Preprint: in RL Amoroso, LH Kauffman, P Rowlands (eds.)
Fundamental Physics at The Vigier Centenary*: "L'Hérétique de la Physique" Lives On,* World Scientific Publishers, London, 2020

The Dirac Electron Hypertube Revisited Nonlocal Parameters Within Extended Particle Elements

RICHARD L AMOROSO and JEAN-PIERRE VIGIER

Noetic Advanced Studies Institute
902 W 5400 N
Beryl, UT 84714
amoroso@noeticadvancedstudies.us

Traditionally, elementary particles, by definition are considered zero-dimensional (0D) or point-like elements; strings or branes on the other hand are dimensionally extended entities. Dirac's electron hypertube model appears to provide insight into this duality. Recent attempts to consider isolated particles and real constitutive wave elements as localized, extended spacetime structures (i.e., moving within time-like hypertubes or M-Theoretic higher dimensional (HD) brane topologies) are developed within a causal extension of the Feynman-Gell-Mann electron model. These extended structures contain real internal motions, (i.e., internal hidden parameters) locally correlated with the "hidden parameters" describing the local collective motions of the corresponding pilot-waves. The Dirac electron hypertube has been missed by the uncertainty principle. Recent experimental evidence and new protocols for supervening uncertainty are discussed.

1. Introduction

The Dirac electron hypertube model was for the most part, ignored in his day and essentially slipped into obscurity, primarily because of the strength of the mystery surrounding an idealized 0D point particle without spatial extension. Now on the cusp of imminent paradigm shift to a 3rd regime of natural science – an Einstein Unified Field Theory (UFT); the local-nonlocal duality inherent in the Dirac electron hypertube inspires new testable theory. We propose spatial extension in wave-particle duality has been hidden behind the uncertainty principle.

Recent developments in the causal stochastic interpretation of Quantum Mechanics are presented to aid interpretation of new observations in Electromagnetic Theory (EM) associated with O(3) invariance and photon mass, m_γ [1-5]. These *hidden* parameters describe internal motion within extended particle elements associated with a Feynman-Gell-Mann type causal electron model. They are related in this work to an extended version of the causal stochastic interpretation of electron theory based on the introduction of real internal spinning motions within the particles, and guiding pilot-wave constitutive elements. This procedure can be interpreted as a local correlation between these new internal motions and the "hidden parameters" describing the collective external pilot-wave motions already introduced to represent the Feynman-Gell-Mann pilot-wave motion [6].

This attempt to re-examine electron theory in the causal interpretation of Quantum Theory in terms of new internal and external motions is justified by the set of problems and questions left open after the astonishing success of QED predictions. Here we mention only:

- The problem of the electron's size (i.e. the discrepancy between its Compton radius $R_C \cong 10^{-16}$ cm and the point like behavior $(R_c$ (charge) $<< R_c)$ of its EM charge in high energy EM scattering (tied to the question of EM divergence);

- The problem of the nature of the electron's spin, of its EM self-interaction and the interpretation of its magnetic moment.
- The problem of the contribution of its charge to its mass;
- The interpretation of its anomalous magnetic moment and unknown origin or the Poincaré forces, which prevent the expansion or its charge distribution.

This introduction rests on an extension of Maxwell's Theory of light to interpret recently observed phenomena [7-9]. It is based on Dirac's suggestion [10] that the vacuum is a real physical medium built of a covariant polarized distribution of EM waves which carry excited linear Maxwellian and nonlinear soliton type photon waves ("piloted" by linear waves) [11]. If this is true one can introduce

- Nonzero electric field divergence and nonzero electron conductivity in vacuo tied to nonzero photon mass [1-5] corresponding to a non-expanding universe cosmology [4,12].
- New extended charged particle (electron and photon) models built with point-like EM charges rotating around a center of mass [4,13-15] as discussed (Fig. 1).

Since in this model the pilot wave and the piloted particle are composed of extended elements (cores), we start with the assumption that each individual element moves within a time-like hypertube[1] which contains:

- A distribution of conserved energy-momentum, $T_{\mu\nu}$ (satisfying $\partial^{\nu} T_{\mu\nu} = 0$ which recovers all internal and external interacting fields. As one knows [4,13-15,] this implies the existence of a covariantly defined center of mass, $Y_{\mu}(\theta)$ where (θ) is the proper time along Y_{μ} 's path [16]. Its internal mass distribution can be assumed to be contained within a relativistic spinning sphere (in Y_{μ} 's rest frame, Π_0) of radius *R* around an axis of rotation centered on Y_{μ} with a moment of inertia $I = \frac{1}{2} mR^2$ in such a way that its equator rotates with a velocity $\simeq c$ in Π_0 [13]. This spherical mass distribution can be assumed to behave, for all practical purposes, like a rigid mass distribution [17] so that an external force applied to it can be separated into two components. i.e., a) a translational

[1] These cores are evidently related to the isolated extended electron model developed by MacGregor (and others) [13] and we shall see that our initial assumptions imply their correspondence with QED and SED results.

force on Y_μ b) torques around Y_μ and X_μ.

