

Quantum classical correspondence suggest that qualia identified as the increments of quantum numbers should have space-time correlates and charged components of weak and color gauge fields are natural candidates in this respect. If this interpretation is correct, sensations of qualia would be assignable to those space-time regions for which space-time sheet has $D > 2$-dimensional $CP_2$ projection. MEs would not thus serve as space-time correlates for qualia but only as communication and control tools.

$D = 3$ extremals allow interpretation them as analogs of spin glass phase possible in the vicinity of magnetization-demagnetization temperature whereas $D = 2$ phase would be analogous to ferromagnetic phase and $D = 4$ phase to de-magnetized phase [D1]. Spin glass property suggests the identification of $D = 3$ extremals as fundamental building bricks of living systems. $D = 3$ extremals have also extremely rich hidden order related to the topology of the field lines of the induced magnetic field lines. Therefore the interpretation of $D = 3$ extremals as space-time correlates of qualia is natural.

A couple of examples are in order.

1. Hearing could correspond to the increment of weak isospin or em charge (or both of them in fixed proportion) and to $D \geq 3$ weak space-time sheets. Classical $W$ fields would serve as a space-time correlate for the basic quale associated with hearing.

2. The increments of color quantum numbers would correspond to the visual colors. The 3+3 charged components of classical gluon field would correspond to basic color-conjugate color pairs. The reduction to $U(2)$ subgroup of color group (for instance, $CP_2$ projection in $r = constant$ 3-sphere of $CP_2$) would correspond to the restriction of color vision to black-white vision. Non-vacuum extremals having $D > 2$ (also those having $D = 2$) carrying classical em fields are always accompanied by classical color fields so that the identification is not in conflict with the existing wisdom. Space-time sheets serving as correlates for color qualia would correspond to p-adic length scales associated with multiply dark gluons.

## 6.10 Mechanisms of $Z^0$ screening

### 6.10.1 General view about dark hierarchy

Classical color gauge fields are always present for non-vacuum extremals and non-Abelian classical weak fields always when the dimension $D$ of the $CP_2$ projection of the space-time sheet satisfies $D > 2$. Quantum classical correspondence forces the conclusion that there must be a p-adic hierarchy of dark matters creating these fields in all length scales. At the level of quantum TGD the p-adic hierarchy of dark matters relates closely with the hierarchy of space-time sheets, hierarchy of infinite primes, and hierarchy of Jones inclusions for hyper-finite type $\text{II}_1$ factors. In TGD inspired theory of consciousness the hierarchy corresponds to the self hierarchy and hierarchy of moments of consciousness with increasing averages duration.

There already exists some guidelines about the physical realization of this hierarchy.

1. Already the p-adic mass calculations of hadron masses led to the conclusion that quarks can appear as several p-adically scaled up variants with masses of variants differing by a multiple of half-octave. There is also experimental support for the view that ordinary neutrinos can appear as several p-adically scaled up variants [25]. This forces to ask whether also electrons could appear as scaled up of scaled down variants even in the ordinary condensed matter, and whether the notion of effective mass of electron varying in wide limits could be replaced by p-adically scaled up mass. A testable prediction is atomic spectra scaled by a power of $\sqrt{2}$.

2. In the TGD based model for atomic nuclei as color bonded nucleons with the quarks/antiquarks at the ends of bonds are identified as p-adically scaled down quarks with electromagnetic space-time sheet having $k = 127$ rather than $k = 113$. Quite generally, exotic quarks and perhaps also leptons (possibly also their color excitations) with p-adically scaled down masses would be associated with the ends of join along boundaries bonds serving as correlates for the bound state formation.

3. The decay width of ordinary weak bosons force the conclusion that the weak space-time sheets associated with exotic quarks have $k \neq 89$ $k = 113$ is a good guess in this respect and would in large $\hbar$ phase correspond to a length scale of order atomic size. The model for tetra-neutron identifies tetra-neutron as alpha particle with two charge color bonds. There is no reason to assume that charged bonds could not appear also in heavier nuclei.

   Their presence would mean also that nucleus has anomalous em and weak charges. One can even consider the possibility that the nuclear strings of neighboring atoms fuse to single nuclear string with long straight portion so that nuclei become colored and possess fractional em charges. Also linking of the nuclear strings might occur.

   If this general picture forced by quantum classical correspondence is taken seriously, one begins to wonder whether even chemical bonds could involve light dark elementary fermions. These dark particles could couple to scaled down copies of both weak bosons and colored gluons.

   Chiral selection in living matter could be due to the axial part of weak interactions between exotic quarks of different nuclei. Even the low compressibility of liquid phase could be due to the $Z^0$ repulsion between nuclei having anomalous weak charges in condensed phase: note that no isotopic dependence is predicted as in the earlier proposal based on the assumption that ordinary quarks are $Z^0$ charged.

4. Besides color and electro-weak numbers dark particles can carry complex conformal weights expressible in terms of zeros of Riemann Zeta. If the conformal weight is conserved in particle reactions and given particle can correspond to only single complex conformal weight, it must be expressible in terms of conserved quantum numbers so that neutral particles have real conformal weights. In the transition to the next level of darkness the particles of previous level could receive complex conformal weights and color and weak quantum numbers.

5. Dark $\leftrightarrow$ visible phase transitions are describable as ordinary vertices in which also a scaling of $\hbar$ occurs and scales the size of the space-time sheet representing the particle.

### 6.10.2 Vacuum screening and screening by particles

Suppose that phase transitions generating charged color bonds and making molecules of condensed matter $Z^0$ charged with the same value of $Z^0$ charge are possible. This transition need not generate em charge since ordinary nuclear charge can be reduced in the transition. Weak charge is however generated. This kind of transition could proceed spontaneously as a two-nucleon process if the nuclei are close enough.

This raises the question about the basic mechanisms of screening of weak charges, in particular $Z^0$ charge. There are two basic mechanism of screening. Vacuum screening occurs automatically above weak length scale $L_w$ and is responsible for the massivation of weak bosons. The screening by $Z^0$ charges of particles occurs in length scales $L \leq L_w$ in a dense weak(ly charged) plasma containing a large number of charged particles in the volume defined by $L_w$.

### Vacuum screening

Vacuum screening occurs automatically and is based on the generation of vacuum charges which reduces the value of weak charge of particle at the weak space-time sheet associated with particle so that the flux feeded to the next sheet is reduced. This mechanism implies massivation of gauge bosons which at each space-time sheet behave classically like massless fields. It is basically the loss of coherence and correlations due to the finiteness of particle space-time sheet which implies the massivation and screening. The screening by vacuum charges makes sense only above the length scale $L_w$ defined by the mass scale of weak bosons.

### Screening by weakly charged dark particles

The screening by dark particles carrying weak charges is appropriate in weak plasma. In situation when the density of $Z^0$ charge is so high that $L_w$ sized region contains large number of $Z^0$ charges, screening must be due to dark particles, such as dark electrons and neutrinos.

1. If ordinary atomic nuclei can make a transition to a phase in which $k = 113$ defines the weak length scale followed by a transition to dark phase with $\hbar_s = n\hbar/v_0$. For $n = 3$, the length scale $L_w$ above which vacuum screening occurs is about $nx$ Angstrom, where $x$ varies in the range $[1, 2]$ and $n = 1, 2, 3, ...$ and screening by dark particles is not necessary in the densities typical to condensed matter. For $n = 3$ the $L_w$ is in the range 3-6 A. The fact that the screening length is of the order of atomic size and length of a typical chemical bond means that dark weak force could play an important role in bio-catalysis as already discussed.

   The situation is quite different from that for $Z^0$ charge localized in nuclear volume. A complete screening by particles is achieved by constant density of $Z^0$ charge for the screening particles equal to the average $Z^0$ charge density of nuclei since the charge density to be screened is constant below $L_w$. By varying the density of screening particles the degree of $Z^0$ screening can be varied.

2. The hypothesis that weak bosons with complex conformal weights correspond to Gaussian Mersennes, such as the biologically highly interesting length scales $k = 151, 157, 163, 167$ varying in the biologically most interesting length scale range 10 nm-2.5 $\mu$m is worth of studying. This kind of dark particles could have ordinary value of $\hbar$ but would possess large weak size $L_w$. In condensed matter weak plasma phase would appear below the length scale $L(k)$ and the weak nuclear charges would be screened by dark electrons.

   Since the $Z^0$ charge density is constant below $L(k)$ screening by constant charge density of dark neutrinos is possible. Experimentally one cannot exclude the possibility that scaled up variants of ordinary neutrinos and their dark counterparts could appear at p-adic length scales $k = 151, ..., 167$. For instance, the model of nerve pulse relies crucially on the assumption that $k = 151$ cell membrane space-time sheet carries neutrinos [M2].

In the sequel a classical model of $Z^0$ screening by dark neutrinos generalizing the Debye model of ionic screening and a genuinely quantum model of screening based on the Bose-Einstein condensate of dark neutrino Cooper pairs are discussed. The Bose-Einstein condensate of sneutrinos predicted by space-time super-symmetry would be ideal for screening purposes. Super-conformal symmetries are basic symmetries of quantum TGD at the level of the "world of classical worlds" but it seems that sparticles are not predicted by quantum TGD if its recent interpretation is correct.

### Different variants of $Z^0$ screening by particles

The model for the $Z^0$ screening allows to consider at least the following options.

*1. Screening by a Bose-Einstein condensate*

Some particles which are bosons would Bose-Einstein condense to the ground state. One can consider several options.

1. Sneutrinos, which are predicted by theories allowing space-time super-symmetry, would be nice option but there are reasons to believe that TGD does not predict them: super-symmetry would be realized only at the level of configuration space of 3-surfaces.

2. Cooper pairs of dark neutrinos is second candidate. A phonon exchange mechanism based on classical $Z^0$ force could allow the formation of Cooper pairs making possible neutrino super conductivity. This mechanism is discussed in some detail in [J3].

   The questionable feature of the Cooper pair option is that the density of neutrinos is so high as compared to the Compton length defined by the rest mass of the neutrino. One can ask whether it makes to sense to regard multi-neutrino state as consisting of Cooper pairs in this kind of situation.

3. The Bose-Einstein condensate of $W$ bosons giving rise to $W$ super-conductivity would define the third option. The simplest option is that the very process generating the charged color bonds in nuclei occurs via emission of $W$ bosons taking also care of screening.

   For $k = 113$ dark $W$ bosons this option is energetically problematic since the rest mass of dark W bosons with $k = 113$ is about 25 MeV and rather high and these bosons are also highly unstable. Note however that complete screening is not needed since vacuum screening occurs automatically above $L_w$, and $W$ Bose-Einstein condensate could control the degree of $Z^0$ screening.

   For $k = 151$ $W$ mass is $\sim 50$ eV and these bosons could be stable (if the masses of exotic leptons are small enough). The negative $Z^0$ Coulombic interaction energy with exotic quark, given roughly by $\sim 2\alpha_Z Q_Z^2(\nu)/a$, $a$ atomic radius, is of same order of magnitude as the rest mass. Therefore the generation of $k = 151$ $W$ Bose-Einstein BE condensate would require rather small net energy and would lead to a gain of energy for $k = 157, 163, 167$.

*2. Dark neutrinos screen the $Z^0$ charge*

For this option dark neutrinos do not form Cooper pairs and thus fill the whole Fermi sphere. For a complete screening the Fermi energy is extremely relativistic, of the order $\pi\hbar_s/a$, $a$ atomic radius so that this option is not energetically favored despite the fact that the ground state energy is negative due to the large $Z^0$ interaction energy having magnitude larger than neutrino mass.

For full screening the value of the Fermi energy for dark neutrinos at level $k = k_Z$ is determined essentially by the density of anomalous isospin per nucleon. This implies that neutrinos at the top of Fermi surface are relativistic: the Fermi energy for $N$ units of weak isospin per nucleon is given by

$$\begin{aligned} E_F &\simeq N^{1/3}\hbar_s \frac{\pi}{a} \ , \\ a &\simeq 10^{-10} \ m \end{aligned} \tag{6.10.1}$$

and does not depend on condensate level. The order of magnitude is $10^4$ eV for ordinary value of $\hbar$ but $n \times 20$ MeV for $\hbar_s = n\hbar/v_0$ and of the same order of magnitude as the rest mass of dark $W$ boson. Hence this option is not energetically much better than $W$ boson option. As noticed, complete screening is not needed so that neutrino screening could serve control purposes.

### 6.10.3 A quantum model for the screening of the dark nuclear $Z^0$ charge

In the sequel a quantum model for the screening of dark $Z^0$ charge is discussed. There are several options corresponding to a screening by neutrinos, by their Cooper pairs, or by light variants of $W$ bosons. The screening by sneutrinos predicted if the theory allows space-time super-symmetry but this does not seem to be the case in TGD.

#### Some relevant observations about dark neutrinos

The experimental data about neutrino mass differences suggests that neutrinos correspond to the p-adic length scale $k = 169$ and possibly also some larger p-adic primes such as $k = 173$ [25]. $k = 169$ neutrinos would have Compton length of about $L(169)$, cell size.

Neutrinos with dark $k = 113$ weak space-time sheet need of course not correspond to the same p-adic length scale as ordinary neutrinos but one can make this assumption as a convenient working hypothesis in order to get some acquaintance with the numbers involved.

A constant $Z^0$ charge density of dark neutrino background can in principle cancel $k = 113$ dark $Z^0$ charge density which is constant in length scales $L < L_w(k_{eff} = 137)$ of order atomic size. The degree of screening is the proper parameter and cannot vary considerably in length scales smaller than $L(169)$ since this would require highly energetic neutrinos.

The Fermi sea of dark neutrinos screening completely the anomalous $Z^0$ charge of nuclei gives rise to Fermi momentum equal to $E_F = p_F = \hbar_s n^{1/3} \simeq N^{1/3}\hbar/L(137) \simeq N^{1/3}(\hbar_s/\hbar) \times 10^4$ eV but this requires energy. Here $N$ is the number of $Z^0$ charges per nucleus.

### The model of $Z^0$ screening based on harmonic oscillator potential does not work

The density of the nuclei is so high that there is large number of nuclei within the Bohr radius, which increases by a factor $n/v_0$ in large $\hbar$ phase. Also the fact that $Z^0$ charge density is constant within $L_w$ favors a different treatment.

The first guess is that the presence of the anomalous nuclear $Z^0$ charge could be treated as a harmonic oscillator potential with origin at the center of the region containing the dark phase. One might hope that this treatment makes sense if the nuclei can be regarded as forming a fixed background stabilized by electromagnetic interactions and by screening. The objection is that translational invariance is lost. It is easy to see that the treatment fails also for other reasons.

The effective potential is given by

$$\begin{aligned}
V_{eff} &= \frac{E}{m}V_Z - \frac{V_Z^2}{2m_\nu} \ , \\
V_Z &= \frac{kr^2}{2} \ , \\
k &= \frac{1}{3}Q_Z^2(\nu)\hbar_s\alpha_Z N\rho_n \ , \qquad (6.10.2)
\end{aligned}$$

where $\rho_n \equiv 1/a^3$ is the number density of nuclei. $N$ is the $Z^0$ charge per nucleus due to the charged color bonds using $Q_Z(\nu)$ as a unit.

The presence of the relativistic correction in-stabilizes the system above some critical value of $r$. The maximum $V = E^2/2m_\nu$ of the effective potential at $V = E$ corresponds to

$$r = \sqrt{\frac{6Ea^3}{\hbar_s}} \times \sqrt{\frac{1}{\alpha_Z N Q_Z^2(\nu)}} \ . \qquad (6.10.3)$$

For non-relativistic energies the order of magnitude for $r$ is

$$r \sim \sqrt{v_0 m_\nu a}/\sqrt{N\alpha_Z Q_Z^2(\nu)}$$

and smaller than the atomic radius. Thus it would seem that the potential is in practice repulsive in the non-relativistic case. For negative energies the potential is repulsive everywhere. Even for relativistic energies of of order $\hbar_s/a$ at the Fermi surface one has $r \sim a/\sqrt{N\alpha_Z Q_Z^2(\nu)}$ and not much larger than atomic radius. Obviously the treatment of nuclei in the proposed manner does not work.

### The model for $Z^0$ screening based on constant potential well

Since $Z^0$ charge density is constant within $L_w$, the safest manner to describe the system is as free dark neutrinos or neutrino Cooper pairs in a potential well characterized by the average $Z^0$ interaction energy of neutrino with nucleus, both idealized as balls of radius $L_w$ carrying a constant $Z^0$ charge density.

By performing a time dependent gauge transformation

$$Z^0_\mu \rightarrow Z^0_\mu + \partial_\mu\Phi \ \ , \ \ \Phi = V_Z t \times \chi \ \ ,$$

where $\chi$ equals to unity inside the potential well and vanishes outside, free d'Alembert equation inside potential well results and solutions can be written as standing waves, which must vanish at the boundary of the well to minimize the singularity resulting from the fact that $A_\mu A^\mu$ term gives square of delta function at boundary. The energy identified from the time dependence of the phase factor of solution is $E_0 + V_Z = \sqrt{p^2 + m^2} + V_Z$ as the non-relativistic treatment would suggest. Negative energy states obviously result if $Z^0$ Coulomb interaction energy $E \sim \alpha_Z Q_Z^2(\nu)N/a$ is larger than neutrino mass.

**Is Bose-Einstein condensate generated spontaneously?**

The formation of neutrino Cooper pairs would correspond to the pairing of neutrinos of opposite spin and would be analogous to the pairing of valence electrons and nucleon pairs inside nuclei. The Bose-Einstein condensation would result basically from the energy gap between the states at the top of Fermi sphere and bound states formed via the scattering possible at the top of Fermi sphere. If the $Z^0$ interaction energy of neutrinos is negative and has larger magnitude than the rest mass at the bottom of Fermi sphere, it is energetically favorable to generate Fermi sea up to a positive energy for which the neutrino system vanishes. Zero energy neutrino-antineutrino pairs for which neutrino has negative energy could be created spontaneously from vacuum and the condensate could thus be generated spontaneously.

$k = 151$ $W$ bosons could form automatically Bose-Einstein condensate. The fact that $Z^0$ interaction energy has larger magnitude than $W$ boson mass favors the spontaneous occurrence of the process. If $W$ bosons are created by the phase transition generating charged color bonds in nuclei their charge is automatically screened.

It is illustrative to recall the basic aspects of the model for Bose-Einstein condensation in the case of ordinary ideal Boson gas.

1. In the absence of the classical $Z^0$ force the energy spectrum of non-relativistic neutrino Cooper pairs is that for a particle in box: $E_n = k\sum_i n_i^2 \times \pi^2/mL^2(169)$, where $k$ is a numerical factor $k$ characterizing the geometry. The natural unit of energy is $\pi^2\hbar^2/2mL^2(169) \simeq .05$ eV.

2. The critical temperature for Bose-Einstein condensation is in recent case obtained by applying the general formula applying in the case of free boson gas with fixed particle number $N$ in volume $V$:

$$T_c = \frac{2\pi\hbar_s^2}{m}(\frac{n}{2.61})^{2/3} = 2\pi\hbar_s^2 \times (\frac{A-Z}{2.61})^{2/3} \times \frac{a^2}{m} . \tag{6.10.4}$$

   $T_c$ is of order .1 GeV so that Bose-Einstein condensation certainly occurs. The fraction of Bose-Einstein condensed particles is given by

$$\frac{N_{BE}}{N} = 1 - (\frac{T}{T_c})^{3/2} . \tag{6.10.5}$$

   From these estimates it should be obvious that also in the recent case Bose Einstein condensation indeed can occur and that most of the bosons are in the negative energy state.

## 6.11 Appendix: Dark neutrino atoms

Dark neutrinos provide a possible screening mechanism for classical $Z^0$ force present in dark condensed matter with weak bosons in dark $k = 113$ phase. If one takes seriously recent experimental evidence [31] and the explanation of the anomalous atmospheric $\mu/e$ ratio [32] in terms of neutrino mixing one must conclude that $\nu_\mu$ and $\nu_\tau$ are condensed on $k = k_Z$ level and that muon and $\tau$ neutrino have suffered large mixing whereas the mixing of $\nu_e$ with remaining neutrinos is much small.

The discussion of [F3] led to the predictions for neutrino masses as a function of common condensation level. In the following table also the $k = 13^2 = 169$ level is included since it predicts exactly the best fit value for $\nu_\tau - \nu_\mu$ mass squared difference whereas $k = 167$ predicts it within 90 per cent confidence limits. $k = 169 = 13^2$ would be allowed if the physically interesting $k$:s are powers of primes instead of primes: this introduces only few new p-adic length scales below one meter.

| k | $m(\nu_e)/eV$ | $m(\nu_\mu)/eV$ | $m(\nu_\tau/eV$ |
|---|---|---|---|
| 163 | 2.16 | 5.28 | 5.36 |
| 167 | .54 | 1.32 | 1.34 |
| $169 = 13^2$ | .27 | .66 | .67 |

Table 2. The table gives the masses of neutrinos as predicted by p-adic mass calculations for three condensate levels.
Only $k = 167$ is allowed by the experimental constraints and p-adic length scale hypothesis in its most stringent form. It must be however emphasized that the elementary particle black hole analogy, discussed in the third part of the book, allows also $k = 169 = 13^2$ giving the best fit to the neutrino mass squared differences. Since the experimental results about electron neutrino-muon neutrino mass difference are preliminary one cannot however exclude the existence of heavy $\tau$ neutrino effecting screening of classical $Z^0$ force in atomic length scales. The upper bound .3 $MeV$ of neutrino mass almost allows $k = 131$ $\tau$ neutrino with mass of .4 $MeV$ and it is interesting to find whether $k = 131$ $\tau$ is physically acceptable alternative. It turns out that this is not the case.

### 6.11.1 Dark neutrino atoms in non-relativistic approximation

To get order of magnitude picture it is useful to look first the Bohr radii and ground state energies for dark neutrino atoms assuming that the non-relativistic approximation makes sense. The Bohr radius $a_\nu = \frac{1}{m_\nu \alpha_Z Q_z^2(\nu)(A-Z)}$ and ground state energy of the neutrino atom read in terms of the ordinary Bohr radius $a_0 \simeq 0.5 \cdot 10^{-10}$ $m$ and hydrogen atom ground state energy $E_H \simeq 13.6$ $eV$

$$\begin{aligned} a_\nu &= \frac{m_e}{m_\nu}\frac{\alpha_{em}}{\alpha_Z Q_Z^2(\nu)}\frac{a_0}{(A-Z)} \\ &\simeq \frac{m_e}{m_\nu}X\frac{a_0}{(A-Z)} \ , \\ E_\nu &= X^{-2}\frac{m_\nu}{m_e}(A-Z)^2 E_H \ , \\ X &= \frac{sin(\theta_W)cos(\theta_W)}{Q_Z^2(\nu)} \simeq 1.68 \ . \end{aligned} \tag{6.11.1}$$

For $\nu_\tau(131)$ (see the table below) Bohr radius is $a(\nu) = 1.95a_0 = 1.05L(137)$ and quite near to the typical size of lattice cell in condensed matter systems.

| $\nu$ | $m$ | $a_\nu$ | $E_0/eV$ | $T_I/K$ |
|---|---|---|---|---|
| $\nu_\tau(131)$ | $0.45$ $MeV$ | $7.5E-10$ $m$ | 4.3 | $.5E+4$ |
| $\nu_{\mu,\tau}(167)$ | $1.32$ $eV$ | 12.8 $\mu m$ | $1.32E-5$ | .13 |
| $\nu_e(167)$ | $.45$ $eV$ | $49.8\mu m$ | $.40E-5$ | .04 |

Table 3. Table gives Bohr radius, energy of ground state and ionization temperature for ground state of neutrino atom for different neutrino species. Data are also given for $k = 131$ $\tau$ neutrino.

For dark matter densities which are of order condensed matter densities neutrino atoms are not possible. One can however consider the possibility that a block of dark matter takes the role of "super nucleus" creating a neutrino "super-atom" with Bohr radius $\propto 1/N(A-Z)$ and binding energy $\propto N^2(A-Z)^2$, where $N$ is the number of nuclei involved.

The observation of the spectral lines of $k = k_Z$ dark neutrino atoms would be a triumph of the theory. The transitions between different energy levels can take place via photon/phonon emission/absorption and the observation of the predicted hydrogen type emission and absorption lines or their phonon counterparts would be a direct verification of the theory.

1. A possible signature of neutrino atoms is weak absorption of light at energies of order $10^{-5}\ eV$. In dipole approximation the transition amplitudes are proportional to the sum of matrix elements for electronic and nuclear dipole moment operators so that matrix elements $(m|\bar{r}(nucleus)|n)$ and $(m|\bar{r}(electron)|n)$ are involved. The coordinate vector operators $\bar{r}(nucleus)$ and $\bar{r}(electron)$ must be expressed in terms of cm coordinates and they contain a small contribution proportional $\frac{m_\nu}{M(nucleus)}\bar{r}_\nu$ as is clear from $\bar{r}(nucleus) = \bar{r}_{cm} + \frac{m_\nu}{m(nucleus)+m_\nu}\bar{r}_{12}$ and corresponding expression for electronic coordinate vector. These terms proportional to $\bar{r}_\nu$ induce transitions between different neutrino energy levels. The transition rates are by a factor $\frac{m_\nu^2}{m^2(nucleus)} \sim 10^{-18}/A^2$ (!) smaller than their atomic physics counter parts. Transition rates are also proportional to the square of the energy difference between the levels in question and this gives additional factor of order $10^{-10}$ for neutrino atoms so that reduction factor of order $10^{-38}$ results! The observation of $k = 167$ neutrino atoms requires temperature of order .1 $K$ and very low densities (fraction of order $10^{-12}$ of ordinary condensed matter density) and one can conclude that the observation of $k = 167$ neutrino atoms is extremely difficult by photon emission or absorption.

2. One can also consider the possibility of observing dark neutrino atoms via phonon absorption or emission: the coupling of the neutrinos to phonons would result indirectly from the coupling of neutrinos to atomic nuclei via classical $Z^0$ force and from the coupling of nuclei to phonons. A rough estimate for the relevant wavelength of sound in temperature of order .1 K gives for the wavelength of the phonon associated with transitions $\lambda \sim 10^{-9}$ meters and frequency of order $10^{10}$ Hz.

### 6.11.2 A relativistic model for dark neutrino atom

The $Z^0$ gauge potential around nucleus is very strong and the classical estimate for the neutrino Coulombic energy has a magnitude much larger than the rest mass of neutrino. This suggests that neutrinos and their Cooper pairs could form negative energy states around nucleus.

For neutrino atoms with several neutrinos one must take into account the screening effect of neutrinos to the $Z^0$ Coulombic potential of the nucleon. The self consistent model is based on the relativistic counterpart of the Schrödinger equation for the order parameter describing bosons in the $Z^0$ Coulomb potential created by the nucleus and neutrino charge density.

#### Self consistent relativistic Schrödinger equation as a model for $Z^0$ screening

The Laplace equation for the self-consistent $Z^0$ Coulomb potential reads as

$$\nabla^2 V_Z = -g_Z^2 Q_Z^2(\nu)(A-Z)\delta(\bar{r}) + g_Z^2 Q_Z^2 \overline{\Psi}\partial_t\Psi \ . \tag{6.11.2}$$

In the lowest order approximation the solution of this equation is Coulomb interaction energy of neutrino with nucleus

$$\begin{aligned} V_Z^0 &= -\frac{k_Z}{r} \ , \\ k_Z &= \alpha_Z Q_Z^2(\nu)(A-Z) \ . \end{aligned} \tag{6.11.3}$$

The d′Alembert equation for the order parameter $\Psi$ characterizing a Bose-Einstein condensate of Cooper pairs of mass $m$ reads as

$$\left[(-i\partial_t - V_Z)^2 + \nabla^2\right]\Psi = m^2\Psi \ . \tag{6.11.4}$$

Specializing to stationary solutions $\Psi \propto exp(iEt)$ corresponding to energy eigenstate and assuming spherically symmetric potential, one has $\Psi = R(r)Y_m^l(\theta,\phi)$.

If $|\Psi|^2$ is spherically symmetric as one can assume under rather general conditions, the model reduces to ordinary differential equations and one can solve it numerically by iterating. By writing $V_Z$ in the form $V_Z = f_Z/r$ one can readily integrate $V_Z$ from

$$V_Z = -\frac{k_Z}{r} + \frac{g_Z^2 Q_Z^2 E}{r}\int_0^r dr_2 \int_0^{r_2} dr_1 r_1 R^2(r_1) \ . \tag{6.11.5}$$

### Bound states

It is possible to understand the general properties of this equation by transforming in to a form which allows to use the rather precise analogy with Schrödinger equation for hydrogen atom. There are two cases to be considered: bound states and negative energy resonances.

For the bound states the appropriate representation of the equation is

$$\left[-\frac{1}{2m}(\partial_r^2 + \frac{2}{r}\partial_r + \frac{l(l+1)}{r^2}) + \frac{E}{m}V_Z - \frac{V_Z^2}{2m}\right] R = \frac{(E^2-m^2)}{2m} \times R \ . \tag{6.11.6}$$

When the screening is not taken into account, the equation has a close resemblance with the Schrödinger equation for the hydrogen atom. The correspondences are following:

$$k_{eff} = \frac{E}{2m}k \ , \quad E_{eff} = \frac{E^2-m^2}{2m} \ , \quad l_{eff}(l_{eff}+1) = l(l+1) - k_Z^2 \ . \tag{6.11.7}$$

In the analog of Schrödinger equation Coulombic potential energy is replaced by an effective potential energy

$$V_{eff} = \frac{E}{m}V_Z - \frac{V_Z^2}{2m} \ . \tag{6.11.8}$$

$V_{eff}$ is negative for large values of $V_Z$, vanishes for $V = -2E$, has a maximum $V_{eff}(max) = E^2/2m$ for $V = E$ and vanishes asymptotically. Therefore $V_{eff}$ has an attractive infinitely deep well surrounded by a potential wall of height $E^2/2m$ so that tunnelling in principle becomes possible. Since $V^2$ term only modifies the effective value of the angular momentum, it is possible to solve the Schrödinger equation explicitly. Bound states correspond to $E < m$. Bound states are non-relativistic with a very long range $m/k_Z^2$ of about $10^{-4}$ meters and are not interesting as far as local screening of $Z^0$ charge is considered.

### Negative energy resonances

Relativistic negative energy resonance like solutions can be localized below the atomic radius and only these are appropriate for local screening of the $Z^0$ charge. For these solutions it is natural to replace the mass of the Cooper pair with its energy $|E|$. With a little re-arranging the following equation analogous to Schrödinger equation for hydrogen atom

$$\left[-\frac{1}{2|E|}(\partial_r^2 + \frac{2}{r}\partial_r + \frac{l(l+1)}{r^2}) - \frac{E}{|E|}V_Z - \frac{V_Z^2}{2|E|}\right] R = \frac{(E^2-m^2)}{2|E|}R \ . \tag{6.11.9}$$

In the lowest order approximation one can use the unscreened $Z^0$ Coulombic potential allowing very close analogy with the hydrogen atom. The analogy with the hydrogen atom is revealed by the replacements

$$m_{eff} = |E| \ , \quad k_{eff} = \frac{k_Z}{2} \ , \quad E_{eff} = \frac{E^2-m^2}{2|E|} \ , \quad l_{eff}(l_{eff}+1) = l(l+1) - k_Z^2 \ . \tag{6.11.10}$$

Note that $l_{eff}$ can be also negative and that for negative energies the Coulombic potential term represents an attractive potential although one has $E_{eff} > 0$. Thus the proper interpretation of the negative energy states are as kind of resonance states.

### An upper bound on the neutron number of nucleus

The general solution for $l_{eff}$ allows to branches

$$l_{eff} = -\frac{1}{2} \pm \frac{1}{2}\sqrt{1+4l(l+1)-4k_Z^2} \ . \tag{6.11.11}$$

The second branch allows $l_{eff} < 0$ even when the right hand side of the equation above is positive.

The condition

$$l(l+1) > k_Z^2 - \frac{1}{4} \tag{6.11.12}$$

guaranteing the reality of $l_{eff}$ must be satisfied. This condition is automatically satisfied for $l = 0$ for nuclei satisfying $k_Z < 1/2$: this gives

$$A - Z \leq \frac{1}{2\alpha_Z Q_Z^2(\nu)} \ . \tag{6.11.13}$$

For biologically important nuclei the condition is satisfied since the lower bound is very roughly $A - Z = 60$.

For $l > 0$ solutions the neutrino perturbation of the Coulombic potential is not spherically symmetric. Hence only $l = 0$ solution allows a simple numerical treatment based on ordinary differential equations.

### The behavior of the negative energy solutions near origin

One can apply standard methods used for solving the Schrödinger equation for hydrogen atom also in the recent case.

1. One can write the normalized order parameter $R$ in the form

$$R(r) = N \times r^{l_{eff}+1} \times exp(-i\frac{r}{|r_0|}) \times w(r) \ . \tag{6.11.14}$$

   The counterpart of Bohr radius is given by

$$|r_0| = \frac{1}{\sqrt{2E_{eff}m_{eff}}} = \frac{1}{\sqrt{E^2 - m^2}} \ . \tag{6.11.15}$$

   For relativistic negative energy solutions the counterpart of Bohr radius is imaginary so that the exponential represents spherical wave.

2. Negative energy solutions are slightly singular at origin as are also the solutions of the relativistic Dirac equation. The requirement that the solution is square integrable at origin gives

$$l_{eff} > -\frac{5}{2} \ , \tag{6.11.16}$$

   The behavior $R^2r^2 \propto r^{2\delta}/r$ for $|\Psi|^2$ near origin is therefore the most singular option.

A more stringent condition results if one requires that the interaction energy between neutrinos and nucleus is finite. In the lowest order the interaction energy density behaves as $r^{2l_{eff}+1}$ so that the constraint reads as

$$l_{eff} \;>\; -2 \; . \qquad (6.11.17)$$

If one requires that neutrino-neutrino Coulombic interaction energy is finite one has

$$l_{eff} \;>\; -\frac{5}{4} \; . \qquad (6.11.18)$$

At large distances $1/r^{1-2\delta}$ even the most singular behavior of $|\Psi|^2$ does not guarantee square integrability but in present case one is interested in non-localized solutions analogous to those characterizing conduction electrons and square integrability is not needed. From the condition

$$l_{eff}(l_{eff}+1) \;=\; l(l+1)-k_Z^2 = l(l+1)-\alpha_Z(A-Z)Q_Z^2(\nu) \qquad (6.11.19)$$

it is clear $l_{eff}$ can be negative only for $l=0$ solution for nuclei for which the condition $A-Z<\alpha_Z Q_Z^2$ is satisfied.

**The condition determining the energy eigen values**

In the case of bound states the function $w(\rho)$ reduces to a polynomial. Also for the negative energies one can consider analogous solution ansatz as a representation of a negative energy resonance state.

1. The condition for the reduction to a polynomial can be deduced using standard power series expansion and reads as

$$2(k+l_{eff}+1) \;=\; -\frac{k_{eff}}{|E_{eff}r_0|} = -k_Z \times \left[\frac{|E|m}{E^2-m^2}\right]^{1/2} \; . \qquad (6.11.20)$$

2. One can write $l_{eff}$ in the form $l_{eff}=-l_{eff}(min)+\Delta l$, where the value of $l_{eff}(min)=-7/2, 2,$ or $-5/4$ depending on the regularity conditions at the origin so that the condition Eq. 6.11.20 gives

$$k \;<\; -l_{eff}(min)-1-\Delta l \geq \frac{1}{4}-\Delta l \; . \qquad (6.11.21)$$

   $w$ is at most a first order polynomial in $r$. The most stringent condition guaranteing the finiteness of $Z^0$ interaction energy allows only the solution for which $w(\rho)$ is constant.

3. The condition of Eq. 6.11.20 guaranteing the reduction of the series of $w$ to a polynomial reduces to the form

$$1-2\delta \;=\; k_Z \times \left[\frac{|E|m}{E^2-m^2}\right]^{1/2} \; . \qquad (6.11.22)$$

   The solutions are

$$\begin{aligned}\frac{|E|}{m} &= \left[b \pm \sqrt{b^2-1}\right]^{1/2} \quad ,\\ b &= 1+\frac{k_Z^2}{2(1+2\delta^2)^2} \quad .\end{aligned} \tag{6.11.23}$$

Solutions are relativistic negative energy solutions but the energy is of the same order of magnitude as the rest energy so that the total energy of the Bose-Einstein condensate is relatively small. Note that the solution is scaling covariant in the sense that in the p-adic scaling $m \rightarrow 2^k m$ also energy scales in the same manner.

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# Chapter 7

# Quantum Coherent Dark Matter and Bio-Systems as Macroscopic Quantum Systems

## 7.1 Introduction

In this chapter a general vision about the unexpected relationships between cosmology, hadron physics, and biology is discussed. The vision is based on p-adic fractality implying that physics and consciousness should share same basic elements in all scales, and to quite dramatic recent findings from astrophysics and hadron physics suggesting that the value of Planck constant might be dynamical so that living systems would correspond to a large value of Planck constant. This would mean that elementary quantum units correspond to systems consisting of very many elementary particles and that characteristic time and length scales are scaled up from those predicted by ordinary quantum theory so that macro-temporal quantum coherence become possible.

### 7.1.1 Dark matter as macroscopic quantum phase with gigantic Planck constant

D. Da Rocha and Laurent Nottale, the developer of Scale Relativity, have ended up with an highly interesting quantum theory like model for the evolution of astrophysical systems [92] (I am grateful for Victor Christianto for informing me about the article). The model is simply Schrödinger equation with Planck constant $\hbar$ replaced with what might be called gravitational Planck constant

$$\hbar \quad \rightarrow \quad \hbar_{gr} = \frac{GmM}{v_0} \quad . \tag{7.1.1}$$

Here I have used units $\hbar = c = 1$. $v_0$ is a velocity parameter having the value $v_0 = 144.7 \pm .7$ km/s giving $v_0/c = 4.6 \times 10^{-4}$. The peak orbital velocity of stars in galactic halos is $142 \pm 2$ km/s whereas the average velocity is $156 \pm 2$ km/s. Also subharmonics and harmonics of $v_0$ seem to appear.

The model makes fascinating predictions which hold true. For instance, the radii of planetary orbits fit nicely with the prediction of the hydrogen atom like model. The inner solar system (planets up to Mars) corresponds to $v_0$ and outer solar system to $v_0/5$.

It is important to notice that effectively a multiplication $n \rightarrow 5n$ of the principal quantum number is in question in the case of outer planets. If one accepts the interpretation that visible matter has concentrated around dark matter, which is in macroscopic quantum phase around Bohr orbits, this allows to consider also the possibility that $\hbar_{gr}$ has same value for all planets.

1. Some external gravitational perturbations have kicked dark matter from inner orbits to $n \, mod \, 5 = 0$ orbits. Gravitational perturbations might have caused the same for visible matter. The fact that the tilt angles of Earth and outer planets other than Pluto are nearly the same suggests that the orbits of these planets might be an outcome of some violent quantum process for dark

matter preserving the orbital plane in a good approximation but kicking dark matter from $n = 5$ orbit of Earth to the orbits $n = 5k$, $k = 2, .., 7$. Pluto might in turn have experienced some violent collision changing its orbital plane.

2. There could exist at least small amounts of dark matter at all orbits but visible matter is concentrated only around orbits containing some critical amount of dark matter and these orbits satisfy $n = 5k$, $k = 2, 3, ...$ for some reason.

The predictions for the distribution of major axis and eccentrities have been tested successfully also for exo-planets. Also the periods of 3 planets around pulsar PSR B1257+12 fit with the predictions with a relative accuracy of few hours/per several months. Also predictions for the distribution of stars in the regions where morphogenesis occurs follow from the Schödinger equation.

What is important is that there are no free parameters besides $v_0$. In [92] a wide variety of astrophysical data is discussed and it seem that the model works and has already now made predictions which have been later verified. A rather detailed model for the formation of solar system making quantitatively correct predictions follows from the study of inclinations and eccentricities predicted by the Bohr rules: the model proposed seems to differ from that of Nottale which makes predictions for the probability distribution of eccentricities and inclinations.

I had proposed already earlier the possibility that Planck constant is quantized. The inverse of the gravitational Planck constant could correspond a gravitational perturbation of this as $1/\hbar_{gr} = v_0/GMm$. The general philosophy would be that when the quantum system would become non-perturbative, a phase transition increasing the value of $\hbar$ occurs to preserve the perturbative character.

TGD predicts correctly the value of the parameter $v_0$ assuming that cosmic strings and their decay remnants are responsible for the dark matter. The harmonics of $v_0$ can be understood as corresponding to perturbations replacing cosmic strings with their n-branched coverings so that tension becomes $n^2$-fold: much like the replacement of a closed orbit with an orbit closing only after $n$ turns. $1/n$-sub-harmonic would result when a magnetic flux tube split into n disjoint magnetic flux tubes.

The study of inclinations (tilt angles with respect to the Earth's orbital plane) leads to a concrete model for the quantum evolution of the planetary system. Only a stepwise breaking of the rotational symmetry and angular momentum Bohr rules plus Newton's equation (or geodesic equation) are needed, and gravitational Shrödinger equation holds true only inside flux quanta for the dark matter.

1. During pre-planetary period dark matter formed a quantum coherent state on the ($Z^0$) magnetic flux quanta (spherical cells or flux tubes). This made the flux quantum effectively a single rigid body with rotational degrees of freedom corresponding to a sphere or circle (full SO(3) or SO(2) symmetry).

2. In the case of spherical shells associated with inner planets the $SO(3) \rightarrow SO(2)$ symmetry breaking led to the generation of a flux tube with the inclination determined by m and j and a further symmetry breaking, kind of an astral traffic jam inside the flux tube, generated a planet moving inside flux tube. The semiclassical interpretation of the angular momentum algebra predicts the inclinations of the inner planets. The predicted (real) inclinations are 6 (7) resp. 2.6 (3.4) degrees for Mercury resp. Venus). The predicted (real) inclination of the Earth's spin axis is 24 (23.5) degrees.

3. The $v_0 \rightarrow v_0/5$ transition allowing to understand the radii of the outer planets in the model of Da Rocha and Nottale can be understood as resulting from the splitting of ($Z^0$) magnetic flux tube to five flux tubes representing Earth and outer planets except Pluto, whose orbital parameters indeed differ dramatically from those of other planets. The flux tube has a shape of a disk with a hole glued to the Earth's spherical flux shell.

It is important to notice that effectively a multiplication $n \rightarrow 5n$ of the principal quantum number is in question. This allows to consider also alternative explanations. Perhaps external gravitational perturbations have kicked dark matter from the orbit or Earth to $n = 5k$, $k = 2, 3, ..., 7$ orbits: the fact that the tilt angles for Earth and all outer planets except Pluto are nearly the same, supports this explanation. Or perhaps there exist at least small amounts of dark matter at all orbits but visible matter is concentrated only around orbits containing some critical amount of dark matter and these orbits satisfy $n \ mod \ 5 = 0$ for some reason.

The most interesting predictions from the point of view of living matter are following.

1. The dark matter is still there and forms quantum coherent structures of astrophysical size. In particular, the ($Z^0$) magnetic flux tubes associated with the planetary orbits define this kind of structures. The enormous value of $h_{gr}$ makes the characteristic time scales of these quantum coherent states extremely long and implies macro-temporal quantum coherence in human and even longer time scales.

2. The rather amazing coincidences between basic bio-rhythms and the periods associated with the orbits in solar system suggest that the frequencies defined by the energy levels of the gravitational Schrödinger equation might entrain with various biological frequencies such as the cyclotron frequencies associated with the magnetic flux tubes. For instance, the period associated with $n = 1$ orbit in the case of Sun is 24 hours within experimental accuracy for $v_0$. Second example is the mysterious 5 second time scale associated with the Comorosan effect [33, 34].

In the following I shall discuss Nottale's model from the point of view of TGD with the emphasis in the model of the planetary system. Only the first rudimentary steps in the understanding of the role of quantum gravitational dark matter in the quantum control and coordination of living matter matter are made. The results however provide firm experimental and theoretical basis for the earlier vision about magnetosphere as a living system responsible for the control of bio-matter.

### 7.1.2 Simulating big bang in laboratory

An important steps in the development of ideas were stimulated by the findings made during period 2002-2005 in Relativist Heavy Ion Collider (RHIC) in Brookhaven compared with the finding of America and for full reason.

1. The first was finding of longitudinal Lorentz invariance at single particle level suggesting a collective behavior. This was around 2002.

2. The collective behavior which was later interpreted in terms of color glass condensate meaning the presence of a blob of liquid like phase decaying later to quark gluon plasma since it was found that the density of what was expected to be quark gluon plasma was about ten times higher than expected.

3. The last finding is that this object seems to absorb partons like black hole and behaves like evaporating black hole.

In my personal Theory Universe the history went as follows.

1. I proposed 2002 a model for Gold-Gold collision as a mini big bang identified as a scaled down variant of TGD inspired cosmology. This makes sense because in TGD based critical cosmology the initial state has vanishing mass per comoving volume instead of being infinite as in radiation dominated cosmology. Any phase transition involving a generation of a new space-time sheet might proceed in this universal manner.

2. Cosmic string soup in the primordial stage is replaced by a tangle of color flux tubes containing the color glass condensate. Flux tubes correspond to flow lines of incompressible liquid flow and non-perturbative phase with a very large $\hbar$ is in question. Gravitational constant is replaced by strong gravitational constant defined by the relevant p-adic length scale squared since color flux tubes are analogs of hadronic strings. Presumably $L_p$, $p = M_107 = 2^107 - 1$, is the p-adic length scale since Mersenne prime $M_{107}$ labels the space-time sheet at which partons feed their color gauge fluxes. Temperature during this phase could correspond to Hagedorn temperature for strings and is determined by string tension. Density would be maximal.

3. Next phase is critical phase in which the notion of space-time in ordinary sense makes sense and 3-space is flat since there is no length scale in critical system (so that curvature vanishes). During this critical phase phase a transition to quark gluon plasma occurs. The duration of this phase fixes all relevant parameters such as temperature (which is the analog of Hagedorn temperature corresponding since critical density is maximal density of gravitational mass in TGD Universe).

4. The next phase is radiation dominated quark gluon plasma phase and then follows hadronization to matter dominated phase provided cosmological picture still applies.

Since black hole formation and evaporation is very much like formation big crunch followed by big bang, the picture is more or less equivalent with the picture in which black hole like object consisting of string like objects (mass is determined by string length just as it is determined by the radius for black holes) is formed and then evaporates. Black hole temperature corresponds to Hagedorn temperature and to the duration of critical period of the mini cosmology.

### 7.1.3 Cosmology of consciousness

Consciousness and cosmology represents a rather weird association from the point of view of materialistically inclined cosmologist. p-Adic physics of cognition however predicts that cognitive consciousness is unavoidably a cosmic phenomenon as far its space-time correlates are considered. Magnetic flux tube hierarchy provides the template for the evolution of conscious, intelligent systems in all length scales in TGD Universe, and bio-systems are predicted to possess magnetic bodies of astrophysical size. Adding to this the enormous spectrum of non-deterministic vacuum extremals (with respect to inertial energy) of field equations allowing interpretation as space-time correlates of intentional action, one has good motivations for a serious consideration of the possibility that intentionality might be realized in astrophysical length scales. There is even some evidence that Sun might act as an intentional system. Fortunately, these speculations are not empty since rather dramatic testable phenomena are predicted.

### 7.1.4 Living matter and dark matter

The most important gift of RHIC was that several theoretical notions and ideas emerged during last years, and applying in hugely different length and time scales by p-adic fractality, integrate nicely.

1. Dark matter is identified as a macroscopic quantum phase with large $\hbar$ for which particles have complex conformal weights. Dark matter controls ordinary matter in living matter. Dark matter also explains the weird looking findings about Bohr rules for planetary orbits.

2. Living matter would be also matter with large value of $\hbar$ and with extremely quantal properties, including free will of course! Dark matter would be responsible for the mysterious vital force.

3. Any system for which some interaction becomes so strong that perturbation theory does not work gives rise to this kind of system in a phase transition in which $\hbar$ increases to not lose perturbativity gives rise to this kind of "super-quantal" matter.

4. Physically $\hbar$ means a larger unit for quantum numbers and this requires that single particle states form larger particle like units. This kind of collective states with weak mutual interactions are of course very natural in strongly interacting systems. At the level of quantum jumps quantum jumps integrate effectively to single quantum jump and longer moments of consciousness result. Entire hierarchy of quantal size scales is predicted corresponding to values of Planck constants associated with $M^4$ and $CP_2$ degrees of freedom. The value of $\hbar$ determines the characteristic time and length scales associated with the conscious living system. One could say that the claim that quantum mechanics in its recent form is not enough for understanding living matter is correct: dynamical $\hbar$ is needed.

5. The picture might have implications also for the understanding of condensed matter. For instance, liquids might be liquids because they contain dark some matter at magnetic/$Z^0$ magnetic flux tubes (darkness follows from the large value of $\hbar$).

## 7.2 Is dark matter in macroscopic quantum phase with a gigantic value of Planck constant?

D. Da Rocha and Laurent Nottale, the developer of Scale Relativity, have ended up with an highly interesting quantum theory like model for the evolution of astrophysical systems [92] (I am grateful for Victor Christianito for informing me about the article). The model is simply Schrödinger equation with Planck constant $\hbar$ replaced with what might be called gravitational Planck constant

$$\hbar \quad \rightarrow \quad \hbar_{gr} = \frac{GmM}{v_0} \quad . \tag{7.2.1}$$

Here I have used units $\hbar = c = 1$. $v_0$ is a velocity parameter having the value $v_0 = 144.7 \pm .7$ km/s giving $v_0/c = 4.6 \times 10^{-4}$. The peak orbital velocity of stars in galactic halos is $142 \pm 2$ km/s whereas the average velocity is $156 \pm 2$ km/s. Also sub-harmonics and harmonics of $v_0$ seem to appear.

The model makes fascinating predictions which hold true. For instance, the radii of planetary orbits fit nicely with the prediction of the hydrogen atom like model. The inner solar system (planets up to Mars) corresponds to $v_0$ and outer solar system to $v_0/5$.

The predictions for the distribution of major axis and eccentrities have been tested successfully also for exoplanets. Also the periods of 3 planets around pulsar PSR B1257+12 fit with the predictions with a relative accuracy of few hours/per several months. Also predictions for the distribution of stars in the regions where morphogenesis occurs follow from the gravitational Schödinger equation.

What is important is that there are no free parameters besides $v_0$. In [92] a wide variety of astrophysical data is discussed and it seem that the model works and has already now made predictions which have been later verified. In the following I shall discuss Nottale's model from the point of view of TGD.

### 7.2.1 TGD prediction for the parameter $v_0$

One of the basic questions is the origin of the parameter $v_0$, which according to a rich amount of experimental data discussed in [92] seems to play a role of a constant of Nature. One of the first applications of cosmic strings in TGD sense was an explanation of the velocity spectrum of stars in the galactic halo in terms of dark matter which could consists of cosmic strings. Cosmic strings could be orthogonal to the galactic plane going through the nucleus (jets) or they could be in galactic plane in which case the strings and their decay products would explain dark matter assuming that the length of cosmic string inside a sphere of radius $R$ is or has been roughly $R$ [D4]. The predicted value of the string tension is determined by the $CP_2$ radius whose ratio to Planck length is fixed by electron mass via p-adic mass calculations. The resulting prediction for the $v_0$ is correct and provides a working model for the constant orbital velocity of stars in the galactic halo.

The parameter $v_0 \simeq 2^{-11}$, which has actually the dimension of velocity unless on puts $c = 1$, and also its harmonics and sub-harmonics appear in the scaling of $\hbar$. $v_0$ corresponds to the velocity of distant stars in the model of galactic dark matter. TGD allows to identify this parameter as the parameter

$$\begin{aligned} v_0 &= 2\sqrt{TG} = \sqrt{\frac{1}{2\alpha_K}}\sqrt{\frac{G}{R^2}} \quad , \\ T &= \frac{1}{8\alpha_K}\frac{\hbar_0}{R^2} \quad . \end{aligned} \tag{7.2.2}$$

Here $T$ is the string tension of cosmic strings, $R$ denotes the "radius" of $CP_2$ ($2R$ is the radius of geodesic sphere of $CP_2$). $\alpha_K$ is Kähler coupling strength, the basic coupling constant strength of TGD, whose evolution as a function of p-adic length scale is fixed by quantum criticality. The condition that $G$ is invariant in the p-adic coupling constant evolution and number theoretical arguments predict

$$\begin{aligned} \alpha_K(p) &= k\frac{1}{log(p) + log(K)} \quad , \\ K &= \frac{R^2}{\hbar_0 G} = 2\times 3\times 5\times 7\times 11\times 13\times 17\times 19\times 23 \quad , \quad k \simeq \pi/4 \quad . \end{aligned} \tag{7.2.3}$$

The predicted value of $v_0$ depends logarithmically on the p-adic length scale and for $p \simeq 2^{127} - 1$ (electron's p-adic length scale) one has $v_0 \simeq 2^{-11}$.

### 7.2.2 Model for planetary orbits without $v_0 \to v_0/5$ scaling

Also harmonics and sub-harmonics of $v_0$ appear in the model of Nottale and Da Rocha. For instance, the outer planets (Jupiter, Saturn,...) correspond to $v_0/5$ whereas inner planets correspond to $v_0$. Quite generally, it is found that the values seem to come as harmonics and sub-harmonics of $v_0$: $v_n = nv_0$ and $v_0/n$, and the argument [92] is that the different values of $n$ relate to fractality. This scaling is not necessary for the planetary orbits in TGD based model.

Effectively a multiplication $n \to 5n$ of the principal quantum number is in question in the case of outer planets. If one accepts the interpretation that visible matter has concentrated around dark matter, which is in macroscopic quantum phase around Bohr orbits, this allows to consider also the possibility that $\hbar_{gr}$ has the same value for all planets.

1. Some gravitational perturbation has kicked dark matter from the region of the asteroid belt to $n \simeq 5k$, $k = 2, .., 6$, orbits. The best fit is obtained by using values of $n$ deviating somewhat from multiples of 5 which suggests that the scaling of $v_0$ is not needed. Gravitational perturbations might have caused the same for the visible matter. The fact that the tilt angles of Earth and outer planets other than Pluto are nearly the same suggests that the orbits of these planets might be an outcome of some violent quantum process for dark matter preserving the orbital plane in a good approximation. Pluto might in turn have experienced some violent collision changing its orbital plane.

2. There could exist at least small amounts of dark matter at all orbits but visible matter is concentrated only around orbits containing some critical amount of dark matter.

| | Exp. | Titius-Bode | $\text{Bohr}_1$ | $\text{Bohr}_2$ |
|---|---|---|---|---|
| Planet | $R/R_M$ | $R/R_M$ | $[n, R/R_M]$ | $[n, R/R_M]$ |
| Mercury | 1 | 1 | [3, 1] | |
| Venus | 1.89 | 1.75 | [4, 1.8] | |
| Earth | 2.6 | 2.5 | [5, 2.8] | |
| Mars | 3.9 | 4 | [6, 4] | |
| Asteroid belt | 6.1-8.7 | 7 | [(7, 8, 9), (5.4, 7.1, 9)] | |
| Jupiter | 13.7 | 13 | [11, 13.4] | [$2\times 5$,11.1] |
| Saturn | 25.0 | 25 | [$3\times 5$, 25] | [$3\times 5$, 25] |
| Uranus | 51.5 | 49 | [22, 53.8] | [$4\times 5$,44.4] |
| Neptune | 78.9 | 97 | [27 , 81] | [$5\times 5$, 69.4] |
| Pluto | 105.2 | 97 | [31, 106.7] | [$6\times 5$,100] |

Table 2. The table represents the experimental average orbital radii of planets, the predictions of Titius-Bode law (note the failure for Neptune), and the predictions of Bohr orbit model assuming a)that the principal quantum number $n$ corresponds to best possible fit, b) the scaling $\lambda \to \lambda/5$ for outer planets. Option 1) gives the best fit with errors being considerably smaller than the maximal error $|\Delta R|/R \simeq 1/n$ except for Uranus.

#### How to understand the harmonics and sub-harmonics of $v_0$ in TGD framework?

Also harmonics and sub-harmonics of $v_0$ appear in the model of Nottale and Da Rocha. In particular, the outer planets (Jupiter, Saturn,...) correspond to $v_0/5$ whereas inner planets correspond to $v_0$ in this model. As already found, TGD allows also an alternative explanation.

Quite generally, it is found that the values seem to come as harmonics and sub-harmonics of $v_0$: $v_n = nv_0$ and $v_0/n$, and the argument [92] is that the different values of $n$ relate to fractality. This quantization is a challenge for TGD since $v_0$ certainly defines a fundamental constant in TGD Universe.

1. Consider first the harmonics of $v_0$. Besides cosmic strings of type $X^2 \times S^2 \subset M^4 \times CP_2$ one can consider also deformations of these strings defining their multiple coverings so that the deformation is $n$-valued as a function of $S^2$-coordinates $(\Theta, \Phi)$ and the projection to $S^2$ is thus an $n \to 1$ map. The solutions are higher dimensional analogs of originally closed orbits which after perturbation close only after $n$ turns. This kind of surfaces emerge in the TGD inspired

model of quantum Hall effect naturally [E9] and $n \to \infty$ limit has an interpretation as an approach to chaos [G2].

Using the coordinates $(x, y, \theta, \phi)$ of $X^2 \times S^2$ and coordinates $m^k$ for $M^4$ of the unperturbed solution the space-time surface the deformation can be expressed as

$$\begin{aligned} m^k &= m^k(x, y, \theta, \phi) \ , \\ (\Theta, \Phi) &= (\theta, n\phi) \ . \end{aligned} \tag{7.2.4}$$

The value of the string tension would be indeed $n^2$-fold in the first approximation since the induced Kähler form defining the Kähler magnetic field would be $J_{\theta\phi} = nsin(\Theta)$ and one would have $v_n = nv_0$. At the limit $m^k = m^k(x, y)$ different branches for these solutions collapse together.

2. Consider next how sub-harmonics appear in TGD framework. Cosmic strings are predicted to decay to magnetic flux tube structures by absolute minimization of Kähler action. The Kähler magnetic flux $\Phi = BS$ is conserved in the process but the thickness of the $M^4$ projection of the cosmic string increases field strength is reduced. This means that string tension, which is proportional to $B^2S$, is reduced (so that also Kähler action is reduced). The fact that space-time surface is Bohr orbit in generalized sense means that the reduced string tension (magnetic energy per unit length) is quantized.

The task is to guess how the quantization occurs. There are two options.

1. The simplest explanation for the reduction of $v_0$ is based on the decay of a flux tube resembling a disk with a hole to $n$ identical flux tubes so that $v_0 \to v_0/n$ results for the resulting flux tubes. It turns out that this mechanism is favored and explains elegantly the value of $\hbar_{gr}$ for outer planetary system. One can also consider small-p p-adicity so that $n$ would be prime.

2. Second explanation is more intricate. Consider a magnetic flux tube. Since magnetic flux is quantized, the magnetic field strengths are quantized in integer multiples of basic strength: $B = nB_0$ and would rather naturally correspond to the multiple coverings of the original magnetic flux tube with magnetic energy quantized in multiples of $n^2$. The idea is to require internal consistency in the sense that the allowed reduced field strengths are such that the spectrum associated with $B_0$ is contained to the spectrum associated with the quantized field strengths $B_1 > B_0$. This would allow only field strengths $B = B_S/n^2$, where $B_S$ denotes the field strength of the fundamental cosmic string and one would have $v_n = v_0/n$. Flux conservation requires that the area of the flux tube scales as $n^2$.

Sub-harmonics might appear in the outer planetary system and there are indications for the higher harmonics below the inner planetary system [92]: for instance, solar radius corresponds to $n = 1$ orbital for $v_3 = 3v_0$. This would suggest that Sun and also planets have an onion like structure with highest harmonics of $v_0$ and strongest string tensions appearing in the solar core and highest sub-harmonics appearing in the outer regions. If the matter results as decay remnants of cosmic strings this means that the mass density inside Sun should correlate strongly with the local value of $n$ characterizing the multiple covering of cosmic strings.

One can ask whether the very process of the formation of the structures could have excited the higher values of $n$ just like closed orbits in a perturbed system become closed only after $n$ turns. The energy density of the cosmic string is about one Planck mass per $\sim 10^7$ Planck lengths so that $n > 1$ excitation increasing this density by a factor of $n^2$ is obviously impossible except under the primordial cosmic string dominated period of cosmology during which the net inertial energy density must have vanished. The structure of the future solar system would have been dictated already during the primordial phase of cosmology when negative energy cosmic string suffered a time reflection to positive energy cosmic strings.

### Nottale equation is consistent with the TGD based model for dark matter

TGD allows two models of dark matter. The first one is spherically symmetric and the second one cylindrically symmetric. The first thing to do is to check whether these models are consistent with the gravitational Schödinger equation/Bohr quantization.

*1. Spherically symmetric model for the dark matter*

The following argument based on Bohr orbit quantization demonstrates that this is indeed the case for the spherically symmetric model for dark matter. The argument generalizes in a trivial manner to the cylindrically symmetric case.

1. The gravitational potential energy $V(r)$ for a mass distribution $M(r) = xTr$ ($T$ denotes string tension) is given by

$$V(r) = Gm\int_r^{R_0} \frac{M(r)}{r^2}dr = GmxTlog(\frac{r}{R_0}) \quad . \tag{7.2.5}$$

   Here $R_0$ corresponds to a large radius so that the potential is negative as it should in the region where binding energy is negative.

2. The Newton equation $\frac{mv^2}{r} = \frac{GmxT}{r}$ for circular orbits gives

$$v = xGT \quad . \tag{7.2.6}$$

3. Bohr quantization condition for angular momentum by replacing $\hbar$ with $\hbar_{gr}$ reads as $mvr = n\hbar_{gr}$ and gives

$$\begin{aligned} r_n &= \frac{n\hbar_{gr}}{mv} = nr_1 \quad , \\ r_1 &= \frac{GM}{vv_0} \quad . \end{aligned} \tag{7.2.7}$$

   Here $v$ is rather near to $v_0$.

4. Bound state energies are given by

$$E_n = \frac{mv^2}{2} - xTlog(\frac{r_1}{R_0}) + xTlog(n) \quad . \tag{7.2.8}$$

   The energies depend only weakly on the radius of the orbit.

5. The centrifugal potential $l(l+1)/r^2$ in the Schrödinger equation is negligible as compared to the potential term at large distances so that one expects that degeneracies of orbits with small values of $l$ do not depend on the radius. This would mean that each orbit is occupied with same probability irrespective of value of its radius. If the mass distribution for the starts does not depend on $r$, the number of stars rotating around galactic nucleus is simply the number of orbits inside sphere of radius $R$ and thus given by $N(R) \propto R/r_0$ so that one has $M(R) \propto R$. Hence the model is self consistent in the sense that one can regard the orbiting stars as remnants of cosmic strings and thus obeying same mass distribution.

*2. Cylindrically symmetric model for the galactic dark matter*

TGD allows also a model of the dark matter based on cylindrical symmetry. In this case the dark matter would correspond to the mass of a cosmic string orthogonal to the galactic plane and traversing through the galactic nucleus. The string tension would the one predicted by TGD. In the directions orthogonal to the plane of galaxy the motion would be free motion so that the orbits would be helical, and this should make it possible to test the model. The quantization of radii of the orbits would be exactly the same as in the spherically symmetric model. Also the quantization of inclinations predicted by the spherically symmetric model could serve as a sensitive test. In this kind of situation general theory of relativity would predict only an angle deficit giving rise to a lens effect. TGD predicts a Newtonian $1/\rho$ potential in a good approximation.

Spiral galaxies are accompanied by jets orthogonal to the galactic plane and a good guess is that they are associated with the cosmic strings. The two models need not exclude each other. The vision about astrophysical structures as pearls of a fractal necklace would suggest that the visible matter has resulted in the decay of cosmic strings originally linked around the cosmic string going through the galactic plane and creating $M(R) \propto R$ for the density of the visible matter in the galactic bulge. The finding that galaxies are organized along linear structures [83] fits nicely with this picture.

*3. MOND and TGD*

TGD based model explains also the MOND (Modified Newton Dynamics) model of Milgrom [84] for the dark matter. Instead of dark matter the model assumes a modification of Newton's laws. The model is based on the observation that the transition to a constant velocity spectrum seems in the galactic halos seems to occur at a constant value of the stellar acceleration equal to $a_0 \simeq 10^{-11}g$, where $g$ is the gravitational acceleration at the Earth. MOND theory assumes that Newtonian laws are modified below $a_0$.

The explanation relies on Bohr quantization. Since the stellar radii in the halo are quantized in integer multiples of a basic radius and since also rotation velocity $v_0$ is constant, the values of the acceleration are quantized as $a(n) = v_0^2/r(n)$ and $a_0$ correspond to the radius $r(n)$ of the smallest Bohr orbit for which the velocity is still constant. For larger orbital radii the acceleration would indeed be below $a_0$. $a_0$ would correspond to the distance above which the density of the visible matter does not appreciably perturb the gravitational potential of the straight string. This of course requires that gravitational potential is that given by Newton's theory and is indeed allowed by TGD.

### 7.2.3 The interpretation of $\hbar_{gr}$ and pre-planetary period

$\hbar_{gr}$ could corresponds to a unit of angular momentum for quantum coherent states at magnetic flux tubes or walls containing macroscopic quantum states. Quantitative estimate demonstrates that $\hbar_{gr}$ for astrophysical objects cannot correspond to spin angular momentum. For Sun-Earth system one would have $\hbar_{gr} \simeq 10^{77}\hbar$. This amount of angular momentum realized as a mere spin would require $10^{77}$ particles! Hence the only possible interpretation is as a unit of orbital angular momentum. The linear dependence of $\hbar_{gr}$ on $m$ is consistent with the additivity of angular momenta in the fusion of magnetic flux tubes to larger units if the angular momentum associated with the tubes is proportional to both $m$ and $M$.

Just as the gravitational acceleration is a more natural concept than gravitational force, also $\hbar_{gr}/m = GM/v_0$ could be more natural unit than $\hbar_{gr}$. It would define a universal unit for the circulation $\oint v \cdot dl$, which is apart from $1/m$-factor equal to the phase integral $\oint p_\phi d\phi$ appearing in Bohr rules for angular momentum. The circulation could be associated with the flow associated with outer boundaries of magnetic flux tubes surrounding the orbit of mass $m$ around the central mass $M \gg m$ and defining light like 3-D CDs analogous to black hole horizons.

The expression of $\hbar_{gr}$ depends on masses $M$ and $m$ and can apply only in space-time regions carrying information about the space-time sheets of $M$ and and the orbit of $m$. Quantum gravitational holography suggests that the formula applies at 3-D light like causal determinant (CD) $X_l^3$ defined by the wormhole contacts gluing the space-time sheet $X_l^3$ of the planet to that of Sun. More generally, $X_l^3$ could be the space-time sheet containing the planet, most naturally the magnetic flux tube surrounding the orbit of the planet and possibly containing dark matter in super-conducting state. This would give a precise meaning for $\hbar_{gr}$ and explain why $\hbar_{gr}$ does not depend on the masses of other planets.

The simplest option consistent with the quantization rules and with the explanatory role of magnetic flux structures is perhaps the following one.

1. $X^3_l$ is a torus like surface around the orbit of the planet containing delocalized dark matter. The key role of magnetic flux quantization in understanding the values of $v_0$ suggests the interpretation of the torus as a magnetic or $Z^0$ magnetic flux tube. At pre-planetary period the dark matter formed a torus like quantum object. The conditions defining the radii of Bohr orbits follow from the requirement that the torus-like object is in an eigen state of angular momentum in the center of mass rotational degrees of freedom. The requirement that rotations do not leave the torus-like object invariant is obviously satisfied. Newton's law required by the quantum-classical correspondence stating that the orbit corresponds to a geodesic line in general relativistic framework gives the additional condition implying Bohr quantization.

2. A simple mechanism leading to the localization of the matter would have been the pinching of the torus causing kind of a traffic jam leading to the formation of the planet. This process could quite well have involved a flow of matter to a smaller planet space-time sheet $Y^3_l$ topologically condensed at $X^3_l$. Most of the angular momentum associated with torus like object would have transformed to that of planet and situation would have become effectively classical.

3. The conservation of magnetic flux means that the splitting of the orbital torus would generate a pair of Kähler magnetic charges. It is not clear whether this is possible dynamically and hence the torus could still be there. In fact, TGD explanation for the tritium beta decay anomaly citeTroitsk,Mainz in terms of classical $Z^0$ force [F8] requires the existence of this kind of torus containing neutrino cloud whose density varies along the torus. This picture suggests that the lacking $n = 1$ and $n = 2$ orbits in the region between Sun and Mercury are still in magnetic flux tube state containing mostly dark matter.

4. The fact that $\hbar_{gr}$ is proportional to $m$ means that it could have varied continuously during the accumulation of the planetary mass without any effect in the planetary motion: this is of course nothing but a manifestation of Equivalence Principle.

5. It is interesting to look for the scaled up versions of Planck mass $m_{Pl} = \sqrt{\hbar_{gr}/\hbar} \times \sqrt{\hbar/G} = \sqrt{M_1M_2/v_0}$ and Planck length $L_{Pl} = \sqrt{\hbar_{gr}/\hbar} \times \sqrt{\hbar/G} = G\sqrt{M_1M_2/v_0}$. For $M_1 = M_2 = M$ this gives $m_{Pl} = M/\sqrt{v_0} \simeq 45.6 \times M$ and $L_{Pl} = r_S/2\sqrt{v_0} \simeq 22.8 \times r_S$, where $r_S$ is Schwartshild radius. For Sun $r_S$ is about 2.9 km so that one has $L_{Pl} \simeq 66$ km. For a few years ago it was found that Sun contains "inner-inner" core of radius about $R = 300$ km [26] which is about $4.5 \times L_{Pl}$.

### 7.2.4 Inclinations for the planetary orbits and the quantum evolution of the planetary system

The inclinations of planetary orbits provide a test bed for the theory. The semiclassical quantization of angular momentum gives the directions of angular momentum from the formula

$$cos(\theta) = \frac{m}{\sqrt{j(j+1)}} \quad , \quad |m| \leq j \quad . \tag{7.2.9}$$

where $\theta$ is the angle between angular momentum and quantization axis and thus also that between orbital plane and (x,y)-plane. This angle defines the angle of tilt between the orbital plane and (x,y)-plane.

$m = j = n$ gives minimal value of angle of tilt for a given value of $n$ of the principal quantum number as

$$cos(\theta) = \frac{n}{\sqrt{n(n+1)}} \quad . \tag{7.2.10}$$

For $n = 3, 4, 5$ (Mercury, Venus, Earth) this gives $\theta = 30.0$, 26.6, and 24.0 degrees respectively.

Only the relative tilt angles can be compared with the experimental data. Taking as usual the Earth's orbital plane as the reference the relative tilt angles give what are known as inclinations. The predicted inclinations are 6 degrees for Mercury and 2.6 degrees for Venus. The observed values [29] are 7.0 and 3.4 degrees so that the agreement is satisfactory. If one allows half-odd integer spin the fit is improved. For $j = m = n - 1/2$ the predictions are 7.1 and 2.9 degrees for Mercury and Venus respectively. For Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto the inclinations are 1.9, 1.3, 2.5, 0.8, 1.8, 17.1 degrees. For Mars and outer planets the tilt angles are predicted to have wrong sign for $m = j$. In a good approximation the inclinations vanish for outer planets except Pluto and this would allow to determine $m$ as $m \simeq \sqrt{5n(n+1)/6}$: the fit is not good.

The assumption that matter has condensed from a matter rotating in (x,y)-plane orthogonal to the quantization axis suggests that the directions of the planetary rotation axes are more or less the same and by angular momentum conservation have not changed appreciably. The prediction for the tilt of the rotation axis of the Earth is 24 degrees of freedom in the limit that the Earth's spin can be treated completely classically, that is for $m = j >> 1$ in the units used for the quantization of the Earth's angular momentum. What is the value of $\hbar_{gr}$ for Earth is not obvious (using the unit $\hbar_{gr} = GM^2/v_0$ the Earth's angular momentum would be much smaller than one). The tilt of the rotation axis of Earth with respect to the orbit plane is 23.5 degrees so that the agreement is again satisfactory. This prediction is essentially quantal: in purely classical theory the most natural guess for the tilt angle for planetary spins is 0 degrees.

