The Ultimate Picture of Particle Physics and Cosmology

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Abstract: The string/M theory, cosmology, General Theory of Relativity and Quantum Physics are the approximate descriptions of Nature so there appear many incorrect assumptions and wrong interpretations. Here we pointed the limitations for the basic method applied in the Quantum Physics associated with the action of orthogonal groups on column vector representing a spinor. Such action leads to the spin representations. Spinor can represent the half-integral spin of a quantum loop in a pair that returns to original position after 720 degree rotation. It is characteristic for the zero-helicity vector particles. This property, the theory of spinors itself, the classification of the Clifford algebras and the double-covers/spin-groups that are the Lie groups, suggest that succeeding phase transitions of the superluminal non-gravitating Higgs field can be in existence and it is the foundations of the lacking part of ultimate theory i.e. the Scale-Symmetric Theory. In the last theory there as well appear the scalar condensates and the imaginary part of Nature that appear in the classification of the Clifford algebras. The succeeding phase transitions radically simplify the basic mainstream theories via elimination of the approximations and free parameters. The classification of the Clifford algebras and the succeeding phase transitions prove that Nature on its lowest level is superluminal, classical and non-relativistic. Within the Scale-Symmetric Theory, theory of spinors, Clifford algebras and Lie algebra, we can show how the only inertial-masses/volumes lead to the Principle of Equivalence. It is the Higgs mechanism. On the other hand, the Principle of Equivalence and the confinement forced by the Mexican-hat mechanism lead to the scalar condensates composed of the Einstein-spacetime components. Unification of the 7 different interactions is possible only via the theory of succeeding phase transitions of the non-gravitating Higgs field and via the atom-like structure of baryons.

1. Introduction

The General Relativity leads to the non-gravitating Higgs field composed of tachyons [1A]. On the other hand, the Scale-Symmetric Theory (SST), [1], shows that the succeeding phase transitions of such Higgs field lead to the different scales of sizes [1A]. Due to the saturation of interactions via the Higgs field and due to the law of conservation of the half-integral spin that is obligatory for all scales, there consequently appear the superluminal binary systems of

closed strings (entanglons) responsible for the quantum entanglement, stable neutrinos and luminal neutrino-antineutrino pairs which are the components of the luminal Einstein spacetime (it is the Planck scale), cores of baryons, and the cosmic structures (protoworlds) that evolution leads to the dark matter, dark energy and expanding universes [1A], [1B]. The non-gravitating tachyons have infinitesimal spin so all listed structures have internal helicity (helicities) which distinguish particles from their antiparticles [1A]. SST shows that a fundamental theory should start from infinite nothingness and pieces of space [1A]. Sizes of pieces of space depend on their velocities [1A]. The inflation field started as the liquid-like field composed of non-gravitating pieces of space [1A]. Cosmoses composed of universes are created because of collisions of big pieces of space [1A], [1B]. During the inflation, the liquid-like inflation field (the non-gravitating superluminal Higgs field) transformed partially into the luminal Einstein spacetime [1A]. In our Cosmos, the two-component spacetime is surrounded by timeless wall – it causes that the fundamental constants are invariant [1A], [1B].

Due to the symmetrical decays of bosons on the equator of the core of baryons, there appears the atom-like structure of baryons described by the Titius-Bode orbits for the nuclear strong interactions [1A].

The two first phase transitions describe the Higgs mechanism that leads from the superluminal non-gravitating Higgs field to the Principle of Equivalence and to the initial conditions applied in the General Theory of Relativity (GR). The three first phase transitions concern the particle physics whereas the structure and evolution of the most sophisticated spinor, i.e. the cosmic spinor/object, defined by the four phase transitions leads to the new cosmology.

SST directly leads to the possible symmetries and to the origin of the broken symmetries. The broken symmetries can be only local (they follow from the internal helicities of the fermions [1A]) whereas the global symmetry of the Cosmos must be conserved (it is realised because of the four-particle symmetry i.e. the quadrupole symmetry; such symmetry causes that in the Einstein spacetime turbulences do not appear [1A]). There are not in existence spontaneously broken symmetries. Such symmetries follow from the fact that the mainstream theories are incomplete – we will prove it in this paper.

On the other hand, the Noether (first) theorem says that any differentiable symmetry of the action of a physical system has a corresponding conservation law [2]. Contrary to the mechanics version, in the field theory version, the Noether theorem is for continuous fields in 4-dimensional spacetime. Via the action invariant under certain transformations of the spacetime coordinates and the fields, there appear the conserved current densities. It means that, for example, electric charge within a sphere is conserved when there is not a flow of a charge through the sphere. When Lagrangian is constant in its third argument, we obtain the conservation law for the stress-energy tensor. For field in the configuration space of smooth functions there appears in the action the Lagrangian density that depends on the field, its derivation and the position. At the end we obtain the Noether current associated with the symmetry [3]. We will show that due to the succeeding phase transitions, we can at once (directly) describe the origin of such symmetries.

In the quantum physics dominate the theory of spinors, the classification of the Clifford algebras and Lie algebra. Most important is the action of orthogonal/Lie/spin groups on a column vector (a spinor) that leads to the spin representations. Applying such method we can only partially decipher structure and behaviour of Nature. We will show the limitations. Just the succeeding phase transitions of the superluminal non-gravitating Higgs field are the lacking part of ultimate theory. In the theory of the orthogonal groups, a spinor is an element of a complex vector space. The classification of the Clifford algebras provides a description of

the spin representations of the spin groups whereas the presented theory of spinors leads to the double-covers/spin-groups that are the Lie groups.

In this paper, comparing the theory of the succeeding phase transitions of the superluminal non-gravitating Higgs field described within the Scale-Symmetric Theory with the mainstream theories, we will show that the basic mainstream theories are incomplete and we will point the incorrect assumptions and wrong interpretations.

Some definitions applied in the Scale-Symmetric Theory are as follows:

Superluminal non-gravitating Higgs field: This field is defined by the initial conditions [1A]. It is the field composed of the classical, non-relativistic, gravitationally massless tachyons. Their undetectable non-gravitating rotational energy is approximately 10^{54} times lower than their undetectable kinetic energy and their angular momentum is about 10^{66} times smaller than the reduced Planck constant so the superluminal non-gravitating Higgs field is the undetectable almost scalar field.