- A practically point-like EM internal charge distribution in each individual extended element corresponding to an internal conserved current, J_M satisfying $\partial^\mu J_\mu = 0$. This implies the existence of a covariantly defined (in Π_0) center of charge, $X_\mu(\tau)$ moving within the hypertube with a proper time τ_0. This assumed distinction between mass and charge distribution, corroborated by experiment on individual electrons [13], implies 1) that EM charge e is contained in a radius $R_E \ll R$ in X_μ's rest frame, Σ; , 2) that X_μ moves with a velocity $v \simeq c$ on the core's equator: and
- An attractive (gravitational) force between Y_μ and the small mass Δm of charged elements contained within the neighborhood $r \le R_E$ of $X_\mu(\tau)$ in Σ_0.

We present this model as follows. In the first part we analyze the internal motions of the free extended elements, which constitute the building blocks of the pilot wave and particle aspect of individual isolated electrons. This analysis implies the introduction of new internal variables (including their individual center of mass and charge) describing these (unobserved) internal motions: a procedure comparable to the introduction of the internal molecular motions within Maxwell's and Boltzmann's theory of point gases. These individual extended elements are thus treated as extended particles with constant internal motions which imply the existence of new types of interactions between neighboring elements, such as the quantum potential and spin-orbit coupling. As we shall see it is possible to start with a model of internal motions which recall former classical electron models.

The second part introduces external interactions (i.e. collective motions) between neighboring extended elements and interactions between the permanent internal motions of each element with its neighbors described in terms of new collective parameters (density, etc.) which imply the existence of waves and piloted soliton-like particles constituting the individual micro-objects analyzed by the Quantum Mechanical formalism in its causal stochastic interpretation [18]. In the last part we shall briefly discuss recent experimental results which can be interpreted within this model.

2. Internal Motions of Particle Individual Extended Elements in Terms of Causal Collective Behavior

If an individual electron is described 1) as a real wave, Ψ comprising extended elements which can be analyzed in terms of collective motions propagating on a covariant stochastic subquantum Dirac type aether [19], and if 2) these collective motions can be analyzed in terms of average drift motions within time-like hypertubes (2-branes) combined with stochastic random path perturbations (like molecules in a gas), then we can introduce at each point, Y_μ a scalar density, $\rho(Y_\mu)$ of these extended elements and the internal parameters, *A* yield an average value <*A*> at $Y_\mu(\theta)$: where θ defines the proper time along the average drift path followed by the condensed density, $\rho(d\rho / d\theta = 0)$ within the collective motion. If the collective motions contain a non-dispersive soliton-like particle like conserved density concentration, $\rho(\theta)$ tied to nonlinear terms in the wave's equation, the ρ 's will follow an average drift line (plus random fluctuations of course) so that the linear part of the Ψ field can be considered as a pilot wave. The model implies that the average individual extended element's internal parameters are related to known electron properties, so that the following description of free extended wave (and particle) elements resemble a classical extended electron model proposed by MacGregor [13], Mckinnon [20] Ignatovich [21] and Vigier [6].

The starting point in this model is that each basic constitutive electron element contains a rotating point-like charge *e* within an extended structure (as initially suggested by Yukawa) and that this charge (centered at X_μ) undergoes a helicoidal motion of constant radius $R = \hbar / mc$ around Y_μ (in Π_0) so that we can write (in Π_0) $R_\mu = Y_\mu - X_\mu$ and $R_\mu(dY_\mu / d\theta) = R_\mu(dX_\mu / d\tau) = 0,$ since there is a constant central force between Y_μ and X_μ. We can also assume (following Faraday, et al. [6,22]) that its magnetic field contains two parts. The first external part is incorporated into the moving mass energy, $\delta m_0 c^2$ of the point-like charged part of the core. The second part, which does not rotate with it (according to Faraday's experiments [6,22]) corresponds in Maxwell theory to a magnetic moment $\mu = e\hbar / mc \cong eR / r.$ The corresponding magnetic self-energy, W_H carried along by the point-like charge. can thus be treated as a self-inductance resulting from the current generated by our point-like electric charge so that we can write

$$i = \left(\frac{e}{c}\right)\frac{\omega}{2\pi} \simeq \frac{e}{2\pi R}, \tag{1}$$

with the magnetic moment $\mu = \pi R^2 \cdot i.$ The corresponding magnetic self-energy, W_H then becomes

$$W_H = \frac{1}{2}L \cdot i^2 = \frac{1}{2}L\left(\frac{e}{2\pi R}\right)^2 \tag{2}$$

which yields (since $L = 4\pi R$ and $i \cong e / 2\pi R$)

$$W_H = \frac{e^2}{2\pi R} = \frac{\alpha}{2\pi}mc^2 \tag{3}$$

where *m* denotes the total mass.