The observation that the inner planets Mercury, Venus, and Earth have in a reasonable approximation the predicted inclinations suggest that they originate from a primordial period during which they formed spherical cells of dark matter and had thus full rotational degrees of freedom and were in eigen states of angular momentum corresponding to a full rotational symmetry. The subsequent $SO(3) \rightarrow SO(2)$ symmetry breaking leading to the formation of torus like configurations did not destroy the information about this period since the information about the value of $j$ and $m$ was coded by the inclination of the planetary orbit.

In contrast to this, the dark matter associated with Earth and outer planets up to Neptune formed a flattened magnetic or $Z^0$ magnetic flux tube resembling a disk with a hole and the subsequent symmetry breaking broke it to separate flux tubes. Earth's spherical disk was joined to the disk formed by the outer planets. The spherical disk could be still present and contain super-conducting dark matter. The presence of this "heavenly sphere" might closely relate to the fact that Earth is a living planet. The time scale $T = 2\pi R/c$ is very nearly equal to 5 minutes and defines a candidate for a bio-rhythm.

If this flux tube carried the same magnetic flux as the flux tubes associated with the inner planets, the decomposition of the disk with a hole to 5 flux tubes corresponding to Earth and to the outer planets Mars, Jupiter, Saturn and Neptune, would explain the value of $v_0$ correctly and also the small inclinations of outer planets. That Pluto would not originate from this structure, is consistent with its anomalously large values of inclination $i = 17.1$ degrees, small value of eccentricity $e = .248$, and anomalously large value of inclination of equator to orbit about 122 degrees as compared to 23.5 degrees in the case of Earth [29].

### 7.2.5 Eccentricities and comets

Bohr-Sommerfeld quantization allows also to deduce the eccentricities of the planetary and comet orbits. One can write the quantization of energy as

$$\begin{aligned} \frac{p_r^2}{2m_1} + \frac{p_\theta^2}{2m_1 r^2} + \frac{p_\phi^2}{2m_1 r^2 sin^2(\theta)} - \frac{k}{r} &= -\frac{E_1}{n^2} \ , \\ E_1 = \frac{k^2}{2\hbar_{gr}^2} \times m_1 &= \frac{v_0^2}{2} \times m_1 \ . \end{aligned} \tag{7.2.11}$$

Here one has $k = GMm_1$. $E_1$ is the binding energy of $n = 1$ state. In the orbital plane ($\theta = \pi/2, p_\theta = 0$) the conditions are simplified. Bohr quantization gives $p_\phi = m\hbar_{gr}$ implying

$$\frac{p_r^2}{2m_1} + \frac{k^2\hbar_{gr}^2}{2m_1 r^2} - \frac{k}{r} = -\frac{E_1}{n^2} \ . \tag{7.2.12}$$

For $p_r = 0$ the formula gives maximum and minimum radii $r_\pm$ and eccentricity is given by

$$e^2 = \frac{r_+ - r_-}{r_+} = \frac{2\sqrt{1-\frac{m^2}{n^2}}}{1+\sqrt{1-\frac{m^2}{n^2}}} \quad . \tag{7.2.13}$$

For small values of $n$ the eccentricities are very large except for $m = n$. For instance, for $(m = n-1, n)$ for $n = 3, 4, 5$ gives $e = (.93, .89, .86)$ to be compared with the experimental values (.206, .007, .0167). Thus the planetary eccentricities with Pluto included ($e = .248$) must vanish in the lowest order approximation and must result as a perturbation of the magnetic flux tube.

The large eccentricities of comet orbits might however have an interpretation in terms of $m < n$ states. The prediction is that comets with small eccentricities have very large orbital radius. Oort's cloud is a system weakly bound to a solar system extending up to 3 light years. This gives the upper bound $n \leq 700$ if the comets of the cloud belong to the same family as Mercury, otherwise the bound is smaller. This gives a lower bound to the eccentricity of not nearly circular orbits in the Oort cloud as $e > .32$.

### 7.2.6 Why the quantum coherent dark matter is not visible?

The obvious objection against quantal astrophysics is that astrophysical systems look extremely classical. Quantal dark matter in many-sheeted space-time resolves this counter argument. As already explained, the sequence of symmetry breakings of the rotational symmetry would explain nicely why astral Bohr rules work. The prediction is however that delocalized quantal dark matter is probably still present at (the boundaries of) magnetic flux tubes and spherical shells. It is however the entire structure defined by the orbit which behaves like a single extended particle so that the localization in quantum measurement does not mean a localization to a point of the orbit. Planet itself corresponds to a smaller localized space-time sheet condensed at the flux tube.

One should however understand why this dark matter with a gigantic Planck constant is not visible. The simplest explanation is that there cannot be any direct quantum interactions between ordinary and dark matter in the sense that particles with different values of Planck constant could appear in the same particle vertex. This would allow also a fractal hierarchy copies of standard model physics to exist with different p-adic mass scales.

There is also second argument. The inability to observe dark matter could mean inability to perform state function reduction localizing the dark matter. The probability for this should be proportional to the strength of the measurement interaction. For photons the strength of the interaction is characterized by the fine structure constant. In the case of dark matter the fine structure constant is replaced with

$$\alpha_{em,gr} = \alpha_{em} \times \frac{\hbar}{\hbar_{gr}} = \alpha_{em} \times \frac{v_0}{GMm} \quad . \tag{7.2.14}$$

For $M = m = m_{Pl} \simeq 10^{-8}$ kg the value of the fine structure constant is smaller than $\alpha_{em} v_0$ and completely negligible for astrophysical masses. However, for processes for which the lowest order classical rates are non-vanishing, rates are not affected in the lowest order since the increase of the Compton length compensates the reduction of $\alpha$. Higher order corrections become however small. What makes dark matter invisible is not the smallness of $\alpha_{em}$ but the fact that the binding energies of say hydrogen atom proportional to $\alpha^2 m_e$ are scaled as $1/\hbar^2$ so that the spectrum is scaled down.

### 7.2.7 Quantum interpretation of gravitational Schrödinger equation

Schrödinger equation in astrophysical length scales with a gigantic value of Planck constant looks sheer madness idea from the standard physics point of view. In TGD Universe situation might be different.

1. In TGD inertial four-momentum (or conserved four-momentum) is not positive definite and the net four-momentum of the Universe vanishes. Already in cosmological length scales the density

of inertial mass vanishes. Gravitational masses and inertial masses can be identified only at the limit when one can neglect the interaction between positive and negative energy matter. The masses appearing in the gravitational Schrödinger equation are gravitational masses and one can ask whether inertial and gravitational Planck constants are different.

2. The fractality of the many-sheeted space-time predicts that quantum effects appear in all length and time scales. In particular, dark matter is at larger space-time sheets and hence almost invisible.

3. An even more weirder looks the idea that Planck constant could have a gigantic value in astrophysical length scales being of order of magnitude of product of masses using Planck mass as a unit for $\hbar = c = 1$. This would mean that gravitation at space-time sheets of astrophysical size would have super quantal character! But even the gigantic value of Planck constant might be understood in TGD framework.

### Beraha numbers and spectrum of Planck constant

The infinite-dimensional Clifford algebra of the configuration space ("the world of classical worlds") gamma matrices defines so called von Neumann algebra with a hierarchy of type $II_1$ sub-factors. So called Beraha numbers

$$B_n = 4cos^2(\frac{\pi}{n}) , \quad n \geq 3 \tag{7.2.15}$$

relate very closely to these factors as also to braid groups and quantum groups. Roughly, $B_n$ corresponds to the quantum dimension $d$ of Clifford algebra of 2-component spinors. There is also a continuum of dimensions $D \geq 4$ for the dimensions of sub-factors of type $II_1$. Obviously, the dimensions behave like energy spectrum of a quantum mechanical systems. That $D = 4$ is the limiting value of bound state dimensions suggests strongly a connection with the fact that the infinities of quantum field theory appear for $D \geq 4$.

The first attempts to understand large values of Planck constant led to a formula for the dependence of Planck constant on $B_n$, which turned out to be badly wrong. The improved understanding of Jones inclusions and their role in TGD however led eventually to an extremely simple formula for the Planck constant, as a matter for separate Planck constants associated with $M^4$ *resp.* $CP_2$ degrees of freedom appearing as scaling factors of $CP_2$ *resp.* $M^4$ metric. This theory is summarized in [A9] and in the introduction and will be briefly summarized below.

### Jones inclusions and quantization of Planck constants

Quantum TGD emerges from infinite-dimensional Clifford algebra defined as infinite power of 8-dimensional Clifford algebra $C(8)$ generalized to a local algebra by constructing power series of quantum octonionic variable having the elements of this Clifford algebra as coefficients. The eigenstates for the commuting hermitian coordinates assignable to this octonionic variable have $M^8$ as spectrum and extremely general arguments imply both classical and quantum TGD. The construction works only for $D = 8$ (by non-associativity of the octonionic units) since for other dimensions the local field defined by algebra could not be distinguished from algebra itself.

Perhaps the most important outcome is a general master formula for S-matrix with interactions described as a deformation of ordinary tensor product to Connes tensor products and new view theory of quantum measurement. Further outcomes are prediction the spectra of the quantized values of $M^4$ and $CP_2$ Planck constants as characterizers of Jones inclusions associated with quantum phases $q = exp(i\pi/n)$.

*1. Some background*

It has been for few years clear that TGD could emerge from the mere infinite-dimensionality of the Clifford algebra of infinite-dimensional "world of classical worlds" and from number theoretical vision in which classical number fields play a key role and determine imbedding space and space-time dimensions. This would fix completely the "world of classical worlds".

Infinite-dimensional Clifford algebra is a standard representation for von Neumann algebra known as a hyper-finite factor of type $II_1$. In TGD framework the infinite tensor power of C(8), Clifford algebra of 8-D space would be the natural representation of this algebra.

*2. How to localize infinite-dimensional Clifford algebra?*

The basic new idea is to make this algebra *local*: local Clifford algebra as a generalization of gamma field of string models.

1. Represent Minkowski coordinate of $M^d$ as linear combination of gamma matrices of D-dimensional space. This is the first guess. One fascinating finding is that this notion can be quantized and classical $M^d$ is genuine quantum $M^d$ with coordinate values eigenvalues of quantal commuting Hermitian operators built from matrix elements. Euclidian space is not obtained in this manner. Minkowski signature is something quantal and the standard quantum group $Gl_(2,q)(C)$ with (non-Hermitian matrix elements) gives $M^4$.
2. Form power series of the $M^d$ coordinate represented as linear combination of gamma matrices with coefficients in corresponding infinite-D Clifford algebra. You would get tensor product of two algebra.
3. There is however a problem: one cannot distinguish the tensor product from the original infinite-D Clifford algebra. $D = 8$ is however an exception! You can replace gammas in the expansion of $M^8$ coordinate by hyper-octonionic units which are non-associative (or octonionic units in quantum complexified-octonionic case). Now you cannot anymore absorb the tensor factor to the Clifford algebra and you get genuine $M^8$-localized factor of type $II_1$. Everything is determined by infinite-dimensional gamma matrix fields analogous to conformal super fields with z replaced by hyperoctonion.
4. Octonionic non-associativity actually reproduces whole classical and quantum TGD: space-time surface must be associative sub-manifolds hence hyper-quaternionic surfaces of $M^8$. Representability as surfaces in $M^4 \times CP_2$ follows naturally, the notion of configuration space of 3-surfaces, etc....

*3. Connes tensor product for free fields as a universal definition of interaction quantum field theory*

This picture has profound implications. Consider first the construction of S-matrix.

1. A non-perturbative construction of S-matrix emerges. The deep principle is simple. The canonical outer automorphism for von Neumann algebras defines a natural candidate unitary transformation giving rise to propagator. This outer automorphism is trivial for $II_1$ factors meaning that all lines appearing in Feynman diagrams must be on mass shell states satisfying Super Virasoro conditions. You can allow all possible diagrams: all on mass shell loop corrections vanish by unitarity and what remains are diagrams with single N-vertex.
2. At 2-surface representing N-vertex space-time sheets representing generalized Bohr orbits of incoming and outgoing particles meet. This vertex involves von Neumann trace (finite!) of localized gamma matrices expressible in terms of fermionic oscillator operators and defining free fields satisfying Super Virasoro conditions.
3. For free fields ordinary tensor product would not give interacting theory. What makes S-matrix non-trivial is that *Connes tensor product* is used instead of the ordinary one. This tensor product is a universal description for interactions and we can forget perturbation theory! Interactions result as a deformation of tensor product. Unitarity of resulting S-matrix is unproven but I dare believe that it holds true.
4. The subfactor $\mathcal{N}$ defining the Connes tensor product has interpretation in terms of the interaction between experimenter and measured system and each interaction type defines its own Connes tensor product. Basically $\mathcal{N}$ represents the limitations of the experimenter. For instance, IR and UV cutoffs could be seen as primitive manners to describe what $\mathcal{N}$ describes much more elegantly. At the limit when $\mathcal{N}$ contains only single element, theory would become free field theory but this is ideal situation never achievable.

*4. The quantization of Planck constant and ADE hierarchies*

The quantization of Planck constant has been the basic them of TGD for more than one and half years and leads also the understanding of ADE correspondences (index $\beta \leq 4$ and $\beta = 4$) from the point of view of Jones inclusions.

1. The new view allows to understand how and why Planck constant is quantized and gives an amazingly simple formula for the separate Planck constants assignable to $M^4$ and $CP_2$ and appearing as scaling constants of their metrics. This in terms of a mild generalizations of standard Jones inclusions. The emergence of imbedding space means only that the scaling of these metrics have spectrum: no landscape.

2. In ordinary phase Planck constants $\hbar(M^4)$ and $\hbar(CP_2)$ are same and have their standard values. Large Planck constant phases correspond to situations in which a transition to a phase in which quantum groups occurs. These situations correspond to standard Jones inclusions in which Clifford algebra is replaced with a sub-algebra of its G-invariant elements. G is product $G_a \times G_b$ of subgroups of $SL(2,C)$ and $SU(2)_L \times \times U(1)$ which also acts as a subgroup of SU(3). Space-time sheets are $n(G_b)$-fold coverings of $M^4$ and $n(G_a)$-fold coverings of $CP_2$ generalizing the picture which has emerged already. An elementary study of these coverings fixes the values of scaling factors of $M^4$ and $CP_2$ Planck constants to orders of the maximal cyclic sub-groups. Mass spectrum is invariant under these scalings. The values of Planck constants are $\hbar(M^4) = n_a\hbar_0$ and $\hbar(CP_2) = n_b\hbar_0$ and scaling factor of $M^4$ covariant metric is $n_b$ and that of $CP_2$ metric $n_a$. In Kähler action only the ratio $n_a/n_b$ occurs and the Planck constant $\hbar_{eff}$ occurring in Schrödinger equation is by quantum classical correspondence $\hbar_{eff}/\hbar_0 = n_a/n_b$.

3. This predicts automatically arbitrarily large and also small values of Planck constant depending in the value of the ratio $n_a/n_b$ and assigns the preferred values of Planck constant to quantum phases $q = exp(i\pi/n_i)$, $i = a, b$ expressible in terms of iterated square roots of rationals: these correspond to polygons obtainable by compass and ruler construction. In particular, experimentally favored values of $\hbar$ in living matter correspond to these special values of Planck constant. This model reproduces also the other aspects of the general vision. The subgroups of $SL(2,C)$ in turn can give rise to re-scaling of $SU(3)$ Planck constant. The most general situation can be described in terms of Jones inclusions for fixed point subalgebras of number theoretic Clifford algebras defined by $G_a \times G_b \subset SL(2,C) \times SU(2)$.

4. These inclusions (apart from those for which $G_a$ contains infinite number of elements) are represented by ADE or extended ADE diagrams depending on the value of index. The group algebras of these groups give rise to additional degrees of freedom which make possible to construct the multiplets of the corresponding gauge groups. For $\beta \leq 4$ the gauge groups $A_n$, $D_2n$, $E_6$, $E_8$ are possible so that TGD seems to be able to mimick these gauge theories. For $\beta = 4$ all ADE Kac Moody groups are possible and again mimicry becomes possible: TGD would be kind of universal physics emulator but it would be anyonic dark matter which would perform this emulation.

**Bohr quantization of planetary orbits and prediction for Planck constant**

The predictions of the generalization of the p-adic length scale hypothesis are consistent with the TGD based model for the Bohr quantization of planetary orbits and some new non-trivial predictions follow.

*1. Generalization of the p-adic length scale hypothesis*

The evolution in phase resolution in p-adic degrees of freedom corresponds to emergence of algebraic extensions allowing increasing variety of phases $exp(i\pi/n)$ expressible p-adically. This evolution can be assigned to the emergence of increasingly complex quantum phases and the increase of Planck constant.

One expects that quantum phases $q = exp(i\pi/n)$ which are expressible using only square roots of rationals are number theoretically very special since they correspond to algebraic extensions of p-adic numbers involving only square roots which should emerge first and therefore systems involving these values of $q$ should be especially abundant in Nature.

These polygons are obtained by ruler and compass construction and Gauss showed that these polygons, which could be called Fermat polygons, have $n_F = 2^k \prod_s F_{n_s}$ sides/vertices: all Fermat primes $F_{n_s}$ in this expression must be different. The analog of the p-adic length scale hypothesis emerges since larger Fermat primes are near a power of 2. The known Fermat primes $F_n = 2^{2^n} + 1$ correspond to $n = 0, 1, 2, 3, 4$ with $F_0 = 3$, $F_1 = 5$, $F_2 = 17$, $F_3 = 257$, $F_4 = 65537$. It is not known whether there are higher Fermat primes. $n = 3, 5, 15$-multiples of p-adic length scales clearly distinguishable from them are also predicted and this prediction is testable in living matter. I have already earlier considered the possibility that Fermat polygons could be of special importance for cognition and for biological information processing [H8].

This condition could be interpreted as a kind of resonance condition guaranteing that scaled up sizes for space-time sheets have sizes given by p-adic length scales. The numbers $n_F$ could take the same role in the evolution of Planck constants assignable with the phase resolution as Mersenne primes have in the evolution assignable to the p-adic length scale resolution.

*2. Do the values of gravitational Planck constant correspond to polygons obtained by ruler and compass construction?*

Since the macroscopic quantum phases with minimum dimension of algebraic extension should be especially abundant in the universe, the natural guess is that the values of the gravitational Planck constant correspond to $n_F$-multiples of ordinary Planck constant.

1. The model can explain the enormous values of gravitational Planck constant $\hbar_{gr}/\hbar_0 =\simeq GMm/v_0) = n_a/n_b$. The favored values of this parameter should correspond to $n_{F_a}/n_{F_b}$ so that the mass ratios $m_1/m_2 = n_{F_{a,1}} n_{F_{b,2}}/n_{F_{b,1}} n_{F_{a,2}}$ for planetary masses should be preferred. The general prediction $GMm/v_0 = n_a/n_b$ is of course not testable.

2. Nottale [92] has suggested that also the harmonics and subharmonics of $\lambda$ are possible and in fact required by the model for planetary Bohr orbits (in TGD framework this is not absolutely necessary). The prediction is that favored values of $n$ should be of form $n_F = 2^k \prod F_i$ such that $F_i$ appears at most once. In Nottale's model for planetary orbits as Bohr orbits in solar system $n = 5$ harmonics appear and are consistent with either $n_{F,a} \rightarrow F_1 n_{F_a}$ or with $n_{F,b} \rightarrow n_{F_b}/F_1$ if possible.

The prediction for the ratios of planetary masses can be tested. In the table below are the experimental mass ratios $r_{exp} = m(pl)/m(E)$, the best choice of $r_R = [n_{F,a}/n_{F,b}] * X$, $X$ common factor for all planets, and the ratios $r_{pred}/r_{exp} = n_{F,a}(planet) n_{F,b}(Earth)/n_{F,a}(Earth) n_{F,b}(planet)$. The deviations are below 10 per cent.

| | | | | | |
|---|---|---|---|---|---|
| $planet$ | $Me$ | $V$ | $E$ | $M$ | $J$ |
| $y$ | $(2^9, 5)$ | $(2^{11}, 17)$ | $(2^9, 5, 17)$ | $(2^{16}, 5)/(17)$ | $(2^{18}, 3, 17)$ |
| $y/x$ | .98 | .98 | 1.00 | 1.01 | .97 |
| $planet$ | $S$ | $U$ | $N$ | $P$ | |
| $y$ | $(2^{22}, 3, 5)/(17)$ | $(2^{21}, 5)/(17)$ | $(2^{17}, 5, 17)/(3, 5)$ | $(1, 5, 17)$ | |
| $y/x$ | .98 | .98 | 0.99 | .98 | |

Table 1. The table compares the ratios $x = m(pl)/(m(E)$ of planetary mass to the mass of Earth to prediction for these ratios in terms of integers $n_F$ associated with Fermat polygons. $y$ gives the best fit for the allowed factors of the known part $y$ of the rational $n_{F,a}/n_{F,b} = yX$ characterizing planet, and the ratios $y/x$. Errors are at most 3 per cent.

A stronger prediction comes from the requirement that $GMm/v_0$ equals to $n = n_{F_a}/n_{F,b}$ $n_F = 2^k \prod_k F_{n_k}$, where $F_i = 2^{2^i} + 1$, $i = 0, 1, 2, 3, 4$ is Fibonacci prime. The fit using solar mass and Earth mass gives $n_F = 2^{254} \times 5 \times 17$ for $1/v_0 = 2044$, which within the experimental accuracy equals to the value $2^{11} = 2048$ whose powers appear as scaling factors of Planck constant in the model for living matter [M3]. For $v_0 = 4.6 \times 10^{-4}$ reported by Nottale the prediction is by a factor 16/17.01 too small (6 per cent discrepancy).

A possible solution of the discrepancy is that the empirical estimate for the factor $GMm/v_0$ is too large since $m$ contains also the the visible mass not actually contributing to the gravitational force between dark matter objects whereas $M$ is known correctly. The assumption that the dark mass is a fraction $1/(1+\epsilon)$ of the total mass for Earth gives

$$1+\epsilon = \frac{17}{16} \quad (7.2.16)$$

in an excellent approximation. This gives for the fraction of the visible matter the estimate $\epsilon = 1/16 \simeq 6$ per cent. The estimate for the fraction of visible matter in cosmos is about 4 per cent so that estimate is reasonable and would mean that most of planetary and solar mass would be also dark.

That $v_0(eff) = v_0/(1-\epsilon) \simeq 4.6\times 10^{-4}$ equals with $v_0(eff) = 1/(2^7\times F_2) = 4.5956\times 10^{-4}$ within the experimental accuracy suggests a number theoretical explanation for the visible-to-dark fraction.

*3. Can one really identify gravitational and inertial Planck constants?*

The original unconsciously performed identification of the gravitational and inertial Planck constants leads to some confusing conclusions but it seems that the new view about the quantization of Planck constants resolves these problems and allows to see $\hbar_{gr}$ as a special case of $\hbar_I$.

1. $\hbar_{gr}$ is proportional to the product of masses of interacting systems and not a universal constant like $\hbar$. One can however express the gravitational Bohr conditions as a quantization of circulation $\oint v\cdot dl = n(GM/v_0)\hbar_0$ so that the dependence on the planet mass disappears as required by Equivalence Principle. This suggests that gravitational Bohr rules relate to velocity rather than inertial momentum as is indeed natural. The quantization of circulation is consistent with the basic prediction that space-time surfaces are analogous to Bohr orbits.

2. $\hbar_{gr}$ seems to characterize a relationship between planet and central mass and quite generally between two systems with the property that smaller system is topologically condensed at the space-time sheet of the larger system. Thus it would seem that $\hbar_{gr}$ is not a universal constant and cannot correspond to a special value of ordinary Planck constant. Certainly this would be the case if $\hbar_I$ is quantized as $\lambda^k$-multiplet of ordinary Planck constant with $\lambda \simeq 2^{11}$.

The recent view about the quantization of Planck constant in terms of coverings of $M^4$ seems to resolve these problems.

1. The integer quantization of Planck constants is consistent with the huge values of gravitational Planck constant within experimental resolution and the killer test for $\hbar = \hbar_{gr}$ emerges if one takes seriously the stronger prediction $\hbar_{gr} = n_{F,a}/n_{F,b}$.

2. One can also regard $\hbar_{gr}$ as ordinary Planck constant $\hbar_{eff}$ associated with the space-time sheet along which the masses interact provided each pair $(M, m_i)$ of masses is characterized by its own sheets. These sheets could correspond to flux tube like structures carrying the gravitational flux of dark matter. If these sheets corresponds to $n_{F_a}$-fold covering of $M^4$, one can understand $\hbar_{gr}$ as a particular instance of the $\hbar_{eff}$.

*4. Gravitational Planck constant and $CP_2$ size*

The large size of $\hbar_{gr}$ can be interpreted in terms of larger size of $\hbar(CP_2)$ and with $G_a$ covering of $CP_2$ by huge number $n_a$. Its huge value implies that also the von Neumann inclusions associated with $M^4$ degrees of freedom meaning that dark matter cosmology has quantal lattice like structure with lattice cell given by $H_a/G$, $H_a$ the $a = constant$ hyperboloid of $M^4_+$ and $G$ subgroup of SL(2,C). The quantization of cosmic redshifts provides support for this prediction.

There is however a heavy objection against this identification. $\hbar_{gr} = n_a/n_b$ identification implies the scaling $R \rightarrow (GMm/v_0)R$ of $CP_2$ radius so that immense values of $CP_2$ radius are possible in the sectors of the imbedding space corresponding to the dark matter. In the case of Sun-Earth system the radius would be of order $10^{20}$ ly! This would mean completely new view about the relationship between $CP_2$ and $M^4$ and space-time would look essentially like $M^8$ in large $\hbar$ sector of imbedding space in astrophysical and even cosmological length scales. This of course looks completely non-sensible. Note however that the scaling does not affect elementary particle mass spectrum in any manner. Also the model for planetary system in terms of vacuum extremals can be still be used and Newton's laws hold in good approximation. And most importantly, it is dark matter space-time sheets for which $CP_2$ size is huge.

### Gravitational Schrödinger equation as a means of avoiding gravitational collapse

Schrödinger equation provided a solution to the infrared catastrophe of the classical model of atom: the classical prediction was that electron would radiate its energy as brehmstrahlung and would be captured by the nucleus. The gravitational variant of this process would be the capture of the planet by a black hole, and more generally, a collapse of the star to a black hole. Gravitational Schrödinger equation could obviously prevent the catastrophe.

For $1/r$ gravitation potential the Bohr radius is given by $a_{gr} = GM/v_0^2 = r_S/2v_0^2$, where $r_S = 2GM$ is the Schwartchild radius of the mass creating the gravitational potential: obviously Bohr radius is much larger than the Schwartschild radius. That the gravitational Bohr radius does not depend on $m$ conforms with Equivalence Principle, and the proportionality $\hbar_{gr} \propto Mm$ can be deduced from it. Gravitational Bohr radius is by a factor $1/2v_0^2$ larger than black hole radius so that black hole can swallow the piece of matter with a considerable rate only if it is in the ground state and also in this state the rate is proportional to the black hole volume to the volume defined by the black hole radius given by $2^3v_0^6 \sim 10^{-20}$.

The $\hbar_{gr} \rightarrow \infty$ limit for $1/r$ gravitational potential means that the exponential factor $exp(-r/a_0)$ of the wave function becomes constant: on the other hand, also Schwartshild and Bohr radii become infinite at this limit. The gravitational Compton length associated with mass $m$ does not depend on $m$ and is given by $GM/v_0$ and the time $T = E_{gr}/\hbar_{gr}$ defined by the gravitational binding energy is twice the time taken to travel a distance defined by the radius of the orbit with velocity $v_0$ which suggests that signals travelling with a maximal velocity $v_0$ are involved with the quantum dynamics.

In the case of planetary system the proportionality $\hbar_{gr} \propto mM$ creates problems of principle since the influence of the other planets is not taken account. One might argue that the generalization of the formula should be such that $M$ is determined by the gravitational field experienced by mass $m$ and thus contains also the effect of other planets. The problem is that this field depends on the position of $m$ which would mean that $\hbar_{gr}$ itself would become kind of field quantity.

### Does the transition to non-perturbative phase correspond to a change in the value of $\hbar$?

Nature is populated by systems for which perturbative quantum theory does not work. Examples are atoms with $Z_1Z_2e^2/4\pi\hbar > 1$ for which the binding energy becomes larger than rest mass, non-perturbative QCD resulting for $Q_{s,1}Q_{s,2}g_s^2/4\pi\hbar > 1$, and gravitational systems satisfying $GM_1M_2/4\pi\hbar > 1$. Quite generally, the condition guaranteeing troubles is of the form $Q_1Q_2g^2/4\pi\hbar > 1$. There is no general mathematical approach for solving the quantum physics of these systems but it is believed that a phase transition to a new phase of some kind occurs.

The gravitational Schrödinger equation forces to ask whether Nature herself takes care of the problem so that this phase transition would involve a change of the value of the Planck constant to guarantee that the perturbative approach works. The values of $\hbar$ would vary in a stepwise manner from $\hbar(\infty)$ to $\hbar(3) = \hbar(\infty)/4$. The non-perturbative phase transition would correspond to transition to the value of

$$\frac{\hbar}{\hbar_0} \rightarrow \left[\frac{Q_1Q_2g^2}{v}\right] \tag{7.2.17}$$

where $[x]$ is the integer nearest to $x$, inducing

$$\frac{Q_1Q_2g^2}{4\pi\hbar} \rightarrow \frac{v}{4\pi} \ . \tag{7.2.18}$$

The simplest (and of course ad hoc) assumption making sense in TGD Universe is that $v$ is a harmonic or subharmonic of $v_0$ appearing in the gravitational Schrödinger equation. For instance, for the Kepler problem the spectrum of binding energies would be universal (independent of the values of charges) and given by $E_n = v^2m/2n^2$ with $v$ playing the role of small coupling. Bohr radius would be $g^2Q_2/v^2$ for $Q_2 \gg Q_1$.

This provides a new insight to the problems encountered in quantizing gravity. QED started from the model of atom solving the infrared catastrophe. In quantum gravity theories one has started directly from the quantum field theory level and the recent decline of the M-theory shows that we are still practically where we started. If the gravitational Schrödinger equation indeed allows quantum interpretation, one could be more modest and start from the solution of the gravitational IR catastrophe by assuming a dynamical spectrum of $\hbar$ determined by Beraha numbers. The implications would be profound: the whole program of quantum gravity would have been misled as far as the quantization of systems with $GM_1M_2/\hbar > 1$ is considered. In practice, these systems are the most interesting ones and the prejudice that their quantization is a mere academic exercise would have been completely wrong.

An alternative formulation for the occurrence of a transition increasing the value of $\hbar$ could rely on the requirement that classical bound states have reasonable quantum counterparts. In the gravitational case one would have $r_n = n^2\hbar_{gr}^2/GM_1^2M$, for $M_1 \ll M$, which is extremely small distance for $\hbar_{gr} = \hbar$ and reasonable values of $n$. Hence, either $n$ is so large that the system is classical or $\hbar_{gr}/\hbar$ is very large. Equivalence Principle requires the independence of $r_n$ on $M_1$, which gives $\hbar = kGM_1M_2$ giving $r_n = n^2kGM$. The requirement that the radius is above Schwartshild radius gives $k \geq 2$. In the case of Dirac equation the solutions cease to exist for $Z \geq 137$ and which suggests that $\hbar$ is large for hypothetical atoms having $Z \geq 137$.

### 7.2.8 How do the magnetic flux tube structures and quantum gravitational bound states relate?

In the case of stars in galactic halo the appearance of the parameter $v_0$ characterizing cosmic strings as orbital rotation velocity can be understood classically. That $v_0$ appears also in the gravitational dynamics of planetary orbits could relate to the dark matter at magnetic flux tubes. The argument explaining the harmonics and sub-harmonics of $v_0$ in terms of properties of cosmic strings and magnetic flux tubes identifiable as their descendants strengthens this expectation.

#### The notion of magnetic body

In TGD inspired theory of consciousness the notion of magnetic body plays a key role: magnetic body is the ultimate intentional agent, experiencer, and performer of bio-control and can have astrophysical size: this does not sound so counter-intuitive if one takes seriously the idea that cognition has p-adic space-time sheets as space-time correlates and that rational points are common to real and p-adic number fields. The point is that infinitesimal in p-adic topology corresponds to infinite in real sense so that cognitive and intentional structures would have literally infinite size.

The magnetic flux tubes carrying various supra phases can be interpreted as special instance of dark energy and dark matter. This suggests a correlation between gravitational self-organization and quantum phases at the magnetic flux tubes and that the gravitational Schrödinger equation somehow relates to the ordinary Schrödinger equation satisfied by the macroscopic quantum phases at magnetic flux tubes. Interestingly, the transition to large Planck constant phase should occur when the masses of interacting is above Planck mass since gravitational self-interaction energy is $V \sim GM^2/R$. For the density of water about $10^3$ kg/m$^3$ the volume carrying a Planck mass correspond to a cube with side $2.8 \times 10^{-4}$ meters. This corresponds to a volume of a large neuron, which suggests that this phase transition might play an important role in neuronal dynamics.

#### Could gravitational Schrödinger equation relate to a quantum control at magnetic flux tubes?

An infinite self hierarchy is the basic prediction of TGD inspired theory of consciousness ("everything is conscious and consciousness can be only lost"). Topological quantization allows to assign to any material system a field body as the topologically quantized field pattern created by the system [N4, K1]. This field body can have an astrophysical size and would utilize the material body as a sensory receptor and motor instrument.

Magnetic flux tube and flux wall structures are natural candidates for the field bodies. Various empirical inputs have led to the hypothesis that the magnetic flux tube structures define a hierarchy of magnetic bodies, and that even Earth and larger astrophysical systems possess magnetic body which makes them conscious self-organizing living systems. In particular, life at Earth would have developed first as a self-organization of the super-conducting dark matter at magnetic flux tubes [N4].

For instance, EEG frequencies corresponds to wavelengths of order Earth size scale and the strange findings of Libet about time delays of conscious experience [35, 36] find an elegant explanation in terms of time taken for signals propagate from brain to the magnetic body [K1]. Cyclotron frequencies, various cavity frequencies, and the frequencies associated with various p-adic frequency scales are in a key role in the model of bio-control performed by the magnetic body. The cyclotron frequency scale is given by $f = eB/m$ and rather low as are also cavity frequencies such as Schumann frequencies: the lowest Schumann frequency is in a good approximation given by $f = 1/2\pi R$ for Earth and equals to 7.8 Hz.

*1. Quantum time scales as "bio-rhythms" in solar system?*

To get some idea about the possible connection of the quantum control possibly performed by the dark matter with gravitational Schrödinger equation, it is useful to look for the values of the periods defined by the gravitational binding energies of test particles in the fields of Sun and Earth and look whether they correspond to some natural time scales. For instance, the period $T = 2GM_S n^2/v_0^3$ defined by the energy of $n^{th}$ planetary orbit depends only on the mass of Sun and defines thus an ideal candidate for a universal "bio-rhytm".

For Sun black hole radius is about 2.9 km. The period defined by the binding energy of lowest state in the gravitational field of Sun is given $T_S = 2GM_S/v_0^3$ and equals to 23.979 hours for $v_0/c = 4.8233 \times 10^{-4}$. Within experimental limits for $v_0/c$ the prediction is consistent with 24 hours! The value of $v_0$ corresponding to exactly 24 hours would be $v_0 = 144.6578$ km/s (as a matter fact, the rotational period of Earth is 23.9345 hours). As if as the frequency defined by the lowest energy state would define a "biological" clock at Earth! Mars is now a strong candidate for a seat of life and the day in Mars lasts 24hr 37m 23s! $n = 1$ and $n = 2$ are orbitals are not realized in solar system as planets but there is evidence for the $n = 1$ orbital as being realized as a peak in the density of IR-dust [92]. One can of course consider the possibility that these levels are populated by small dark matter planets with matter at larger space-time sheets. Bet as it may, the result supports the notion of quantum gravitational entrainment in the solar system.

The slower rhythms would become as $n^2$ sub-harmonics of this time scale. Earth itself corresponds to $n = 5$ state and to a rhythm of .96 hours: perhaps the choice of 1 hour to serve as a fundamental time unit is not merely accidental. The magnetic field with a typical ionic cyclotron frequency around 24 hours would be very weak: for 10 Hz cyclotron frequency in Earth's magnetic field the field strength would about $10^{-11}$ T. However, $T = 24$ hours corresponds with 6 per cent accuracy to the p-adic time scale $T(k = 280) = 2^{13}T(2, 127)$, where $T(2, 127)$ corresponds to the secondary p-adic time scale of .1 s associated with the Mersenne prime $M_{127} = 2^{127} - 1$ characterizing electron and defining a fundamental bio-rhytm and the duration of memetic codon [11].

Comorosan effect [33, 34, J5] demonstrates rather peculiar looking facts about the interaction of organic molecules with visible laser light at wavelength $\lambda = 546$ $nm$. As a result of irradiation molecules seem to undergo a transition $S \rightarrow S^*$. $S^*$ state has anomalously long lifetime and stability in solution. $S \rightarrow S^*$ transition has been detected through the interaction of $S^*$ molecules with different biological macromolecules, like enzymes and cellular receptors. Later Comorosan found that the effect occurs also in non-living matter. The basic time scale is $\tau = 5$ seconds. p-Adic length scale hypothesis does not explain $\tau$, and it does not correspond to any obvious astrophysical time scale and has remained a mystery.

The idea about astro-quantal dark matter as a fundamental bio-controller inspires the guess that $\tau$ could correspond to some Bohr radius $R$ for a solar system via the correspondence $\tau = R/c$. As observed by Nottale, $n = 1$ orbit for $v_0 \rightarrow 3v_0$ corresponds in a good approximation to the solar radius and to $\tau = 2.18$ seconds. For $v_0 \rightarrow 2v_0$ $n = 1$ orbit corresponds to $\tau = AU/(4 \times 25) = 4.992$ seconds: here $R = AU$ is the astronomical unit equal to the average distance of Earth from Sun. The deviation from $\tau_C$ is only one per cent and of the same order of magnitude as the variation of the radius for the orbit due to orbital eccentricity $(a - b)/a = .0167$ [29].

*2. Earth-Moon system*

For Earth serving as the central mass the Bohr radius is about 18.7 km, much smaller than Earth radius so that Moon would correspond to $n = 147.47$ for $v_0$ and $n = 1.02$ for the sub-harmonic $v_0/12$ of $v_0$. For an afficionado of cosmic jokes or a numerologist the presence of the number of months in this formula might be of some interest. Those knowing that the Mayan calendar had 11 months and that Moon is receding from Earth might rush to check whether a transition from $v/11$ to $v/12$ state has occurred after the Mayan culture ceased to exist: the increase of the orbital radius by about 3 per cent would be required! Returning to a more serious mode, an interesting question is whether light satellites of Earth consisting of dark matter at larger space-time sheets could be present. For instance, in [N4] I have discussed the possibility that the larger space-time sheets of Earth could carry some kind of intelligent life crucial for the bio-control in the Earth's length scale.

The period corresponding to the lowest energy state is from the ratio of the masses of Earth and Sun given by $M_E/M_S = (5.974/1.989) \times 10^{-6}$ given by $T_E = (M_E/M_S) \times T_S = .2595$ s. The corresponding frequency $f_E = 3.8535$ Hz frequency is at the lower end of the theta band in EEG and is by 10 per cent higher than the p-adic frequency $f(251) = 3.5355$ Hz associated with the p-adic prime $p \simeq 2^k$, $k = 251$. The corresponding wavelength is 2.02 times Earth's circumference. Note that the cyclotron frequencies of Nn, Fe, Co, Ni, and Cu are $5.5, 5.0, 5.2, 4.8$ Hz in the magnetic field of $.5 \times 10^{-4}$ Tesla, which is the nominal value of the Earth's magnetic field. In [M4] I have proposed that the cyclotron frequencies of Fe and Co could define biological rhythms important for brain functioning. For $v_0/12$ associated with Moon orbit the period would be 7.47 s: I do not know whether this corresponds to some bio-rhytm.

It is better to leave for the reader to decide whether these findings support the idea that the super conducting cold dark matter at the magnetic flux tubes could perform bio-control and whether the gravitational quantum states and ordinary quantum states associated with the magnetic flux tubes couple to each other and are synchronized.

### 7.2.9 p-Adic length scale hypothesis and $v_0 \rightarrow v_0/5$ transition at inner-outer border for planetary system

$v_0 \rightarrow v_0/5$ transition would allow to interpret the orbits of outer planets as $n \geq 1$ orbits. The obvious question is whether inner to outer zone as $v_0 \rightarrow v_0/5$ transition could be interpreted in terms of the p-adic length scale hierarchy.

1. The most important p-adic length scale are given by primary p-adic length scales $L(k) = 2^{(k-151)/2} \times 10$ nm and secondary p-adic length scales $L(2,k) = 2^{k-151} \times 10$ nm, $k$ prime.

2. The p-adic scale $L(2,139) = 114$ Mkm is slightly above the orbital radius 109.4 Mkm of Venus. The p-adic length scale $L(2,137) \simeq 28.5$ Mkm is roughly one half of Mercury's orbital radius 57.9 Mkm. Thus strong form of p-adic length scale hypothesis could explain why the transition $v_0 \rightarrow v_0/5$ occurs in the region between Venus and Earth ($n = 5$ orbit for $v_0$ layer and $n = 1$ orbit for $v_0/5$ layer).

3. Interestingly, the *primary* p-adic length scales $L(137)$ and $L(139)$ correspond to fundamental atomic length scales which suggests that solar system be seen as a fractally scaled up "secondary" version of atomic system.

4. Planetary radii have been fitted also using Titius-Bode law predicting $r(n) = r_0 + r_1 \times 2^n$. Hence on can ask whether planets are in one-one correspondence with primary and secondary p-adic length scales $L(k)$. For the orbital radii $58, 110, 150, 228$ Mkm of Mercury, Venus, Earth, and Mars indeed correspond approximately to k= $276, 278, 279, 281$: note the special position of Earth with respect to its predecessor. For Jupiter, Saturn, Uranus, Neptune, and Pluto the radii are 52,95,191,301,395 Mkm and would correspond to p-adic length scales $L(280 + 2n))$, $n = 0, ..., 3$. Obviously the transition $v_0 \rightarrow v_0/5$ could occur in order to make the planet–p-adic length scale one-one correspondence possible.

5. It is interesting to look whether the p-adic length scale hierarchy applies also to the solar structure. In a good approximation solar radius .696 Mkm corresponds to $L(270)$, the lower radius .496 Mkm of the convective zone corresponds to $L(269)$, and the lower radius .174 Mkm of the radiative zone (radius of the solar core) corresponds to $L(266)$. This encourages the hypothesis that solar core has an onion like sub-structure corresponding to various p-adic length scales. In particular, $L(2,127)$ ($L(127)$ corresponds to electron) would correspond to 28 Mm. The core is believed to contain a structure with radius of about 10 km: this would correspond to $L(231)$. This picture would suggest universality of star structure in the sense that stars would differ basically by the number of the onion like shells having standard sizes.

Quite generally, in TGD Universe the formation of join along boundaries bonds is the space-time correlate for the formation of bound states. This encourages to think that ($Z^0$) magnetic flux tubes are involved with the formation of gravitational bound states and that for $v_0 \rightarrow v_0/k$ corresponds either to a splitting of a flux tube resembling a disk with a whole to $k$ pieces, or to the scaling down $B \rightarrow B/k^2$ so that the magnetic energy for the flux tube thickened and stretched by the same factor $k^2$ would not change.

### 7.2.10 Further evidence for dark matter

The notion of many-sheeted space-time has been continually receiving qualitative support from various anomalies. In the following two latest anomalies are summarized briefly.

#### First dark matter galaxy found

The propose model for dark matter suggests an existence of dark matter planets and even dark matter galaxies. Therefore the news about finding of the first dark galaxy in New Scientist [85] came as a pleasant surprise. The galaxy is located at a distance of $10^7$ light years. It contains 1 per cent hydrogen gas and and 99 per cent dark matter and is identified by 21 cm hydrogen line: hence the name VIRGOH21. The amount of dark matter counts as $10^8$ average stars.

#### Anomalous chemical compositions at the surface of Sun as evidence for dark matter

Physics in Action, February 2005 contained the popular article "Chemical Controversy at the Solar Surface" by J. Bahcall in Physics in Action [86]. The article describes the problems created by results reported in the article "The Solar Chemical Decomposition" by M. Asplund, N. Grevesse, J. Sauval [87]. The abundances of C, N, O, Ne, Ar at the solar surface are about 30-40 per cent less than predicted by the standard solar model. If these abundances are feeded into the standard solar model as input the predictions change in the range $.45R - .73R$ of distances from solar interior ($R$ is solar radius). In particular, sound velocity is predicted incorrectly. Interestingly, these abundances are consistent with the abundances in the gaseous medium in the neighborhood of our galaxy.

In TGD framework a possible solution of paradox comes from already old model of solar corona and solar magnetic field. Part of matter resides as dark matter at magnetic and $Z^0$ magnetic flux tubes of Sun (dark energy) and enters to the solar corona along these. That also gaseous medium in the neighborhood of our galaxy contains same abundances suggests that the formation of Sun has proceeded by a transformation of part of dark matter to a visible matter by leakage to space-time sheets visible to us. This is indeed what TGD inspired model for the formation of solar system based on quantal dark matter suggests.

#### Does Sun have a solid surface?

$n = 1$ Bohr orbit corresponds in a reasonable approximation to $L(276)/9 \simeq L(270)$ and thus to solar radius. This raises the question whether solar surface could contain spherical shell representing a topological condensate of dense matter around dark matter, kind of spherical preform of planet below the photosphere.

Recently new satellites have begun to provide information about what lurks beneath the photosphere. The pictures produced by Lockheed Martin's Trace Satellite and YOHKOH, TRACE and SOHO satellite programs are publicly available in the web. SERTS program for the spectral analysis suggest a new picture challenging the simple gas sphere picture [75]. The visual inspection of the pictures combined with spectral analysis has led Michael Moshina to suggests that Sun has a solid, conductive spherical surface layer consisting of calcium ferrite. The article of Moshina [75] provides impressive pictures, which in my humble non-specialist opinion support this view. Of course, I have not worked personally with the analysis of these pictures so that I do not have the competence to decide how compelling the conclusions of Moshina are. In any case, I think that his web article [75] deserves a summary.

Before SERTS people were familiar with hydrogen, helium, and calcium emissions from Sun. The careful analysis of SERTS spectrum however suggest the presence of a layer or layers containing ferrite and other heavy metals. Besides ferrite SERTS found silicon, magnesium, manganese, chromium, aluminum, and neon in solar emissions. Also elevated levels of sulphur and nickel were observed during more active cycles of Sun. In the gas sphere model these elements are expected to be present only in minor amounts. As many as 57 different types of emissions from 10 different kinds of elements had to be considered to construct a picture about the surface of the Sun.

Moshina has visually analyzed the pictures constructed from the surface of Sun using light at wave lengths corresponding to three lines of ferrite ions (171, 195, 284 Angstroms). On basis of his analysis he concludes that the spectrum originates from rigid and fixed surface structures, which can survive for days. A further analysis shows that these rigid structure rotate uniformly.

The existence of a rigid structure idealizable as spherical shell in the first approximation could by previous observation be interpreted as a spherical shell corresponding to $n = 1$ Bohr orbit of a planet not yet formed. This structure would already contain the germs of iron core and of crust containing Silicon, Ca and and other elements.

There is also another similar piece of evidence [88]. A new planet has been discovered orbiting around a star in a triple-star system in the constellation Cygnus. The planet is a so-called hot Jupiter but it orbits the parent star at distance of .05 AU, which much less that than allowed by current theories of planetary formation. Indeed, the so called migration theory predicts that the gravitational pull of the two stars should have stripped away the proto-planetary disk from the parent star. If an underlying dark matter structure serves as a condensation template for the visible matter, the planetary orbit is stabilized by Bohr quantization.

There is however a problem: ordinary iron and also ordinary iron topologically condensed at dark space-time sheets, becomes liquid at temperature 1811 K at atmospheric pressure. Using for the photospheric pressure $p_{ph}$, the ideal gas approximation $p_{ph} = n_{ph}T_{ph}$, the values of photospheric temperature $T_{ph} \sim 5800$ K and density $\rho_{ph} \sim 10^{-2}\rho_{atm}$, and idealizing photosphere as a plasma of hydrogen ions and atmosphere as a gas of $O_2$ molecules, one obtains $n_{ph} \sim .32 n_{atm}$ giving $p_{ph} \sim 6.4 p_{atm}$. This suggests that calcium ferrite cannot be solid at temperatures of order 5800 K prevailing in the photosphere (the material with highest known melting temperature is graphite with melting temperature of 3984 K at atmospheric pressure). Thus it would seem that dark calcium ferrite at the surface of the Sun cannot be just ordinary calcium ferrite at dark space-time sheets.

The alternative model of inherently dark atom developed in this chapter and applied also in [L2, N2] provides a possible solution of the problem. The transition energies of dark $N$-molecules are $N$-fold as compared to those of the ordinary molecules. Therefore $N$-molecules can be stable and also exist in solid phase at $N$ times higher temperatures than ordinary molecules. The $N$-photons emitted by dark $N$-molecules can decay to $N$ ordinary photons and produce the spectral signatures of the ordinary molecules. Therefore the solid surface of the Sun would consists of dark $N$-matter. Quite generally, the spectral lines of molecules detected in environments where they are not thermally stable would be the signature of $N$-molecules and could be used to test the proposed model.

### How to create dark matter in laboratory...

The creation of dark matter at laboratory is of course the crucial test. The hints for what to do come already from the findings of Tesla, which did not fit completely with Maxwell's electrodynamics (, which, using M-theory inspired jargon, had become "the only known classical theory of electromagnetism",) and were thus forgotten.

To transform visible matter to dark matter in laboratory one might try to generate conditions in which visible matter leaks to larger space-time sheets. What one could try is to generate pulsed current of electrons. For instance, current could flow to a circuit component acting as a charge reservoir. When the circuit is opened, and current cannot leave the charge reservoir, a situation analogous to a traffic jam occurs and some electrons might leak to larger space-time sheets via join along boundaries bonds generated in the process. Di-electric breakdown along larger space-time sheet would be in question. Recoil effects and zero point kinetic energy liberated as ionizing radiation would serve as a signature of the process. The production of dark matter might occur also in the usual di-electric breakdown and lead to the appearance of electrons in much larger volume after it partially re-enters original space-time sheets. The change of zero point kinetic energy would be liberated as radiation and would cause formation of plasma. Tesla detected dramatic effects of this kind in experiments utilizing sharp pulses.

#### ..or has it already been done?

In their article "Investigation of high voltage discharges in low pressure gases through large ceramic super-conducting electrodes", Modanese and Podkletnov [95] report a fascinating discovery suggesting that some new form of radiation is generated in the di-electric breakdown of a capacitor at low temperature and having super-conductor as a second electrode. This radiation induces oscillatory motion of test penduli but, and this is very strange, its intensity is not reduced with distance.

The TGD based explanation [G3] would be in terms of either "topological light rays" or what I call in honor of Tesla "scalar wave pulses" (much like a capacitor moving with velocity of light predicted by TGD but not allowed by Maxwell's ED). This radiation would induce the formation of join along boundaries bonds between atomic and larger space-time sheets and part of electrons from penduli would leak to larger space-time sheets and their motion would result as a recoil effect. The radiation would have only the role of control signal and this would explain why its intensity is not weakened.

From the point of view of single sheeted space-time an over-unity device would be in question since the zero point kinetic energy would be transformed to kinetic energy. The transformation of visible matter to dark matter is in TGD Universe the basic mechanism of metabolism predicting universality of metabolic energy currencies and living matter in TGD Universe has developed a refined machinery to recycle the dropped charges back to the atomic space-time sheets to be used again. Combined with time mirror mechanism this makes, not a perpetuum mobile, but an extremely flexible mechanism of metabolism.

## 7.3 Consciousness and cosmology

The words consciousness and cosmology at the same line represent a totally insane association unless one has assimilated the conceptual background provided by TGD inspired theory of consciousness, where p-adic physics of cognition means that cognitive consciousness is unavoidably cosmic phenomenon as far its space-time correlates are considered and magnetic flux tube hierarchy provides the template for the evolution of conscious, intelligent systems in all length scales.

There is a further argument supporting the view that conscious intelligence is the basic property of Universe. As found in the chapter "Intentionality, Cognition, and Physics as Number theory or Space-Time Point as Platonia", the need to algebraically continue rational physics to all number fields was shown to lead to a generalization of the notion of space-time point to what might be regarded as realization of the monad concept of Leibniz. Mathematical points are still completely structureless in the real sense but with respect to p-adic topologies situation changes profoundly. One can assign to space-time point a free algebra, kind of "Mother of All Algebraic Structures" allowing representation of any algebraic structure. This would realize Universe as an algebraic hologram, and give good hopes of understanding of what are the space-time correlates of mathematical cognition.

### 7.3.1 Gravitation and consciousness

The purpose of the following arguments is to persuade the reader to consider seriously the possibility that classical gravitational interactions are space-time correlate for the subjective existence defined as sequence of quantum jumps.

#### p-Adic self hierarchy

Quantum jump as moment of consciousness and self as a system able to not develop bound state entanglement are basic notions of TGD inspired theory of consciousness [10]. The contents of consciousness of self are determined as a statistical average over the ensemble formed by quantum jumps which have occurred after the last "wake-up".

Macro-temporal quantum coherence corresponds to generation of bound state entanglement with rational or extended rational entanglement probabilities stable against state function reduction and preparation processes occurring in each quantum jump. The implication is that state function reduction and preparation processes cease in appropriate degrees of freedom and de-coherence does not occur. As a consequence, the entropy of quantum jump ensemble does not increase and self stays negentropic. Since mental images correspond to sub-selves, mental images remain sharp during macro-temporal quantum coherence. One can say that moments of consciousness effectively integrate to a single long lasting moment of consciousness during macro-temporal quantum coherence. Quantum jumps represent the elementary particles of consciousness, and bound state entanglement binds both elementary particles and moments of consciousness to larger structural elements. The outcome is a fractal hierarchy of consciousness completely analogous and very intimately related to the corresponding hierarchy of matter.

Self hierarchy is the basic prediction of TGD inspired theory of consciousness differentiating it from many competing theories: everything is conscious and consciousness can be only lost. At the bottom of the self hierarchy are elementary particles and at the top of it is the entire Universe. p-Adic fractality suggests that the self hierarchy looks essentially the same at every level. p-Adic physics as physics of cognition adds additional weight to this vision since real and p-adic space-time sheets have rational points as common points and p-adically infinitesimal distances correspond to infinite real distances. On basis of these arguments one has reasons to believe that even structures of cosmological size should be conscious, intelligent, and capable of intentional action. The non-determinism of the vacuum extremals suggests the same at classical level.

#### Subjective time-geometric time, gravitational mass-inertial mass

Quite generally, the dynamics of topologically condensed matter is about the evolution of "gravitational" counterparts of various currents defined as differences of the currents associated with positive and negative energy matter. Interestingly, this is what one could expect on the basis of quantum classical correspondence. Quantum jump is the basic building block of conscious experience and only changes can be experienced consciously. One the other hand, crossing symmetry allows to regard positive and negative energy particles as the initial and final states of particle reaction. In terms of TGD inspired theory of consciousness, "inertial" corresponds to the "objective" existence (quantum states) and "gravitational" to the "subjective" existence (quantum jumps). Classical fields and quanta of fields ($CP_2$ type extremals) correspond also to the gravitational-inertial dichotomy.

1. The space-time sheet is an absolute minimum of Kähler action and classical electro-weak and color fields are determined by this dynamics. The energy momentum tensor of Kähler action characterizes the net four-momentum density. The dynamics of the induced spinor fields is the super-symmetric counterpart of Kähler action and thus corresponds to the "inertial sector" of the theory. The fundamental role of the induced spinor fields in quantum theory suggests the same. That induced Kähler field and induced spinor field do not directly correspond to change or difference of any quantum number and are not directly observable conforms with their "inertial" character.

2. The divergences of classical YM fields are non-vanishing in general and define non-conserved vacuum gauge currents. Einstein's equations make sense only if the divergences of the energy momentum tensor of matter and those of classical YM fields cancel each other. The goal is achieved if the YM currents associated with the topologically condensed matter are equal to the vacuum YM currents. Also the net divergences of other contributions to the energy momentum tensor must vanish and this gives to the analogs of hydrodynamical equations.

3. The question is whether the YM currents correspond to the sum or difference of currents associated with positive and negative energy matter. Internal consistency suggests that the dynamics is for the differences of various charges for matter and antimatter so that the currents would correspond to "gravitational" counterparts of gauge charges. This would be also consistent with the facts that only the covariant divergence of these currents is vanishing and that they are not genuinely conserved. Fortunately, the expressions for the currents would be exactly the same as in the standard approach assuming opposite charges for negative energy matter.

With this interpretation even the predicted presence of long range electro-weak and color gauge fields becomes understandable. For instance, the presence of long range $W^{\pm}$ fields codes for the occurrence of quantum jumps in which electro-weak quantum numbers are changed. Classical gauge fields would be in a well-defined sense "gravitational" counterparts of the quantum fields corresponding to elementary particles. This interpretation applies also in the case of electromagnetic current. Indeed, classical em current corresponds to the covariant divergence of em field and if classical $W^{\pm}$ fields are present em current fails to be conserved.

#### Vacuum extremals, gravitation, intentionality, and Universe engineering itself

Kähler action has a gigantic vacuum degeneracy: any four-surface $X^4 \subset M^4_+ \times Y^2$, $Y^2 \subset CP_2$ a Legendre manifold with a vanishing induced Kähler form, is a vacuum extremal with respect to the inertial energy. The physical interpretation of this degeneracy remained open for a long time although it became clear that it is responsible for spin glass degeneracy and quantum criticality of TGD Universe crucial for understanding of living matter. The fact that vacuum extremals are not vacua with respect to gravitational four-momentum provides the sought for interpretation. Vacuum extremals correspond to the space-time correlate for that aspect of the Universe, which is engineered and can be affected by intentional action. Living creatures are certainly natural candidates for a phase of matter modellable in terms vacuum extremals or their small deformations.

p-Adic fractality and the fact that the evolution of cognition as cognitive growth proceeds from long to short length scales (p-adically infinitesimal corresponds to infinite in real context) forces to take very seriously the possibility that Universe is a product of conscious, intentional engineering in all length scales and could be seen as a kind of four-dimensional artwork or a living organism of cosmic size in 4-dimensional homeostatic equilibrium.

The changes of gravitational mass provide direct signature of intentional action. Intentional action leads to a generation of a pair of positive and negative energy space-time sheets with a vanishing net (conserved) inertial energy: $E_+ + E_- = 0$. The gravitational energy of the system increases by $\Delta E_{gr} = E_+ - E_- = 2E_+$. It would be possible to measure the weight of intention by a gravitational scale! Also the reverse effect is possible. The ceasing of intentional actions at the moment of biological death could relate to the claimed loss of weight at the moment of biological death. Note that the annihilation of pairs of positive energy fermions and negative energy anti-fermions to photons and their phase conjugates provides a possible source of antigravity effects and it might be possible to develop antigravity machines utilizing this effect and possibly already utilized by living matter.

It would seem that Penrose's intuition about the role of quantum gravity is both right and wrong. Penrose proposes that it is possible to reduce the non-determinism of quantum jump to non-computable dynamics of gravitational fields, perhaps even at classical level. In TGD Universe classical gravitation involves genuine classical non-determinism which serves as a symbolic representations for conscious, intentional existence which at fundamental level corresponds to the dynamics of quantum jumps.

#### Topological thermodynamics and TGD

The dimension of $CP_2$ projection of space-time surface is an important classifier for the phases of matter in TGD Universe. R. M. Kiehn has developed highly interesting differential-topological view about thermodynamics, which he calls topological thermodynamics [17]. The basic goal is to reduce thermodynamics to differential topology using so called Pfaff systems defined by one-forms $A_k$ identified as various thermodynamical potentials and completely analogous to action 1-forms in symplectic mechanics. The basic classifier for thermodynamical phases is the so called topological dimension associated with the Pfaff system defined by one-form $A$ identified as action in Kiehn's approach. The topological dimension $d$ of Pfaff system is the number of non-vanishing terms in the sequence $\{A, dA, A \wedge dA, dA \wedge dA, ..\}$. Even differential-topological definition of entropy is achieved in this approach.

The construction of solutions of field equations in TGD framework relies on the idea that the absolute minima of Kähler action corresponds asymptotically to self-organization patterns which do not dissipate anymore and that this is reflected as the vanishing of Lorentz-Kähler 4-force. Against this essentially thermodynamical background it is not surprising that there is very close relationship to Kiehn's approach. In TGD context action $A$ is identifiable as the induced Kähler gauge potential $A$ whereas $d$ corresponds to the dimension of $CP_2$ projection of the space-time sheet.

For vacuum vacuum extremals $d$ is 1 or 2. For instance, Lorentz invariant Robertson-Walker cosmologies have $d = 1$, whereas critical cosmology has $d = 2$. Besides vacuum extremals also Kähler magnetic flux tubes have $d = 2$ and correspond to highly ordered ferromagnetic phase. $d = 4$ corresponds to chaos. The most interesting phase from the point of view of living systems and information processing (perhaps by topological quantum computation) has $d = 3$ and is identifiable as spin glass phase representing the critical transition region between $d = 2$ and $d = 4$ phases. Thus $d = 2$ vacuum extremals seem to provide the hardware, the matter which conscious intelligent systems manipulate and perhaps also create from it $d = 3$ systems by small perturbations.

Kiehn's detailed thermodynamical interpretation of the contact and symplectic structure associated with $A$ allows in principle a rather detailed thermodynamical interpretation of the absolute minima of Kähler action. For instance, vacuum extremals can be interpreted as thermodynamical equilibria for which entropy function associated with various points of space-time sheet is constant. The classical non-determinism of the space-time sheets could thus be also seen as a thermal randomness. This randomness would be however absolutely essential for space-time engineering by first melting the space-time sheet to a vacuum extremal, deforming it to the desired shape, and then allowing to cool it again. $d = 3$ corresponds in Kiehn's approach to thermal non-equilibrium states far from equilibrium and identifiable as topological defects.

#### Topological quantum computation in cosmic length scales?

Magnetic flux tube structures are the basic building blocks of living matter in TGD inspired quantum biology [M1, M3], and the assumption has been that the creation of pairs of positive and negative energy flux tube structures is one of the basic mechanisms of intentional action. For example, the self-assembly of proteins could be identified as a reversed time evolution for negative energy magnetic flux tube structures serving as templates for the formation of living matter. TGD inspired model of quantum biology leads to model for DNA in which the DNA double strand and also other helical structures corresponds to pairs of positive and negative energy magnetic flux tubes.

Also cosmic strings form tightly coiled pairs and can form complex knotted and linked structures. The scale is different but by p-adic fractality and quantum criticality of TGD Universe these structures should be very similar. Even more, cosmic strings should evolve to magnetic and $Z^0$ magnetic flux tubes by gradual thickening and by generation of fermion or anti-fermion number.

The TGD inspired model for topological quantum computation (TQC) using linking and braiding of magnetic flux tubes [E9] led to the proposal that also the double strand of DNA and/or RNA might perform TQC. The two strands would correspond to positive and negative energy magnetic flux tubes with linking and knotting of RNA coding for TQC program. The braiding of the two strands would define not only a TQC program but also its geometric time reversal. The possibility of quantum parallel dissipation makes also possible generalization of topological quantum computation to that involving dissipation.

p-Adic fractality and the view about evolution of cognition as a process proceeding from long length and time scales towards shorter ones inspires the question whether the coiled pairs of cosmic strings could be seen as fractally scaled up versions of pairs of RNA strands and define cosmic topological quantum computations such that negative energy string corresponds to communication to and control of the geometric past making possible endless iteration of TQC.

### 7.3.2 Is solar system a genuine self-organizing quantum system?

There are two means of determining the positions of planets in the solar system [89, 90, 91, 32]. The first method is based on optical measurements and determines the position of planets with respect to the distant stars. Already thirty years ago [32] came the first indications that the planetary positions determined in this manner drift from their predicted values as if planets were in accelerated motion. The second method determines the relative positions of planets using radar ranging: this method does not reveal any such acceleration.

C. J. Masreliez [90] has proposed that this acceleration could be due to a gradual scaling of the planetary system so that the sizes $L$ of the planetary orbits are reduced by an over-all scale factor $L \rightarrow L/\lambda$, which implies the acceleration $\omega \rightarrow \lambda^{3/2}\omega$ in accordance with the Kepler's law $\omega \propto 1/L^{3/2}$. This scaling would exactly compensate the cosmological scaling $L \rightarrow (R(t)/R_0) \times L$ of the solar system size $L$, where $R(t)$ the curvature parameter of Robertson-Walker cosmology having the line element

$$ds^2 = dt^2 - R^2(t)\left(\frac{dr^2}{1+r^2} + r^2 d\Omega^2\right) . \qquad (7.3.1)$$

According to Masreliez, the model explains also some other anomalies in the solar system, such as angular momentum discrepancy between the lunar motion and the spin-down of the Earth [90]. The model also changes the rate for the estimated drift of the Moon away from the Earth so that the Moon could have very well formed together with Earth some five billion years ago.

In the TGD framework planetary acceleration could reflect non-trivial dynamics of quantum jumps so that quantum effects would be directly observable in the scale of solar system. Two times would be involved: subjective time defined by sequence of quantum jumps and geometric time. The dynamics with respect to the geometric time would be determined by the equations of motion for planetary dynamics in expanding background for the space-time sheet representing solar system: the radar measurements would probe this dynamics.

The dynamics with respect to subjective time would make itself visible since the space-time sheet would be replaced by a new one in each quantum jump and characterized by slightly different parameters after each quantum jump. The optical measurements measuring positions of stars with respect to distant stars would probe this dynamics. The basic parameter would be the size of the solar system as measured with respect to $M^4_+$ metric. The scaling compensating the cosmic expansion would guarantee that the observed size remains constant. For each geometric history the size would increase in the geometric future. The solar system would utilize quantum non-determinism in order to avoid decay by cosmic expansion.

#### The basic coordinate systems

Consider now the previous argument in more detail. The first task is to identify the coordinates appearing in the equations of motion of the planetary system. Denote the standard spherical Minkowski coordinates by $(m^0, r_M, \theta, \phi)$. The line element reads as

$$ds^2 = d(m^0)^2 - dr_M^2 - r_M^2 d\Omega^2 \ . \tag{7.3.2}$$

Light cone coordinates are related to these coordinates by the relationship

$$a = \sqrt{m_0^2 - r_M^2} \ , \quad r = r_M/a \ . \tag{7.3.3}$$

Here $a$ is the light cone proper time along radii from the dip of the light cone $a = constant$ surfaces are hyperboloids. The line element is given

$$ds^2 = da^2 - a^2 \left( \frac{dr^2}{1+r^2} + r^2 d\Omega^2 \right) \tag{7.3.4}$$

and is nothing but the empty space Minkowski metric.

The Robertson-Walker metric for the space-time sheet reads as

$$ds^2 = g_{aa} da^2 - a^2 ( \frac{dr^2}{1+r^2} + r^2 d\Omega^2) \ . \tag{7.3.5}$$

The space-time sheet possessing this metric as induced metric is obtained as a map $M^4_+ \rightarrow CP_2$ having the form $s^k = s^k(a)$, where $s^k$ denote $CP_2$ coordinates satisfying the constraint

$$g_{aa} = 1 - s_{kl} \partial_a s^k \partial_a s^l \ , \tag{7.3.6}$$

where $s_{kl}$ denotes the metric tensor of $CP_2$.

One can introduce cosmic time as proper time coordinate $t$, or Hubble time as it is called, by the equation

$$\frac{dt}{da} = \sqrt{g_{aa}} \ . \tag{7.3.7}$$

For the matter-dominated cosmology one as

$$\frac{t}{t_0} = (\frac{a}{a_0})^{3/2} \ . \tag{7.3.8}$$

$t \simeq 1.5 \times 10^{10}$ ly is the value which explains the planetary acceleration in the model of Masreliez.

The basic question concerns the connection between cosmic coordinates and the radial and time coordinates $(r_{PN}, t_{PN})$ used in Post-Newtonian approximation. The correspondence $(t = t_{PN}, r = r_{PN})$ is the natural first approximation.

The cosmic time dilation would slow down the time scale of the planetary dynamics and cosmic expansion would lead to adiabatic expansion of the size of the solar system. This would predict the scaling $L(a)/L(a_0) = a/a_0$ for the sizes of the planetary orbits as measured using the $r_M$ coordinate of $M^4_+$ metric whereas angular velocities of planets would remain constant $\omega(a)/\omega(a_0) = constant$. The solar system would gradually decay.

### Quantum compensation of the cosmic expansion

In order to compensate the cosmic expansion solar system should perform quantum jumps compensating the scaling caused by the cosmic expansion so that the observed size of the solar system would remain unchanged. This requires $L(a)/L(a_0) = constant$ and the scalings

$$\frac{\omega(a)}{\omega(a_0)} = (\frac{a}{a_0})^{3/2} = \frac{t}{t_0} \ , \quad \frac{v(a)}{v(a_0)} = (\frac{a}{a_0})^{1/2} = (\frac{t}{t_0})^{1/2} \tag{7.3.9}$$

for the angular velocity $\omega$ and and tangential velocity $v$ along the orbit. The equation for the angular acceleration is $d\omega/dt = \omega/t$. This result differs by a factor of 3 from the equation $d\omega/dt = 3\omega/t$ of Masreliez [90]. On basis of work of Masreliez one can conclude this kind of scaling indeed explains the observed drift quite satisfactorily for $t \simeq 5$ billion years (instead of $t = 15$ billion years of [90]). Thus the effect would allow to see the effects of the cosmic expansion in human time scale and would make possible to determine the value of cosmic time $t$ from the planetary dynamics.

The obvious question is why this kind of scaling would occur and a possible answer suggested by TGD inspired theory of consciousness is that the solar system is conscious self-organizing system which purposefully tends to avoid the decay caused by cosmic expansion. There must be some mechanism making the scaling possible. One can imagine at least the following mechanisms.

1. A gradual generation of $Z^0$ charges, which are opposite sign for Sun and planets would provide a possible mechanism of this kind. The weakness of the model is that it requires constant $Z^0$ charge/mass ratio.

2. Also the creation of pairs of positive and negative energy magnetic flux tubes from vacuum could generate gravitational mass. The strong magnetic and $Z^0$ magnetic field of solar magnetic field zone could consist pairs of flux tubes with positive and negative inertial energies. If the gravitational mass $M_{gr}$ of Sun relates to its radius $R$ by $M_{gr}R^3 = constant$ law holding true for non-rotating non-relativistic astrophysical objects [16], the growth of mass and solar radius would obey the law $dlog(M)/dlog(a) = 3/4$ and $dlog(R)/dlog(a) = -1/4$. In the context provided by general philosophy of TGD inspired theory of consciousness the extremely complex self-organizing magnetic flux tube structure of convective zone brings unavoidably in mind cortical layers of brain. The new view about dark matter as a super-quantal system gives additional impetus to the otherwise weird sounding idea about the solar system as intelligent and conscious system.

### Explanation of the anomalous acceleration of space-crafts

The model for solar system as a self-organizing system provides also an explanation for the anomalous acceleration $a_F = (8.744 \pm 1.33) \times 10^{-8}$ cm/s$^2$ of space crafts discussed in the earlier section. The value of the anomalous acceleration has been found to be given by Hubble constant: $a_F = cH$. $H = 82$ km/s/Mpc gives $a_F = 8 \times 10^{-8}$ cm/s$^2$. It is very difficult to believe that this could be an accident. Indeed, if the planets suffer an anomalous inward acceleration compensating for the cosmic expansion, then also the space-crafts in the radial motion experience the same acceleration. Unless it is assumed that $Z^0$ charge to mass ratio is same for objects in the size scale ranging from space-crafts to planets, the anomalous acceleration favors the model for the compensation of the cosmic expansion based on the increase of the gravitational mass of Sun or Sun and the inner planetary system.