Higgs mechanism: There are four constituents of this mechanism: one pseudoscalar (it is a tachyon when we neglect its infinitesimal angular momentum), two vectors i.e. the spins of the entanglons and of the Einstein-spacetime components, and one scalar i.e. the condensate of the entanglons in the centre of the torus of neutrino [1A]. It is defined by the Clifford algebra $Cl_{0,2}(\mathbf{R})$ and it is spinor in two dimensions. When we neglect the infinitesimal angular momentum of the tachyons, then there appear the spontaneously broken symmetries that, in reality, are not in existence.

Entanglon: It is the directly undetectable binary system of the superluminal closed strings created due to the first phase transition of the superluminal non-gravitating Higgs field. Spins of the closed strings are half-integral and parallel whereas their helicities are opposite. They are the zero-helicity vector particles. Since the global symmetry of the Higgs field must be conserved so the entanglons appear as the binary systems with antiparallel spins of the components.

Component of the Einstein spacetime: It is the neutrino-antineutrino pair with opposite weak charges defined by torus of neutrino [1A]. A torus of a neutrino is built of the entanglons in such a way that all spins are perpendicular to the surface of the torus and all point the inside of the torus or all point the outside. Since torus has internal helicity so there are the four possibilities that lead to the four-neutrino symmetry (there are four different stable neutrinos i.e. the electron-neutrino, muon-neutrino, and their antineutrinos; the third tau-"neutrino" is the unstable "neutrino" composed of three different stable neutrinos [1A]). Since the global symmetry of the Einstein spacetime (Es) must be conserved so the Es components appeared during the inflation as the binary systems of the stable neutrino-antineutrino pairs with antiparallel spins of the components. Only spins of the entanglons placed on the plane of the equator of the torus of a neutrino are perpendicular (orthogonal) to the spin of the neutrino/spinor – this plane is very important for the interactions. We can see that the theory of spinors and the Clifford algebras do not fully describe the bare half-integral-spin fermions (i.e. spinors) or their pairs (they are the spinors as well and they are the zero-helicity unitary-spin vector particles) that are useful in descriptions of the interactions. The Es components are as well the zero-helicity vector particles.

The state of a bare fermion-antifermion pair we can describe via two-component spinors.

The quantum time-like loops are produced inside the tori of the spinors. They have the same helicity as the spinors. For example, we can describe the quantum time-like loops produced inside particles/spinors defining the product of the gamma matrices within the Clifford algebra $Cl_{1,3}(\mathbf{R})$. Such matrix (it is not a fifth gamma matrix) is useful to describe the quantum mechanical chirality. There appears the left-handed and right-handed two-component Weyl spinor.

2. The special theory of spinors realized by Nature

Due to the succeeding phase transitions of the superluminal non-gravitating Higgs field, there appear the spinors. History of quantum physics proves that the spinors are essential to understand Nature. What a spinor is?

A spinor is a generalization of tensor and vector whereas tensor is a generalization of vector and scalar. One of most important mathematical method is the action of orthogonal group on column vector (spinor) that leads to spin representations. Via investigating the spin representations we can decipher structure and behaviour of Nature. On the other hand, there are some representations of the Lie algebra of the orthogonal groups (the double-covers i.e. spin-groups $Spin(p,q)$) that cannot be formed by the tensor constructions. These missing representations lead to the spin representations. It suggests that some part of Nature cannot be described within the General Theory of Relativity. Emphasize: There is action of the double-covers/spin-groups on the spinors that leads to the spin representations; then, the classification of Clifford algebras provides a complete description of the spin representations of the spin groups so we can as well find the relationships between the spin representations.

The phase transitions show that the vector objects on higher and higher levels of Nature consist of increasing number of different vector particles arranged in specific way. The succeeding objects which appear in the phase transitions are the tori/spinors having half-integral spin and helicity. A bigger torus consists of the next smaller torus-antitorus pairs, and so on. At the lowest level, there is the superluminal non-gravitating Higgs field. There are the three dual tori and the circle/closed-string which as well has the internal helicity and it is the condensation of the tachyons into circle. A torus consists of the next smaller torus-antitorus pairs that spins are unitary and all of them point the interior of the torus or all point its exterior. The resultant speeds of the pairs of the same size are the same. This leads to conclusion that besides the spin speeds of the pairs on a torus, there appear their radial speeds. Only the pairs placed on the equator of a torus have the radial component of their velocity equal to zero. The radial components of the velocities of the pairs on a torus cause that in centre of the torus there appears a condensate.

We can see that some parts of the objects created in the succeeding phase transitions behave as the spinors. It concerns the resultant spinor and the spinors on its equator also. For the three first phase transitions, the spins of the resultant spinor and of the two different pairs/spinors on the equator of the resultant spinor (it is the core of baryons which consists of the Einstein-spacetime components and the entanglons) are orthogonal. Presented here the extended theory of spinors concerns as well the condensate in the centre of baryons which is responsible for the nuclear weak interactions at very low energies. Inside the torus, there arise the time-like quantum loops (pions are the zero-spin binary systems of such loops) which spin is unitary and parallel to the spin of the resultant spinor. The resultant internal helicity of the time-like quantum loops is the same as the resultant spinor. Just the time-like quantum loops acquire similar properties as the resultant spatial spinors. We can see that we can describe the core of baryons applying the Clifford algebra $C\mathrm{l}_{1,3}(\mathbf{R})$ and it as well is in the 1(time)+3(space) dimensional relativistic quantum field theory. Using the 4×4 Dirac gamma matrices (they generate a matrix representation of the Clifford algebras $C\mathrm{l}_{1,3}(\mathbf{R})$), we obtain the 4 component Dirac spinors. We can describe the helicity of quantum time-like loops produced inside spinors defining the product of the gamma matrices within the Clifford algebra $C\mathrm{l}_{1,3}(\mathbf{R})$. Such matrix (it is not a fifth gamma matrix) is useful to describe the quantum mechanical chirality. There appears the left-handed or right-handed Weyl spinor.

What is the difference between the spatial-like objects and time-like objects? The time-like loops arise inside the stable (so time-independent) spatial-like torus and acquire some its properties. But the time-like loops are not an integral part of its source i.e. a spatial-like torus.

