Speculation on a Unified Field Theory (UFT), Grand Unification Theories (GUT) and Supersymmetry and Superstring Theories

Richard L Amoroso[1] & Elizabeth A Rauscher
[1]amoroso@noeticadvancedstudies.us

The search for a comprehensive theory of the Universe, i.e. a theory of everything (TOE) has been the desire and attempted fulfillment throughout history. In this chapter, we cannot give a comprehensive description of this unfolding story but will present some of the lights from our perspective and particularly that of (EAR) from her Lawrence Berkeley National laboratory (LBNL) days when she was a graduate student and then a staff member in the Nuclear Science and Department of Theoretical Physics. She was one of the very few staff members, not only interested in particle physics, general relativity, astrophysics and cosmology, but also the nature of consciousness. Both of us have a passion to ken the Universe, which clearly includes conscious sentient beings. Here we address the issues in unified field theories that relate to our work in this volume on multidimensional geometries and their relationship to describing nonlocal, nonlinear, anticipatory phenomena. One of our motivations is to include a domain for the action and participation of the conscious observer and consciousness in general. The process of scientific discovery involves observation, data systemization and theoretical hypothesis and formulation about the observed data. The process of experimental examination and theoretical hypothesis and further tests of these concepts, leads to the development of scientific rules or laws.

Sit down before fact like a little child and be prepared to give up every preconceived notion. Follow humbly wherever and to whatever abyss nature leads, or you shall learn nothing. – Thomas H. Huxley

Eugene Wigner's curiosity about mathematics and its meaning, like many physicists, have put forward the idea that some of the most important concepts in physics, including that of quantum theory, owe their success to mathematical systems that have been devised without any idea as to what they would someday be applied to. "It is difficult to avoid the impression that a miracle confronts us here." Wigner wrote this comment in his paper entitled, The Unreasonable Effectiveness of Mathematics in Natural Science, 1980 – E.A. Rauscher

1. The Observer in the Quest for Truth

In any unified theory a reality, it appears to us its observer must be included (as, in fact, also chemistry biology and life). Does the unobserved universe really exist or as in Descartes' and Wheeler's views are observation and perception required for existence to exist? How are the observer and observed connected and what is observed and how is it observed? And what of the role of the observer / participator in the collapse of the wave function in the case of linear quantum theory, in the

Schrödinger's cat paradox? In the The Schrödinger cat paradox arose out of heated discussions in the 1930's as to what is quantum measurement and how the entangled wave function collapses to a single state solution. In this *gedanke*n experiment, a cat is contained in an enclosed cage. A radioactive source decay, which is a form of random number generator, (RNG) will determine the time at which a pellet containing a lethal gas such as cyanide is broken by a hammer set into action by the RNG that breaks to containment vile and kills the cat. The unobserved system has the wave function $\Psi = a\,\Psi_{alive} + b\,\Psi_{dead}$ that is two states for the cat's condition of cat alive and cat dead exist simultaneously which is the paradox. See figure 1. It is through an observation or measurement that collapses the wave function to either state Ψ_{alive} or Ψ_{dead}. The longer time goes on the more likely that Ψ_{dead} will be the observed state. But who really measures the state? The cat "knows" if it is alive and facetiously the cat "knows" if it is dead, if there is life after death, if there is life after death for a cat. What of the rat or gnat paradox? Is there a mutual subject – experimenter wave function collapse?

Who or what is conscious? Standard quantum mechanics deals with the additions summations of probabilities. If there are small nonlinear terms in the quantum theory, such as solving the Schrödinger equation in complex 8-space,, such that a shift in probabilities occurs which increases the likelihood of say b Ψ_{dead} if b is larger than a in the earlier equation. As Wheeler suggests, it is a participatory universe; the observer no longer remains passive. It is clear what one does to the Universe, such as in the photoelectric effect, the Compton Effect, etc. implies that one effect a system to observe it. Wheeler suggested that the Universe may not be able to exist without an observer as well as the observed. [1]

So how does the relative scale of a (human) observer effect the collapse of the wave function? The path towards a comprehension of physical reality involves the scale from the mini black hole to the size of the Universe and all in between. In figure 2, we present a scale from the size of the Universe, as it is conceived of in current physical theories. If the Universe is 10^{28} cm in size with a mass of 10^{56} gms, it fits the Schwarzschild condition of $r_s = 2GM / c^2$ where G is the gravitational constant, for a mass, M undergoing the gravitational collapse. The Universe, in this sense fits the Schwarzschild condition even though the Schwarzschild solution is an exterior solution. If the quantum form of space has a lower limit of a minus Planck black hole of $\ell = \left(\hbar G / c^3\right)^{\frac{1}{2}}$ also fits the Schwarzschild condition. The length ℓ is 10^{-33} cm.

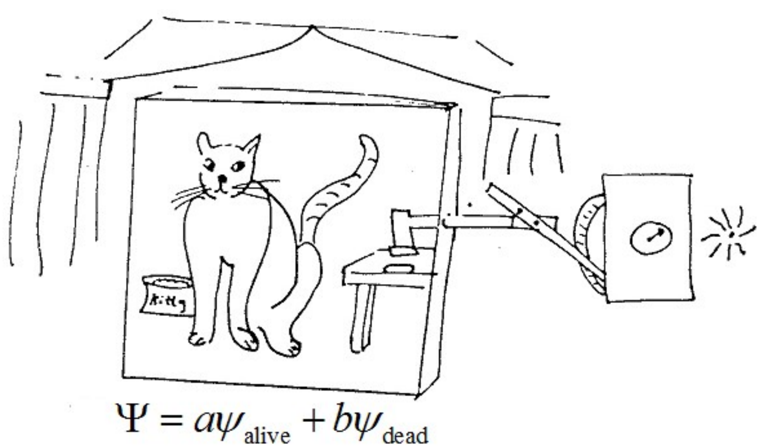

Figure 1. A depiction of the Schrödinger cat paradox. A cat in in a sealed box with air and a hammer that can break a cyan.ide pellet. The trigger for the hammer is set off by the nuclear decay of a radioactive element, which acts as a random number generator, RNG.

An interesting consideration in terms of interconnectedness in scale is Mach's principle. Mach's principle is concerned with the relationship of local phenomena to cosmic, large-scale phenomena. If a bucket of fluid is rotated, the meniscus (surface of the fluid) changes shape, from flat to parabolic. The faster the rotation, the more parabolic the surface becomes. Ernst Mach stated that the rotation of the bucket effects the surface of the liquid because the rotation is defined and occurs relative to the fixed star system (or the whole Universe). It appears that Mach's principle and other nonlocal phenomena display macroscopic as well as microscopic remote interconnectedness.