### 7.3.3 The independence of the age distribution of stars in galaxies on the age of galaxy as evidence for quantum coherent dark matter

Big bang cosmology is in a middle of deep crisis. Various aspects of the situation were discussed in the first Crisis in Cosmology conference held 23-25 June 2005 in Portugal. One of the most serious arguments against Big Bang cosmology is the evidence that the age distribution of stars in galaxies does not depend on the age of the galaxy. As if the cosmology were steady state cosmology in a sharp contrast to the voluminous experimental evidence suggesting an expanding cosmology [31]. The defenders of the standard cosmology have claimed that the measurement inaccuracies are so high that one cannot draw definite conclusions about the situation.

In TGD framework, the independence of the age distribution of stars on the age of the galaxy would add a further item to the long list of paradoxes due to the erratic identification of the notions of geometric time and experienced time. The TGD based explanation of the anomaly generalizes the earlier model for the shrinking of planetary radii for which there is also evidence [89, 90, 91]. Rather unexpectedly, the finding lends support for the basic predictions of TGD inspired theory of consciousness including the existence of the infinite hierarchy of conscious entities, and allows to considerably sharpen the earlier view about the relationship between geometric and experienced time.

#### The connection between the notions of geometric and experienced time

Consider first the TGD based view about the connection between geometric and experienced time.

1. *Time flow as a drift of the space-time sheet of observer relative to environment*

1. The space-time sheet $X^4_o$ associated with the conscious observer drifts towards geometric future with respect to the space-time sheet $X^4_e$ defined by the environment. From the perceived change of the environment the conscious observer concludes that time flows. The motion towards geometric future corresponds to some average increment $\tau$ of geometric time per quantum jump: $\tau$ can be identified as a drift velocity $v = \tau$ with respect to subjective time measured using single quantum jump as a unit. Its inverse $1/v$ gives the number of quantum jumps per geometric time defining a measure for the temporal resolution of the conscious experience. This connection explains the origin of the natural but erratic identification of the geometric time with the experienced time.

2. Drift velocity $\tau$ characterizes system-subsystem pair and can in principle vary. Geometric considerations suggests that there is a minimal drift velocity (maximal temporal resolution) corresponding to an average increment of geometric time per quantum jump or order $CP_2$ time $\tau_{CP_2} = R/c$. Quantum classical correspondence allows to consider the possibility that relativity principle for geometric time might have an analog at the level of subjective time.

3. The experience of the flow of subjective time is associated with the number $1/v$ of quantum jumps per unit of geometric time measuring the rate of dissipation. The dissipated power $P$ could be identified as the time component of four-force causing a drift towards geometric future. Dimensional considerations and p-adic fractality suggests that the inverse of the drift velocity (number $1/\tau$ of quantum jumps per geometric time) would be proportional to $P/M$, where $M$ is the rest mass of the sub-system:

$$\frac{1}{\tau}\frac{dt}{ds} = \frac{P}{M} . \quad (7.3.10)$$

Here $t$ denotes the geometric time coordinate, most naturally $M^4_+$ proper time, and $s$ the curve length along the orbit of the space-time sheet regarded as a point-like object. This predicts that for light systems such as elementary particles the number of quantum jumps per geometric time is high and small for larger systems. For $P = 0$ there would be no experience of time flow since single quantum jump would have an infinite geometric duration and the system would be in a state of Eternal Now.

*2. p-Adic time scale hierarchy for time resolutions of conscious experience*

The hierarchy of p-adic length and time scales would relate naturally to the hierarchy of drift velocities and dissipation rates $P$. The first guess is

$$P \propto \frac{kM}{T_p} , \qquad (7.3.11)$$

where $M$ is the rest mass of particles condensed at space-time sheet characterized by the p-adic prime $p$. This gives

$$\tau_p = \frac{T_p}{k} , \qquad (7.3.12)$$

which is also what p-adic fractality would suggest. The time resolution of conscious experience with respect to the geometric time would weaken as $p$ grows in accordance with the idea that p-adic hierarchy defines a hierarchy of length and time resolutions. The higher the dissipation rate, the shorter then geometric duration of quantum jump and the slower the system drifts towards geometric future.

*3. Hierarchy of quantum jumps and dark matter*

TGD inspired theory of consciousness predicts a hierarchy of quantum jumps such that single quantum jump at given level would correspond to a sequence of quantum jumps at the level below it. The self at the higher level of hierarchy experiences its sub-selves as mental images, and the sub-sub-..-selves at lower levels give rise to a kind of diffuse background experience giving rise to an experience of time flow during single quantum jump.

This hierarchy of moments of consciousness of increasing subjective and geometric durations defines a direct counterpart for the hierarchy formed by elementary particles, hadrons, atoms, molecules, etc.... Indeed, the formation of bound states with rational entanglement probabilities characterized by positive entanglement negentropy identified as a p-adic variant of Shannon entropy is identified as be the physical correlate for the hierarchy or moments of consciousness [H2]. The generalization of this picture to the case of of hyper-finite type $II_1$ factors is also discussed in [H2].

This hierarchy of consciousness should relate closely to the hierarchy of Planck constants defined by Beraha numbers $B_n = 4sin^2(\pi/n)$ and their generalizations $B_r$ with $r$ rational. For large values of $\hbar$ and dark matter the average increment of geometric time per quantum jump would be longer than for small values of $\hbar$ and to ordinary matter and each quantum jump would be experienced as longer and longer lasting "Eternal Now".

*4. Life as an attempt to climb as far as possible to the geometric future*

That human beings and presumably all living systems experience time flow would be due to the dissipation by the component of the living system consisting of ordinary matter. The basic goal of the life cycle would be to run faster than the environment to future get as far as possible to the geometric future to be able to experience what the environment at more advanced levels of evolution looks like. Climbing up hill would be a good metaphor for life.

This would serve a good quantum physical definition for the notion of progress. One can imagine several means for achieving this goal: the increase of the p-adic prime $p$ (size of the system), the minimization of the dissipation rate, and the transition to a higher level in the hierarchy of dark matter. The price paid would be a poorer time resolution of direct conscious experience. The diffuse background due to sub-sub...-selves however provides the experience about time flow. Somewhat paradoxically, in quantum jumps of long geometric duration the highest level contribution to the experience would be that of Eternal Now experienced in pure form during experiences like NDEs when the contributions from the biological body are minimal.

The p-adic length scale hierarchy associated with the biological body would define a hierarchy of these goals. At a given level of hierarchy of moments of consciousness (the hierarchy of Planck constants) the geometric time would run the faster, the longer the p-adic length scale characterizing partially the level in the evolutionary hierarchy is. If the number of quantum jumps is roughly the same at various levels of p-adic hierarchy, the subjectively experienced life span defined as number of quantum jumps would be also more or less the same.

*5. Life cycle as single moment of consciousness?*

There is a group of questions relating to the identification of "me" in the hierarchy of conscious entities. What is the geometric duration of moment of consciousness for "me" as the highest level intentional agent affecting my life ("silent witness")? Does it correspond to some neurophysiological time scale, say some EEG period, to single day in life, or does biological life cycle correspond to a single moment of consciousness of "silent witness" so that all its experiences in shorter time scales would correspond to mental images defined by sub-sub-...-selves with a smaller value of $\tau$ (in particular, moments of sensory consciousness with a geometric time duration of order .1 seconds). Meditative practices indeed claim that we are conscious also during deep sleep but do not usually remember anything about this period.

If "I" would cease to exist as a conscious entity during deep sleep my directly experienced life history could not be longer than single day in life unless the communications with other conscious entities generate a mental image about longer life history as a cognitive construct.

This supports the view that "me" as an intentional agent responsible for the grand design of the life cycle corresponds to the "silent witness". Lower level intentional "me's" are present but their effects of lower level selves to the geometric future have a shorter time span by statistical determinism, and characterized by the corresponding p-adic time scales.

*6. Time mirror mechanism for intentional action and time localization of the sensory experience and intentional inertness of the geometric past*

The proposed picture does not yet resolve all imaginable paradoxes.

1. My sensory experience is more or less from single moment of geometric time rather than from the entire 4-dimensional body as would be suggested by life span a single moment of consciousness picture. It would seem that the state of the sensory space-time sheets of the geometric past is such that they do not contribute to the everyday conscious experience. Sensory memories and perhaps also cognitive memories (clearly distinguishable from sensory reality) define exceptions to this rule. If the basic character of the sensory experience is such that it takes the sensory receptor into a state in which further sensory perception is not possible for a sufficiently long period of time, this would be the case.

2. In TGD based model for sensory receptors sensory receptors are analogous to population inverted lasers which return to the ground state during sensory perception (in the capacitor model of sensory receptors sensory input generates a discharge of the capacitor [K3]). By classical non-determinism it is possible to have a situation in which the return to the ground state in a given quantum jump occurs only in a finite time interval defined naturally by an appropriate space-time sheet. Since the return to the initial state requires energy feed, there is some recovery time, perhaps even of order life span, for the sensory receptors. Quantum classical correspondence and the fact subjective past does not change in quantum jumps would suggest that no recovery occurs. The quantum jump sequence should induce the falling down of the the domino pieces ordered along the time axis and the pieces should not get up too soon.

Unless the geometric past is inert with respect to intentional action, one can imagine a situation in which the intentional action on the geometric past can affect the fate of the entire biological body of geometric future in time scales of life span. Rather paradoxical situations can result. For instance, a musician could wake up as physicist when a young "me" in the geometric past or the highest level intentional agent makes a different choice. Paradoxes are avoided if geometric past becomes inert with respect to intentional action.

The view about how intentional action is realized allows to understand both the time localization of the contents of sensory experience and the inertness of the geometric past with respect to intentional action.

1. According to the TGD based model, intentional action is realized as a negative energy signal sent to the geometric past representing a desire about action inducing positive energy signals realizing the action. The intentional action has a fractal structure: the desire about action at highest level and longest length and time scale induces desires at lower levels proceeding down to the bio-molecular level. The temporal distances at which the signals propagate into geometric past is expected to be proportional to $T_p$ so that lower dimensional intentional agents would have a shorter span of intentional action.

2. A negative energy signal from the geometric future induces the return of the population inverted many-sheeted laser defining a sensory receptor to the ground state inducing the positive energy signal responsible for the action. Because of the finite recovery time the subsequent intentional actions of the lower level intentional agents induce a drift of the front of sensory experience towards geometric future. One can of course imagine the possibility that the recovery time is shorter than life span in which the revived youth begins to contribute to the conscious experience: this might relate to the fact that old people can relive the youth.

3. Intentional and sensory life could be seen as an analog of p-adic length scale evolution in which shorter and shorter p-adic time scales are excited with downwards scaling mapped to the time evolution. Life cycle would be like carving a statue by starting from a rough sketch and adding details. This conforms also with the basic anatomy of quantum jump.

*7. The drift velocities towards geometric future must be same for communicating intentional agents in biosphere*

The assumption that the drift velocities towards geometric future are different for conscious entities able to communicate also leads to a paradoxical situations. For instance, if my drift velocity is lower than that of my friend, I soon find that my friend looks more or less like a dead statue if the hypothesis about intentional inertness is true. If my drift velocity is higher, I would learn that my friend is in a macroscopic quantum superposition of different variants of my friend: one would be musician, one would be physicist, etc... This suggests that the drift velocity is same for conscious entities able to communicate. The findings about planetary system and age distribution of stars are consistent with this assumption. The assumption becomes natural if the intentional agents correspond to dark matter in general.

### Quantum explanation for the shrinking planetary radii and apparent steady state cosmology

The independence of the age distribution of stars on the age of galaxy suggests that cosmology looks like a steady state cosmology with respect to the subjective time and expanding cosmology with respect to the geometric time. The explanation for why this is the case would be same as for the shrinking of the orbital radii of planets [89, 90].

*1. The model*

Consider next the explanation for the shrinking of the orbital radii of planets and for the independence of the age distribution of stars on the age of galaxy.

1. Assume that the Newtonian radii correspond to the radial coordinate $r$ of the Robertson-Walker coordinate system with origin at the Sun. Assume that quantum jumps have physical effects even in astrophysical length scales, and are such that they compensate completely the increase of the distance $s$ of the planet from Sun caused by the cosmic expansion so that $s = a\int_0^r dr/(1+r^2) \simeq ar$ stays constant apart from the oscillatory variation caused by the non-circular motion.

2. This situation is achieved if the space-time sheet $X^4_o$ associated with the observer drifts with respect to the space-time sheet $X^4_p$ associated with the planetary system, which in turn drifts with the same velocity at the space-time sheet $X^4_g$ of galaxy. This implies that the change of perceived 3-D environment at $X^4_p$ due to the drift of $X^4_o$ at $X^4_p$ is compensated by the drift of $X^4_p$ at $X^4_g$.

3. In the same manner, the independence of the age distribution of stars on the age of galaxy can be understood if $X^4_o$ drifts at $X^4_g$ with the same velocity as $X^4_g$ sheets drift at the cosmological space-time sheet $X^4_c$. The equality of the drift velocities is consistent with the hypothesis that field/magnetic bodies of even galactic size contribute to our conscious experience.

4. Also p-adic fractality implying cosmologies with cosmologies picture suggests that the age distribution of stars does not depend on the age of galaxy.

*2. The interpretation of the astrophysical and cosmic anomalies as a support for the quantum coherence of dark matter*

The assumption that dark matter is in a quantum coherent state in astrophysical and even cosmic length and time scales means that the systems consisting of dark matter do not dissipate much and thus do not drift much with respect to each other.

Since Universe consists mostly of dark matter, the shrinking of planetary radii and the constancy of the age distributions of stars in galaxies can be seen as an evidence for the quantum coherence of dark matter and for the assumption that dark matter at our magnetic bodies is what makes us intentional agents. The findings support also the view that universe is conscious even in the length and time scales of galaxies and even enjoy what meditative practices call enlightened states or cosmic consciousness and that these length scales contribute also to our consciousness.

## 7.4 Living matter and dark matter

The most precious gift of RHIC to TGD was that several theoretical notions and ideas, which have emerged during last years, and applying in hugely disparate length and time scales by p-adic fractality, integrate nicely. Especially interesting are the implications for the understanding of what differentiates between living and ordinary matter and what gives living systems its macroscopic and macro-temporal quantum coherence.

I have already mentioned the black hole like objects identified in Relativistic Heavy Ion Collider in Brookhaven. Because of the exceptional importance of the finding I summarize briefly the main findings and theoretical concepts and ideas again from a more holistic point of view. The discovery of black hole like objects was third in a series of discoveries.

### 7.4.1 Living matter as ordinary matter quantum controlled by dark matter

Also living matter could be ordinary matter controlled by dark matter with a large value of $\hbar$ and thus possessing extremely quantal properties, including free will and intentional action in time scales familiar to us! Dark matter would be responsible for the mysterious vital force.

Any system for which some interaction becomes so strong that perturbation theory does not work, could give rise to this kind of system in a phase transition in which $\hbar$ increases to not lose perturbativity gives rise to this kind of "super-quantal" matter. In this sense emergence corresponds to strong coupling. One must however remember that emergence is actually much more and involves the notion of quantum jump. Dark matter made possible by dynamical $\hbar$ is necessary for macroscopic and macro-temporal quantum coherence and is thus prerequisite for emergence.

Physically large $\hbar$ means a larger unit for quantum numbers and this requires that single particle states form larger particle like units. This kind of collective states with weak mutual interactions are of course very natural in strongly interacting systems. At the level of quantum jumps quantum jumps integrate effectively to single quantum jump and longer moments of consciousness result. Entire hierarchy of quantal size scales is predicted corresponding to values of $\hbar$. The larger the value of $\hbar$ the longer the characteristic time scale of consciousness and of a typical life cycle.

In RHIC color glass condensate resembles incompressible liquid. Liquids might be liquids because they contain some dark matter at magnetic/$Z^0$ magnetic flux tubes (darkness follows from the large value of $\hbar$). Incompressibility of liquid could correspond to maximal density of flux tubes and to the fact that magnetic fields have no sources. In accordance with the previous ideas already water would be living and conscious system in some primitive sense.

The notion of field body in turn means that dark matter at the magnetic flux tubes would serve as an intentional agent using biological body as a motor instrument and sensory receptor. Dark matter would be the miraculous substance that living systems are fighting for, and perhaps the most important substance in metabolic cycle.

### 7.4.2 Could biology, cosmology, and hadron physics have something in common?

p-Adic fractality suggests that scaled versions of cosmological evolution appear in all length and time scales and that biological life cycle and cosmological life cycle from big bang to big crunch might have much common as far as mathematical description is considered.

There are very important differences between biology and cosmology as we usually understand the latter. Usually cosmology is thought to be something occurring just once, not engineered, and not receiving an energy flow forcing self-organization. Intentional action is not believed to play any role.

In TGD situation looks however different. The new notions of energy and geometric time imply that all matter is in principle creatable from vacuum by intentional action. Fractal hierarchy of cosmologies within cosmologies means that cosmologies are interacting and can receive self-organizing energy feed. Our inability to detect life forms unless they sufficiently resemble us might be a cause of an enormous distortion in our world view. Bet it as may, if a proposed kind of universality prevails, it becomes in principle possible to test whether system characterized by much longer or shorter time and length scales has some features possessed by living systems.

If this vision is taken seriously, many-sheeted cosmology might even provide some concrete help in attempts to understand the growth of biological organism and its eventual decay. At least the very fact that we are born and eventually die could be understood as the unavoidable fate of any space-time sheet and analogous to process leading from big bang to big crunch. For instance, the models for the early periods in the development of organism might profit something from fractal thinking and critical cosmology suggests universal dynamics in the roughest description of these processes.

Just for fun and taking the liberty of being very naive one could look whether something useful might result from kind of analogy. The early phase consisting of flux tubes and small amount of visible matter (DNA) on them might correspond to the dominance of magnetic body.

Chromosomes containing DNA indeed correspond to multiply coiled very dense many-sheeted structure filling the cell nucleus and would be a natural candidate for the primordial magnetic flux tube dominated phase carrying quantum controlling dark matter. Also proteins would naturally correspond to flux tube like structures. These structures would fractally organize to larger scaled up versions also having similar flux tube like structure and living matter is filled with this kind of structures in various scales.

Quantum critical period during which the space-time in ordinary sense emerges could correspond to the generation of cellular structures larger than basic bio-molecules. Radiation dominated phase could correspond to the period during which cells replicate but visible structures have not yet emerged. Matter dominated period during which organelles are formed around existing magnetic flux tube structures containing quantum controlling dark matter might correspond to the generation of structures from pre-existing micro-structures defined by the magnetic flux tube structures.

One can of course argue that hadrons differ from living matter in the sense each cell of living matter contains these magnetic flux tube structures but hadrons do not. This need not be the case. As I have proposed valence quarks could form a structure connected by color magnetic flux tubes containing gluon condensate, and define the hadronic analog of DNA contained by every hadron. In RHIC experiments a very long structure of this kind analogous to chromosomes would formed when the energy of colliding nuclei is materialized as they slow down.

I have also proposed in cosmological context the idea about linked and knotted cosmic strings as counterparts of DNA double strands [D4]. Here the time orientations for cosmic strings could be different. Even the flux tubes associated with DNA strand and its conjugate might have opposite time orientations and could be created from vacuum. If one takes completely seriously fractality and the hierarchy of Planck constants implying consciousness in all scales, one must conclude that linked and knotted structures might be responsible for topological quantum computation in all length and time scales [E9].

### 7.4.3 Overall view

Dark matter is identified as a macroscopic quantum phase with large $\hbar$ for which particles have complex conformal weights.

The sum of the imaginary parts of conformal weights assumed for number theoretical reasons to be expressible as sums of imaginary parts for the zeros of Riemann Zeta would define a new conserved quantum number, "scaling momentum" [C1]. The conjugation of the complex conformal weight would distinguish between quantum states and their phase conjugates. This point is important since phase conjugate photons represent negative energy signals propagating into geometric past, assumed to be distinguishable from positive energy signals propagating into geometric future, play a key role in TGD based biology: this distinction cannot be made in QFT context.

Living matter could be matter with a large value of $\hbar$ and hence dark, and form conformally confined blobs behaving like single units with extremely quantal properties, including free will and intentional action in time scales familiar to us. Dark matter would be responsible for the mysterious vital force.

Any system for which some interaction becomes so strong that perturbation theory does not work, could give rise to this kind of system in a phase transition in which $\hbar$ increases to not lose perturbativity gives rise to this kind of "super-quantal" matter. In this sense emergence would corresponds to strong coupling. The interpretation would be that strong fluctuations at strong coupling give rise to a large number of orbifold points so that the S-matrix elements to a phase with larger Planck constant become large. Dark matter made possible by dynamical $\hbar$ is necessary for macroscopic and macro-temporal quantum coherence and is thus prerequisite for emergence.

Physically large $\hbar$ means a larger unit for quantum numbers and this requires that single particle states form larger particle like units. This kind of collective states with weak mutual interactions are of course very natural in strongly interacting systems. The $N$ sheets of $M^4_\pm$, where $N$ is the order of group $G_b$ involved with the Jones inclusion in question. Each partonic 2-surface appears as $N$ geometrically identical copies which can however carry different fermionic quantum numbers. Hence the N-fold space-time sheet carry up to $N$ $G_b$ invariant partons with identical quantum numbers so that an effective breaking of Fermi statistics becomes possible.

One implication would be the notion of N-atom, which at the level of quantum jumps quantum jumps integrate effectively to single quantum jump and longer moments of consciousness result. Entire hierarchy of size scales for matter blobs is predicted corresponding to values of $\hbar$. The larger the value of $\hbar$ the longer the characteristic time scale of consciousness and of a typical life cycle.

In RHIC color glass condensate resembles incompressible liquid. Liquids might be liquids because they contain some dark matter at magnetic/$Z^0$ magnetic flux tubes (darkness follows from the large value of $\hbar$). Incompressibility of liquid could correspond to maximal density of flux tubes and to the fact that magnetic fields have no sources. In accordance with the previous ideas already water could be living and conscious system in some primitive sense.

The notion of field body in turn means that dark matter at the magnetic flux tubes would serve as an intentional agent using biological body as a motor instrument and sensory receptor. Dark matter would be the miraculous substance that living systems are fighting for, and perhaps the most important substance in metabolic cycle.

#### Hierarchy of dark matters and hierarchy of minds

The notion of dark matter is only relative concept in the sense that dark matter is invisible from the point of view of the ordinary matter. One can imagine an entire hierarchy of dark matter structures corresponding to the hierarchy of space-time sheets for which p-adic length scales differ by a factor $1/v_0 \sim 2^{11}$. The BE condensates of $N_{cr}$ ordinary matter particles would serve as dynamical units for "doubly dark matter" invisible to the dark matter. The above discussed criticality criterion can be applied at all levels of the hierarchy to determine the value of the dynamical interaction strength for which BE condensates of BE condensates are formed.

This hierarchy would give rise to a hierarchy of the values of $\hbar_n/\hbar$ coming as powers of $v_0^{-n}$ as well as a hierarchy of wavelengths with same energy coming as powers or $v_0^n$. For zero point kinetic energies proportional to $\hbar^2$ this hierarchy would come in powers of $v_0^{-2n}$, for magnetic interaction energies proportional to $\hbar$ the hierarchy would come in powers $v_0^{-n}$ whereas for atomics energy levels the hierarchy would come in powers of $v_0^{2n}$ (assuming that this hierarchy makes sense).

The most interesting new physics would emerge from the interaction between length scales differing by powers of $v_0$ made possible by the decay of BE condensates of dark photons to ordinary photons having wavelength shorter by a factor $\sim v_0$. This interaction could provide the royal road to the quantitative understanding how living matter manages to build up extremely complex coherent interactions between different length and time scales.

In the time domain dark matter hierarchy could allow to understand how moments of consciousness organize to a hierarchy with respect to the time scales of moment of consciousness coming as $2^{11k}$ multiples of $CP_2$ time scale. Even human life span could be seen as single moment of consciousness at $k = 14^{th}$ level of the dark matter hierarchy whereas single day in human life would correspond to $k = 12$.

### Realization of intentional action and hierarchy of dark matters

How long length scales are able to control the dynamics in short length scales so that the extremely complex process extending down to atomic length scales realizing my intention to write this word is possible. This question has remained without a convincing answer in the recent day biology and there strong objections against the idea that this process is planned and initiated at neuronal level.

I have proposed a concrete mechanism for the realization of intentional action in terms of time mirror mechanism involving the emission of negative energy photons and proceeding as a cascade in a reversed direction of geometric time from long to short length scales [K1]. This cascade would induce as a reaction analogous processes proceeding in the normal direction of geometric time as a response and would correspond to the neural correlates of intentional action in very general sense of the word.

The counterparts for the negative energy signals propagating to the geometric past would be phase conjugate (negative energy) laser beams identifiable as Bose-Einstein condensates of dark photons. In the time reflection these beams would transform to positive energy dark matter photons eventually decaying to ordinary photons. The space-time correlate would be MEs decaying into MEs and eventually to $CP_2$ type extremals representing ordinary photons.

The realization of intentional action as desires of boss expressed to lower level boss would naturally represented the decay of the phase conjugate dark laser beam to lower level laser beams decaying to lower level laser beams decaying to... . This would represent the desire for action whereas the time reflection at some level would represent the realization desire as stepwise decay to lower level laser beams and eventually to ordinary photons. The strong quantitative prediction would be that these levels correspond to a length and time scale hierarchies coming in powers of $1/v_0 \sim 2^{11}$.

### Wave-length hierarchy, coherent metabolism, and proton-electron mass ratio

The fact that a given wavelength length corresponds to energies related to each other by a scaling with powers of $v_0$ provides a mechanism allowing to transfer energy from long to short long scales by a de-coherence occurring either in the standard or reversed direction of geometric time. De-coherence in the reversed direction of time would be associated with mysterious looking processes like self-assembly allowing thus an interpretation as a normal decay process in reversed time direction.

It is perhaps not an accident that the value of $v_0 \simeq 4.6 \times 10^{-4}$ is not too far from the ratio of $m_e/m_p \simeq 5.3 \times 10^{-4}$ giving the ratio of zero point kinetic energies of proton and electron for a given space-time sheet. Proton mass ratio $m_p/m_e = 1836.15267261$ corresponds in good approximation to $n = 2^2 \times 3^3 \times 17 = 1836$. This integer is of form $n = 9 \times n_F$. This co-incidence could in principle make possible a metabolic mechanism in which dark protons and ordinary electrons co-operate in the sense that dark protons generate dark photon BE condensates with wave length $\lambda$ transforming to ordinary photons with wavelength $v_0\lambda$ absorbed by ordinary electrons.

Some examples are in order to illustrate these ideas.

1. As already found, in the case of dark atoms the scaling of binding energies as $1/\hbar^2$ allows the coupling of $\sim 9$ cm scale of brain hemisphere with the length scale $\sim 50$ $\mu$m of large neuron. $N_{cr} \leq 137$ ordinary IR photons would be emitted in single burst and interacting with neuron.

2. For a non-relativistic particle in a box of size $L$ the energy scale is given by $E_1 = \hbar^2\pi^2/2mL^2$ so that the visible photons emitted would have energy scaled up by a factor $(\hbar_s/\hbar)^2 \simeq 4 \times 10^6$. The collective dropping of $N_{cr}$ dark protons to larger space-time sheet would liberate a laser beam of dark photons with energy equal to the liberated zero point kinetic energy. For instance, for

the p-adic length scale $L(k = 159 = 3 \times 53) \simeq .63\ \mu$m this process would generate laser beam of IR dark photons with energy $\sim .5$ eV also generated by the dropping of ordinary protons from $k = 137$ atomic space-time sheet. There would thus be an interaction between dark protons in cell length scale and ordinary protons in atomic length scale. For instance, the dropping of dark protons in cell length scale could induce driving of protons back to the atomic space-time sheet essential for the metabolism [K6]. Similar argument applies to electrons with the scale of the zero point kinetic energy about 1 keV.

3. If the energy spectrum associated with the conformational degrees of freedom of proteins, which corresponds roughly to a frequency scale of 10 GHz remains also invariant in the phase transition to dark protein state, coherent emissions of dark photons with microwave wave lengths would generate ordinary infrared photons. For instance, metabolic energy quanta of $\sim .5$ eV could result from macroscopic Bose-Einstein condensates of 58 GHz dark photons resulting from the oscillations in the conformational degrees of freedom of dark proteins. A second option is that the conformal energies are scaled by $\hbar_s/\hbar$ ($\omega$ would remain invariant). In this case these coherent excitations would generate ordinary photons with energy of about 1 keV able to drive electrons back to the atomic $k = 137$ space-time sheet.

4. Since magnetic flux tubes have a profound role in TGD inspired theory of consciousness, it is interesting to look also for the behavior of effective magnetic transition energies in the phase transition to the dark matter phase. This transition increases the scale of the magnetic interaction energy so that anomalously large magnetic spin splitting $\hbar_s eB/m$ in the external magnetic field could serve as a signature of dark atoms. The dark transition energies relate by a factor $\hbar_s/\hbar$ to the ordinary magnetic transition energies.

For instance, in the magnetic field $B_{end} = 2B_E/5 = .2$ Gauss, where $B_E = .5$ Gauss is the nominal value of the Earth's magnetic field, explaining the effects of ELF em fields on vertebrate brain, dark electron cyclotron frequency is $6 \times 10^5$ Hz and corresponds to ordinary microwave photon with frequency $\sim 1.2$ GHz and wavelength $\lambda \simeq 25$ cm. For proton the cyclotron frequency of 300 Hz would correspond to energy of ordinary photon with frequency of $6 \times 10^5$ Hz and could induce electronic cyclotron transitions and spin flips in turn generating for instance magneto-static waves.

It is easy to imagine a few step dark matter hierarchy connecting EEG frequencies of dark matter with frequencies of visible light for ordinary photons. This kind of hierarchy would give considerable concreteness for the notion of magnetic body having size scale of Earth.

### A connection with bio-photons

The biologically active radiation at UV energies was first discovered by Russian researcher Gurwitz using a very elegant experimental arrangement [55]. Gurwitz christened this radiation mitogenetic radiation since it was especially intense during the division of cell.

A direct proof for the biological activity of mitogenetic radiation consisted of a simple experiment in which either quartz or glass plate was put between two samples. The first sample contained already growing onion roots whereas the second sample contained roots which did not yet grow. In the case of quartz plate no stimulation of growth occurred unlike for glass plate. Since quartz is not transparent to UV light whereas the ordinary glass is, the conclusion was that the stimulation of growth is due to UV light.

The phenomenon was condemned by skeptics as a pseudo science and only the modern detection technologies demonstrated its existence [54], and mitogenetic radiation became also known as bio-photons (the TGD based model for bio-photons is discussed in [K6]). Bio-photons form a relatively featureless continuum at visible wavelengths continuing also to UV energies, and are believed to be generated by DNA or at least to couple with DNA. The emission of bio-photons is most intense from biologically active organisms and the irradiation by UV light induces an emission of mitogenetic radiation by a some kind of amplification mechanism. It has been suggested that bio-photons represent some kind of leakage of a coherent light emitted by living matter.

According to Russian researcher V. M. Injushin [56], mitochondrios emit red light at wavelengths 620 nm and 680 nm corresponding to energies 2 eV and 1.82 eV. According to the same source, the nucleus of cell sends UV light at wavelengths 190, 280 and 330 nm corresponding to the energies 6.5, 4.4 and 3.8 eV. The interpretation as a kind of leakage of coherent light would conform with the identification in terms of BE condensates of dark photons with $\hbar_s/\hbar \simeq 2^{11}$ emitted at wavelengths varying in the range $.3 - 1.25$ mm and decaying to photons with energies visible and UV range. For instance, 1.82 eV radiation corresponds to a dark photon wave length of 1.4 mm for $v_0(eff) = 2^{-11}$. A bio-control of ordinary bio-matter at sub-cellular level performed by dark matter from the millimeter length scale could be in question. This proposal conforms with the fact that 1 mm defines the scale of the blobs of neurons serving as structural units in cortex.

The analysis of Kirlian photographs has shown that the pattern of visible light emitted by various body parts, for instance ear, code information about other body parts [57]. These bio-holograms for which a general model is discussed in [K4] could be realized as dark photon laser beams.

In phantom DNA effect [82] a chamber containing DNA is irradiated with a visible laser light and the DNA generates as a response coherent visible radiation at same wavelength. Strangely enough, the chamber continues to emit weak laser light even after the removal of DNA. This effect could be due to the decay of a dark photon BE condensate remaining in the chamber. Also the findings of Peter Gariaev [51] about the effects of visible laser light on DNA, in particular the stimulated emission of radio waves in kHz-MHz frequency range might also relate to dark photons somehow.

#### A connection with the scaling law of homeopathy

The value of the parameter $1/v_0 \simeq 2083$ is essentially the ratio of $CP_2$ radius and Planck length scale (as also the ratio of Compton lengths of electron and proton) and rather near to $2^{11} = 2048$. Interestingly, much larger number $2 \times 10^{11} \simeq 3 \times 2^{36}$ appears in the simplest form for what I have christened the scaling law of homeopathy [K5]. This rule has been proposed on basis of experimental findings [47] but has no convincing theoretical justification. The scaling law of homeopathy states that high frequency em radiation transforms to a low frequency radiation and vice versa preferably with the frequency ratio $f_{high}/f_{low} \simeq 2 \times 10^{11}$.

The proposed hierarchy of dark matter and ensuing hierarchy of dark laser beams decaying into lower level beams might provide a deeper explanation for the scaling law of homeopathy. The factor $2 \times 10^{11}$ is with 3 per cent accuracy equal to the integer $n_F = 3 \times 2^{36} \simeq 2.06 \times 10^{11}$ characterizing ruler and compass quantum phase. Hence the interpretation in terms of a phase transition leading from a phase with a large value of Planck constant $\hbar = n_F\hbar_0$ to ordinary phase is possible.

In [K5] I have discussed some mechanisms for the transformation of high energy photons to low energy photons consistent with the rule and proposed a generalization of the rule based on p-adic length scale hypothesis. For instance, high energy visible photons of frequency $f$ could induce an excitation of the receiving system having same frequency, propagating with velocity $\beta = v/c \simeq 10^{-11}/2$, and having wave length equal $\lambda_0 = f/v = \lambda/\beta$. This excitation would in turn couple to photons of wavelength $\lambda_0$ and frequency $f_0 = \beta f$.

## 7.5 Plasmoids as life forms and dark matter

The idea that plasmoids defined as magnetic flux tube structures containing plasma could define primitive life forms emerged several years ago[M1, N1, N2, N4]. For about a year ago I experienced pleasant surprise while reading the news that plasmoids sharing basic signatures assigned to living systems appear in simple electric circuits [59].

The work with the model for the strange experimental findings about the behavior of rotating magnetic system involving a static magnet at center and smaller cylindrical magnets rolling along it (Searl machine) carried out by Russian researchers Godin and Roschin [61] led to a a realization that this system might have in common with living systems very important basic function, namely remote metabolism based on time mirror mechanism [K1].

The first key element of the model was the rotating magnetic field generating radial vacuum electric field with a non-vanishing density of vacuum electric charge not possible in Maxwell's electrodynamics. This generates radial ohmic current charging the system and means that the fundamental prerequisite of self-organization is satisfied: there is feed of charge and energy forcing the system to self-organize with dissipation taking the role of Darwinian selector.

One of the strange features of this system is the appearance of cylindrical magnetic walls spaced at even intervals during the period when the rotational motion of the rollers accelerates spontaneously. The realization was that these magnetic walls provide energy and angular momentum via remote metabolism to the roller magnets. They could be also seen as a concrete example of magnetic body central in the TGD based model of living systems [M1, N1].

At that time I had not realized that the formation of the radial ohmic current is the quintessential property of the system as a self-organizing system, nor that the simple magnetic flux tube structure defining an elementary plasmoid, say topologically quantized magnetic dipole field, must rotate along its symmetry axis to generate radial ohmic current charging the core region containing the ordinary matter.

Neither had I discovered the possibility that Planck constant might be dynamical and quantized, and that dark matter and living matter would involve in an essential manner a macroscopic quantum phase with a large value of $\hbar$ very naturally located at the magnetic flux tubes or walls emanating from the core region.

## 7.5.1 Charged plasmoids as primitive life forms

The simplest primitive life form could consist of a topologically quantized magnetic dipole field for which magnetic flux tubes are replaced by rotating magnetic walls emanating from an extended dipole region. One can consider also separate flux tubes emanating from the extended dipole spinning synchronously around their axes but synchronous spinning might be not represent as stable a situation as magnetic walls.

The region containing the physical counterpart of the extended dipole would be analogous to the stator magnet in Searl's device and carry ordinary matter. If magnetized, this matter can amplify further the magnetic field created by the dark matter. Flux tubes/magnetic walls would contain magnetized dark matter in a spinning/rotational motion creating a rotating magnetic flux along the dipole lines flowing to the central dipole core visualizable as bar magnet. If matter creates magnetic field, it is forced to co-rotate and amplifies the rotating magnetic field in the matter region. The rotation/spinning in turn generates the over-all important radial Ohmic current forcing self-organization in the matter system ("bar magnet") and leading to bio-molecular evolution with Darwinian selection performed by dissipation.

### Plasmoids and universal metabolism

As far as metabolism is considered, this configuration is ideal in many respects.

1. Dark matter behaves quantum coherently and makes spin flip transitions and cyclotron transitions coherently. As a consequence, the resulting magnetic field is highly stable and individual contributions and up coherently rather than tending to cancel each other.

2. The dark matter part of the system can apply remote metabolism using time mirror mechanism, that is send negative energy (phase conjugate) dark photon laser beams to a power source generating radiation at spin flip frequency or more general magnetic transition frequency. Of course, there must be mechanism kicking the particles back to the original space-time sheets: otherwise over unity mode cannot last for long.

3. Since $\hbar$ is large, the cyclotron energy is also higher than usually by a factor $\hbar_s/\hbar$. Because of their small mass electrons are obviously ideal in this respect. Ordinary matter would in turn receive metabolic energy by receiving positive energy dark laser pulses from the dark matter. An especially interesting option is dropping of electrons, protons or other ions to larger space-time sheets from the space-time sheets associated with the core region of dipole containing ordinary matter. This means a spectrum of universal metabolic energy currencies. Dark matter would act essentially as a negentropy source forcing coherence to the behavior of the material system. Second law need not be broken since it applies with respect to subjective time defined by the quantum jump sequence (geometric time reversal makes decay process to look like self assembly).

### Formation of small $\hbar$ versions of atoms as a source of energy

The experiments of Mills [73] suggest fractionization of hydrogen atom energies in plasma sate. The simplest explanation is as a phase transition changing the value of Planck constant to $\hbar = (n_a/n_b)\hbar_0$ with $n_a/n_b < 1$ leading to the increase of binding energy scale by a factor $(n_b/n_a)^2$. For $n_b/n_a = k$ one obtains the states reported by Mills. As suggested in [F10], this phase transition could proceed via a formation of q-hydrogen atoms allowing fractional energy states with $n = 1/2$ and $n \simeq 1/k$, $k = 3, 4, ....$ The transformation of ordinary matter to small $\hbar$ matter would provide an ideal mechanism for generating energy and plasmoids could apply also this mechanism. The general systematics seems to be that formation of large $\hbar$ phases requires metabolic energy whereas formation of small $\hbar$ phases provides ordered energy. This conforms with the general thermodynamical picture.

### Plasmoids, bio-molecules, and living cells

The basic properties of plasmoids make obvious the basic properties of bio-molecules and of living cell difficult to understand in the framework of the standard chemistry.

1. The rotation of the magnetic field generates a radial electric field with a non-vanishing divergence (vacuum charge density whose sign depends on the direction of rotation), which in turns induces an Ohmic current, which forces self-organization with dissipation acting as a Darwinian selector. The Ohmic current also gradually generates charge in the material system. For some critical charge di-electric breakdown occurs in which electrons, protons and possibly other ions drop from the space-time sheets associated with the system and liberate zero point kinetic energy which can be utilized by the dark matter part of the system applying time mirror mechanism. The metabolic energy quanta are universal and the usual $\sim .5$ eV quantum liberated in the dropping of proton from the atomic space-time sheet represents only one instance in the hierarchy of metabolic energy quanta.

2. Parity breaking is an automatic consequence since the sign of the charge of the system depends on the direction of rotation. In fact, the presence of classical $Z^0$ magnetic fields prefers second direction of rotation and induces parity breaking. The ordinary chiral selection in living system would be induced by this fundamental chiral selection. Linear bio-molecules are indeed excellent candidates counterparts fro the stator of the Searl machine with the magnetic flux at magnetic walls carrying the dark matter and defining the magnetic body of the bio-molecule. Chiral selection implies that bio-molecules are charged and the sign of charge is always the same. Bio-molecules like DNA and proteins are always negatively charged.

3. The model predicts the basic properties of cells. The space-time containing plasmoids carries negative charge by parity breaking. Living cells are indeed negatively charged and this property is necessary for the presence of the resting potential. Nerve pulses could have developed from di-electric breakdowns occurring in the system under continual generation of charge. The spherical capacitor like system defined by a membrane like outer boundary allows a simple realization for a sensory receptor in which di-electric breakdown produces sensory qualia identified as quantum number increments of interior of the cell like structure in the process [M5].

4. During the cell division (for an animation see [60]) cell exhibits a structure which brings in mind a dipolar magnetic field replicating itself by a process in which the dipole lines containing the dark matter are pinched in the middle plane of the center dipole. Essentially the analog for the splitting of bar magnet to two bar magnets would take place: hard to imagine anything simpler. This process occurring also in molecular length scales would be accompanied by a complex molecular replication developed during the chemical evolution.

### Could microwave induced ionization distinguish between the chemistries of living and dead matter?

TGD inspired explanation for microwave induced ionization is following.

1. A rotating approximately dipole magnetic field is generated and the induced radial Ohmic current generates a negative charge at the space-time sheet carrying the magnetic field inside the region corresponding to the magnet. This space-time sheet corresponds to a space-time sheet larger than $k = 137$ space-time sheet associated with the electrons of the atoms of air.

2. The microscopic mechanism generating the radial Ohmic current involves the dropping of electrons of surrounding air from $k = 137$ atomic space-time sheet to the space-time sheet of the

magnet and drifting to the region of magnet. The electron in question must have a small kinetic energy so that the large zero point kinetic of electron at $k = 137$ atomic space-time sheet must be emitted as a virtual X ray and be absorbed by a second atom or molecule of air: two-particle process is required by the momentum conservation.

3. The zero point kinetic energy of electron is $\sim .94$ keV for $k = 137$ atomic space-time sheet and is enough to induce the ionization of $C, O$ and $N$ molecules (for $N$ the ionization energy of $n = 1$ electron is .87 keV according to Bohr model). The energetic electrons from the ionized atoms in turn excite and ionize further atoms and molecules. That the zero point kinetic energy of $k = 137$ electron is enough to ionize $n = 1$ inner non-valence electrons of $C, O$ and $N$ atoms but not those of heavier atoms, might distinguish them from the chemically similar atoms $Si, P$ and $S$ in the next period of the periodic system and relate to their role as basic building blocks of bio-molecules. A kind of primitive metabolic symbiosis between $C, O$ and $N$ atoms and plasmoids leading to the evolution of more complex bio-molecules would look like a natural outcome of the self-organization process induced by the radial Ohmic current.

4. Molecules containing $P$ ions ($Z = 15$) have exceptional role in the ADP-ATP cycle, and the ionization energy of $n = 2$ electron of $P$ differs by a factor $(15/16)^2$ from that for $n = 1$ electron for $O$. Hence one can wonder whether for the $P^+$ ions of living matter might lack the inner $n = 2$ electrons of $P$ and possess all valence electrons and whether same might apply to $\mathrm{Na}^+$ and $Mg^+$ with $Z = 11$ and 12. $K^+$, $Ca^{++}$, $Mn^+$ and $Fe^{++}$ with $Z = 19, 20, 25$ and 26 important for the functioning of living matter might be produced by the same ionization mechanism. The ionization energies of $n = 3$ electron of $Mn$ and $Fe$ are nearly equal to that of $O$. The proposed ionization mechanism is not able to ionize atoms with $Z \geq 40$.

To sum up, the question raised by these consideration is whether the microwave induced ionization of the inner atomic electrons could distinguish between the chemistries of living and dead matter.

#### Generalizations

Topological quantized dipole magnetic field represents a candidate for the simplest life-form that one can imagine. TGD however predicts several closely related dynamical hierarchies. There is a hierarchy p-adic length scales quantifying the hierarchy of space-time sheets: to each level it is possible to assign a "magnetic body" generalizing the notion of rotating magnetic walls and inducing radial Ohmic current forcing self organization at corresponding space-time sheet. There is a hierarchy of dark matter in which dark matter systems of given level form Bose Einstein condensates at the new level. There is also a hierarchy of cognitive representations for which TGD predicts even S-matrix from the general structure of von Neumann algebras and inclusions [C6].

All these hierarchies have space-time correlates and the key features of the model of plasmoid as life form in principle generalize to more complex cases. In particular, the notion of magnetic body with size defined by the wavelength of EEG waves, and even hierarchy of larger magnetic bodies, makes perfect sense in this framework. The mysterious dark matter would solve the riddle of life.

#### How to detect the magnetic body of the plasmoid?

Plasmoid should possess a magnetic body consisting of flux quanta which could be flux tubes and/or flux sheets. Rotating magnetic systems studied by Godin and Roschin [93] are reported to involve cylindrical magnetic walls with thickness of about 5 cm and distance between walls about 5. m. Also a formation of plasma phase and cooling of the the air near the rotating systems is reported. Hence the interpretation in terms of a formation of plasmoid might make sense.

If plasmoid is moving the flux quanta of the magnetic body should pass through a stationary magnetometer and induce magnetic pulses whose duration is inversely proportional to the velocity of the motion of plasmoid. Dave Akers has studied the anomalous luminous phenomena (ALPs) in Yakama Indian Reservation at Toppenish, Washington [94], and has detected sequences of magnetic pulses with a wide range of durations possible assignable to ALPs. The intensity of the magnetic pulse is typically in the range 15-25 mGauss but also intensities of .3 Gauss have been detected. Recall that the intensity of magnetic fields associated with effects of ELF em fields on vertebrate brain is .2 Gauss.

Magnetic pulses could be quite generally a signature of the magnetic body, and it would be interesting to find whether a magnetometer moving with respect to a living organism might record sequence of magnetic pulses.

### 7.5.2 Plasmoids, tornadoes, lightnings, and ball lightnings

The notion of plasmoid provides also a model for tornadoes, generation huge voltages in thunder storms, lightnings, and ball lightnings.

#### Development of thunder clouds and plasmoids

With the advent of advanced measurement techniques lightnings are beginning to look increasingly mysterious [64]. For instance, in the framework of standard physics it is very difficult to understand the huge voltages generated in thunder clouds, and how the electrons flowing to ground during lightning can gain the observed immense energies as indicated by the detected emission of X rays [65]. Even more, intensive gamma ray bursts are associated with lightnings and precede them by about 1 microsecond [66].

The arguments which led to a more precise formulation of the notion of plasmoid were actually stimulated by the idea that the generation of the polarization of thunder cloud might involve the formation of pairs of positively and negatively charged plasmoids. The rotating magnetic field would induce the radial Ohmic current in the core of a dipolar magnetic field configuration of plasmoid and induce large plasmoid charge. If only the negatively charged plasmoids are stable, the base of the thunder cloud would contain plasmoids and top positive charge as ordinary ions.

If the water is partially dark matter in the sense that protons of nuclei can be in a phase with a large value of $\hbar$, one could understand why the presence of water (generation of clouds) is an essential prerequisite for the formation of plasmoids.

Consider now the explanation for the gamma rays. An acceleration of electrons or dark electrons could occur in the strong electric field of thunder cloud either to the direction of positively charged ground or of positively charged top of the cloud and generate brehmstrahlung. This mechanism should explain the X ray bursts observed on ground and gamma ray bursts observed in upper atmosphere.

The problem from the point of view of standard physics is that the acceleration of ordinary electrons in the atmosphere involves dissipation and cannot yield gamma rays. Situation would be different for a macroscopic quantum phase of electrons at larger space-time sheets. In a(n idealized) static situation the potential difference between two points at which two space-time sheets are in contact is the same irrespective of along which space-time sheet it is taken so that the strong electric field is indeed present also at larger space-time sheets. A coherent acceleration of block of $N_{cr}$ dark electrons would lead to an emission of BE condensates of dark gamma rays decaying to $N_{cr}$ ordinary gamma rays. The charge-over-mass ratio is same as for an ordinary electron so that the acceleration is same and the overall energy scale of emitted gamma rays is predicted to be same as for ordinary electrons.

#### Ball lightnings and plasmoids

Plasmoids from the base of the thunder cloud could drift to the surface of Earth in the radial electric field of Earth. Space-time sheets containing negatively charged plasmoids could correspond to ball lightnings. The negatively charged ball lightnings would be attracted by the Earth's electric field so that the usual counter argument that light plasma balls should raise up in the air unlike ball lightnings which fall down, can be circumvented. The spectrum of sizes of ball lightnings would range from molecular length scales to macroscopic length scales, and an interesting experimental challenge is to find whether micro plasmoids are produced copiously during thunder storms.

Thunder storms occurred continually in the primordial atmosphere and could have created abundantly negatively charged ball lightnings. This picture raises obvious questions. Did biological life develop from molecular and cell sized ball lightings by some stabilization mechanism? Or could small ball lightnings be inherently more stable than large ones? Did large ball lightnings decay to smaller ones? Did the plasmoids find a safe seat where the continual feed of metabolic energy needed to kick electrons and other charged particles back to smaller space-time sheets was guaranteed?

### Tornadoes as plasmoids

Also tornadoes might be regarded as primitive life forms involving the rotating core, which would correspond to a spiral helix containing ordinary matter in rotational motion and return flux walls containing the dark matter. Both ordinary and $Z^0$ magnetic fields would be involved. The dropping of charges to larger space-time sheets would serve also now as a source of metabolic energy. Tornadoes are indeed known to develop charge and intense emission of light, in particular blue light suggesting collisions of molecules of the atmosphere with highly energetic electrons, is often reported.

The rotation of convective eddies makes them natural candidates for seeds of tornadoes defining natural candidates for primitive life forms serving as templates for the formation of more complex life forms. Interestingly, tornadoes are now known to appear abundantly in Mars [67]. They are about 10 km tall, one kilometer across, and throw up clouds of dust and spray lightning bolts. These "red devils" could make the Martian atmosphere not only a dangerous place for humans, but also a laboratory for the study of the simple predecessors of more complex life forms.

### Ball lightnings created in microwave oven

As I proposed for years ago that microwaves, typically associated with magnetic transitions in external magnetic field, could serve as "food" of plasmoids just as ordinary light serves as "food" of plants, some pragmatic soul wondered whether these plasmoids could be created in microwave ovens. It did not occur to me to type to search engine something like "plasma" and "microwave oven". When I realized the connection with between plasmoids and rotating magnetic systems needing a feed of microwave radiation to rotate the magnetic field, I did this and Google told me that any one can generate ball lightnings in his own microwave oven [63]!

The simplest procedure is to put a vertically oriented burning match into oven. More generally, it seems that a source of carbon polymers, in this case cellulose, must be used. The resulting plasma balls last for seconds and raise upwards unlike ordinary ball lightnings. Either the air heated by the burning and rising upwards yields a lift winning the attraction of Earth's electric field or the plasma ball has a positive charge.

By adding various elements to the system it has been found that their emission lines appear in the spectrum of light emitted so that either a high temperature plasma is involved or the highly energetic electrons dropping to a larger space-time sheet excite the atoms and molecules of the air without necessary heating it.

Consider now a model for the situation based on the formation of light ball containing plasmoids.

1. Plasmoids would be most naturally associated with the macromolecules of the cellulose. Heating would lead to their evaporation from the burning match.

2. Microwaves provide the metabolic energy guaranteing the rotation of the magnetic field. The mechanism would be the emission of negative energy dark photon maser beams from dark matter at the rotating magnetic walls associated with the molecules: microwave radiation would to some extend bring the organic molecules back to life. This is absolutely essential in order to put the magnetic field in rotation. In living matter bio-molecules themselves are expected to generate the microwave radiation: for instance, the conformational dynamics of proteins and dark matter super-molecules and condensed dark matter generate microwave radiation. Also the dropping of ions from suitable space-time sheets can do the same trick.

3. The material evaporated from the burning match should define the conductive medium carrying the crucial radial Ohmic current. Electrically charged organic macro-molecules, such as DNA, are known to act as conductors [62] and also cellulose molecules could do so. The dropping of electric charges from core region liberates metabolic energy and produces the plasma phase.

4. Microwave ovens utilize microwave frequency 2.54 GHz, which corresponds to 11.4 cm wavelength belonging the wavelength interval .3 mm-30 cm coupling strongly to bio-molecules. This frequency corresponds to an electronic spin flip frequency in a field of .2 Tesla, which corresponds to magnetic length (roughly the radius of magnetic flux tube carrying single flux quantum) of order 100 nm, a sub-cellular length scale and possibly assignable to the linear macromolecules evaporated from the match during burning.

For dark electrons the field needed would correspond to $B \sim 10^{-4}$ Tesla, that is $B \sim 2B_e/X$, where $B_e$ denotes the Earth's magnetic field. That Earth's magnetic field could be in question, conforms with the view that dark matter self-organizes around the flux tubes of the Earth's magnetic field and controls ordinary matter associated with organic molecules carrying much stronger magnetic field. The fact that the magnetic field has disappeared from Mars might relate to the recent absence of higher life forms.

**Jean Naudin's glow discharge plasma panel power tests**

The measurements performed by Jean Naudin [68, 69, 70] are related to the work of Industrial Plasma Engineering Group of the UTK Plasma Sciences Laboratory, which has been supported by NASA Grant NCC 1-223 since October 1, 1995 to develop the applications of a One Atmosphere Uniform Glow Discharge Plasma (OAUGDP) to aerodynamic boundary layer and flow control. These and related applications are described in U. S. Patent 5,669,583, "Method and Apparatus for Covering Bodies with a Uniform Glow Discharge Plasma and Applications Thereof". Wind tunnel measurements for this research were taken in the 7 X 11 inch Low Speed Wind Tunnel of the NASA Langley Research Center's Fluid Modeling and Control Branch, Hampton, VA. More references to the phenomenon can found on Naudin's web pages.

The basic observation behind the experiments is that microwave radiation induces ionization of the air in front of the wing and this in turn reduces the drag. The mechanism of the microwave induced ionization of air by the mechanism generating the radial Ohmic current carrying electrons from the surrounding air to the space-time sheet of the magnet has been already discussed, and was found to allow the ionization of atoms with nuclear charge not higher than $Z = 8$ so that $C, O$ and $N$ atoms are indeed ionized.

The electrons at the magnetic walls are an essential element of the system taking care of the preservation and rotation of the dark matter magnetic field. The energy needed for this is sucked from microwave power source by time mirror mechanism by sending phase conjugate laser beams of negative energy dark photons decaying into ordinary negative energy photons absorbed by the power source.

Jean Naudin has studied a system that he calls glow discharge plasma panel (GDP panel) [68] in an attempt to understand what happens in the generation of plasma by microwaves (see Figs 7.5.2 and 7.5.2). The system studied consists of a primary system generating pulses at frequency of $\sim 6$ kHz coupled via an ignition coil to a GDP coil containing no magnetic core. The GDP panel starts to glow and generates a plasma discharge in the surrounding air. The system is interesting since it could provide information allowing to develop a more detailed model for rotating magnetic systems and plasmoids.

The findings of J. Naudin relate to the behavior of currents breaking the basic rules of circuit theory, in particular the conservation of current. The resolution of the strange findings is based on the presence of the radial ohmic current in the GDP coil implying an exchange of charge with the surrounding air and also with the secondary ignition coil along the flux tubes of mutual induction magnetic field connecting these systems.

*1. How the rapid oscillating part of the current through the secondary ignition coil is generated*

The measurements [69, 70] show that in a closed circuit containing the secondary coil of ignition coil and GDP (glow discharge plasma) panel the voltage $V$ measured through the panel oscillates smoothly with a period of $\sim 6$ kHz (see Figs 7.5.2 and 7.5.2). On the other hand, the current $I$ through a resistor below the secondary coil of ignition coil oscillates rapidly and the amplitude of oscillation fluctuates wildly when the magnitude of $V$ is in certain critical interval. Also the correlation between $V$ and $I$ disappears during oscillations as the Lissajous figures demonstrate (see Figs 7.5.2 and 7.5.2).

Charge conservation requires that the secondary coil of the ignition coil must exchange charge with some system. What comes in mind is that there is oscillatory exchange of charge with the GDP coil.

Since the current through the resistor flows to the GDP coil and the voltage $V$ through it is smooth, there must be some compensation mechanism which takes care of this. The only thing that one can imagine is that following one. The oscillating current to GDP coil generates an oscillating part to the magnetic field through the GDP coil. This in turn induces an oscillating part to the radial ohmic current. If all of this oscillating current runs to the secondary of ignition coil it is in principle possible to have a situation in which the oscillating radial current compensates the effects of the oscillating ohmic current so that $V$ remains smooth.

*2. Why the magnitude of the output current from GDP coil is than the magnitude of the input current?*

The magnitude of the output $I_{GDP,out}$ current from the GDP coil is by a factor $\sim 3$ larger than the input current $I_{GDP,in}$ to the GDP coil. One can understand also this in terms of the current non-conservation caused by the radial Ohmic current.

The parity breaking implied by the classical long range $Z^0$ force is expected to favor second direction of rotation for the magnetic field and thus either positive or negative net charge for the GDP foil. Bio-molecules and cells, which provide basic examples of plasmoids, are negatively charged. If this holds also now, the radial Ohmic current tends to reduce the electron current running from output of GDP to its input associated with the rotating magnetic field since the current wire can provide electrons to the interior of the GDP coil.

There is however a problem. When the electron current flows from GDP input to output, input current should be larger than output current: this does not occur. Obviously, the direction of the rotation of the magnetic field should change during the second half of the oscillation period of $\sim 6$ kHz. The magneto-static frequency is given by $\omega GDP = \pm eH_{GDP}/m_e$, where $H_{GDP}$ corresponds to the magnitude of the magnetic field created by the current $I_{GDP}$. The change of sign is indeed possible if $H_{GDP}$ is proportional to $I_{GDP}$ so that it varies in an oscillatory manner during $\sim 6$ kHz period of oscillation. If $\omega$ changes sign when $H_{GDP}$ changes its direction, the behavior of the radial current is oscillatory. $H_{GDP}$ is proportional to $\int V_{GDP}dt$ in the approximation that the charge leakage due to the the radial ohmic current is neglected.

*3. The rapidly oscillating current through secondary ignition coil as a resonant coupling with GDP coil*

The wildly oscillating part to the current and the loss of $V - I$ correlation appears in certain critical range of absolute values of the voltage $V$ (see Figs 7.5.2 and 7.5.2). This conforms with the assumption that a magneto-static wave is generated in the ignition coil. The frequency of this wave is given by

$$\omega_I = \sqrt{\omega_{H_I} \times \omega_{H_I+M}} \ ,$$

where $M$ corresponds to the contribution to magnetic field from permanent magnetization of the ignition coil and $H_I$ from the current. Also this frequency changes its sign during $\sim 6$ kHz period. The resonance is achieved for

$$\omega_I = \omega_{GDP}$$

so that the resonant current flow between the two systems occurs only in some range of voltages $V$ for which the resonance condition is approximately satisfied.

The simplest assumption is that the charge flow between secondary ignition coil and GDP coil results from the dropping of electrons to the magnetic flux tubes of the mutual magnetic induction connecting the secondary ignition coil and GDP coil. At these coils the rotation of the magnetic field corresponds to spinning.

Naudin assumes that the rapid periodic oscillation corresponds to the onset of a plasma generation. Due to the shortness of the period of oscillation this assumption cannot be justified on basis of visual observations. In TGD framework this period corresponds to the onset of a rapidly oscillating component in the radial Ohmic current, whereas the slowly varying component is present all the time.

*4. The output current from GDP coil is reduced when the resistance in the output is increased*

A further anomalous feature from the point of view of ordinary circuit theory relates to the output current from GDP. Several independent measurements give the value $\sim 80$ mA for the GDP output current using 10 Ohm resistor and thus a power consumption of .8 Watt. On the other hand, the temperature of 100 Ohm resistor raises only by 2 Kelvins during 2 minutes. This means that the current through the 100 Ohm resistor must be much smaller than 80 mA through 10 Ohm resistor. This is not possible in standard circuit theory.

The resolution of the paradox is based on the presence of the radial Ohmic current. Current flow tends to favor the route of minimal resistance. If the value of the resistance is increased by a factor of 10, the portion of the radial Ohmic current going along the GDP wire is reduced and a larger portion of the current leaks to the surrounding air (its space-time sheet).

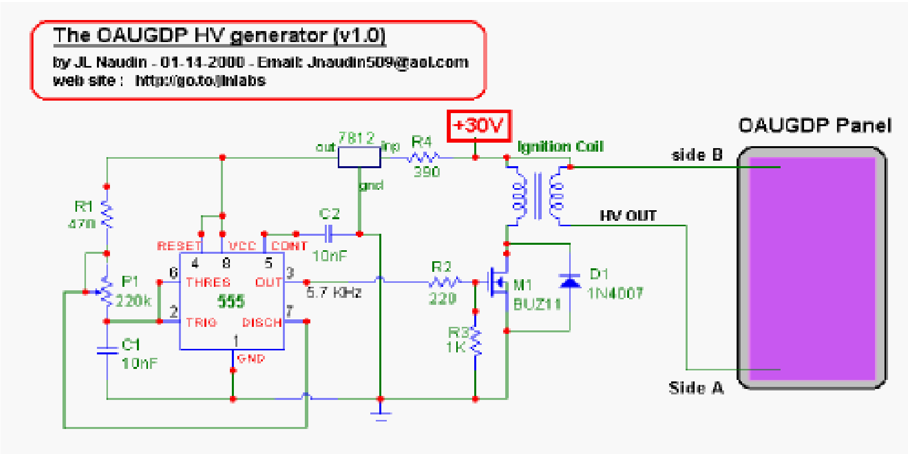


Figure 7.1: The figure illustrates the circuit used in Naudin's experiments. GDP coil does not have a magnetic core.

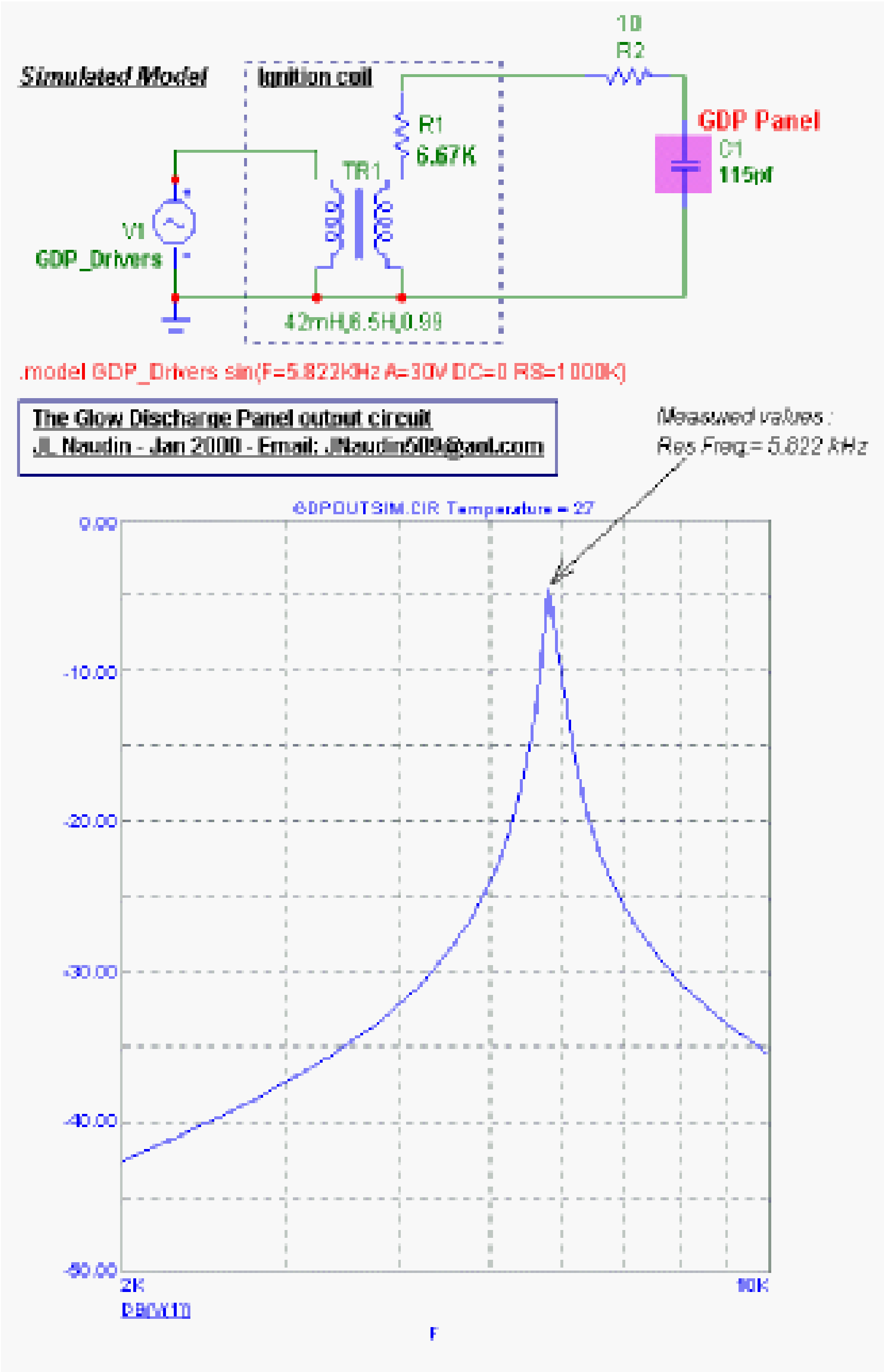


Figure 7.2: A schematic description of the experimental arrangement used by Naudin and the frequency distribution of current peaking around 5.822 kHz.

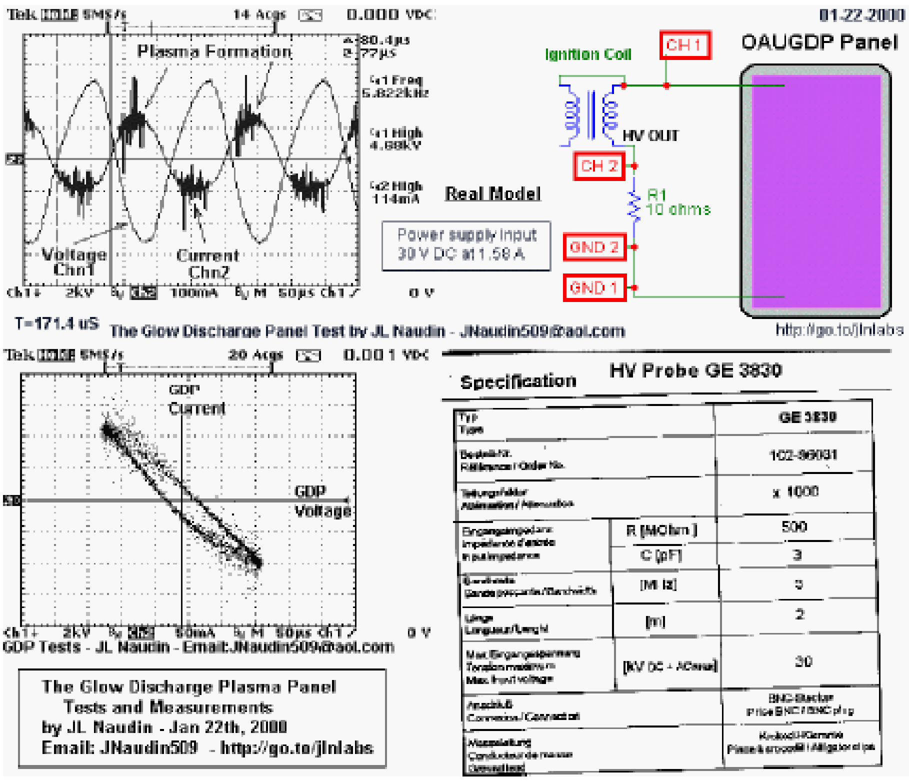


Figure 7.3: The figure illustrates the voltage $V$ over the GDP coil and the current $I$ through the 10 Ohm resistor as well as the Lissajous figure for expressing the correlation and phase relation between $V$ and $I$. Note that $V$ does not exhibit the rapid oscillation and that $I-V$ correlation disappears as the rapid oscillation appears in the current. $V$ and $I$ have same sign in the region where $I-V$ correlation is lost to high degree.

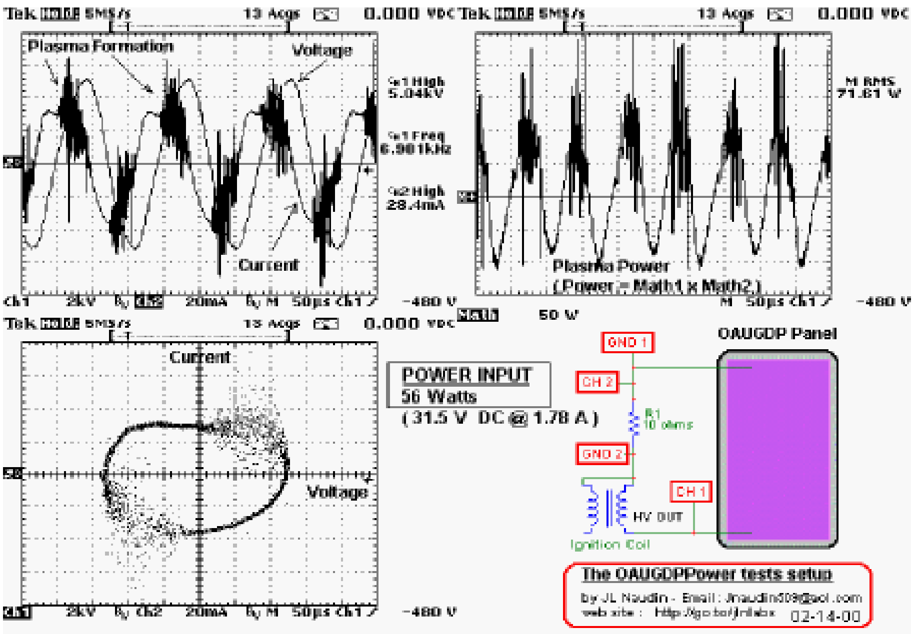


Figure 7.4: Second example of a similar measurement based with slightly different values of input DC voltage and current. Note that $I$ and $V$ have *opposite* sign over almost entire Lissajous figure, in particular in the region where $I - V$ correlation is lost to high degree.

#### Crop circles and plasmoids

During its development the idea about microwaves serving as a "food" of plasmoids found support from various sources. Intelligently behaving light balls are standard stuff of UFO reports. Plasma balls are also often reported to be associated with crop circles [71] (for a TGD based model of crop circle formations see [N2]).

Crop circles tend to appear in regions where the soil has a high concentration of calcium carbonate (lime stone) and is therefore electron rich meaning that the generation of negatively charged plasmoids is easier. Magnetic material is found in two thirds of the cases studied confined in regions of radius about .5 m.

Microwaves generated by plasmoids provide also the mechanism leading to the downing of crops. In regions where crops are flattened, there are clear alterations in growth nodes in the crop formation areas [72]. In particular, an expansion of growth nodes relative to normal is observed: this expansion is about 115 per cent for regular and 200 per cent for the irregular crop formations. Also tufts of standing plants within formation have node expansions equal to or exceeding the expansion level in flattened plants. Expanded nodes contain expulsion cavities which can be understood as resulting from a rapid and intense heating by micro-waves causing pressure buildup [72]: cellular components have literally blown out through epidermal cell walls. Node expansion is also accompanied by a bending. This suggests that the node expansion makes possible the downing of the crops.