They arise due to the quantum entanglement of the Einstein-spacetime components. The time-like loops are emitted by the core of baryons (i.e. they disappear in one place and appear in another one, and so on, so they are the time-like and quantum objects) and are responsible for the nuclear strong interactions. How we can unify the time-dimension with the spatial dimension within the orthogonal groups? We can assume that the time dimension is imaginary – it is the mathematical trick. The theory of the complex numbers shows that the transition from the real axis to the imaginary plane is under the $\pi/2$ rotation i.e. the real and imaginary axes are orthogonal. In this case, the mathematical trick has physical meaning. The entanglons responsible for the quantum entanglement are the classical objects i.e. they are moving but they cannot disappear in one place and appear in another one, and so on, so they are the spatial vectors. But due to these objects, the loops can behave in a quantum way. Moreover, the superluminal entanglons are the gravitationally massless objects so they, when free, have broken contact with fields that have gravitational mass density i.e. we can describe motions of the entanglons (more precisely: the motions of the condensate of the tachyons into the binary system of closed strings; it does not concern the spin of the entanglon) in an imaginary space separated from the fields. It causes that the Clifford algebra $Cl_{1,3}(\mathbf{R})$ can coherently describe Nature. Moreover, the phase transitions described within the Scale-Symmetric Theory leads to conclusion that the equatorial plane of the torus of baryons is very important when we want to describe the interactions.

In the Scale-Symmetric Theory, the Higgs mechanism is associated with the Clifford algebra $Cl_{0,2}(\mathbf{R})$ where the zero defines the time dimensions whereas the 2 defines the spatial dimensions. This means that the Higgs mechanism is associated with the two first phase transitions whereas the Higgs bosons appear due to the third phase transition.

So, why the mainstream theories are such messy? Why there appear the approximations, mathematical tricks and free parameters?

2.1

The mainstream theories incorrectly describe the bare fermions. They neglect the existence of the tori that define the charges, spins and internal helicity and they neglect the central condensate.

2.2

They neglect the atom-like structure of baryons.

2.3

The spontaneously broken symmetries appear because the mainstream theories neglect some fundamental properties of physical objects i.e. the internal helicity of fermions, internal helicity of the nuclear strong fields, and the fact that the two components of spacetime (i.e. the Higgs field and Einstein spacetime) try to eliminate turbulences so there appears the quadrupole symmetry. For example, in reality, the Higgs field is not a scalar field (see the definition). It causes that the entanglons and Es components are the zero-helicity vector particles. The entanglons are the binary systems of the closed strings with parallel spins and opposite internal helicities. Since the global symmetry of the Cosmos cannot be broken then the entanglons were produced as the binary systems with opposite spins i.e. a fully symmetric group must contain 4 closed strings. The same concerns the Es components. We can see that there is broken the local symmetry but it follows from the properties of the Higgs field. It is not a spontaneously broken symmetry. We should eliminate the term “spontaneously broken symmetries” from the theories.

There appears a problem when we try to describe fully the structure and evolution of the cosmic objects produced in the fourth phase transition. The universes appear as the double loops produced inside the cosmic torii (they are the analogs to neutral pions produced inside the torus in the core of baryons) [1B], [1A]. It is very easy to describe the structure and evolution of the protoworlds and universes within the Scale-Symmetric Theory but it is very difficult to do it within the methods applied in the relativistic quantum field theory. Just there are the 4 different spatial spinors and the cosmic loop in which, due to the very high mass density, time is going very slowly). There appear as well the time-like quantum loops inside the baryons. It is easy to see that we need following Clifford algebra $Cl_{4,4}(\mathbf{R})$ i.e. there must be four orthogonal real axes and four imaginary axes. Physically it is impossible because space is 3-dimensional. But we can neglect the first phase transition which is responsible for the quantum entanglement and which leads to the confinement i.e. to the two foundations of the Quantum Physics. Then, the gravity can dominate. Such approximation leads to the dark matter and the expansion of the Universe [1B]. The core of Protoworld looked as big core of baryons but the entangled Es components we must replace for the nucleon-nucleon pairs [1A].

Spinor can represent the half-integral spin of a quantum loop (in reality they are the binary systems carrying the unitary spin) that returns to original position after 720 degree rotation. We can see that a 360 degree rotation associated with the helicity, transforms the numeric coordinates of the spinor into their negatives. The complex numbers associated with the spinors under a rotation of the helicity angular momentum by angle φ get multiplied by $e^{\pm i\varphi/2}$ (it is associated with the rotation of the spin of a spinor as a whole).

The tori have strictly determined sizes i.e. the circle associated with the spin speed has circumference two times longer than the circles associated with the internal helicity [1A]. It means that under the helicity rotation of a test particle interacting with surface of a torus by angle 720^o, the spin rotation is 360^o only.

Generally, the bare fermions arise as the particle/spinor-antiparticle/antispinor pairs. Due to the vortices produced in the Einstein spacetime, the matter-antimatter symmetry can be broken. For example, such vortices breaks the electron-positron and proton-antiproton symmetries in such a way that there are produced the proton-electron pairs as well [1B]. Consider an electron-positron pair. One component of the pair has mass two times smaller than the binary system. We know that length of wave representing mass is inversely proportional to the mass. This means that when length 2λ (or 720^o) represents rotation of a component of the binary system then λ (or 360^o) represents rotation of the binary system. It leads to conclusion that such spinor as the electron-positron pair with parallel spins and opposite helicities of the components, under a rotation of spin by angle 180 degrees causes the rotation of the angular momentum associated with internal helicity of a torus by angle 360 degrees.

The spinors are elements of a vector space. The theory of spinors shows that for a given quadratic form, many different spaces of spinors may be in existence. It leads to conclusion that on a defined higher level of Nature there can be many different spinors. The Clifford algebras provide a complete picture of the spin representations.

Unification of the GR and QP within the same methods is impossible (gravitational fields are the gradients in the superluminal non-gravitating Higgs field whereas the Standard-Model interactions are directly associated with the luminal gravitating Einstein spacetime) but we can see that there is possible a partial unification via the succeeding phase transitions of the superluminal non-gravitating Higgs field (see the ultimate equation in following paper [1A]).