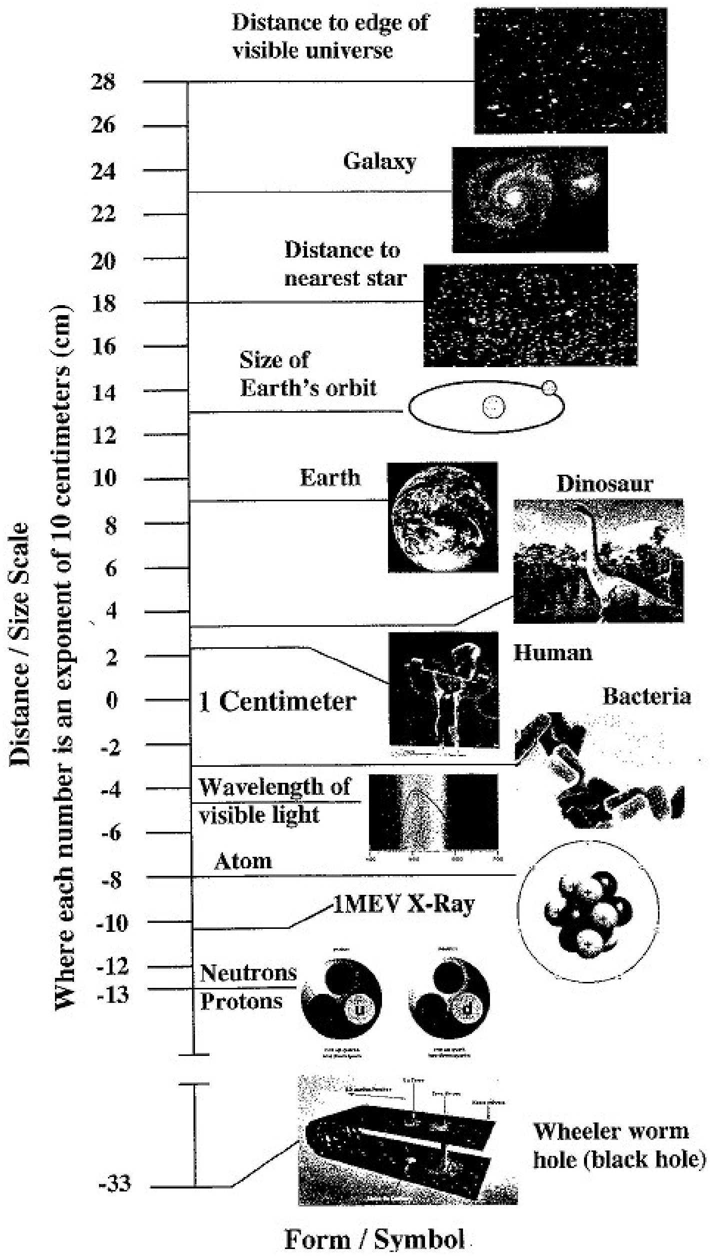

Figure 2. Represents scale of various small to large objects in the Universe. On the vertical axis, we denote the exponent x factor of 10^x (in cm) and corresponding to the vertical axis size scale is given some examples of objects of various sizes from the mini Planck black hole to the observable size of the Universe. Note that the observer human has a good vantage point of being roughly between $\ell_{mp} \sim 10^{-33}$ cm and $U_R \sim 10^{28}$ cm (The center of which would be $10^{2.5}$ smaller than a human.) The size scale of a form determines what symbology we give to create a thought content relative to our size.

Knowledge is an accumulation of facts, theories, concepts, ideas and beliefs. Throughout history there are those who pursued the path of reason (originating from the Greek word for ratio or relationship) and logic (from the Greek word for Logos or "the word"), which are the foundation of natural philosophy, currently known as physics. The origin of the word philosophy is lover of knowledge. Many scientists have contributed to our body of knowledge. We do not know of the useful knowledge that has been lost such as the burning of the Library of Alexandria. From the Greek, Egyptians, Ionians and other early civilizations have built the knowledge base of our social, political, military and academic institutions. The basis of science and the scientific method have evolved over the centuries [4,5].

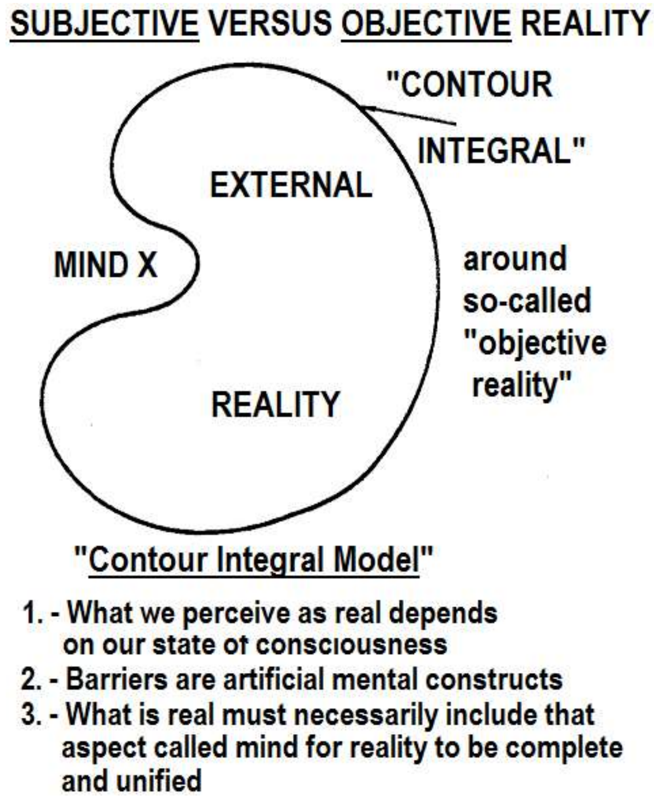

Figure 3. Subjective versus objective reality in the contour integral model

It is assumed that physics is the most fundamental of all sciences and its perhaps the basis for all human knowledge, using the precise and logical language of mathematics. Our current understanding of physics grows out of our attempt to understand the natural world and has been the result of accumulated knowledge by a succession of inductive and deductive inferences derived from observation and theoretical hypothesis and theoretical explanation and prediction and experimental confirmation. The concept of a unified theory of physics or a theory of everything (TOE) assumes there is a point at which the origin of everything is explained and also it can be explained in terms of a single obvious source. Since knowledge can occur when one does not know "things", that is, one can only learn what we do not already know or think we know. So is it possible for the dream of a "final theory of everything" possible or, as in the past, the process of learning is an ongoing process.

One can consider, as in the past, that objectivity involves what one knows, because that is all on knows what is in one's mind and that external reality is the subjective reality, i.e. the subject of one's study. Currently, we define objective reality as what is "out there" as fixed and immutable and that what one knows is subjective, incomplete and inaccurate knowledge of the objective reality. The objective reality, physics, biology, etc. but what of the mind/brain issue? Is consciousness just an epiphenomenon of brain neuronal activity [2]? We do not think it is just collective neuronal, glial cell activity and there is evidence it isn't. [3] Some features of conscious affection appear to act nonlocally. This in one of many attributes of consciousness as well as doing math, physics, science and creating civilization that leads one to an inevitable and reasonable conclusion that there is more to consciousness than the firing of a programmed set of neurons.

In Figure 3 we represent the objective view of reality as a "contour integral" of which the inside contains objective reality. The reality of the mind is excluded as some subjective entity not fully describable by that which lies within the contour integral. In the complex hyper dimensional space, the contour integral includes the mind.

- What we perceive as real depends on our State of Consciousness
- Barriers to new knowledge are artificial constructs of mind
- What is real must necessarily include that aspect called mind reality to be complete or unified

2. GUT, TOE Supersymmetry Models, Complex 8-Spacetime and Kaluza-Klein Theory

This chapter in not a comprehensive discourse on group theory and a detailed formulation of the foundations of physics, our purpose is to present enough background to the current approaches to fundamental physics and to demonstrate the manner in which the complex eight space and the Kaluza-Klein geometry, as well as spinors and twisters, occupy a basic role in the foundations of physics.

The Kaluza-Klein approach lead to the concepts of additional dimensions, XD which required consideration in developing a UFT or TOE theory. The foundation of the standard theory is group theory and, in the context of this approach, and that of the supersymmetry models, is group theory, which has greatly expanded our understanding of the vast accelerator particle physics "zoo" data. [6] In the supersymmetry models and superstring theory, the attempt is to include gravity to the GUT theories. The so termed standard model involves the three stronger forces, the strong, electromagnetic and weak forces of SU_3, U_1 and SU_2 respectively. Particles are split by their quantum number properties, that is for example, symmetry breaking effects are those that violate the invariance of a given symmetry scheme. For example, is that of change independence of the strong force which is broken by the electromagnetic and weal (electroweak) interactions of SU_2 x U_1. The supersymmetry models include gravity and comprise the TOE approach.