Expression (3) also results from the relation, $w = v / R \simeq c / R$, with

$$i = \left(\frac{e}{c}\right)\left(\frac{v}{2\pi R}\right) \simeq \frac{e}{2\pi R};\ \mu = \left(\frac{eR}{2}\right)\left(\frac{v}{c}\right) \simeq \frac{eR}{2} = \frac{e\hbar}{2mc} \tag{4}$$

Indeed, W_H can also be considered the interaction of its non-rotating magnetic moment, μ with the field (magnetic moment) corresponding to a magnetic radius, R_H. As shown by Born and Schrödinger, we get [23]

$$W_H \cong \frac{2\mu^2}{3R_M^3} \tag{5}$$

The Einstein-de Broglie particle relation $E = mc^2 = hv$ follows immediately for single individual elements. Indeed, since we have $\lambda v = c$, one rotation of X_μ around Y_μ so that $\lambda = 2\pi R_s = h / mc$ and $c = \lambda \cdot v$, the corresponding angular momentum is thus $2\pi R \cdot mc = h,$ which yields $R_s = h / mc.$

Since there is a central constant force between X_μ and Y_μ we can also define an internal spinning motion of the elements of the system within their time-like boundaries by their angular momentum tensors, $S_{\alpha\beta}$. Following MacGregor [13] these properties can be visualized by assuming that the cores and soliton electrons behave like rigid relativistic bodies in the sense:

- That all pairs of its internal extended elements are separated by constant space-like relativistic intervals during their motion;
- That if one characterizes each internal point-like internal element by a coordinate, z_μ in the rest inertial frame Σ_0 of $X_\mu(\dot{x}=0)$ the particle (i.e. $z_\mu = X_\mu$) rotates twice around X_μ when X_μ undergoes one rotation around Y_μ according to Dirac's analysis [24];
- That one can define two different radii related to different types of fields, *i.e.,* 1) a radius *R* around Y_μ which contains all material (charged and uncharged) elements, charged and neutral field sources within the hypertube, but is smaller than the EM self-field's extension; and 2) a radius $R_E \ll R_c$ centered on $X_\mu(\tau)$ which contains charged elements, *i.e.* sources of the self-EM fields.

This implies two evident physical consequences. One needs two radii for each extended element since one has two source distributions, *i.e.* one small radius, R_E for the charge distribution around X_μ, and one Compton-like radius, $R_c \ll R_E$ for all the neutral electron elements since the extended electron contains point-like sources *and* fields.

Since X_μ is surrounded by a moving EM field, the magnetic Faraday field's energy distribution moves with $X_\mu(\tau)$ and carries self-energy. The charged sub-elements (which move with a velocity, $\simeq c$ repel but are held together by the magnetic pinch forces resulting from their velocity (a Tokamak-like behavior) and the magnetic self-field does not rotate around X_μ, according to Maxwell's theory. The representation of the corresponding EM contribution to the charged part's total mass, Δm is a longitudinal vector potential, A_μ^L and one must add to it the usual transverse potential contribution A_μ^T emitted as a consequence of X_μ's acceleration in its orbital and spinning motion around Y_μ. The usual EM contributions to the core's energy W_E and W_H can be represented by

$W_E = 0$. Since W_H is only 0.1% of the total energy mc^2, this total mass is essentially of gravitational origin associated with the internal orbital spinning motions of the electron. This suggested relation between observed masses and internal relativistic spinning motions (which enhance bare masses in relativity theory [6]) has its historical origin in Descartes' original model of vortex-like atoms.

If one thus assumes, as results from extended charge particle models, that a core (*i.e.* an electron's total mass with m = 0.511 MeV) is the sum, in any given inertial frame, of the contributions of its various moving internal parts. For example, τ in the rest frame, Π_0, of $Y_\mu(0)$ one should add the contribution of the rigid rotating electrically charged core (spin) which contains the total charge e and radius R_E which rotates locally around X_μ to the angular velocity of the orbital motion of X_μ around Y_μ. The spin vector, S_μ located at $X_\mu(\tau)$ is in general not parallel to the axis of rotation (centered at Y_μ.) of the orbital circular motion of X_μ around Y_μ. In other words, the charged core behaves like a spinning rotating plane around $X_\mu(\tau)$. As we shall now show, their angle is determined by the relativistic conservation laws.