We can see that particle physics needs the Clifford algebra $Cl_{1,3}(\mathbf{R})$. Such Clifford algebra provides a complete picture of the spin representations. The matrices applied in physics

represent the action of a set of orthogonal basis vectors. They act on the column vectors and the resultant object is the space of spinors on which the Clifford algebras of spacetime act. In such a mechanism can appear infinitesimal spatial rotations. Emphasize once more that using the 4×4 Dirac gamma matrices (they generate a matrix representation of the Clifford algebra $Cl_{1,3}(\mathbf{R})$) we obtain the 4 component Dirac spinors. They are used in the 1(time)+3(space) dimensional relativistic quantum field theory.

The spinors representing the fermions have the internal helicity. It forces to introduce the product of the four gamma matrices but it is not an element of the gamma matrices. The product of 4 Dirac matrices we can use to describe the quantum mechanical chirality. Then, in the Dirac field can appear the left-handed or right-handed 1-component spinors. Remember that, for example, the Pauli matrices are a set of matrices with metric of the Euclidean signature ($t = 0$, $s = 3$). Existence of the simpler Clifford algebras suggests that Nature on its lowest level should be classical.

The Scale-Symmetric Theory shows that existence of the spinors follows from the succeeding phase transitions of the superluminal non-gravitating Higgs field composed of the classical non-relativistic tachyons and that the spinors are objects associated to a vector space. The complete theory of the spinors should be based on the Clifford algebra $Cl_{4,4}(\mathbf{R})$ but we will prove that under the dogma that there are maximum the three spatial dimensions, such algebra is mathematically incoherent. The composite Higgs boson with a mass of 125 GeV looks similar to the central scalar condensate in the core of baryons but such condensate is not directly associated with the Higgs mechanism that transforms the non-gravitating Higgs field into the lightest gravitational masses i.e. neutrinos and their pairs [1A]. The central condensates in fermions are produced due to the Mexican-hat mechanism (the confinement [1A]) concerning the Einstein-spacetime components and follows from the internal structure of the stable neutrinos.

There are three dual spinors i.e. protoworld, core of baryon and stable neutrino. In the symmetric Einstein spacetime they arise as the object-antiobject pairs. The bigger spinor or pair of spinors consists of the smaller spinors. This causes that there are the subgroups of the orthogonal groups. A group containing more constituents covers the groups which contain smaller number of constituents.

In the theory of spinors, there appear the double-covers/spin-groups that are Lie groups. Can we show a physical interpretation of the double-covers within presented above extended theory of spinors that follows from the succeeding phase transitions described within the Scale-Symmetric Theory? The set of all unit quaternions (4) is very important for the orthogonal groups. Such set forms a 3-dimensional sphere and a Lie group under multiplication of the unit quaternions. The Lie group is double covering the spin group of rotation $SO(3,\mathbf{R})$ of real orthogonal 3×3 matrices. It is because two unit quaternions concern each rotation ($4/2 = 2$). It causes that under the same rotation, there appear two possibilities. Can we within the extended theory of spinors show that this “incoherence” has physical meaning? We proved that the entanglons and the Einstein-spacetime components are the zero-helicity vector particles. There are the two possibilities for senses of their spins on equator of the torus in the core of baryons or leptons: one arrangement leads to torus/particle whereas the second to antitorus/antiparticle. This means that under $\pi/2$ rotation of the spin of the resultant spinor, we obtain two states (i.e. under the same rotation there appear two different states) i.e. the double-covers indeed describe the reality. The double covers, i.e. Lie groups, are referred to as the spin groups $Spin(p,q)$. The spin groups define all the properties of spinors. The Lie algebra corresponding to Lie groups $O(n,F)$ and $SO(n,F)$ consists of the anti-symmetric $n\times n$ matrices, with the Lie bracket defined by the commutator.

The succeeding phase transitions of the superluminal non-gravitating Higgs field, described within the Scale-Symmetric Theory, suggest the new point of view. The phase transitions show how the spinors look. Without any mathematics we can understand behaviour of the spinors under any rotation. We even do not need the Lie groups to know how the spinors behave under the orthogonal transformations. Just there is in existence only one strictly determined picture. The picture that follows from the phase transitions shows that the mainstream description is incomplete and within the Scale-Symmetric-Theory picture we can decode much more properties of the spinors and say much more about their interactions. Just most important is the internal structure of the spinors/particles. Such picture radically simplifies mathematical description of motions and interactions. Most important is the fact that the larger spinors/particles consist of smaller spinors, and so on, and that there appear the simple mathematical objects as the tori/charges/spins/vectors and balls/condensates/scalars.

3. Higgs mechanism

Tachyon fields play a very important role in modern physics. The phase transitions described within the Scale-Symmetric Theory lead to conclusion that the tachyon field is not a quantum field. Due to the infinitesimal inertial-only angular momentum of the classical tachyons, the tachyon field is only some approximation of the pseudoscalar field. In the Scale-Symmetric Theory the mean angular momentum of tachyons is not neglected so there do not appear the spontaneously broken symmetries. The term “unobserved tachyons” means that tachyons are not surrounded by any field.

The Higgs mechanism involves four constituents: in approximation there is one pseudoscalar (tachyon), two vectors i.e. the spins of the entanglons and of the Einstein-spacetime components, and one scalar i.e. the condensate of the entanglons in the centre of the torus of neutrino. It is defined by the Clifford algebra $Cl_{0,2}(\mathbf{R})$ and it is a spinor in two spatial dimensions. This mechanism describes the transition from the non-gravitating Higgs field to the Principle of Equivalence. Such mechanism was possible during the inflation. At first, there were the transformations of the condensates of the tachyons into the binary systems of the closed strings. Due to the infinitesimal angular momentum of the tachyons, the closed strings have internal helicity. Due to their interactions with the non-gravitating Higgs field, they produce the antiparallel tachyon half-jets that we refer to as the lines of gravitational forces. Due to the second phase transitions, there were produced the neutrinos. The torus of a neutrino produces divergent field composed of the half-jets. Due to the collisions of the tachyons in the half-jets, with the tachyons in the Higgs field, there arises gradient in the Higgs field. It is the gravitational field of the neutrino [1A]. Since the global symmetry of the Higgs field must be conserved so neutrinos were produced as the groups of four different stable neutrinos in such a way that total weak charge, spin and internal helicity of each group were equal to zero. We can see that the local symmetries are broken but they are not the spontaneously broken symmetries.