Current unification theories involve multidimensional geometries. Physicists currently are attempting to develop a unified theorem of the four major force fields, strong nuclear force, electromagnetic force, weak nuclear decay force, and the gravitational force. The mathematical model involving partial group symmetries leads to an 11D space in the GUT scheme, combined with the gravitational force, leading to the supersymmetry models. In some models, scientists consider a 24-element group is given in terms of spacetime and strong and weak interactions and the electromagnetic fields.

The GUT (grand unification theory) involves strong, electromagnetic, and weak force, and involves ten or more dimensions and ten or more Vector Bosons exchanged as a subset of the superstring model as $SU_2 \otimes U(1)$ and SU_3 where U(1) is the group of electromagnetic interactions with the exchange of a photon and electroweak interaction with an exchange of the three Vector Bosons $W_{\pm}$, Z^0 and the eight gluons of the strong nuclear force (holding nucleons together), obeying the group SU_3 so that we have the group of elements of 1 (of U(1), 2 (of SU_2), and 8 (SU_3) so we have 1+2+8 comprising an 11D GUT theory. To summarize, electromagnetic and weak interactions are combined as the electroweak interaction force, which combined with the strong force, or quantum chromodynamics (QCD) and this model, is termed the GUT model, which when unified with the gravitational field is termed the supersymmetry unified model.

In Table 1 lists various current formulations of the foundations of physics of particular interest is the U_4 are the 4-spacetime dimensions of $U_2 \times \tilde{U}_2$ for the complexification of M_4 space, the U_2 group is that of the 4D real spacetime and $\tilde{U}_2$ constitutes the imaginary 4D spacetime which comprise the 8D space, $\mathbb{C}_4$ which is a subset of the GUT scheme. For the 5D Kaluza-Klein geometry the electromagnetic space for U_1 is related to the proper orthogonal group of rotations SO_3^+ as a rolled up dimension of the order of the Planck length $\ell = \left(\hbar G / c^3\right)^{1/2} \sim 10^{-33} cm$. Table 1 lists some of the major tenets of group theoretical features for the unification of the four fundamental force fields. The GUT and TOE theories are examined. The complex $\mathbb{C}_4$ space, Kaluza-Klein and twistor spaces are examined as subsets of the GUT and TOE theories.

Table 1
ALTERNATE GROUP AND GUT THEORIES

- $S_4 = U(1) \otimes U(1) \otimes SU_2 \otimes SU_3 \otimes SU_3 = 11$
- $SU_5 = SU_2 \otimes SU_3 \otimes U(1)$
- 25-1=254 Permutations in Eddington-Klein Group $\overline{S}_4 = U_2 \otimes \tilde{U}_2 \otimes U(4)$ AND 24=4+4+16
- $\overline{S}_4 = SU(2,2/1)$ Penrose Twistor and Supergravity Matter Fields
- The U(4) are 4-Space and Time $U(2) \otimes \tilde{U}(2)$ for the Complexification of 4-Space

$$\left.\begin{array}{l} U(2): 4 \text{ Real Space and Times} \\ \\ \tilde{U}(2): 4 \text{ Imaginary Space and Times} \end{array}\right] \frac{\text{Complex Space as}}{\text{a Penrose Twistor}}$$

- Kaluza-Klein 5-space, U(1) Relates to SO_3 + Electromagnetic and Gravitational Fields and the Spinor Calculus
- The 8-Space Twistor Algebra is Mapable to the Spinor Calculus of the 5D Space

The approach is the supersymmetry models for the 11D space unifying the four force fields includes the strong force with SU_3 symmetry of the gluons or 8D and strongly interacting particles, the electromagnetic force, with U_1 symmetry of 1D and the weak force nuclear decay symmetry of SU_2 symmetry with 2D which comprises the 11D GUT picture. See Table 1 In Table 1 we present some of the recent approaches to the unified field theories such as the grand unification theory, GUT, and supersymmetry models. These approaches are related to those of Sirag [7], and Penrose [8] as well as the complex Minkowski space of Hanson and Newman [9] and Rauscher [10, 11]. See Chaps. 2 and 4. Rauscher has demonstrated the relationship of the Kaluza-Klein geometry and the complex eight space, which is related to the twistor algebra of the complex eight space through the spinor calculus of the Kaluza-Klein geometry or other spinor models. See Chapter 11. It is interesting to note that the triple torus, which comes out of the Calabi-Yau string theory, can also be constructed from the Penrose model [12-16]. See Table 2 for a schematic of the strategy for relating superstring theory to models of reality.

Table 2 the Strategy for Superstring Theories

- Superstrings in 11D (4D noncompactified and 7D compactified) relates the strong, electroweak and gravitational forces.
- The 10D supergravity involves the compactification on a Calabi-Yau manifold which is a 3-torus, $U_2 \times U_2 \times U_2$.
- The 4D "no-scale" supergravity and the Gauge group $\subseteq E_6$ predict Gaugino condensation in hidden vector space.

- Local supersymmetry, that is, broken gravitino rest mass, $\neq 0$ and rest mass $\neq 0$ produced by quantum vacuum state polarization.
- Effective low-energy theory in which Supersymmetric Gauge Theory yields non-zero particle masses, i.e. having gravitational effects which would require an expansion of Gauge conditions.
- Additional neutral currents and additional matter particles may require additional dimensions (XD).
- We await empirical results from the CERN supercollider, but more recent theories suggest 11 noncompactified dimensions, no superpartners (sparticles), no Higgs Boson, and no quantum gravity in the form currently sought. These parameters instead become topological conditions of the complex space.

Table 3 presents some of the superstring theories, in particular, the Calabi-Yau manifold and its relation to torus topology and the quantum vacuum. The concept of small but finite rest mass of the photon, m_γ is suggested by Vigier, Rauscher and others. Rauscher has demonstrated that the solutions of Maxwell's equations in a complexified Minkowski space, $\hat{M}_4 \subset \mathbb{C}_4$ also requires generalized gauge conditions and a finite rest mass of the photon, m_γ. The vacuum state polarization produces effects on quantum systems and perhaps larger non-quantum systems. Mathematical formulations which include material particles may require additional dimensions.

Table 3

FORCE	COUPLING CONSTSNT	RANGE (fm)	INTERACTION TIME	
8 SU(3)	Strong (Nuclear)	1 to 10	1 fm	10^{-23}
1 U(1)	Electromagnetic	10^{-2} to 10^{-9}	∞	10^{-21}
2 SU(2)	Weak (Decay)	10^{-11} to 10^{-14}	Short Range	10^{-6} to 10^{-9}
G (2)	Gravitational	10^{-39}	∞	∞

Table 3. Relative force strengths. The relative magnitude and range of the four major forces are given.

In Table 3 we list the four force fields of physics, the strong nuclear, the electromagnetic, the weak nuclear and gravitational force and their relative strengths or coupling constants. Also the interaction range and decay times are given. The relevant group theory is also noted in the first column leading to the supersymmetry 11D space theory [18].

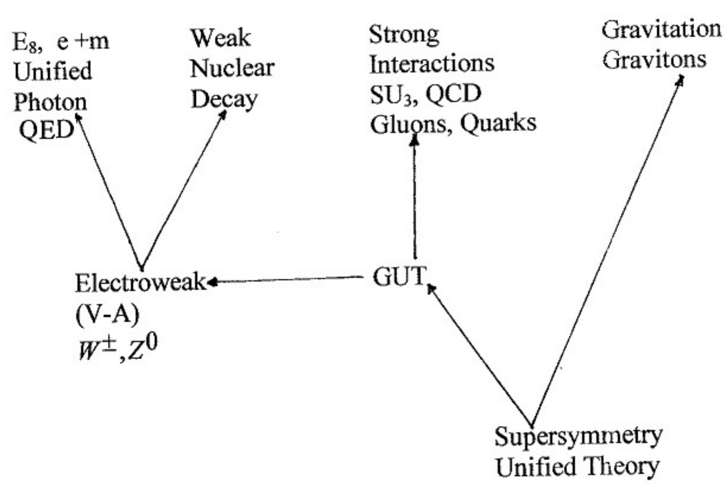

Figure 4. Unification schemes: The strong color gauge is $SU(10)_c$ can be decomposed into $U(1)_c \times SU(9)_c$. Symmetries is associated with conserved color components of the electric charge of fermions.