### 7.5.3 Earth's magnetosphere as a gigantic plasmoid: did life evolve in the womb of Mother Gaia?

For a couple of years ago I studied a highly speculative scenario for a pre-biotic evolution involving plasmoids in an essential manner [N4]. The scenario led also to a model for the evolution of genetic code and DNA. The vision was inspired both by the problems of existing scenarios for pre-biotic evolution as well as by the ideas inspired by the work with crop circles [N2].

The crazy sounding idea, which I still find impossible to represent without some tongue in cheek, is that in many-sheeted space-time (and only here!) the interior of Earth could serve as a seat for plasmoid like life forms. Boundaries between two phases are always the regions where strong gradients appear and thus also intense self-organization occurs, and the boundary between solid mantle and liquid core is especially interesting as far as the evolution of plasmoid life forms is considered. The metabolic energy would be provided in this kind of environment continually by the dropping of particles from the hot space-time sheet carrying the molten iron.

The question is whether the creation of plasmoids in thunder storms is consistent with the idea that life evolved in the interior of Earth. To get some perspective one can pose first pose the question about whether Sun could provide X ray energy kicking electrons to atomic space-time sheets in some regions of atmosphere.

X rays are indeed emitted by Sun, by planets including Earth, and even by comets [73]. The formation of solar Corona and emission of X rays from it has remained more or less a mystery. The dropping of electrons to larger space-time sheets is a natural explanation for both the formation of corona consisting of highly ionized plasma in high temperature and for the emission of X rays from Corona [D6].

Plasmoids in the corona could provide a mechanism producing these X rays which supports the earlier suggestion that primitive plasmoid like life could flourish even under the extreme conditions of solar corona. X rays would be emitted by excited neutral and partially ionized molecules. The ionization and excitations would be produced in the collisions of highly energetic electrons dropped from $k = 131$ and $k = 137$ space-time sheets to larger space-time sheets (zero point kinetic energies are around 64 keV *resp.* 1 keV in these two cases). The dropping can also liberate highly energetic photons that can kick electrons back to the atomic space-time sheets of plasmoids.

X ray radiation from Sun reaches only the upper atmosphere down to height of about 40 km and ionizes it (the outcome is so called E layer) whereas the height at which thunder clouds develop is about 10-20 km. E layer could contain plasmoids but it is not clear whether solar X rays could supply metabolic energy for plasmoids in thunderstorms by kicking electrons back to the atomic space-time sheets. It might be that the lifetime of the primitive life forms in upper atmosphere and thunder storms is not longer than single day. If this the case the plasmoids would have excellent reason to penetrate to the interior of Earth.

The hypothesis that life in the biosphere has matured in the womb of Mother Gaia would solve several difficult problems of the standard scenarios of chemical evolution. The very notion of plasmoid alone could solve several basic problems since it replaces the dissipative energy feed with a precisely defined radial Ohmic current tailored for the individual anatomy of matter carrying space-time sheet, defines a hierarchy of universal metabolic energy currencies, and predicts pre-existing complex topological information carrying patterns defined by the magnetic bodies.

The problem is how to guarantee continual metabolism and sufficiently long life-time for plasmoids. The minimal requirement is radiation feeding energy to the dark matter magnetic transitions and highly energetic photons kicking ions back to the atomic space-time sheets. The space-time sheets in the interior of Earth could define a warm and safe womb for the life to evolve through the first crucial stages of chemical evolution when the chemical metabolic machinery including the ability to store photonic energy as chemical energy does not yet exist. In the many-sheeted space-time Earth's surface need not define an in-penetrable wall for plasmoids generated during thunder storms, and they could leak into the interior of Earth without difficulty (a metaphoric counterpart for fertilization).

This vision must sound absolutely bizarre in the mind set of simple standard physicist producing publications in single sheeted space-time but is perfectly natural in the fractal view in which also Earth's rotating magnetic field would naturally give rise to radial Ohmic currents and self organization in the interior of Earth. Magnetosphere would contain dark matter and be responsible for the higher levels of consciousness and serve as a seat of intentional action in accordance with the general vision [M1, N1]. EEG could be seen as a tool of commutations between brain and magnetosphere, and the strange delays of conscious experience [74] very difficult to understand in the framework of standard neuroscience have an elegant explanation in terms of finite signal velocity [K1].

### 7.5.4 Is the transformation of ordinary matter to dark matter possible in macroscopic length scales?

Even the possibility to transform ordinary matter to dark matter molecular length scales would have dramatic implications. For instance, it would give substantial support for the vision that the magnetic body of the Earth's magnetic field or its dark counterpart carrying the field $B_{end} = 2B_E/5$ serves as a circuitry allowing the transfer of bio-molecules in the length scale of magnetosphere [N4]. Note that the endogenous magnetic field $B_{end} = .2$ Gauss rather than $B_E$ with nominal value of .5 Gauss (as was the original erratic belief) explains the effects of ELF em fields in vertebrate brain in terms of cyclotron transitions. The model for these effects inspires the hypothesis that flux quanta of $B_E$ is accompanied by those of $B_{end}$ carrying dark matter with scaled up value of Planck constant $\hbar = n\hbar_0$ [M3]. For $B_{end}$ one would have $n = 5$.

The finding that rotating magnetic systems generate magnetic walls [61] and the hypothesis that these walls carry dark matter provide good clues about how to achieve this kind of phase transition. The model for plasmoids as primitive life-forms involving rotating magnetic fields relies on this finding. Plasmoids themselves might be able to transform to dark matter. Shoulders discovered the existence of micron sized negatively charged clusters containing about $10^{11}$ electrons and about $10^6$ ions which he reports to be able to transform to a invisible form [76, 77].

The possibility to perform this transformation for macroscopic objects would have even more dramatic implications since the objects in dark matter phase would pass through ordinary solids without any difficulty. The first implications that come in mind relate to technology (manipulation of properties of condensed matter from interior), to medicine (many-sheeted surgical operations), and research of large condensed matter systems (say the study of Earth's interior).

#### Are macroscopic visible-to-dark phase transitions possible?

One can wonder whether visible-to-dark phase transition could occur also spontaneously in macroscopic length scales. There is indeed quite a lot of documented evidence.

1. Hutchison effect [78] involves a catastrophic fracture of metal samples when posed to a radiation. Also physical objects of different composition were reported to become inexplicably embedded in each other once these objects were radiated. For a couple of years I discussed a model for this effect in [G1]. The phase transition involved with this model was not identified as ordinary-to-dark matter transformation but the basic many-sheeted mechanism inducing the temporary transparency is essentially the same.

2. The appearance of human made artifacts in places where they should not occur is this kind of effect. There are a lot of reports for this kind of artifacts [99, 100, 79]. These reports can of course be claimed to be just folklore. On the other hand, many of these artifacts are in museums and precise reports about where they were found exist. There are also reports about this kind of objects in journals like Scientific American [96] and Nature [97]. Hence one must consider seriously the possibility that the stories about artifacts in wrong place are real. Creationists have used these artifacts as an objection against Darwinian view about evolution and as a support that the actual age of universe is not more than what Bible tells. This kind of explanation is very difficult to take seriously by anyone with basic knowledge about science. T. Twietmeyer [79] has proposed that a transformation of the ordinary matter to a form in which it can pass ordinary matter is involved with these phenomena.

Man-made objects are reported to appear in so old archeological layers that even our species did not yet exist. The ages of the artifacts discussed in [99, 100, 79], if really the same as that of environment, vary from 50.000 years up to 300 million years.

Artifacts have been found inside rock, inside geods which are small spherical stones with hollow interiors lined with crystals, and inside coal. Examples of artifacts found are an object which seems to be a candlestick holder [96], "coin", nails, screw, an object which resembles spark plug [101], a strange cube like object made of iron [97], metal nodules, gold chain, iron pot, brass bell, etc...

Tornadoes are reported to induce transfer of human made artifacts to places where they should not exist [79]. A piece of field straw penetrating through a window pane without breaking it has been reported. According to second report, a rubber tire which was not cut appeared after tornado surrounding a telephone pole that had a wooden crossbar and power lines on top. This kind of topological impossibilities would be a clear-cut signature of the ordinary-to-dark phase transition. Tornadoes are indeed basic examples of primitive living systems involving rotating magnetic and $Z^0$ magnetic fields and thus generating magnetic walls or more general rotating flux quanta containing dark matter.

### TGD based explanation for artifacts in wrong places

The TGD based mechanism explaining the findings would be the transformation of the artifact to dark matter phase (its mass would not be changed appreciably) and subsequent free fall in the gravitational field of Earth in the case that the object still feeds its gravitational flux to the space-time sheet carrying Earth's gravitational field. The object would quite literally be swallowed by Earth. For a vanishing initial velocity the time $t$ spent in the dark matter phase would relate the depth $h$ at which the object falls freely as $t = \sqrt{2h/g}$, $g \simeq 10$ m/s$^2$. From the typical depths at which the objects are found, one can conclude that the time spent in dark matter phase is measured in seconds. A possible explanation is that the rotation period of magnetic field creating the dark matter phase is usually not longer than this.

Macroscopic quantities of dark matter could result in catastrophic events like fractures. The potential wall hindering the formation of the fracture might be overcome by the formation of dark matter phase in the immediate vicinity of the fracture. Nuclear transmutations should occur routinely in dark matter phase and there is indeed evidence for the transmutations in living matter [44], in cold fusion, and in fracto-fusion [43]. The long lasting emission of light from fractures (earth lights observed in the lines of seismic activity) might be identifiable as coherent beams of dark photons decaying to ordinary photons. Also UFOs might have interpretation as plasmoids.

The observed difficult-to-understand properties of lightnings might find explanation if lightning track is in dark matter phase so that charged particles are in effectively super-conducting phase so that electrons can accelerate to relativistic velocities. This suggests that electric discharges in high voltage could produce dark matter (perhaps this is one function of nerve pulse). Ball lightnings might induced generation of dark matter.

To sum up, it is very easy to get scientific respect by claiming that all these reports are cooked up by swindlers and taken seriously by crackpots. I however dare hope that some ingenious experimentalist would see the trouble of finding whether TGD explanation is correct by trying to develop a method of inducing the phase transition to dark matter along the lines proposed.

### Dark matter and supersolids

It might be that the strange ability of solid matter objects corresponding to different space-time sheets to move through each other has been already observed [30]. The existence of so called supersolids was predicted long time ago by Russian theoreticians Andreev and Liftschitz, who proposed that $^4$He, which is a bosonic solid at low temperatures and as a noble element has weak bonds between atoms, could make under a high enough pressure a phase transition to a supersolid state which is the analog of super-fluid state. Supersolid can be regarded as a Bose-Einstein condensate behaving like single particle and having vanishing friction with respect to other solids.

What the loss of friction with respect to other solid means is not quite clear. The conservative view is that supersolid can glide along another solid without friction. A more radical view is that supersolid can flow through other solids, even ordinary, without any friction.

There is empirical support for the latter option. The experimental procedure used by M. Chan and his student E. Kim [30] is roughly the following.

1. Compress $^4$He gas into a small glass disk made of fused silica containing atomic-sized pores.

2. Construct a torsional oscillator by hanging this disk to a string spinning with kHz frequency back and forth. Increase the pressure gradually from the solidification pressure 40 atm to 62 atm and monitor the oscillation frequency as the pressure is increased.

What is observed is a sudden increase of oscillation frequency at .2 K as if some of $^4$He had leaked out and the system would have lost some of its inertia. The experimenters have however excluded the leakage. Their explanation is in terms of the emergence of $^4$He supersolid phase which remains at rest since it has no friction: glass simply flows through it. The effect is absent for $^3$He, which is a fermionic solid, and this supports the conclusion of the experimentalists.

The ability to flow through another solid makes the notion of supersolid highly counterintuitive in ordinary single-sheeted space-time. Intuitively one tends to assign the friction with the boundary of the supersolid and solid rather than interior and this would mean that supersolid would only glide without friction along but not flow through another solid.

Quantum classical correspondence is the basic interpretational guideline of TGD and forces to ask what the space-time correlate for the formation of supersolid, or whatever is in question in the experiment, might be. The ability of the two solids to flow through each other can be understood if the formation of the supersolid involves the separation of supersolid phase to its own space-time sheet. This separation becomes possible if the friction between ordinary solid and supersolid vanishes. Obviously this interpretation is consistent with the conservative view and implies the radical view in many-sheeted space-time.

Large $\hbar$ supersolids could exist even at room temperature so that technological implications would be quite dramatic. Also the artifacts in wrong places could result by a temporary phase transition to large $\hbar$ supersolid phase. The low temperature of the phase transition suggests that $^4He$ is not large $\hbar$ phase.

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# Chapter 8

# About the New Physics Behind Qualia

## 8.1 Introduction

As the title expresses, this chapter was originally about the new physics behind qualia. The model of qualia indeed involves a lot of new physics: many-sheeted space-time; massless extremals; exotic Super Virasoro representations associated with discrete qualia; magnetic and cyclotron phase transitions associated with quantum critical quantum spin glass phases of exotic super conductors at cellular space-time sheets; classical color and electro-weak gauge fields in macroscopic length scales, to name the most important ingredients. Gradually the chapter however expanded so that it touches practically all new physics possibly relevant to TGD inspired quantum biology. Various physical mechanisms are discussed in exploratory spirit rather than restricting the consideration to those ideas which seem to be the final word about quantum biology or qualia just at this moment.

### 8.1.1 Living matter and dark matter

Dark matter is identified as a macroscopic quantum phase with large $\hbar$. Also living matter would involve in in an essential manner matter with a large value of $\hbar$ and hence dark, and form conformally confined (in the sense that the net conformal weight of the state is real) blobs behaving like single units with extremely quantal properties, including free will and intentional action in time scales familiar to us. Dark matter would be responsible for the mysterious vital force.

Any system for which some interaction becomes so strong that perturbation theory does not work, gives rise to this kind of system in a phase transition in which $\hbar$ increases to not lose perturbativity gives rise to this kind of "super-quantal" matter. In this sense emergence corresponds to strong coupling. One must however remember that emergence is actually much more and involves the notion of quantum jump. Dark matter made possible by dynamical $\hbar$ is necessary for macroscopic and macro-temporal quantum coherence and is thus prerequisite for emergence.

Physically large $\hbar$ means a larger unit for quantum numbers and this requires that single particle states form larger particle like units. This kind of collective states with weak mutual interactions are of course very natural in strongly interacting systems. At the level of quantum jumps quantum jumps integrate effectively to single quantum jump and longer moments of consciousness result. Conformal confinement guarantees all this. Entire hierarchy of size scales for conformally confined blobs is predicted corresponding to values of $\hbar$ related to Beraha numbers [E9, C6] but there would be only single value corresponding to very large $\hbar$ for given values of system parameters (gravitational masses, charges,...). The larger the value of $\hbar$ the longer the characteristic time scale of consciousness and of a typical life cycle.

The notion of field body means that dark matter at the magnetic flux tubes would serve as an intentional agent using biological body as a motor instrument and sensory receptor. Dark matter would be the miraculous substance that living systems are fighting for, and perhaps the most important substance in metabolic cycle.

### 8.1.2 Macroscopic quantum phases in many-sheeted space-time

The crucial empirical ingredient turned out to be the observations about the effects of oscillating ELF electromagnetic fields on central nervous system, endocrine system and immune system made after sixties [45, 42, 43, 45]. The largest effects are obtained at odd multiples of cyclotron frequencies of various biologically important ions like $Ca_{++}$ in Earth's magnetic field. Also amplitude modulation of RF and MW fields by these frequencies has effects. This leads to a surprising conclusion in violent conflict with standard physics view about world. Magnetically confined states of ions in Earth's magnetic field having minimal size of order cell size and energy scale of order $10^{-14}$ eV would be in question if ordinary quantum theory would be the final word. Dark matter hierarchy with the spectrum of Planck constants given by $\hbar(k) = \lambda^k \hbar_0$, $\lambda \simeq 2^{11}$, resolves the paradox [M3]. For $k = 4$ level of the dark matter hierarchy the energies $E(k) = \hbar(k)\omega$ of ELF photons are above thermal threshold for $f \geq 1$ Hz.

The notion of many-sheeted ionic equilibrium brings in in the mechanism with which supra-currents at the magnetic flux tubes control the matter at atomic space-time sheets. The strange anomalies challenging the notions of ionic channels and pumps [46] provide support for the resulting general vision.

### 8.1.3 Mind like space-time sheets as massless extremals

Mind like space-time sheets are the geometric correlates of selves. So called massless extremals (MEs) [J4] provide ideal and unique candidates for mind like space-time sheets. MEs give rise to hologram like cognitive representations. The assumption that they serve as Josephson junctions allows to understand the amplitude windows associated with the interaction of ELF em fields with brain tissue. The properties of MEs inspire the hypothesis that they give rise to an infinite hierarchy of electromagnetic life forms living in symbiosis with each other and bio-matter. EEG can be interpreted as associated with ELF MEs which is one important level in this hierarchy responsible for the cultural aspects of consciousness.

Our mental images propagating in neural circuits should correspond to microwave (MW) MEs with wavelengths below .3 meters. The communications between quantum antennae associated with ELF and RF MEs provides an elegant model for the formation and recall of long term memories and realize hologrammic cognitive representations. Self hierarchy has as a particular dynamical correlate the hierarchy of Josephson currents modulated by Josephson currents modulated by... having magnetic transition frequencies as their basic frequencies. Josephson currents flow along join along boundaries bonds connecting space-time sheets belonging at various levels of the hierarchy ('biofeedback').

### 8.1.4 Classical color and electro-weak fields in macroscopic length scales

One can say that the basic physics of standard model without symmetry breaking and color magnetic confinement is realized at classical level on cellular space-time sheets. Classical $Z^0$ fields, $W$ fields and gluon fields unavoidably accompany non-orthogonal electric and magnetic fields. The proper interpretation of this prediction is in terms of a p-adic and dark fractal hierarchies of standard model physics with scaled down mass scales making possible long range weak and color interactions in arbitrarily long length scales.

This prediction forces to modify even the model of nuclei [F8]. Nucleons carry exotic color and form nuclear strings consisting of color bonds with exotic quark $q$ and antiquark $\overline{q}$ at their ends. These exotic quarks correspond to $k = 127$ level of dark matter hierarchy. Also dark variants of ordinary quarks with size of about atom are possible. It is also possible to have $u\overline{d}$ and $\overline{u}d$ type color bonds which carry em and weak charge and this means exotic nuclear ionization. Tetraneutron [69, 70] would represent one particular example of this kind of exotically ionized nucleus [F8]. Exotic nuclear physics would have also implications for the ordinary condensed matter physics and could be involved with the very low compressibility of liquid phase and the anomalous behavior of water [F10].

Exotic ionization is the key element in the quantum model for the control action of the magnetic body on biological body. Exotic ionization induces dark plasma oscillations which in turn generate via classical em fields ordinary ohmic currents at the level of the ordinary matter. Nerve pulse patterns [M2] and $Ca^{2+}$ waves [K6, K5] would represent examples of physiological correlates of this quantum control.

### 8.1.5 p-Adic-to-real transitions as transformation of intentions to actions

Hearing and cognition are very closely related: one could even argue that we think using language. The view that p-adic physics is physics of intention and cognition leads to the vision that the transformation of thoughts to actions and sensory inputs to thoughts correspond to real–p-adic phase transitions for space-time sheets. For a long time the question how p-adic space-time sheets relate to the real ones lacked a precise answer, and therefore also the question what the transformation of p-adic space-time sheet to real ones really means. The advances in the understanding the precise relationship between p-adic and real space-time sheets discussed in [E1] led however to a definite progress in this respect [H8].

The transformation of p-adic space-time sheets to real ones must respect the conservation of quantum numbers: this requires that the real system either receives or sends energy when the p-adic-to-real transitions realizing the intention occurs. If p-adic ME is transformed to a negative energy ME in the process, real system must make a transition to a higher energy state. This kind of transitions cannot occur spontaneously so that the outcome is a precisely targeted realization of intention. The additional bonus is that buy now-let others pay mechanism makes possible extreme flexibility. There are reasons to expect that the energies involves cannot be too high however.

The model of intentional action as a quantum transition for which the probabilities for various intention-action pairs should in principle be deducible from S-matrix is discussed in [E1] using the vision about physics as a generalized number theory as a guide line. This model leads to fresh insights about the construction of the ordinary S-matrix and essentially the same kind of general expressions for S-matrix elements result as in the case of ordinary scattering.

This picture provides conceptual tools making it possible to discuss the questions what the notion of p-adic cognitive neutrino pair could mean and whether it makes sense to speak about the transformation of p-adic cognitive neutrino pairs to a real cognitive neutrino pairs.

### 8.1.6 Exotic super-Virasoro representations

A further piece of new physics of qualia are super-canonical and super-conformal algebras associated with the light-like $M^4_+$ projections of the light-like boundaries MEs. p-Adic considerations suggest that $L_0 = 0$ condition might be replaced by a weaker condition $L_0 \ mod \ p^n = 0$ in the p-adic context. The interpretation would be in terms of continuous scaling invariance broken to discrete scalings by powers of $p$: the analogy with lattice systems of condensed matter is obvious. The general condition $a^{L_0} \ mod \ p = 1$, $a$ positive integer, stating invariance under scalings is by Fermat's little theorem satisfied $L_0 \ mod \ p = 0$ and would state that these scalings act like translations by multiples of lattice vector in lattice.

$p \simeq 2^k$ would guarantee approximately the conditions for $a = 2$. For Mersenne primes, which are in an exceptional role physically, these conditions are satisfied in excellent approximation. The so called Gaussian Mersennes allow also to satisfy these conditions in somewhat more general sense and, rather remarkably, there are four Gaussian Mersennes in the length scale range between cell membrane thickness and cell size.

The model for how local p-adic physics codes for the p-adic fractality of the real physics and for intentional action as a quantum jump transforming p-adic space-time sheet to a real one leads to a rather detailed view about the p-adic fractals possibly giving rise to exotic Super Virasoro representations [E1, H8].

The degeneracy of states for exotic representations (number of states with same $L_0$) is enormous for the physically interesting values of p-adic prime $p$. This means that these states provide huge negentropy resources. Thus exotic super-canonical representations be interpreted as quantum level articulation for the statement that TGD Universe is quantum critical quantum spin glass. Exotic super-canonical representations clearly provide an excellent candidate for an infinite hierarchy of life forms. These life forms would come in two classes.

1. The representatives of the first class labelled by three integers $(k, m, n)$ if one assumes that physically interesting primes correspond to $p \simeq 2^{k^m}$, $k$ prime and $m$ are integers: $n$ is the power appearing in $L_0 \propto p^n$.

2. The representatives of the second class are labelled by the integers $k$ $L_0 \propto 2^k$, such that $2^k - 1$ is Mersenne prime or $(1 + i)^k - 1$ is Gaussian Mersenne.

It is tempting to assume that it is these life forms emerge already in elementary particle length scales and become increasingly complex when the p-adic length scale increases. Life could perhaps be regarded as a symbiosis of these life forms with super-conducting magnetic flux tubes and ordinary matter at atomic space-time sheets. These life forms ('mind') interact with each other, super-conducting magnetic flux tubes and ordinary matter via the classical gauge fields associated with MEs. A natural hypothesis is that the quantum phase transitions of the macroscopic quantum phases for the particles of the exotic super-canonical representations formed in classical fields of MEs (mind like space-time sheets) give rise to some (but not all) qualia.

## 8.2 Dark matter and living matter

In the sequel general ideas about the role of dark matter in condensed matter physics are described.

### 8.2.1 Quantum criticality, hierarchy of dark matters, and dynamical $\hbar$

Quantum criticality is the basic characteristic of TGD Universe and quantum critical superconductors provide an excellent test bed to develop the ideas related to quantum criticality into a more concrete form.

#### Quantization of Planck constants and the generalization of the notion of imbedding space

The recent geometric interpretation for the quantization of Planck constants is based on Jones inclusions of hyper-finite factors of type $II_1$ [A9].

1. Different values of Planck constant correspond to imbedding space metrics involving scalings of $M^4$ *resp.* $CP_2$ parts of the metric deduced from the requirement that distances scale as $\hbar(M^4)$ *resp.* $\hbar(M^4)$. Denoting the Planck constants by $\hbar(M^4) = n_a\hbar_0$ and $\hbar(CP_2) = n_b\hbar_0$, one has that covariant metric of $M^4$ is proportional to $n_b^2$ and covariant metric of $CP_2$ to $n_a^2$. In Kähler action only the effective Planck constant $\hbar_{eff}/\hbar_0 = \hbar(M^4)/\hbar(CP_2)$ appears and by quantum classical correspondence same is true for Schödinger equation. Elementary particle mass spectrum is also invariant. Same applies to gravitational constant. The alternative assumption that $M^4$ Planck constant is proportional to $n_b$ would imply invariance of Schrödinger equation but would not allow to explain Bohr quantization of planetary orbits and would to certain degree trivialize the theory.

2. $M^4$ and $CP_2$ Planck constants do not fully characterize a given sector $M^4_\pm \times CP_2$. Rather, the scaling factors of Planck constant given by the integer $n$ characterizing the quantum phase $q = exp(i\pi/n)$ corresponds to the order of the maximal cyclic subgroup for the group $G \subset SU(2)$ characterizing the Jones inclusion $\mathcal{N} \subset \mathcal{M}$ of hyper-finite factors realized as subalgebras of the Clifford algebra of the "world of the classical worlds". This means that subfactor $\mathcal{N}$ gives rise to $G$-invariant configuration space spinors having interpretation as $G$-invariant fermionic states.

3. $G_b \subset SU(2) \subset SU(3)$ defines a covering of $M^4_+$ by $CP_2$ points and $G_a \subset SU(2) \subset SL(2,C)$ covering of $CP_2$ by $M^4_+$ points with fixed points defining orbifold singularities. Different sectors are glued together along $CP_2$ if $G_b$ is same for them and along $M^4_+$ if $G_a$ is same for them. The degrees of freedom lost by $G$-invariance in fermionic degrees of freedom are gained back since the discrete degrees of freedom provided by covering allow many-particle states formed from single particle states realized in $G$ group algebra. Among other things these many-particle states make possible the notion of N-atom.

4. Phases with different values of scalings of $M^4$ and $CP_2$ Planck constants behave like dark matter with respect to each other in the sense that they do not have direct interactions except at criticality corresponding to a leakage between different sectors of imbedding space glued together along $M^4$ or $CP_2$ factors. In large $\hbar(M^4)$ phases various quantum time and length scales are scaled up which means macroscopic and macro-temporal quantum coherence. In particular, quantum energies associated with classical frequencies are scaled up by a factor $n_a/n_b$ which is of special relevance for cyclotron energies and phonon energies (superconductivity). For large $\hbar(CP_2)$ the value of $\hbar_{eff}$ is small: this leads to interesting physics: in particular the binding energy scale of hydrogen atom increases by the factor $n_b/n_a^2$.

### A further generalization of the notion of imbedding space?

The original idea was that the proposed modification of the imbedding space could explain naturally phenomena like quantum Hall effect involving fractionization of quantum numbers like spin and charge. This does not however seem to be the case. $G_a \times G_b$ implies just the opposite if these quantum numbers are assigned with the symmetries of the imbedding space. For instance, quantization unit for orbital angular momentum becomes $n_a$ where $Z_{n_a}$ is the maximal cyclic subgroup of $G_a$.

One can however imagine of obtaining fractionization at the level of imbedding space for space-time sheets, which are analogous to multi-sheeted Riemann surfaces (say Riemann surfaces associated with $z^{1/n}$ since the rotation by $2\pi$ understood as a homotopy of $M^4$ lifted to the space-time sheet is a non-closed curve. Continuity requirement indeed allows fractionization of the orbital quantum numbers and color in this kind of situation.

*1. Both covering spaces and factor spaces are possible*

The observation above stimulates the question whether it might be possible in some sense to replace $H$ or its factors by their multiple coverings.

1. This is certainly not possible for $M^4$, $CP_2$, or $H$ since their fundamental groups are trivial. On the other hand, the fixing of quantization axes implies a selection of the sub-space $H_4 = M^2 \times S^2 \subset M^4 \times CP_2$, where $S^2$ is a geodesic sphere of $CP_2$. $\hat{M}^4 = M^4 \backslash M^2$ and $\hat{CP}_2 = CP_2 \backslash S^2$ have fundamental group $Z$ since the codimension of the excluded sub-manifold is equal to two and homotopically the situation is like that for a punctured plane. The exclusion of these sub-manifolds defined by the choice of quantization axes could naturally give rise to the desired situation.

2. Zero energy ontology forces to modify this picture somewhat. In zero energy ontology causal diamonds ($CD$s) defined as the intersections of future and past directed light-cones are loci for zero energy states containing positive and negative energy parts of state at the two light-cone boundaries. The location of $CD$ in $M^4$ is arbitrary but p-adic length scale hypothesis suggests that the temporal distances between tips of $CD$ come as powers of 2 using $CP_2$ size as unit. Thus $M^4$ is replaces by $CD$ and $\hat{M}^4$ is replaced with $\hat{CD}$ defined in obvious manner.

3. $H_4$ represents a straight cosmic string inside $CD$. Quantum field theory phase corresponds to Jones inclusions with Jones index $\mathcal{M} : \mathcal{N} < 4$. Stringy phase would by previous arguments correspond to $\mathcal{M} : \mathcal{N} = 4$. Also these Jones inclusions are labeled by finite subgroups of $SO(3)$ and thus by $Z_n$ identified as a maximal Abelian subgroup.

   One can argue that cosmic strings are not allowed in QFT phase. This would encourage the replacement $\hat{CD} \times \hat{CP}_2$ implying that surfaces in $CD \times S^2$ and $(M^2 \cap CD) \times CP_2$ are not allowed. In particular, cosmic strings and $CP_2$ type extremals with $M^4$ projection in $M^2$ and thus light-like geodesic without zitterwebegung essential for massivation are forbidden. This brings in mind instability of Higgs=0 phase.

4. The covering spaces in question would correspond to the Cartesian products $\hat{CD}_{n_a} \times \hat{CP}_{2n_b}$ of the covering spaces of $\hat{CD}$ and $\hat{CP}_2$ by $Z_{n_a}$ and $Z_{n_b}$ with fundamental group is $Z_{n_a} \times Z_{n_b}$. One can also consider extension by replacing $M^2 \cap CD$ and $S^2$ with its orbit under $G_a$ (say tedrahedral, octahedral, or icosahedral group). The resulting space will be denoted by $\hat{CD} \hat{\times} G_a$ *resp.* $\hat{CP}_2 \hat{\times} G_b$.

5. One expects the discrete subgroups of $SU(2)$ emerge naturally in this framework if one allows the action of these groups on the singular sub-manifolds $M^2 \cap CD$ or $S^2$. This would replace the singular manifold with a set of its rotated copies in the case that the subgroups have genuinely 3-dimensional action (the subgroups which corresponds to exceptional groups in the ADE correspondence). For instance, in the case of $M^2 \cap CD$ the quantization axes for angular momentum would be replaced by the set of quantization axes going through the vertices of tedrahedron, octahedron, or icosahedron. This would bring non-commutative homotopy groups into the picture in a natural manner.

6. Also the orbifolds $\hat{CD}/G_a \times \hat{CP}_2/G_b$ can be allowed as also the spaces $\hat{CD}/G_a \times (\hat{CP}_2 \hat{\times} G_b)$ and $(\hat{CD} \hat{\times} G_a) \times \hat{CP}_2/G_b$. Hence the previous framework would generalize considerably by the allowance of both coset spaces and covering spaces.

There are several non-trivial questions related to the details of the gluing procedure and phase transition as motion of partonic 2-surface from one sector of the imbedding space to another one.

1. How the gluing of copies of imbedding space at $(M^2 \cap CD) \times CP_2$ takes place? It would seem that the covariant metric of $M^4$ factor proportional to $\hbar^2$ must be discontinuous at the singular manifold since only in this manner the idea about different scaling factor of $M^4$ metric can make sense. This is consistent with the identical vanishing of Chern-Simons action in $M^2 \times S^2$.

2. One might worry whether the phase transition changing Planck constant means an instantaneous change of the size of partonic 2-surface in $CD$ degrees of freedom. This is not the case. Light-likeness in $(M^2 \cap CD) \times S^2$ makes sense only for surfaces $X^1 \times D^2 \subset (M^2 \cap CD) \times S^2$, where $X^1$ is light-like geodesic. The requirement that the partonic 2-surface $X^2$ moving from one sector of $H$ to another one is light-like at $(M^2 \cap CD) \times S^2$ irrespective of the value of Planck constant requires that $X^2$ has single point of $(M^2 \cap CD)$ as $M^2$ projection. Hence no sudden change of the size $X^2$ occurs.

3. A natural question is whether the phase transition changing the value of Planck constant can occur purely classically or whether it is analogous to quantum tunneling. Classical non-vacuum extremals of Chern-Simons action have two-dimensional $CP_2$ projection to homologically non-trivial geodesic sphere $S^2_I$. The deformation of the entire $S^2_I$ to homologically trivial geodesic sphere $S^2_{II}$ is not possible so that only combinations of partonic 2-surfaces with vanishing total homology charge (Kähler magnetic charge) can in principle move from sector to another one, and this process involves fusion of these 2-surfaces such that $CP_2$ projection becomes single homologically trivial 2-surface. A piece of a non-trivial geodesic sphere $S^2_I$ of $CP_2$ can be deformed to that of $S^2_{II}$ using 2-dimensional homotopy flattening the piece of $S^2$ to curve. If this homotopy cannot be chosen to be light-like, the phase transitions changing Planck constant take place only via quantum tunnelling. Obviously the notions of light-like homotopies (cobordisms) and classical light-like homotopies (cobordisms) are very relevant for the understanding of phase transitions changing Planck constant.

*2. Do factor spaces and coverings correspond to the two kinds of Jones inclusions?*

What could be the interpretation of these two kinds of spaces?

1. Jones inclusions appear in two varieties corresponding to $\mathcal{M} : \mathcal{N} < 4$ and $\mathcal{M} : \mathcal{N} = 4$ and one can assign a hierarchy of subgroups of $SU(2)$ with both of them. In particular, their maximal Abelian subgroups $Z_n$ label these inclusions. The interpretation of $Z_n$ as invariance group is natural for $\mathcal{M} : \mathcal{N} < 4$ and it naturally corresponds to the coset spaces. For $\mathcal{M} : \mathcal{N} = 4$ the interpretation of $Z_n$ has remained open. Obviously the interpretation of $Z_n$ as the homology group defining covering would be natural.

2. $\mathcal{M} : \mathcal{N} = 4$ should correspond to the allowance of cosmic strings and other analogous objects. Does the introduction of the covering spaces bring in cosmic strings in some controlled manner? Formally the subgroup of $SU(2)$ defining the inclusion is $SU(2)$ would mean that states are $SU(2)$ singlets which is something non-physical. For covering spaces one would however obtain the degrees of freedom associated with the discrete fiber and the degrees of freedom in question would not disappear completely and would be characterized by the discrete subgroup of $SU(2)$.

   For anyons the non-trivial homotopy of plane brings in non-trivial connection with a flat curvature and the non-trivial dynamics of topological QFTs. Also now one might expect similar non-trivial contribution to appear in the spinor connection of $\hat{CD}\hat{\times}G_a$ and $\hat{CP}_2\hat{\times}G_b$. In conformal field theory models non-trivial monodromy would correspond to the presence of punctures in plane.

3. For factor spaces the unit for quantum numbers like orbital angular momentum is multiplied by $n_a$ *resp.* $n_b$ and for coverings it is divided by this number. These two kind of spaces are in a well defined sense obtained by multiplying and dividing the factors of $\hat{H}$ by $G_a$ *resp.* $G_b$ and multiplication and division are expected to relate to Jones inclusions with $\mathcal{M} : \mathcal{N} < 4$ and $\mathcal{M} : \mathcal{N} = 4$, which both are labeled by a subset of discrete subgroups of SU(2).

4. The discrete subgroups of $SU(2)$ with fixed quantization axes possess a well defined multiplication with product defined as the group generated by forming all possible products of group elements as elements of $SU(2)$. This product is commutative and all elements are idempotent and thus analogous to projectors. Trivial group $G_1$, two-element group $G_2$ consisting of reflection and identity, the cyclic groups $Z_p$, $p$ prime, and tedrahedral, octahedral, and icosahedral groups are the generators of this algebra.

By commutativity one can regard this algebra as an 11-dimensional module having natural numbers as coefficients ("rig"). The trivial group $G_1$, two-element group $G_2$¡ generated by reflection, and tedrahedral, octahedral, and icosahedral groups define 5 generating elements for this algebra. The products of groups other than trivial group define 10 units for this algebra so that there are 11 units altogether. The groups $Z_p$ generate a structure analogous to natural numbers acting as analog of coefficients of this structure. Clearly, one has effectively 11-dimensional commutative algebra in 1-1 correspondence with the 11-dimensional "half-lattice" $N^{11}$ ($N$ denotes natural numbers). Leaving away reflections, one obtains $N^7$. The projector representation suggests a connection with Jones inclusions. An interesting question concerns the possible Jones inclusions assignable to the subgroups containing infinitely manner elements. Reader has of course already asked whether dimensions 11, 7 and their difference 4 might relate somehow to the mathematical structures of M-theory with 7 compactified dimensions. One could introduce generalized configuration space spinor fields in the configuration space labelled by sectors of $H$ with given quantization axes. By introducing Fourier transform in $N^{11}$ one would formally obtain an infinite-component field in 11-D space.

The question how do the Planck constants associated with factors and coverings relate is far from trivial and I have considered several options.

1. If one assumes that $\hbar^2(X)$, $X = M^4$, $CP_2$ corresponds to the scaling of the covariant metric tensor $g_{ij}$ and performs an over-all scaling of metric allowed by Weyl invariance of Kähler action by dividing metric with $\hbar^2(CP_2)$, one obtains $r^2 \equiv \hbar^2/\hbar_0^2\hbar^2(M^4)/\hbar^2(CP_2)$. This puts $M^4$ and $CP_2$ in a very symmetric role and allows much more flexibility in the identification of symmetries associated with large Planck constant phases.

2. Algebraist would argue that Planck constant must define a homomorphism respecting multiplication and division (when possible) by $G_i$. This requires $r(X) = \hbar(X)\hbar_0 = n$ for covering and $r(X) = 1/n$ for factor space or vice versa. This gives two options.

3. Option I: $r(X) = n$ for covering and $r(X) = 1/n$ for factor space gives $r \equiv \hbar/\hbar_0 = r(M^4)/r(CP_2)$. This gives $r = n_a/n_b$ for $\hat{H}/G_a \times G_b$ option and $r = n_b/n_a$ for $\hat{H}ti\hat{m}es(G_a \times G_b)$ option with obvious formulas for hybrid cases.

4. Option II: $r(X) = 1/n$ for covering and $r(X) = n$ for factor space gives $r = r(CP_2)/r(M^4)$. This gives $r = n_b/n_a$ for $\hat{H}/G_a \times G_b$ option and $r = n_a/n_b$ for $\hat{H}ti\hat{m}es(G_a \times G_b)$ option with obvious formulas for the hybrid cases.

5. At quantum level the fractionization would come from the modification of fermionic anti-commutation (bosonic commutation) relations involving $\hbar$ at the right hand side so that particle number becomes a multiple of $1/n$ or $n$. If one postulates that the total number states is invariant in the transition, the increase in the number of sheets is compensated by the increase of the fundamental phase space volume proportional to $\hbar$. This would give $r(X) \rightarrow r(X)/n$ for factor space and $r(X) \rightarrow nr(X)$ for the covering space to compensate the $n$-fold reduction/increase of states. This would favor Option II.

6. The second manner to distinguish between these two options is to apply the theory to concrete physical situations. Since $G_a$ and $G_b$ act as symmetries in $CD$ and $CP_2$ degrees of freedom, one might of being able to distinguish between the two options if it is possible to distinguish between the action of $G$ as symmetry of quantum states associated with covering and factor space. Also the quantization of the orbital spin quantum number at single particle level as multiples of $n$ can be distinguished from that in multiples of $1/n$.

*3. A simple model of fractional quantum Hall effect*

The generalization of the imbedding space suggests that it could possible to understand fractional quantum Hall effect [35] at the level of basic quantum TGD. This section represents the first rough model of QHE constructed for a couple of years ago is discussed. Needless to emphasize, the model represents only the basic idea and involves ad hoc assumption about charge fractionization.

Recall that the formula for the quantized Hall conductance is given by

$$\begin{aligned} \sigma &= \nu \times \frac{e^2}{h} \ , \\ \nu &= \frac{n}{m} \ . \end{aligned} \tag{8.2.1}$$

Series of fractions in $\nu = 1/3, 2/5, 3/7, 4/9, 5/11, 6/13, 7/15..., 2/3, 3/5, 4/7, 5/9, 6/11, 7/13..., 5/3, 8/5, 11/7, 14/9...4/3, 7/5, 10$ $1/5, 2/9, 3/13..., 2/7, 3/11..., 1/7....$ with odd denominator have been observed as are also $\nu = 1/2$ and $\nu = 5/2$ states with even denominator [35].

The model of Laughlin [34] cannot explain all aspects of FQHE. The best existing model proposed originally by Jain is based on composite fermions resulting as bound states of electron and even number of magnetic flux quanta [36]. Electrons remain integer charged but due to the effective magnetic field electrons appear to have fractional charges. Composite fermion picture predicts all the observed fractions and also their relative intensities and the order in which they appear as the quality of sample improves.

The generalization of the notion of imbedding space suggests the possibility to interpret these states in terms of fractionized charge, spin, and electron number. There are four combinations of covering and factors spaces of $CP_2$ and three of them can lead to the increase of Planck constant. Besides this there are two options for the formula of Planck constant so that which the very meager theoretical background one can make only guesses. On the following just for fun consideration option I is considered although the conservation of number of states in the phase transition changing $\hbar$ favors option II.

1. The easiest manner to understand the observed fractions is by assuming that both $M^4$ and $CP_2$ correspond to covering spaces so that both spin and electric charge and fermion number are fractionized. This means that $e$ in electronic charge density is replaced with fractional charge. Quantized magnetic flux is proportional to $e$ and the question is whether also here fractional charge appears. Assume that this does not occur.

2. With this assumption the expression for the Planck constant becomes for Option II as $r = \hbar/\hbar_0 = n_a/n_b$ and charge and spin units are equal to $1/n_b$ and $1/n_a$ respectively. This gives $\nu = nn_a/n_b$. The values $m = 2, 3, 5, 7, ..$ are observed. Planck constant can have arbitrarily large values. There are general arguments stating that also spin is fractionized in FQHE.

3. The appearance of $\nu = 5/2$ has been observed [37]. The fractionized charge is $e/4$ in this case. Since $n_i > 3$ holds true if coverings are correlates for Jones inclusions, this requires to $n_b = 4$ and $n_a = 10$. $n_b$ predicting a correct fractionization of charge. The alternative option would be $n_b = 2$ that also $Z_2$ would appear as the fundamental group of the covering space. Filling fraction 1/2 corresponds in the composite fermion model and also experimentally to the limit of zero magnetic field [36]. $n_b = 2$ is however inconsistent with the observed fractionization of electric charge and with the vision inspired by Jones inclusions.

4. A possible problematic aspect of the TGD based model is the experimental absence of even values of $n_b$ except $n_b = 2$ (Laughlin's model predicts only odd values of $n$). A possible explanation is that by some symmetry condition possibly related to fermionic statistics (as in Laughlin model) $n_a/n_b$ must reduce to a rational with an odd denominator for $n_b > 2$. In other words, one has $n_a \propto 2^r$, where $2^r$ the largest power of 2 divisor of $n_b$.

5. Large values of $n_a$ emerge as $B$ increases. This can be understood from flux quantization. One has $e\int BdS = n\hbar(M^4) = nn_a\hbar_0$. By using actual fractional charge $e_F = e/n_b$ in the flux factor would give $e_F \int BdS = n(n_a/n_b)\hbar_0 = n\hbar$. The interpretation is that each of the $n_a$ sheets contributes one unit to the flux for $e$. Note that the value of magnetic field in given sheet is not affected so that the build-up of multiple covering seems to keep magnetic field strength below critical value.

6. The understanding of the thermal stability is not trivial. The original FQHE was observed in 80 mK temperature corresponding roughly to a thermal energy of $T \sim 10^{-5}$ eV. For graphene the effect is observed at room temperature. Cyclotron energy for electron is (from $f_e = 6 \times 10^5$ Hz at $B = .2$ Gauss) of order thermal energy at room temperature in a magnetic field varying in the range 1-10 Tesla. This raises the question why the original FQHE requires so low temperature. The magnetic energy of a flux tube of length $L$ is by flux quantization roughly $e^2B^2S \sim E_c(e)m_eL$ ($\hbar_0 = c = 1$) and exceeds cyclotron roughly by a factor $L/L_e$, $L_e$ electron Compton length so that thermal stability of magnetic flux quanta is not the explanation. A possible explanation is that since FQHE involves several values of Planck constant, it is quantum critical phenomenon and is characterized by a critical temperature. The differences of the energies associated with the phase with ordinary Planck constant and phases with different Planck constant would characterize the transition temperature.

As already noticed, it is possible to imagine several other options and the identification of charge unit is rather ad hoc. Therefore this model can be taken only as a warm-up exercise. In [F12] Quantum Hall effect and charge fractionization are discussed in detail and one ends up with a rather detailed view about the delicacies of the Kähler structure of generalized imbedding space.

### Preferred values of Planck constants

Number theoretic considerations favor the hypothesis that the integers corresponding to Fermat polygons constructible using only ruler and compass and given as products $n_F = 2^k \prod_s F_s$, where $F_s = 2^{2^s} + 1$ are distinct Fermat primes, are favored. The reason would be that quantum phase $q = exp(i\pi/n)$ is in this case expressible using only iterated square root operation by starting from rationals. The known Fermat primes correspond to $s = 0, 1, 2, 3, 4$ so that the hypothesis is very strong and predicts that p-adic length scales have satellite length scales given as multiples of $n_F$ of fundamental p-adic length scale. $n_F = 2^{11}$ corresponds in TGD framework to a fundamental constant expressible as a combination of Kähler coupling strength, $CP_2$ radius and Planck length appearing in the expression for the tension of cosmic strings, and the powers of $2^{11}$ seem to be especially favored as values of $n_a$ in living matter [M3].

### How Planck constants are visible in Kähler action?

$\hbar(M^4)$ and $\hbar(CP_2)$ appear in the commutation and anticommutation relations of various superconformal algebras. Only the ratio of $M^4$ and $CP_2$ Planck constants appears in Kähler action and is due to the fact that the $M^4$ and $CP_2$ metrics of the imbedding space sector with given values of Planck constants are proportional to the corresponding Planck constants [A9]. This implies that Kähler function codes for radiative corrections to the classical action, which makes possible to consider the possibility that higher order radiative corrections to functional integral vanish as one might expect at quantum criticality. For a given p-adic length scale space-time sheets with all allowed values of Planck constants are possible. Hence the spectrum of quantum critical fluctuations could in the ideal case correspond to the spectrum of $\hbar$ coding for the scaled up values of Compton lengths and other quantal lengths and times. If so, large $\hbar$ phases could be crucial for understanding of quantum critical superconductors, in particular high $T_c$ superconductors.

### Phase transitions changing the level in dark matter hierarchy

The identification of the precise criterion characterizing dark matter phase is far from obvious. TGD actually suggests an infinite number of phases which are dark relative to each other in some sense and can transform to each other only via a phase transition which might be called de-coherence or its reversal and which should be also characterized precisely.

A possible solution of the problem comes from the general construction recipe for S-matrix. Fundamental vertices correspond to partonic 2-surfaces representing intersections of incoming and outgoing light-like partonic 3-surfaces.

1. If the characterization of the interaction vertices involves all points of partonic 2-surfaces, they must correspond to definite value of Planck constant and more precisely, definite groups $G_a$ and $G_b$ characterizing dark matter hierarchy. Particles of different phases could not appear

in the same vertex and a phase transition changing the particles to each other analogous to a de-coherence would be necessary.

2. If transition amplitudes involve only a discrete set of common orbifold points of 2-surface belonging to different sectors then the phase transition between relatively dark matters can be described in terms of S-matrix. It seems that this option is the correct one. In fact, also propagators are essential for the interactions of visible and dark matter and since virtual elementary particles correspond at space-time level $CP_2$ type extremals with 4-dimensional $CP_2$ projection, they cannot leak between different sectors of imbedding space and therefore cannot mediate interactions between different levels of the dark matter hierarchy. This would suggest that the direct interactions between dark and ordinary matter are very weak.

   If the matrix elements for real-real partonic transitions involve all or at least a circle of the partonic 2-surface as stringy considerations suggest [C2], then one would have clear distinction between quantum phase transitions and ordinary quantum transitions. Of course, the fact that the points which correspond to zero of Riemann Zeta form only a small subset of points common to real partonic 2-surface and corresponding p-adic 2-surface, implies that the rate for phase transition is in general small. On the other hand, for the non-diagonal S-matrix elements for ordinary transitions would become very small by almost randomness caused by strong fluctuations and the rate for phase transition could begin to dominate.

#### Transition to large $\hbar$ phase and failure of perturbation theory

A further idea is that the transition to large $\hbar$ phase occurs when perturbation theory based on the expansion in terms of gauge coupling constant ceases to converge: Mother Nature would take care of the problems of theoretician. The transition to large $\hbar$ phase obviously reduces gauge coupling strength $\alpha$ so that higher orders in perturbation theory are reduced whereas the lowest order "classical" predictions remain unchanged. A possible quantitative formulation of the criterion is that maximal 2-particle gauge interaction strength parameterized as $Q_1Q_2\alpha$ satisfies the condition $Q_1Q_2\alpha \simeq 1$.

A justification for this picture would be that in non-perturbative phase large quantum fluctuations are present (as functional integral formalism suggests). At space-time level this would mean that space-time sheet is near to a non-deterministic vacuum extremal. At parton level this would mean that partonic surface contains large number of $CP_2$ orbifold points so that S-matrix elements for the phase transition becomes large. At certain critical value of coupling constant strength one expects that the transition amplitude for phase transition becomes very large.

### 8.2.2 From naive formulas to conceptualization

I have spent a considerable amount of time on various sidetracks in attempts to understand what the quantization of Planck constant does really mean. As usual, the understanding has emerged by unconscious processing rather than by a direct attack.

#### Naive approach based on formulas

The whole business started from the naive generalization of various formulas for quantized energies by replacing Planck constant with is scaled value. It seems that this approach does not lead to wrong predictions, and is indeed fully supported by the basic applications of the theory. Mention only the quantization of cyclotron energies crucial for the biological applications, the quantization of hydrogen atom, etc... The necessity for conceptualization emerges when one asks what else the theory predicts besides the simple zoomed up versions of various systems.

#### The geometric view about the quantization of Planck constant

After the naive approach based on simple substitutions came the attempt to conceptualize by visualizing geometrically what dark atoms could look like, and the description in terms of $N(G_a)\times N(G_b)$-fold covering $H \to H/G_a \times G_b$ emerged.

Especially confusing was the question whether one should assign Planck constant to particles or to their interactions or both. It is now clear that one can assign Planck constant to both the "personal" field bodies assignable to particles and to their interactions ("relative" or interaction field bodies), and that each interaction can correspond to both kinds of field bodies. Planck constant for the relative field bodies depends on the quantum numbers of both particles as it does in the case of gravitation. The Planck constant assignable to the particle's "personal" field body makes possible generalizations like the notion of N-atom.

Each sheet of the "personal" field body corresponds to one particular Compton length characterizing one particular interaction and electromagnetic interaction would define the ordinary Compton length. The original picture was that topological condensation of $CP_2$ type vacuum extremal occurs at space-time sheet with size of Compton length identified usually with particle. In the new picture this space-time sheet can be identified as electromagnetic field body.

Elementary particles have light-like partonic 3-surfaces as space-time correlates. If these 3-surfaces are fully quantum critical, they belong to the intersection of all spaces $H/G_a \times G_b$ with fixed quantization axes. This space is just the 4-D subspace $M^2 \times S^2 \subset M^4 \times CP_2$, where $S^2$ is geodesic sphere of $CP_2$. Partonic 2-surfaces are in general non-critical and one can assign to them a definite value of Planck constant.

There are two geodesic spheres in $CP_2$. Which one should choose or are both possible?

1. For the homologically non-trivial one corresponding to cosmic strings, the isometry group is $SU(2) \subset SU(3)$. The homologically trivial one $S^2$ corresponds to vacuum extremals and has isometry group $SO(3) \subset SU(3)$. The natural question is which one should choose. At quantum criticality the value of Planck constant is undetermined. The vacuum extremal would be a natural choice from the point of view of quantum criticality since in this case the value of Planck constant does not matter at all and one would obtain a direct connection with the vacuum degeneracy.

   One can of course ask whether all surfaces $M^2 \times Y^2$, $Y^2$ Lagrangian sub-manifold of $CP_2$ defining vacuum sectors of the theory should be allowed. The answer seems to be "No" since in the generic case $SO(3)$ does not act as $H$-isometries of $Y^2$. If one allows these sub-manifolds or even sub-manifolds of form $M^4 \times Y^2$ to appear as intersection of fractally scaled up variants, one must replace Cartan algebra as algebra associated with $SO(3)$ subgroup of canonical transformations of $CP_2$ mapping $Y^2$ to itself (if this kind of algebra exists).

2. The choice of the homologically non-trivial geodesic sphere as a quantum critical sub-manifold would conform with the previous guess that $\mathcal{M} : \mathcal{N} = 4$ corresponds to cosmic strings. It is however questionable whether the ill-definedness of the Planck constant is consistent with the non-vacuum extremal property of cosmic strings unless one assumes that for partonic 3-surfaces $X^3 \subset M^2 \times S^2$ the effective degrees of freedom reduce to mere topological ones.

#### Fractionization of quantum numbers and the hierarchy of Planck constants

The original generalization of the notion of imbedding space to a union of the factor spaces $\hat{H}/G_a \times G_b$ discussed in the section "General ideas about dark matter" does not allow charge fractionization whereas the covering spaces $\hat{H}\hat{\times}(G_a \times G_b)$ allow a fractionization in a natural manner. Also hybrid cases are obtained corresponding $(\hat{M}^4\hat{\times}G_a) \times (\hat{CP}_2/G_b)$ and $(\hat{M}^4/G_a) \times (\hat{CP}_2\hat{\times}G_b)$.

The simplest assumption is that Planck constant is a homomorphism from the lattice like structure of groups with product of groups defined to be the group generated by the groups. This does not fix the formula for the Planck constants completely since one can consider replacing the right hand side of the formula for $\hbar$ by its inverse and only physical input can fix the formula completely.

*1. $\hat{H}/G_a \times G_b$ option*

The safest and indeed natural assumption motivated by Jones inclusions is that physical states in sector $H/G_a \times G_b$ are $G_a \times G_b$ invariant meaning a discrete analog of color confinement. This alone excludes fractionization and actually implies just the opposite of it.

1. For states with vanishing fermionic quantum numbers $G_a \times G_b$ invariance means that wave functions live in the base space $H/G_a \times G_b$. For instance, $L_z$ would be a multiple of $n_a$ defining the order of maximal cyclic subgroup of $G_a$. Analogous conclusion would hold true for color quantum numbers.

2. Just as in the case of ordinary spin fermionic quantum numbers (spin, electro-weak spin) necessarily correspond to the covering group of the isometry group since a state with a half-odd integer spin does not remain invariant under the subgroups of the rotation group. In particular, states with odd fermion number cannot be $G_a \times G_b$ invariant. For even fermion numbers it is possible to have many-particle states for which individual particles transform non-trivially under orbital $G_a \times G_b$ if total $G_a \times G_b$ quantum numbers in spin like degrees of freedom compensate for the orbital quantum numbers (for instance, total spin is multiple of $n_a$). Hence the group algebra of $G_a \times G_b$ would characterize the states in orbital degrees of freedom as indeed assumed. The earlier picture would be correct apart from the lacking assumption about overall $G_a \times G_b$ invariance.

3. The construction of these states could be carried out just like the construction of ordinary $G_a \times G_b$ invariant states in $H$ so that the mathematical treatment of the situation involves no mystics elements. Since $G_a \times G_b$ is actually assigned with a sector $M^4_\pm \times CP_2$ with fixed quantization axes and preferred point of $H$, one has center of mass degrees of freedom for the position of tip of $M^4_\pm$ and a preferred point of $CP_2$. This gives new degrees of freedom and one would have a rich spectrum of N-electrons, N-nucleons, N-atoms, etc.... behaving effectively as elementary particles. For example, one interesting question is whether 2-electrons could be interpreted as Cooper pairs of particular kind This would require either $s_z = 0, l_z = 0$ or $s_z = 1, l_z = mn_a - 1$, $m = 0, 1, 2...$ For instance, for $n_a = 3$ (the minimal value of $n_a$) one could have $s_z = l, l_z = 2$ with $J_z = 3$. One can also ask whether some high spin nuclei could correspond to N-nuclei.

4. This picture is quite predictive. For instance, in the case of gravitational interactions it would mean that the spin angular momentum of an astrophysical system is a multiple of "personal" gravitational Planck constant $GM^2/v_0$. The value of $v_0$ could be deduced from this condition and is expected to be a negative power of 2. In the same manner the relative angular momentum of planet-Sun system would be a multiple of $GMm/v_0$ using the gravitational Planck constant as a unit. This is a strong prediction but reduces to the Bohr quantization rule for circular orbits.

*2. $\hat{H}\hat{\times}(G_a \times G_b)$ option*

For this option the units of orbital angular momentum and color hyper charge and isospin are naturally scaled down by the factor $n_i$. In the case of spin and electro-weak spin this kind of scaling would require a covering group of Abelian Cartan group. Since the first homotopy group of SU(2) vanishes there are no coverings of $SU(2)$ in the ordinary sense of the word but quantum version of $SU(2)$ is an excellent candidate for the counterpart of the covering. Also quantum variants of other Lie groups are highly suggestive on basis of ADE correspondence.

There does not seem to be any absolute need for assuming $G_a \times G_b$ singletness. If so, there would be asymmetry between coverings and factor spaces bringing in mind confined and de-confined phases. Since coverings *resp.* factor spaces are labelled by $N^{11}$-valued lattice momenta *resp.* their negatives, this asymmetry would be analogous to time reversal asymmetry. Note however that all components of lattice momenta are either positive or negative and that this fits nicely with the interpretation of p-adic integers as naturals and "super-naturals". An intriguing question is whether there might be some connection with M-theory and its 4-D compactifications (dropping reflection group one obtains 7-D lattice).

*3. Implications of the new picture*

This picture has several important implications.

1. There is a symmetry between $CP_2$ and $M^4$ so that for a given value of Planck constant one obtains factor space with divisor group $G_a \times G_b$ and covering space with homotopy group $G_b \times G_a$. For large values of Planck constant the large $Z_n$ symmetry acts in $M^4$ factor *resp.* $CP_2$ factor for these two options. Therefore the large $Z_n$ symmetry in $M^4$ degrees of freedom, which can be challenged in some of the applications, could be replaced with large $Z^n$ symmetry in $CP_2$ degrees of freedom emerging rather naturally.

2. For a large value of Planck constant it is possible to obtain a relatively small dark matter symmetry group in $M^4$ factor and also the small genuinely 3-dimensional symmetry groups

(tedrahedral, octahedral, icosahedral groups) can act in $M^4$ factor as symmetries of dark matter. Hence the groups appearing as symmetries of molecular physics (aromatic rings, DNA,...) could be identified as symmetries of dark electron pairs. These symmetries appear also in longer length scales (snow flakes and even astrophysical structures). In earlier picture one had to assume symmetry breaking at the level of visible matter.

3. The notion of N-atom generalizes. The original model predicted large electronic charges suggesting instability plus large $Z_n$ symmetry in $M^4$ degrees of freedom (identified as a symmetry of field body). For instance, in the case of DNA double helix this kind of large rotational symmetry is questionable. Same applies to astrophysical systems with a gigantic value of gravitational Planck constant. The change of the roles of $M^4$ and $CP_2$ and charge fractionization would resolve these problems. This would provide a support for the idea that the electronic or protonic hot spots of catalyst and substrate correspond to fractional charges summing up to a unit charge. This framework could provide a proper realization for the original vision that symbolic level of dynamics and sex emerge already at the molecular level with sequences of catalyst sites representing "words" and their conjugates (opposite molecular sexes).

### 8.2.3 Dark atoms and dark cyclotron states

The development of the notion of dark atom involves many side tracks which make me blush. The first naive guess was that dark atom would be obtained by simply replacing Planck constant with its scaled counterpart in the basic formulas and interpreting the results geometrically. After some obligatory twists and turns it became clear that this assumption is indeed the most plausible one. The main source of confusion has been the lack of precise view about what the hierarchy of Planck constants means at the level of imbedding space at space-time.

#### The assumptions of the model of dark atom

Let us briefly summarize the basic assumptions of the model.

1. The quantized values of effective Planck constant appearing in Schrödinger equation are in the set $\hbar_{eff}/\hbar_0 \in \{n_a/n_b, n_b/n_a, n_a n_b, 1/(n_a n_b)$ corresponding to the sectors $\hat{H}/G_a \times G_b$, $\hat{H}\hat{\times}(G_a \times G_b)$, $\hat{M}^4/G_a \times (\hat{CP}_2\hat{\times})G_b$, and $(\hat{M}^4\hat{\times}G_a) \times \hat{CP}_2/G_b$. Note that one can consider the replacement of the right hand side of the formula for Planck constant by its inverse, and at this stage one must just keep mind open for the options.

2. In the case of covering spaces the units of quantum numbers are replaced by $1/n_a$ and $1/n_b$, $n_i$ the order of maximal cyclic subgroup. Both fermion number, spin, color, and electro-weak quantum numbers can fractionize. For factor spaces units are inverses of these and in this case states are $G_a \times G_b$ singlets: hence N-atoms with dark electrons in general involve many-electron states with even number of electrons. Simplest situation corresponds to spin singlet electron pair and one cannot exclude the possibility that valence electrons are dark electrons.

3. It is assumed that the quantum critical sub-manifolds $M^2 \times S^2$ correspond to homologically trivial geodesic sphere. Note that although quantum critical parton orbits are vacuum extremals, induced electric and $Z^0$ fields are non-vanishing in general. This is a very important point since it makes possible electric and magnetic fluxes between different sectors of the generalized imbedding space $H$. For instance, nucleus and electrons can belong to different sectors of $H$. A helpful visualization is provided by a book with pages glued together along $M^2 \times S^2$. Both electric and magnetic flux are assumed to be conserved as it flows from a sector to another one: therefore dark electron in the covering experiences the electric charge of nucleus as scaled down by a factor $1/N(G_b)$ giving the number of sectors.

4. In the case of factor spaces 3-surface is invariant under $G_i$ so that one has $N(G_i)$ strict copies of the particle: $G_i$ invariance selects states with $l_z = nn_a$ and forces many electron states in order to satisfy quantization conditions in the case of spin. Here one can consider the possibility that single particle states transform according to irreducible representations of $G_i$ although the entire state is $G_i$ invariant.

5. In the case of covering spaces there is no need to assume that partonic 3-surface consists of $N(G_i)$ identical copies. In this case the states are naturally classified by the representations of $G_a \times G_b$ identifiable as elements of the corresponding group algebra. Apparently one has a modified statistics since $N(G_a) \times N(G_b)$ states correspond to the same state in the ordinary sense of the word. It can happen that the action of $G_i$ in $H$ has some isotropy subgroup. In fact, the action of $D_{2n}$ in $M^2$ and $S^2$ reduces to the action of the corresponding cyclic group $Z_n$ so that has $N(G_i) = n_i$.

6. One can consider quite a number of variants for the dark atom. Even nucleus could be dark (either fractionally charged or $N$-nucleus with charge $N(G_b)$). Second interesting possibility is atom with ordinary nucleus and dark electrons. It is also possible that only valence electrons are dark and correspond to one of the allowed varieties.

**Thermal stability**

The energy scale of hydrogen atom is proportional to $1/\hbar^2$. Depending on the sector of $H$ and on the values of $n_a$ and $n_b$ the scale of energy can increase or be reduced. Also charge fractionization in case of covering spaces of $\hat{CP_2}$ reduces the energy scale. By the conservation of electric flux this takes place for both proton and electron so that the energy scale receives a factor $1/N(G_b)^2$. For large values of Planck constant the energy scale is reduced and thermal stability poses upper limit on the value of Planck constant if dark matter is assumed to be in thermal equilibrium with ordinary matter.

The following table lists the four possible options.

| $I$ | $II$ | $III$ | $IV$ |
|---|---|---|---|
| $\hat{H}\hat{\times}G_a \times G_b$ | $\hat{H}/(G_a \times G_b)$ | $(\hat{H}/G_a)\hat{\times}G_b$ | $(\hat{H}/G_b)\hat{\times}G_a$ |

One can also consider two options for the formula of Planck constant.

1. For $\hbar/\hbar_0 = n_a/n_b$ in case of option I and $G_b = Z_n$ thermal stability condition boils down to the condition

$$\begin{array}{ll} I: & Z \geq \frac{n_b^3}{n_a} \times x \ , \\ II: & Z \geq \frac{n_a}{n_b} \times x \ , \\ III: & Z \geq n_a n_b^3 \times x \ , \\ IV: & Z \geq \frac{1}{n_a n_b} \times x \ . \end{array} \quad x \equiv \sqrt{\frac{E_{th}}{E_1}} \ . \tag{8.2.2}$$

Here $E_{th}$ denotes thermal energy. Here $E_{th}$ denotes thermal energy. Note that option III maximizes Planck constant for given $G_a \times G_b$ and is therefore especially interesting. Option IV minimizes in turn minimizes it.

By replacing the formula for Planck constant with its inverse ($\hbar/\hbar_0 = n_b/n_a$ for option I) one obtains the conditions

$$\begin{array}{ll} I: & Z \geq n_b^2 n_a \times x \ , \\ II: & Z \geq \frac{n_b}{n_a^3} \times x \ , \\ III: & Z \geq \frac{n_b^3}{n_a} \times x \ , \\ IV: & Z \geq n_a n_b \times x \ . \end{array} \quad x \equiv \sqrt{\frac{E_{th}}{E_1}} \ . \tag{8.2.3}$$

Recall that the preferred values of $n_a$ and $n_b$ correspond to the number theoretically simple quantum phases $exp(i2\pi/n_i)$ expressible using only square root function and rational functions applied on rationals. $n_i$ are given as products $2^k \times \prod_i F_i$, where $F_i$ are distinct Fermat primes.

2. The original proposal for the hierarchy of Planck constants coming as $\hbar/\hbar_0 = \lambda = 2^{11k}$ does not allow stable hydrogen atom at room temperature. This is not a problem since this hierarchy is associated with cyclotron energies.

3. For option I with $n_a = 1$ and $n_b \in \{3, 5, 6, 12\}$ one would have $Z \geq z \in \{1, 6, 10, 81\}$. Carbon atom would satisfy the condition fors $(n_b = 5, n_a = 1)$ and $(n_b = 6, n_a = 2)$.

4. For option II with $n_b = 1$ one obtains $Z \geq n_a$ for $E_{th} \sim E_1$. What is intriguing that aromatic carbon 5- and 6-cycles, which are abundant in biology and correspond to factor space option, would satisfy this condition for $E_{th} \sim E_1$. For $n > 6$-cycles the condition would not be satisfied. Could this condition state something non-trivial about pre-biotic evolution at high temperatures?

5. For option III with $n_b = 3$ meaning charge fractionization and $n_a$-fold cyclic symmetry one obtains $Z \geq n_a \times 1.3$ at room temperature. For $n_b = 3$ 5-cycles with $\hbar/\hbar_0 = 15$ and 6-cycles with $\hbar/\hbar_0 = 18$ would be stable below room temperature but not higher cycles. This estimate is of course very rough since the energy scale $E_1$ for possibly dark delocalized free electron pairs appearing in n-cycles need not be exactly equal to $E_1$.

6. If one replaces the right hand side by its inverse in the expression of Planck constant the factor space option would favor the thermal stability for large values of $n_a$ and n-cycles with large $n$ so that this option does not look reasonable.

**Is the fractionization of principal quantum number possible?**

One can also consider the fractionization $n \rightarrow n/n_b$ of the principal quantum number of hydrogen analogous to that occurring for angular momentum. If one assumes that fractionization occurs only for isometry charges this option is excluded. This argument might quite well be enough to exclude this kind of fractionization.

Since s-wave states correspond to orbits which represent radial motion between two extremes, one could consider the possibility of periodic radial orbits which run to maximal radius, back to the maximum radius at the opposite side and close after $N_b$ loops of this kind, where $N_b$ is the order of maximal cyclic subgroup of $G_b$. This would be direct a counterpart for a rotational orbit which closes only after $N_b$ full $2\pi$ rotations.

One can consider the occurrence of this phenomenon also in the case of ordinary imbedding space. At least inn this case the interpretation in terms of a transition to chaos might be appropriate. In case of generalized imbedding space one could speak about transition to chaos by period $N_b$-folding and suggest fractionization of the radial quantum number to $n/N_b$. Similar fractionization could makes sense for all orbits which are not precisely circular. This fractionization would increase the energy scale by a factor $n_b^2$.

In empty space fractional diagonal quantum number would mean that ordinary hydrogen atom wave functions diverge at spatial infinity. This kind of scaling is consistent with finiteness inside dark sector if the copies of sheet fuse together at at 3-surface belonging to the quantum critical manifold $M^2 \times S^2$.

**Possible experimental implications**

An interesting possibility is the formation of stable hydrogen bonds as a fusion of N-hydrogen atoms with $N-k$ and $k$ electrons to give rise to a full shell of electrons possessing an exceptional stability.

1. In the case of factor space the state would be analogous to full Fermi sea or full atomic or nuclear shells. The large value of electric charge might make the state unstable. The resulting state would be invariant under $G_a \times G_b$.

2. For covering space option the total quantum numbers for the resulting state would be those of electron. The degeneracy of states is $N(G_a) \times N(G_b)$-fold corresponding to the group algebra of $G_a \times G_b$. This would mean that the full shell for states with given energy $E_n$ would have total energy $n_a n_b E_n$.

Consider next the possible experimental implications of N-atom concept.

1. Valence electrons could transform to dark electrons in one of the four possible senses.

   i) For covering space option fractal electrons could result. Fractal electron and its conjugate would combine to form a particle with quantum numbers of electrons but with larger mass.

Catalytic sites are one possible candidate for fractal electrons and catalyst activity could be understood as a strong tendency of fractal electron and its conjugate to fuse to form an ordinary electron. The anomalously high mass would be the tell-tale signature of these exotic electrons. The effective mass of electron in condensed matter is known to vary in wide limits and to exceed electron mass even by a factor of order hundred: is this really a mere standard physics effect?

ii) For factor space option full electron shells would be the most stable states and would have have rather high fermion number but vanishing spin. Spin singlet electron pairs would define stable $G_a \times G_b$ singlets. These states might behave like Cooper pairs.

iii) If the value of Planck constant is smaller than its standard value, the molecular bonds containing dark electrons could be stable at anomalously high temperatures. Note that the dependence of the bond energy on Planck constant need not be non-perturbative as it is for atoms. For instance, a naive application of the formulas for vibrational and rotational energies assuming that the parameters of Hamiltonian (such as vibrational energy scale) do not depend on Planck constant would suggest that large Planck constant implies thermal stability in this kind of situations.

iv) Both fermionic a $(Na^+, K^+, Cl^-)$ and bosonic $(Ca^{++}, Mg^{++})$ ions are very important in biology. Optimist would interpret this as a support for the plasmoids as predecessors of biological life. These ions are formed in some manner and the simplest manner would be transformation of valence electrons to dark electrons and subsequence delocalization.