Emphasize once more that the Higgs mechanism describes how the Einstein-spacetime components acquired their gravitational mass during the inflation.

The gravitational constant G depends on the internal structure of the Es components and inertial-mass density of the Higgs field. The Higgs mechanism is beyond the General Theory of Relativity but leads to the initial conditions applied in this theory. The SST leads directly to properties of the torus of neutrinos and shows that its size is close to the Planck length but increasing energy causes that effective radius of neutrino increases [1A], [4].

Notice that in the Scale-Symmetric Theory, the entanglons and Es components are the zero-helicity vector particles. On the other hand, the broken gauge symmetries lead to the massless

Goldstone bosons [5]. Then, many authors noticed that we can eliminate the massless bosons introducing zero-helicity states of vector particles associated with broken local symmetries. Due to such Higgs mechanism, the vector particles acquire their masses. We can see that it is consistent with the Higgs mechanism described within the Scale-Symmetric Theory but within the SST we described as well the internal structure of the zero-helicity vector particles and calculated their inertial masses, sizes, speeds and the other properties. On base of such Higgs mechanism we can understand the electroweak interactions [6]. But due to the phase transitions described within the Scale-Symmetric Theory we can radically simplify the description of the electroweak interactions and eliminate the free parameters (see the paragraph titled "*Electroweak interactions*").

There are two types of mass generation models: gravity-free models and models that involve gravity. But it is obvious that Nature can realize only one Higgs mechanism. Due to the Higgs mechanism described within the Scale-Symmetric Theory, during the inflation there appeared the ground state of the Einstein spacetime which components are moving with the speed of light c.

As we wrote, in the Scale-Symmetric Theory, the Higgs mechanism is associated with the Clifford algebra $C\mathrm{l}_{0,2}(\mathbf{R})$, where the zero defines the time dimensions whereas the number 2 the spatial. This means that the Higgs mechanism is associated with the two first phase transitions whereas the Higgs bosons appear due to the third phase transition, i.e. the theory of the mainstream Higgs bosons (in reality, the SST shows that the lowest-mass Higgs boson is the group of four different stable neutrinos but there can be produced Higgs bosons/condensates composed of big number of such groups/quadrupoles) is associated with the Clifford algebra $C\mathrm{l}_{1,3}(\mathbf{R})$ (we described it in the next paragraphs). Creation of the Higgs bosons is associated with the confinement which concerns the Higgs mechanism as well and follows from the Mexican-hat mechanism.

4. The Mexican-hat mechanism in the Scale-Symmetric Theory

The complete and mathematically coherent theory of the phase transitions lead to the basic foundations of the quantum physics i.e. to both the confinement that follows from the Mexican-hat mechanism associated with the Einstein-spacetime components, and the superluminal entanglement.

The stable neutrinos, cores of baryons and cores of protoworlds are dual [1A]. It means that phenomena concerning these structures are similar but due to the different scales, there appear constant factors. From confinement described within SST, [1A], follows that its range results from emission and absorption by the neutrino-antineutrino pairs some characteristic groups of the entanglons. The calculated range of such Mexican-hat mechanism is $R_{weak\text{-}well} = 3510.1831\ r_{neutrino}$. On the other hand, the mean distance between the neutrino-antineutrino pairs in the Einstein spacetime is $L_{ES} = 3510.2121\ r_{neutrino}$. The difference is very small so it should be very easy to produce condensates in the Einstein spacetime.

Similar situation is when photons interact with electric charge of proton – then there are produced the electron-positron pairs. The annihilations of the electron-positron pairs cause that around the proton is created the potential electric well that radius is 3510.1831 times greater than the reduced Compton length of the bare electron $\lambda\!\!\!^{-}_{bare\text{-}electron} = 3.8661\cdot10^{-13}$ m so the radius of the electric well of any atomic nucleus is

$$R_{electric\text{-}well} = 3510.1831\ \lambda\!\!\!^{-}_{bare\text{-}electron} = 1.3571\cdot10^{-9}\ \mathrm{m}. \qquad (1)$$

The potential is raised inside and very close to a nucleus and sharply increases on the edge of it. It looks in an approximation as the Mexican-hat. Can we indirectly detect existence of

such Mexican-hat mechanism? Notice that the range of the well is 25.645 greater than the Bohr radius. This leads to conclusion that only 5 electron shells are inside the electric well. We can compare it with the spectrum of the Hydrogen atoms.

The same concerns the other atoms. Classical radius is inversely proportional to number of protons, **Z**, in atomic nucleus. On the other hand, number of produced electron-positron pairs is directly proportional to **Z** so to associated length of wave also, so the radius of the well as well, is inversely proportional to **Z**. This means that inside an atom the upper limit for number of electrons is 110 (i.e. $2\ (1^2 + 2^2 + 3^2 + 4^2 + 5^2) = 110$).

We can see that the electromagnetic interactions and confinement have “tangent points”.

5. The electroweak interactions

Here we will compare the descriptions of the electroweak interactions in the Scale-Symmetric Theory and the mainstream theory.

In the Scale-Symmetric Theory, the condensates of the Einstein-spacetime components arise due to the radial velocities that appear in the spinors. Concentrate on the weak interactions of the baryons. At low energies (it is below the vacuum expectation value defined in the mainstream electroweak theory, i.e. about 250 GeV), for the weak interactions is responsible the rest or relativistic mass of the condensate in the centre of baryons. The mass of the resting condensate is $Y = 424.12$ MeV [1A].

Calculate within the Scale-Symmetric Theory the vacuum expectation value for weak interactions via the W and Z bosons. Within this theory we calculated the mass of the composite Higgs boson with a mass of $H = 125.00$ GeV (such boson consists of big number of the ground states of the Higgs boson i.e. of the quadrupoles of neutrinos) [1A], [7]. It follows from the electromagnetic interactions of the core of baryons and density of the Einstein spacetime. Due to the confinement of the Es components that appears inside the Higgs boson because of the energy of collision, the mean distance of the Es components R_{Es} decreases from

$$R_{Es} = (2\, m_{neutrino} / \rho_{Es})^{1/3} = 3510.2121\, r_{neutrino}, \tag{2}$$

where $2m_{neutrino}$ is the mass of Es components whereas ρ_{Es} is the mass density of the Es, to $R_{weak\text{-}well} = 3510.1831\, r_{neutrino}$.