Invariance under the local gauge group SU_2 can be extended to larger groups SU_n. The Yang-Mills theory is a theory which is invariant under the local gauge group SU_n. Quantum chromodymics (QCD) is an extension of QED to include the strong force and is a Yang-Mills theory with the gauge group SU_3. [17] That is QCD is defined as the Yang-Mills theory with SU_3 as local gauge invariance. In this scheme, it is well known that the quarks are fermions and each flavor or type of quark has three internal degrees of freedom i.e. color. There are $n^2 - 1 = 8$ vector gauge fields or gluons. For the SU_n gauge group, each Fermion has n internal degrees of freedom and is coupled to $n^2 - 1$ vector gauge fields, g. As we know, Hadrons, which include strongly interacting particles which includes all baryons, π and K mesons but not the muons or electrons, μ or τ and neutrinos, ν_e, ν_m and ν_τ which are leptons or Fermions.

In Figure 4 is another manner of examining the relationship the four force fields (FFF) and current physical theories. Their interrelationship is denoted relevant to the current unified physics theories, under the supersymmetry scheme. The QED, electroweak, and strong force are unified under the GUT scheme. The QCD formalism is a strong force theory which allows the GUT theory, to be combined with gravitation, leading to the supersymmetry unified theory.

We enumerate the details of the standard 11D theory that incorporates the four force fields. This approach is basic to current the emergent TOE theories. In these theories the concept of dimension involves the usual extended dimensions of 4D spacetime and rolled up 7D spinor like dimensions such as in the Kaluza-Klein geometry. The essential aspects of the theory are:

- Kaluza-Klein geometry relates gravity and electromagnetics the additional 5th dimension as an internal dimension acts to create a charge, for a clockwise loop as a plus charge and counterclockwise a minus charge. One dimension is for the electromagnetic field and the other four is for the gravitational Minkowski field.
- The weak force involves the exchange of intermediate Vector Bosons $W^{\pm}$ and Z^0 in the Vector minus axial vector theory having 2 dimensions.
- The strong nuclear force, 8 charged particles for quarks, 8D for 8 gluons.
- Hence, the total dimensions is 1D for the U_1 (electromagnetism), 2D for the SU_2 (weak interactions), 8D (gluons and quarks for the octet and triplet of SU_3) is 11D. that is 7D plus spacetime (4D) for the four forces. In the GUT, the scheme implies a 10 or more Vector Bosons exchanged which is a subset of substring.

The following table lists some of the theoretical approaches that are utilized in developing a unified field theory.

- The properties and characteristics of the four force fields.
- Strong nuclear processes that involve strongly interacting hadrons (Baryons) with substructure, quarks and near massless gluons which transmit hadronic energy between the quarks.
- Symmetry triplet of quark, color SU_3. From the SU_3 type model, five flavors, three families.
- up (u) and down (d)
- charm (c), strangeness (s)
- top (t), and bottom (b)
- Left (L) and right (R) or dextral.
- Quark confinement in quantum chomodynamics (QCD), white color singlet are found in independent particle entities.
- Three primary color values of quarks which represent hadronic charge, threefold, triplet, R (red), G (green), and B (blue) and anti color counterparts, $\overline{R}$, $\overline{G}$ and $\overline{B}$. The three quarks make up a white particle or baryons as R, G, B and mesons are made up of quark – antiquark pair.
- Photons act as the transmitters electromagnetic energy; the symmetry group is U_1 where all

phase factors, that is, complex numbers of unit magnitude, and we have electric charge.
- spin 2 graviton, mediator of the gravitational force.

The foundation of the standard model is a fiber bundle which is a union of the usual 4D spacetime with an extended version of isotopic spin space. This picture is exemplified by the usual gauge conditions. The gauge transformation is characterized by gauge parameters. In the standard model, the four vector potential is quantized as the spin 1 Bosonic field, the photon. The fiber bundle is built from the usual 4D spacetime in which each fiber represents one of the groups U_1, SU_2. and SU_3 which include the strong, electromagnetic and weak forces. See Chap. 8.

Superstring theory accommodates a supersymmetry which relates Bosons and Fermions. Superstrings contain the supersymmetry model. The hope is in a "final theory" or theory of everything (TOE). When Einstein attempted to unify gravity and quantum mechanics, his concept and others was to find a unique set of equations with a unique solution. However, string theory allows 10^{100} or so possible vacuum solutions. So why does it appear we "live in" a unique universe? Maybe we do not according to some superstring models incorporating the Multiverse concept. [16]

In Figure 2.1 in chapter 2 also represents the current Multiverse that comes out of the superstring theory that accommodates supersymmetry (relating bosons and fermions) to string theory. Since string theory and superstrings do not provide a unique vacuum solution, this view is akin to the Copenhagen quantum view in which solutions remain unmeasured or entangled or as a Everett, Graham, Wheeler multiple universe or Multiverse model. This approach is one in which the does not require one of the vast multitude of string theories to be the only unique "our universe" correct string theory. String theory is current leading proposal for unifying quantum theory and relativity. In order to have a diffeomorphic manifold for relativity, particles are not considered as point particle, creating singularities, but a tine vibrating strings. The size of these rolled up dimensions, which are like the Kaluza-Klein electromagnetic, dimension are of the order of the Planck length $\ell \sim 10^{-33}cm$.

3. Lorentz Transforms and the Univesality of the Laws of Physics, Analyticity and Unitarity

Elsewhere we presented some of the major principle of modern physics. These are Lorentz invariances, analyticity and unitarity. Since we are address GUT and TOE theories, the principles are most applicable.

3.1. LORENTZ INVARIANT CONDITIONS

The principle of covariance states that the general laws of physics can be expressed in a form which is independent of the choice of spacetime coordinates and the essential physical contents of these laws are unchanged by a proper Lorentz transformation. The Lorentz group is defined as all real linear transformations,

$$X^{u'} = L^{\mu}_{\nu} X^{\nu} \text{ and } \det\left|L^{\mu}_{\nu}\right| = \pm 1. \qquad (1)$$

The laws of physics are independent of the choice of spacetime coordinates or the basis set of vectors of the space. For a Lorentz transformation we can write for $X^{'}_{\nu} = L_{\nu\mu} X^{\mu} + a_{\nu}$ for the inhomogeneous transformation or translation and rotation or for the homogeneous transformation $X^{'}_{\nu} = L_{\nu\mu} X^{\mu}$ which can also be written $\underline{u}^{'}_{\nu}\left(X^{'}\right) = L^{\mu}_{\nu} u_{\mu}\left(X\right)$ for covariant and contravariant tensors and mixed tensors another manner to state the above conditions is conformal invariances is the mathematical property which permits the using to be written in new equivalent ways.

For the metric of the space, $g_{\mu\nu}$ we have $ds^2 = g_{\mu\nu} X^{\mu} X^{\nu}$ and for the Lorentz invariance of the metric

$$g_{\mu\nu} L^{\mu}_{\alpha} L^{\nu}_{\beta} = g_{\alpha\beta} . \tag{2}$$

For gauge invariance we define a gradient

$$A_{\mu} = \frac{\partial \Lambda}{\partial x_{\mu}} \tag{3}$$

so that the potential does not change the fields by anything physically observable. See chap. 8 for the generalization of gauge invariance conditions.