2. The recently discovered evidence [75] that Sun has a solid surface consisting mostly of calcium-ferrite is inconsistent with the fact that photosphere has temperature 5800 K (iron melts at 1811 K and calcium-aluminium ferrite in the range 1670-1720 K at normal pressure). Metallic bonds responsible for the solid state are due to the interaction of delocalized conduction electrons with metal atoms. If the valence electrons giving rise to conduction bands have a reduced value of Planck constant, the energy scale of the valence bands would become higher and raise the melting temperature. The reduction of Planck constant seems necessary by the non-perturbative dependence of atomic binding energies on $\hbar$.

3. The claims of Mills [73] about the scaling up of the binding energy of the hydrogen ground state by a square $k^2$ $(k = 2, 3, 4, 5, 6, 7, 10)$ of an integer in plasma state are a challenge for the theory. The simplest explanation is that the Planck constant is reduced by factor $1/k$.

Before I had realized that $\hbar_{eff}$ satisfies the formula $\hbar_{eff}/\hbar_0 = n_a/n_b$, the presence of $k = 2$ state in spectrum was a difficult problem and I ended up with the idea that the quantum variant of Laguerre polynomials associated with quantized radial motion could explain $n = 1/2$ and also other fractional states. Later it will be found that this approach indeed predicts these quantum numbers approximately! This raises the question whether these states might appear as metastable intermediate states for hydrogen atom in the phase having $\hbar_{eff}/\hbar_0 = 1$ and $n_a = n_b > 1$. These states would be unstable against the phase transition leading to $n_b > kn_a$, $k = 2, 3, .....$

Living matter could perhaps be understood in terms of quantum deformations of the ordinary matter, which would be characterized by the quantum phases $q = exp(i2\pi/N)$. Hence quantum groups, which have for long time suspected to have significance in elementary particle physics, might explain the mystery of living matter and predict an entire hierarchy of new forms of matter.

As demonstrated in [N4], the notion of $N$-atom leads to an elegant model for the lock and key mechanism of bio-catalysis as well as the understanding of the DNA replication based on the spontaneous decay and completion of fermionic $N < N(G)$-particles to $N = N(G)$-particles. Optimal candidates for the $N$-particles are $N$-hydrogen atoms associated with bio-molecules appearing as letters in the "pieces of text" labelling the molecules. Lock and key would correspond to conjugate names in the sense that $N_1$ and $N_2$ for the letters in the name and its conjugate satisfy $N_1 + N_2 = N = N(G)$: as the molecules combine, a full fermion shell represented is formed.

**What about cyclotron states?**

Dark cyclotron states have scaled spectrum $E_n = (n_a/n_b)E_n$ and for large values of $n_a$ one can have energies above thermal threshold. The crucial observation is that the flux of ordinary magnetic field cannot divide into $N(G)$ dark fluxes since magnetic fluxes necessarily vanish at orbifold surfaces.

Hence dark magnetic field would carry total flux which is $N(G)$ times higher than the flux of ordinary magnetic field of same intensity. Fermionic analogs of Bose-Einstein condensates are possible so that each cyclotron energy $E_n = n\hbar_0\omega$ would be replaced with spectrum extending from $(n_a/n_b)E_n$ to $(n_a/n_b)N(G_b)E_n$ in case of fractionization.

### 8.2.4 Dark matter and mind: general ideas

Dark matter is identified as a macroscopic quantum phase with large $\hbar$ for which particles have complex conformal weights.

The sum of the imaginary parts of conformal weights assumed for number theoretical reasons to be expressible as sums of imaginary parts for the zeros of Riemann Zeta would define a new conserved quantum number, "scaling momentum" [C1]. The conjugation of the complex conformal weight would distinguish between quantum states and their phase conjugates. This point is important since phase conjugate photons represent negative energy signals propagating into geometric past, assumed to be distinguishable from positive energy signals propagating into geometric future, play a key role in TGD based biology: this distinction cannot be made in QFT context.

Living matter could be matter with a large value of $\hbar$ and hence dark, and form conformally confined blobs behaving like single units with extremely quantal properties, including free will and intentional action in time scales familiar to us. Dark matter would be responsible for the mysterious vital force.

Any system for which some interaction becomes so strong that perturbation theory does not work, could give rise to this kind of system in a phase transition in which $\hbar$ increases to not lose perturbativity gives rise to this kind of "super-quantal" matter. In this sense emergence would corresponds to strong coupling. The interpretation would be that strong fluctuations at strong coupling give rise to a large number of orbifold points so that the S-matrix elements to a phase with larger Planck constant become large. Dark matter made possible by dynamical $\hbar$ is necessary for macroscopic and macro-temporal quantum coherence and is thus prerequisite for emergence.

Physically large $\hbar$ means a larger unit for quantum numbers and this requires that single particle states form larger particle like units. This kind of collective states with weak mutual interactions are of course very natural in strongly interacting systems. The $N$ sheets of $M^4_\pm$, where $N$ is the order of group $G_b$ involved with the Jones inclusion in question. Each partonic 2-surface appears as $N$ geometrically identical copies which can however carry different fermionic quantum numbers. Hence the N-fold space-time sheet carry up to $N$ $G_b$ invariant partons with identical quantum numbers so that an effective breaking of Fermi statistics becomes possible.

One implication would be the notion of N-atom, which at the level of quantum jumps quantum jumps integrate effectively to single quantum jump and longer moments of consciousness result. Entire hierarchy of size scales for matter blobs is predicted corresponding to values of $\hbar$. The larger the value of $\hbar$ the longer the characteristic time scale of consciousness and of a typical life cycle.

In RHIC color glass condensate resembles incompressible liquid. Liquids might be liquids because they contain some dark matter at magnetic/$Z^0$ magnetic flux tubes (darkness follows from the large value of $\hbar$). Incompressibility of liquid could correspond to maximal density of flux tubes and to the fact that magnetic fields have no sources. In accordance with the previous ideas already water could be living and conscious system in some primitive sense.

The notion of field body in turn means that dark matter at the magnetic flux tubes would serve as an intentional agent using biological body as a motor instrument and sensory receptor. Dark matter would be the miraculous substance that living systems are fighting for, and perhaps the most important substance in metabolic cycle.

#### Hierarchy of dark matters and hierarchy of minds

The notion of dark matter is only relative concept in the sense that dark matter is invisible from the point of view of the ordinary matter. One can imagine an entire hierarchy of dark matter structures corresponding to the hierarchy of space-time sheets for which p-adic length scales differ by a factor $1/v_0 \sim 2^{11}$. The BE condensates of $N_{cr}$ ordinary matter particles would serve as dynamical units for "doubly dark matter" invisible to the dark matter. The above discussed criticality criterion can be applied at all levels of the hierarchy to determine the value of the dynamical interaction strength for which BE condensates of BE condensates are formed.

This hierarchy would give rise to a hierarchy of the values of $\hbar_n/\hbar$ coming as powers of $v_0^{-n}$ as well as a hierarchy of wavelengths with same energy coming as powers or $v_0^n$. For zero point kinetic energies proportional to $\hbar^2$ this hierarchy would come in powers of $v_0^{-2n}$, for magnetic interaction energies proportional to $\hbar$ the hierarchy would come in powers $v_0^{-n}$ whereas for atomics energy levels the hierarchy would come in powers of $v_0^{2n}$ (assuming that this hierarchy makes sense).

The most interesting new physics would emerge from the interaction between length scales differing by powers of $v_0$ made possible by the decay of BE condensates of dark photons to ordinary photons having wavelength shorter by a factor $\sim v_0$. This interaction could provide the royal road to the quantitative understanding how living matter manages to build up extremely complex coherent interactions between different length and time scales.

In the time domain dark matter hierarchy could allow to understand how moments of consciousness organize to a hierarchy with respect to the time scales of moment of consciousness coming as $2^{11k}$ multiples of $CP_2$ time scale. Even human life span could be seen as single moment of consciousness at $k = 14^{th}$ level of the dark matter hierarchy whereas single day in human life would correspond to $k = 12$.

**Realization of intentional action and hierarchy of dark matters**

How long length scales are able to control the dynamics in short length scales so that the extremely complex process extending down to atomic length scales realizing my intention to write this word is possible. This question has remained without a convincing answer in the recent day biology and there strong objections against the idea that this process is planned and initiated at neuronal level.

I have proposed a concrete mechanism for the realization of intentional action in terms of time mirror mechanism involving the emission of negative energy photons and proceeding as a cascade in a reversed direction of geometric time from long to short length scales [K1]. This cascade would induce as a reaction analogous processes proceeding in the normal direction of geometric time as a response and would correspond to the neural correlates of intentional action in very general sense of the word.

The counterparts for the negative energy signals propagating to the geometric past would be phase conjugate (negative energy) laser beams identifiable as Bose-Einstein condensates of dark photons. In the time reflection these beams would transform to positive energy dark matter photons eventually decaying to ordinary photons. The space-time correlate would be MEs decaying into MEs and eventually to $CP_2$ type extremals representing ordinary photons.

The realization of intentional action as desires of boss expressed to lower level boss would naturally represented the decay of the phase conjugate dark laser beam to lower level laser beams decaying to lower level laser beams decaying to... . This would represent the desire for action whereas the time reflection at some level would represent the realization desire as stepwise decay to lower level laser beams and eventually to ordinary photons. The strong quantitative prediction would be that these levels correspond to a length and time scale hierarchies coming in powers of $1/v_0 \sim 2^{11}$.

**Wave-length hierarchy, coherent metabolism, and proton-electron mass ratio**

The fact that a given wavelength length corresponds to energies related to each other by a scaling with powers of $v_0$ provides a mechanism allowing to transfer energy from long to short long scales by a de-coherence occurring either in the standard or reversed direction of geometric time. De-coherence in the reversed direction of time would be associated with mysterious looking processes like self-assembly allowing thus an interpretation as a normal decay process in reversed time direction.

It is perhaps not an accident that the value of $v_0 \simeq 4.6 \times 10^{-4}$ is not too far from the ratio of $m_e/m_p \simeq 5.3 \times 10^{-4}$ giving the ratio of zero point kinetic energies of proton and electron for a given space-time sheet. Proton mass ratio $m_p/m_e = 1836.15267261$ corresponds in good approximation to $n = 2^2 \times 3^3 \times 17 = 1836$. This integer is of form $n = 9 \times n_F$. This co-incidence could in principle make possible a metabolic mechanism in which dark protons and ordinary electrons co-operate in the sense that dark protons generate dark photon BE condensates with wave length $\lambda$ transforming to ordinary photons with wavelength $v_0\lambda$ absorbed by ordinary electrons.

Some examples are in order to illustrate these ideas.

1. As already found, in the case of dark atoms the scaling of binding energies as $1/\hbar^2$ allows the coupling of $\sim$ 9 cm scale of brain hemisphere with the length scale $\sim$ 50 $\mu$m of large neuron. $N_{cr} \leq 137$ ordinary IR photons would be emitted in single burst and interacting with neuron.

2. For a non-relativistic particle in a box of size $L$ the energy scale is given by $E_1 = \hbar^2\pi^2/2mL^2$ so that the visible photons emitted would have energy scaled up by a factor $(\hbar_s/\hbar)^2 \simeq 4 \times 10^6$. The collective dropping of $N_{cr}$ dark protons to larger space-time sheet would liberate a laser beam of dark photons with energy equal to the liberated zero point kinetic energy. For instance, for the p-adic length scale $L(k = 159 = 3 \times 53) \simeq .63$ $\mu$m this process would generate laser beam of IR dark photons with energy $\sim .5$ eV also generated by the dropping of ordinary protons from $k = 137$ atomic space-time sheet. There would thus be an interaction between dark protons in cell length scale and ordinary protons in atomic length scale. For instance, the dropping of dark protons in cell length scale could induce driving of protons back to the atomic space-time sheet essential for the metabolism [K6]. Similar argument applies to electrons with the scale of the zero point kinetic energy about 1 keV.

3. If the energy spectrum associated with the conformational degrees of freedom of proteins, which corresponds roughly to a frequency scale of 10 GHz remains also invariant in the phase transition to dark protein state, coherent emissions of dark photons with microwave wave lengths would generate ordinary infrared photons. For instance, metabolic energy quanta of $\sim .5$ eV could result from macroscopic Bose-Einstein condensates of 58 GHz dark photons resulting from the oscillations in the conformational degrees of freedom of dark proteins. A second option is that the conformal energies are scaled by $\hbar_s/\hbar$ ($\omega$ would remain invariant). In this case these coherent excitations would generate ordinary photons with energy of about 1 keV able to drive electrons back to the atomic $k = 137$ space-time sheet.

4. Since magnetic flux tubes have a profound role in TGD inspired theory of consciousness, it is interesting to look also for the behavior of effective magnetic transition energies in the phase transition to the dark matter phase. This transition increases the scale of the magnetic interaction energy so that anomalously large magnetic spin splitting $\hbar_s eB/m$ in the external magnetic field could serve as a signature of dark atoms. The dark transition energies relate by a factor $\hbar_s/\hbar$ to the ordinary magnetic transition energies.

For instance, in the magnetic field $B_{end} = 2B_E/5 = .2$ Gauss, where $B_E = .5$ Gauss is the nominal value of the Earth's magnetic field, explaining the effects of ELF em fields on vertebrate brain, dark electron cyclotron frequency is $6 \times 10^5$ Hz and corresponds to ordinary microwave photon with frequency $\sim 1.2$ GHz and wavelength $\lambda \simeq 25$ cm. For proton the cyclotron frequency of 300 Hz would correspond to energy of ordinary photon with frequency of $6 \times 10^5$ Hz and could induce electronic cyclotron transitions and spin flips in turn generating for instance magneto-static waves.

It is easy to imagine a few step dark matter hierarchy connecting EEG frequencies of dark matter with frequencies of visible light for ordinary photons. This kind of hierarchy would give considerable concreteness for the notion of magnetic body having size scale of Earth.

#### A connection with bio-photons

The biologically active radiation at UV energies was first discovered by Russian researcher Gurwitz using a very elegant experimental arrangement [55]. Gurwitz christened this radiation mitogenetic radiation since it was especially intense during the division of cell.

A direct proof for the biological activity of mitogenetic radiation consisted of a simple experiment in which either quartz or glass plate was put between two samples. The first sample contained already growing onion roots whereas the second sample contained roots which did not yet grow. In the case of quartz plate no stimulation of growth occurred unlike for glass plate. Since quartz is not transparent to UV light whereas the ordinary glass is, the conclusion was that the stimulation of growth is due to UV light.

The phenomenon was condemned by skeptics as a pseudo science and only the modern detection technologies demonstrated its existence [54], and mitogenetic radiation became also known as bio-photons (the TGD based model for bio-photons is discussed in [K6]). Bio-photons form a relatively featureless continuum at visible wavelengths continuing also to UV energies, and are believed to be generated by DNA or at least to couple with DNA. The emission of bio-photons is most intense from biologically active organisms and the irradiation by UV light induces an emission of mitogenetic radiation by a some kind of amplification mechanism. It has been suggested that bio-photons represent some kind of leakage of a coherent light emitted by living matter.

According to Russian researcher V. M. Injushin [56], mitochondrios emit red light at wavelengths 620 nm and 680 nm corresponding to energies 2 eV and 1.82 eV. According to the same source, the nucleus of cell sends UV light at wavelengths 190, 280 and 330 nm corresponding to the energies 6.5, 4.4 and 3.8 eV. The interpretation as a kind of leakage of coherent light would conform with the identification in terms of BE condensates of dark photons with $\hbar_s/\hbar \simeq 2^{11}$ emitted at wavelengths varying in the range $.3 - 1.25$ mm and decaying to photons with energies visible and UV range. For instance, 1.82 eV radiation corresponds to a dark photon wave length of 1.4 mm for $v_0(eff) = 2^{-11}$. A bio-control of ordinary bio-matter at sub-cellular level performed by dark matter from the millimeter length scale could be in question. This proposal conforms with the fact that 1 mm defines the scale of the blobs of neurons serving as structural units in cortex.

The analysis of Kirlian photographs has shown that the pattern of visible light emitted by various body parts, for instance ear, code information about other body parts [57]. These bio-holograms for which a general model is discussed in [K4] could be realized as dark photon laser beams.

In phantom DNA effect [52] a chamber containing DNA is irradiated with a visible laser light and the DNA generates as a response coherent visible radiation at same wavelength. Strangely enough, the chamber continues to emit weak laser light even after the removal of DNA. This effect could be due to the decay of a dark photon BE condensate remaining in the chamber. Also the findings of Peter Gariaev [51] about the effects of visible laser light on DNA, in particular the stimulated emission of radio waves in kHz-MHz frequency range might also relate to dark photons somehow.

**A connection with the scaling law of homeopathy**

The value of the parameter $1/v_0 \simeq 2083$ is essentially the ratio of $CP_2$ radius and Planck length scale (as also the ratio of Compton lengths of electron and proton) and rather near to $2^{11} = 2048$. Interestingly, much larger number $2 \times 10^{11} \simeq 3 \times 2^{36}$ appears in the simplest form for what I have christened the scaling law of homeopathy [K5]. This rule has been proposed on basis of experimental findings [47] but has no convincing theoretical justification. The scaling law of homeopathy states that high frequency em radiation transforms to a low frequency radiation and vice versa preferably with the frequency ratio $f_{high}/f_{low} \simeq 2 \times 10^{11}$.

The proposed hierarchy of dark matter and ensuing hierarchy of dark laser beams decaying into lower level beams might provide a deeper explanation for the scaling law of homeopathy. The factor $2 \times 10^{11}$ is with 3 per cent accuracy equal to the integer $n_F = 3 \times 2^{36} \simeq 2.06 \times 10^{11}$ characterizing ruler and compass quantum phase. Hence the interpretation in terms of a phase transition leading from a phase with a large value of Planck constant $\hbar = n_F\hbar_0$ to ordinary phase is possible.

In [K5] I have discussed some mechanisms for the transformation of high energy photons to low energy photons consistent with the rule and proposed a generalization of the rule based on p-adic length scale hypothesis. For instance, high energy visible photons of frequency $f$ could induce an excitation of the receiving system having same frequency, propagating with velocity $\beta = v/c \simeq 10^{-11}/2$, and having wave length equal $\lambda_0 = f/v = \lambda/\beta$. This excitation would in turn couple to photons of wavelength $\lambda_0$ and frequency $f_0 = \beta f$.

### 8.2.5 Dark matter hierarchy, sensory representations, and motor action

Dark matter hierarchy allows to develop a detailed model for how magnetic bodies use biological bodies as sensory receptors and motor instruments [M3] leading among other things to a generalization of the notion of genome.

For ordinary quantum mechanics photons at EEG frequencies correspond to ridiculously small energies. Dark matter hierarchy is accompanied by a hierarchy of EEGs and its generalizations with the scalings of frequencies predicted to come in powers of $\lambda \simeq 2^{11}$ [M3]. For $k_{em} = 4$ the energies of EEG photons are above thermal threshold at room temperature for $f \geq 1$ Hz, and 5 Hz frequency corresponds to 86 meV energy.

The fact that arbitrarily small frequencies can correspond to energies above thermal threshold at higher levels of dark matter hierarchy implies that photons with arbitrarily low frequencies can have sizable physical effects on matter. This conforms with the findings about the effects of ELF em fields on living matter [M3], and these effects allow to develop a rather detailed model for EEG and identify the parts of EEG correlating with communications of sensory data to the magnetic body and with quantum control performed by the magnetic body [M3].

### Bose-Einstein condensates at magnetic flux quanta in astrophysical length scales

The new model for the topological condensation at magnetic flux quanta of Earth's magnetic field is based on the dark matter hierarchy with levels characterized by the value of $\hbar(k_{em}) = \lambda^{k_{em}}\hbar_0$, $\lambda \simeq 2^{11}$.

1. There are several levels of dynamics. In topological condensation the internal dynamics of ions is unaffected and $\hbar$ has the ordinary value. The formation of Cooper pairs involves dynamics at $k_{em} = 1$ level of dark matter hierarchy. Also the dynamics of ionic Cooper pairs remains unaffected in the topological condensation to magnetic flux quanta obeying $k_{em} > 1$ dynamics.

2. Cyclotron energies scale as as $\lambda^{k_{em}}$ so that for a sufficiently high value of $k$ thermal stability of cyclotron states at room temperature is achieved. Spin interaction energy $\mu \cdot B \propto S \cdot B$ scales as $1/\hbar$ since four-momentum and angular momentum are by Poincare symmetry invariant under the scaling of $\hbar$ (the highly non-trivial implications of the invariance of angular momentum are discussed in [C6]). Hence spin interaction energy has the ordinary value. Unless thermal isolation is assumed, spin degrees of freedom are thermalized, and only cyclotron degrees of freedom can be quantum coherent. This is a testable prediction distinguishing between the new and old model.

3. If the flux quanta of Earth's magnetic field correspond to $k_{em} = 4$ level of dark matter hierarchy, cyclotron energies $E = (\hbar/2\pi) \times ZeB/Am_p$ are scaled up by a factor $\lambda^4 \simeq 2^{44}$ from their ordinary values and are above thermal energy at room temperature for $A \leq 233Z$, where $Z$ is the charge of the ion. Even for $Z = 1$ this includes all stable nuclei. Bose-Einstein condensates of bosonic ions are thus possible at room temperatures at Earth's surface. Cooper pairs of fermionic ions are possible only for $A \leq 4$ leaving in practice only protons into consideration. Also bosonic molecular ions can suffer BE condensation.

### Fractal hierarchy of magnetic flux sheets

The notion of magnetic body is central in the TGD inspired theory of living matter. Every system possesses magnetic body and there are strong reasons to believe that the magnetic body associated with human body is of order Earth size and that there could be hierarchy of these bodies with even much larger sizes. Therefore the question arises what distinguishes between the magnetic bodies of Earth and human body. The quantization of magnetic flux suggests an answer to this question.

There are several manners to achieve quantization of magnetic flux with dynamical $\hbar$. From the point of view of EEG and ZEG especially interesting are flux flux sheets which have thickness $L(169)/\lambda = L(151) = 2.5$ nm carrying magnetic field having strength of Earth's magnetic field. These flux sheets have thickness of DNA double strand and total transversal length $L(169 + 5 \times 22) = L(257) = 1.6 \times 10^8$ km from flux quantization at $k_{em} = 4$ level of dark matter hierarchy necessary in order that the energies associated with cyclotron frequencies are above thermal threshold. Strongly folded flux sheets of this thickness might be associated with living matter and connect their DNAs to single coherent structure.

Suppose that the magnetic flux flows in head to tail direction so that the magnetic flux arrives to the human body through a layer of cortical neurons. Assume that the flux sheets traverse through the uppermost layer of neurons and also lower layers and that DNA of each neuronal nuclei define a transversal sections organized along flux sheet like text lines of a book page. The total length of DNA in single human cell is about one meter. It seem that single brain cannot provide the needed total length of DNA if DNA dominates the contribution: this if of course not at all necessarily. Even for $k_{em} < 4$ levels magnetic flux sheets could traverse nuclei belonging to different organisms.

This leads to the notion of super- and hyper genes. Super genes consist of genes in different cell nuclei arranged to threads along magnetic flux sheets like text lines on the page of book whereas hyper genes traverse through genomes of different organisms. Super and hyper genes provide an enormous representative capacity and together with the dark matter hierarchy allows to resolve the paradox created by the observation that human genome does not differ appreciably in size from that of wheat.

**Charge entanglement as a tool of generalized motor action**

The charge entanglement by $W$ MEs is an essentially new element in the model for generalized motor actions by magnetic body. Also the telepathic sharing of mental images could rely on charge entanglement. The notion was originally applied in the model of nerve pulse generation [M2]. Neutral MEs would in turn be related to communications and memory. The reduction of charge entanglement can induce a quantum jump to a state in which local Bose-Einstein condensates become exotically ionized with certain probability depending on the intensity of $W$ field. Bose-Einstein condensates define pixels of generalized motor maps.

Exotic ionization induces dark plasma oscillations in turn generating various physiological responses such as $Ca^{++}$, $Mg^{++}$ waves, and nerve pulse patterns giving rise to the motor action as an asymptotic self-organization pattern. Plasma oscillation patterns utilize typically dark microwave photons as metabolic energy. Field code is the correspondence between the spatio-temporal pattern of plasma oscillations and generalized motor action and the number theoretical model for genetic code [L3] generalizes to this context.

**Overview about quantum control and coordination**

The following general overview about quantum communication and control emerges in this framework.

1. Cyclotron frequencies relate to the control of the biological body by the magnetic body and could be assigned with the magnetic flux sheets going through DNA since it is genome where protein synthesis is initiated and is thus the optimal intermediate step in the cellular control.

2. One of the basic functions of cell membranes is to perceive the chemical environment using various kinds of receptors as sensors. Neurons have specialized to receive symbolic representations of the sensory data of primary sensory organs about the situation in the external world. Receptor proteins would communicate cell level sensory input to the magnetic body via MEs parallel to magnetic flux tubes connecting them to the magnetic body. We ourselves would be in an abstract sense fractally scaled up counterparts of receptor proteins and associated with dark matter iono-lito Josephson junction connecting the parts of magnetosphere below litosphere and above magnetosphere.

3. This picture would explain why the temperature of brain must be in the narrow range 36-37 K to guarantee optimal functionality of the organism. If interior superconductivity is lost, magnetic body receives sensory data but is paralyzed since its desires cannot be realized. If boundary superconductivity is lost, magnetic body can move but is blind.

4. In the length scales below the weak length scale $L_w$ also charged weak bosons behave as massless particles and the exchange of virtual $W$ bosons makes possible a nonlocal charge transfer. Dark quark-antiquark pairs associated with the color bonds of the atomic nuclei can become charged via the emission of dark $W$ boson and thus produce and exotic ion. The same can happen at the higher levels of dark matter hierarchy. This provides a nonlocal quantal mechanism inducing or changing electromagnetic polarization in turn inducing ordinary charge flows and thus making possible quantum control.

5. Massless extremals (MEs, topological light rays) serve as correlates for dark bosons. Besides neutral massless extremals (em and $Z^0$ MEs) TGD predicts also charged massless extremals obtained from their neutral counterparts by a mere color rotation (color and weak quantum numbers are not totally independent in TGD framework). The interpretation of the charged MEs has remained open hitherto. Charged $W$ MEs (hierarchy of WEGs!) could induce long length scale charge entanglement of Bose-Einstein condensates by inducing exotic ionization of ionic nuclei. State function reduction could lead to a state containing a Bose-Einstein condensate in exotically ionized state.

   In this manner the dark charge inside neuron and thus by Faraday's law also membrane potential could be affected by magnetic body. The generation of nerve pulse could rely on the reduction of the resting potential below the critical value by this kind of mechanism inducing charge transfer between cell interior and exterior. The mechanism might apply even in the scale of magnetic body and make possible the control of central nervous system. Also remote mental interactions, in particular telekinesis, might rely on this mechanism.

Summarizing, charged massless extremals could be seen as correlates for nonlocal quantum control by affecting charge equilibria whereas neutral MEs would serve as correlates for coordination and communication. Color charged MEs could also induce color charge polarization and flows of color charges and thus generate visual color qualia by the capacitor mechanism discussed in [K3].

## 8.3 MEs and mes

The development of the model for the detailed identification of the sensory qualia and brain led to a general vision about the evolution of consciousness and information processing in brain. In this section various properties of MEs are summarized.

### 8.3.1 Massless extremals

Massless extremals (MEs) are an extremely general solution set of field equations associated with Kähler action [B1] and representing various gauge – and gravitational fields [J4]. Being scale invariant, MEs come in all size scales. The geometry has axial symmetry in the sense that $CP_2$ coordinates are arbitrary functions of two variables constructed from Minkowski coordinates: light-like coordinate $t-z$ and arbitrary function of the coordinates of the plane orthogonal to the z-axis defining the direction of propagation. The polarization of the electromagnetic field depends on the point of the plane but is temporally constant. MEs represent waves propagating with velocity of light in single direction so that there is no dispersion: preservation of the pulse shape makes MEs ideal for classical communications.

Electric and magnetic parts of various gauge fields are orthogonal to each other and to the direction of propagation. Classical gauge field is sum of a free part plus part having as its source light-like vacuum current. The time dependence of the vacuum current is arbitrary, this is only possible by its light-likeness. This makes it possible to code all kinds of physical information to the time dependence of the vacuum current. MEs can have finite spatial size and in this case they are classical counterparts of virtual photons exchanged between charged particles and represent classical communication between material space-time sheets. MEs carry gravitational waves and also classical $Z^0$ fields propagating with light velocity.

MEs can also carry constant electric field. In this case either vacuum charges or actual charges near the boundaries of ME contain define the sources of this field. This situation can be also achieved if MEs form double-sheeted structures and wormhole contacts serve as effectively sources of the field. TGD allows the possibility that the two sheets have opposite time orientations and therefore also opposite classical energies. More generally, the exchange of two or more MEs between material space-time sheets can be such that no net momentum exchange occurs so that the absolute minimum of Kähler action only in a finite region of space-time and gives rise to new degenerate absolute minimum of Kähler action since ME has vanishing action. This kind of structures are obvious candidates for cognitive structures since classical nondeterminism is localized in a finite space-time volume. The Universe should be full of MEs with all possible sizes since they have vanishing action: addition of ME with finite time duration yields new absolute minimum of Kähler action since Kähler action does not change in this operation. This suggests that MEs should be of crucial importance in TGD Universe.

MEs serve as receiving and sending quantum antennae [J4]. Light-like vacuum current generates coherent light. Also coherent gravitons are generated. MEs serve also as templates for BE condensation of photons and gravitons with momenta parallel to the light-like vacuum current. Linear structures, say DNA and micro-tubules, are natural but not the only candidates for structures accompanied by MEs. Since MEs are massless, they carry maximal possible momentum. This makes exchange of ME ideal mechanism for locomotion. The possibility of negative energy MEs is especially fascinating since it suggests 'buy now, pay later' mechanism of energy production: perhaps living matter uses MEs to generate coherent motions [I4, I5].

#### Massless extremals as general solutions of field equations

Let $k = (k^0, k^3, 0, 0)$ be a light like vector of $M^4$ and $u = u(m^1, m^2)$ arbitrary function of the Minkowski coordinates $m^1$ and $m^2$ in the plane orthogonal to the direction of the 3-vector $(k^3, 0, 0)$ associated with $k$. The surfaces defined by the map

$$s^k = f^k(k \cdot m, u) \ , \tag{8.3.1}$$

where $f^k$ and $u$ are arbitrary functions define massless extremals. They describe the propagation of massless fields in the direction of $k$: the fields are periodic with a period $\lambda = 2\pi/k$ so that only $k$ and its integer multiples are possible wave vectors. The polarization associated with various induced gauge fields depends on the position in $(m^1, m^2)$-plane and is in the direction of the gradient of $u$. Field equations involve tensor contractions of the energy momentum tensor and gauge current but these are proportional to $kk$ and $k$ respectively and vanish by the light-likeness of $k$. Linear superposition holds true only in a restricted sense since both the propagation direction and the polarization direction in each $(m^1, m^2) = const$ plane is fixed.

What is remarkable that these solutions are not solutions of the ordinary Maxwell equations in vacuum: Kähler current density $J_K$ is in general non-vanishing(!) and proportional to the light like four-momentum $k$. As a consequence, also a light-like electromagnetic current is in general (but not necessarily) present. The interpretation of the em current $J$ as charged elementary particle current is impossible and the correct interpretation as a vacuum current associated with the induced gauge fields. The finite length of the micro-tubule plus the requirement that the total vacuum charge vanishes, implies that the Fourier decompositions of the massless fields contain only integer multiples of the basic four-momentum $k$. The direct detection of the light-like vacuum current inside a micro-tubule would provide strong support for TGD.

The physical importance of these extremals is suggested by the fact they are in certain sense elementary particle like objects: in fact, the original interpretation was as a model for the exterior space-time of a topologically condensed massless particle. The solution set is also very general involving several arbitrary functions. Although the minimization of the Kähler action favors the formation of Kähler electric fields, massless extremals might well appear as space-time sheets of the effective space-time. These space-time sheets should not contain ordinary charges since their presence implies a transition to the Maxwell phase described in an excellent approximation by the ordinary Maxwell electrodynamics. The fact that vacuum em current and vacuum Einstein tensor do not in general vanish, could mean that massless extremals serve as sources of coherent photons and gravitons.

Massless extremals can also reduce to vacuum extremals of the Kähler action in the case that the $CP_2$ projection is, in general two-dimensional, Legendre manifold of $CP_2$. These extremals are however not gravitational vacua.

#### Generalization of the solution ansatz defining MEs

The solution ansatz for MEs has developed gradually to an increasingly general form and the following formulation is the most general one achieved hitherto. Rather remarkably, it rather closely resembles the solution ansatz for the $CP_2$ type extremals and has direct interpretation in terms of geometric optics. Equally remarkable is that the latest generalization based on the introduction of the local light-cone coordinates was inspired by quantum holography principle.

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*1. Local light-cone coordinates*

The solution involves a decomposition of $M^4_+$ tangent space localizing the decomposition of Minkowski space to an orthogonal direct sum $M^2 \oplus E^2$ defined by light-like wave vector and polarization vector orthogonal to it. This decomposition defines what might be called local light-cone coordinates.

1. Denote by $m^i$ the linear Minkowski coordinates of $M^4$. Let $(S_+, S_-, E_1, E_2)$ denote local coo-ordinates of $M^4_+$ defining a *local* decomposition of the tangent space $M^4$ of $M^4_+$ into a direct *orthogonal* sum $M^4 = M^2 \oplus E_2$ of spaces $M^2$ and $E^2$. This decomposition has interpretation in terms of the longitudinal and transversal degrees of freedom defined by local light-like four-velocities $v_\pm = \nabla S_\pm$ and polarization vectors $\epsilon_i = \nabla E_i$ assignable to light ray.

2. In accordance with this physical picture, $S_+$ and $S_-$ define light-like curves and thus satisfy the equation:

$$(\nabla S_\pm)^2 = 0 \quad .$$

The gradients of $S_\pm$ are obviously analogous to local light like velocities $v = (1,\overline{v})$ and $\tilde{v} = (1,-\overline{v})$. These equations are also obtained in geometric optics from Hamilton Jacobi equation by replacing photon's four-velocity with the gradient $\nabla S$: this is consistent with the interpretation of MEs as Bohr orbits of em field.

3. With these assumptions the coordinates $(S_\pm, E_i)$ define local light-cone coordinates with the metric element having the form

$$ds^2 = g_{S_+S_-} dS_+ dS_- + g_{11} dE_1^2 + g_{22} dE_2^2 \quad .$$

Conformal transformations of $M^4_+$ leave the general form of this decomposition invariant. The task is to find all possible local light-cone coordinates defining one-parameter families 2-surfaces defined by the condition $S_i = constant$, $i = +\ or\ = -$, dual to each other and expanding with light velocity.

*2. A conformally invariant family of local light-cone coordinates*

The simplest solutions to the equations defining local light-cone coordinates are of form $S_\pm = k\cdot m$ giving as a special case $S_\pm = m^0 \pm m^3$. For more general solutions of from

$$S_\pm = m^0 \pm f(m^1,m^2,m^3) \ \ , \ \ (\nabla_3 f)^2 = 1 \ \ ,$$

where $f$ is an otherwise arbitrary function, this relationship reads as

$$S_+ + S_- = 2m^0 \quad .$$

This condition defines a natural rest frame. One can integrate $f$ from its initial data at some two-dimensional $f = constant$ surface and solution describes curvilinear light rays emanating from this surface and orthogonal to it. The flow velocity field $\overline{v} = \nabla f$ is irrotational so that closed flow lines are not possible in a connected region of space and the condition $\overline{v}^2 = 1$ excludes also closed flow line configuration with singularity at origin such as $v = 1/\rho$ rotational flow around axis.

One can identify $E^2$ as a local tangent space spanned by polarization vectors and orthogonal to the flow lines of the velocity field $\overline{v} = \nabla f(m^1,m^2,m^3)$. Since the metric tensor of any 3-dimensional space allows always diagonalization in suitable coordinates, one can always find coordinates $(E_1,E_2)$ such that $(f,E_1,E_2)$ form orthogonal coordinates for $m^0 = constant$ hyperplane. Obviously one can select the coordinates $E_1$ and $E_2$ in infinitely many manners.

3. Closer inspection of the conditions defining local light-cone coordinates

Whether the conformal transforms of the local light-cone coordinates $\{S_\pm = m^0 \pm f(m^1,m^2,m^3), E_i\}$ define the only possible compositions $M^2 \oplus E^2$ with the required properties, remains an open question. The best that one might hope is that any function $S_+$ defining a family of light-like curves defines a local decomposition $M^4 = M^2 \oplus E^2$ with required properties.

1. Suppose that $S_+$ and $S_-$ define light-like vector fields which are not orthogonal (proportional to each other). Suppose that the polarization vector fields $\epsilon_i = \nabla E_i$ tangential to local $E^2$ satisfy the conditions $\epsilon_i \cdot \nabla S_+ = 0$. One can formally integrate the functions $E_i$ from these condition sonce the initial values of $E_i$ are given at $m^0 = constant$ slice.

2. The solution to the condition $\nabla S_+ \cdot \epsilon_i = 0$ is determined only modulo the replacement

$$\epsilon_i \rightarrow \hat{\epsilon}_i = \epsilon_i + k\nabla S_+ \quad ,$$

where $k$ is any function. With the choice

$$k = -\frac{\nabla E_i \cdot \nabla S_-}{\nabla S_+ \cdot \nabla S_-}$$

one can satisfy also the condition $\hat{\epsilon}_i \cdot \nabla S_- = 0$.

3. The requirement that also $\hat{\epsilon}_i$ is gradient is satisfied if the integrability condition

$$k = k(S_+)$$

is satisfied: in this case $\hat{\epsilon}_i$ is obtained by a gauge transformation from $\epsilon_i$. The integrability condition can be regarded as an additional, and obviously very strong, condition for $S_-$ once $S_+$ and $E_i$ are known.

4. The problem boils down to that of finding local momentum and polarization directions defined by the functions $S_+$, $S_-$ and $E_1$ and $E_2$ satisfying the orthogonality and integrability conditions

$$(\nabla S_+)^2 = (\nabla S_-)^2 = 0 \ , \quad \nabla S_+ \cdot \nabla S_- \neq 0 \ ,$$

$$\nabla S_+ \cdot \nabla E_i = 0 \ , \qquad \frac{\nabla E_i \cdot \nabla S_-}{\nabla S_+ \cdot \nabla S_-} = k_i(S_+) \ .$$

The number of intebrability conditions is 3+3 (all derivatives of $k_i$ except the one with respect to $S_+$ vanish): thus it seems that there are not much hopes of finding a solution unless some discrete symmetry relating $S_+$ and $S_-$ eliminates the integrability conditions altogether.

A generalization of the spatial reflection $f \rightarrow -f$ working for the separable Hamilton Jacobi function $S_\pm = m^0 \pm f$ ansatz could relate $S_+$ and $S_-$ to each other and trivialize the integrability conditions. The symmetry transformation of $M^4_+$ must perform the permutation $S_+ \leftrightarrow S_-$, preserve the light-likeness property, map $E^2$ to $E^2$, and multiply the inner products between $M^2$ and $E^2$ vectors by a mere conformal factor. This encourages the conjecture that all solutions are obtained by conformal transformations from the solutions $S_\pm = m^0 \pm f$.

*4. General solution ansatz for MEs for given choice of local light-cone coordinates*

Consider now the general solution ansatz assuming that a local wave-vector-polarization decomposition of $M^4_+$ tangent space has been found.

1. Let $E(S_+, E_1, E_2)$ be an arbitrary function of its arguments: the gradient $\nabla E$ defines at each point of $E^2$ an $S_+$-dependent (and thus time dependent) polarization direction orthogonal to the direction of local wave vector defined by $\nabla S_+$. Polarization vector depends on $E^2$ position only.

2. The most general MEs correspond to the solution family of the field equations having the general form

$$s^k = f^k(S_+, E) \ ,$$

where $s^k$ denotes $CP_2$ coordinates and $f^k$ is an arbitrary function of $S_+$ and $E$. The solution represents a wave propagating with light velocity and having definite $S_+$ dependent polarization in the direction of $\nabla E$. By replacing $S_+$ with $S_-$ one obtains a dual solution. Field equations are satisfied because energy momentum tensor and Kähler current are light-like so that all tensor contractions involved with the field equations vanish: the orthogonality of $M^2$ and $E^2$ is essential for the light-likeness of energy momentum tensor and Kähler current.

3. The simplest solutions of the form $S_\pm = m^0 \pm m^3$, $(E_1, E_2) = (m^1, m^2)$ and correspond to a cylindrical MEs representing waves propagating in the direction of the cylinder axis with light velocity and having polarization which depends on point $(E^1, E^2)$ and $S_+$ (and thus time). For these solutions four-momentum is light-like: for more general solutions this cannot be the case. Polarization is in general case time dependent so that both linearly and circularly polarized waves are possible. If $m^3$ varies in a finite range of length $L$, then 'free' solution represents geometrically a cylinder of length $L$ moving with a light velocity. Of course, ends could be also anchored to the emitting or absorbing space-time surfaces.

4. For the general solution the cylinder is replaced by a three-dimensional family of light like curves and in this case the rectilinear motion of the ends of the cylinder is replaced with a curvilinear motion with light velocity unless the ends are anchored to emitting/absorbing space-time surfaces. The non-rotational character of the velocity flow suggests that the freely moving particle like 3-surface defined by ME cannot remain in a infinite spatial volume. The most general ansatz for MEs should be useful in the intermediate and nearby regions of a radiating object whereas in the far away region radiation solution is excepted to decompose to cylindrical ray like MEs for which the function $f(m^1, m^2, m^2)$ is a linear linear function of $m^i$.

### 8.3.2 About the electro-weak and color fields associated with massless extremals

Space-time sheets carrying em fields carry usually also $Z^0$ and $W$ fields and it is not possible to speak about em or $Z^0$ type MEs. It is however possible to speak about neutral and $W$ MEs. The $CP_2$ projection of ME is 2-dimensional and in a special case it reduces to a geodesic sphere. There are two kinds of geodesic spheres in $CP_2$.

1. For space-time sheets for which $\mathrm{CP}_2$ projection is $r = \infty$ homologically non-trivial geodesic sphere of $CP_2$ one has

$$\gamma = (\frac{3}{4} - \frac{sin^2(\theta_W)}{2})Z^0 \simeq \frac{5Z^0}{8} \quad .$$

   The induced $W$ fields vanish in this case and they vanish also for all geodesic sphere obtained by $SU(3)$ rotation.

2. For homologically trivial geodesic sphere a standard representative is obtained by using for the phase angles of standard complex $CP_2$ coordinates constant values. In this case induced em, $Z^0$, and Kähler fields vanish but induced $W$ fields are non-vanishing. This holds also for surfaces obtained by color rotation. Hence one can say that for non-vacuum extremals with 2-D $\mathrm{CP}_2$ projection color rotations and weak symmetries commute.

The MEs corresponding to these two geodesic spheres could be called neutral and $W$ MEs and they carry color fields for which the color group $SU(3)$ reduces to some of its $U(1)$ subgroups. Quite generally, the holonomy algebra of color group is Abelian since the induced color field is of the form $g^A_{\alpha\beta} \propto H^A J_{\alpha\beta}$, where $H^A$ denotes color Hamiltonian. Neutral MEs are excellent candidates for mediating EEG type communications from the biological body to the magnetic body whereas charge entanglement induced by $W$ MEs would be ideal for the realization of motor actions of the magnetic body.

MEs are excellent candidates for the space-time correlates of laser beams. Dark matter hierarchy implies that also MEs can be classified by the level of the dark matter hierarchy involved. A very general argument leads to the conclusion that dark space-time sheets, in particular MEs, at the $k^{th}$ level of the dark matter hierarchy correspond to space-time sheets defining $\lambda^k$-fold coverings of $M^4$ (recall that one has $\hbar(k) = \lambda^k \hbar_0$ and $\lambda \simeq 2^{11}$) [C6, M3]. $k = 0$ MEs would correspond to the ordinary laser light.

### 8.3.3 MEs as absorbing and emitting quantum antennae

#### How massless extremals generate coherent states of photons?

ME:s can be in 'dormant' or active state according to whether the em current associated with the ME is vanishing or not. In active state ME:s generate Bose Einstein condensate type state for ordinary photons. This means in TGD context the emission of (topological) vapour phase photons ($CP_2$ type extremals), which can condense on other condensate levels. ME:s generate gravitonic BE condensate and the possible biological role of this condensate will be discussed later.

Assuming that the coupling of quantized photon field to the massless extremal is given by regarding the massless extremal as a classical background field one obtains QED with a light like source $J^\alpha$:

$$
\begin{aligned}
D_\beta F^{\alpha\beta} &= eJ^\alpha \ , \\
J^\alpha &= Jk^\alpha \ .
\end{aligned} \tag{8.3.2}
$$

The system is equivalent with an infinite number of harmonic oscillators each driven by a harmonic external force and a basic exercise in the quantum mechanics shows that the solutions of the field equations give the new oscillator operators as sums of free oscillator operators plus c-number term, which is essentially the Fourier component of the light like current in the direction of the polarization.

In the limit that ME has infinite duration and is a cylindrical structure of finite length $L$ (that is micro-tubule) one has for $J \propto sin(k_z(t-z))$

$$
\begin{aligned}
a^\dagger(p) &\rightarrow a^\dagger(p) + g(p) \ , \\
g(p) &= \sum_n \delta(p^0, k_n^0) K(p, k_n) J(k_n^z, p_T) \ , \\
K(p,k) &= \epsilon(p)\cdot k \frac{1}{i(p_z - k_z)}(exp(ip_z L) - 1) \ , \\
k_n &= nk_0 = \frac{n2\pi}{L}(1,1,0,0) \ .
\end{aligned} \tag{8.3.3}
$$

Here $p$ denotes the momentum of the photon and $k$ the 4-momentum associated with the Fourier component of a light-like current. $\epsilon(p)$ denotes the polarization of the photon. $J(k_n^z, p_T)$ is essentially the 3-dimensional Fourier transform of the scalar function $J$. The infrared behavior of $J(k_z, p_T)$ as a function of the transversal momentum $p_T$ can be deduced from the fact that the transverse dimension of the micro-tubule is small (about 25 nm) as compared to $1/p_T$ so that the Fourier component is in good approximation independent of $p_T$.

For the frequencies present in the Fourier decomposition of the massless extremal, the ordinary oscillator vacuum is transformed to a coherent state in the corresponding Fourier mode of the quantized photon field. The essential point is that the wave vectors of the radiation field and massless extremal are nonorthogonal. The radiation pattern resembles the ordinary antenna pattern associated with an oscillating current $J(t) = exp(i\omega t)$ in that the intensity of radiation vanishes at angles $\theta = \pi/2$ and $\theta = 0$. For $J \propto sin(k_z(z-t))$ $|K|^2$ has maxima for $\theta = 48.6$ degrees and 131.4 degrees. For an ordinary dipole with $J = sin(\omega t)$, $\omega = 2\pi/L$ the radiation pattern is concentrated at angles $\theta \geq 40$ degrees with maximum and 69.3 degrees and 110.7 degrees.

A more complicated situation corresponds to a group of several massless extremals (say micro-tubules). If massless extremals are parallel and have same length the previous expression generalizes with superposition of terms

$$
g(p) \rightarrow \sum_n exp(i\phi_n) exp(ip_z z_n) exp(ip_T \cdot x_T) g_n(p) \ . \tag{8.3.4}
$$

The phase $\phi_n$ is the phase difference between $n$:th light like current with respect to some reference current. If the positions of micro-tubules and/or phases of the individual light like currents are suitably chosen then various terms interfere constructively and macroscopic quantum coherence is obtained at resonant frequencies. Suffice it so say that the needed timing is extremely accurate: less than $10^{-12}$ seconds! Since $p_z$ is small rather larger transversal distances are allowed by the requirement of constructive interference. In a more general situation also the orientations of micro-tubules can vary in certain limits. Note that light-like energy momentum generates also gravitonic BE condensates at preferred frequencies.

**Massless extremal is accompanied by a Bose-Einstein condensate of parallel photons**

The interaction Lagrangian describing the interaction of photon field with the light-like vacuum current does not couple to the photons collinear with the vacuum current (light-like wave vector has vanishing length squared). Therefore the ground states of the system are degenerate since one can add to any coherent state generated by the vacuum current any number of photons collinear with the vacuum current and topologically condensed inside the massless extremal. This means Bose-Einstein condensation in collinear degrees of freedom.

Collinear Bose-Einstein condensates of photons are crucial for the model of the quantum correlates of the sensory qualia. Sensory quale is characterized partially by the BE condensate of photons associated with the massless extremal parallel to the axon. The existence of the BE condensate makes possible induced emission. For instance, Josephson currents generate photons with frequencies which are multiples of the Josephson frequency. If the potential difference in Josephson junction equals to a multiple of the cyclotron frequency of some super conducting ion, the current flows resonantly in the sense that Josephson current serves as a harmonic perturbation generating quantum jumps and gives rise to a large dissipative current and also quantum jumps in either super conductor. Since the emission rate for photons by the current is proportional to $N^2$, where $N$ is the number of photons already in the state, the presence of the BE condensate of photons with this frequency amplifies the emission rate. This kind of resonance mechanism is assumed in the model of sensory experience since it elegantly explains why given neuron corresponds to single quale. Since the potential difference over the Josephson junction can correspond to only single cyclotron frequency, the dominance of single quale is unavoidable even when all macroscopic quantum phases are present.

The existing BE condensate increases the probability of topological condensation of coherent photons generated by other massless extremals to the massless extremal. This mechanism could provide inter-neuronal communication mechanism and realize the metaphor about brain as a society of neutrons, the notion of neuronal window idea and also give a more precise content to the music metaphor. In particular, neurons far away from each other could communicate using wavelengths in a narrow wave length range by this mechanism.

The wave vectors of the photons are multiples of $k = \pi/L$. This means that the length of the massless extremal correlates with the maximal allowed wavelength. For ELF photons associated with EEG frequencies of order 10 Hz the length of massless extremal is of order Earth's circumference. This suggests that more general massless extremals with a topology of torus instead of linear topology could characterize the topological field quanta of ELF fields. It is however impossible to say, whether the field equations allow more general solutions resembling massless extremals.

### 8.3.4 Quantum holography and quantum information theory

Sokolov and collaborators [17] have proposed a model of quantum holographic teleportation in which the *classical* photocurrents from the sender to receiver take the role of a dynamical hologram. The connection with MEs is obvious.

1. MEs are carriers of classical light-like vacuum currents (one of the basic differences between TGD and Maxwell theory). This suggests that MEs could be interpreted also as *classical* holograms, which are *dynamical* as in quantum information theory. Light-like current would be like a dynamical (four-dimensional) diffraction grating. Light-like vacuum currents and vacuum Einstein tensor generate also coherent states of photons and gravitons and MEs serve as templates for the topological condensation of photons and gravitons to the Bose-Einstein condensate of photons collinear with ME. The Bose-Einstein condensation of collinear photons and their generalizations to colored configuration space photons should affect the vacuum current by adding to the reference current what might be called evoked response. This condensation process could generate conscious experience and higher level qualia. Thus it would seem that MEs have a triple role as receiving and sending quantum antennae as well as classical holograms.

2. The proposal of [17] generalizes to the case of MEs provided one can device a method of coding quantum states of photon field to the vacuum currents. The high efficiency photodetector matrix is in which each pixel gives rise to a photocurrent [17], is replaced with ME or set of parallel MEs. The neural window hypothesis [H4] states that neuronal axons are accompanied by parallel MEs carrying information between sensory organs and brain and various parts of brain. This is only a less standard manner to say that ME represents classical dynamical hologram. The possibility of local light-cone coordinates allows also MEs which define curved deformations of the simplest cylindrical MEs.

The concrete realization of holographic teleportation proposed in [17] brings strongly in mind the architecture of the visual pathways. Thus one can wonder whether brain is perfoming internal teleportation of photonic quantum states with spike patterns being directly coded to the pattern of the vacuum currents flowing along MEs. If spike patterns code the dynamical hologram, a surprisingly close relationship with Pribram's views about hologrammic brain results. Nerve pulse patterns could be seen as specifying the necessary classical aspects of the quantum teleportation (in TGD classical physics is essential part of quantum physics, rather than some effective theory).

3. Vacuum current at a 3-dimensional time-like section of ME as a function function of time defines a dynamical 3-dimensional hologram. This is consistent with the fact that our visual experience is two-dimensional: the information is always about outer boundaries of the objects of the perceptive field. The values of the vacuum current at a given point are non-deterministic which means that vacuum current is ideal for coding information. Classical data also propagate without dispersion with light velocity obeying the laws of geometric optics and MEs imply channelling so that MEs are taylor-made for classical information transfer.

4. Space-time sheets can have both positive and negative time orientations and the sign of energy depends on time orientation in TGD framework. This means that classical communication can occur both in the direction of the geometric future and past: this is essential for the classical model of the long term memories as a question communicated to the geometric past followed by answer. The dynamical nature of the holograms means that there is no need to combine 2- or 3-dimensional holograms associated with several moments of geometric time to single hologram. To remember is to perceive an object located in the geometric past. Of course, fractality might make possible temporally scaled down versions of the geometric past but the principle would remain the same.

5. Quantum hologram view suggests that the super-canonical representations at the light-like boundaries of MEs characterized by gigantic almost-degeneracies are the real carriers of biological information. According to the general theory of qualia [K3] this information would become conscious since elementary qualia would correspond to quantum jumps for which increments of the quantum numbers correspond to the quantum numbers labelling super-canonical generators in the complement of Cartan algebra. In this view super-conducting magnetic flux tubes could perhaps be seen as intermediate level in the control circuitry controlled by MEs and controlling atomic level.

6. This picture leaves open whether there is a level controlling the thicknesses of the magnetic flux tubes and thus also magnetic transition frequency scales, and what this level might be. The entrainment of the endogenous frequencies to exogenous frequencies [K5] explains water memory and the effects of homeopathic remedies [47] and could make possible also endogenous NMR spectroscopy and chemical senses. The key to the puzzle might be a purely mathematical problem: how the boundary conditions at the boundaries of the magnetic flux tubes can be satisfied? It might be that the induced metric must become degenerate at the boundaries ($\sqrt{g} = 0$) implying a degeneracy of the induced metric at the boundary of the magnetic space-time sheet. This need not however mean that the $M^4_+$ projection of the boundary is a light-like surface: the projection could well be completely static. This supports the view that the boundaries do not carry super-canonical representations, which are associated with the imbedding space projection of the boundary rather than the boundary itself. One can imagine that ME with the same transversal section as magnetic flux tube is glued to the magnetic flux tube along this section: this kind of gluing results in a singular 4-surface analogous to the vertex region of Feynmann diagram and somekind of smoothing-out procedure is needed. The smoothed-out vertex region would make possible for ME to control magnetic flux tube thickness by varying its own transversal thickness.

#### MEs as quantum holograms in the sense of quantum gravitation

Quantum holography principle naturally generalizes to an approximate principle expected to hold true also in non-cosmological length and time scales.

1. The most general ansatz for MEs (inspired by the quantum holographic thinking) relies on the introduction of the notion of local light-cone coordinates $S_+, S_-, E_1, E_2$. The gradients $\nabla S_+$ and $\nabla S_-$ define two light-like directions just like Hamilton Jacobi functions define the direction of propagation of wave in geometric optics. The two polarization vectori fields $\nabla E_1$ and $\nabla E_2$ are orthogonal to the direction of propagation defined by either $S_+$ or $S_-$. Since also $E_1$ and $E_2$ can be chosen to be orthogonal, the metric of $M^4_+$ can be written locally as $ds^2 = g_{+-}dS_+dS_- + g_{11}dE_1^2 + g_{22}dE_2^2$. In the earlier ansatz $S_+$ and $S_-$ where restricted to the variables $k \cdot m$ and $\tilde{k} \cdot m$, where $k$ and $\tilde{k}$ correspond to light-like momentum and its mirror image and $m$ denotes linear $M^4$ coordinates: these MEs describe cylindrical structures with constant direction of wave propagation expected to be most important in regions faraway from the source of radiation.

2. Boundary conditions are satisfied if the 3-dimensional boundaries of MEs have one light-like direction ($S_+$ or $S_-$ is constant). This means that the boundary of ME has metric dimension $d = 2$ and is characterized by an infinite-dimensional super-canonical and super-conformal symmetries just like the boundary of the imbedding space $M^4_+ \times CP_2$: The boundaries are like moments for mini big bangs (in TGD based fractal cosmology big bang is actually replaced with what might be called a silent whisper amplified to not necessarily so big bang). Quantum holography would mean that effectively 2-dimensional conformal field theory at the boundary of $M^4_+$ region determined by ME determines what happens in the interior at QFT limit when space-time surface is not regarded as a dynamical object.

3. These observations inspire the conjecture that boundary conditions for $M^4$ like space-time sheets fixed by the absolute minimization of Kähler action quite generally require that space-time boundaries correspond to light-like 3-surfaces with metric dimension equal to $d = 2$. Quantum holography principle would state that the dynamics related to the metric of the configuration space, that is genuine quantum gravitation, would reduce to the boundaries of space-time sheets. The dynamics in zero modes and quaternion conformal degrees of freedom crucial for elementary particle physics would not however allow this kind of reduction. This would be consistent with the fractality which is expected to be a basic characteristic of the quantum critical Universe predicted by TGD. The approximate super-canonical and conformal symmetries would be associated with the light-like boundaries of the space-time sheets. Super-canonical invariance would be broken only by quantum gravitational effects at the level of the configuration space by the fact that the boundaries of space-time surfaces are actually dynamical rather than fixed. The cosmological light-cone boundary would be however non-dynamical and this would guarantee the exactness of the cosmological super-canonical invariance.

### More concrete view about MEs as holograms

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5. Quantum hologram view suggests that the super-canonical representations at the light-like boundaries of MEs characterized by gigantic almost-degeneracies are the real carriers of biological information. According to the general theory of qualia [K3] this information would become conscious since elementary qualia would correspond to quantum jumps for which increments of the quantum numbers correspond to the quantum numbers labelling super-canonical generators in the complement of Cartan algebra. In this view super-conducting magnetic flux tubes could perhaps be seen as intermediate level in the control circuitry controlled by MEs and controlling atomic level.

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### MEs and super-canonical and super-conformal symmetries

TGD predicts two kinds of super-conformal symmetries [E2]. Quaternion conformal symmetries correspond to the gauge symmetries of fundamental interactions. Cosmological super-canonical symmetries act on the boundary of light-cone and are cosmological symmetries.

The non-determinism of Kähler action however implies that the light-like $M^4_+$projections of light-like boundaries of MEs take the role of the boundary of future light-cone as quantum holograms and super-canonical symmetry becomes ordinary macroscopic symmetry. Thus there is a fractal hierarchy of quantum holograms inside quantum holograms. One can identify the light-like boundaries of MEs as geometric correlates for selves. Also space-like selves are very probably needed and magnetic flux tube structures could represent them. Indeed, the non-determinism of $CP_2$ type extremals representing elementary particles (their $M^4_+$ projections are random light-like curves) makes it impossible to characterize the quantum state completely by the data on the light-like boundaries of MEs.

MEs are natural carriers of super-canonical representations obtained by multiplying ordinary physical states by configuration space Hamiltonians (functions of $CP_2$ coordinates and coordinates $E_1, E_2$ and $S_+$ or $S_-$ which can obviously be arranged into irreducible representations of the color group $SU(3)$) and define an excellent candidate for a hierarchy of higher level life forms. The intuitive belief that quantum gravitation is crucial for higher level consciousness can be indeed justified in this framework: the 'worlds about worlds' aspect of higher level consciousness is what requires genuine quantum gravitational states.

The boundary of ME having one light-like direction gives rise to conformal quantum hologram representing quantum correlation functions for quantum field theory defined in the interior of ME. This 3-dimensional dynamical quantum hologram should code for conscious information about external world. This information could be determined by coherent light and gravitons scattered from the outer boundaries of other space-time sheets and could provide a quantum representation for the geometry of the boundaries of the other space-time sheets.

Super-canonical degrees of freedom makes MEs ideal candidates for the correlates of higher level consciousness.

1. The states of super-canonical representations have gigantic almost-degeneracies broken only by non-commutativity of super-canonical and Poincare symmetries which means huge information storage capacities. Super-canonical representations can be realized in real context using Bose Einstein condensates of massless elementary particles on MEs. Super-canonical representations correspond to genuine quantum gravitational effects since wave functionals in the space of three-surfaces are involved: space-time ceases to be a passive arena of quantum dynamics. In fact, canonical transformations of $CP_2$ are approximate symmetries of the theory broken only by classical gravitation. The notion of 'configuration space photon' having nontrivial dependence on configuration space degrees of freedom characterized by Hamiltonian suggests strongly itself and seems to be crucial for understanding of the visual colors.

2. Super-canonical representations have universal transition frequency spectrum given as multiples of the fundamental frequency determined by the length of ME. If one assumes that MEs have lengths given by p-adic length scale hypothesis, fundamental frequencies turn out to correspond to important resonance frequencies in EEG.

For these reasons super-canonical representations are ideal candidates for an infinite hierarchy of life forms associated with MEs. The great vision is that MEs and magnetic super-conductors associated with the magnetic flux tube structures form a fractal hierarchy interacting with the ordinary bio-matter via the classical gauge fields associated with MEs [K3, M3, M4, M5].

The standard manner to see the evolution of organism is as an initial value problem with data given at time=constant space-like section of Minkowski space. This view is definitely wrong in TGD framework, where the classical non-determinism of Kähler action is absolutely essential for the understanding of bio-systems and consciousness. Rather, one should see the problem as a boundary value problem with data given at light-like surfaces bounding MEs analogous to light-cone boundary identifiable as the moment of big bang. This view conforms nicely with the active intentional aspects of the biological evolution: system can decide what it will be and life is more like a narrative with definite goals than random Brownian zigzag curve. The life cycle of the organism is specified by posing some requirements which it must satisfy in the form of boundary conditions and organism does it best to satisfy them.

**Mechanism for generation of configuration space photons**

The super-canonical representations should have some interaction mechanism with ordinary matter, if they are to be important for life. In particular, a mechanism making MEs to emit and absorb configuration space photons coupling to em charge, should exist. There are good reasons to expect that direct couplings between exotic super-canonical states and ordinary elementary particles are very weak. The quantum number $L_0 = n$ defined by the Virasoro generator $L_0 = zd/dz$ (complex scaling) acting effectively as Hamiltonian in string diagrams is conserved in vertices. For matter representations massless ground states correspond have scaling quantum number $n = n_0$, where $n_0$ defines the negative value of the vacuum weight. It must be emphasized that for super-canonical representations $L_0$ does not seem to allow the interpretation as mass squared operator as in the case of quaternion conformal representations. The vertices in which $L_0 = O(p^k)$ state emits ordinary particle correspond to $np^k \leftrightarrow (np^k - m_0) + (m_0)$. The intermediate state is with $L_0 = np^k - m_0$ is has ultralarge scaling quantum number so that the amplitude is suppressed by a huge propagator factor. The processes involving only $L_0 = O(p^k)$ states are however not suppressed.

The interaction of the exotic super-canonical states with the classical gauge fields associated with MEs provides a unique mechanism of 'matter-mind interaction'. The vanishing of the vacuum weight of Super Virasoro is very much analogous to the vanishing of the Higgs vacuum expectation value in ordinary gauge theories. Indeed, the exotic super-canonical representations have unbroken gauge symmetries, which means that electro-weak and color interactions occur like in symmetry-nonbroken unconfined gauge theory. The presence of long range classical color and electro-weak gauge fields implying unbroken symmetries at classical level is important part of the story.

MEs have already at the space-time level symmetries supporting the view that super-canonical algebra acts as isometry algebra of the configuration space.

First, canonical transformations of $E^2 \times CP_2$, where $E^2$ is plane orthogonal to the light-like wave vector $k$ associated with ME, are symmetries of MEs. Also canonical transformations made local with respect to the light-like coordinate $u$ and coordinate variable $v$ orthogonal to $u$ are also symmetries.

Secondly, arbitrary dependence on the variable $u$ is equivalent with the invariance with respect to hypercomplex analytic transformations

$$x + ey \rightarrow f(x + ey) \ ,$$

$$e^2 = 1 \ .$$

where $f$ is arbitrary function. These transformations obey Lie-algebra which is essentially identical with the Virasoro algebra spanned by the infinitesimal holomorphic transformations.

The general interaction Hamiltonian for this interaction can be guessed by recognizing the following facts.

1. Interaction Hamiltonian should have the general current-vector potential form

$$H_{int} = \sum_D \int G_\mu^A(D) J^{A\mu}(x|D) \sqrt{g_4} d^4x \ ,$$

where sum is over the representations $D$ of color group defined by color Hamiltonians and where $G^A(D)$ represents analog of the classical gluon field associated with a particular color representation. In the case of color octet representation $G_\mu^A(\text{"8"})$ represents classical gluon field and is simply the projection of the Killing vector field of the color isometry to the space-time surface. The obvious generalization is that also in general case the vector field defined by the color transformation defines the classical gluon field. $J^{A\mu}(x|D)$ is the local current defined as the superposition of canonical generators continued to a function of space-time coordinates.

2. The construction of a local current defined on entire space-time surface having super canonical generator as conserved charge is highly nontrivial task. It should be based on the observation that for ME there is a unique decomposition of $M^4$ tangent space to $M^4 = M^2 \times E^2$ such that $E^2$ is space-like plane orthogonal to the light-like wave vector $k$ associated with ME. Let $u$ denote the coordinate

$$u = k \cdot m \ .$$

The task is to continue the canonical generator localized with respect to the radial coordinate of the light-cone boundary to a function in entire $M^4_+$. A possible manner to do this is to multiply the generator by a plane wave

$$exp(i2\pi f(u-u_0)) \ ,$$

where $u$ denotes the restriction of the coordinate $u$ to the light-cone boundary

$$u_0 = u_{|\delta M^4_+} \ .$$

The task is to fix the physical identification of the ME frequency. It turns out that interpretation as energy is the most plausible identification.

It might well be that only classical color fields define interaction vertices leading to the generation of configuration space photons. If this is the case the octet representation for configuration space photons would have a unique role. This would explain why visual colors, which can be identified as counterparts of the charged Hamiltonians associated with configuration space photons, are in a special role. Furthermore, MEs have always 2-dimensional $CP_2$ projection and carry classical color fields and currents restricted to $U(1)$ sub-algebra of color algebra, which need not be however color neutral. This implies that only particular configuration space photon and its conjugate are emitted and that only single color is created by the BE condensation of configuration space photons generated by a particular ME on other MEs.

### 8.3.5 MEs and quantum control

#### MEs and classical de-coherence

TGD approach inspires the idea that classical de-coherence corresponds to the decomposition of a space-time sheet carrying superposition of em fields to separate space-time sheets carrying the em fields appearing in the superposition. Since em fields live at different space-time sheets, interference effects are indeed absent which means de-coherence. A more precise and rather far reaching form of this hypothesis is that classical em field is unstable against decomposition to MEs. This mechanism allows to understand what might happen when amplitude modulated em field acts with living matter in the experiments of Blackman [45].

The extreme nonlinearity of the dynamics of absolute miminization of Kähler action implies that ELF modulated radio frequency field induces also em field component with modulating ELF frequency. If classical de-coherence generates MEs then classical amplitude modulated em fields leads to the generation of a large number of MEs at various frequencies and directions of wave vector. For instance, modulation frequency and carrier frequency could correspond to different MEs glued to each other by 'wormhole contacts'. Classical de-coherence and geometrically realized Fourier analysis would be the geometric and classical counterparts for field quantization reflecting the fact that absolute minimization of Kähler action implies that space-time surfaces are analogous to Bohr orbits.

#### MEs and conscious holograms

The notion of conscious hologram is much more practical than the concept of quantum gravitational hologram and generalizes the notion of ordinary hologram by fusing it with the notion of self [K4]. Universe is an extremely complex fractal Feynmann diagram with lines replaced by 4-dimensional space-time sheets and MEs are particular kinds of lines analogous to photon lines. These lines are like laser beams, which interfere in the vertices of the Feynmann diagram: vertices correspond to material space-time sheets, atoms, molecules, ..., cells, ... The 3-D hologram vision corresponds at the level of conscious hologram stereo consciousness resulting when the mental images associated with different points of the hologram fuse to single mental image by quantum entanglement involving also the sharing of mental images.

An important piece of the picture is fact that MEs appear as pairs of high frequency and low frequency MEs. The low frequency MEs serve as correlates for remote quantum entanglement, now between different parts of brain. High frequency MEs travel like massless particles along the bridges defined by the low frequency MEs and serve as bridges between different space-time sheets at the receiving end. This induces a leakage of ions between different space-time sheets, breaking of super-conductivity and dissipative self-organization: this process which is analogous to the formation of hologram, is responsible for homeostasis and metabolism and gives rise to many-sheeted ionic flow equilibrium. Also many-sheeted lasers acting in a very wide range of frequencies become possible. The frequencies correspond to differences for the energies of ions at the space-time sheets involved. MEs parallel to axons can also act as Josephson junctions connecting space-time sheets which can correspond to different p-adic primes.

Phase conjugate laser beams have as their counterpart negative energy MEs and negative energy photons resulting in time reversal. The time reversal for the dissipation induced by super current leakage seems also to be a key mechanism of bio-control. This leads to the working hypothesis that negative energy MEs are responsible for motor control whereas positive energy MEs are involved with perception and cognition: motor action is time reversed sensory perception in appropriate p-adic time scale. Among other things negative energy MEs make possible emission of negative energies making possible buy now-pay later (or let others pay) mechanism and thus extreme flexibility of energy economy.

#### Many-sheeted ionic flow equilibrium controlled by MEs

A crucial empirical ingredient supporting the view about a hierarchy of magnetic super-conductors are the puzzling observations of cell biology (for a summary see the first chapter of [46]) challenging the association of ionic channels and pumps to cell membrane. The paradoxes disappear if cell and its exterior are assumed to be in a many-sheeted ionic flow equilibrium with ionic currents flowing from super-conducting space-time sheets to atomic space-time sheets and back, so that the densities of ions at atomic space-time sheets are controlled by the the very small densities and quantized currents of dark ions at super-conducting magnetic flux tube space-time sheets and coding the information about homeostasis of bio-matter [J3]. Also a reason why for liquid crystal and electret properties of bio-matter emerges and one can understand the function of electric circuitry associated with body [62].

In this picture ionic channels and pumps would play the role of sensors detecting the concentrations of various ions and membrane voltages. The dominant part of the ionic currents would flow between cell interior and exterior as (possibly dark) supra currents and would dissipate very little. The dominant part of the metabolic energy would be used to build-up of dark EEG with photon energies above thermal threshold. Also negative dark $W$ MEs responsible for motor actions would suck metabolic energy.

$W$ MEs connecting magnetic body and biological body can induce charge entanglement by super-position of pairs of exotically ionized states with opposite exotic charges. State function reduction then selects either of the resulting states. Exotic ionization generates dark plasma oscillations which induce by Faraday law electric fields at the space-time sheets of the ordinary matter. The resulting ohmic currents in turn realize the control action on the ordinary matter (nerve pulse patterns, $Ca^{2+}$ waves, etc...).

Neutral MEs can induce supra currents in super-conducting magnetic circuits by magnetic induction mechanism, serve as Josephson junctions between magnetic flux tubes, and induce magnetic quantum phase transitions. MEs can generate reference waves or their phase conjugates (time reversals) acting on lower level MEs serving as dynamical holograms. The induced coherent light pattern and its phase conjugate could act as a control command and its time reversed version. Conjugate reference waves provide an extremely simple mechanism of healing by time reversal allowing the living matter to fight against second law.

MEs could "read" DNA strand to the light-like vacuum current by moving along it and thus code DNA strand/conjugate strand to a hologram or its phase conjugate in turn acting as a control command or its time reversal. ELF MEs could do the same at the level of axons: instead of DNA sequences nerve pulse patterns would be read now. Thus living matter could be regarded as a symbiosis in which MEs control super-conducting magnetic flux tubes controlling ordinary matter at atomic space-time sheets via many-sheeted ionic flow equilibrium. DNA would represent the ROM of this system.