The difference is very small so we can assume that density of the condensate is practically equal to the mass density of the Einstein spacetime (in reality, it is 1 part in $40{,}362.942$ parts higher [1A]).

The vacuum expectation value $\boldsymbol{O}$ concerns the collisions so there appears a pair so the vacuum expectation value is $\boldsymbol{O} = H\,H = 250.0$ GeV.

Calculate the masses of the W and Z bosons. From the vacuum expectation value can be created the Z boson and the W^+W^- pair (the Z and W denote the masses as well). Since the HH pair is the scalar so such production should be the 3-jet event. We obtain following relation

$$\boldsymbol{O^*} = H\,H + 4\, m_{bare\text{-}electron} = 2\,W + Z. \tag{3}$$

For the weak interactions is characteristic the 4-particle symmetry [1A]. Assume that the W^+W^- pair is created in the collision of two objects each composed of 4 electron-positron pairs due to the transitions from the weak interactions of electrons-muons to the weak

interactions of baryons. The ratio of the weak coupling constants for proton and electron-muon is $X_W = 19685.3$ [1A]). Then the mass of a W boson is

$$W = 4{\cdot}2\ m_{bare\text{-}electron}\ X_W = 80.380\ \text{GeV}. \quad (4)$$

The mass of the Z boson calculated from formula (3) is $Z = 91.282$ GeV.

We can see that SST contrary to the mainstream theory does not contain any free parameters. In the mainstream electroweak theory, to calculate the mass of W boson we need the three free parameters taken from experimental data. They are the mass of Z boson, the Weinberg angle and $\alpha_{em}(O)$.

Photons are the rotational energies of the Es components. They can be entangled due to the exchanges of the superluminal entanglons between the Es components. In the Scale-Symmetric Theory the photons are massless because the mean distance between their carriers, i.e. the Es components, is greater than the range of the confinement defined by the Mexican-hat mechanism. Mass density of the carriers of an entangled photon is the same as the Einstein spacetime. The broken symmetry between the weak and electromagnetic interactions follows from the difference of the range of the confinement of the Es components that follows from the Mexican-hat mechanism, and the present-day distance between them. During the inflation there was period when all Es components were confined. It is easy to notice that in this period the W and Z bosons were "massless" (i.e. their mass density was the same as the confined Einstein spacetime) i.e. they were the Goldstone bosons.

6. Hierarchy problem

The hierarchy problem we solved here [1A]. The Es components consist of the superluminal entanglons. The Es components acquire their gravitational mass due to the Higgs mechanism. It causes that the superluminal energy (not gravitational mass) frozen inside the Es components is approximately $0.6{\cdot}10^{119}$ times higher than the gravitational mass of these components [1A]. It is the lacking energy that follows from the quantum physics and concerns the ranges smaller than the Planck length. It solves the hierarchy problem.

On the other hand, within the mainstream theory is assumed that supersymmetry will solve the hierarchy problem. The problem associated with the hierarchy problem is as follows. Contrary to the fields of fermions and gauge bosons, the scalar fields can acquire big bare masses. No symmetry of the Standard Model can introduce a mechanism leading to an upper limit for the masses of the bare scalar fields [5]. It leads as well to conclusion that other masses should be close to the Planck mass about $2{\cdot}10^{-8}$ kg. It is assumed that the hierarchy problem can be solved by placing the Standard Model in the supersymmetric theory. Then, above the unification energy the scalars and fermions could be massless [5].

But the Scale-Symmetric Theory shows that the masses of the scalar condensates follow from the radial speeds in the spinors. Moreover, the scalar condensate inside the centre of the baryons, which is responsible for the weak interactions of baryons at low energy, is the black hole in respect of the weak interactions [1A]. The Scale-Symmetric Theory leads to the limitations for the masses of the scalar condensates but not for their massless energy. But the statement that the hierarchy problem can be solved by placing the Standard Model in the supersymmetric theory is generally incorrect because SST shows that there cannot be produced the superpartners to known particles.

7. The basic problem in the Standard Model at very low energy

The extended theory of spinors shows that the assumption that resting nucleons consist of the relativistic up and down quarks is incorrect. Inside the baryons, there is the core/spinor

whereas outside it, due to the symmetrical decays of some bosons, is obligatory the Titius-Bode law for the nuclear strong interactions – it is the atom-like structure of baryons [1A]. The wrong assumption causes that we still cannot calculate exact mass and spin of nucleons from the Standard-Model initial conditions. The domination of the quarks is at high energies [1D].

8. Redshift and illusion of acceleration of the expansion of the Universe

The quantum entanglement fixes the speed c of photons in relation to their source or in relation to a last-interaction object and it can be a detector. Such is the correct interpretation of the Michelson-Morley experiment.

On the other hand, at the beginning of the expansion of the Universe (SST shows that such expansion was separated in time from the inflation [1B]), the inflows of the dark energy and dark matter into the very early Universe created protuberances in the Einstein spacetime that carried away the protogalaxies [1B]. At first, their observed redshift was greater than 1 i.e. they were unobserved on Earth. But the protuberances were quickly dampened (so radial speeds of protogalaxies carried by them as well) whereas due to the quantum entanglement, photons emitted earlier by them must still have relative speed equal to c – it looks as an acceleration of the photons so there appears the redshift. It leads to conclusion that when relative radial speeds of such protogalaxies decreased below c (such galaxies we can see) then their redshift is higher than 1.

It is not true that the redshift higher than 1 is due to some relativistic phenomena. The observed acceleration in expansion of the Universe is an illusion because we apply the invalid relativistic formula for redshift: $z_r = (z^2 + 2z) / (z^2 + 2z + 2)$.

The two-component spacetime cannot expand because then the basic physical constants could change – it would destroy our Cosmos.

9. The answers to some questions

9.1
Why we must apply the orthogonal groups in physics?

The phase transitions described within the Scale-Symmetric Theory lead to the spinors. But why there is the action of the orthogonal groups on the spinors to obtain the spin representations?