Let us define a vector potential, A_{μ} form the electromagnetic fields,

$$F_{\mu\nu} = \frac{\partial A_{\nu}(x)}{\partial x_{\mu}} - \frac{\partial A_{\mu}(x)}{\partial x_{\nu}} \tag{4}$$

the gauge transform is given as

$$A'_{\mu}(x) \rightarrow A_{\mu}(x) + \frac{\partial A_{\mu}(x)}{\partial x_{\mu}} \tag{5}$$

The Lorentz condition yields $\frac{\partial A_{\nu}(x)}{\partial x_{\nu}} = 0$ and then the equation of motion becomes

$$\Box A_{\mu}(x) = 0 \text{ and } \Box \frac{\partial A_{\mu}(x)}{\partial x_{\nu}} = 0 \tag{6}$$

for free potentials, A_{μ}. Then we have the commutation relations

$$\left[A_{\mu}(x), A_{\nu}(x) \right]_{x=x'_0} = 0 \tag{7}$$

where we define $\partial_{\mu} \equiv \partial / \partial x_{\mu}$ as that $\partial_{\mu} \partial^{\mu} \equiv \nabla^2$.

3.2 THE ANALYTIC S-MATRIX IN PARTICLE PHYSICS

In analytic function is analytic throughout a region in a plane if its derivative exists at every point in the region. Analyticity is one of the principles of physics and particular relates to the solutions of equations of motion in the complex plane. Two major approaches to particle physics were at sway in the 1960's, 1970's and 1980's at LBNL where the S-matrix approach [19] and other was the field theoretic approach. [20] The analytic S-matrix and the field theoretic approach both had their advantages and disadvantages such as divergencies and singularities which the string theories attempting to resolve, but both have their usefulness and also their incompleteness. From the S-matrix days arose the Veneziano model, which led to the string theories. The field theoretic approach, using creation and destruction operators to describe particle interactions gave rise to QED and later QCD. The group theory formalism yielded great progress in understanding particle properties and their interactions.

The S-matrix is a unitary matrix which relates Ψ_i to Ψ_f so that $\Psi_f = SU_1\Psi_i$ where Ψ_i is the initial state and Ψ_f is the final state. The S-matrix analyticity properties, as well as Poincairé invariance and unitarity are implied by the observed characteristics of the real world, then there may exist one possible S-matrix compatible with Euclidian spacetime unlike string theory with its multiple possibilities. In view of the S-matrix theory of the 1970's, the partial bootstrap hypothesis [21] is that the observed hadron phenomena correspond to the unique Lorentz invariant, unitary, analytic S-matrix containing only singularities that correspond to particle states or only Regge Poles. The Regge trajectory and recurrence are paths of spin as a function of mass, s(m) that connects particles having the same Baryon number, B and I and Y spin numbers. The quantum number strangeness, S, hypercharge Y are quantum numbers assigned to hadrons to assure the law of conservation of strangeness to be formulated. Both S and Y are conserved by strong interactions as Y = B + S and $Y = \frac{1}{2}Q + B$ where Q is the charge for the I spin triplet *n, p*+ and Λ and for charge conjugation to antiparticles $I_z = Q - \frac{1}{2}B$

Experimental research indicates that S-matrix elements are analytic functions of the hadron momenta on which they depend. In the absence of zero-mass hadrons there is no bar to analytic continuation of complex values of momentum, energy, and mass, apart from isolated singularities required by unitarity. Among these singularities, simple poles correspond to particles, the pole position determining the particle mass, the residue determining a partial width which corresponds to the imaginary part of complex mass which means that the hadron is unstable, the imaginary part of the mass corresponding to the lifetime. There also occur various branch point associated Landau's work and related to the possibility that complicated reactions proceed through a succession of simpler reactions. Causality is ensured by the proper location of the Landau branch points [22]. The S-matrix constraint of "first-degree analyticity" requires postulation of no momentum singularities other than particle poles and Landau branch points. This third constraint has substantial experimental support, although its basis is not as compelling as that for the constraints of Lorentz invariance and unitarity.

The concept is that the fundamental constituents of matter are entities with distinct properties (elementary and composite particles) connected as a series of events in spacetime. The properties of particles can be described in terms of their quantum numbers. The location of the poles and cuts in complex momentum space of p_{Im} vertical and p_{Re} longitudinal coordinates yielded the particle mass and the residue of the pole gave the irradiative decay time. In formulating equations of motion, the manifold is diffeomorphic was plagued by infinities from the expanded series such as the e^{alg} = group elements and singularities in the domain. Then Veneziano model was the first attempt to develop a singularity free theory in the 1970's which led to the current Witton et. al. [16,23-25] string theories. The mathematics of the Veneziano model is similar to string theory. For hadrons the string size is similar to 10^{-13}cm but for gravity, the scale is of the order of 10^{-33}cm.

The nice idea of a unique solution such as in the S-matrix approach was soon lost in a morass of solutions and possibilities so that the concept of finding a single solution to a set of equations, which describes our unique only universe was lost and the Multiverse concept was born. This view also captures the essence of one way out of the Schrödinger cat paradox, that is it leaves the cat alive, Ψ_{alive} and cat dead, Ψ_{dead} but in alternate universes so infinitum! See Fig. 1.

3.3 CONSERVATION PRINCIPLE IN QUANTUM MECHANICS AND RELATIVITY THEORY

We briefly present some basic concepts related to conservation principles in the quantum and relativity theory. The U matrix is unitary and then $UU^+=1$ or $U^{-1}=U^+$ so that when

- Ψ is transformed as $\Psi^{'} = U\Psi$ leaves the operators the same so as $A' \leq \Psi \left| U^{1} A U^{-1} \right| \Psi >$ or
- the transform $A' = UAU^{-1}$ where A is a diagonal matrix which leaves the wave functions unchanged but both cannot be true.

So, U = U^{+} = U^{-1} and U is the identity element, $\underset{\sim}{I}$ where U^{+} is the Hermitian conjugate of U and U^{-1} is the inverse of U. A unitary matrix assures that the total probabilities $< \Psi \left| \Psi \right. >$ are conserved [28]. In the relativity theory, we consider the conservation principles for mass energy. In terms of the stress energy tensor $T_{\mu\nu}$ we have $\frac{\partial T_{\mu\nu}}{\partial x^{2\nu}} = 0$ that is, the divergence of the field vanishes. This can also be written in more compact notation as $T^{\mu\nu}_{,\nu} = 0$. Note that the rotation also used is $\partial_{\mu} \equiv \partial / \partial_{\mu}$ and $\partial_{\mu}\partial^{\mu} = \nabla^{2}$ are previously stated.

The principle of invariance leads directly to the conservation laws of physics such as the conservation of energy or mass – energy and the continuity equation. The continuity equation can relate to change, current and mass conditions such as $\frac{\partial \rho}{\partial t} + \nabla \bullet \left(ev \right) = 0$ where ρ can stand for mass density or current density Also for 4 spacetime $\iiiint \sqrt{-g}\, d\tau$ is an invariant for $d\tau = \prod_{\nu} dx_{n} = dx_{1}dx_{2}dx_{3}dx_{4}$ where index n runs 1 to 4. In relativity theory c, the velocity of light is an invariant or a constant. Under affine connections, transformations are linear and rotational in a uniform manner. Straight lines are carried into straight and parallel lines into parallel lines but distances between points and angle can be altered. Orthogonal transformations in five dimensions with metric (1,1,1,1,-1) and transformation matrix determinate, det = +1 is the S0(1, 4) group. The Lorentz group SO(1,3) is similarly defined relative to the 4D Minkowski space with the metric (1,1,1,-1).

4. A Brief Background on Group Theory

Unification theories have their expression in group theoretical terms. Group theory comprises a powerful tool for codifying the basic symmetry observed in physics from elementary particle interactions to crystals, to flowers, to tornados and hurricanes to galaxies. The basis of physical law is the formulation, in terms of variables and constants of the relationship, constancy (conservation),and symmetry of the physical universe. Both finite groups with finite algebraic generators of the group and Lie groups with infinitesimal generators of the group, which comprise the algebra are extremely useful mathematical tools.