As one knows in the case of a spinning motion around an axis with an equatorial velocity, $c(\omega = c / R)$, the relativistic spinning mass, M_s is related to the rest frame mass by the relation

$$M_s = \frac{3}{2} m \tag{6}$$

so that writing as usual $I = (M_s R^2)/2$ we get $I = (3/4)mR^2 = (1/2)M_s R^2$ where M is the rotating part of the rest mass.

If we then define the spin angular momentum of the relativistic spinning sphere

by
$$\vec{J} = I\vec{\omega}; \tag{7}$$

and introduce the "spinning mass Compton radius", $R_c = \hbar / M_s c$ we obtain

$$J = \frac{1}{2}\hbar, \tag{8}$$

so that this contribution yields $m_s = (3/2)m$ $(s, o = \text{spinning, non-spinning})$

$$I = \frac{1}{2} m_s R^2, \quad \left(R_\mu = Y_\mu - X_\mu\right) \tag{9}$$

with $\omega \cong c/R$ and $R = \hbar / M_s c$,

$$J = I\vec{\omega} = \frac{1}{2} m_s R \cdot c = \frac{\hbar}{2} \tag{10}$$

where $\hbar/2$ is the projection of the spin on the *z*-axis centered on Y_μ. We can now calculate the mass-energy contribution of the moving charge and associated moving EM Maxwellian fields and the corresponding *g* factor. As one knows, if one denotes by *v* the velocity of Y_μ (*i.e.* $\lambda = 1/(1 - v^2/c^2)$) one has in the associated inertial frame, Σ_{lab}

$$m_{(lab)} = \gamma m_{(em)};\ \sqrt{b^2 - 4ac};\ J_{(lab)} = J_{(em)}; M_{(lab)} = M_{(em)}\gamma;\ \vartheta_{(lab)} = \frac{\vartheta_{(em)}}{\gamma} \tag{11}$$

where *M* represents the electron's and core's magnetic moment. This is not enough, however, since we know from our spin-½ model, [13] that one has

$$J = \frac{1}{2}\left(1 + \frac{1}{2}\right)^{\frac{1}{2}} \cdot \hbar = \frac{\sqrt{3}}{e}\hbar \tag{12}$$

so that one should write, $R = \sqrt{3} \cdot \hbar / mc$ since relativity theory yields, $J = (1/2)mRc$, *i.e.* increases *R* and *J* by the factor $\sqrt{3}$.

If we now recall that the spin axis *z* (centered on X_μ) is not parallel to the axis (centered on Y_μ) perpendicular to the equatorial plane of the motion of X_μ, this implies that the charge's motion generates a dipole with total magnetic moment $\sqrt{3}e\hbar/2mc$ (along with a *z* component $e\hbar/2mc$) so that the magnetic moment which corresponds to this current loop is

$$\mu = \frac{e}{2} R_Q = \sqrt{3}\,\frac{e\hbar}{2mc} \tag{13}$$

associated with the increased radius volume, $R_Q = \sqrt{3}R.$

The associated gyromagnetic ratio of the electron thus becomes

$$g = \frac{\mu}{J} \cdot \frac{2mc}{e} = 2 \tag{14}$$

and the angle between the two axes of rotation (centered on Y_μ and X_μ) corresponds to the value $\theta = \pm \arctan\left(1/\sqrt{3}\right) = \pm 54.70.$ This is to be expected, since it has been shown that the corresponding quadrupole moment vanishes in that case, so that angular energy-momentum conservation, as confirmed by experiment, and the central force between Y_μ and X_μ, are automatically preserved.

In the preceding calculations of m_s we have left aside the contributions to the rotating mass (energy) of the EM fields generated by the dipole motion. Denoting by W_E and W_H their contributions, we see that one should take $W_E \cong 0 =$ constant in this model. Indeed, as a consequence of Maxwell's theory, Feynman's calculations and Faraday's experiments, we see that the Coulomb electric field around the charged core does not rotate, so that it does not contribute to m_s. The situation is different for W_M. Experiments have shown since Fermi's first experiments [24] the electron's magnetic field structures were much larger (R_H »R_E) than its electric charge distribution.