The Scale-Symmetric Theory shows that a resultant spinor can emit the subspinors (for example, in the theory of baryons they are the carriers of gluons and the superluminal entanglons responsible for the quantum phenomena) in directions parallel to the spins of the resultant spinors and to the subspinors the resultant spinors consist of and they should lie on the equator of the resultant spinor. In the theory of baryons there arises a jet and the plane of interactions on which the equator of the resultant spinor lies. The plane is perpendicular to the jet. To describe the jet, we need one spatial dimension whereas to describe the plane we need two orthogonal directions because the spins of the different subspinors are perpendicular. The spin of the quantum loop responsible for the nuclear strong interactions is parallel to the spin of the resultant spinor but if we define it as the imaginary direction then we obtain the four orthogonal directions. But why we take into account only the equators of the tori? It is because only on the equator the spin speeds of the next smaller spinors are the same as in spacetime and fields (in the theory of baryons they are the carriers of gluons).

We can see that the action that leads to the spin representations, fully describes the interactions. We can investigate the spin representations to understand how Nature acts.

9.2
Why the zero-spin pions are responsible for the nuclear strong interactions?

The loops produced inside the torus cannot change the spin, internal helicity and charge of the torus in the core of baryons. This means that resultant spin, internal helicity and charge of the particles produced inside the torus must be equal to zero. It causes that there appear the binary systems of the quantum loops with antiparallel spins so the resultant helicity is equal to zero as well. Such binary systems of loops are the neutral pions [1A].

9.3
Why massless gluons and photons have different properties?

The gluons and photons are the rotational energies of the Es components. Their properties are different since their carriers, i.e. the Es components, have three different helicities/colours. Contrary to the electromagnetic field, the nuclear strong fields have internal helicity so we cannot neglect in such fields the internal helicities of the carriers. Just outside the strong fields the gluons behave as photons. The Scale-Symmetric Theory shows that there is one photon and 8 gluons [1A].

9.4
Why a gauge of the electric potential and a gauge of the vector potential cannot change electric charge?

The global symmetry of the Cosmos must be conserved so the absolute value of the electric charges of electrons and protons must be the same. Due to the two shortest range of the quantum entanglement between the neutrino-antineutrino pairs the torus of proton consists of (the coupling constant has tremendous value [1A]), it is practically indestructible and its density is much higher than the Einstein spacetime. On the other hand, the density of the other fields is much lower than the Einstein spacetime. This leads to conclusion that no gauge can change the electric charge of proton.

9.5
Can the dark matter be detected?

The dark matter consists of the additional entangled Es components that appeared due to the evolution of the core of the Protoworld [1A]. We cannot detect directly its components because we cannot distinguish them from the Einstein-spacetime components.

9.6
Is there possible a simultaneous flatness and curvature of spacetime?

Gravitational masses produce the potentials in the superluminal non-gravitating Higgs field. This field is curved by masses. The Einstein spacetime cannot be curved, it is flat [1B]. Since inertial mass density of the superluminal non-gravitating Higgs field is about 10^{-43} times lower than the gravitational mass density of the Einstein spacetime so the spacetime as a whole is flat.

9.7
What is shape of rotating black hole?

SST shows that there are not in existence black holes with central singularity, [1B], but there are in existence the modified neutron black holes (MNBHs) in which is a circle with spin speed equal to c. The observed black holes are built of the MNBHs.

When density of matter is sufficiently high then the Einstein spacetime inside a MNBH rotates with the same angular velocity as such black hole. This means that rotating black hole is in the rest in relation to the inner Einstein spacetime. This means that there is the spherical symmetry.

9.8
Are gravitational waves in existence?

Gravitational waves are not in existence because the gravity is associated with the superluminal non-gravitating Higgs field composed of the tachyons. Today, from the tachyons cannot be created any particles. It is the reason that quantum gravity is today invalid.

To change gravitational potential of a mass, the mass must emit particles having gravitational mass i.e. must emit the Es components. This means that there must be created radial outflows of dark matter i.e. flows of the additional Es components. It is possible when number of annihilating particle-antiparticle pairs is greater than created.

9.9
Is the interpretation of the formula $E = mc^2$ correct?

Due to the entanglons, the massless rotational energy of the Es components (the entangled photons or gluons) can behave in a quantum way i.e. there can disappear one configuration of entangled photons and appear another one, and so on. A configuration is entangled via the superluminal entanglons. When there appears a vortex of entangled massless energy E then due to the ordered motions (it is the vortex), the local pressure of the Einstein spacetime inside the vortex decreases. Since pressure in the Einstein spacetime must be conserved then there are the inflows of the additional Es components into the vortex that increase the local mass density of the Einstein spacetime i.e. there appears the gravitational mass m equal to E. Since the Es components are moving with the speed c so there is obligatory the formula $E = mc^2$. The correct interpretation of this formula is as follows. It is true that the massless energy E is "equal" to the gravitational mass but it is untrue that the massless energy E can physically transform into gravitational mass. For example, when an electron-positron pair annihilates then there appears the massless energy/information E whereas the mass m expands similarly as the dark matter in our Universe – the dark matter consists of the additional non-rotating-spin Es components that are entangled.

Emphasize that the Higgs mechanism shows how the non-gravitating tachyons transform into gravitational masses i.e. the Higgs mechanism has nothing with the interpretation of the Einstein formula $E = mc^2$.

10. The ultimate picture of particle physics and cosmology

Let us return to the action of rotation of orthogonal groups/spin-groups/matrices (generators) on column vector (spinor) that leads to the spin representations. Within such method we can investigate the properties/picture of the spin representations. Using other words, we can say that the column vectors on which the matrices act become a space of spinors. It can represent infinitesimal spatial rotations. They are very important in seeking the symmetries and next, the laws of conservation.