Group theory is based on point group sets, continuous groups which the foundation of the GUT scheme. There are three types of simple reflection spaces; these are A, D, and E and there are two infinite series reflection spaces A and D. We also have the finite discrete point groups or crystallographic groups. It may be possible to form an analogy between the formation of such a crystal as an example of symmetry breaking which is analogous to the spontaneous symmetry breaking in the GUT theory. Let us form some analogies,

- Symmetry for the crystal of rotational invariance analogous to GUT is electron, photon and quark indistinguishablility under the three force interactions,
- Spontaneous symmetry breaking in the crystal which has axes chosen from three distinct directions and in the GUT theory, the Higg's field chooses out three distinct particles i.e. the electron, photon and quark also the three distinct interaction force fields as displayed in the SU_3 scheme

- At low energy, less than 100 GeV of ordinary particle interactions, for the crystal, three fundamental axes of space, for the GUT theory, yield three distinct particles, the electron, neutrino and quark, and
- High temperature "Big Bang" physics for the crystal-rotational invariance is restored, for the GUT theory, phase transitions at $T \approx 10^{27}$ degrees Kelvin ultimate symmetry is restored i.e. there is no separation of the four force fields. This is presumably the case at the time of the initial "Big Bang", the mass density is $\rho = 10^{93}$ gm/cm^3 at t~10^{-44} sec [29-31].

The basis for modern group theoretical description of based on the work of Sophus Lie in the 1890's [32]. His work was on infinite groups which have infinitesimal groups generators and infinite elements. Most group theory is involved with groups having finite elements and are based on the crystal group description [33]. A continuous group is defined as a system of objects called group elements which can be characterized by parameters varying continuously in a certain region. To every group element corresponds a set of values of the parameter within a specific region. These regions are called a group space. There is a one-to-one correspondence between group elements and points in group space. Group elements, whose parameters differ only slightly from one another, are said to be "adjacent". The products and reciprocals of adjacent elements must also be adjacent. The laws of associative law, identity element and inverse remain valid, being supplemented by the requirement of continuity. If the parameter changes continuously, we say that the group elements change continuously. Groups whose elements can be denoted by n parameters are known as n-parametric group. The region of variability of the parameters can be simply or multiply connected. The portion of the group to which the identity element is known as the infinitesimal group.

For particle physics Lie groups are particularly applicable [34,35]. We can use the short hand notation that $e^{\text{alg.}}$ = group, that is for example

$$e^{tA} = \sum_{n=0}^{\infty} \frac{t_n}{n!} A^n \tag{8}$$

where the group elements form a Taylor series and $\underset{\sim}{A}$ is a square matrix representation of a group or A_{nm} where indices n = m. If we have $e^{tA}e^{tB}$, e^{tA} can be used as a unitary transformation (such as to conserve the elements of the system) as $e^{tA}Be^{-tA}$ then e^{tA} = U, a unitary matrix of $U_{mn}^{-1} = U_{mn}^{+}$. In an *nxn* square matrix, *n* is the number of degrees of freedom, then *A* and *B* are matrices that obey commutation relations. For example $\Omega_n(A,B)$ form commutation relations such that the transformation preserve operators. Then $\Omega_0 = (A,B) \equiv B,\ \ \Omega_1(A,B) = [A,B]\ \ and\ \ \Omega_2(A,B) = [A,[A,B]]$ or in general $\Omega_{n+1}(A,B) = [A, \Omega_n(A,B)]$ which are the formal power series as the group representations. We have

$$e^{tA}Be^{-tA} = \sum_{n-0}^{A} \frac{t^n}{n!} \Omega_n(A,B) \tag{9}$$

and as we said e^{tA} can comprise a unitary transformation as $e^{tA}Be^{-tA}$ = B'. If B is a similarity transformation then B`=UBU$^+$=UBU^{-1}. We can say that there are elements of $\alpha x_i \supset A$ and x_j are the elements of B as $x_j \supset B$. In general terms $e^x = 1 + x + x^2 + x^3 \ldots x^n$.

Unitary operators preserve normals of vectors; for $\langle U\Phi | U\Phi \rangle = \langle \Phi | \Phi \rangle$ where $< \Phi|$ is a bra vector and 1 Φ > is a ket vector. For A and B commuting we have [A,B] = 0 and we can write U = A + i B so that A = ½ (U + U^+) and B = = ½(U – U^+) for $U = \frac{1+iK}{1-iK}$ for U = iK where A is Hermitian and generates a complex space, see Chaps 2 and 5. The SU_2 group is the symmetry of charge independence associated with isotopic spin rotations in charge space to account for the two charge states of the nucleon, n or p^0 and p^+ which is compared with the two spin states of the electron e^+ and e^-. The SU_3 symmetry group, the special unitary group in 3D correspond to the unitary unimodular transformation of charge and hypercharge. The quark triplet and antiparticle triplet, that transforms into each other under the SU_3 transformation which have fractional electronic charge and baryon number. Quarks have the same isospin and strangeness as the proton, neutron and lambda particle, Λ.

The conserved quantities of a system will prove to be invariant under the symmetry group considered such as the group of rotations U = $e^{i\Theta J}$ where J are the generators of the group. For example, for $[J_+, J_-] = i\sigma_z$ which for the algebra of the group. Both J as $(J_\pm, J_z)$ and I or $(I_\pm, I_z)$ are generators of the SU_2 group, where O_3 + is the cover group of SU_3 with generators for the type $[I_+, I_-] = iI_z$. The triplets, octets and decaplets of particle groupings have mass splitting or mass difference because of the preserved of the all pervasive Higg's field. Note that in the 1970's other larger groups were considered but found to be insufficient for a unified field theory including SU_6 and $\tilde{U}_{12}$ [35]. The A_4 reflection space was utilized by Georgi and Glashow to unify the three main non-gravitational forces. [13] The dimensions were allocated as electromagnetic 1D, weak force 1D and strong force as 2D in which were developed the GUT theory using SU_5. The SU_3 group theory predicts the mass splitting and quantum numbers of the octets and deceplets of the strong color force but is non relativistically invariant. The J and I spins SU_2 are conserved but are not completely conserved in SU_3. For example for a Hamiltonian operator H then UHU^{-1} for U, a unitary transformation [U, H] = 0. For a unitary group for SU_3 then these transformation $[U, H] \neq 0$. If H = H^+, then H is a Hermitian operator and if $U^{-1}_{mn} = U^+_{nm}$ then U is unitary. See Chap. 3 on the principles of modern physics and in particular conservation laws and unitarity.

As we stated, fundamental geometrical forms and their group representation and interpretation are based on the relationship between finite and infinitesimal groups. Some descriptions of groups can stand for either finite point groups such as A_n and the exceptional groups, E_n but also these group labels can designate the infinitesimal Lie groups. For the finite groups we have the self dual tetrahedron A_4 group. The octahedron S_4 system is dual to the cube and the icosahedron has its own group A_5. Symmetry groups act on vertices as permutations into themselves thus describing the geometric figures' form. These solid geometric point group systems can be related to the formalism of modern physics. For example, the stellar octahedral as a "mirror image" of the cube represents the eigenvalues of the strong color (quark) force. The eight vertices denote the three quarks and three antiquarks for the $\nu + e^- -\rightarrow \underline{\nu} + e^+$ reaction, yielding the correct electrical quark charge of 1/3 and/or 2/3's. The cube octahedron with twelve vertices contains the eigenvalues of the U(1) and SU_3 or the SU_4 group, which is a 15 elements group i.e. the 16 element, 16-1=15 with the identity element. Particle mass splitting is associated with a reflection like space based on the lattice groups where the points are eigenvalues. Lattice spaces are related to the reflective groups, A_3, B_1, C_2, C_3 and G_2 to Lie groups, special unitary, SU_2, SU_3, and SU_5 and orthogonal groups O_2, O_3 and their geometric forms and the unitary U_1 group. For example, the G_2 group is associated with a dodecahedral structure and the orthogonal O_n group includes the two superimposed reversal triangles.