What makes this so interesting is that MEs are at the highest level of quantum control in the TGD based view about bio-system as a symbiosis in which MEs control super-conducting magnetic flux tubes controlling ordinary matter at atomic space-time sheets via many-sheeted ionic flow equilibrium. The coherent light pattern emitted by ME resulting from the interaction of ME with the reference wave (its phase conjugate) could act as a control command (time reversed control command) inducing process (time reversed process). Conjugate reference waves would thus provide an incredibly simple and general mechanism of healing by time reversal allowing the living matter to fight against second law. This would be like a general initiating a war by just nodding or shaking his head.

The formation of the phase conjugates could occur completely routinely and explain also why DNA appears in double strands. ME could read DNA strand to the pulse pattern of the light-like vacuum current by moving along the strand and thus code DNA strand (conjugate strand) to a hologram (its phase conjugate) in turn acting as a control command (its time reversal). ELF MEs could do the same at the level of axons: instead of DNA sequences nerve pulse patterns would be read now. DNA would clearly represent the ROM of this system. The coding of proteins would thus not be the only function related to DNA: DNA would be for the cell society what the first written laws were for human society, and the presence of the conjugate strand would make possible a systematic self repair at the cellular level by time reversal. More detailed considerations along these lines, in particular some empirical evidence for the hologrammic realization of the genetic code in terms of light-like vacuum currents, are represented in [H8].

#### MEs as Josephson junctions?

MEs can induce Josephson junctions between bio-structures. Since the electric field of ME is orthogonal to the direction of the propagation of vacuum current, the Josephson junction with potential difference is formed most naturally when super conductors are joined by join along boundaries bonds to ME in the direction of the electric field associated with ME. MEs can in principle be arbitrary thin so that the thickness of Josephson junction can be much smaller than the dominating wavelength of ME.

ME electric field can contain also constant component. In this case is however ME is necessary double sheeted since constant electric field is created by wormhole throats on boundaries of ME serving as effective charges. These MEs could give rise to the Josephson junctions with constant potential difference. An attractive hypothesis is that these ME pairs have opposite time orientations so that total energy of ME pair can vanish and can be created from vacuum without any energy cost. Clearly, these structures are cognitive in the strong sense of the word.

This coding of the transversal potential difference associated with ME pair to Josephson frequency is expected to be fundamental information coding mechanism in living matter. ME pair can contain also oscillating electric field over Josephson junction at magnetic or some other transition frequency so that MEs are ideal for control purposes.

#### MEs and the interaction of the classical em fields with bio-matter

MEs acting as Josephson junctions and containing oscillating em field at ELF frequency give rise to a harmonic perturbation inducing quantum jumps of the magnetic states of ions and explains the effect of ELF em fields on bio-matter. Also the presence of the mysterious intensity windows [43, 45, 44] can be understood. Josephson current paradigm allows to understand this effect if RF or MW MEs associated with the external field act as Josephson junctions.

1. The external electric field oscillating with frequency $\omega$ (now radio frequency) defines slowly varying potential difference over Josephson junction of length $d$ acting as Josephson junction provided that the condition

   $$\omega \ll \omega_J(max) = ZeV = ZeEd$$

   holds true. This gives

   $$d \gg \frac{\omega}{ZeE} \quad .$$

   For $E \sim .1$ V/m and $\omega \sim GHz$ which are typical values used in experiments [45], this condition gives $d \gg 10^{-6}$ meters which is satisfied if Josephson junctions have size not smaller than cell length scale.

2. For fixed length of Josephson junction amplitude window results if the maximal Josephson frequency $\omega_J(max)$ is slightly above some transition frequency since in this case the stationary maxima and minima of amplitude lead to long lasting resonant excitation of quantum transitions. Denoting the relative width of the resonance by $\Delta\omega/\omega = P$, the ratio of the time spent in resonance at $\Omega_J(max)$ to the time spent off resonance at $\Omega_J$ is of order

$$\frac{t(max)}{t} \sim \sqrt{1 - \frac{\Omega_J^2}{\Omega_J^2(max)}} \times \frac{1}{\sqrt{P}} \ .$$

For a narrow resonance width this ratio can be very large so that amplitude window results for fixed value of $d$.

3. Amplitude window results if there is a correlation between the thickness of ME and transversal electric field so that $\omega_J(max) = ZeEd(E)$ satisfies resonance condition for some values of $E$ only, if any. In absence of this correlation Josephson junctions must have discrete spectrum of effective lengths for amplitude window to result.

4. For electric fields in the range .1 V/m the frequencies $\omega_J$ are above GHz for $d$ larger than $3 \times 10^{-5}$ meters and correspond to the frequencies for the conformational dynamics of proteins. There are obviously a large number of frequencies of this kind and several intensity windows. EM fields with these strengths should have special effects on living matter: it could be even that some kind of feature recognition process involving self-organization occurs at these field strengths. Note that the minimal size of Josephson junctions corresponds to the p-adic length scale $L(173) \simeq 1.6 \times 10^{-5}$ meters characterizing structures next to cells in the p-adic length scale hierarchy.

**The interaction of MEs with super-conducting magnetic flux tubes**

The interaction of brain with MEs could mean that the super-conducting magnetic fluxtube circuitry associated with brain effectively acts as magnetometer somewhat in the same way as SQUID magnetometer measures the magnetic fields generated by brain. The resulting conceptual framework makes it easier to develop a quantum level model for the generation of nerve pulse and for the interaction of MEs and bio-super-conductors in terms of Josephson currents and super currents and relying on the notion of stochastic resonance.

Brain could measure the magnetic fields of MEs by using a mechanism which is very much like the mechanism of SQUID based magnetometers [18] used to measure the magnetic fields induced by brain.

1. A large collecting circuit in which the magnetic field of ME generates a compensating current by the quantization of the magnetic flux might be involved.

2. The amplification of this field could be achieved if the circuit contains a part which is spiral like and contains large number of loops in a small area.

3. In the core region the current flowing in the loop gives rise to an amplified magnetic field which in turn can penetrate into a super-conductor in form of flux tubes and in multiples of flux quantum. By counting the number of flux quanta one obtains rough measure for the magnetic field. In the case of brain the quantized magnetic flux would directly affect the state of neurons and the model for the generation of nerve pulse specifies this interaction. This effect on neurons would be long lasting as compared with the short-lasting action induced by the nerve pulse patterns.

4. The deviation of the flux of the amplified magnetic field from an integer number of flux quanta could be measured by a neuronal counterpart of SQUID, which basically consists of a closed loop decomposing to two parts which are joined together by insulator so that current rapidly dissipates to a minimum value forced by the flux quantization. The current in SQUID serves as a measure for very weak magnetic fields of MEs. The non-linear dynamics of SQUID allows also stochastic resonance allowing to amplify very weak periodic signals. This measurement mechanism might be interpreted as a mechanism of interaction between super-conducting magnetic flux tubes and neuronal circuits inducing also an interaction between MEs and neuronal circuits. One might

guess that nerve pulse generation might involve this kind of mechanism: stochastic resonance seems to be indeed involved but not in this manner.

The collecting circuits for the neuronal SQUIDs could be of order body size or even larger. In [K3] I have proposed the notion of magnetic circulation analogous to blood circulation to be a basic control system in bio-systems. This circulation could be seen also as a collecting circuitry for magnetic flux amplified in brain, where amplifying and SQUID type components of the circuitry are located. Amplifying and SQUID type parts of the circuitry might be also located in other organs like heart: perhaps even muscles contain amplifying circuits and neuronal SQUIDs. One cannot exclude the possibility of much larger collecting circuits making possible the control of the organism by the higher levels of self hierarchy.

The spiral loops used in SQUIDs to amplify the magnetic field bring in mind the spiral structures associated with the self-organizing excitable media [49]. I have proposed in [I4, I5] that spiral structures might in TGD framework correspond to magnetic or $Z^0$ magnetic flux tubes which enter along the first space-time sheet to the vertex of the spiral structure, flow to the second space-time sheet, and return along the spiral loop. These spiral loops could be also ionic em or $Z^0$ super-conductors. This kind of spiral loop might perhaps serve as an amplifier of the magnetic flux generated by the super current flowing along the loop.

Very general empirical inputs [46] in dramatic conflict with the standard vision about what home-ostasis between cell interior and exterior means, lead naturally to a model in which the interaction of MEs with neuron occurs via magnetic induction mechanism leading also to the generation of nerve pulses. The notion of flow equilibrium in the many-sheeted space-time is essentially involved. The mechanism can also involve stochastic resonance as a means of transforming the oscillatory motion of the gravitational pendulum serving as an analog system to a rotational motion. The necessary noise could correspond to the noisy part of the super current perhaps induced by the incoming nerve pulses.

### Genetic code and color?

It is gradually becoming clear that the possibility of classical color gauge fields, the center of mass color degrees of freedom of space-time sheets analogous to rigid body degrees of freedom, and configuration space color might have deep implications for the understanding of living matter and consciousness. Colored MEs, or what what might be called configuration space photons, are one possible candidate for colored particles involved with the realization of color vision. They might be also an essential element of bio-control using the analogs of laser beams and there phase conjugates to represent control commands and their time reversals. This raises the question whether color might relate somehow with the realization of genetic code. The following speculations are just first speculations but might help to open gates of imagination.

*1. Minimal translation of the genetic code to holograms*

Configuration space photons represent genuinely quantum gravitational states, state functionals in the 'world of worlds', and thus they should correspond to highest level of self hierarchy and perform quantum control. Since color and polarization represented as angular momentum component in direction of ME characterize configuration space dependence, they could play a fundamental role in the control mechanism and control commands represented by quantum holograms should be characterized by a collection of these quantum numbers. In particular, genetic code might be expressible in terms of these basic quantum numbers.

There is a thought provoking connection with the TGD based model of genetic code predicting entire hierarchy of genetic codes.

1. At the first interesting level one has 4 nucleotides corresponding to $2^2 = 4$ mutually consistent statements in the set of $7 = 2^3 - 1$ statements coded by 3 bits and one statement thrown away.

2. DNA triplets correspond to the subset of $2^6 = 64$ mutually consistent statements of $2^7 - 1 = 127$ statements coded by 7 bits with one statement thrown away. At the next level one has $2^{127} - 1$ statements and the number of the mutually consistent statements is $2^{126} = 2^{6\times 21}$. It is not an accident that 126 decomposes into the product of numbers 6 and 21, where 21 is the number of different aminoacids with stopping sign counted formally as an aminoacid.

What makes the bell ringing is the appearance of the number $6 = 3 + 3$ primary colors and their conjugates. Could the number of nucleotides in the DNA triplet and its conjugate somehow correspond to the 3 primary colors and their complementary colors somehow? Note that also the 2-dimensional configuration spin is involved, and has two symmetry-related values $J$ and $-J$ (configuration space spin should be responsible for polarization sense). How could this correspondence be consistent with the idea about MEs generating coherent states of configuration space photons having configuration space color and spin and acting as control commands?

Consider first a minimal model in which, somewhat disappointingly, color is not necessarily needed.

1. The proposal of Gariaev and collaborators that DNA can be effectively regarded as a static sequence of laser mirrors [52] suggests a concrete guess for the coding of genes to sequences of MEs. In TGD framework laser mirrors could correspond to transversal MEs associated with DNA nucleotides. The requirement that two orthogonal polarizations are possible, implies that there must be a pair of mutually orthogonal MEs associated with each nucleotide and orthogonal to the DNA strand.

2. Configuration space spin of ME, which is 2-dimensional spin, is either $J$ or $-J$ so that $2 \times 2 = 4$ spin combinations $(\pm J, \pm J)$ are possible for the pair of MEs. The four nucleotides A,C,T,G naturally code for these spin configurations and the reversal of spin orientations corresponds naturally to the conjugations $A \leftrightarrow T$, $C \leftrightarrow G$ conjugations. Clearly, this model does not require color.

*2. How color could emerge in the translation of the genetic code to holograms?*

Color does not code for anything in the minimal model of the genetic code, and one could realize the genetic code using non-colored configuration space photons having only polarization degree of freedom or even ordinary polarized coherent light. There are some motivations for color however.

Each hologrammic command should have time reversed version giving rise to the phase conjugate command. Color and spin conjugation is a very natural manner to represent this operation. The conjugate hologram is naturally associated with the conjugate DNA strand. This observation allows to considerably generalize the model by only requiring that MEs correspond to any of the six basic colors and that complementary nucleotides correspond to conjugate colors. This option raises the possibility that DNA code words, genes or some other sub-units of DNA strands could define color singlets. This would obviously provide a very elegant manner to decompose genetic text to subunits. A more general, and perhaps more plausible, manner to decompose genetic text to subunits is as tensor products of unentangled and irreducible color representations.

This option however allows the possibility that genetic codewords are self conjugate. What if one excludes this possibility? It is possible to exclude the possibility of self conjugate commands by using 3+3 decomposition of color algebra corresponding to colors and complementary colors. The pairs of MEs associated with the subsequent nucleotides could be assumed to correspond to, say, (red, blue, white) in this order so that the conjugate strand corresponds to (green, yellow, black). In fact, the ordering of the colors is not essential since spin states of MEs code for the information. At quantum level the requirement that three colors are different would boil down to the requirement that there is complete asymmetry with respect to the permutations of the colors of three parallel MEs. Note that in this case the color quantum numbers of the DNA strand or its complementary strand cannot sum up to zero.

Note that the three different colors for the subsequent nucleotides might make possible that the corresponding control commands act on different MEs, which could be MEs associated with DNA itself.

*3. Color confinement and bio-control*

If color is really there, it must have some crucially important function besides making it possible to define time reversals of the control commands and decomposition of DNA to unentangle linguistic subunits. A good guess is that color confinement is involved with this function very intimately. Color confinement in the length scale of DNA MEs requires color neutrality in this length scale. DNA strand and its conjugate, even triplet and its conjugate, can give rise to a color singlet state but this is not possible if only the MEs associated with DNA strand are activated. In this case color confinement requires that somewhere else another colored state is activated so that the resulting overall state is color singlet. Thus long range correlations in the length scale of MEs perhaps crucial for biological self organization are unavoidable.

The work of Gariaev and collaborators is based on effects associated with visible laser light interacting with DNA. This encourages to think that the lengths of DNA MEs should be of order $E-7-E-6$ meters. This conforms with the idea that genes should directly control the functioning of the cell or at least the cell nucleus. Note that genes might be regarded as longitudinally color entangled portions of DNA acting. Configuration space color entanglement in length scale of chromosome and nucleus could obviously be possible. If this picture is correct, color confinement would be much more, that an eternal nuisance of elementary particle theorist.

*4. Also memetic codewords could be coded to holograms*

One can imagine also the translation of the memetic code to a sequence of orthogonal ME pairs. The $6\times 21 = 126$ bits for the maximal number of mutually consistent statements of the memetic code decompose into a sequence of 21 6-bit sequences interpreted as statements consisting of 21 words. Each 6-bit sequence consisting of three 2-bit units in turn is in one-one correspondence with a DNA triplet. Each 2-bit unit would code for the configuration space spins $\pm J$ for a a pair of orthogonal MEs possibly forming an antisymmetrized triplet of the basic colors. The duration of the memetic codeword corresponds to the secondary p-adic time scale $T_2(M_{127}) = .1$ seconds so that by Uncertainty Principle memetic code could imply long range color correlations in the length scale of Earth. ELF MEs propagating in phase with the nerve pulse sequence (this is essential and explains why ELF MEs must scan the cortex!) could translate the memetic codewords represented by the sequences of the cognitive neutrino pairs to quantum holograms.

### 8.3.6 Experimental evidence for MEs

There is indeed evidence for the presence of MEs in bio-system. In CASYS'2000 conference Peter Marcer reviewed the work done by him in collaboration with Russian group [52] led by Peter Gariaev providing experimental evidence for the hypothesis that DNA acts as a receiving and sending quantum antenna. What was observed that irradiation of DNA with visible laser light induced emission of coherent light with both visible and radio frequencies. The emitted radiation was also modulated in time scale of about .01 seconds. The modulation could be due to propagation of soliton sequences propagating along Josephson junction formed by the strands of DNA or due to nonpropagating spatially constant Josephson current: both cases are mathematically equivalent with gravitational pendulum. Phantom DNA effect [53] has explanation in terms of mind like space-time sheets identifiable as MEs. The experiments of Russian group replicated the observations of Poponin.

With inspiration coming from the experimental results, Gariaev has also suggested that DNA is accompanied by a sequence of some kind of laser mirrors. TGD suggests their interpretation as MEs [52]. The assumption that each nucleotide is accompanied by an orthogonal pair of MEs (two orthogonal polarizations) allows a holographic realization of the genetic code. Four nucleotides are mapped to four pairs of values of the configuration spin $\pm J$ in the simplest realization [K3]. Color degrees of freedom would bring in the long term correlations forced by color confinement in the length scale of DNA ME, which should be of order of wavelength of visible light, and thus forcing structures of this size to behave like coherent units.

The bio-photons of Popp [54] could correspond to coherent photons generated by MEs. Homeopathy could also have explanation in terms of MEs coding relevant frequency information to MEs about medicine, whose effect is also based on MEs [J5]. MEs would simply mimic the medicine. There are well documented effects related to the ability of water to absorb and transmit frequencies [59]. The ability of water to absorb and transmit frequencies could rely on the generation of mind like space-time sheets, most naturally MEs, oscillating with the same frequency as stimulus. Water would form cognitive representation for the stimulus, mimic it, in terms of light-like vacuum current giving rise to classical em or $Z^0$ field providing nonlike hologram like representation for the stimulus.

MEs are predicted to form a scale invariant family and quite recent cosmological data provides support for MEs in cosmological(!) length scales [19]. An intense beam of photons with energies of roughly 100 proton masses from a blazar at distance of about $10^8$ light years have been observed. Blazar is so called gamma ray burster producing extremely intense energy fluxes in form of two jets. How these jets are produced is mystery of its own in standard physics. In TGD these jets correspond to the ends of cosmic string decaying like a cosmic firecracker into ordinary matter giving rise to galaxies.

What makes observation 'impossible' is that photons with these energies should never reach Earth but lose their energy via scattering with cosmic microwaves background. Somehow these photons are however able to defy laws of standard physics. One TGD based model for phenomenon is very simple: photons are Bose-Einstein condensed on and travel, not along material space-time sheet were energy would be rapidly lost, but along 'massless extremal' (ME) of cosmic size scale. Cosmic laser beam is in question. One can also consider the possibility that the light-like vacuum current associated with cosmic ME generates the observed photons.

The general model for quantum control and coordination relies crucially on the existence of a hierarchy of superconductors associated with the self hierarchy (self defined as a quantum system able to avoid bound state entanglement with environment) controlling the ionic densities at atomic space-time sheets via many-sheeted ionic flow equilibrium and being quantum controlled with the mediation of the fractal hierarchy of MEs.

## 8.4 Bio-systems as superconductors

TGD Universe provides also the hardware for the realization of bio-system, in particular brain, as a macroscopic quantum system involving various kinds of super conductors. The essential elements are quantum criticality, spin glass analogy and generalization of the space-time concept and TGD based gauge field concept.

### 8.4.1 General mechanisms for superconductivity

The many-sheeted space-time concept provides a very general mechanism of superconductivity based on the 'dropping' of charged particles from atomic space-time sheets to larger space-time sheets. The first guess was that larger space-time sheets are very dry, cool and silent so that the necessary conditions for the formation of high $T_c$ macroscopic quantum phases are met.

The possibility of large $\hbar$ quantum coherent phases makes however the assumption about thermal isolation between space-time sheets un-necessary. At larger space-time sheet the interactions of the charged particles with classical em fields generated by various wormhole contacts feeding gauge fluxes to and from the space-time sheet in question give rise to the necessary gap energy. The simplest model for Cooper pair is space-time sheet containing charged particles having attractive Coulombic interaction with the quarks and antiquarks associated with the throats of the wormhole contacts.

A crucial element is quantum criticality predicting that superconductivity appears at the fluctuating boundaries of competing ordinary and large $\hbar$ phases for nuclei. This assumption predicts several anomalous phenomena such as cold fusion and nuclear transmutations. Also high $T_c$ superfluidity of bosonic atoms dropped to space-time sheets of electronic Cooper pairs becomes possible besides ionic super conductivity. Even dark neutrino superconductivity can be considered below the weak length scale of scaled down weak bosons.

Magnetic and $Z^0$ magnetic flux tubes and walls are especially interesting candidates for supra current carries. In this case the Cooper pairs must have spin one and this is indeed possible for wormholy Cooper pairs. The fact that the critical magnetic ($Z^0$ magnetic) fields can be very weak or large values of $\hbar$ is in accordance with the idea that various almost topological quantum numbers characterizing induced magnetic fields provide a storage mechanism of bio-information.

This mechanism is extremely general and works for electrons, protons, ions and even charged molecules so that an entire zoo of high $T_c$ bio-superconductors and super-fluids is predicted. All atoms and ions can be regarded as completely ionized $Z^0$ ions and also $Z^0$ superconductors (or super fluids) are predicted.

1. The experimental data about the effects of ELF em fields at cyclotron frequencies of various ions in Earth's magnetic field on bio-systems [58] provide support for this scenario. Most remarkably, the cyclotron frequencies of biologically important ions correspond to the important frequencies of EEG and the time scale of nerve pulse corresponds to $n = 3$ multiple of proton cyclotron frequency so that a direct quantitative contact with brain consciousness results.

2. Electronic super conductors are of type II with defect regions being typically cylindrical: DNA sequences, proteins, microtubules,... could provide examples of the defect regions. One ends up also with a model of high $T_c$ super conductors in which the interaction of the electrons with

wormhole BE condensate gives rise to Cooper pairs. The model explains elegantly the basic peculiar features of the high $T_c$ superconductors.

3. Long ranged $Z^0$ force due to anomalous weak isospin of nuclei [F8, F10] and $Z^0$ charged wormholes make possible also $Z^0$ ionic superconductivity and even dark neutrino super conductivity. For instance, $Z^0$ ionic superconductivity is crucial in the model for the quantum correlate of hearing: audible frequencies are mapped to $Z^0$ cyclotron frequencies. Dark neutrino super conductors are of type I in the interesting length scale range and defect regions are stripe like. Besides cell and endoplasma membranes, epithelial sheets consisting of two cell layers and some larger structures in cortex could correspond to regions of this kind and the interpretation as a physical realization of cognitive hierarchy suggests itself.

### 8.4.2 Superconductivity at magnetic flux quanta in astrophysical length scales

Magnetic flux tubes of endogenous magnetic field $B_{end} = 2B_E/5 = .2$ Gauss, where $B_E = .5$ Gauss is the nominal value of the Earth's magnetic field, are crucial for the TGD based model of superconductivity. Since the models of auroras assume that the magnetic flux lines act effectively as conducting wires, the natural hypothesis is that superconductivity is an astrophysical phenomenon. This leads to a model of auroras explaining the latest findings and providing further insights to the superconductivity and the manner how it breaks down. Critical temperature can be identified as the temperature at which the join along boundaries bonds making possible the leakage of the supra currents to the non-superconducting space-time sheets become possible and can be gigantic as compared to the temperature at the superconducting space-time sheets if space-time sheets are thermally isolated. On the other hand, the possibility of large $\hbar$ phases in principle makes possible arbitrarily high critical temperatures in a given length scale.

p-Adic length scale hierarchy and the hierarchy of dark matters labelled by values of $\hbar$ suggest the existence of an entire hierarchy of super conducting space-time sheets giving rise to a hierarchy of cognitive representations (abstractions about abstractions about...). The possibility of complex conformal weights expressible in terms of zeros of Riemann Zeta such that the net conformal weight is real, and the hierarchy of algebraic extensions of p-adic number fields suggest the existence of additional hierarchies.

### 8.4.3 Fractal hierarchy of EEGs and ZEGs

There are three contributions to EEG besides neural noise: Schumann frequencies, cyclotron frequencies, and the frequencies associated with Josephson junctions determined by the sum of the constant voltage and voltage perturbation determined by the superposition of cyclotron frequencies. Cyclotron contribution can be interpreted as a control signal from a magnetic body in question labelled by $k_d$ and affects both the ions at the flux sheets traversing DNA and the Josephson junction. The coherent state of photons generated by Josephson current corresponds to a reaction to this signal received by the magnetic body as a feedback. Schumann frequencies can be assigned to the control by magnetic body of Earth and correlate with the collective aspects of consciousness.

The analysis of the Josephson current [M3] leads to the conclusion that the frequencies in the coherent state of photons are in general sums and differences of Josephson frequency and harmonics of cyclotron frequencies. For small amplitudes this implies that alpha band to which the cyclotron frequencies most biologically important bosonic ions corresponds has as satellites theta and beta bands. Higher harmonics correspond to gamma and higher bands having also satellites. For large amplitudes EEG becomes chaotic which is indeed the property of beta band during say intense concentration or anxiety. The findings of Nunez [38] about narrow 1-2 Hz wide bands at 3,5,7 Hz and 13,15,17 Hz confirm with the prediction of satellite bands and fix the Josephson frequency to 5 Hz. This picture explains the general characteristics of EEG in wake-up state qualitatively and quantitatively.

In order to understand the characteristics during various stages of deep sleep one must assume that the cyclotron frequency scale of ions is scaled down by a factor of 1/2. One explanation is that right *resp.* left brain hemisphere corresponds to $Z = 2$ *resp.* $Z = 1$ quantization condition $Z \int BdS = n\hbar$ for the magnetic flux. $Z = 2$ case allows only doubly charged bosonic ions at magnetic flux sheets. $Z = 1$ case also also singly charged ions be their bosons or fermions and for this option magnetic field is scaled down by a factor of 1/2. The alternative explanation is that during sleep only Bose-Einstein condensates of singly charged exotic ions resulting when color bond inside nucleus becomes charged are present. This reduces the scale of cyclotron frequencies by a factor 1/2 and leaves only theta and delta bands. During stage 4 sleep only only DNA cyclotron frequencies in delta band are around 1 Hz and just above the thermal threshold are predicted to be present. For $k_d = 3$ and magnetic field scaled up by $\lambda$ and flux tube area scaled down by $\lambda^{-2}$ DNA frequencies are scaled up to kHz for $Z = 2$ flux quantization and might define neuronal synchronization frequencies.

The generalization of the model for EEG hierarchy to the case of ZEG is straightforward and cyclotron frequency spectrum is essentially the same [M3]. $Z^0$ ions are obtained when nuclear color bonds become charged and the combination of ordinary and exotic ionization can produce also em neutral $Z^0$ ions. Any atom, almost always boson, has an exotically charged counterpart with same statistics so that very rich spectrum of Bose-Einstein condensates results.

### 8.4.4 TGD assigns 10 Hz biorhythm to electron as an intrinsic frequency scale

p-Adic coupling constant evolution and origins of p-adic length scale hypothesis have remained for a long time poorly understood. The progress made in the understanding of the S-matrix of the theory (or rather, its generalization M-matrix) [C2] has however changed the situation. The unexpected prediction is that zero energy ontology assigns to elementary particles macroscopic times scales. In particular, the time scale assignable to electron correspond to the fundamental biorhythm of 10 Hz.

#### M-matrix and coupling constant evolution

The final breakthrough in the understanding of p-adic coupling constant evolution came through the understanding of S-matrix, or actually M-matrix defining entanglement coefficients between positive and negative energy parts of zero energy states in zero energy ontology [C2]. M-matrix has interpretation as a "complex square root" of density matrix and thus provides a unification of thermodynamics and quantum theory. S-matrix is analogous to the phase of Schrödinger amplitude multiplying positive and real square root of density matrix analogous to modulus of Schrödinger amplitude.

The notion of finite measurement resolution realized in terms of inclusions of von Neumann algebras allows to demonstrate that the irreducible components of M-matrix are unique and possesses huge symmetries in the sense that the hermitian elements of included factor $\mathcal{N} \subset \mathcal{M}$ defining the measurement resolution act as symmetries of M-matrix, which suggests a connection with integrable quantum field theories.

It is also possible to understand coupling constant evolution as a discretized evolution associated with time scales $T_n$, which come as octaves of a fundamental time scale: $T_n = 2^n T_0$. Number theoretic universality requires that renormalized coupling constants are rational or at most algebraic numbers and this is achieved by this discretization since the logarithms of discretized mass scale appearing in the expressions of renormalized coupling constants reduce to the form $log(2^n) = nlog(2)$ and with a proper choice of the coefficient of logarithm log(2) dependence disappears so that rational number results.

#### p-Adic coupling constant evolution

Could the time scale hierarchy $T_n = 2^n T_0$ defining hierarchy of measurement resolutions in time variable induce p-adic coupling constant evolution and explain why p-adic length scales correspond to $L_p \propto \sqrt{p}R$, $p \simeq 2^k$, $R$ $CP_2$ length scale? This looks attractive but there is a problem. p-Adic length scales come as powers of $\sqrt{2}$ rather than 2 and the strongly favored values of $k$ are primes and thus odd so that $n = k/2$ would be half odd integer. This problem can be solved.

1. The observation that the distance traveled by a Brownian particle during time $t$ satisfies $r^2 = Dt$ suggests a solution to the problem. p-Adic thermodynamics applies because the partonic 3-surfaces $X^2$ are as 2-D dynamical systems random apart from light-likeness of their orbit. For $CP_2$ type vacuum extremals the situation reduces to that for a one-dimensional random light-like curve in $M^4$. The orbits of Brownian particle would now correspond to light-like geodesics $\gamma_3$ at $X^3$. The projection of $\gamma_3$ to a time=constant section $X^2 \subset X^3$ would define the 2-D path $\gamma_2$ of

the Brownian particle. The $M^4$ distance $r$ between the end points of $\gamma_2$ would be given $r^2 = Dt$. The favored values of $t$ would correspond to $T_n = 2^n T_0$ (the full light-like geodesic). p-Adic length scales would result as $L^2(k) = DT(k) = D2^k T_0$ for $D = R^2/T_0$. Since only $CP_2$ scale is available as a fundamental scale, one would have $T_0 = R$ and $D = R$ and $L^2(k) = T(k)R$.

2. p-Adic primes near powers of 2 would be in preferred position. p-Adic time scale would not relate to the p-adic length scale via $T_p = L_p/c$ as assumed implicitly earlier but via $T_p = L_p^2/R_0 = \sqrt{p}L_p$, which corresponds to secondary p-adic length scale. For instance, in the case of electron with $p = M_{127}$ one would have $T_{127} = .1$ second which defines a fundamental biological rhythm. Neutrinos with mass around .1 eV would correspond to $L(169) \simeq 5$ $\mu$m (size of a small cell) and $T(169) \simeq 1. \times 10^4$ years. A deep connection between elementary particle physics and biology becomes highly suggestive.

3. In the proposed picture the p-adic prime $p \simeq 2^k$ would characterize the thermodynamics of the random motion of light-like geodesics of $X^3$ so that p-adic prime $p$ would indeed be an inherent property of $X^3$.

4. The fundamental role of 2-adicity suggests that the fundamental coupling constant evolution and p-adic mass calculations could be formulated also in terms of 2-adic thermodynamics. With a suitable definition of the canonical identification used to map 2-adic mass squared values to real numbers this is possible, and the differences between 2-adic and p-adic thermodynamics are extremely small for large values of for $p \simeq 2^k$. 2-adic temperature must be chosen to be $T_2 = 1/k$ whereas p-adic temperature is $T_p = 1$ for fermions. If the canonical identification is defined as

$$\sum_{n\geq 0} b_n 2^n \rightarrow \sum_{m\geq 1} 2^{-m+1} \sum_{(k-1)m\leq n<km} b_n 2^n \quad .$$

It maps all 2-adic integers $n < 2^k$ to themselves and the predictions are essentially same as for p-adic thermodynamics. For large values of $p \simeq 2^k$ 2-adic real thermodynamics with $T_R = 1/k$ gives essentially the same results as the 2-adic one in the lowest order so that the interpretation in terms of effective 2-adic/p-adic topology is possible.

**p-Adic length scale hypothesis and biology**

The basic implication of zero energy ontology is the formula $T(k) \simeq 2^{k/2} L(k)/c = L(2,k)/c$. This would be the analog of $E = hf$ in quantum mechanics and together hierarchy of Planck constants would imply direct connection between elementary particle physics and macroscopic physics. Especially important this connection would be in macroscopic quantum systems, say for Bose Einstein condensates of Cooper pairs, whose signature the rhythms with $T(k)$ as period would be. The presence of this kind of rhythms might even allow to deduce the existence of Bose-Einstein condensates of hitherto unknown particles.

1. For electron one has $T(k) = .1$ seconds which defines the fundamental $f_e = 10$ Hz bio-rhythm appearing as a peak frequency in alpha band. This could be seen as a direct evidence for a Bose-Einstein condensate of Cooper pairs of high $T_c$ super-conductivity. That transition to "creative" states of mind involving transition to resonance in alpha band might be seen as evidence for formation of large BE condensates of electron Cooper pairs.

2. TGD based model for atomic nucleus [F9] predicts that nucleons are connected by flux tubes having at their ends light quarks and anti-quarks with masses not too far from electron mass. The corresponding p-adic frequencies $f_q = 2^k f_e$ could serve as a biological signature of exotic quarks connecting nucleons to nuclear strings . $k_q = 118$ suggested by nuclear string model would give $f_q = 2^{18} f_e = 26.2$ Hz. Schumann resonances are around 7.8, 14.3, 20.8, 27.3 and 33.8 Hz and $f_q$ is not too far from 27.3 Hz Schumann resonance and the cyclotron frequency $f_c(^{11}B^+) = 27.3$ Hz for $B = .2$ Gauss explaining the effects of ELF em fields on vertebrate brain.

3. For a given $T(k)$ the harmonics of the fundamental frequency $f = 1/T(k)$ are predicted as special time scales. Also resonance like phenomena might present. In the case of cyclotron frequencies they would favor values of magnetic field for which the resonance condition is achieved. The magnetic field which in case of electron gives cyclotron frequency equal to 10 Hz is $B_e \simeq 3.03$ nT. For ion with charge $Z$ and mass number $A$ the magnetic field would be $B_I = \frac{A}{Z}(m_p/m_e)B_e$. The $B = .2$ Gauss magnetic field explaining the findings about effects of ELF em fields on vertebrate brain is near to $B_I$ for ions with $f_c$ alpha band. Hence the value of $B$ could be understood in terms of resonance with electronic B-E condensate.

4. The hierarchy of Planck constants predicts additional time scales $T(k)$. The prediction depends on the strength of the additional assumptions made. One could have scales of form $nT(k)/m$ with $m$ labeling the levels of hierarchy. $m = 1$ would give integers multiples of $T(k)$. Integers $n$ could correspond to ruler and compass integers expressible as products of first powers of Fermat primes and power of 2. There are only four known Fermat primes so that one has $n = 2^n \prod_i F_i$, $F_i \in \{3, 5, 17, 257, 2^{16} + 1\}$. In the first approximation only 3- and 5- and 17-multiples of 2-adic length scales would result besides 2-adic length scales. In more general case products $m_1m_2$ and ratios $m_1/m_2$ of ruler and compass integers and their inverses $1/m_1m_2$ and $m_2m_1$ are possible.

5. Mersenne primes are expected to define the most important fundamental p-adic time scales. The list of real and Gaussian (complex) Mersennes $M_n$ possibly relevant for biology is given by n=89, 107, 113*, 127, 151*,157*, 163*, 167* ('*' tells that Gaussian Mersenne is in question).

$$\begin{array}{lllll}
n & 89 & 107 & 113 & 127 \\
f/Hz & 2.7\times 10^{12} & 1.0\times 10^{7} & 1.6\times 10^{5} & 10 \\
n & 151 & 157 & 163 & 167 \\
T & 19.4\ d & 3.40\ y & 218.0\ y & 3.49\times 10^{3}\ y
\end{array} \qquad (8.4.1)$$

## 8.5 Many-sheeted space-time, universal metabolic quanta, and plasmoids as primitive life forms

In the following the evidence for many-sheeted space-time will be discussed.

### 8.5.1 Evidence for many-sheeted space-time

The dropping of particle to a larger space-time sheet liberates energy which is the difference of the energies of the particle at two space-time sheets. If the interaction energy of the particle with the matter at space-time sheet can be neglected the energy is just the difference of zero point kinetic energies. This energy depends on the details of the geometry of the space-time sheet. Assuming p-adic length scale hypothesis the general formula for the zero point kinetic energy can be written as

$$E(k) = x \times E_0(k) \ \ , \ \ E_0(k) = \frac{3}{2}\frac{\pi^2}{mL^2(k)} \ \ .$$

Here $x$ is a numerical factor taking into account the geometry of the space-time sheet and equals to $x = 1$ for cubic geometry.

The liberated zero point kinetic energy in the case that the particle drops to a space-time sheet labelled by $k_f = k + \Delta k$ with same value of $x$ is

$$\Delta E(k, \Delta k) = x \times E_0(k) \times (1 - 2^{-\Delta k}) \ \ .$$

The transitions are seen as discrete lines for some resolution $\Delta k \leq \Delta k_{max}$. At the limit $k \to \infty$ transitions give rise to a quasicontinuous band. The photon energy for $k \to \infty$ transition is same as the energy from $k - 1 \to k$ transition, which brings in additional option to the model building.

For a proton dropping from the atomic space-time sheet $k = 137$ to very large space-time sheet ($\Delta k \to \infty$) one has $\Delta E(k) = E(k) \sim x \times .5$ eV. Since the ratio of electron and proton masses is $m_p/m_e \simeq .94 \times 2^{11}$, the dropping of electron from space-time sheet $k_e = k_p + 11$ liberates zero point kinetic energy which is by is by a factor .9196 smaller. For $k_p = 137$ one would have $k_e = 148$.

This energy corresponds to the metabolic energy currency of living systems and the idea is that the differences of zero point kinetic energies define universal metabolic energy currencies present already in the metabolism of pre-biotic systems. In the following fit electron's zero point kinetic energy will be taken to be $E_0(148) = .5$ eV so that for proton the zero point kinetic energy would be $E_0(137) = .544$ eV.

The hypothesis predicts the existence of anomalous lines in the spectrum of infrared photons. Also fractally scaled up and scaled down variants of these lines obtained by scaling by powers of 2 are predicted. The wavelength corresponding to .5 eV photon would be $\lambda = 2.48$ $\mu$m. These lines should be detectable both in laboratory and astrophysical systems and might even serve as a signature for a primitive metabolism. One can also consider dropping of Cooper pairs in which case zero point kinetic energy is scaled down by a factor of 1/2.

Interestingly, the spectrum of diffuse interstellar medium exhibits three poorly understood structures [20]: Unidentified Infrared Bands (UIBs), Diffuse Interstellar Bands (DIBs) [21], and Extended Red Emission (ERE) [24] allowing an interpretation in terms of dropping of protons or electrons (or their Cooper pairs) to larger space-time sheets. The model also suggests the interpretation of bio-photons in terms of generalizes EREs.

#### Unidentified Infrared Bands

Unidentified infrared bands (UIBs) contain strong bands at $\lambda = 3.3, 6.2, 11.3$ microns [20]. The best fit for the values of $k$ and $\Delta k$ assuming dropping of either electron or proton are given by the following table. The last row of the table gives the ratio of predicted photon energy to the energy characterizing the band and assuming $x = 1$ and $E_0(148, e) = .5$ eV. Discrepancies are below 8 per cent. Also the dropping of protonic Cooper pair from $k = 137$ space-time sheet could reproduce the line $\Delta E = .2$ eV. The fit is quite satisfactory although there is of course the uncertainty related to the geometric parameter $x$.

| $\lambda/nm$ | $E/.5eV$ | $k$ | $\Delta k$ | $\Delta E(k,\Delta k)/E$ | $p/e$ |
|---|---|---|---|---|---|
| 3300 | .7515 | 137 | $\sim\infty$ | 1.002 | e |
| 6200 | .4000 | 138 | 3 | 1.067 | e |
| 11300 | .2195 | 139 | 3 | 0.878 | p |
| 11300 | .2195 | 139+11=150 | 3 | 1.076 | e |

Table 1. Table gives the best fit for UIBs assuming that they result from dropping of proton or electron to a larger space-time sheet and one has $E_0(148, e) = .5$ eV. The fourth column the table gives the ratio of predicted photon energy to the energy characterizing the band and assuming $x = 1$. $e/p$ tells whether electron or proton is in question.

According to [20], UIBs are detected along a large number of interstellar sight-lines covering a wide range of excitation conditions. Recent laboratory IR spectra of neutral and positively charged poly-cyclic aromatic hydrocarbons (PAHs) has been successfully used by Allamandola [23] to model the observed UIBs. It is believed that PAHs are produced in reactions involving photosynthesis and are regarded as predecessors of biotic life [22]. This would conform with the presence of metabolic energy quanta.

DNA sugar backbone, some aminoacids, and various hallucinogens involve 5- and 6-cycles and the proposal is that these cycles involve free electron pairs, which possess Planck constant $\hbar = n\hbar_0$, $n = 5, 6$. These free electron pairs would explain the anomalous conductivity of DNA and would be an essential characteristic of living matter. The emergence of $n = 5, 6$ levels could be seen as the first step in the pre-biotic evolution.

#### Diffuse Interstellar Bands

There are diffuse interstellar bands (DIBs) at wavelengths 578.0 and 579.7 nanometers and also at 628.4, 661.4 and 443.0 nm. The 443.0 nm DIB is particularly broad at about 1.2 nm across - typical intrinsic stellar absorption features are 0.1 nm [20]. The following table proposes a possible identification of these lines in terms of differences of zero point kinetic energies. Also now the best fit has errors below 7 per cent.

| $\lambda/nm$ | $E/.5eV$ | $k$ | $\Delta k$ | $\Delta E(k,\Delta k)/E$ | $p/e$ |
|---|---|---|---|---|---|
| 628.4 | 3.947 | $135 = 3^3 \times 5$ | $\sim \infty$ | 0.987 | p |
| 661.4 | 3.750 | $135 + 11 = 2 \times 73$ | 3 | 0.985 | e |
| 443.0 | 5.598 | $134 = 2 \times 67$ | 2 | 0.933 | p |
| 578.0 | 4.291 | $135 + 11 = 2 \times 73$ | $\sim \infty$ | 0.986 | e |
| 579.7 | 4.278 | $135 + 11 = 2 \times 73$ | $\sim \infty$ | 0.984 | e |

Table 2. Table gives the best fit for DIBs assuming that they result from dropping of proton or electron to a larger space-time sheet. Notations are same as in the previous table.

The peak wavelengths in chlorophyll and photosynthesis are around 650 nm and 450 nm and would correspond to second and third row of the table.

### The Extended Red Emission

The Extended Red Emission (ERE) [20, 24] is a broad unstructured emission band with width about 80 nm and located between 540 and 900 nm. The large variety of peak wavelength of the band is its characteristic feature. In majority of cases the peak is observed in the range 650-750 nm but also the range 610-750 nm appears. ERE has been observed in a wide variety of dusty astronomical environments. The necessary conditions for its appearance is illumination by UV photons with energies $E \geq 7.25$ eV from source with $T \geq 10^4$ K. The position of the peak depends on the distance from the source [24].

According to [20] the current interpretation attributes ERE to a luminescence originating from some dust component of the ISM, powered by UV/visible photons. Various carbonaceous compounds seem to provide a good fit to the observational constraints. However, the real nature of ERE is still unknown since most candidates seem to be unable to simultaneously match the spectral distribution of ERE and the required photon conversion efficiency.

1. Consider first the band 650-750 nm appearing in the majority of cases. The most natural interpretation is that the lower end of the band corresponds to the zero point kinetic energy of electron at $k = 135+11 = 146 = 2 \times 73$ space-time sheet. This would mean that the lines would accumulate near 650 nm and obey the period doubling formula

$$\frac{\lambda(k) - \lambda(\infty)}{\lambda(\infty)} = \frac{2^{-k}}{1 - 2^{-k}} \ .$$

   By the estimate of Table 2 the lower end should correspond to $\lambda = 628.4$ nm with a correction factor $x < 1$ reducing the zero point kinetic energy. The reduction would be smaller than 4 per cent. $\Delta k = 3$ transition would correspond to 744 nm quite near to the upper end of the band. For $\Delta k = 2$ transition one has $\lambda = 867$ nm not to far from the upper end 900 nm. $\Delta k = 1$ corresponds to 1.3 $\mu$m.

2. For proton with $k = 135 = 146$ the energy band would shift by the factor $2^{11} m_e/m_p \simeq 1.0874$ giving the range (598,690) nm.

3. The variation for the position of the peak can be understood if the charged particles at the smaller space-time sheet can have excess energy liberated in the dropping to the larger space-time sheet. This excess energy would determine the position of the lower end of the band in the range $(540, 650)$ nm.

4. One should also understand the role of UV photons with energy larger than 7.25 eV. For proton the energy would be 8.76 eV. For proton the energy would be 8.76 eV. UV photon with energy $E \geq 8$ eV could kick electrons from large space-time sheets to $k = 144 = 146-4$ space-time sheet where they have zero point kinetic energy of 8 eV plus possible additional energy (for proton the energy would be 8.76 eV). One possibility is that these electrons drop first to $k = 145$ by the emission of $\sim$ 4 eV UV photon and then to $k = 144$ by the emission $\sim$ 2 eV photon corresponding to 650 nm line. The further dropping to larger space-time sheets would produce besides this line also the lines with longer wavelengths in the band.

The energy of UV photons brings in mind the bond energy 7.36 eV of $N_2$ molecule and the possibility of metabolic mechanism using UV light as metabolic energy and based on the dissociation of $N_2$ followed by re-association liberating metabolic energy kicking protons or electrons to a smaller space-time sheet. For the $k \rightarrow k+3$ transition of electron the energy would be 7 eV which suggests that this transition defines important metabolic energy quantum for living interstellar dust using dissociation and its reversal as basic metabolic mechanism.

## 8.5.2 Laboratory evidence for plasmoids as life forms

### From dust to dust

The article *From Plasma crystals and helical structures towards inorganic living matter* of Tsytovich *et al* in August issue of New Journal of Physics provides new empirical support for plasmoids as living life forms. The results of article suggest that interstellar dust could behave like living matter in some respects: it could even have variant of genetic code. This is a really shattering finding and with single blow destroys the standard dogma about life as something purely chemical. It should also give also some headaches for those influental colleagues who have decided that it is necessary to accept the anthropic principle. Here is little popularization of the result.

*SCIENTISTS have discovered that inorganic material can take on the characteristics of living organisms in space, a development that could transform views of alien life.*

*An international panel from the Russian Academy of Sciences, the Max Planck institute in Germany and the University of Sydney found that galactic dust could form spontaneously into helixes and double helixes and that the inorganic creations had memory and the power to reproduce themselves.*

*A similar rethinking of prospective alien life is being undertaken by the National Research Council, an advisory body to the US government. It says Nasa should start a search for what it describes as weird life - organisms that lack DNA or other molecules found in life on Earth.*

*The new research, to be published this week in the New Journal of Physics, found nonorganic dust, when held in the form of plasma in zero gravity, formed the helical structures found in DNA. The particles are held together by electromagnetic forces that the scientists say could contain a code comparable to the genetic information held in organic matter. It appeared that this code could be transferred to the next generation.*

*Professor Greg Morfill, of the Max Planck institute of extra-terrestrial physics, said: Going by our current narrow definitions of what life is, it qualifies.*

*The question now is to see if it can evolve to become intelligent. Its a little bit like science fiction at the moment. The potential level of complexity we are looking at is of an amoeba or a plant.*

*I do not believe that the systems we are talking about are life as we know it. We need to define the criteria for what we think of as life much more clearly.*

*It may be that science is starting to study territory already explored by science fiction. The television series The X-Files, for example, has featured life in the form of a silicon-based parasitic spore.*

*The Max Planck experiments were conducted in zero gravity conditions in Germany and on the International Space Station 200 miles above earth.*

*The findings have provoked speculation that the helix could be a common structure that underpins all life, organic and nonorganic.*

To sum up the essentials, plasma phase is involved and the dust life is able to construct analogs of DNA double helices and this has been achieved also in laboratory. "From dust to dust" seems to have a very deep side meaning!

Here is a more quantitative summary of the results reported in [30].

1. The scale of the dust balls seems to be few micrometers. It is essential that the system is open in the sense that there is both metabolic energy feed and continual feed of plasma to negatively charged dust particles to preserve their charges. Authors speak about effective "gravitational" instability as a mechanism leading to the formation of the helices and identify effective gravitational coupling (the formula contains a trivial typo) as a function of charge and mass of the particle plus dimensionless parameter characterizing the modification of Debye model implied by the fact that dust particles are not electrically closed systems. Authors give a long list of life-like properties possessed by the helical structures.

2. Helical structures are generated spontaneously and possess negative charges. The repulsion of the helical structures transforms to attraction at some critical distance interval due to the fact that the large electrostatic self energy depends on the distance between helices and this makes possible double helices (authors speak about over-screening in the formal model). Similar mechanism might work also in the case of ordinary DNA double helices whose stability is poorly understood since also in this case the large negative charge could be preserved by continual feed of charge.

3. The twist angle of the helix makes bifurcations as a function of radius of helix and the values of twist angle could define the letters of genetic code. Also a mechanism for how the twist angle is communicated to neighboring helix is proposed. Also dust vortices are observed and might be those which one can occasionally observe during hot summer days.

4. Authors do not mention magnetic fields but my guess is that the helical structures reflect directly the geometry of the helical magnetic flux tubes, and that dark electron pairs with large Planck constant at these tubes might be the quantal aspect of the system. These currents might relate closely to the plasma current, which charges the dust particles. Also DNA, which is insulator, is known to be able to act as conductor, and here the free electron pairs associated with aromatic rings having $\hbar = n \times hbar_0$, $n = 5$ or 6, could make conduction possible since their Compton size would be n-fold.

**Elephant trunks in astrophysics**

TGD Universe is fractal and this means that the visible structures are formed around magnetic flux quanta containing dark matter with large hbar appear in all length scales and have geometric patterns reflecting the exact discrete symmetries of dark matter acting as rotational symmetries of the field body and at the level of visible matter giving rise to broken symmetries typical for molecular structures. The helical structures found from the rings of some planets could be one example of fractal life.

For some time ago I learned about "elephant trunks" found by Hubble (I am grateful for Miika Väisälä telling about the trunks and for giving references to the papers about the finding). They appear in very wide range of length scales: at least from 1000 au to 1 pc. They are found in close connection with molecular clouds and HII regions excite by one or more young hot stars (a "metabolic connection" with the above mentioned unidentified bands and lines and PAHs present only if there is also UV source present does not look like a bad guess). In general the trunks are

Another important finding supporting TGD view about Universe which might be seen as a fractally scaled variant of above helices. pointing like fingers to the hot stars. Here is abstract of the paper by P. Carlquist, G. F. Gahm, and H. Kristen [32].

*Using the 2.6 m Nordic Optical Telescope we have observed a large number of elephant trunks in several regions. Here, we present a small selection of this material consisting of a few large, well-developed trunks, and some smaller ones. We find that: (i) the well-developed trunks are made up of dark filaments and knots which show evidence of twisted structures, (ii) the trunks are connected with essentially two filamentary legs running in V-shape, and (iii) all trunks have the maximum extinction in their heads. We advance a theory of twisted elephant trunks which is based on the presence of magnetic flux ropes in molecular clouds where hot OB stars are formed. If the rope contains a local condensation it may adopt a V-shape as the region around the hot stars expands. If, in addition, the magnetic field in the rope is sufficiently twisted, the rope may form a double helix at the apex of the V. The double helix is identified with the twisted elephant trunks. In order to illustrate the mechanisms behind the double helix we have constructed a mechanical analogy model of the magnetic flux rope in which the rope has been replaced by a bundle of elastic strings loaded by a weight. Experiments with the model clearly show that part of the bundle will transform into a double helix when the twist of the bundle is sufficiently large. We have also worked out a simple theoretical model of a mass-loaded magnetic flux rope. Numerical calculations show that a double helix will indeed form when the twist of the rope exceeds a certain critical limit. Numerical model calculations are applied to both the analogy model experiments and one of the well-developed elephant trunks. On the basis of our model we also suggest a new interpretation of the so called EGGs.*

*The double helix mechanism is quite general, and should be active also in other suitable environments. One such environment may be the shell of supernova remnants. Another example is the expanding bubble outlined by the North Celestial Pole Loop.*

For fractally thinking physicist consisting mostly of dark matter with large Planck constant this does not leave many options: life and even intelligent life is everywhere and in all length scales. This provides also a new view about Fermi paradox: see the article [16], which summarizes also the essentials of TGD, TGD based ontology, and TGD based quantum biology.

### 8.5.3 Universal metabolic quanta

Universal energy quanta might have rather interesting implications. For instance, irradiation of cells could provide a direct metabolic mechanism when the normal metabolic machinery fails. The universal metabolic quanta should have also played a key role during pre-biotic evolution when chemical storage mechanism were absent or primitive so that energy metabolism relied on direct absorption of photons.

#### Direct support for universal metabolic energy quanta

There is direct support for the notion of universal energy quanta. The first support comes from the effect of low-power laser light on living matter. More than 30 years ago a method known with various names such as low-power laser therapy, biostimulation, or photobiomodulation emerged [61] and has now a wide range of applications. The treatment can apply both non-coherent (light emitting diodes) or coherent (laser light). In the case of of non-coherent light the method applies thin structures with thickness smaller than coherence length of light so that there is no difference between non-coherent and laser light. Laser light applies to situation when both the thickness of the surface layer and structure itself in range 1 mm- 1 cm and shorter than coherence length. Often the irradiation is applied to wounds and sites of injuries, acupuncture points, and muscle trigger points. The method involves several parameters such as wavelength in the range 400-900 nm (IR and near IR light), output power (10 100 mW), continuous wave and pulsed operation modes, and pulse parameters.

*1. What is known?*

The article of Karu [61] gives a good summary about what is known.

1. The action spectrum characterizes the maxima of the biological response as a function of wavelength. Action spectrum is essentially universal. For near IR and IR light the maxima of spectra are at 620, 680, 760, 820-830 nm. The spectrum continues also to visible light [61] but I do not have access these data.

2. The action can induce both physiological and morphological changes in non-pigmental cells via absorption in mitochondria. HeNe laser ($\lambda = 632.8$ nm) can alter the firing pattern of nerves and can mimic the effect of peripheral stimulation of a behavioral reflex.

*2. Biochemical approach*

In [61] the biochemical approach to the situation is discussed.

1. In standard biochemistry based approach the natural hypothesis is that the maxima correspond to some molecular absorption lines and the task is to identify the photo acceptor. The primary acceptor in IR-to red spectral region is believed to be the terminal enzyme of the respiratory chain cytochrome c oxidase located in mitochondrion but this is just an assumption.In the violet-to-blue spectral region flavoproteins (e.g. NADHdehydrogenace in the beginning of respiratory chain) are among the photo acceptors as terminal oxidases. It is known that also non-mitochondrial enhancement of cellular metabolism exist, which does not fit well with the vision about mitochondria as power plants of cell. It is believed that electronic excitation occurs and somehow leads to the biological effect.

2. The natural assumption in biochemistry framework is that the stimulation increases the effectiveness of cellular metabolism by making the utilization of oxygen more effective. The effect of the light would occur at the control level and induce secondary reactions (cellular signaling cascades or photo signal transduction and amplification) affecting eventually the gene expression.

3. Three different regulation pathways have been suggested [61]. Since small changes in ATP level can alter cellular metabolism significantly, the obvious idea is that photoacceptor controls the

level of intracellular ATP. In starving cells this looks especially attractive hypothesis. In many cases however the role of redox homeostasis is however believed to be more important than that of ATP. The second and third pathways would indeed affect cellular redox potential shifting it to more oxidized direction. The mechanism of regulation is however not understood. Hence one can say that there is no experimental proof or disproof for the standard approach.

*3. TGD inspired approach*

In TGD framework the first guess is that irradiation pumps directly metabolic energy to the system by kicking particles to smaller space-time sheets. This kind of direct energy feed would be natural when the cell is starving or injured so that its control mechanisms responsible for the utilization of oxygen are not working properly. For Bose-Einstein condensate of photons this effect would be especially strong being proportional to $N^2$ rather than $N$, where $N$ is photon number. The effect would also appear coherently in a region whose size is dictated by coherence length when the target is thick enough.

There is a simple killer test for the proposal. The predicted energies are universal in the approximation that the interactions of protons (or electrons) kicked to the smaller space-time sheets with other particles can be neglected. The precise scale of metabolic energy quanta can be fixed by using the nominal value of metabolic energy quantum .5 eV in case of proton. This predicts the following spectrum of universal energy quanta for proton and electron

$$\begin{array}{l} \Delta E_{k,n}(p) = E_0(k,p) \times (1-2^{-n}) \ , \\ E_0(k,p) = E_0(137,p)2^{137-k} \simeq 2^{137-k} \times .5 \ eV \ . \\ \\ \Delta E_{k,n}(e) = E_0(k,e) \times (1-2^{-n}) \ , \\ E_0(k,e) = \frac{m_p}{2^{11}m_e}E_0(137,p)2^{148-k} \simeq 2^{148-k} \times .4 \ eV \ . \end{array}$$

$k$ characterizes the p-adic length scale and the transition corresponds to the kicking of charged particle from space-time sheet having $k_1 = k+n$ to $k = n$.

The shortest wavelength 630 nm is rather close to the wavelength of HeNe laser and corresponds to red light with $E_0 = 2.00$ eV. Thus one would have $k = 135$ in the case of proton which corresponds to roughly one of atomic radius for ordinary value of $\hbar$. For electron one would have $k = 150$ which corresponds to $L(151)/\sqrt{2}$: $L(151) = 10$ nm corresponds to cell membrane thickness. The following table gives the energies of photons for action spectrum and predicted values in the case of proton, which provides a better fit to the data.

| $n$ | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| $\lambda/nm$ | 825 | 760 | 680 | 620 |
| $E_{exp}/eV$ | 1.50 | 1.63 | 1.82 | 2.00 |
| $E_{pred}/eV$ | 1.50 | 1.75 | 1.88 | 1.94 |
| $E_{pred}/E_{exp}$ | 1.00 | 1.07 | 1.02 | 0.97 |

(8.5.1)

The largest error is 7 per cent and occurs for $n = 3$ transition. Other errors are below 3 per cent. Note that also in experiments of Gariaev [51, 52] laser light consisting of 2 eV photons was used: in this case the induced radio wave photons - possibly dark photons with energy 2 eV - had positive effect on growth of potatoes.

### Possible explanation for the effect of IR light on brain

The exposure of brain to IR light at wavelength of 1072 nm is known to improve learning performance and give kick start to cognitive function [60]. The simplest explanation is that this light reloads the metabolic energy batteries of neurons by kicking electrons or protons or their Cooper pairs to larger space-time sheets. The wavelength in question is roughly one half of the wavelength associated with metabolic energy quantum with average energy .5 eV (2480 $\mu$m) assignable to the dropping of proton to a very large space-time sheet from k=137 space-time sheet or of electron from k=137+11= 148 space-time sheet. This if the electron and proton are approximated to be free particles. Energy band is in question since both the particles can have additional interaction energy.

For the kicking of electron from very large space-time sheet to $k = 147$ space-time sheet the wave length would be below 1240 nm which is more than 10 per cent longer than 1072 nm. This would suggest that the final state electron is in excited state. The surplus energy is consistent with the width about 100 nm for the UIBs. This identification - if correct - would support the view that metabolic energy quanta are universal and have preceded the evolution of the biochemical machinery associated with metabolism and that the loading of metabolic energy batteries at the fundamental level correspond to the kicking of charged particles to smaller space-time sheets.

### Connection between laser induced healing, acupuncture, and association of DC currents with the healing of wounds

The findings of Robert Becker (the book "Electromagnetism and Life" by Becker and Marino can be found from web [62]) meant a breakthrough in the development of bioelectromagnetics. One aspect of bioelectromagnetic phenomena was the discovery of Becker that DC currents and voltages play a pivotal role in various regeneration processes. Why this is the case is still poorly understood and Becker's book is a treasure trove for anyone ready to challenge existing dogmas. The general vision guiding Becker can be summarized by a citation from the introduction of the book.

*Growth effects include the alteration of bone growth by electromagnetic energy, the restoration of partial limb regeneration in mammals by small direct currents, the inhibition of growth of implanted tumors by currents and fields, the effect upon cephalocaudal axis development in the regenerating flatworm in a polarity-dependent fashion by applied direct currents, and the production of morphological alterations in embryonic development by manipulation of the electrochemical species present in the environment. This partial list illustrates the great variety of known bioelectromagnetic phenomena.*

*The reported biological effects involve basic functions of living material that are under remarkably precise control by mechanisms which have, to date, escaped description in terms of solution biochemistry. This suggests that bioelectromagnetic phenomena are fundamental attributes of living things ones that must have been present in the first living things. The traditional approach to biogenesis postulates that life began in an aqueous environment, with the development of complex molecules and their subsequent sequestration from the environment by membranous structures. The solid-state approach proposes an origin in complex crystalline structures that possess such properties as semiconductivity, photoconductivity, and piezoelectricity. All of the reported effects of electromagnetic forces seem to lend support to the latter hypothesis.*

*1. Observations relating to CNS*

The following more quantitative findings, many of them due to Becker, are of special interest as one tries to understand the role of DC currents in TGD framework.

1. CNS and the rest of perineural tissue (tissue surrounding neurons including also glial cells) form a dipole like structure with neural system in positive potential and perineural tissue in negative potential. There is also an electric field along neuron in the direction of nerve pulse propagation (dendrites correspond to - and axon to +) (note that motor nerves and sensory nerves form a closed loop). Also microtubules within axon carry electric field and these fields are probably closely related by the many-sheeted variants of Gauss's and Faraday's laws implying that voltages along two different space-time sheets in contact at two points are same in a static situation.

2. A longitudinal potential along front to back in brain with frontal lobes in negative potential with respect to occipital lobes and with magnitude of few mV was discovered. The strength of the electric field correlates with the level of consciousness. As the potential becomes weaker and changes sign, consciousness is lost. Libet and Gerard observed traveling waves of potentials across the cortical layers (with speeds of about 6 m/s: TGD inspired model of nerve pulse predicts this kind of waves [M2]). Propagating potentials were discovered also in glial cells. The interpretation was in terms of electrical currents.

3. It was found that brain injury generated positive polarization so that the neurons ceased to function in an area much larger than the area of injury. Negative shifts of neuronal potentials were associated with incoming sensory stimuli and motor activity whereas sleep was associated with a positive shift. Very small voltages and currents could modulate the firing of neurons without affecting the resting potential. The "generating" potentials in sensory receptors inducing

nerve pulse were found to be graded and non-propagating and the sign of the generating potential correlated with sensory input (say increase/reduction of pressure). Standard wisdom about cell membrane has difficulties in explaining these findings.

4. The natural hypothesis was that these electric fields are accompanied by DC currents. There are several experimental demonstrations for this. For instance, the deflection of assumed DC currents by external magnetic field (Hall effect) was shown to lead to a loss of consciousness.

*2. Observations relating to regeneration*

The second class of experiments used artificial electrical currents to enhance regeneration of body parts. These currents are nowadays used in clinical practice to induce healing or retard tumor growth. Note that tissue regeneration is a genuine regeneration of an entire part of organism rather than mere simple cell replication. Salamander limb generation is one of the most studied examples. Spontaneous regeneration becomes rare at higher evolutionary levels and for humans it occurs spontaneously only in the fractures of long bones.

1. An interesting series of experiments on Planaria, a species of simple flatworm with a primitive nervous system and simple head-to-tail axis of organization, was carried out. Electrical measurements indicated a simple head-tail dipole field. The animal had remarkable regenerative powers; it could be cut transversely into a number of segments, all of which would regenerate a new total organism. The original head-tail axis was preserved in each regenerate, with that portion nearest the original head end becoming the head of the new organism. The hypothesis was that the original head-tail electrical vector persisted in the cut segments and provided the morphological information for the regenerate. The prediction was that the reversal of the electrical gradient by exposing the cut surface to an external current source of proper orientation should produce some reversal of the head-tail gradient in the regenerate. While performing the experiment it was found found that as the current levels were increased the first response was to form a head at each end of the regenerating segment. With still further increases in the current the expected reversal of the head-tail gradient did occur, indicating that the electrical gradient which naturally existed in these animals was capable of transmitting morphological information.

2. Tissue regeneration occurs only if some minimum amount of neural tissue is present suggesting that CNS plays a role in the process although the usual neural activity is absent. The repeated needling of the stump had positive effect on regeneration and the DC current was found to be proportional to innervation. Hence needling seems to stimulate innervation or at least inducing formation of DC currents. Something like this might occur also in the case of acupuncture.

3. Regeneration involves de-differentiation of cells to form a blastema from which the regenerated tissue is formed. Quite early it was learned that carcinogens induce de-differentiation of cells because of their steric properties and by making electron transfer possible and that denervation induces tumor formation. From these findings Becker concluded that the formation of blastema could be a relatively simple process analogous to tumor growth whereas the regeneration proper is a complex self-organization process during which the control by signals from CNS are necessary and possibly realized in terms of potential waves.

4. Regeneration is possible in salamander but not in frog. This motivated Becker and collaborators to compare these situations. In an amputated leg of both salamander and frog the original negative potential of or order -1 mV went first positive value of order +10 mV. In frog it returned smoothly to its original value without regeneration. In salamander it returned during three days to the original base line and then went to a much higher negative value around -20 mV (resting potential is around -70 mV) followed by a return to the original value as regeneration had occurred. Thus the large negative potential is necessary for the regeneration and responsible for the formation of blastema. Furthermore, artificial electron current induced regeneration also in the case of frog and in even in the denervated situation. Thus the flow of electrons to the stump is necessary for the formation of blastema and the difference between salamander and frog is that frog is not able to provide the needed electronic current although positive potential is present.

5. It was also learned that a so called neural epidermic junction (NEJ) formed in the healing process of salamander stump was responsible for the regeneration in the presence of nervation. The conclusion was that the DC voltage and electronic current relevant for regeneration can be assigned the interface between CNS and tissue rather than with the entire nerve and regeneration seems to be a local process, perhaps a feed of metabolic energy driving self-organization. Furthermore, NEJ seems to make possible the flow of electrons from CNS to the stump.

6. The red blood cells of animals other than mammals are complete and possess thus nuclei. Becker and collaborators observed that also red blood cells dedifferentiated to form blastema. Being normally in a quiescent state, they are ideal for studying de-differentiation. It was found that electric current acted as a trigger at the level of cell membrane inducing de-differentiation reflected as an increased amount of mRNA serving as signal for gene expression. Also pulsed magnetic field was found to trigger the de-differentiation, perhaps via induced electric field. By the way, the role of the cell membrane fits nicely with the view about DNA-cell membrane system as topological quantum computer with magnetic flux tubes connecting DNA and cell membrane serving as braids.

7. The experiments of Becker and collaborators support the identification of the charge carriers of DC currents responsible for the formation of large negative potential of stump as electrons. The test was based on the different temperature dependence of electronic and protonic conductivities. Electronic conductivity increases with temperature and protonic conductivity decreases and an increase was observed. In TGD based model also super-conducting charge carriers are possible and this finding does not tell anything about them.

*3. A TGD based model for the situation*

On basis of these observations one can try to develop a unified view about the effects of laser light, acupuncture, and DC currents. It is perhaps appropriate to start with the following - somewhat leading - questions inspired by a strong background prejudice that the healing process - with control signals from CNS included - utilizes the loading of many-sheeted metabolic batteries by supra currents as a basic mechanism. In the case of control signals the energy would go to the "moving of the control knob".

1. Becker assigns to the system involved with DC currents an effective semiconductor property. Could the effective semiconductor property be due the fact that the transfer of charge carriers to a smaller space-time sheet by first accelerating them in electric field is analogous to the transfer of electrons between conduction bands in semiconductor junction? If so, semiconductor property would be a direct signature of the realization of the metabolic energy quanta as zero point kinetic energies.

2. Supra currents flowing along magnetic flux tubes would make possible dissipation free loading of metabolic energy batteries. This even when oscillating Josephson currents are in question since the transformation to ohmic currents in semiconductor junction makes possible energy transfer only during second half of oscillation period. Could this be a completely general mechanism applying in various states of regeneration process. This might be the case. In quantal situation the metabolic energy quanta have very precise values as indeed required. For ohmic currents at room temperature the thermal energies are considerably higher than those corresponding to the voltage involved so that they seem to be excluded. The temperature at magnetic flux tubes should be however lower than the physiological temperature by a factor of order $10^{-2}$ at least for the voltage of -1 mV. This would suggest high $T_c$ super-conductivity is only effective at the magnetic flux tubes involved. The finding that nerve pulse involves a slight cooling of the axonal membrane proposed in the TGD based model of nerve pulse [M2] to be caused by a convective cooling due the return flow of ionic Josephson currents would conform with this picture.

3. What meridians are and what kind of currents flow along them? Could these currents be supra currents making possible dissipation-free energy transfer in the healthy situation? Does the negative potential of order -1 mV make possible flow of protonic supra currents and loading of metabolic batteries by kicking protons to smaller space-time sheets? Could electronic supra currents in opposite direct induce similar loading of metabolic batteries? Could these tow miniature metabolisms realize control signals (protons) and feedback (electrons)?

The model answering these questions relies on following picture. Consider first meridians.

1. The direct feed of metabolic energy as universal metabolic currencies realized as a transfer of charge carriers to smaller space-time sheets is assumed to underly all the phenomena involving healing aspect. Meridian system would make possible a lossless metabolic energy feed - transfer of "Chi" - besides the transfer of chemically stored energy via blood flow. The metabolic energy currencies involved are very small as compared to .5 eV and might be responsible only for "turning control knobs". The correlation of the level of consciousness with the overall strength of DC electric fields would reduce to the level of remote metabolic energy transfer.

2. The model should explain why meridians have not been observed. Dark currents along magnetic flux tubes are ideal for the energy transfer. If the length of the superconducting "wire" is long in the scale defined by the appropriate quantum scale proportional to $\hbar$, classical picture makes sense and charge carriers can be said to accelerate and gain energy $ZeV$. For large values of $\hbar$ an oscillating Josephson current would be in question. The semiconductor like structure at the end of meridian -possibly realized in terms of pair of space-time sheets with different sizes- makes possible a net transfer of metabolic energy even in this case as pulses at each half period of oscillation. The transfer of energy with minimal dissipation would thus explain why semiconductor like property is needed and why acupuncture points have high value of conductivity. The identification of meridians as invisible magnetic flux tubes carrying dark matter would explain the failure to observe them: one further direct demonstration for the presence of dark matter in biological systems.

3. In the case of regeneration process NEJs would be accompanied by a scaled down version of meridian with magnetic flux tubes mediating the electronic Josephson current during blastema generation and protonic supra current during the regeneration proper. Space-time sheets of proton *resp.* electron correspond to $k_p$ and $k_e = k_p + 11$. In a static situation many-sheeted Gauss law in static situation would guarantee that voltages over NJE are same.

4. One can of course worry about the smallness of electrostatic energies $ZeV$ as compared to the thermal energy. Zero point kinetic energy could correspond also to the magnetic energy of the charged particle. For sufficiently large values of Planck constant magnetic energy scale is higher than the thermal energy and the function of voltage could be only to drive the charged particles along the flux tubes to the target: and perhaps act as a control knob with electrostatic energy compensating for the small lacking energy. Suppose for definiteness magnetic field strength of $B = .2$ Gauss explaining the effects of ELF em fields on brain and appearing in the model of EEG. Assume that charged particle is in minimum energy state with cyclotron quantum number $n = 1$ and spin direction giving negative interaction energy between spin and magnetic field so that the energy is $(g-2)\hbar eB/2m_p$. Assume that the favored values of hbar correspond to number theoretically simple ones expressible as a product of distinct Fermat primes and power of 2. In the case of proton with $g \simeq 2.7927$ the standard metabolic energy quantum $E_0 = .5$ eV would require roughly $\hbar/\hbar_0 = 17 \times 2^{34}$. For electron $g - 2 \simeq \alpha/\pi \simeq .002328$ gives $\hbar/\hbar_0 = 5 \times 17 \times 2^{30}$.

Consider next NEJs and semiconductor like behavior and charging of metabolic batteries.