Concentrate on the field of the most sophisticated spinor in the Scale-Symmetric Theory i.e. on the zero-helicity-vector-cosmic-pair/spinor i.e. the protoworld-antiprotoworld pair (or, more precisely, the cosmic torus-antitorus pair). Its column vector should be complex with four complex components i.e. 4 real and 4 imaginary components. The Protoworld is left-handed whereas antiprotoworld is right-handed [1B]. The torus/supercharge is unitary. We can use the left-handed and right-handed two-component Weyl spinor to separate the descriptions of the Protoworld and Antiprotoword. Concentrate on the left-handed component – it is the Protoworld that created our Universe as the left-handed loop inside the left-handed cosmic torus [1B]. The column vector of the Protoworld looks as follows

$$\begin{pmatrix} \mathbf{a_E} + i\,\mathbf{b_{E\text{-}L}} \\ \mathbf{c_S} + i\,\mathbf{d_{S\text{-}L}} \\ \mathbf{e_D} + i\,\mathbf{f_{D\text{-}L}} \\ \mathbf{g_P} + i\,\mathbf{h_{U\text{-}L}} \end{pmatrix}$$

The i is the imaginary unit $i = sqrt(-1)$,

$\mathbf{a_E}$ defines the unitary spin of the entanglons,

$\mathbf{b_{E\text{-}L}}$ defines angular momentums of tachyons in their condensate to the closed loop,

$\mathbf{c_S}$ defines the unitary spin of the Einstein-spacetime components (neutrino-antineutrino pairs),

$\mathbf{d_{S\text{-}L}}$ defines angular momentums of the entanglons in their condensate to the loop inside the torus of a neutrino,

$\mathbf{e_D}$ defines the unitary spin of the neutron-proton(plus electron) pairs the torus of the Protoworld consisted of,

$\mathbf{f_{D\text{-}L}}$ defines angular momentums of the Es components in their condensate to the quantum loop inside the torus in the core of nucleons,

$\mathbf{g_P}$ defines the half-integral spin of the Protoworld,

$\mathbf{h_{U\text{-}L}}$ defines angular momentums of the protogalaxies (composed of the MNBHs) in their condensate to the cosmic double loop inside the cosmic torus [1B].

The limitations of such description of Nature are as follows.

10.1

In the above description is the lack of the three condensates in centres of the tori i.e. in centre of neutrino, core of baryons and protoworld. It must be described in some sub-theory.

10.2

In Quantum Theory of Fields, spinors describe the state of relativistic many-particle systems. It is not true. The objects $\mathbf{a_E}$ and $\mathbf{b_{E\text{-}L}}$ are classical and non-relativistic but superluminal.

10.3

There are the four loops that define the different times inside the resultant spinor and the different subspinors.

10.4

There are the three orthogonal spins i.e. of the resultant spinor (i.e. of the Protoworld) and of the next two smaller spinors (i.e. of the nucleon-nucleon pairs and Es components) whereas we cannot define direction of the spin of the entanglons on the equator of the Protoworld because their tori do not cross the equator in any point. This means that the particle-physics-cosmology theory can be the mathematically coherent theory when we neglect the first component in the column vector i.e. we must neglect the confinement and the superluminal entanglement both responsible for the quantum effects. Of course, we can describe the quantum effects but we must reject the resultant spinor i.e. we must reject cosmology.

We can see that within the methods applied in the Quantum Physics we cannot unify Quantum Physics with cosmology. It is possible only via the phase transitions of the superluminal non-gravitating Higgs field described within the lacking part of ultimate theory i.e. the Scale-Symmetric Theory.

To describe fully the Protoworld we need following Clifford algebra $C\mathrm{l}_{4,4}(\mathbf{R})$. Under the dogma that space must be 3-dimensional, such algebra is mathematically incoherent. But we can define in a coherent way some Clifford subalgebras. It leads to conclusion that there is not in existence an ultimate equation of Nature. There can be in existence only a set of coherent theories but each theory from such a set is incomplete. We can unify partially all the possible interactions only via the phase transitions of the non-gravitating Higgs field [1A].

11. Summary

The string/M theory, cosmology, General Theory of Relativity and Quantum Physics are the approximate descriptions of Nature. These theories do not lead to the complete and coherent theory of the succeeding phase transitions of the superluminal non-gravitating Higgs field so there appear many incorrect assumptions, wrong interpretations and many alternative descriptions of the same phenomena. Here we pointed the limitations for the basic method applied in the Quantum Theory of Fields associated with the action of orthogonal groups on column vector representing a spinor. Such action leads to the spin representations that we can investigate to decipher the structure, motions and interactions of particles.

Spinor can represent the half-integral spin of a quantum loop that returns to original position after 720 degree rotation. It is characteristic as well for the zero-helicity vector particles. This property, the theory of spinors itself, the classification of the Clifford algebras and the double-covers/spin-groups that are the Lie groups, suggest that succeeding phase transitions of the superluminal non-gravitating Higgs field can be in existence and it is the foundations of the lacking part of ultimate theory i.e. the Scale-Symmetric Theory. In the last theory there as well appear the scalar condensates and the imaginary part of Nature that appear in the classification of the Clifford algebras. Most important is the fact that larger spinors/particles consist of smaller spinors, and so on, and that there appear the simple mathematical objects as the tori/charges/spins/vectors and balls/condensates/scalars. The return to original position after 720 degree rotation leads directly to the proportions of the torus and next to the fractional charges *1e/3* and *2e/3*.

The succeeding phase transitions radically simplify the basic mainstream theories via elimination of the approximations and free parameters (the physical constants and the mathematical constants applied in physics are the free parameters in the mainstream theories). The Scale-Symmetric Theory points the incorrect assumptions and the wrong interpretations in the mainstream theories.

Here, on base of the mathematically coherent and complete theory of succeeding phase transitions of the Higgs field, we solved many basic problems.

The classification of the Clifford algebras and the succeeding phase transitions prove that Nature on its lowest level is superluminal, classical and non-relativistic. Within the Scale-Symmetric Theory, Clifford algebras and theory of spinors we can show how the only inertial-masses/volumes lead to the Principle of Equivalence. It is the Higgs mechanism. On the other hand, the Principle of Equivalence and the confinement forced by the Mexican-hat mechanism lead to the scalar condensates composed of the Einstein-spacetime components. Unification of the 7 different interactions is possible only via the theory of succeeding phase transitions. The succeeding phase transitions are indeed the lacking part of ultimate theory because it leads as well to the physical constants and the mathematical constants applied in physics and to a thousand results consistent or very close to experimental data. There are as well results that cannot be calculated within the mainstream theories as, for example, the masses of the nucleons and quarks and the free parameters applied in the correct parts of the mainstream theories. The Scale-Symmetric Theory is based on 7 parameters only – it is much less than in the Standard Model.

The complete and mathematically coherent theory of the phase transitions leads to the basic foundations of the quantum physics i.e. to both the confinement that follows from the Mexican-hat mechanism associated with the Einstein-spacetime components, and to the superluminal entanglement.

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