We also find that the value $g = 2$ was not quite exact; and that the value $M = e\hbar/2mc$, where *m* is the observed electron mass, was a bit too small. Evidently this result can be interpreted in our model since, following Faraday [22], all the EM energy of the free electron does not rotate, and one should write

$$m_s = m_0 - \Delta m \tag{15}$$

where $\Delta m = m(\alpha / 2\pi)$ which according to QED [24] represents the non-rotating part of the internal electron energy. Which yields

$$\mu = \frac{e\hbar}{2mc}\left(1+\frac{\alpha}{2\pi}\right) \tag{16}$$

and $g = (2mc/e)(\mu/J)$ so that

$$g-2 = \frac{2\alpha}{e\pi} \tag{17}$$

and we have

$$\begin{cases} W_H = 593\text{eV} \\ m_s = m\left(1-\dfrac{\alpha}{2\pi}\right) = 0.51041\dfrac{\text{MeV}}{c^2} \\ R = \sqrt{3}\cdot\dfrac{\hbar}{mc}\left(1-\dfrac{\alpha}{2\pi}\right) = 6.6962\times10^{-11}\text{cm} \\ g = 2\times1.001159652193 \end{cases} \tag{18}$$

In this model the electron has a very small charge radius $R_F << 10^{-16}$, an extended rotating charge and a mass and EM field distribution (around Y_μ) with $\vec{s} = \hbar$ where the center of charge X_μ has a velocity $\simeq c$.

3. Different Moving Mass and EM Energy-Momentum Distributions in Individual Extended Cores

Within the classical and relativistic theory, the transition from point-like elements (associated arbitrarily with Ψ waves endowed with mass, EM charge, spin, *etc.*) to extended elements into the hydrodynamical description of field behavior has evident qualitative consequences. The corresponding Lagrangian and Hamiltonian formalism now contains two types of variables associated

- With the internal elements' motions located at any given point, and
- With the average collective motion of these elements around the said point, which correspond (*i.e.* react differently) to the local and external interaction around this point.

In other words, a description of a fluid recovers the description of its individual internal motions and the description of its waves' collective motions, described in terms of different internal parameters.

To clarify the consequences of this point, introduced some time ago in the literature [17] let us first briefly recall the extremely simple case of a relativistic fluid built with rotating rigid spheres of rest mass M_o, radius *R* and spinning around an axis with equators moving very close to the velocity of light, *c*. As a consequence of this rotation, the relativistic spinning mass, M_s is related to M_o by the relation $M_s = (3/2)\, M_o$ and the internal measured density of the mass remains constant. Also as a consequence, the relativistic moment of inertia, *I* becomes larger than the corresponding non-relativistic moment of inertia, $I_c = (2/5)M_0R^2$ and becomes $I = (1/2)M_sR^2$ due to the increase of mass at a distance from the axis of rotation. The spin angular momentum of our relativistic spinning sphere then becomes [13]

$$\vec{J} = I\vec{\omega} \tag{19}$$

where $\vec{\omega}$ represents the angular velocity, which satisfies the relation in our model. We thus get

$$J = \frac{1}{2}M_s \cdot Rc = \frac{1}{2}\hbar. \tag{20}$$

If we consider angular momentum seen from an external point just outside the element's equator - an expression which implies that all diameter points external or on the equator satisfy, with respect to its center, O, a relation similar to the usual Heisenberg equations for each value of $r < R$. This description of an extended relativistic rotating massive sphere does not include EM charge. This model is thus insufficient since it does not apply to electron theory and corresponds to a massive neutrino if one assumes that it is held together by gravitational interactions [25].

If there is equilibrium between the centrifugal force and the attractive gravitational force along Y_μ and X_μ relation (19) yields a new realistic interpretation of the physical nature of Planck's constant [4] which is now related to the angular momentum of our model, which only depends on the $R \cdot M_s$ product, a property which can be experimentally tested.

An extension of this chargeless model to an interpretation of electron motion has been proposed by Mac Gregor [13]. One adds to the model a very small localized distribution of charged matter on a core's equator, *i.e.,* of total mass, δm carrying a charge e and radius $R_E \ll A$, carried with a velocity c, so that the whole model rotates as a block in the rest frame of O. This pointlike charge distribution is the source of electric and magnetic self-fields (denoted $\vec{E}$ and $\vec{H}$) influenced by external EM fields and held together by its own self-fields (since it behaves qualitatively like a Tokomak current pinched by its own magnetic field) with negligible electric self-energy W_E and small magnetic self-energy, W_H . If δm is small this rigid model has the remarkable property that the total observed rotating spin, $\vec{J} = \hbar / 2$ (mass and charge) around Y_μ and the EM spin (tied to X_μ) are equal in the rest frame of the charged core (which practically coincides with the point O) as a consequence of the core's rigidity if δm is small enough.