Symmetry groups and their operation are fundamental to modern physics. We examined the possible mappings, of compact Lie groups on a manifold to C_n. It is possible to choose a smooth C^∞ which is infinitely differentiable to compare or map to a crystal symmetry group lattice space C_n of E (the Euclidean group). The subgroup $K \subset E$, transforms C into itself, K is a discrete subgroup of E such that we have a homogenous space E M K or E:K where E is mapped onto K. That is we find a representation C^∞ that has a subgroup of C_n so that we can find a mapping that allows the smooth operation of a compact Lie algebra with all its entailed properties and infinitesimal generators to the crystallographic finite discrete algebra of C_n. It appears that this single mapping or morphism is possible because of the symmetry breaking in the Lie algebras of SU_2 since these groups then approximate finite discrete point group sets.

Current physics is based on symmetry principles and conservation laws which describe the objects and process. These symmetry principles and conservation laws are expressed in the algebras that generate the groups in both the broken symmetries of particle physics and the operations principles in crystallographic point group sets. These operations describe the structure of and processes in the space being considered. These operations involve translation, rotation, reflection, inversion and reciprocity or reciprocal operations. Note that this is the type of group theory "Bookkeeping" that also applies to crystallographic sets.

The symmetry properties of the Lorentz group of the Lorentz transform-ations is fundamental to the concept that translation (Lorentz group) and rotations (inhomogeneous Lorentz group) do not modify the laws of physics. This is related to the general principle of experimental physics and the observation of the results of experimentation and observation, that when and where an experiment is conducted leads to reproducibility. This is more difficult for complicated experiments which require knowledge of the "state of the art".

The group SL(n,c) is a subgroup of GL(n,c) formed by the matrices of a determinant one. This is where the Lorentz group of Lorentz space-time operations comes in. For n=2 on the Minkowski light cone the operation of SL(2,C) on E_{n^3} =E (Euclidean). The center Z_2 of SL(2,C) acts trivially and the quotient group SL(2,C)/Z_2 acts effectively as the isomorphic group connected to the Lorentz group with the conjugate group SU_2. The Lorentz group algebra is the set transformations that allow the Laws of Physics to remain invariant under the set of space-time transformations under physical processes. The group generated by the translations and the connected Lorentz group transformations is the connected Poincairé group. See Chapter 3. Then space-time is one orbit of this group; the stabilizer of any point 0 is the Lorentz group leaving 0 the origin fixed.

Mappings on a sphere as an ultimate symmetry figure abstracts is of important. We can relate E, SO_n, SU_n and U_1 and U_2 type groups to GL(n,C) type groups. Consider the transformations or actions of our groups on a sphere. On a sphere we have a center, equator including the center and a vertical axis or pole through the center perpendicular to the plane of the equator. For the relationship of SO_2 (spherical rotation group) and S_2 (spherical group) of 2 dimensions their orbits one parallel circles is 2 dimensional. The two poles are fixed point and the so termed "little group" SO_2. The action SO_2 on S_2 has a symmetry through the center, having no fixed points, each orbit with 2 parallels with the same N (up), S (down) latitude, one orbit and 2 poles, and the equator.

Although superstring theories have their critics, due to the fact that those theories contain a large number of "free" parameters, there has been great interest in these theories by the physics community. Superstring theory has been related to the standard model. Some string theories contain gravity and others do not. One of the major features of superstring theory is to treat particles as tiny loops rather than as point particles so as to avoid the problem of singularities. In the string theory, particles are treated as vibrations of a membrane (M-Brane surface), which is swept out by the vibrating string occurring in 8D space. These eight dimensions comprise 8D of the 10D standard model in which two of the dimensions are the string surface itself. This vibrational space carries the symmetry of the Lie group E_8. Superstring theory represents both bosonic and fermionic particle states. The usual string theories occupy a 26-dimensional spacetime, representing bosonic particle states. A quantum state of identical bosonic particles is symmetric under the exchange of any two particles. A quantum state of identical fermionic particles is antisymmetric under the exchange of any two particles which includes the photon and gravitation. Then we have $8 \times 8 = 64$ dimensional states in some superstring theories. The closed string theory is called a type II string theory, which has the doubly fermionic states included, for a total of $2 \times 8 \times 8 = 128$ fermionic states.

In addition to the Type-II string theory, there are two heterotic superstring theories which involve closed strings. Out of the 26-L bosonic coordinates of the bosonic factor, only ten are matched to R-bosonic coordinates of the superstring factor, hence this theory effectively exists in 10D spacetime. Heterotic strings comes in two versions, that is $E_8 \times E_8$ and the SO(32) type. The vacuum is included and E_8 is the highest dimensional exceptional group. The E_8 x E_8 superstring theory is derived from the compilation of M-Theory. One of the most promising superstring theories that unifies the four forces is the E_8 x E_8 reflection space. This is possible only because reflection embedding provides for an embedding of A_4 in E_8. the relationship between the SO(32) heterotic string theory also utilizes the E_8 x E_8 formalism [14].

In general, the Lie algebra, A_n associated with a reflection space C^n has a compact Lie group SU_{n+1}. Sirag attempts to develop an interesting unified field theory in terms of U_1 x SU_2 x SU_3 x SU_4 where he identifies the SU_4 group with the tensor gravitational field [7]. The SO(32), or SO_{32}, is the group generated by 32-by-32 matrices that are orthogonal. For the strong force, gluons are described by a four-dimensional SU_3 Yang-Mills theory. [20] The full set of standard model gauge bosons is described by the Yang-Mills theory with the gauge group SU_3 x SU_2 x U_1. Alternatively, for the $U_5 = SU_2$ x SU_3 Yang-Mills theory, the gauge group that emerges as U_3 x $U_2 = SU_3$ x SU_2 x U_1 x U_1 where U_1 x U_1 is the topology of the torus.

The complex spacetime is implied in the group algebra C(OD). Embedded in this algebra is the unitary group U_2 x U_2 which Sirag gives the name complexified conformally compactified spacetime [7]. This is the exact spacetime required for twister theory [8] and there is a profound connection between twister theory and superstring theory approach to quantum gravity [14,37]. Any quantum gravity theory is considered to exist in at least 10D. As we stated the superstring theory replaces the point particles with vibrational modes of strings. The most popular version of string theory is the E_8 x E_8 Lie group which is a 496 D space hyperspace. The dimensionality of E_8 is a 248 D hyperspace and the full symmetry group of the standard superstring theory is a product of two E_8's as E_8 x E_8 with a dimensionality double that of E_8 or 496 D. For the product of two groups, the dimensionality of the space adds.

Some of these theories will be put to some replicative test and new tests with the advent of the CERN Hadron Supercollider may soon come into extensive use. The LHC collides two 6×10^9 proton beams every second and is considered at 7TeV to reproduce the conditions at $t \sim 10^{-12}$ sec. after the Big Bang which is the implicit model. This is the era when mass condensed out of thought to be the radiation fields. The LHC may also yield clues about the so-called extra curled up dimensions as well as our approach to hyperdimensional geometries. In the spring of 2010, the CERN large hadron supercollider (LHC) brought together two proton beams with sustained collections. The two proton beams, each having 3.5 Tev electron volts combined 7 Tev is by far the largest and highest energy collider in the world and is expected to produce the energy for particle creation. It is 27 km in circumference using superconducting magnets to steer the beam. The search is on for the Higgs boson where the matter creation era in the Universe's evolution occurred. Perhaps other dimensions may be experimentally explored through the determination of possible properties of the so termed dark matter. In addition, it is hypothesized by some that mini or Planck unit black holes may be created and decay rapidly.