1. Since NEJ seems resembles cell membrane in some respects, the wisdom gained from the model of cell membrane and DNA as tqc can be used. The model for nerve pulse and the model for DNA as topological quantum computer suggest that dark ionic currents flowing along magnetic flux tubes characterized by a large value of Planck constant are involved with both meridians and NJEs and might even dominate. Magnetic flux tubes act as Josephson junctions generating oscillatory supra currents of ions and electrons. For large values of $\hbar$ also meridians are short in the relevant dark length scale and act as Josephson junctions carrying oscillatory Josephson currents.

2. The findings of Becker suggest that acu points correspond to sensory receptors which are normally in a negative potential. The model for the effects of laser light favors (but only slightly) the assumption that in a healthy situation it is protons arriving along magnetic flux tubes which are kicked to the smaller space-time sheets and that negative charge density at acu point attracts protons to the acu point. Electrons could of course flow in reverse direction along their own

magnetic flux tubes and be kicked to the smaller space-time sheets at the positive end of the circuit. In the case of brain, protonic end would correspond to the frontal lobes and electronic end to the occipital lobes. This kind of structure could appear as fractally scaled variants. For instance, glial cells and neurons could form this kind of pair with neurons in negative potential and glial cells in positive potential as suggested by the fact that neuronal damage generates positive local potential.

3. Classically the charge carriers would gain energy $E = ZeV$ as they travel along the magnetic flux tube to NJE. If this energy is higher than the metabolic energy quantum involved, it allows the transfer of charge carrier to a smaller space-time sheet so that metabolic resources are regenerated. Several metabolic quanta could be involved and the value of $V(t)$ would determine, which quantum is activated. The reduction of the $V$ below critical value would lead to a starvation of the cell or at least to the failure of control signals to "turn the control knob". This should relate to various symptoms like pain at acupuncture points. In a situation requiring acupuncture the voltage along flux tubes would be so small that the transfer of protons to the smaller space-time sheets becomes impossible. As a consequence, the positive charge carriers would accumulate to the acu point and cause a further reduction of the voltage. Acupuncture needle would create a "wound" stimulating large positive potential and the situation would be very much like in regeneration process and de-differentiation induced by acupuncture could be understood.

Many questions remain to be answered.

1. What causes the de-differentiation of the cells? The mere charging of metabolic energy batteries perhaps? If so then the amount of metabolic energy- "chi"- possessed by cell would serve as a measure for the biological age of cell and meridian system feeding "chi" identified as dark metabolic energy would serve as a rejuvenating agent also with respect to gene expression. Or does the electric field define an external energy feed to a self-organizing system and create an electromagnetic environment similar to that prevailing during morphogenesis inducing a transition of cells to a dedifferentiated state? Or could DNA as tqc allow to understand the modification of gene expression as being due to the necessity to use tqc programs appropriate for regeneration? Or should cells and wounded body part be seen as intentional agents doing their best to survive rather than as passive parts of biochemical system?

2. Acupuncture and DC current generation are known to induce generation of endorphins. Do endorphins contribute to welfare by reducing the pain or do they give a conscious expression for the fact that situation has improved as a result of recharging of the metabolic energy batteries?

3. Could the continual charging of metabolic energy batteries by DC currents occur also in the case of cell membrane? The metabolic energy quantum would be around .07 eV in this case and correspond to p-adic length scale $k = 140$ for proton (the quantum is roughly a fraction 1/8 of the fundamental metabolic energy quantum .5 eV corresponding to $k = 137$).

#### Gene activation by electrostatic fields?

The basic question concerns the method of activation. The discovery of chemists Guido Ebner and Guido Schuerch [64, 65, 66] raises the hope that these ideas might be more than over-active imagination and their work also provides a concrete proposal for the activation mechanism. These findings are briefly described in the article of Hardmuth Mueller [66] who proposes quite different explanation for the strange findings. Ebner and Schuerch studied the effect of electrostatic fields on the growth and morphogenesis of various organisms. Germ, seeds, or eggs were placed between conducting plates creating an electric field in the range .5-2 kV/m: note that the Earth's electric field is in the range $.1 - 4$ kV/m and of the same order of magnitude.

The outcome was rather surprising and in the year 1989 their employer Ciba Geigy (now Novaris) applied for a patent "Method of enhanced fish breeding" [64] for what is called Ciba Geigy effect. The researchers describe how fishes (trouts) develop and grow much better, if their eggs have been conditioned in an electrostatic field. The researchers report [64, 65] that also the morphology of the fishes was altered to what seems to represent an ancient evolutionary form: this was not mentioned in the patent.

The chemists founded their own Institute of Pharmaceutical Research near Basel, where Guido Ebner applied for another very detailed patent, which was never granted (it is not difficult to guess the reasons why!). In the patent he describes the effect of electrostatic fields on several life forms (cress, wheat, corn, fern, micro-organisms, bacteria) in their early stage of development. A clear change in the morphogenesis was observed. For instance, in one example fern had all sort of leaves in single plant apparently providing a series of snapshots about the evolution of the plant. The evolutionary age of the first leaf appeared to be about 300 million years whereas the last grown-up leaf looked close to its recent form.

If one takes these finding seriously, one must consider the possibility that the exposure to an electrostatic field can activate passive genes and change the gene expression so that older morphologies are expressed. The activation of not yet existing morphologies is probably more difficult since strong consistency conditions must be satisfied (activation of program requires activation of a proper hardware). This would suggest that genome is a kind of archive containing also older genomes even potential genomes or that topological quantum computer programs [?] determine the morphology to certain extent and that external conditions such as electric field determine the self-organization patters characterizing these programs.

It is known that the developing embryo has an electric field along the head-tail axis and that this field plays an important role in the control of growth. These fields are much weaker than the fields used in the experiment. p-Adic length scale hierarchy however predicts an entire hierarchy of electric fields and living matter is indeed known to be full of electret structures. The strength of the electric field in some p-adic length scale related to DNA might somehow serve as the selector of the evolutionary age. The recapitulation of phylogeny during the ontogeny could mean a gradual shift of the activated part of the memone, perhaps assignable to tqc programs, and be controlled by the gradually evolving electric field strength.

The finding that led Ebner to his discovery was that it was possible to "wake up" ancient bacteria by an exposure to an electrostatic field. The interpretation would be in terms of loading of metabolic batteries. This would also suggest that in the case of primitive life forms like bacteria the electric field of Earth has served as metabolic energy source whereas in higher life forms endogenous electric fields have taken the role of Earth's electric field.

### Could UV photons have some metabolic role?

The correlation between UV photons and ERE brings in mind the vision that high temperature plasmoids are primitive life-forms possibly having universal metabolic energy quanta in UV range. One can imagine that the development of chemical energy storage mechanisms has made it possible to use visible light from Sun as a source of metabolic energy and get rid of UV quanta having disastrous biological effects. Ozone layer shields out most of UV light and also air absorbs the UV light below wavelength 200 nm, which justifies the term vacuum UV (VUV) for this range.

| $\Delta k$ | 1 | 2 | $\geq 3$ | $\infty$ |
|---|---|---|---|---|
| $\Delta E(144, \Delta k)/eV$ | 4 | 6 | $\geq 7$ | 8 |
| $\lambda/nm$ | 310(UVB) | 207(UVB) | $\leq 177$ (VUV) | 155 (VUV) |

Table 3. The lines corresponding to the dropping of electron from $k = 144$ space time sheet defining a candidate for UV light inducing generation of ERE in the interstellar dust.

From Table 3 one finds that $\Delta k > 2$ electronic transitions cascading to 8 eV (155 nm) by period doubling) belong to vacuum UV (VUV) absorbed by air. The lines 310 nm and 207 nm corresponding to $\Delta k = 1$ and $\Delta k = 2$ could however define frequency windows since these lines need not correspond to any atomic or molecular electronic transitions.

In the solar photosphere the temperature is about 5800 K, roughly half of the minimum temperature $10^4$ K needed to generate the UV radiation inducing ERE in interstellar dust. Solar corona however has temperature of about $10^6$ K, which corresponds to a thermal energy of order 100 eV and the UV radiation from corona at above mentioned discrete frequencies resulting in dropping of electrons could serve as a metabolic energy source for pre-biotics in the interstellar space. This raises obvious questions. Should the stellar sources inducing ERE possess also corona? Could 4 eV and 6 eV

UV photons from the solar corona serve as a source of metabolic energy for some primitive organisms like blue algae?

### A simple model for the metabolism of plasmoids

Extended Red Emissions (EREs) are associated with the interstellar dust in presence of UV light with energies above 7.25 eV and source with temperature not below $10^4$ K (maximum of wave length distribution of black body radiation corresponds to the energy 4.97 eV at this temperature). This suggests that plasmoids using UV photons as metabolic energy are involved.

1. Since the bond energies of molecules vary in few eV range and their formation typically liberates photons in UV range, the natural hypothesis is that the metabolic cycle is based on the formation of some molecule liberating UV photon kicking electron/proton to a smaller space-time sheet. UV photons from energy source would in turn induce dissociation of the molecule and thus drive the process. The process as a whole would involve several p-adic length scales and several metabolic currencies.

2. This situation is of course encountered also in the ordinary biology but with highly developed sharing of labor. Biosphere would burn hydrocarbons in animal cells with carbon dioxide as the eventual outcome. Carbon dioxide would in turn be used by plants to regenerate the hydrocarbons. Note that in the recent day technology the loop is open: hydrocarbons are burned but there is no process regenerating them: perhaps photons with large Planck constant might some day used to regenerate the fuel and give rise to "living" and perhaps tidier technology.

3. It is believed that complex organic molecules like amino-acids can form in the interstellar dust and the spontaneous formation of aminoacids is known to be possible in the interstellar ice under UV radiation. Hence at least $N_2$ and perhaps also $CO$ can be expected to be present. The table below gives dissociation energies of some simple molecules.

| Molecule | $H_2$ | $O_2$ | $N_2$ | CO | NO |
|---|---|---|---|---|---|
| $E_D$/eV | 4.48 | 5.08 | 7.37 | 11.11 | 5.2 |

   i) $N_2$ has bond energy 7.37 eV is slightly above the UV threshold 7.26 eV for ERE, which strongly suggests that $N_2$ is one of the molecules involved with the metabolism of interstellar plasmoids.

   ii) If ice is present then carbon monoxide $CO$ would be an excellent candidate for a metabolic molecule since its bond energy is as high as 11.11 eV. The exceptionally large bond energy would naturally relate to the fact that carbon and oxygen are the key molecules of life.

### Anomalous light phenomena as plasmoids

TGD suggests that anomalous light phenomena (ALPs, or light balls, or UFOs depending on one's tastes and assumptions) are identifiable as plasmoids behaving as primitive life forms. In the conference held in Röros Björn Gitle-Hauge told about the determination of the spectrum of visible light emitted by some light balls observed in Hessdalen [25] ("Hessdalen phenomenon" is the term used).

1. The spectrum is a band in the interval 500-600 nm whereas the typical ERE [24] is concentrated in the interval 650-750 nm. The peak is in the interval 540-900 nm, the width of the band is also now 100 nm, and there are no sharp peaks. Therefore the interpretation as ERE can be considered.

2. Because Hessdalen is an old mining district, authors propose that the light ball could consist of burning dust containing some metals. Author proposes that the burning of Titanium and Scandium (encountered only in Scandinavia) might provide the energy for the light ball. $Sc$ reacts vigorously with acids and air (burning in oxygen gives $Sc_2O_3$ as end product). $Ti$ burns in oxygen and is the only element that burns in nitrogen. $Ti$ is used in fireworks since it produces spectacular fires.

Author notices that the emission lines of $N^+$, $Al^{++}$, *resp.* $Sc^+$ at 528.02 nm, 528.2 nm, *resp.* 528.576 nm might contribute to the band. This might be the case but the explanation of the band solely in terms of molecular transitions is not favored by its smoothness.

3. The bond energies of $TiO$ and $TiN$ are 6.9 eV and 5.23 eV so that the radiation resulting in their formation is in UV range and could provide part of the metabolic energy. I do not know about bond energy of Scandium oxide.

4. $TiO_2$ is known to catalyze photolysis in the presence of UV light [28, 27], which in turn is basic step in photosynthesis [26], the basic step of which in TGD Universe would be the kicking of electrons/protons to smaller space-time sheets. Therefore the UV photons liberated in the formation of molecules containing $Ti$ could catalyze photosynthesis like process.

### 8.5.4 Life as a symbiosis of plasmoids and biological life

If evolution has discovered something it usually keeps it so that plasmoids and UV metabolism should be still there. This suggests that plasmoids are still in ionosphere. What could this mean? There also also other questions and I am grateful for Sampo Vesterinen for some of them. The key questions are perhaps the following ones. Do plasmoids and biological life forms live in symbiosis in some sense? If this is the case, what plasmoids can give to us and what we can give to plasmoids?

*1. Magnetic bodies as quantum plasmoids and plasmoids in magnetosphere*

One must make clear what one means with plasmoid. One can consider a plasma made of ordinary visible matter and also large $\hbar$ quantum plasma at magnetic bodies in a form of Bose-Einstein condensates of charged particles. The symbiosis of plasmoids and biomatter could correspond to the symbiosis of magnetic body and biological body.

One can imagine also the possibility that visible matter plasmoids and bio-matter are in symbiosis via the mediation of magnetic bodies. Note that DNA strands are negatively charged so that there is a resemblance with a plasma like state. One aspect of symbiosis would be that magnetic body would feed charged particles to DNA.

*2. Some basic facts about magnetosphere*

Magnetosphere would be a natural environment for plasmoid population. If one restricts plasmoids to to visible matter, then ionosphere, plasma sphere and plasma sheet are the most interesting objects of interest.

1. The temperature in the highest F layer of the ionosphere (extending from 150 km to 1500 km depending on source) is about 1200-1300 K: the photon energy is about .6-.65 eV at the maximum wavelength of thermal distribution. Hence F layer plasmoids might receive metabolic energy in the form of .5 eV metabolic energy quanta via thermal photons. Self-organization occurs in transition layers and especially interesting is the transition region 85-300 km from mesosphere to ionosphere at which temperature increases 300 K to about 1200 K.

2. Inner magnetosphere is a toruslike structure whose extension varies between $4R_E$ (day side) and $8R_E$ (night side) and shielded from solar wind. In the inner magnetosphere the typical density is about 1 ion per cubic centimeter. Inner magnetosphere is bounded by a transition layer of thickness of $\sim R$ (magneto-pause). In this region the density of the ions drops rapidly.

   Inner magnetosphere contains plasma sphere whose radius varies in the range $2R_E - 4R_E$ at day side and $2R_E - 6R_E$ at night side. Plasma has a ionospheric origin. The density of the cold plasma consisting mainly of protons sphere varies in the range $10 - 10^3$ ions/cm$^3$, whereas the temperature is $\sim 5 \times 10^3$ K, which corresponds to metabolic energy quantum of .5 eV. Note however that the energy of photon at maximum of thermal distribution is about 2.5 eV which suggests 2 eV metabolic quantum.

   The cold, dense plasma of plasma sphere is frozen around magnetic flux lines which co-rotate with Earth. In TGD framework this means that flux tubes co-rotate and thus change shape. In the equitorial plane the density of the plasma sphere drops sharply down to $\sim 1$ ion/cm$^3$ at $r = 4R$. This transition region is known as a plasma pause. During magnetic storms the outer radius decreases since the pressure of the solar wind compresses the plasma sphere. The day-night variation of the shape of the plasma sphere is rather small. Within this region the magnetic field has in a reasonable approximation dipole shape with radiation belts forming an exception.

The surface temperature of Sun is $6 \times 10^3$ K. This temperature is roughly half of the minimum temperature $10^4$ K needed for EREs from interstellar dust [24]. This corresponds to photon energy of 3 eV at the maximum of thermal distribution and cannot induce dissociation of $N_2$ and other simple diatomic molecules. There is also solar corona but its temperature is about $10^6$ K ($10^2$ eV) so that the flux of thermal photons at UV energies is very low.

Taking seriously the finding that $T \geq 10^4$K for source is necessary for EREs, one might ask whether the plasmoids at the day side are able to receive enough metabolic energy from UV radiation of Sun. If course, there is is no need to assume that dissociation of $N_2$ molecules is key element in metabolic mechanism. The temperatures in both F layer and plasma sphere allow kicking of protons and electrons to smaller space-time sheets and this might save the situation. Hence metabolism is not a problem for the plasmoids except perhaps during night-time when the plasma cools down somewhat.

3. The plasma sheet [29, N1] at the night side of Earth dark is the most prominent feature of the outer magnetosphere. It has a thickness about Earth radius $R_E$ and extends beyond Moon's orbit (with radius $10^3 R_E$). The average densities of charged particles are very low and same order of magnitude as in plasma sphere: about .4-2 per cm$^3$ for both protons and electrons and correlates with solar wind density.

   The temperature is very high: the thermal energy of electrons is in keV range and ionic temperatures are even higher. The high temperature is due to the leakage of matter from solar wind. Note that up to the distance $d \sim 10^2 R_E$ equator region of outer magnetosphere at the night side of Earth experiences a continual solar eclipse so that this region does not receive radiation energy from Sun: the high temperature of plasma sheet solves this metabolic problem.

   The presence of keV photons would destroy molecules at plasma sheet and induce a high degree of ionization so that plasmoid life must be based on ions and electrons. The energy needed to kick an electron to an atomic space-time sheet is about keV from $m_e/m_p \sim 2^{-11}$: hence the dropping of electrons from atomic space-time sheets would be the natural metabolic mechanism for plasmoid life at plasma sheet.

   One of the original motivations for the plasmoid hypothesis was the strange finding that plasma sheet at the equator at the dark side of Earth is highly self-organized structure and the velocity distributions of electrons present patterns like "flowers", "eyes", "butterflies" [N1].

*3. What plasmoids could give to us and what we could give to plasmoids?*

An attractive general motivation for the symbiosis would be that magnetic bodies would give us ability to think and we would give them ability to sense.

1. The model of cognitive representations relies on the intersections of magnetic bodies with corresponding p-adic space-time sheets possessing literally infinite size in the real sense. The larger the magnetic body, the better the representations. Magnetic bodies could thus provide us with cognitive representations and an interesting question is whether and how this relates to the strange self-organization patterns at plasma sheet.

2. We could provide for magnetic bodies sensory input and serve as their motor instruments. These magnetic bodies might be also associated with plasma sheet and the plasmoids of ionosphere and plasma sphere and could also use plasmoids of visible matter as sensory receptors and perhaps even primitive motor instruments.

One can imagine also more concrete motivations for the symbiosis.

1. Plasmoids in the day-side ionosphere could shield biosphere from UV light by "eating" the incoming UV light. Magnetic bodies could also feed negative electronic charge from the plasmoids of magnetosphere to DNA double strands.

2. Plasmoids are not in a need of metabolic energy unless it happens that the temperature in F layer cools too much during night time from $T \sim 0.12$ eV. One might imagine that plasmoids suck metabolic energy from the biosphere during sleep (say brains which remain active): this would be a possible explanation for why we sleep. One can even imagine that during sleep magnetospheric collective levels of consciousness take command and life forms in the biosphere entangle to form kind of stereo consciousness providing a collective view what is to be human, member of species, or a part of biosphere.

*4. About the interpretation of bio-photons?*

Also the wave lengths of bio-photons are in the range of visible photons. Their spectrum is claimed to be featureless, which would suggest that identification in terms of photons resulting in dropping of electrons and protons to larger space-time sheets might not make sense. The variation of the geometric shape of space-time sheets, the possibility of surplus energy, and the clustering of the transition lines around the lower end of wave length spectrum might however give rise to effectively featureless spectrum.

Suppose that bio-photons correspond to superposition of ERE bands and thus reflect the presence of UV energy feed. Unless biological body is not able to generate the needed UV photons, they must arrive from Sun. Bio-photons or their dark counterparts with much longer wavelengths could indeed live at the flux quanta of the magnetic bodies and observed visible bio-photons could represent some kind of leakage.

*5. Gariaev's experiments*

Gariaev's experiments [51] involved the irradiation of DNA using visible laser light with photon energy 1.9595 eV. The irradiation induced emission of radio waves with same polarization with frequencies above kHz. Radio waves induced growth of potatoes. A possible interpretation is that 2 eV photons kicked electrons to a smaller space-time sheet and thus gave metabolic energy to DNA. The radio waves possibly resulting in the dropping of electrons back to the larger space-time sheets could have consisted of dark photons with same or smaller energy and could have been used as a metabolic energy by the potatoes. That the dropping can occur to several space-time sheets would explain why several radio wave frequencies were observed. The prediction would be sum of period doubling spectra discussed earlier since sequences of droppings are possible. The radio-wave signal would result from the de-coherence of dark radio-wave photons to a bundle of ordinary radio-wave photons.

*6. Earth's interior as a living system?*

For years ago I developed in detail the working hypothesis that entire magnetosphere is a living system. Even Earth's interior (and also solar surface) could contain plasmoid life [N4, N1]. The temperature below the mantle of Earth does not differ too much from the surface temperature of Sun and metabolic energy could come from the radioactive decays from the interior of Earth. There would be UV shielding by Earth: UV light has energies above 3.1 eV whereas the temperature at the mantle-core boundary is 4300 K which corresponds to energy 2.2 eV energy at the maximum of thermal distribution. Metabolic energy quantum of 2 eV would be highly suggestive and might be directly used to kick protons and electrons to smaller space-time sheet.

The metabolism would not probably involve energy quantum of .5 eV. Magnetic flux tubes could also mediate metabolic energy from the biosphere and possibly also ionosphere and the plasmoid life in question could be at an evolutionary level not tolerating UV light and involve molecules in essential manner.

## 8.6 Exotic color and electro-weak interactions

The finding of a correct interpretation of long ranged electro-weak and color gauge fields predicted by classical TGD has been the basic stumbling block for the development of the understanding of TGD Universe and it took about 27 years before the time was ripe to see that TGD predicts entire fractal hierarchy of scaled down copies of standard model physics so that TGD Universe can be seen as a kind of inversion of Mandelbrot fractal for which each new bird eye of view reveals new structures assignable to higher levels in the hierarchy of consciousness.

### 8.6.1 Long range classical weak and color gauge fields as correlates for dark massless weak bosons

Long ranged electro-weak gauge fields are unavoidably present when the dimension $D$ of the $CP_2$ projection of the space-time sheet is larger than 2. Classical color gauge fields are non-vanishing for all non-vacuum extremals. This poses deep interpretational problems. If ordinary quarks and leptons are assumed to carry weak charges feeded to larger space-time sheets within electro-weak length scale, large hadronic, nuclear, and atomic parity breaking effects, large contributions of the classical $Z^0$ force to Rutherford scattering, and strong isotopic effects, are expected. If weak charges are screened within electro-weak length scale, the question about the interpretation of long ranged classical weak fields remains.

#### Various interpretations for the long ranged classical electro-weak fields

During years I have discussed several solutions to the problems listed above.

*Option I*: The trivial solution of the constraints is that $Z^0$ charges are neutralized at electro-weak length scale. The problem is that this option leaves open the interpretation of classical long ranged electro-weak gauge fields unavoidably present in all length scales when the dimension for the $CP_2$ projection of the space-time surface satisfies $D > 2$.

*Option II*: Second option involves several variants but the basic assumption is that nuclei or even quarks feed their $Z^0$ charges to a space-time sheet with size of order neutrino Compton length. The large parity breaking effects in hadronic, atomic, and nuclear length scales is not the only difficulty. The scattering of electrons, neutrons and protons in the classical long range $Z^0$ force contributes to the Rutherford cross section and it is very difficult to see how neutrino screening could make these effects small enough. Strong isotopic effects in condensed matter due to the classical $Z^0$ interaction energy are expected. It is far from clear whether all these constraints can be satisfied by any assumptions about the structure of topological condensate.

*Option III*: During 2005 (27 years after the birth of TGD!) third option solving the problems emerged based on the progress in the understanding of the basic mathematics behind TGD.

In ordinary phase the $Z^0$ charges of elementary particles are indeed neutralized in intermediate boson length scale so that the problems related to the parity breaking, the large contributions of classical $Z^0$ force to Rutherford scattering, and large isotopic effects in condensed matter, trivialize.

Classical electro-weak gauge fields in macroscopic length scales are identified as space-time correlates for the gauge fields created by dark matter, which corresponds to a macroscopically quantum coherent phase for which elementary particles possess complex conformal weights such that the net conformal weight of the system is real.

In this phase $U(2)_{ew}$ symmetry is not broken below the scaled up weak scale except for fermions so that gauge bosons are massless below this length scale whereas fermion masses are essentially the same as for ordinary matter. By charge screening gauge bosons look massive in length scales much longer than the relevant p-adic length scale. The large parity breaking effects in living matter (chiral selection for bio-molecules) support the view that dark matter is what makes living matter living.

#### Classical color gauge fields

Classical long ranged color gauge fields always present for non-vacuum extremals are interpreted as space-time correlates of gluon fields associated with dark copies of hadron physics. It seems that this picture is indeed what TGD predicts. A very special feature of classical color fields is that the holonomy group is Abelian. This follows directly from the expression $g^A_{\alpha\beta} \propto H^A J_{\alpha\beta}$ of induced gluon fields in terms of Hamiltonians $H^A$ of color isometries and induced Kähler form $J_{\alpha\beta}$. This means that classical color magnetic and electric fluxes reduce to the analogs of ordinary magnetic fluxes appearing in the construction of configuration space geometry [B2, B3].

By a local color rotation the color field can be rotated to a fixed direction so that genuinely Abelian field would be in question apart from the possible presence of gauge singularities making impossible a global selection of color direction. These singularities could be present since Kähler form defines a magnetic monopole field. An interesting question inspired by quantum classical correspondence is what the Abelian holonomy tells about the sources of color gauge fields and color confinement.

For instance, could Abelian holonomy mean that colored gluons (and presumably also other colored particles) do not propagate in the p-adic length scale considered? Color neutral gluons would propagate but since also their sources must be color neutral, they should have vanishing net color electric fluxes. This form of confinement would allow those states of color multiplets which have vanishing color charges and obviously symmetry breaking down to $U(1) \times U(1)$ would be in question. This would serve as a signal for monopole confinement which would not exclude higher multipoles for the Abelian color fields. This kind of fields appear in the the TGD based model for nuclei as nuclear strings bound together by color flux tubes [F8]. In the sequel the model for nuclear color force is briefly discussed in order to give an idea about how the dark color forces might act also in longer length scales.

### 8.6.2 Dark color force as a space-time correlate for the strong nuclear force?

Color confinement suggests a basic application of the basic criteria for the transition to large $\hbar$ phase. The obvious guess is that valence quarks are dark [J6, F10]. Dark matter phase for quarks does not change the lowest order classical strong interaction cross sections but reduces dramatically higher order perturbative corrections and resolves the problems created by the large value of QCD coupling strength in the hadronic phase.

The challenge is to understand the strong binding solely in terms of dark QCD with large value of $\hbar$ reducing color coupling strength of valence quarks to $v_0 \simeq 2^{-11}$. The best manner to introduce the basic ideas is as a series of not so frequently asked questions and answers.

#### Rubber band model of strong nuclear force as starting point

The first question is what is the vision for nuclear strong interaction that one can start from. The sticky toffee model of Chris Illert [72] is based on the paradox created by the fact alpha particles can tunnel from the nucleus but that the reversal of this process in nuclear collisions does not occur. Illert proposes a classical model for the tunnelling of alpha particles from nucleus based on dynamical electromagnetic charge. Illert is forced to assume that virtual pions inside nuclei have considerably larger size than predicted by QCD and the model. Strikingly, the model favors fractional alpha particle charges at the nuclear surface. The TGD based interpretation would be based on the identification of the rubber bands of Illert as long color bonds having exotic light quark and anti-quark at their ends and connecting escaping alpha particle to the mother nucleus. The challenge is to give meaning to the attribute "exotic".

#### How the darkness of valence quarks can be consistent with the known sizes of nuclei?

The assumption about darkness of valence quarks in the sense of of large $\hbar$ ($\hbar_s = \hbar/v_0$) is very natural if one takes the basic criterion for darkness seriously. The obvious question is how the dark color force can bind the nucleons to nuclei of ordinary size if the strength of color force is $v_0$ and color sizes of valence quarks are about $L(129)$?

It seems also obvious that $L(107)$ in some sense defines the size for nucleons, and somehow this should be consistent with scaled up size $L(k_{eff} = 129)$ implied by the valence quarks with large $\hbar$. The proposal of [J6, F10] inspired by RHIC findings [67] is that valence quarks are dark in the sense of having large value of $\hbar$ and thus correspond to $k_{eff} = 129$ whereas sea quarks correspond to ordinary value for $\hbar$ and give rise to the QCD size $\sim L(107)$ of nucleon.

If one assumes that the typical distances between sea quark space-time sheets of nucleons is obtained by scaling down the size scale of valence quarks, the size scale of nuclei comes out correctly.

#### Valence quarks and exotic quarks cannot be identical

The hypothesis is that nucleons contain or there are associated with them pairs of exotic quarks and flux tubes of color field bodies of size $\sim L(129)$ connecting the exotic quark and anti-quark in separate nuclei. Nucleons would be structures with the size of ordinary nucleus formed as densely packed structures of size $L(129)$ identifiable as the size of color magnetic body.

The masses of exotic quarks must be however small so that they must differ from valence quarks. The simplest possibility is that exotic quarks are not dark but p-adically scaled down versions of sea quarks with ordinary value of $\hbar$ having $k = 127$ so that masses are scaled down by a factor $2^{-10}$.

Energetic considerations favor the option that exotic quarks associate with nucleons via the $k_{eff} = 111$ space-time sheets containing nucleons and dark quarks. Encouragingly, the assumption that nucleons topologically condense at the weak $k_{eff} = 111$ space-time sheet of size $L(111) \simeq 10^{-14}$ m of exotic quarks predicts essentially correctly the mass number of the highest known super-massive nucleus. Neutron halos are outside this radius and can be understood in terms color Coulombic binding by dark gluons. Tetraneutron can be identified as alpha particle containing two negatively charged color bonds.

#### What determines the binding energy per nucleon?

The binding energies per nucleon for $A \geq 4$ to not vary too much from 7 MeV but the lighter nuclei have anomalously small binding energies. The color bond defined by a color magnetic flux tube of length $\sim L(k = 127)$ or $\sim L(k_{eff} = 129)$ connecting exotic quark and anti-quark in separate nucleons with scaled down masses $m_q(dark) \sim xm_q$, with $x = 2^{-10}$ for option for $k = 127$, is a good candidate in this respect. Color magnetic spin-spin interaction would give the dominant contribution to the interaction energy as in the case of hadrons. This interaction energy is expected to depend on exotic quark pair only. The large zero point kinetic energy of light nuclei topologically condensed at $k_{eff} = 111$ space-time sheet having possible identification as the dark variant of $k = 89$ weak space-time sheet explains why the binding energies of D and $^3He$ are anomalously small.

#### What can one assume about the color bonds?

Can one allow only quark anti-quark type color bonds? Can one allow the bonds to be also electromagnetically charged as the earlier model for tetra-neutron suggests (tetra-neutron would be alpha particle containing two negatively charged color bonds so that the problems with the Fermi statistics are circumvented). Can one apply Fermi statistics simultaneously to exotic quarks and anti-quarks and dark valence quarks?

Option I: Assume that exotic and dark valence quarks are identical in the sense of Fermi statistics. This assumption sounds somewhat non-convincing but is favored by p-adic mass calculations supporting the view that the p-adic mass scale of hadronic quarks can vary. If this hypothesis holds true at least effectively, very few color bonds from a given nucleon are allowed by statistics and there are good reasons to argue that nucleons are arranged to highly tangled string like structures filling nuclear volume with two nucleons being connected by color bonds having of length of order $L(129)$. The organization into closed strings is also favored by the conservation of magnetic flux.

The notion of nuclear string is strongly supported by the resulting model explaining the nuclear binding energies per nucleon. It is essential that nucleons form what might be called nuclear strings rather than more general tangles. Attractive p-p and n-n bonds must correspond to colored $\rho_0$ type bonds with spin one and attractive p-n type bonds to color singlet pion type bonds. The quantitative estimates for the spin-spin interaction energy of the lightest nuclei lead to more precise estimates for the lengths of color bonds. The resulting net color quantum numbers must be compensated by dark gluon condensate, the existence of which is suggested by RHIC experiments [67]. This option is strongly favored by the estimate of nuclear binding energies.

Option II: If Fermi statistics is not assumed to apply in the proposed manner, then color magnetic flux tubes bonds between any pair of nucleons are possible. The identification of color isospin as strong isospin still effective removes color degree of freedom. As many as 8 color tubes can leave the nucleus if exotic quarks and anti-quarks are in the same orbital state and a cubic lattice like structure would become possible. This picture would be consistent with the idea that in ordinary field theory all particle pairs contribute to the interaction energy. The large scale of the magnetic flux tubes would suggest that the contributions cannot depend much on particle pair. The behavior of the binding energies favors strongly the idea of nuclear string and reduces this option to the first one.

#### What is the origin of strong force and strong isospin?

Here the answer is motivated by the geometry of $CP_2$ allowing to identify the holonomy group of electro-weak spinor connection as U(2) subgroup of color group. Strong isospin group SU(2) is identified as subgroup of isotropy group U(2) for space-time surfaces in a sub-theory defined by $M^4 \times S^2$, $S^2$ a homologically non-trivial geodesic sphere of $CP_2$ and second factor of $U(1) \times U(1)$ subgroup of the holonomies for the induced Abelian gauge fields corresponds to strong isospin component $I_3$. The extremely tight correlations between various classical fields lead to the hypothesis that the strong isospin identifiable as color isospin $I_3$ of exotic quarks at the ends of color bonds attached to a given nucleon is identical with the weak isospin of the nucleon. Note that this does not require that exotic and valence quarks are identical particles in the sense of Fermi statistics.

Does the model explain the strong spin orbit coupling ($L \cdot S$ force)? This force can be identified as an effect due to the motion of fermion string containing the effectively color charged nucleons in the color magnetic field $v \times E$ induced by the motion of string in the color electric field at the dark $k = 107$ space-time sheet.

**How the phenomenological shell model with harmonic oscillator potential emerges?**

Nucleus can be seen as a collection of of long color magnetic flux tubes glued to nucleons with the mediation of exotic quarks and anti-quarks. If nuclei form closed string, as one expects in the case of Fermi statistics constraint, also this string defines a closed string or possibly a collection of linked and knotted closed strings. If Fermi statistics constraint is not applied, the nuclear strings form a more complex knotted and linked tangle. The stringy space-time sheets would be the color magnetic flux tubes connecting exotic quarks belonging to different nucleons.

The color bonds between the nucleons are indeed strings connecting them and the averaged interaction between neighboring nucleons in the nuclear string gives in the lowest order approximation 3-D harmonic oscillator potential although strings have $D = 2$ transversal degrees of freedom. Even in the case that nucleons for nuclear strings and thus have only two bonds to neighbors the average force around equilibrium position is expected to be a harmonic force in a good approximation. The nuclear wave functions fix the restrictions of stringy wave functionals to the positions of nucleons at the nuclear strings. Using M-theory language, nucleons would represent branes connected by color magnetic flux tubes representing strings whose ends co-move with branes.

**Which nuclei are the most stable ones and what is the origin of magic numbers?**

$P = N$ closed strings correspond to energy minima and their deformations obtained by adding or subtracting nucleons in general correspond to smaller binding energy per nucleon. Thus the observed strong correlation between P and N finds a natural explanation unlike in the harmonic oscillator model. For large values of $A$ the generation of dark gluon condensate and corresponding color Coulombic binding energy favors the surplus of neutrons and the generation of neutron halos. The model explains also the spectrum of light nuclei, in particular the absence of pp, nn, ppp, and nnn nuclei.

In the standard framework spin-orbit coupling explains the magic nuclei and color Coulombic force gives rise to this kind of force in the same manner as in atomic physics context. Besides the standard magic numbers there are also non-standard ones (such as $Z, N = 6, 12$) if the maximum of binding energy is taken as a definition of magic, there are also other magic numbers than the standard ones. Hence can consider also alternative explanations for magic numbers. The geometric view about nucleus suggests that the five Platonic regular solids might defined favor nuclear configurations and it indeed turns that they explain non-standard magic numbers for light nuclei.

New magic nuclei might be obtained by linking strings representing doubly magic nuclei. An entire hierarchy of linkings becomes possible and could explain the new magic numbers 14, 16, 30, 32 discovered for neutrons [68]. Linking of the nuclear strings could be rather stable by Pauli Exclusion Principle. For instance, $^{16}$O would corresponds to linked $^4He$ and $^{12}C$ nuclei. Higher magic numbers $28, 50, ...$ allow partitions to sums of lower magic numbers which encourages to consider the geometric interpretation as linked nuclei. p-Adic length scale hypothesis in turn suggest the existence of magic numbers coming as powers of $2^3$.

### 8.6.3 How brain could deduce the position and velocity of an object of perceptive field?

The basic degrees of freedom for mind like space-time sheets can be regarded as parameters specifying color quantization axes and spin quantization axis. The parameters characterizing the choices of the color quantization axes define 3+3-dimensional symplectic flag-manifold $F_3 = SU(3)/U(1) \times U(1)$ whereas the parameters fixing spin-quantization axes define two-dimensional flag-manifold $F_2 = SU(1)/U(1) = S^2$, which is identical to two-sphere and whose point characterizes some orientation vector. A mathematically attractive identification of the flag manifold $F_3$ is as a representation for the possible positions and velocities of an object of the perceptive field whereas $F_2$ could represent some orientation, say ear-to-ear orientation axis. This identification, if correct, provides additional support for the uniqueness of the choice of the imbedding space $H = M^4_+ \times CP_2$. Amazingly, the model of honeybee dance by Barbara Shipman leads to the identification of the flag manifold $F_3$ as a fundamental mathematical structure associated with the cognition of the honeybee.

Without a good physical justification this kind of identification is however ad hoc. Fortunately, the following argument makes it possible to understand why $F_3$ should code the position and the velocity of the objects of the perceptive field.

1. The time development by quantum self-organization is expected to lead to well defined asymptotic values of $(P,Q)$ coordinates during each wake-up period of the mind like space-time sheet representing object of the perceptive field and in self-state.

2. The crucial observation is that classical em and $Z^0$ fields are accompanied by classical color fields in TGD. Color rotations rotate the color field in color space whereas induced Kähler form remains unchanged. Most importantly: classical em and $Z^0$ fields do not remain invariant under color rotations as they would remain in standard model. This leads to the idea that different $(P,Q)$ values obtained by color rotations of cognitive and neuronal space-time sheets correspond to slightly different membrane potentials and that it is the dependence of the membrane potential on the position and velocity of the object of the perceptive field, which leads to $(P,Q)$ coding.

3. An observation not directly related to $(P,Q)$ coding is that classical em and color fields induce tiny color polarization at quark level leading to color polarization of nuclei: this color polarization could provide the quantum correlate for the color quale. The representation of color in this manner however requires that $(P,Q)$ are same for all neurons in the perceptive field so that the coding of positions and velocities and color are mutually exclusive. Positions and velocities and color are indeed represented by different regions of cortex.

4. Color rotation induces motion in $F_3$ rotating color quantization axes and leaving the induced Kähler field invariant so that absolute minima of Kähler action are mapped to absolute minima and zero modes are not changed. Classical $Z^0$ and em fields are however *not* invariant under color rotations. How classical em and $Z^0$ depend on Kähler form becomes clear from the the following formulas:

$$\begin{aligned} \gamma &= 3J - \frac{1}{2} sin^2\theta_W Z^0 \ , \\ Z^0 &= 2J + 4e^0 \wedge e^3 \ , \\ J &= 2(e^0 \wedge e^3 + e^1 \wedge e^2) \ . \end{aligned} \tag{8.6.1}$$

Here $J$ denotes Kähler form invariant under color rotations and $e^k$ denote vierbein vectors of $CP_2$. $e^0 \wedge e^3$ denotes the part of $Z^0$, which is not invariant under color rotations. From these formulas it is evident that classical photon field is not in general invariant since it is a superposition of the induced Kähler field and classical $Z^0$ field and reduces to induced Kähler field only when the Weinberg angle vanishes: the physical value of the Weinberg angle is about $sin^2(\theta_W) = 1/4$. This means that various points $(P,Q)$ of (3+3)-dimensional $F_3$ indeed correspond to different classical $Z^0$ fields and classical em fields.

5. There is however an important exception to this picture. If $CP_2$ projection belongs to geodesic sphere $S^2$, the field equations reduces to those for $X^4 \subset M^4 \times S^2$. For space-time sheets for which $CP_2$ projection is $r = \infty$ homologically non-trivial geodesic sphere of $CP_2$ one has

$$\gamma = (\frac{3}{4} - \frac{sin^2(\theta_W)}{2})Z^0 \simeq \frac{5Z^0}{8}$$

as the explicit study of $r = \infty$ geodesic sphere shows (see the appendix of the book). The induced $W$ fields vanish in this case and they vanish also for all geodesic spheres obtained by $SU(3)$ rotation. There are excellent reasons to believe that also the relationship between $Z^0$ and $\gamma$ is $SU(3)$ invariant so that there would be no mixing between em and $Z^0$ fields. For homologically trivial geodesic spheres $\gamma$ and $Z^0$ vanish and only $W$ fields are non-vanishing. This kind of MEs would naturally correspond to $W$ MEs.

For $D > 2$-dimensional $CP_2$ projection the situation changes. MEs have always 2-D $CP_2$ projection field equations and field equations are satisfied without assuming that $CP_2$ projection is a geodesic sphere and in this case one can hope of getting mixing of $\gamma$ and $Z^0$ also in this case perhaps characterizable in terms of the value of the Weinberg angle. Also $W$ fields can be present in this case.

6. Assuming that the values of $(P, Q)$ coordinates are the same for the neuronal group representing an object of the perceptive field and the mind like space-time sheet associated with it (this could be forced by the wormhole contacts), $(P, Q)$ coding for the positions and velocities for the objects of the perceptive field follows if these observables are coded into the properties of the classical $Z^0$ field associated with the neuronal membrane. This seems plausible since a change of the classical $Z^0$ field implies a change of the classical em field if the induced Kähler field remains invariant (as is natural). Thus the problem of understanding $(P, Q)$ coding for position and velocity reduces to the problem of understanding why the position and velocity should affect some natural em field associated with cell membrane. Obviously membrane resting potential is an excellent candidate for this em field.

7. The dependence of the value of the membrane resting potential for the representation of an object of the perceptive field on the the position and velocity of the object is natural. For instance, it is advantageous for the neurons representing object near to the observer to be nearer to the criticality for firing. Thus the membrane potential must be reduced by a suitable color rotation and effective code position of the object to $Q$ coordinates. Also, when the object moves towards/away from the observer, the resting potential should be reduced/increased and this means that velocity is coded to $P$ value (note that there is infinite number of canonical coordinates at use). From these correlations it is quite plausible that $(P, Q)$ coding could be a result of natural selection. Of course, the coding of position and velocity to $(P, Q)$ values need not be one-to-one. For instance, simple organisms are sensitive for velocity only and some organisms experience world as 2-dimensional.

### 8.6.4 Boolean mind and dark neutrinos

The unavoidable prediction of classical TGD is the presence of long ranged classical electro-weak fields in all long scales and the only reasonable interpretation is in terms of dark matter hierarchy suggesting the existence of light copies of ordinary elementary particles in all length scales coupling to ordinary matter only via gravitation. Even more, the length scale range 10 nm-2.5 $\mu$m contains four Gaussian Mersennes possibly assignable to fractally scaled down copies of electro-weak physics.

One ends up with a rather concrete quantum model for Boolean mind based on neutrinos by

1. combining the concept of association sequence as 3-surface which is a union of space-like 3-surface with time-like separations with the fermionic realization of Boolean algebra ;

2. requiring that fermionic states exist only in a finite time interval defined by the duration of the mind-like space-time sheets;

3. assuming that time-like entanglement is possible for many-fermion states. A rigorous definition of time like entanglement in terms of so called Connes tensor product is discussed in [C6]. According to this identification time-like entanglement at given level of cognitive hierarchy represents the S-matrix at lower level of hierarchy as entanglement coefficients so that states at higher level can represent dynamics at the lower level. This highly restricted form of entanglement is in accordance with the very restricted failure of classical determinism.

Ordinary fermions cannot reside on mind-like space-time sheets unless they are created as pairs with vanishing total quantum numbers (in particular energy!) such that the quantum numbers of fermion and anti-fermion at space-time sheets of opposite time orientation compensate each other. Dark neutrinos are however exceptional since their interaction energy [F8, F10] is negative and it is possible to create pairs with vanishing net energy such that both members are at space-time sheet of positive time orientation.

Dark neutrinos are an ideal tool of cognition since they do not couple to electromagnetic interactions and, having couplings only to dark weak bosons, dissipate extremely weakly. The creation of cognitive neutrino pairs by the splitting of a wormhole contact connecting two space-time sheets is indeed possible and provides a possible realization for thinking system. Wormhole contact itself can be regarded as a neutrino-antineutrino pair bound assignable to the causal horizons of the wormhole contact. Logical statement and its negation correspond naturally to Fock sates of dark antineutrinos (resp. dark neutrinos).

Quantum classical correspondence suggests that it is localization in zero modes, in fact the conscious selection between degenerate absolute minima of Kähler action, which selects beween various configurations of the classical $Z^0$ field. If the pattern of cognitive neutrino pairs is fixed by the classical $Z^0$ field, the premises and conclusions of the logical deductions would be represented in terms of cognitive neutrinos. This assumption is also in accordance with the hypothesis that the exponent of the Kähler action provides a measure for the cognitive resources of 3-surface defined as the number of degenerate absolute minima of Kähler action associated with the 3-surface [H7].

From this it is still a long way to precise models and one can make only educated guesses.

1. Cognitive neutrino pairs could reside in the defect regions of neutrino super conductor which is super-conductor of type I having complicated stripe like defect regions near criticality. TGD based model for the interaction of dark neutrinos with condensed matter predicts that the thickness of the defect regions is of order $10^{-8}$ meters. Hence cell membranes are excellent candidates for the defect regions. The model for the generation of cognitive neutrino pairs as zero energy states favors this option very strongly.

2. Also chromosomes (having same thickness as cell membranes) could be identified as defect regions of dark neutrino super conductor. Very simple model for the abstraction process as a hierarchy of Boolean statements about Boolean statements about... starting from two basic statements explains the basic numbers of the genetic code (see the chapter [H7]). It is difficult to believe that this could be mere accident. Cognitive neutrino pairs indeed allow to construct a model of a many-sheeted DNA realizing gene level Boolean mind and possibly explaining the mystery of introns [39].

Of course, conscious Boolean mind at gene level need not have anything to do with *our* logical mind, and probably does not. If it has, new forms of gene expression are necessary. The model for abstraction process however predicts entire hierarchy of "genetic codes", and the level next to the level realizing genetic code might correspond to what might be called memetic code realized in terms of the cognitive neutrino pairs associated with the cell membrane in accordance with the option 1) and leads up to a concrete model for memetic code relating temporal sequences of cognitive neutrino pairs associated with axons to cognitive experiences [L1].

## 8.7 The relationship between p-adic and real physics

p-Adic physics as physics of cognition and intentionality are the most exotic new physics involved with TGD and only heuristic ideas about the relationship of real and p-adic physics exist. The interpretation of the p-adic as physics of cognition and the vision about reduction of physics to rational physics continuable algebraically to various extensions of rationals and p-adic number fields is an attractive general framework allowing to understand how p-adic fractality could emerge in real physics. In this section it will be found that this vision provides a concrete tool in principle allowing to construct global solutions of field equations by reducing long length scale real physics to short length scale p-adic physics. Also p-adic length scale hypothesis can be understood and the notion of multi-p p-fractality can be formulated in precise sense in this framework. This vision leads also to a concrete quantum model for how intentions are transformed to actions and the S-matrix for the process has the same general form as the ordinary S-matrix.

### 8.7.1 p-Adic physics and the construction of solutions of field equations

The number theoretic vision about physics relies on the idea that physics or, rather what we can know about it, is basically rational number based. One interpretation would be that space-time surfaces, the induced spinors at space-time surfaces, configuration space spinor fields, S-matrix, etc..., can be obtained by algebraically continuing their values in a discrete subset of rational variant of the geometric structure considered to appropriate completion of rationals (real or p-adic). The existence of the algebraic continuation poses very strong additional constraints on physics but has not provided any practical means to solve quantum TGD.

In the following it is however demonstrated that this view leads to a very powerful iterative method of constructing global solutions of classical field equations from local data and at the same time gives justification for the notion of p-adic fractality, which has provided very successful approach not only to elementary particle physics but also physics at longer scales. The basic idea is that mere p-adic continuity and smoothness imply fractal long range correlations between rational points which are very close p-adically but far from each other in the real sense and vice versa.

#### The emergence of a rational cutoff

For a given p-adic continuation only a subset of rational points is acceptable since the simultaneous requirements of real and p-adic continuity can be satisfied only if one introduces ultraviolet cutoff length scale. This means that the distances between subset of rational points fixing the dynamics of the quantities involved are above some cutoff length scale, which is expected to depend on the p-adic number field $R_p$ as well as a particular solution of field equations. The continued quantities coincide only in this subset of rationals but not in shorter length scales.

The presence of the rational cutoff implies that the dynamics at short scales becomes effectively discrete. Reality is however not discrete: discreteness and rationality only characterize the inherent limitations of our knowledge about reality. This conforms with the fact that our numerical calculations are always discrete and involve finite set of points.

The intersection points of various p-adic continuations with real space-time surface should code for all actual information that a particular p-adic physics can give about real physics in classical sense. There are reasons to believe that real space-time sheets are in the general case characterized by integers $n$ decomposing into products of powers of primes $p_i$. One can expect that for $p_i$-adic continuations the sets of intersection points are especially large and that these p-adic space-time surfaces can be said to provide a good discrete cognitive mimicry of the real space-time surface.

Adelic formula represents real number as product of inverse of its p-adic norms. This raises the hope that taken together these intersections could allow to determine the real surface and thus classical physics to a high degree. This idea generalizes to quantum context too.

The actual construction of the algebraic continuation from a subset of rational points is of course something which cannot be done in practice and this is not even necessary since much more elegant approach is possible.

#### Hierarchy of algebraic physics

One of the basic hypothesis of quantum TGD is that it is possible to define exponent of Kähler action in terms of fermionic determinants associated with the modified Dirac operator derivable from a Dirac action related super-symmetrically to the Kähler action.

If this is true, a very elegant manner to define hierarchy of physics in various algebraic extensions of rational numbers and p-adic numbers becomes possible. The observation is that the continuation to various p-adic numbers fields and their extensions for the fermionic determinant can be simply done by allowing only the eigenvalues which belong to the extension of rationals involved and solve field equations for the resulting Kähler function. Hence a hierarchy of fermionic determinants results. The value of the dynamical Planck constant characterizes in this approach the scale factor of the $M^4$ metric in various number theoretical variants of the imbedding space $H = M^4 \times CP_2$ glued together along subsets of rational points of $H$. The values of $\hbar$ are determined from the requirement of quantum criticality [C6] meaning that Kähler coupling strength is analogous to critical temperature.

In this approach there is no need to restrict the imbedding space points to the algebraic extension of rationals and to try to formulate the counterparts of field equations in these discrete imbedding spaces.

### p-Adic short range physics codes for long range real physics and vice versa

One should be able to construct global solutions of field equations numerically or by engineering them from the large repertoire of known exact solutions [D1]. This challenge looks formidable since the field equations are extremely non-linear and the failure of the strict non-determinism seems to make even in principle the construction of global solutions impossible as a boundary value problem or initial value problem.

The hope is that short distance physics might somehow code for long distance physics. If this kind of coding is possible at all, p-adicity should be crucial for achieving it. This suggests that one must articulate the question more precisely by characterizing what we mean with the phrases "short distance" and "long distance". The notion of short distance in p-adic physics is completely different from that in real physics, where rationals very close to each other can be arbitrary far away in the real sense, and vice versa. Could it be that in the statement "Short length scale physics codes for long length scale physics" the attribute "short"/"long" could refer to p-adic/real norm, real/p-adic norm, or both depending on the situation?

The point is that rational imbedding space points very near to each other in the real sense are in general at arbitrarily large distances in p-adic sense and vice versa. This observation leads to an elegant method of constructing solutions of field equations.

1. Select a rational point of the imbedding space and solve field equations in the real sense in an arbitrary small neighborhood $U$ of this point. This can be done with an arbitrary accuracy by choosing $U$ to be sufficiently small. It is possible to solve the linearized field equations or use a piece of an exact solution going through the point in question.

2. Select a subset of rational points in $U$ and interpret them as points of p-adic imbedding space and space-time surface. In the p-adic sense these points are in general at arbitrary large distances from each and real continuity and smoothness alone imply p-adic long range correlations. Solve now p-adic field equations in p-adically small neighborhoods of these points. Again the accuracy can be arbitrarily high if the neighborhoods are choose small enough. The use of exact solutions of course allows to overcome the numerical restrictions.

3. Restrict the solutions in these small p-adic neighborhoods to rational points and interpret these points as real points having arbitrarily large distances. p-Adic smoothness and continuity alone imply fractal long range correlations between rational points which are arbitrary distant in the real sense. Return to 1) and continue the loop indefinitely.

In this manner one obtains even in numerical approach more and more small neighborhoods representing almost exact p-adic and real solutions and the process can be continued indefinitely.

Some comments about the construction are in order.

1. Essentially two different field equations are in question: real field equations fix the local behavior of the real solutions and p-adic field equations fix the long range behavior of real solutions. Real/p-adic global behavior is transformed to local p-adic/real behavior. This might be the deepest reason why for the hierarchy of p-adic physics.

2. The failure of the strict determinism for the dynamics dictated by Kähler action and p-adic non-determinism due to the existence of p-adic pseudo constants give good hopes that the construction indeed makes it possible to glue together the (not necessarily) small pieces of space-time surfaces inside which solutions are very precise or exact.

3. Although the full solution might be impossible to achieve, the predicted long range correlations implied by the p-adic fractality at the real space-time surface are a testable prediction for which p-adic mass calculations and applications of TGD to biology provide support.

4. It is also possible to generalize the procedure by changing the value of $p$ at some rational points and in this manner construct real space-time sheets characterized by different p-adic primes.

5. One can consider also the possibility that several p-adic solutions are constructed at given rational point and the rational points associated with p-adic space-time sheets labelled by $p_1, ...., p_n$ belong to the real surface. This would mean that real surface would be multi-p p-adic fractal.

I have earlier suggested that even elementary particles are indeed characterized by integers and that only particles for which the integers have common prime factors interact by exchanging particles characterized by common prime factors. In particular, the primes $p = 2, 3, ....., 23$ would be common to the known elementary particles and appear in the expression of the gravitational constant. Multi-p p-fractality leads also to an explanation for the weakness of the gravitational constant. The construction recipe for the solutions would give a concrete meaning for these heuristic proposals.

This approach is not restricted to space-time dynamics but is expected to apply also at the level of say S-matrix and all mathematical object having physical relevance. For instance, p-adic four-momenta appear as parameters of S-matrix elements. p-Adic four-momenta very near to each other p-adically restricted to rational momenta define real momenta which are not close to each other and the mere p-adic continuity and smoothness imply fractal long range correlations in the real momentum space and vice versa.

### p-Adic length scale hypothesis

Approximate $p_1$-adicity implies also approximate $p_2$-adicity of the space-time surface for primes $p \simeq p_1^k$. p-Adic length scale hypothesis indeed states that primes $p \simeq 2^k$ are favored and this might be due to simultaneous $p \simeq 2^k$- and 2-adicity. The long range fractal correlations in real space-time implied by 2-adicity would indeed resemble those implied by $p \simeq 2^k$ and both $p \simeq 2^k$-adic and 2-adic space-time sheets have larger number of common points with the real space-time sheet.

If the scaling factor $\lambda$ of $\hbar$ appearing in the dark matter hierarchy is in good approximation $\lambda = 2^{11}$ also dark matter hierarchy comes into play in a resonant manner and dark space-time sheets at various levels of the hierarchy tend to have many intersection points with each other.

There is however a problem involved with the understanding of the origin of the p-adic length scale hypothesis if the correspondence via common rationals is assumed.

1. The mass calculations based on p-adic thermodynamics for Virasoro generator $L_0$ predict that mass squared is proportional to $1/p$ and Uncertainty Principle implies that $L_p$ is proportional to $\sqrt{p}$ rather than $p$, which looks more natural if common rationals define the correspondence between real and p-adic physics.

2. It would seem that length $d_p \simeq pR$, $R$ or order CP$_2$ length, in the induced space-time metric must correspond to a length $L_p \simeq \sqrt{p}R$ in $M^4$. This could be understood if space-like geodesic lines at real space-time sheet obeying effective p-adic topology are like orbits of a particle performing Brownian motion so that the space-like geodesic connecting points with $M^4$ distance $r_{M^4}$ has a length $r_{X^4} \propto r_{M^4}^2$. Geodesic random walk with randomness associated with the motion in CP$_2$ degrees of freedom could be in question. The effective p-adic topology indeed induces a strong local wiggling in $CP_2$ degrees of freedom so that $r_{X^4}$ increases and can depend non-linearly on $r_{M^4}$.

3. If the size of the space-time sheet associated with the particle has size $d_p \sim pR$ in the induced metric, the corresponding $M^4$ size would be about $L_p \propto \sqrt{p}R$ and p-adic length scale hypothesis results.

4. The strongly non-perturbative and chaotic behavior $r_{X^4} \propto r_{M^4}^2$ is assumed to continue only up to $L_p$. At longer length scales the space-time distance $d_p$ associated with $L_p$ becomes the unit of space-time distance and geodesic distance $r_{X^4}$ is in a good approximation given by

$$r_{X^4} = \frac{r_{M^4}}{L_p} d_p \propto \sqrt{p} \times r_{M^4} \quad , \tag{8.7.1}$$

and is thus linear in $M^4$ distance $r_{M^4}$.

### Does cognition automatically solve real field equations in long length scales?

In TGD inspired theory of consciousness p-adic space-time sheets are identified as space-time correlates of cognition. Therefore our thoughts would have literally infinite size in the real topology if p-adics and reals correspond to each other via common rationals (also other correspondence based on the separate canonical identification of integers $m$ and $n$ in $q = m/n$ with p-adic numbers).

The cognitive solution of field equations in very small p-adic region would solve field equations in real sense in a discrete point set in very long real length scales. This would allow to understand why the notions of Universe and infinity are a natural part of our conscious experience although our sensory input is about an infinitesimally small region in the scale of universe.

The idea about Universe performing mimicry at all possible levels is one of the basic ideas of TGD inspired theory of consciousness. Universe could indeed understand and represent the long length scale real dynamics using local p-adic physics. The challenge would be to make quantum jumps generating p-adic surfaces having large number of common points with the real space-time surface. We are used to call this activity theorizing and the progress of science towards smaller real length scales means progress towards longer length scales in p-adic sense. Also real physics can represent p-adic physics: written language and computer represent examples of this mimicry.

## 8.7.2 A more detailed view about how local p-adic physics codes for p-adic fractal long range correlations of the real physics

The vision described earlier gives only a rough heuristic view about how the local p-adic physics could code for the p-adic fractality of long range real physics. There are highly non-trivial details related to the treatment of $M^4$ and $CP_2$ coordinates and to the mapping of p-adic $H$-coordinates to their real counterparts and vice versa.

### How real and p-adic space-time regions are glued together?

The first task is to visualize how real and p-adic space-time regions relate to each other. It is convenient to start with the extension of real axis to contain also p-adic points. For finite rationals $q = m/n$, $m$ and $n$ have finite power expansions in powers of $p$ and one can always write $q = p^k \times r/s$ such that $r$ and $s$ are not divisible by $p$ and thus have pinary expansion of in powers of $p$ as $x = x_0 + \sum_1^N x_n p^n$, $x_i \in \{0, p\}$, $x_0 \neq 0$.

One can always express p-adic number as $x = p^n y$ where $y$ has p-adic norm 1 and has expansion in non-negative powers of $p$. When $x$ is rational but not integer the expansion contains infinite number of terms but is periodic. If the expansion is infinite and non-periodic, one can speak about *strictly p-adic* number having infinite value as a real number.

In the same manner real number $x$ can be written as $x = p^n y$, where $y$ is either rational or has infinite non-periodic expansion $y = r_0 + \sum_{n>0} r_n p^{-n}$ in negative powers of $p$. As a p-adic number $y$ is infinite. In this case one can speak about strictly real numbers.

This gives a visual idea about what the solution of field equations locally in various number fields could mean and how these solutions are glued together along common rationals. In the following I shall be somewhat sloppy and treat the rational points of the imbedding space as if they were points of real axis in order to avoid clumsy formulas.

1. The p-adic variants of field equations can be solved in the strictly p-adic realm and by p-adic smoothness these solutions are well defined also in as subset of rational points. The strictly p-adic points in a neighborhood of a given rational point correspond as real points to infinitely distant points of $M^4$. The possibility of p-adic pseudo constants means that for rational points of $M^4$ having sufficiently large p-adic norm, the values of $CP_2$ coordinates or induced spinor fields can be chosen more or less freely.

2. One can solve the p-adic field equations in any p-adic neighborhood $U_n(q) = \{x = q + p^n y\}$ of a rational point $q$ of $M^4$, where $y$ has a unit p-adic norm and select the values of fields at different points $q_1$ and $q_2$ freely as long as the spheres $U_n(q_1)$ and $U_n(q_2)$ are disjoint (these spheres are either identical or disjoint by p-adic ultra-metricity).

   The points in the p-adic continuum part of these solutions are at an infinite distance from $q$ in $M^4$. The points which are well-defined in real sense form a discrete subset of rational points of

$M^4$. The p-adic space-time surface constructed in this manner defines a discrete fractal hierarchy of rational space-time points besides the original points inside the p-adic spheres. In real sense the rational points have finite distances and could belong to disjoint real space-time sheets. The failure of the strict non-determinism for the field equations in the real sense gives hopes for gluing these sheets partially together (say in particle reactions with particles represented as 3-surfaces).

3. All rational points $q$ of the p-adic space-time sheet can be interpreted as real rational points and one can solve the field equations in the real sense in the neighborhoods $U_n(q) = \{x = q + p^n y\}$ corresponding to real numbers in the the range $p^n \leq x \leq p^{n+1}$. Real smoothness and continuity fix the solutions at finite rational points inside $U_n(q)$ and by the phenomenon of p-adic pseudo constants these values can be consistent with p-adic field equations. Obviously one can can continue the construction process indefinitely.

### p-Adic scalings act only in $M^4$ degrees of freedom

p-Adic fractality suggests that finite real space-time sheets around points $x + p^n$, $x = 0$, are obtained as by just scaling of the $M^4$ coordinates having origin at $x = 0$ by $p^n$ of the solution defined in a neighborhood of $x$ and leaving $CP_2$ coordinates as such. The known extremals of Kähler action indeed allow $M^4$ scalings as dynamical symmetries.

One can understand why no scaling should appear in $CP_2$ degrees of freedom. $CP_2$ is complex projective space for which points can be regarded as complex planes and for these p-adic scalings act trivially. It is worth of emphasizing that here could lie a further deep number theoretic reason for why the space $S$ in $H = M^4 \times S$ must be a projective space.

### What p-adic fractality for real space-time surfaces really means?

The identification of p-adic and real $M^4$ coordinates of rational points as such is crucial for p-adic fractality. On the other hand, the identification rational real and p-adic $CP_2$ coordinates as such would not be consistent with the idea that p-adic smoothness and continuity imply p-adic fractality manifested as long range correlations for real space-time sheets

The point is that p-adic fractality is not stable against small p-adic deformations of $CP_2$ coordinates as function of $M^4$ coordinates for solutions representable as maps $M^4 \rightarrow CP_2$. Indeed, if the rational valued p-adic $CP_2$ coordinates are mapped as such to real coordinates, the addition of large power $p^n$ to $CP_2$ coordinate implies small modification in p-adic sense but large change in the real sense so that correlations of $CP_2$ at p-adically scaled $M^4$ points would be completely lost.

The situation changes if the map of p-adic $CP_2$ coordinates to real ones is continuous so that p-adically small deformations of the p-adic space-time points are mapped to small real deformations of the real space-time points.

1. Canonical identification $I : x = \sum x_n p^n \rightarrow \sum x_n p^{-n}$ satisfies continuity constraint but does not map rationals to rationals.

2. The modification of the canonical identification given by

$$I(q = p^k \times \frac{r}{s}) = p^k \times \frac{I(r)}{I(s)} \tag{8.7.2}$$

is uniquely defined for rational points, maps rationals to rationals, has a symmetry under exchange of target and domain. This map reduces to a direct identification of rationals for $0 \leq r < p$ and $0 \leq s < p$.

3. The form of this map is not general coordinate invariant nor invariant under color isometries. The natural requirement is that the map should respect the symmetries of $CP_2$ maximally. Therefore the complex coordinates transforming linearly under U(2) subgroup of SU(3) defining the projective coordinates of $CP_2$ are a natural choice. The map in question would map the real components of complex coordinates to their p-adic variants and vice versa. The residual $U(2)$

symmetries correspond to rational unitary $2\times 2$-matrices for which matrix elements are of form $U_{ij} = p^k r/s$, $r<p, s<p$. It would seem that these transformations must form a finite subgroup if they define a subgroup at all. In case of $U(1)$ Pythagorean phases define rational phases but sufficiently high powers fail to satisfy the conditions $r<p, s<p$. Also algebraic extensions of p-adic numbers can be considered.

4. The possibility of pseudo constant allows to modify canonical identification further so that it reduces to the direct identification of real and p-adic rationals if the highest powers of $p$ in $r$ and $s$ ($q = p^n r/s$) are not higher than $p^N$. Write $x = \sum_{n\geq 0} x_n p^n = x^{N)} + p^{N+1}y$ with $x^{N)} = \sum_{n=0}^{N} x_n p^n$, $x_0 \neq 0$, $y_0 \neq 0$, and define $I_N(x) = x^{N)} + p^{N+1}I(y)$. For $q = p^n r/s$ define $I_N(q) = p^n I_N(r)/I_N(s)$. This map reduces to the direct identification of real and p-adic rationals for $y = 0$.

5. There is no need to introduce the imaginary unit explicitly. In case of spinors imaginary unit can be represented by the antisymmetric $2\times 2$-matrix $\epsilon_{ij}$ satisfying $\epsilon_{12} = 1$. As a matter fact, the introduction of imaginary unit as number would lead to problems since for $p\ mod\ 4 = 3$ imaginary unit should be introduced as an algebraic extension and $CP_2$ in this sense would be an algebraic extension of $RP_2$. The fact that the algebraic extension of p-adic numbers by $\sqrt{-1}$ is equivalent with an extension introducing $\sqrt{p-1}$ supports the view that algebraic imaginary unit has nothing to do with the geometric imaginary unit defined by Kähler form of $CP_2$. For $p\ mod\ 4 = 1$ $\sqrt{-1}$ exists as a p-adic number but is infinite as a real number so that the notion of finite complex rational would not make sense.

### Preferred $CP_2$ coordinates as a space-time correlate for the selection of quantization axis

Complex $CP_2$ coordinates are fixed only apart from the choice of the quantization directions of color isospin and hyper charge axis in SU(3) Lie algebra. Hence the selection of quantization axes seems to emerge at the level of the generalized space-time geometry as quantum classical correspondence indeed requires.

In a well-defined sense the choice of the quantization axis and a special coordinate system implies the breaking of color symmetry and general coordinate invariance. This breaking is induced by the presence of p-adic space-time sheets identified as correlates for cognition and intentionality. One could perhaps say that the cognition affects real physics via the imbedding space points shared by real and p-adic space-time sheets and that these common points define discrete coordinatization of the real space-time surface analogous to discretization resulting in any numerical computation.

### Relationship between real and p-adic induced spinor fields

Besides imbedding space coordinates also induced spinor fields are fundamental variables in TGD. The free second quantized induced spinor fields define the fermionic oscillator operators in terms of which the gamma matrices giving rise to spinor structure of the "world of classical worlds" can be expressed.

p-Adic fractal long range correlations must hold true also for the induced spinor fields and they are in exactly the same role as $CP_2$ coordinates so that the variant of canonical identification mapping rationals to rationals should map the real and imaginary parts of of real induced spinor fields to their p-adic counterparts and vice versa at the rational space-time points common to p-adic and real space-time sheets.

### Could quantum jumps transforming intentions to actions really occur?

The idea that intentional action corresponds to a quantum jump in which p-adic space-time sheet is transformed to a real one traversing through rational points common to p-adic and real space-time sheet is consistent with the conservation laws since the sign of the conserved inertial energy can be also negative in TGD framework and the density of inertial energy vanishes in cosmological length scales [D5]. Also the non-diagonal transitions $p_1 \rightarrow p_2$ are in principle possible and would correspond to intersections of p-adic space-time sheets having a common subset of rational points. Kind of phase transitions changing the character of intention or cognition would be in question.

1. *Realization of intention as a scattering process*

The first question concerns the interpretation of this process and possibility to find some familiar counterpart for it in quantum field theory framework. The general framework of quantum TGD suggests that the points common to real and p-adic space-time sheets could perhaps be regarded as arguments of an n-point function determining the transition amplitudes for p-adic to real transition or $p_1 \rightarrow p_2$-adic transitions. The scattering event transforming an p-adic surface (infinitely distant real surface in real $M^4$) to a real finite sized surface (infinitely distant p-adic surface in p-adic $M^4$) would be in question.

*2. Could S-matrix for realizations of intentions have the same general form as the ordinary S-matrix?*

One might hope that the realization of intention as a number theoretic scattering process could be characterized by an S-matrix, which one might hope of being unitary in some sense. These S-matrix elements could be interpreted at fundamental level as probability amplitudes between intentions to prepare a define initial state and the state resulting in the process.

Super-conformal invariance is a basic symmetry of quantum TGD which suggests that the S-matrix in question should be constructible in terms of n-point functions of a conformal field theory restricted to a subset of rational points shared by real and p-adic space-time surfaces or their causal determinants. According to the general vision discussed in [C1], the construction of n-point functions effectively reduces to that at 2-dimensional sections of light-like causal determinants of space-time surfaces identified as partonic space-time sheets.

The idea that physics in various number fields results by algebraic continuation of rational physics serves as a valuable guideline and suggests that the form of the S-matrices between different number fields (call them non-diagonal S-matrices) could be essentially the same as that of diagonal S-matrices. If this picture is correct then the basic differences to ordinary real S-matrix would be following.

1. Intentional action could transform p-adic space-time surface to a real one only if the exponent of Kähler function for both is rational valued (or belongs to algebraic extension of rationals).

2. The points appearing as arguments of n-point function associated with the non-diagonal S-matrix are a subset of rational points of imbedding space whereas in the real case, where the integration over these points is well defined, all values of arguments can be allowed. Thus the difference between ordinary S-matrix and more general S-matrices would be that a continuous Fourier transform of n-point function in space-time domain is not possible in the latter case. The inherent nature of cognition would be that it favors localization in the position space.

*3. Objection and its resolution*

Exponent of Kähler function is the key piece of the configuration space spinor field. There is a strong counter argument against the existence of the Kähler function in the p-adic context. The basic problem is that the definite integral defining the Kähler action is not p-adically well-defined except in the special cases when it can be done algebraically. Algebraic integration is however very tricky and numerically completely unstable.

The definition of the exponent of Kähler function in terms of Dirac determinants or, perhaps equivalently, as a result of normal ordering of the modified Dirac action for second quantized induced spinors might however lead to an elegant resolution of this problem. This approach is discussed in detail in [B4, D1]. The idea is that Dirac determinant can be defined as a product of eigenvalues of the modified Dirac operator and one ends up to a hierarchy of theories based on the restriction of the eigenvalues to various algebraic extensions of rationals identified as a hierarchy associated with corresponding algebraic extensions of p-adic numbers. This hierarchy corresponds to a hierarchy of theories (and also physics!) based on varying values of Kähler coupling constant and Planck constant. The elegance of this approach is that no discretization at space-time level would be needed: everything reduces to the generalized eigenvalue spectrum of the modified Dirac operator.

*4. A more detailed view*

Consider the proposed approach in more detail.