Two physical consequences follow immediately from this model:

- The charge spherical distribution in its own rest frame is practically flattened into a very small disk in Y_μ's rest frame and the EM spin, b_μ^3 is tangent to the X_μ velocity since the velocity is $\simeq c$ in the present model. In other words, the extended electron charged model recalls Bohr's original hydrogen model where the proton-electron Coulomb attraction is replaced by a $Y_\mu - X_\mu$ $m_s - \delta m$ gravitational interaction as the charge has to rotate twice on itself (following Dirac's argument) in order to recover its external EM distribution;
- If the mass and electric distributions belong to a single rigid material block, then there is a unique spin orientation in space-time. If we denote by $\int_{\alpha\beta}^{(m)\omega}$ the core's material mass angular momentum with radius in the rest frame of the mass center, Y_μ , a Lorentz transform will give its value and orientation at X_μ .

At this stage we consider the physical reasons for the real spin axis orientation from the observed orientation, J_z with ($J = \hbar / 2$) in an external inertial frame. As one knows. An equatorial loop current produces in general observable multipolar electric effects, since its real rotation axis is not parallel in general to the axis observed in the experiments. Now one knows that in relativity theory the separate conservation in motion of angular momentum is only possible within a central field of forces. Since this is the case for our model, if we assume that the real interactions associated with measurement processes do not modify the magnitude of internal spin J which corresponds to values, J_x, J_y, J_z in the rest frame Σ_0 of the center of charge, X_μ with the Pauli matrices (so that $\mathrm{J} = (J_x^2 + J_y^2 + J_z^2) \cdot (\hbar / 2)$ we see 1) that $\mathrm{J} = (\sqrt{3}/2)\hbar,$ and 2) that the model has an effective vanishing electric quadrupole moment which is zero along Oz and vanishes along Ox and Oy (in Σ_0) when averaged over a closed cycle (in Π_0) of precessional motion, which corresponds, in the rest frame of Y_μ to two rotations of X_μ around Y_μ so that $E = mc^2 = h\nu.$ This implies of course that Dirac's analysis, corresponding during the motion to the non-crisscrossing Faraday lines of force centered on X_μ now appear, in this model, as a consequence of central gravitational forces between Y_μ and X_μ.

This also implies, as shown by MacGregor [13], that the forces associated with a *J* (or magnetic moment) of a charged particle, when combined with the internal central forces of the model, a reorientation of the core's real physical orientation in space - so that the angle between the real rotation axis $\vec{J}$ in Π_0 and the measured $\vec{J}_z$ axis (with $J_z = \hbar / 2$ takes the value $\Theta = \arccos(1/\sqrt{3}) = 5.7.$ The model yields a direct interpretation of the gyromagnetic *g* factor with $\alpha = e^2 / \hbar c.$ As for the spin and the radius, one must distinguish for the same real physical reasons between the observed and real intrinsic qualities in that case.

The preceding physical interpretation (justification) by each individual core element of QED predictions implies some interesting consequences, *i.e.*:

a) The proposal that the internal charge core of the electron undergoes internal oscillations equivalent to the presence of an internal electron current, implies that Planck's constant $\hbar$, initially discovered as a consequence of the collective behavior of black-body radiation, is in reality a constant related to the electron's internal charged core rotation (the original Stoney [4,26]). Its constancy can be shown to result from the self-EM fields [27].

b) The existence of stable internal oscillations is evident in this model.

Following Maxwell, the charged core's oscillations imply accelerations. As the core accelerates, it must, by Ampere's law, build up a magnetic field. That build-up. by Faraday's law, will induce an electric field, whose direction, by Lenz's law, is opposed to the acceleration, so that its acceleration is the cause of its deceleration, which will reduce the magnetic field and induce a Faraday electric field since this process accelerates the core again.

This explains the core's internal oscillations. As discovered by Beckmann [28] if the frequency of the velocity of oscillation is v and the average velocity v (about which the velocity fluctuates) and if the distance measured along the paths of Y_μ between the points at which the electron attains successive maxima of its fluctuating velocity is λ, one sees by elementary kinematics that we have the relation

$$v = v\lambda \tag{21}$$

where λ is the length associated with one revolution of X_μ around Y_μ.