Phenomenological models treat the mini or Planck unit black holes with their self energy and Hawking like radiation effect so that the Tevatron LHC energy would be high enough to create short lived and detectable black holes with the Tevatron LHC. Their predicted size is about 10^{-6} or more times smaller than a proton. Various researchers debate the lifetime of the LHC produced mini black holes from extremely short to about 10^{-3} sec. The lifetime depends on the nature of the self energy and the rate of the evaporation by the emission of Hawking-like radiation which involves a γ going into an e^+e^- pair at the event horizon [38]. The bare Plank mass of $\sim 10^{-5}$ gm is exceedingly large compared to the free particle proton mass of $\sim 10^{-24}$ gm. Also, the extra dimensions arising from the background metric is of interest as in these experiments. Many researchers conjecture that these experiments will confirm the existence of mini black holes and the predictions of Hawking radiation and thus hold clues about the very nature of the fabric of space itself.

Well over four thousand papers have formulated and detail their concept of the LHC high energy collider factory of mini black holes. The Hawking radiation is expected to be observed as high energy photons (γ and x-rays) and leptons from the subcomponents quarks or partrons of the accelerated hadrons (protons) in the center of mass of the LHC colliding beams. Some researchers treat the produced mini black holes as the sudden decay of the Schwarzschild black hole state, and other researchers include charge and angular momentum, i.e., using the Reissner-Nordstrom or the Kerr black hole. The rotating charged Kerr-Newman black hole requires a much more complex calculation for the cross section of black holes production in the LHD collisions. Some of the original motivation for constructing super high energy accelerators was to find the massive Higgs boson. Now much of the current effort at the LHC is the search for mini black holes. Both the Higgs particle and mini black holes are fundamental to the construct of a unified model of the four force fields. The Higgs field elementary particles and quarks may be describable in terms of the mini black holes.

The standard unified model of current physics requires the existence of the elusive Higgs boson. Higgs suggested that space was filled with heavy molasses like substance, currently termed the Higgs field. [29, 30] This field may be associated with a massive boson particle around 80-120 GeV. It is hypothesized that such a particle gives all particle their mass as they interact through the mediator particle, the Higgs boson. This yet undetected particle was used, as is the mini black holes, to explain the missing dark matter in the universe and may be revealed in the LHC accelerator experiments. The existence of the mini black hole production from the vacuum energy may be observed through a process analogous to Hawking radiation from astrophysical black holes such as the Dirac vacuum. While the carriers of the electroweak force, i.e. the $W^{\pm}$ and Z^0 bosons have mass unlike the photon mediator of the quantum electrodynamics, photons are abundant whereas the electroweak bosons are not. Diligent work at the CERN-LEP accelerator has not revealed the elusive Higgs boson. This work has been part of a 30-year quest that, in part was the motivation for the construction of the LHC. But now a major emphasis of the work on the LHC has turned, in force, to the search for the mini black holes as the mediator particle that fills all space in analogy to vertical vacuum pair production (or mini black holes) from an energetic vacuum having a theoretical density of 10^{93} gm/cm^3 [37]. This picture yields a unification of the compatibility of QED and QCD from the early universe and as yet may be revealed in the LHC high energy experiments in the current universe.

The revolution of the prediction and observation of the mini black holes in accelerator physics will yield a much more exciting and rich find, in that now gravity can be taken into account in terms of quantum gravity, but also that gravity is unified with the strong and electroweak force as in the supersymmetry models. A new basis of a unified theory model through the mini black hole model relate, to the massive black hole of stellar and interstellar space, exploring the so called missing mass problem in cosmology [39]. Through this theory, incorporating the existence of a vacuum field of mini black holes, a unified view can incorporate gravity which utilizes the plenum of a full vacuum concept. We suggest a dual 3-brane model in which one contains the standard model fields and the other model incorporates the spin-2 graviton excitation including the vacuum energy which acts as part of the gravitational field force fields. In the quantum gravity picture, the universe may be full of HD string theory objects. These dimensions are termed branes from membranes or 2D+ spatial strings.

It is important to consider Gödel's incompleteness theorem when considering the possibility of the development of a TOE theory. Loosely stated no mathematical system can be completely self described since all the rules necessary for describing the system cannot be stated within the system. because there are more truths of a mathematical system than axioms for an algebraic system. Gödel's theorem has been demonstrated to apply to algebraic systems and geometric systems which are open and incomplete systems within themselves. Since mathematics is our tool for describing a theory of everything (TOE) as a complete theory and perhaps a complete truth, what happens if our tool, mathematics is necessarily incomplete? It is clear that structure of a TOE theory in the form of a complete theory must have within it the manner in which to address Gödel's incompleteness theorem [40].

The authors would caution to not be too hasty and quick to judge that we are soon to reach a final theory. There are many conceptual and mathematical issues to be resolved. There have been many eras in history in which led to a rude awakening to new knowledge and wondrous new discoveries to be made. Knowledge and the search for truth is an ongoing process [41].

In most societies, people tend to believe they have "complete" or "near complete" knowledge of philosophical and religious beliefs and scientific knowledge and in some cases, they know all they need to know. There are always knowledge seekers who look beyond and search for the deeper meaning, interpretation and data gathering with its organization into theory. These seekers and listeners to the heart beat of nature will ever expand our view of us and the Universe.

A brief consideration should be made as to the manner in which scientific exploration expands and it is not all an orderly process. In 1899, the Commissioner of Patents suggested closing the Patent Office because almost everything had been invented! Yet many more inventions were made and patented, some by the authors of this text. After an illustrious career, Lord William Thomson Kelven retired in the 1880's. He announced that all the discoveries in physics had been made and that all that was to adjust the last decimal point in various measurements and hence students should not go into physics. He also pointed out that there were two blots on the horizon of physics. One was the interpretation of the Michelson-Morley experiment [42] and the other was the problem of the fit of the Rayleigh-Jean's law of black body radiation called the ultraviolet catastrophe [43]. The first, is said, to have led to the relativity theory and the second to the quantum theory through Max Planck's correct fit with the introduction of his, Planck's constant, $\hbar$. One should always be suspicious of statements such as "we almost know everything". Such a position is almost always a gateway to a new scientific revolution! The end of civilizations and the beginning of new ones most likely grow from such a hypothesis. Major changes in thinking such as the Copernican revolution as well as the advent of the quantum mechanics and relativity have vast philosophical as well as scientific effects so as to create a paradigm shift in thinking.

We believe we are heading for a crisis and hence a revolution I physics. For example the non understood hypothesis of dark matter and dark energy, Higgs particles and mini black holes, etc point to the need for a deeper more thorough reexamination. But through crisis comes new knowledge through the resolution of crisis and to the next deeper knowledge, ourselves, life existence and truth. We hope that our work is another step towards a new and viable approach that, as the uncertainty principle did, nonlocally does by discovering and formulating another truth and in some manner which incorporates the observer and observed in our ongoing glory of discovery [44,45].

Grand unified theories (GUTs) are an attempt to unify the mathematical description of the electromagnetic and weak force (electromagnetic force) with the strong force. Supersymmetry models, string theory, the "theory of everything" use GUT theories to form a unity with the gravitational force (a spin 2, tensor force). The GUT description finds its origin with James Clerk Maxwell's unification of electricity and magnetism. A further major step was taken with the development in the context of the quantum theory is the theory of quantum electrodynamics (QED). No GUT theory comprises a complete theory even an adequate unification and, of course, does not contain gravity, which is necessary for a so termed "theory of everything". String theories are notorious for not containing uniqueness and a huge number of such theories exist. No complete, comprehensive and unique supersymmetry, string theory or "theory of everything" (TOE) exists. The progress to a TOE is desirable but needs to proceed with caution. We would be most hesitant to embrace a TOE as it appears that knowledge is an ever expanding. Our work is a path to new knowledge, which leads us all to newer knowledge and truths. The fundamental question is can we find "the truth of everything" or only relative greater truths. What one sought and found as true yesterday, with new knowledge and new data, guides us in a new direction today, and tomorrow! Like traveling on towards a rainbow as it ever moves from us as we approach.

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