1. Fermionic oscillator operators are assigned with the generalized eigenvectors of the modified Dirac operator defined at the light-like causal determinants:

$$\begin{aligned} \Psi &= \sum_n \Psi_n b_n \ , \\ D\Psi_n &= \Gamma^\alpha D_\alpha \Psi_n = \lambda_n O \Psi_n \ , \ \ O \equiv n_\alpha \Gamma^\alpha \ . \end{aligned} \tag{8.7.3}$$

Here $\Gamma^\alpha = T^{\alpha k}\Gamma_k$ denote so called modified gamma matrices expressible in terms of the energy momentum current $T^{\alpha k}$ assignable to Kähler action [B4]. The replacement of the ordinary gamma matrices with modified ones is forced by the requirement that the super-symmetries of the modified Dirac action are consistent with the property of being an extremal of Kähler action. $n_\alpha$ is a light like vector assignable to the light-like causal determinant and $O = n_\alpha \Gamma^\alpha$ must be rational and have the same value at real and p-adic side at rational points. The integer $n$ labels the eigenvalues $\lambda_n$ of the modified Dirac operator, and $b_n$ corresponds to the corresponding fermionic oscillator operator.

2. The condition that the p-adic and real variants $\Psi$ if the $\Psi$ are identical at common rational points of real and p-adic space-time surface (the same applies to 4-surfaces corresponding to different p-adic number fields) poses a strong constraint on the algebraic continuation from rationals to p-adics and gives hopes of deriving implications of this approach.

3. Ordinary fermionic anti-commutation relations do not refer specifically to any number field. Super Virasoro (anti-)commutation relations involve only rationals. This suggest that fermionic Fock space spanned by the oscillator operators $b_n$ is universal and same for reals and p-adic numbers and can be regarded as rational. Same would apply to Super Virasoro representations. Also the possibility to interpret configuration space spinor fields as quantum superpositions of Boolean statements supports this kind of universality. This gives good hopes that the contribution of the inner produces between Fock states to the S-matrix elements are number field independent.

4. Dirac determinant can be defined as the product of the eigenvalues $\lambda_n$ restricted to a given algebraic extension of rationals. The solutions of the modified Dirac equation correspond to vanishing eigen values and define zero modes generating conformal super-symmetries and are not of course included.

5. Only those operators $b_n$ for which $\lambda_n$ belongs to the algebraic extension of rationals in question are used to construct physical states for a given algebraic extension of rationals. This might mean an enormous simplification of the formalism in accordance with the fact that configuration space Clifford algebra corresponds as a von Neumann algebra to a hyper-finite factor of type $II_1$ for which finite truncations by definition allow excellent approximations [C6]. One can even ask whether this hierarchy of algebraic extensions of rationals could in fact define a hierarchy of finite-dimensional Clifford algebras. If so then the general theory of hyper-finite factors of type $II_1$ would provide an extremely powerful tool.

## 8.8 Exotic representations of super-canonical algebra

The unique feature of the Super Virasoro algebra is that it allows a fractal hierarchy of sub-algebras and one obtains hierarchy of exotic representations in p-adic sector. One must however assume that Super Virasoro gauge conditions allow arbitrary values of the super-canonical scaling quantum number $L_0$ is non-vanishing. $L_0 = 0$ condition would be replaced by $L_0 \ mod \ p^n = 0$ condition in the p-adic context so that conformal invariance would become approximate in p-adic sense. The alternative interpretation would be as fractality in the sense that scalings would leave the states almost invariant.

One could however argue that exotic Super Virasoro representations can make sense only in the purely p-adic sense and the assumption that mass values values $M^2 \propto p^n$, which are gigantic in real sense, can be mapped by the canonical identification to $M^2 \propto p^{-n}$ is highly counter intuitive and has no physical basis. Also in p-adic mass calculations the canonical identification is applied only to fix the real probabilities as canonical images of the p-adic probabilities. Essentially the same predictions would result by using a real statistical ensemble defined by the real counterparts of the p-adic probabilities since the three lowest powers of $p$ determine the outcome in an excellent approximation (that is only the states with $M^2 \propto n$, $n \in \{0,1,2\}$ are included).

The idea that the states $L_0 \ mod \ p^n = 0$ are light in some well-defined physical sense is however too beautiful to be given up immediately, and an analogy with condensed matter lattice systems comes in rescue. For a one-dimensional lattice with lattice constant $a$ only a discrete sub-group of translations acts as symmetries and momentum cutoff emerges via the condition $p \equiv p + n\hbar/a$. Although the large momenta $p = n\hbar/a$ are still real, they correspond to the motion of the entire lattice.

By replacing the lattice obtained by translations with a lattice obtained by scalings one would obtain a highly analogous situation. More concretely, suppose that $L_0$ act as infinitesimal scaling of the imbedding space coordinates of the space-time surface. The action is almost trivial if the space-time surface has a fractal structure in the sense of being approximately invariant under the scaling of the points of $M^4$ by powers of $p$. Let $a$ be a positive integer replacing $e$ as the base of exponential so that $a^{mL_0}$ defines an exponentiated scaling. The condition $a^{mL_0} \ mod \ p = 1$ states that the state remains invariant under this scaling and corresponds to the invariance of lattice state under translation by a multiple $ma$ of the lattice vector. By Fermat's little theorem this condition is satisfied if one has $L_0 \ mod \ p^n = 0$.

One can consider also the 2-based exponential of $L_0$ giving $2^{mL_0} \ mod \ p = 0$. p-Adic length scale hypothesis in its most general form stating $p \simeq 2^m$, $m$ a positive integer, provides an approximate solution to this condition. Note that the fractal lattice picture suggests that p-adic cognitive codons corresponds to octaves of the p-adic frequency $f(n,k) = \hbar/T(n,k)$. In the case of memetic code this would mean that the frequency range $10 - 10^3$ Hz dictated by the time scale 1 ms of nerve pulse activity would contain 6 octaves meaning an effective reduction to genetic code with 6 bits. The prediction would be that the frequencies 10,20,40,80,160,320,640 Hz are in a special role in neural dynamics.

The idea p-adic local dynamics codes for the p-adic fractality of the long length scale real dynamics indeed leads to this kind of picture and leads to a concrete quantum model for intentional action allowing even to show that the S-matrix for intention-to-action transitions has the same general form as the ordinary S-matrix [E1, H8].

### 8.8.1 Exotic p-adic representations as representations for which states are almost p-adic fractals

When the value of $L_0$ is power of $p$: $L_0 \propto p^n$, $n = 1, 2, ..$, the real counterpart of the scaling quantum number is extremely small since it is proportional to $1/p^n$ in this case. In particular, the scalings $a^{L_0}$ are p-adically very near to identity transformation for any integer by Fermat's theorem. Fractals are invariant under scalings and since the states of exotic representations are in good approximation invariant under the group of scalings one could say that they are fractals modulo $O(1/p)$, perhaps resulting as asymptotic states of self-organization processes. One can also say that Virasoro conditions are satisfied to order $O(1/p)$ and that approximate conformal invariance is realized ($L_0 = 0$ condition would completely trivialize the super-canonical representations since mass squared operator is not involved now). Note that the subalgebra of super-canonical algebra with conformal weights proportional to $p^m$ emerges naturally as an algebra replacing the entire super-conformal algebra.

One could sharpen the notion of approximate super-conformal representation. The failure of $L_0$ to annihilate the states means that $L_{mp^n}$ can generate zero norm state only in order $O(p^n)$. Thus only the generators $L_{-mp^n}$, $m \geq 0$, but not $L_{mp^n}$ can annihilate the physical states. Same would hold true also for the super generators and super-canonical generators. Also multi-p-adic exotic representations are possible since any integer $n = \prod_i p_i^{k_i}$ defines a sub-algebra spanned by the generators for which conformal weights are proportional to $n$.

The representations of the conformal algebra with a non-vanishing central charge could be in question. The central charge term in the commutators of the conformal generators, being proportional to $(c/12)(n^3 - n)$ ($c$ is central charge) is of order $O(p^k)$ unless $p$ divides 12 (,that is $p = 2$ or $p = 3$ holds true,) or $p$ divides the denominator of $c$, which is in general rational number. The central extension term for the anti-commutator of the fermionic super-generators $G_n$ and $G_{-n}$ is $\frac{c}{12}(2n-1)(2n+1)$ and is *not* of order $O(p^k)$ for $n$ multiple of $p^k$.

Semiclassical argument suggests that the lengths of MEs associated with these representations correspond to p-adic length scales and it turns out that corresponding fundamental frequencies correspond to important EEG frequencies in ELF frequency range. This encourages to think that the exotic representations of super-canonical algebra might of special interest from the point of view of cognition.

Also quaternion conformal representations allow similar phenomenon and in this case p-adic mass squared proportional to $L_0$ has extremely small real counterpart. The mass squared associated with the corresponding real states is however astrophysical and, in contrast to the original working hypothesis, it will be assumed that these states are not important for consciousness. There are however indications supporting the importance of these states in hadron physics: one could perhaps understand non-perturbative aspects of QCD in terms of exotic p-adic quaternion-conformal representations.

### 8.8.2 Mersenne primes and Gaussian Mersennes are special

#### Mersenne primes

One can also consider the milder requirement that the exponent $\lambda = 2^{\epsilon L_0}$ represents trivial scaling represented by unit in good approximation for some p-adic topology. Not surprisingly, this is the case for $L_0 = mp^k$ since by Fermat's theorem $a^p \ mod \ p = 1$ for any integer $a$, in particular $a = 2$. This is also the case for $L_0 = mk$ such that $2^k \ mod \ p = 1$ for $p$ prime. This occurs if $2^k - 1$ is Mersenne prime: in this case one has $2^{L_0} = 1$ modulo $p$ so that the sizes of the fractal sub-algebras are exponentially larger than the sizes of $L_0 \propto p^n$ algebras. Note that all scalings $a^{L_0}$ are near to unity for $L_0 = p^n$ whereas now only $a = 2$ gives scalings near unity for Mersenne primes. Perhaps this extended fractality provides the fundamental explanation for the special importance of Mersenne primes.

In this case integrated scalings $2^{L_0}$ leave the states almost invariant so that even a stronger form of the breaking of the exact conformal invariance would be in question in the super-canonical case. The representation would be defined by the generators for which conformal weights are odd multiples of $n$ ($M_n = 2^n - 1$) and $L_{-kn}$, $k > 0$ would generate zero norm states only in order $O(1/M_n)$.

Especially interesting is the hierarchy of primes defined by the so called Combinatorial Hierarchy resulting from TGD based model for abstraction process. The primes are given by $2, 3, 7 = 2^3 - 1, 127 = 2^7 - 1, 2^{127} - 1$,..: $L_0 = n \times 127$ would correspond to $M_{127}$-adicity crucial for the memetic code.

#### Gaussian Mersennes are also special

If one allows also Gaussian primes then the notion of Mersenne prime generalizes: Gaussian Mersennes are of form $(1 \pm i)^n - 1$. In this case one could replace the scaling operations by scaling combined with a twist of $\pi/4$ around some symmetry axis: $1 + i = \sqrt{2} exp(i\pi/4)$ and generalized p-adic fractality would mean that for certain values of $n$ the exponentiated operation consisting of $n$ basic operations would be very near to unity.

i) The integers $k$ associated with the lowest Gaussian Mersennes are following: $2, 3, 5, 7, 11, 19, 29, 47, 73, 79, 113$. $k = 113$ corresponds to the p-adic length scale associated with the atomic nucleus and muon. Thus all known charged leptons, rather than only $e$ and $\tau$, as well as nuclear physics length scale, correspond to Mersenne primes in the generalized sense.

ii) The primes $k = 151, 157, 163, 167$ define perhaps the most fundamental biological length scales: $k = 151$ corresponds to the thickness of the cell membrane of about ten nanometers and $k = 167$ to cell size about 2.56 $\mu m$. This observation also suggests that cellular organisms have evolved to their present form through four basic evolutionary stages. This also encourages to think that $\sqrt{2} exp(i\pi/4)$ operation giving rise to logarithmic spirals abundant in living matter is fundamental dynamical symmetry in bio-matter.

Logarithmic spiral provides the simplest model for biological growth as a repetition of the basic operation $\sqrt{2} exp(i\pi/4)$. The naive interpretation would be that growth processes consist of $k = 151, 157, 163, 167$ steps involving scaling by $\sqrt{2}$. This however requires the strange looking assumption that growth starts from a structure of size of order $CP_2$ length. Perhaps this exotic growth process is associated with pair of MEs or magnetic flux tubes of opposite time orientation and energy emergenging $CP_2$ sized region in a mini big bang type process and that the resulting structure serves as a template for the biological growth.

iii) $k = 239, 241, 283, 353, 367, 379, 457$ associated with the next Gaussian Mersennes define astronomical length scales. $k = 239$ and $k = 241$ correspond to the p-adic time scales .55 ms and 1.1 ms: basic time scales associated with nerve pulse transmission are in question. $k = 283$ corresponds to the time scale of 38.6 $min$. An interesting question is whether this period could define a fundamental biological rhythm. The length scale $L(353)$ corresponds to about $2.6\times10^6$ light years, roughly the size scale of galaxies. The length scale $L(367)\simeq\times3.3\times10^8$ light years is of same order of magnitude as the size scale of the large voids containing galaxies on their boundaries (note the analogy with cells). $T(379)\simeq2.1\times10^{10}$ years corresponds to the lower bound for the order of the age of the Universe. $T(457)\sim10^{22}$ years defines a completely superastronomical time and length scale.

**Connection with the em realization of genetic code and Gaussian Mersennes?**

The considerations above suggest that $\sqrt{2}\times exp(i\pi/4)$ might code for a fundamental logarithmic spiral growth step in some sense. The powers of the phase factor $exp(i\pi/4)$ define 8-element cyclic group which should be thus fundamental for 2-adic logarithmic spiral growth process in which the diagonal of square becomes the side of the next square rotated by $\pi/4$ with respect to original one.

Perhaps it is worth of noticing that for 3-bit Boolean algebra with one statement excluded the maximal Boolean algebra corresponds to 2 bits of information, and is naturally associated with the predecessor of the genetic code in the hierarchy of codes predicted by the TGD based model for abstraction process. In this case the counterpart of 64 DNA triplets code for 4 statements and the 4 DNA nucleotides themselves might correspond to these "basic truths".

Second point perhaps worth of noticing is that the model of electromagnetic realization of the genetic code discussed in [H8], which was inspired by the observations Cyril Smith [47] about the coding of arithmetic operations to the sequences of 7 binary electromagnetic pulses, led to a guess for a 7-bit binary code for binary arithmetic operations of type $f=f(f_1,f_2)=Xf_1OYf_2$ giving output frequency as a function of two input frequencies $f_1$ and $f_2$. $O$ codes for the arithmetic operation proper represented by single bit and the eight operations $X$ and $Y$ acting on the operands are represented by 3 bits each. Depending on context, $O=0/1$ represents either $+/-$ or $\times//$.

There are eight different operations $X$ $(Y)$, which suggests an interpretation in terms of 8-element cyclic group. Perhaps the coding of the growth process might be achieved by this kind of coding. Each DNA triplet would code this kind of elementary growth process whereas conjugate triplet would code its time reversal. MEs would read genes to sequences of pulses of light-like vacuum current generating hologram realized in terms of coherent photons in turn coding the growth program and conjugate DNA would give rise to time reversed phase conjugate hologram coding for the time reversal of the growth step.

What remains to be understood is the meaning of the arithmetic operation in the growth process. The coding of growth process might reduce to coding of the growth of MEs and super-conducting magnetic flux tubes. If the eight rotations are accompanied by scalings, then multiplication and division of two growth steps would make sense since also the inverse of growth step makes sense. What remains however mysterious why DNA triplets would code the growth steps in this manner. An alternative interpretation is that a growth process of binary structures in question and that arithmetic operation $\pm$ tells something about the second member of the binary structure. For instance, pairs of mind like space-time sheets might be in question (pairs of spiralling MEs with light-like boundaries or wormhole magnetic fields) and $\pm$ might tell whether the other space-time sheet has positive or negative time orientation.

### 8.8.3 The huge degeneracies of the exotic states make them ideal for representational purposes

For a given eigenvalue of $L_0$ there is degeneracy of states given essentially by the exponent of $L_0$. The states with $L_0=O(p^n)$ have enormous degeneracy since the degeneracy of states increases exponentially as function of mass (this in fact leads to Hagedorn temperature). Huge ground state degeneracy is just what also spin glass analogy suggests and effective information storage and processing requires. The huge (really!) information processing potential suggests that these states correspond to an infinite hierarchy of life forms. Thus matter or 'flesh' would correspond to states of super-canonical algebra with $L_0=0$ whereas the 'spirit' would correspond to states with $L_0$ eigenvalue divisible by $p^n$, $n=1,2,..,p$ prime and to states with $L_0\propto n$, $2^n-1$ Mersenne prime. The identification of mind like space-time sheets as MEs which allow these sub-Super Virasoro representations, means that this hypothesis is consistent with TGD inspired theory of consciousness.

Thus one can conclude that life forms would be characterized by integer triplets

$$(p, m, n), \quad p \text{ prime} \ .$$

This is a rather far-reaching prediction effectively promising a resolution to the riddle of life as a quantum physical phenomenon and gives a hint about the predictive and explanatory powers of geometrization of physics using p-adic numbers.

The Super Virasoro representations in question are associated with the algebra of super-canonical transformations. There are two kinds of bosonic generators. The generators of first kind correspond to infinitesimal canonical transformations of $E^2 \times CP_2$ localized with respect to the light-like coordinate $S_+$ of the light-like projection of the light-like boundary of ME. The coordinate lines of $S_\pm$ correspond in geometric optics picture curved light rays. $E^2$ denotes $S_+ = constant$ (or $S_- = constant$) 2-surface and can be obviously chosen in several manners. If ME is glued along a space-like section to some matter like 4-surface then this section most naturally corresponds to $S_+ = constant$ section. A tempting assumption is that sensory experience could be determined by the properties of the quantum state in this section. The generators of second type correspond to the radial Virasoro algebra (functions of $S_+$ coordinate) localized with respect to $CP_2$ coordinates so that they act as $CP_2$-local radial deformations of the light-like boundary. Fermionic generators are in one-one correspondence with the bosonic generators and correspond to configuration space gamma matrices. In the case of future light cone boundary similar algebra generates the isometries of the configuration space of 3-surfaces [B2, B3].

As noticed super-canonical and super-conformal degrees of freedom do not contribute to mass squared unlike quaternion conformal degrees of freedom. This means an immense degeneracy of states with respect to energy broken only by the non-commutativity of Poincare algebra and super-canonical and super-conformal algebras. It is not at all obvious whether one can assing this degeneracy to elementary particles or only with the light-like boundaries of MEs.

Any function of $E^2 \times CP_2$ coordinates and of the radial coordinate $S_+$ of the light-like boundary (that is function of the coordinates of light-cone boundary $\delta M^4_+$) defines Hamiltonian and thus configuration space isometry. It is convenient to assume that Hamiltonians correspond to $CP_2$ partial waves with well defined color quantum numbers. In the case of $S^2$ one could assume angular momentum eigenstates but this choice is not practical. Generalized Super Virasoro algebra acts as $CP_2$-local conformal symmetries of light-cone boundary which by its metric 2-dimensionality indeed allows infinite-group of conformal symmetries. The functions of $E^2 \times CP_2$ coordinate having no dependence on the light-like coordinate $E_+$ of the light-cone boundary define the Hamiltonians of canonical transformations of $E^2 \times CP_2$. The subset of Hamiltonians with vanishing color and angular momentum quantum numbers $((I_3, Y)$ and $J_z)$ correspond to the zero modes in the proposed complexification of the configuration space tangent space [B2, B3]. The group of these canonical transformations divided by the Cartan group of $U(1) \times SU(3)$ defines infinite-dimensional flag-manifold parametrizing all possible choices of quantization axes.

Super generators are expressible in terms of fermionic oscillator operators carrying quantum numbers of quarks and leptons. The Super Virasoro representations differ from the standard representations used in superstring models in that super generators are not Hermitian $G_r^\dagger \neq G_{-r}$) and carry fermion number [C1]. In quaternion confromal case Super generators carry lepton number in the case of Ramond type representations and quark number in the case of Neveu-Schwartz type representations. Super-canonical representations are Ramond type representations. Both quaternion conformal and super canonical representations carry all possible quark/lepton numbers and thus spans what is very much like the Fock states of second quantized theory with configuration space degrees of freedom included as additional degrees of freedom and reflecting the fact that point like particles are replaces with 3-D surfaces.

### 8.8.4 Could one assign life-forms to the exotic Super-Virasoro representations?

#### First order life forms associated with elementary particles

Exotic representations are possible also in quaternion-conformal sector. In this case mass squared operator is of order $M^2 = O(p)$ p-adically so that the real counterpart of the p-adic mass would be of the order of elementary particle mass. Also now degeneracies of the states are gigantic. Unless p-adic and real string tensions are different, the mass of the corresponding real state is by a factor of order $p$ higher ($\sim 10^{-4} \times \sqrt{p}$ Planck masses!). This can be seen as a strong objection either against the existence of light real counterparts of the exotic p-adic states or against the applicability of the canonical identification map outside the realm of p-adic thermodynamics.

It is not clear whether super-canonical degeneracy is present for the quaternion conformal representations. In fact, it might be that quaternion conformal representations are associated with $CP_2$ type extremals representing elementary particles and cannot be assigned to the light-like boundaries of MEs. This would mean that the boundaries of MEs represent completely new form of light-like matter. Massless states with super-canonical conformal weight $L_0 = O(p)$ are possible and momentum scale for these states is naturally determined by $p$. They define a more promising fractal hierarchy of life forms.

The lowest quaternion-conformal life form in the hierarchy are states having mass squared $M^2 \propto L_0 = O(p)$ could be called first order life[1]. These states have masses which are same order of magnitude as the masses of elementary particles with same value of $p$ but have nothing to do with the elementary particles themselves. The extremely weak direct interaction between these these representations and ordinary elementary particles might mean that these life forms do not affect elementary particle physics directly. On the other hand, there is intriguing numerical evidence that non-perturbative aspects of hadron physics might be understood if transition from high energy hadron physics to low energy hadron physics corresponds to a phase transition replacing ordinary Super Virasoro representations with exotic Super Virasoro representations (Regge slope and pion mass are predicted with few percent accuracy: see the chapter [F5]. This result is intriguing and forces to keep mind open for new interpretations of the p-adicity. Life requires also the presence of macroscopic quantum phases and one cannot therefore exclude the possibility of hadronic life when macroscopic quantum phases like Bose-Einstein condensates of pions or of super conducting neutron pairs are possible. Neutron super-conductivity is indeed believed to be possible in neutron stars.

To generate first order life forms in elementary particle length scales one would need MEs with wavelengths of order elementary particle Compton length. Presumably also temperature should be in interval around the energy defined by the secondary p-adic length scale. The Darwinian selection implied by self-organization should select some preferred p-adic primes as winners in the struggle for survival. Elementary particles are survivers at the lowest level and the first guess is that the primes corresponding to elementary particles provide good candidates for survivers at higher levels. The p-adic length scale $L(169) \simeq 5.1$ microns associated with neutrinos is especially interesting as far as first order life is considered and could (actually should, as the model of memetic code suggests) be an essential aspect of life in cell length scale.

Also the other primary p-adic lengths scales seem to be important for the structure of bio-matter, which suggests that first order life in these length scales is important for the understanding of living matter.

### Higher order life forms in biologically interesting length scales

$L_0 = O(p^n)$ $n \geq 1$, representations of p-adic super-canonical algebra defining 'n:th order life' are especially interesting as far as living matter is considered. The reason is that the energy scale for these excitations is so small that the 'matter-mind interaction' with low frequency classical fields associated with MEs becomes possible. There seems to be no obvious difference between life forms with different values of $n$ having p-adic length scales $L(n,k)$ of same order of magnitude as far as degeneracy of states is considered. However, if the negentropy gain in single quantum jump is limited by $log(p)$ or $plog(p)$ as the simplest scenario suggests [H2]), then first order life forms have potential for more information rich conscious experiences than higher order life forms with roughly the same p-adic length scale. Also the estimate for the maximal number of primary qualia allows more primary qualia for first order life forms.

What makes the hypothesis so interesting is that the number of interesting-to-us p-adic length scales associated with the exotic representations is rather small. Especially interesting are the secondary p-adic length- and time scales defined by Mersenne primes. Mersenne primes $M_{89}$, $M_{107}$ and $M_{127}$ define fundamental p-adic length scale in elementary particle physics and correspond to intermediate gauge bosons, hadrons and electron. $M_{61}$ could correspond also to new ultra high energy

[1] Note that also Super Virasoro representations associated with ordinary particles allow light excitations with $L_0 - n_0 = O(p)$.

physics. The natural guess is that secondary p-adic length scales, and those associated with Mersenne primes in particular, are especially important for consciousness and life.

*1. Higher order life in nanoscales*

The secondary p-adic length associated with $M_{61}$ is $L(127)/2^{3/2}$ and is slightly below electron length scale. Besides primary p-adic length scales $L(k)$, $k = 127, 131, 137, 139$ listed in table below, also the secondary p-adic length scales $L_2(k) = L(2k)$, $k = 67, 71, 73$ and even the tertiary length scales $L_3(43) = L(129)$ and $L_3(47) = L(141)$ could have been important for the evolution of bio-intelligence. $L_2(67)$ is .28 Angstroms, $L_3(47) = 3.1$ Angstroms, $L_2(71) = 4.4$ Angstroms and $L_2(73) =$ 1.8 nanometers might be crucial for self-organization and intelligence at level of DNA and proteins. Thus the miracles of biochemical self-organization would not be reducible to standard chemistry but would involve in absolutely essential manner the symbiosis with higher life forms. The energy scale involved is in nanometer length scales of order keV and seems quite too high for life: room temperature which corresponds to $10^{-2}$ eV or at least the energy scale of atomic transitions seems to be the natural energy scale in protein length scales.

| k | 127 | 131 | $67_2$ | 137 | 139 | $71_2$ | $73_2$ |
|---|---|---|---|---|---|---|---|
| $L(k,n)/10^{-10}m$ | .025 | .1 | .28 | .8 | 1.6 | 4.5 | 18.0 |

Table 1. p-Adic length scales $L(k,n)$ possibly relevant to consciousness and life in atomic and nanolength scales. The length scale $L(151)$ is taken to be the thickness of cell membrane, which is $10^{-8}$ meters in a good approximation.

*2. Higher order life forms in subcellular length scales and retina as living creature*

First order life forms in subcellular length scales correspond to $k = 149, 151, 157, 163, 167$ and 169: corresponding p-adic length scales vary in the range of 5 nanometers and 5 micrometers and are given in the table below. Second order life forms associated with $L_2(79) = L(158) = 113$ nanometers, $L_2(83) = L(166) = 1.8$ micrometers as well as third order life form associated with $L_3(53) = L(159) =$ 160 nanometers could also be important for self-organization and intelligence at subcellular levels. The energies for the secondary excitations of $k = 83$ Super Virasoro are in the region of visible light and an interesting possibility is that that these excitations might be excited when photons are absorbed by retina and that retina could be regarded as an intelligent conscious living being. This would also partially explain why our vision is just in this particular wavelength range. To decide whether interaction between photons and secondary Super Virasoro excitations is strong enough one should be able to device a model for this interaction.

| k | 149 | 151 | 157 | $79_2$ | $53_3$ | 163 | $83_2$ | 167 | 169 |
|---|---|---|---|---|---|---|---|---|---|
| $L_p/10^{-8}m$ | .5 | 1 | 8 | 11.3 | 16 | 64 | 181 | 256 | 512 |

Table 2. p-Adic length scales $L(k,n)$ possibly relevant to consciousness and life between cell membrane and cellular length scales.

*3. Higher order life in submillimeter length scales*

The length scale range between $k = 169$ and $k = 191$ contains primary length scales $k =$ 173, 179, 181 given in table below, secondary length scale $L_2(89) = L(178) = 1.1 \times 10^{-4}$ meters, and tertiary length scale $L_3(59) = L(177) = .8 \times 10^{-4}$ meters. The special importance of Mersenne primes suggests $M_{89}$ second order life have managed to survive and might have meant a breakthrough in evolution. The size scale of largest neurons, say pyramidal neurons in cortex is indeed of order $L_2(M_{89})$. The fact that the lengths of micro-tubuli inside axons have length of order $10^{-4}$ meters suggests that they are accompanied by MEs corresponding to $M_{89}$. This hypothesis is inspired also by quantum antenna hypothesis and by the notion that MEs associated with axons serve as neural windows. The frequency scale associated with $M_{89}$ is $3.3 \times 10^{12}$ Hz and in infrared range. The energies involved correspond to $10^{-12}$ eV which is the thermal energy associated with the room temperature. This might explain the crucial importance of temperature for biolife. In too low temperatures secondary Super Virasoro excitations would be frozen whereas in too high temperatures situation would be thermalized.

| k | 173 | $59_3$ | $89_2$ | 179 | 181 |
|---|---|---|---|---|---|
| $L_p/10^{-4}m$ | .2 | .8 | 1.1 | 1.6 | 3.2 |

Table 4. p-Adic length scales $L(k,n)$ possibly relevant to consciousness and life between cellular and submillimeter length scales.

IR radiation is known to be important for odor perception of at least insects [50]: the energies of $k = 89$ Super Virasoro are in this energy range. The structure of olfactory receptors also resembles the structure of the photoreceptors in retina. This would suggest that odor (and possibly also taste) perception might be regarded basically as IR vision with various odors playing the role of colors. The large number of different odors suggests that the number of different 'cones' is much higher than in the case of vision. The secondary p-adic length scale associated with $M_{89}$ could give rise to secondary excitations of electro-weak fields with huge degeneracies. If the size of the 'pixel' characterizing sensory experience corresponds to the p-adic length scale of Super Virasoro associated with primary sensory organ, then one must conclude that also tactile senses could correspond to $M_{89}$ or some smaller prime. Quite generally, vision, olfaction (and possibly also tastes) and tactile senses could thus be related with the secondary p-adic length scales $L_2(83)$ and $L_2(89)$ and/or with the primary length scales $L(169)$ and $L(173)$ and $L(179) = \sqrt{2}L_2(89)$. Note that the classical gauge fields associated with MEs could be used to generate secondary sensory experiences in longer p-adic length scales.

*4. Higher order life forms in human length scales*

The length scale range relevant to the structures of human brain contains the primary length scales corresponding to $k = 191, 193, 197$ and 199 varying in the range of 1-16 cm and are listed in the table below. The secondary and tertiary length scales $L_2(97) = 2.8$ cm, $L_3(67) = .32$ meters, $L_2(101) = .45$ meters and $L_2(103) = 1.81$ meters covers length scale range between brain nuclei and human body size. The fact that these primes correspond to the p-adic length scales associated with elementary particles (quarks) suggest that also second order life in these length scales is winner in the fight for survival. $L_2(97)$ corresponds to the size scale of brain nuclei which suggests that single pixel now provides a summary about sensory experience of brain nucleus. For instance, 'amygdalar emotions' might be in question.

It could be that the mind like space-times sheet with the size of brain and other body parts and entire body correspond carries exotic representations of $k = 67_3$, $k = 101_2$ and $k = 103_2$ Super Virasoro. The hypothesis that these levels correspond to emotions understood as generalized sensory experiences about the state of body solve the puzzles why emotions are 'single pixel' emotions and determined by the state of body. Secondary p-adic length scale should determine the size of the pixel in the bitmap provided by generalized sensory experience: since the size of pixel is of order human brain or even body, one could understand why emotions are 'single-pixel' emotions. Note that 'our experience' about these emotions probably does not correspond to this experience but experience coded to ELF level of self hierarchy. Body length scale would be associated with 'body-consciousness' quite different from our consciousness which corresponds to much higher level of the hierarchy.

| k | 191 | 193 | $97_2$ | 197 | 199 | $67_3$ | $101_2$ | $103_2$ |
|---|---|---|---|---|---|---|---|---|
| $L_p/m$ | .01 | .02 | 2.8 | .08 | .16 | .32 | .45 | 1.8 |

Table 5. p-Adic length scales $L(k,n)$ possibly relevant to consciousness and life at length scales relevant to human brain and body.

*5. Higher order life above body length scale*

The primary p-adic length scales $k = 211, 223, 227, 229, 233, 239, 241$ and 251 between body size and $L_2(127)$ (quite near to Earth's circumference), and also longer p-adic length scales are listed in the table above. This range contains the secondary length scales $k = 107, 113$ and $k = 127$ correspond to a hierarchy of collective consciousness from the point of view of body (but, as it seems, not from our point of view!). The reader is encouraged to find the tertiary length scales in this range.

| | | | | | |
|---|---|---|---|---|---|
| k | 211 | $71_3$ | $107_2$ | $109_2$ | 223 |
| $L_p/m$ | 10 | 20 | 28.3 | 113 | 640 |
| $T_p/\mu s$ | 3.3E-2 | 6.6E-2 | 9.2E-2 | .37 | 2.1 |
| k | $113_2$ | 227 | 229 | 233 | $79_3$ |
| $L_p/m$ | 1.8E+3 | $2.5E+3$ | $5E+3$ | $2E+4$ | 8E+4 |
| $T_p/\mu s$ | 6.1 | 8.6 | 17 | 69 | 276 |
| k | 239 | 241 | $3^5=243$ | $83_3$ | $2_2^5$ |
| $L_p/m$ | $1.6E+5$ | $3.2E+5$ | 6.4E+5 | 5.1E+6 | 7.2E+6 |
| $T_p/ms$ | .55 | 1.1 | 2.2 | 17.6 | 24.9 |
| k | 251 | $127_2$ | 257 | $131_2$ | 263 |
| $L_p/m$ | $E+7$ | 2.8E+7 | $8E+7$ | 44.8 | $6.4E+8$ |
| $T_p$ | 35 $ms$ | .1 s | .28 $s$ | 1.6 s | 2.26 $s$ |
| k | 269 | 271 | $137_2$ | 277 | $139_2$ |
| $L_p/m$ | $5E+9$ | $E+10$ | 2.8E+10 | $7.7E+10$ | 11.2E+10 |
| $T_p$ | 18.1 $s$ | 36.2 $s$ | 1.7 min | 4.3 $min$ | 6.1 min |
| k | 281 | 283 | 289 | $97_3$ | 293 |
| $L_p/m$ | 3.2E+11 | 6.4E+11 | $5.2E+12$ | 1.1E+13 | $2.1E+13$ |
| $T_p$ | 17.3 min | 34.6 min | 4.6 $h$ | 6.3 h | 18.5 $h$ |
| k | $149_2$ | $151_2$ | $101_3$ | 307 | $103_3$ |
| $L_p/ld$ | 4.9 | 19.5 | 27.6 | 98.6 | 197.2 |
| $T_p/d$ | 4.9 | 19.5 | 27.6 | 98.6 | 197.2 |

Table 6. p-Adic length and time scales above length scale $L(211) = 10$ meters possibly relevant to life and consciousness.

The emergence of Mersenne prime $M_{107}$ could perhaps be associated with the emergence of social groups. Amusingly, $M_{107}$ is hadronic length scale and associated with the emergence of color confined many-quark states, kind of societies also these! More seriously, color confinement should make sense also for the exotic Super Virasoro representations and might have some counterpart at the level of consciousness. For $M_{107}$ the p-adic length scale is about 29.0 meters, which is between $L(211) = 10.2$ meters and $L(223) = 655$ meters. The corresponding frequency scale is 6 MHz. $L_2(113) \simeq 1853$ meters is the length scale associated with the next secondary Super Virasoro.

The tertiary length scales $L_3(83) = L(249)$, $L_2(k = 5^3 = 125) = L(250)$; secondary length scale $L_2(127)$, and the primary p-adic length scales $L(251)$, $L_2(127)$, $L(2^{2^8}) = L(256)$ and $L(257)$ correspond to the sequence of fundamental Super Virasoro frequencies

$$\frac{f(1,0)}{Hz} \in \{56.4, 40, 28.2, 10.0, 5.0, 3.5\} \ ,$$

which are important resonance frequencies of EEG which strongly encouratges the view that exotic Super Virasoro are involved with our qualia.

$M_{127}$ corresponds to Earth size and to frequency of 10 Hz which is in EEG range. Next Mersenne prime corresponds to a completetely super-astronomical length scale. Uncertainty Principle suggests that if EEG frequencies stimulate the quantum transitions giving rise to our conscious experiences, then our mental images should correspond to MEs with $k = 127$ and 131. $k = 131$ indeed corresponds to frequencies above .63 Hz (1.6 seconds) covering delta, theta and alpha frequencies up to 10 Hz where the range of $k = 127$ frequencies begins (note however that the difference of $M_{127}$ energies can be also below 10 Hz). Also the basic rhythms of body (heart beat and respiration) could correspond to $k = 131$ time scales.

The next secondary p-adic time scales corresponding to $k = 137, 139, 149$ and $k = 151$. $T_2(137)$ is are 1 minute 40 seconds, $T_2(139)$ is 6 minutes 40 seconds, $T_2(149)$ is 4.2 days roughly, $T_2(151)$ is 16.8 days roughly. $T_2(157)$ is roughly 1078.5 days (roughly three years). $T_2(163)$ is roughly 69024 days which makes roughly 189 years. These time scales could be important for human life cycle and the secondary excitations of these Super Virasoros could define important biological rhythms.

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# Appendix A

# Appendix

## A-1 Basic properties of $CP_2$

### A-1.1 $CP_2$ as a manifold

$CP_2$, the complex projective space of two complex dimensions, is obtained by identifying the points of complex 3-space $C^3$ under the projective equivalence

$$(z^1, z^2, z^3) \equiv \lambda(z^1, z^2, z^3) \ . \tag{A-1.1}$$

Here $\lambda$ is any nonzero complex number. Note that $CP_2$ can also regarded as the coset space $SU(3)/U(2)$. The pair $z^i/z^j$ for fixed $j$ and $z^i \neq 0$ defines a complex coordinate chart for $CP_2$. As $j$ runs from 1 to 3 one obtains an atlas of three charts covering $CP_2$, the charts being holomorphically related to each other (e.g. $CP_2$ is a complex manifold). The points $z^3 \neq 0$ form a subset of $CP_2$ homoeomorphic to $R^4$ and the points with $z^3 = 0$ a set homeomorphic to $S^2$. Therefore $CP_2$ is obtained by "adding the 2-sphere at infinity to $R^4$".

Besides the standard complex coordinates $\xi^i = z^i/z^3$ , $i = 1, 2$ the coordinates of Eguchi and Freund [2] will be used and their relation to the complex coordinates is given by

$$\begin{aligned} \xi^1 &= z + it \ , \\ \xi^2 &= x + iy \ . \end{aligned} \tag{A-1.2}$$

These are related to the "spherical coordinates" via the equations

$$\begin{aligned} \xi^1 &= rexp(i\frac{(\Psi + \Phi)}{2})cos(\frac{\Theta}{2}) \ , \\ \xi^2 &= rexp(i\frac{(\Psi - \Phi)}{2})sin(\frac{\Theta}{2}) \ . \end{aligned} \tag{A-1.3}$$

The ranges of the variables $r, \Theta, \Phi, \Psi$ are $[0, \infty], [0, \pi], [0, 4\pi], [0, 2\pi]$ respectively.

Considered as a real four-manifold $CP_2$ is compact and simply connec- ted, with Euler number 3, Pontryagin number 3 and second Betti number $b = 1$.

### A-1.2 Metric and Kähler structures of $CP_2$

In order to obtain a natural metric for $CP_2$, observe that $CP_2$ can be thought of as a set of the orbits of the isometries $z^i \rightarrow exp(i\alpha)z^i$ on the sphere $S^5$: $\sum z^i \bar{z}^i = R^2$. The metric of $CP_2$ is obtained by projecting the metric of $S^5$ orthogonally to the orbits of the isometries. Therefore the distance between the points of $CP_2$ is that between the representative orbits on $S^5$. The line element has the following form in the complex coordinates

$$ds^2 = g_{a\bar{b}} d\xi^a d\bar{\xi}^b \ , \tag{A-1.4}$$

where the Hermitian, in fact Kähler, metric $g_{a\bar{b}}$ is defined by

$$g_{a\bar{b}} = R^2 \partial_a \partial_{\bar{b}} K \ , \tag{A-1.5}$$

where the function $K$, Kähler function, is defined as

$$\begin{aligned} K &= lnF \ , \\ F &= 1 + r^2 \ . \end{aligned} \tag{A-1.6}$$

The representation of the metric is given by

$$\frac{ds^2}{R^2} = \frac{(dr^2 + r^2\sigma_3^2)}{F^2} + \frac{r^2(\sigma_1^2 + \sigma_2^2)}{F} \ , \tag{A-1.7}$$

where the quantities $\sigma_i$ are defined as

$$\begin{aligned} r^2\sigma_1 &= Im(\xi^1 d\xi^2 - \xi^2 d\xi^1) \ , \\ r^2\sigma_2 &= -Re(\xi^1 d\xi^2 - \xi^2 d\xi^1) \ , \\ r^2\sigma_3 &= -Im(\xi^1 d\bar{\xi}^1 + \xi^2 d\bar{\xi}^2) \ . \end{aligned} \tag{A-1.8}$$

The vierbein forms, which satisfy the defining relation

$$s_{kl} = R^2 \sum_A e_k^A e_l^A \ , \tag{A-1.9}$$

are given by

$$\begin{aligned} e^0 &= \tfrac{dr}{F} \ , \quad e^1 = \tfrac{r\sigma_1}{\sqrt{F}} \ , \\ e^2 &= \tfrac{r\sigma_2}{\sqrt{F}} \ , \quad e^3 = \tfrac{r\sigma_3}{F} \ . \end{aligned} \tag{A-1.10}$$

The explicit representations of vierbein vectors are given by

$$\begin{aligned} e^0 &= \tfrac{dr}{F} \ , & e^1 &= \tfrac{r(sin\Theta cos\Psi d\Phi + sin\Psi d\Theta)}{2\sqrt{F}} \ , \\ e^2 &= \tfrac{r(sin\Theta sin\Psi d\Phi - cos\Psi d\Theta)}{2\sqrt{F}} \ , & e^3 &= \tfrac{r(d\Psi + cos\Theta d\Phi)}{2F} \ . \end{aligned} \tag{A-1.11}$$

The explicit representation of the line element is given by the expression

$$ds^2/R^2 = dr^2/F^2 + (r^2/4F^2)(d\Psi + cos\Theta d\Phi)^2 + (r^2/4F)(d\Theta^2 + sin^2\Theta d\Phi^2) \ . \tag{A-1.12}$$

The vierbein connection satisfying the defining relation

$$de^A = -V_B^A \wedge e^B \ , \tag{A-1.13}$$

is given by

$$
\begin{array}{lllllll}
V_{01} & = & -\frac{e^1}{r} \ , & V_{23} & = & \frac{e^1}{r} \ , \\
V_{02} & = & -\frac{e^2}{r} \ , & V_{31} & = & \frac{e^2}{r} \ , \\
V_{03} & = & (r-\frac{1}{r})e^3 \ , & V_{12} & = & (2r+\frac{1}{r})e^3 \ .
\end{array} \tag{A-1.14}
$$

The representation of the covariantly constant curvature tensor is given by

$$
\begin{array}{lllllll}
R_{01} & = & e^0\wedge e^1 - e^2\wedge e^3 \ , & R_{23} & = & e^0\wedge e^1 - e^2\wedge e^3 \ , \\
R_{02} & = & e^0\wedge e^2 - e^3\wedge e^1 \ , & R_{31} & = & -e^0\wedge e^2 + e^3\wedge e^1 \ , \\
R_{03} & = & 4e^0\wedge e^3 + 2e^1\wedge e^2 \ , & R_{12} & = & 2e^0\wedge e^3 + 4e^1\wedge e^2 \ .
\end{array} \tag{A-1.15}
$$

Metric defines a real, covariantly constant, and therefore closed 2-form $J$

$$
J = -ig_{a\bar{b}}d\xi^a d\bar{\xi}^b \ , \tag{A-1.16}
$$

the so called Kähler form. Kähler form $J$ defines in $CP_2$ a symplectic structure because it satisfies the condition

$$
J^k_{\ r}J^{rl} = -s^{kl} \ . \tag{A-1.17}
$$

The form $J$ is integer valued and by its covariant constancy satisfies free Maxwell equations. Hence it can be regarded as a curvature form of a $U(1)$ gauge potential $B$ carrying a magnetic charge of unit $1/2g$ ($g$ denotes the gauge coupling). Locally one has therefore

$$
J = dB \ , \tag{A-1.18}
$$

where $B$ is the so called Kähler potential, which is not defined globally since $J$ describes magnetic monopole.

It should be noticed that the magnetic flux of $J$ through a 2-surface in $CP_2$ is proportional to its homology equivalence class, which is integer valued. The explicit representations of $J$ and $B$ are given by

$$
\begin{aligned}
B &= 2re^3 \ , \\
J &= 2(e^0\wedge e^3 + e^1\wedge e^2) = \frac{r}{F^2}dr\wedge(d\Psi + cos\Theta d\Phi) + \frac{r^2}{2F}sin\Theta d\Theta d\Phi \ .
\end{aligned} \tag{A-1.19}
$$

The vielbein curvature form and Kähler form are covariantly constant and have in the complex coordinates only components of type (1,1).

Useful coordinates for $CP_2$ are the so called canonical coordinates in which Kähler potential and Kähler form have very simple expressions

$$
\begin{aligned}
B &= \sum_{k=1,2} P_k dQ_k \ , \\
J &= \sum_{k=1,2} dP_k\wedge dQ_k \ .
\end{aligned} \tag{A-1.20}
$$

The relationship of the canonical coordinates to the "spherical" coordinates is given by the equations

$$
\begin{aligned}
P_1 &= -\frac{1}{1+r^2} \ , \\
P_2 &= \frac{r^2 cos\Theta}{2(1+r^2)} \ , \\
Q_1 &= \Psi \ , \\
Q_2 &= \Phi \ .
\end{aligned} \tag{A-1.21}
$$

### A-1.3 Spinors in $CP_2$

$CP_2$ doesn't allow spinor structure in the conventional sense [5]. However, the coupling of the spinors to a half odd multiple of the Kähler potential leads to a respectable spinor structure. Because the delicacies associated with the spinor structure of $CP_2$ play a fundamental role in TGD, the arguments of Hawking are repeated here.

To see how the space can fail to have an ordinary spinor structure consider the parallel transport of the vierbein in a simply connected space $M$. The parallel propagation around a closed curve with a base point $x$ leads to a rotated vierbein at $x$: $e^A = R^A_B e^B$ and one can associate to each closed path an element of $SO(4)$.

Consider now a one-parameter family of closed curves $\gamma(v) : v \in (0,1)$ with the same base point x and $\gamma(0)$ and $\gamma(1)$ trivial paths. Clearly these paths define a sphere $S^2$ in M and the element $R^A_B(v)$ defines a closed path in $SO(4)$. When the sphere $S^2$ is contractible to a point e.g., homologically trivial, the path in $SO(4)$ is also contractible to a point and therefore represents a trivial element of the homotopy group $\Pi_1(SO(4)) = Z_2$.

For a homologically nontrivial 2-surface $S^2$ the associated path in $SO(4)$ can be homotopically nontrivial and therefore corresponds to a nonclosed path in the covering group Spin(4) (leading from the matrix 1 to -1 in the matrix representation). Assume this is the case.

Assume now that the space allows spinor structure. Then one can parallelly propagate also spinors and by the above construction associate a closed path of Spin(4) to the surface $S^2$. Now, however this path corresponds to a lift of the corresponding $SO(4)$ path and cannot be closed. Thus one ends up with a contradiction.

From the preceding argument it is clear that one could compensate the nonallowed $-1$- factor associated with the parallel transport of the spinor around the sphere $S^2$ by coupling it to a gauge potential in such a way that in the parallel transport the gauge potential introduces a compensating $-1$-factor. For a $U(1)$ gauge potential this factor is given by the exponential $exp(i2\Phi)$ , where $\Phi$ is the the magnetic flux through the surface. This factor has the value $-1$ provided the $U(1)$ potential carries half odd multiple of Dirac charge $1/2g$. In case of $CP_2$ the required gauge potential is half odd multiple of the Kähler potential $B$ defined previously. In the case of $M^4 \times CP_2$ one can in addition couple the spinor components with different chiralities independently to an odd multiple of $B/2$.

### A-1.4 Geodesic submanifolds of $CP_2$

Geodesic submanifolds are defined as submanifolds having common geodesic lines with the imbedding space. As a consequence the second fundamental form of the geodesic manifold vanishes, which means that the tangent vectors $h^k_\alpha$ (understood as vectors of $H$) are covariantly constant quantities with respect to the covariant derivative taking into account that the tangent vectors are vectors both with respect to $H$ and $X^4$.

In [3] a general characterization of the geodesic submanifolds for an arbitrary symmetric space $G/H$ is given. Geodesic submanifolds are in 1-1-correspondence with the so called Lie triple systems of the Lie-algebra $g$ of the group $G$. The Lie triple system $t$ is defined as a subspace of $g$ characterized by the closedness property with respect to double commutation

$$[X,[Y,Z]] \in t \quad \text{for} \quad X,Y,Z \in t \ . \tag{A-1.22}$$

$SU(3)$ allows, besides geodesic lines, two nonequivalent (not isometry related) geodesic spheres. This is understood by observing that $SU(3)$ allows two nonequivalent $SU(2)$ algebras corresponding to subgroups $SO(3)$ (orthogonal $3 \times 3$ matrices) and the usual isospin group $SU(2)$. By taking any subset of two generators from these algebras, one obtains a Lie triple system and by exponentiating this system, one obtains a 2-dimensional geodesic submanifold of $CP_2$.

Standard representatives for the geodesic spheres of $CP_2$ are given by the equations

$$S^2_I \ : \ \xi^1 = \bar{\xi}^2 \ \text{ or equivalently } \ (\Theta = \pi/2, \Psi = 0) \ ,$$

$$S^2_{II} \ : \ \xi^1 = \xi^2 \ \text{ or equivalently } \ (\Theta = \pi/2, \Phi = 0) \ .$$

The nonequivalence of these submanifolds is clear from the fact that isometries act as holomorphic transformations in $CP_2$. The vanishing of the second fundamental form is also easy to verify. The first geodesic manifold is homologically trivial: in fact, the induced Kähler form vanishes identically for $S^2_I$. $S^2_{II}$ is homologically nontrivial and the flux of the Kähler form gives its homology equivalence class.

## A-2 Identification of the electroweak couplings

The delicacies of the spinor structure of $CP_2$ make it a unique candidate for space $S$. First, the coupling of the spinors to the $U(1)$ gauge potential defined by the Kähler structure provides the missing $U(1)$ factor in the gauge group. Secondly, it is possible to couple different $H$-chiralities independently to a half odd multiple of the Kähler potential. Thus the hopes of obtaining a correct spectrum for the electromagnetic charge are considerable. In the following it will be demonstrated that the couplings of the induced spinor connection are indeed those of the GWS model [4] and in particular that the right handed neutrinos decouple completely from the electroweak interactions.

To begin with, recall that the space $H$ allows to define three different chiralities for spinors. Spinors with fixed $H$-chirality $e = \pm 1$, $CP_2$-chirality $l, r$ and $M^4$-chirality $L, R$ are defined by the condition

$$\begin{aligned} \Gamma\Psi &= e\Psi \ , \\ e &= \pm 1 \ , \end{aligned} \tag{A-2.1}$$

where $\Gamma$ denotes the matrix $\Gamma_9 = \gamma_5 \times \gamma_5$, $1 \times \gamma_5$ and $\gamma_5 \times 1$ respectively. Clearly, for a fixed $H$-chirality $CP_2$- and $M^4$-chiralities are correlated.

The spinors with $H$-chirality $e = \pm 1$ can be identified as quark and lepton like spinors respectively. The separate conservation of baryon and lepton numbers can be understood as a consequence of generalized chiral invariance if this identification is accepted. For the spinors with a definite $H$-chirality one can identify the vielbein group of $CP_2$ as the electroweak group: $SO(4) = SU(2)_L \times SU(2)_R$.

The covariant derivatives are defined by the spinorial connection

$$A = V + \frac{B}{2}(n_+ 1_+ + n_- 1_-) \ . \tag{A-2.2}$$

Here $V$ and $B$ denote the projections of the vielbein and Kähler gauge potentials respectively and $1_{+(-)}$ projects to the spinor $H$-chirality $+(-)$. The integers $n_\pm$ are odd from the requirement of a respectable spinor structure.

The explicit representation of the vielbein connection $V$ and of $B$ are given by the equations

$$\begin{aligned} V_{01} &= -\frac{e^1}{r} \ , & V_{23} &= \frac{e^1}{r} \ , \\ V_{02} &= -\frac{e^2}{r} \ , & V_{31} &= \frac{e^2}{r} \ , \\ V_{03} &= (r - \frac{1}{r})e^3 \ , & V_{12} &= (2r + \frac{1}{r})e^3 \ , \end{aligned} \tag{A-2.3}$$

and

$$B = 2re^3 \ , \tag{A-2.4}$$

respectively. The explicit representation of the vielbein is not needed here.

Let us first show that the charged part of the spinor connection couples purely left handedly. Identifying $\Sigma^0_3$ and $\Sigma^1_2$ as the diagonal (neutral) Lie-algebra generators of $SO(4)$, one finds that the charged part of the spinor connection is given by

$$A_{ch} = 2V_{23}I^1_L + 2V_{13}I^2_L \ , \tag{A-2.5}$$

where one have defined

$$
\begin{aligned}
I_L^1 &= \frac{(\Sigma_{01}-\Sigma_{23})}{2} \quad , \\
I_L^2 &= \frac{(\Sigma_{02}-\Sigma_{13})}{2} \quad .
\end{aligned} \tag{A-2.6}
$$

$A_{ch}$ is clearly left handed so that one can perform the identification

$$
W^{\pm} = \frac{2(e^1 \pm ie^2)}{r} \quad , \tag{A-2.7}
$$

where $W^{\pm}$ denotes the charged intermediate vector boson.

Consider next the identification of the neutral gauge bosons $\gamma$ and $Z^0$ as appropriate linear combinations of the two functionally independent quanties

$$
\begin{aligned}
X &= re^3 \quad , \\
Y &= \frac{e^3}{r} \quad ,
\end{aligned} \tag{A-2.8}
$$

appearing in the neutral part of the spinor connection. We show first that the mere requirement that photon couples vectorially implies the basic coupling structure of the GWS model leaving only the value of Weinberg angle undetermined.

To begin with let us define

$$
\begin{aligned}
\bar{\gamma} &= aX + bY \quad , \\
\bar{Z}^0 &= cX + dY \quad ,
\end{aligned} \tag{A-2.9}
$$

where the normalization condition

$$
ad - bc = 1 \quad ,
$$

is satisfied. The physical fields $\gamma$ and $Z^0$ are related to $\bar{\gamma}$ and $\bar{Z}^0$ by simple normalization factors.

Expressing the neutral part of the spinor connection in term of these fields one obtains

$$
\begin{aligned}
A_{nc} &= [(c+d)2\Sigma_{03} + (2d-c)2\Sigma_{12} + d(n_+1_+ + n_-1_-)]\bar{\gamma} \\
&+ [(a-b)2\Sigma_{03} + (a-2b)2\Sigma_{12} - b(n_+1_+ + n_-1_-)]\bar{Z}^0 \quad .
\end{aligned} \tag{A-2.10}
$$

Identifying $\Sigma_{12}$ and $\Sigma_{03} = 1 \times \gamma_5 \Sigma_{12}$ as vectorial and axial Lie-algebra generators, respectively, the requirement that $\gamma$ couples vectorially leads to the condition

$$
c = -d \quad . \tag{A-2.11}
$$

Using this result plus previous equations, one obtains for the neutral part of the connection the expression

$$
A_{nc} = \gamma Q_{em} + Z^0(I_L^3 - sin^2\theta_W Q_{em}) \quad . \tag{A-2.12}
$$

Here the electromagnetic charge $Q_{em}$ and the weak isospin are defined by

$$
\begin{aligned}
Q_{em} &= \Sigma^{12} + \frac{(n_+1_+ + n_-1_-)}{6} \quad , \\
I_L^3 &= \frac{(\Sigma^{12} - \Sigma^{03})}{2} \quad .
\end{aligned} \tag{A-2.13}
$$

The fields $\gamma$ and $Z^0$ are defined via the relations

$$\begin{aligned} \gamma &= 6d\bar{\gamma} = \frac{6}{(a+b)}(aX+bY) \ , \\ Z^0 &= 4(a+b)\bar{Z}^0 = 4(X-Y) \ . \end{aligned} \tag{A-2.14}$$

The value of the Weinberg angle is given by

$$sin^2\theta_W = \frac{3b}{2(a+b)} \ , \tag{A-2.15}$$

and is not fixed completely. Observe that right handed neutrinos decouple completely from the electroweak interactions.

The determination of the value of Weinberg angle is a dynamical problem. The angle is completely fixed once the YM action is fixed by requiring that action contains no crossterm of type $\gamma Z^0$. Pure symmetry nonbroken electroweak YM action leads to a definite value for the Weinberg angle. One can however add a symmetry breaking term proportional to Kähler action and this changes the value of the Weinberg angle.

To evaluate the value of the Weinberg angle one can express the neutral part $F_{nc}$ of the induced gauge field as

$$F_{nc} = 2R_{03}\Sigma^{03} + 2R_{12}\Sigma^{12} + J(n_+1_+ + n_-1_-) \ , \tag{A-2.16}$$

where one has

$$\begin{aligned} R_{03} &= 2(2e^0\wedge e^3 + e^1\wedge e^2) \ , \\ R_{12} &= 2(e^0\wedge e^3 + 2e^1\wedge e^2) \ , \\ J &= 2(e^0\wedge e^3 + e^1\wedge e^2) \ , \end{aligned} \tag{A-2.17}$$

in terms of the fields $\gamma$ and $Z^0$ (photon and $Z$- boson)

$$F_{nc} = \gamma Q_{em} + Z^0(I_L^3 - sin^2\theta_W Q_{em}) \ . \tag{A-2.18}$$

Evaluating the expressions above one obtains for $\gamma$ and $Z^0$ the expressions

$$\begin{aligned} \gamma &= 3J - sin^2\theta_W R_{03} \ , \\ Z^0 &= 2R_{03} \ . \end{aligned} \tag{A-2.19}$$

For the Kähler field one obtains

$$J = \frac{1}{3}(\gamma + sin^2\theta_W Z^0) \ . \tag{A-2.20}$$

Expressing the neutral part of the symmetry broken YM action

$$\begin{aligned} L_{ew} &= L_{sym} + fJ^{\alpha\beta}J_{\alpha\beta} \ , \\ L_{sym} &= \frac{1}{4g^2}Tr(F^{\alpha\beta}F_{\alpha\beta}) \ , \end{aligned} \tag{A-2.21}$$

where the trace is taken in spinor representation, in terms of $\gamma$ and $Z^0$ one obtains for the coefficient $X$ of the $\gamma Z^0$ crossterm (this coefficient must vanish) the expresssion

$$
\begin{aligned}
X &= -\frac{K}{2g^2} + \frac{fp}{18} \ , \\
K &= Tr\left[Q_{em}(I_L^3 - sin^2\theta_W Q_{em})\right] \ , 
\end{aligned}
\tag{A-2.22}
$$

In the general case the value of the coefficient $K$ is given by

$$
K = \sum_i \left[-\frac{(18+2n_i^2)sin^2\theta_W}{9}\right] \ , \tag{A-2.23}
$$

where the sum is over the spinor chiralities, which appear as elementary fermions and $n_i$ is the integer describing the coupling of the spinor field to the the Kähler potential. The cross term vanishes provided the value of the Weinberg angle is given by

$$
sin^2\theta_W = \frac{9\sum_i 1}{(fg^2 + 2\sum_i(18+n_i^2))} \ . \tag{A-2.24}
$$

In the scenario where both leptons and quarks are elemantary fermions the value of the Weinberg angle is given by

$$
sin^2\theta_W = \frac{9}{(\frac{fg^2}{2} + 28)} \ . \tag{A-2.25}
$$

The bare value of the Weinberg angle is 9/28 in this scenario, which is quite close to the typical value 9/24 of GUTs [6].

### A-2.1 Discrete symmetries

The treatment of discrete symmetries C, P, and T is based on the following requirements:
a) Symmetries must be realized as purely geometric transformations.
b) Transformation properties of the field variables should be essentially the same as in the conventional quantum field theories [1].

The action of the reflection $P$ on spinors of is given by

$$
\Psi \rightarrow P\Psi = \gamma^0 \otimes \gamma^0 \Psi \ . \tag{A-2.26}
$$

in the representation of the gamma matrices for which $\gamma^0$ is diagonal. It should be noticed that $W$ and $Z^0$ bosons break parity symmetry as they should since their charge matrices do not commute with the matrix of P.

The guess that a complex conjugation in $CP_2$ is associated with T transformation of the physicist turns out to be correct. One can verify by a direct calculation that pure Dirac action is invariant under T realized according to

$$
\begin{aligned}
m^k &\rightarrow T(M^k) \ , \\
\xi^k &\rightarrow \bar{\xi}^k \ , \\
\Psi &\rightarrow \gamma^1\gamma^3 \otimes 1\Psi \ .
\end{aligned}
\tag{A-2.27}
$$

The operation bearing closest resemblance to the ordinary charge conjugation corresponds geometrically to complex conjugation in $CP_2$:

$$
\begin{aligned}
\xi^k &\rightarrow \bar{\xi}^k \ , \\
\Psi &\rightarrow \Psi^\dagger\gamma^2\gamma^0 \otimes 1 \ .
\end{aligned}
\tag{A-2.28}
$$

As one might have expected symmetries CP and T are exact symmetries of the pure Dirac action.

## A-3 Space-time surfaces with vanishing em, $Z^0$, Kähler, or $W$ fields

In the sequel it is shown that space-times for which either em, $Z^0$, or Kähler field vanishes decompose into regions characterized by six vacuum parameters: two of these quantum numbers ($\omega_1$ and $\omega_2$) are frequency type parameters, two ($k_1$ and $k_2$ ) are wave vector like quantum numbers, two of the quantum numbers ($n_1$ and $n_2$) are integers. The parameters $\omega_i$ and $n_i$ will be referred as electric and magnetic quantum numbers. The existence of these quantum numbers is not a feature of these solutions alone but represents a much more general phenomenon differentiating in a clear cut manner between TGD and Maxwell's electrodynamics.

The simplest manner to avoid surface Kähler charges and discontinuities or infinities in the derivatives of $CP_2$ coordinates on the common boundary of two neighboring regions with different vacuum quantum numbers is topological field quantization, 3-space decomposes into disjoint topological field quanta, 3-surfaces having outer boundaries with possibly macroscopic size.

If one requires that space-time surface is an extremal of Kähler action and has a 2-dimensional $CP_2$ projection, only vacuum extremals and space-time surfaces for which $CP_2$ projection is a geodesic sphere, are allowed. Homologically non-trivial geodesic sphere correspond to vanishing $W$ fields and homologically non-trivial sphere to non-vanishing $W$ fields but vanishing $\gamma$ and $Z^0$. For vacuum extremals all electro-weak gauge fields are in general non-vanishing although the net gauge field has U(1) holonomy.

### A-3.1 Em neutral space-times

Em and $Z^0$ neutral space-times are especially interesting space-times as far as applications of TGD are considered. Consider first the electromagnetically neutral space-times. Using spherical coordinates $(r, \Theta, \Psi, \Phi)$ for $CP_2$, the expression of Kähler form reads as

$$\begin{aligned} J &= \frac{r}{F^2} dr \wedge (d\Psi + cos(\Theta) d\Phi) + \frac{r^2}{2F} sin(\Theta) d\Theta \wedge d\Phi \ , \\ F &= 1 + r^2 \ . \end{aligned} \tag{A-3.1}$$

The general expression of electromagnetic field reads as

$$\begin{aligned} F_{em} &= (3+2p)\frac{r}{F^2} dr \wedge (d\Psi + cos(\Theta) d\Phi) + (3+p)\frac{r^2}{2F} sin(\Theta) d\Theta \wedge d\Phi \ , \\ p &= sin^2(\Theta_W) \ , \end{aligned} \tag{A-3.2}$$

where $\Theta_W$ denotes Weinberg angle.

The vanishing of the electromagnetic fields is guaranteed, when the conditions

$$\begin{aligned} \Psi &= k\Phi \ , \\ (3+2p)\frac{1}{r^2 F}(d(r^2)/d\Theta)(k + cos(\Theta)) &+ (3+p) sin(\Theta) = 0 \ , \end{aligned} \tag{A-3.3}$$

hold true. The conditions imply that $CP_2$ projection of the electromagnetically neutral space-time is 2-dimensional. Solving the differential equation one obtains

$$\begin{aligned} r &= \sqrt{\frac{X}{1-X}} \ , \\ X &= D\left[|\frac{(k+u}{C}|\right]^{\epsilon} \ , \\ u &\equiv cos(\Theta) \ , \ C = k + cos(\Theta_0) \ , \ D = \frac{r_0^2}{1+r_0^2} \ , \ \epsilon = \frac{3+p}{3+2p} \ , \end{aligned} \tag{A-3.4}$$

where $C$ and $D$ are integration constants. $0 \leq X \leq 1$ is required by the reality of $r$. $r = 0$ would correspond to $X = 0$ giving $u = -k$ achieved only for $|k| \leq 1$ and $r = \infty$ to $X = 1$ giving $|u + k| = [(1 + r_0^2)/r_0^2)]^{(3+2p)/(3+p)}$ achieved only for

$$sign(u+k) \times [\frac{1+r_0^2}{r_0^2}]^{\frac{3+2p}{3+p}} \leq k+1 \ ,$$

where $sign(x)$ denotes the sign of $x$.

Under rather general conditions the coordinates $\Psi$ and $\Phi$ can be written in the form

$$\begin{aligned} \Psi &= \omega_2 m^0 + k_2 m^3 + n_2\phi + \text{Fourier expansion} \ , \\ \Phi &= \omega_1 m^0 + k_1 m^3 + n_1\phi + \text{Fourier expansion} \ . \end{aligned} \tag{A-3.5}$$

$m^0$,$m^3$ and $\phi$ denote the coordinate variables of the cylindrical $M^4$ coordinates) so that one has $k = \omega_2/\omega_1 = n_2/n_1 = k_2/k_1$. The regions of the space-time surface with given values of the vacuum parameters $\omega_i$,$k_i$ and $n_i$ and $m$ and $C$ are bounded by the surfaces at which the electromagnetically neutral imbeddings become ill-defined, say by $r > 0$ or $r < \infty$ surfaces.

The space-time surface decomposes into regions characterized by different values of the vacuum parameters $r_0$ and $\Theta_0$. At $r = \infty$ surfaces $n_2$,$\omega_2$ and $m$ can change since all values of $\Psi$ correspond to the same point of $CP_2$: at $r = 0$ surfaces also $n_1$ and $\omega_1$ can change since all values of $\Phi$ correspond to same point of $CP_2$, too. If $r = 0$ or $r = \infty$ is not in the allowed range space-time surface develops a boundary.

This implies what might be called topological quantization since in general it is not possible to find a smooth global imbedding for, say a constant magnetic field. Although global imbedding exists it decomposes into regions with different values of the vacuum parameters and the coordinate $u$ in general possesses discontinuous derivative at $r = 0$ and $r = \infty$ surfaces. A possible manner to avoid edges of space-time is to allow field quantization so that 3-space (and field) decomposes into disjoint quanta, which can be regarded as structurally stable units a 3-space (and of the gauge field). This doesn't exclude partial join along boundaries for neighboring field quanta provided some additional conditions guaranteing the absence of edges are satisfied.

The vanishing of the electromagnetic fields implies that the condition

$$\Omega \equiv \frac{\omega_2}{n_2} - \frac{\omega_1}{n_1} = 0 \ , \tag{A-3.6}$$

is satisfied. In particular, the ratio $\omega_2/\omega_1$ is rational number for the electromagnetically neutral regions of space-time surface. The change of the parameter $n_1$ and $n_2$ ($\omega_1$ and $\omega_2$) in general generates magnetic field and therefore these integers will be referred to as magnetic (electric) quantum numbers.

The expression for the Kähler form and $Z^0$ field of the electromagnetically neutral space-time surface will be needed in sequel and is given by

$$\begin{aligned} J &= -\frac{p}{3+2p} X du \wedge d\Phi \ , \\ Z^0 &= -\frac{6}{p} J \ . \end{aligned} \tag{A-3.7}$$

The components of the electromagnetic field generated by varying vacuum parameters are proportional to the components of the Kähler field: in particular, the magnetic field is parallel to the Kähler magnetic field. The generation of a long range $Z^0$ vacuum field is a purely TGD based feature not encountered in the standard gauge theories.

The effective form of the $CP_2$ metric is given by

$$\begin{aligned} ds^2_{eff} &= (s_{rr}(\frac{dr}{d\Theta})^2 + s_{\Theta\Theta})d\Theta^2 + (s_{\Phi\Phi} + 2ks_{\Phi\Psi})d\Phi^2 = \frac{R^2}{4}[s^{eff}_{\Theta\Theta}d\Theta^2 + s^{eff}_{\Phi\Phi}d\Phi^2] \ , \\ s^{eff}_{\Theta\Theta} &= X \times \left[\frac{\epsilon^2(1-u^2)}{(k+u)^2} \times \frac{1}{1-X} + 1 - X\right] \ , \\ s^{eff}_{\Phi\Phi} &= X \times \left[(1-X)(k+u)^2 + 1 - u^2\right] \ , \end{aligned} \tag{A-3.8}$$

and is useful in the construction of electromagnetically neutral imbedding of, say Schwartchild metric. Note however that in general these imbeddings are not extremals of Kähler action.

### A-3.2 Space-times with vanishing $Z^0$ or Kähler fields

The results just derived generalize to the $Z^0$ neutral case as such. The only modification is the replacement of the parameter $\epsilon$ with $\epsilon = 1/2$ as becomes clear by considering the condition stating that $Z^0$ field vanishes identically also the relationship $F_{em} = 3J = -\frac{3}{4}\frac{r^2}{F}du \wedge d\Phi$ is useful.

Also the generalization to the case of vacuum extremals is straightforward and corresponds to $\epsilon = 1, p = 0$ in the formula for em neutral space-times. In this case classical em and $Z^0$ fields are proportional to each other:

$$\begin{aligned} Z^0 &= 2e^0 \wedge e^3 = \frac{r}{F^2}(k+u)\frac{\partial r}{\partial u}du \wedge d\Phi = (k+u)du \wedge d\Phi \ , \\ r &= \sqrt{\frac{X}{1-X}} \ , \ X = D|k+u| \ , \\ \gamma &= -\frac{p}{2}Z^0 \ . \end{aligned} \tag{A-3.9}$$

For vanishing value of Weinberg angle ($p = 0$) em field vanishes and only $Z^0$ field remains as a long range gauge field. Vacuum extremals for which long range $Z^0$ field vanishes but em field is non-vanishing are not possible.

For vacuum extremals with vanishing induced Kähler form classical em field $\gamma$ and $Z^0$ field satisfy

$$\gamma = -\frac{sin^2(\theta_W)}{2}Z^0 \simeq -\frac{Z^0}{8}$$

for $\sin^2(\theta_W) = .23$.

### A-3.3 Induced gauge fields for space-times for which $CP_2$ projection is a geodesic sphere

For space-time sheets for which $CP_2$ projection is $r = \infty$ homologically non-trivial geodesic sphere of $CP_2$ one has

$$\gamma = (\frac{3}{4} - \frac{sin^2(\theta_W)}{2})Z^0 \simeq \frac{5Z^0}{8} \ .$$

The induced $W$ fields vanish in this case and they vanish also for all geodesic sphere obtained by $SU(3)$ rotation.

For homologically trivial geodesic sphere a standard representative is obtained by using for the phase angles of standard complex $CP_2$ coordinates constant values. In this case induced em, $Z^0$, and Kähler fields vanish but induced $W$ fields are non-vanishing. This holds also for surfaces obtained by color rotation. Hence one can say that for non-vacuum extremals with 2-D $CP_2$ projection color rotations and weak symmetries commute.

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