The determination of the extend internal core's distribution of electric charge, $\rho(x)$ and the possible forms of the corresponding self-induced electrostatic field in the frame of $X_\mu(\tau)$ have been discussed recently [29]. Assuming that ε and ε_0 represent the permittivity of the medium inside and outside the rigid (*i.e.* static) core in the rotating rigid frame $b_\mu(r \leq R_E \text{ inside})$ we have $\phi(x) = Q / 4\pi c_0 \cdot |x|$ where Q is the core's total charge and $x \leq R_E$. Assuming $\varepsilon_0 \Delta\phi(x) = 0$ for $|x| \geq R_E$ and $\varepsilon\Delta\phi(x) = -\rho\left[\phi(x)\right]$ for $|x| \leq R_E$ we get by writing $\varepsilon = A / k^2$ (k^2 being a real number) the total charge in the form

$$Q = \int_{|x| \leq R_E} \Omega(x)\phi(x) d^3x \tag{22}$$

with $Q_v = 4\pi r^2 D_\mu(r) = Q$ for $r \geq R_E$. The corresponding electrostatic energy of the self-induced fields is

$$W_E = \frac{1}{2} \int_{x \leq R_E} \Omega(x)\phi^2(x) d^3x \tag{23}$$

with an associated mass *M* given by

$$\int_{x \le R_E} \Omega(x)\phi^2(x)d^3x = 2Mc^2 \,. \tag{24}$$

It has been shown that the continuity of the values of ϕ for the value $r = R_E$ implies that

$$Q = 4c\varepsilon_0 \sqrt{\frac{\pi M}{AR_E}} \sin(kr) \tag{25}$$

which yields

$$\phi(r) = \frac{e}{4\pi\varepsilon_0} \frac{\sin\left(\pi r / 2R_E\right)}{r} \tag{26}$$

so that if we take into account the oscillation of X_μ around Y_μ then $R / R_E \ge 10^7$.

This model implies that the extended electron's constitutive elements contain two different types of internal distributions:

- An extended charge distribution, *i.e.* a charged core centered on $Y_\mu(\tau)$ with a small radius R_E moving with a velocity $\simeq c$ along an equator surrounded by an EM field which carries energy momentum and a mass, ~ 0.01 m; and
- An extended uncharged matter distribution with an energy-momentum distribution centered on $Y_\mu(\theta)$ with a larger radius $R \simeq 10^{-11}$cm and a mass $\cong$ 0.99 *m* with $m = 510.406\text{eV} = m_{\text{observer}}\ (1 - \alpha / 2\pi)$.

As discussed above both distributions are spinning, and as shown by Mac Gregor [13], at different angular velocities can be treated as "rigid" in the relativistic sense of the term. As one knows, an external force applied to this type of rigid body can be separated into two components, i.e.:

- A translational force that acts through the mass center;
- Torques that act through the charge and mass center; from which one can predict the existence of a helical channeling window (Mott scattering) in electron-positron and electron-electron scattering, presently suggested by various experiments [20].

4. Charge and Self-EM Field Motions with Free Extended Cores

Since the point-like charge *e* within each extended element is actually surrounded in its rest frame S_o by an irrotational Coulomb field E_c (which is time varying for an observer moving through it, *i.e.* behaves like a moving charge carrying a flattened Coulomb field with it), and by an induced Faraday field, Ψ which corresponds to inertial electro-magnetic reactions, thus, in S_o the self-field is:

$$E = E_c + \Psi \tag{27}$$

and by definition

$$\nabla E_c = 0; \;\; \nabla \times \Psi = -\frac{\partial B}{\partial t} \tag{28}$$

with the relations $B = \nabla \times A,$ with $E_c = -\nabla \phi$ ($i.e.$ $\Psi = -\partial A / \partial t$) and where the current, $J = \rho v$ corresponds to the core's orbital motion $\nabla \times B - (1/c^2)(\partial E / \partial t) = \mu J,$ ρ is the charge density and *v* the current velocity. Using the Lorenz gauge $(\nabla \cdot A = (1/c^2)(\partial \phi / \partial \tau))$ and Maxwell's equations, we get for the self-field the relation

$$\Psi = -\frac{1}{c^2}\left(\phi \frac{dv}{dt} + v \frac{d\phi}{dt}\right) \tag{29}$$

which implies that the force exerted on the charge by its own field is

$$e\Psi = \int\int\int \left[\rho\phi \frac{dv}{dt} + \rho v \frac{d\phi}{dt}\right] dv \tag{30}$$

accompanied by the Maxwellian equations

$$\phi = -\frac{\rho}{\varepsilon} \text{ and } A = \frac{\mu}{4\pi}\int\int\int \frac{J}{r}\, dv = \frac{\phi v}{c^2} \tag{31}$$

and we see by $d\phi / dt = (d\phi / dr) v \cdot \cos\theta$ and $dv = 2\pi r^2 \sin\theta dr d\theta$ and (where r and θ denote the usual coordinates in S_o) that the second term vanishes by integration, so that

$$\Psi = -\frac{\phi}{c^2}\frac{dv}{dt} \tag{32}$$

and the Faraday force is $e\Psi = -e\phi / c^2$. Moreover, if one works in Σ_0 one can replace E by Ψ and use $H = B / \mu$ so that the Poynting-Heaviside Theorem yields for the change of EM energy in a volume V the relation

$$\iint (\Psi \times H) \cdot dS + \iiint J \cdot \Psi \cdot dV = \iiint \left[\frac{1}{2} \varepsilon \Psi^2 + \mu H^2 \right] dV = 0 \tag{33}$$

if this energy is conserved.

Since Ψ is proportional to v and H *is* proportional to v, then

$$\frac{\partial}{\partial t}\left(c_1 \dot{v}^2 + c_2 v^2 \right) = 0 \tag{34}$$

which yields by differentiation and multiplication by $2\dot{v}$ the constant orbital rotation of X_μ around Y_μ, *i.e.*,

$$\dot{v} + \omega^2 \cdot \dot{v} = 0 \tag{35}$$

where $c_2 / c_1 = \omega^2$.

This shows that the helicoidal motion of the EM self-field of the rotating charge is associated with a total energy δmc^2 which should be subtracted from the total core energy mc^2 to obtain the rotating energy $m_s c^2$. Since we have

$$m_s c^2 = mc^2 \left(1 - \frac{\alpha}{2o} \right) = (m - \delta m) c^2 \tag{36}$$

with $mc^2 = hv$ and $c \cong \lambda v$ we get the following table:

TABLE 1

A. Nonrotating Rest Frame Properties	
$m_0 = m(1-\alpha/2\pi)(2/3)$ $R = \sqrt{3}(\hbar/mc)(1+\alpha/2\pi)$ $W_E = 0$ $e =$ equatorial point charge	$m_0 =$ mechanical mass $m =$ experimental mass $W_E =$ electrostatic self-energy
B. Calculated Rotating Inertial Properties	
$M_s = m(1-\alpha/2\pi)$ $W_H = mc^2(\alpha/2\pi)$ $I = \frac{1}{2}m_s R^2$	$M_s =$ spinning inertial mass $W_H =$ magnetic self-energy $\omega = c/R =$ relativistic limit

C. Calculated Spectroscopic Quantization	
$J = \sqrt{3}/2 \cdot \hbar$	vanishing electric dipole moment
$\mu = \sqrt{3} \cdot e\hbar/2mc \cdot (1+\alpha/2\pi)$	nonvanishing electric dipole moment
D. Spectroscopic Quantities at Quantization Angle Θ_{QM}	
$J_z = 1/2 \cdot \hbar$	$\Theta_{QM} = \pm 54.7^\circ$
$\mu_z = e\hbar/(2mc) \cdot (1+\alpha/2\pi)$	vanishing electric quadrupole moment

5. Spinors and Wave Equation Describing Internal Rotations of Extended Core Elements

The transition from point-like to extended core elements implies (in our model) the existence of internal rotations. These can be represented in various mathematical languages such as the tensor and spinor languages. For internal motions, the question is how they are related to Y_μ and X_μ.

Of course, the description of such collective motions can be developed in different ways. The simplest is to split spacetime into small 4-volume elements into which we define average variables which correspond

- To the average values of the core's internal motions within such domains; and

- To the average values, such as the density, ρ the drift current, etc. of the quantities which characterize locally these collective motions and to describe their evolution within drift hypertubes, recalling that the evolution of such quantities along paths tangent to a 4-vector, v_r associated with a proper-time, τ is given by $\partial^{\mu}(A \cdot v_{\mu})$ since we are now dealing with conserved densities.

This amounts to a description of a collective wave in a fluid where we have introduced the variables which connect the local average internal motion of its constitutive extended elements (such as spin) with the external variables associated with the collective motion of neighboring particles in contiguous hypertubes (like pressure), a process which enlarges the usual Maxwell-Boltzmann description to local average internal elements' internal motions and implies that the wave equations of Quantum Mechanics describe simultaneously collective measurable (*i.e.* probabilistic) external and internal motions. The utilization of vectors or spinors in this description is thus only a matter of convenience.

If we start with a set of elements the transition to collective motions implies if one works within hypertubes containing all the X_{μ}'s of the enclosed conserved set, that one can introduce within it an internal set of average quantities densities *A* (representing their average position) whose proper-time derivative (w.r.t. the hypertube's time-like axis parameter) is given by $\partial^{\mu}(A \cdot v_{\mu})$ where v_{μ} is the 4-velocity of this axis.

To discuss individual motions of our extended cores we start from the description, notations and results of reference [30]. The motion of a single isolated core wave element is described by a center of matter density $x_{\mu}(z)$ with $v_{\mu} = \alpha x_{\mu} / dz$, internal angular momentum, $S_{\alpha\beta}$ and 4-momentum, G_{μ} satisfying the Wayrsenhoff equations

$$\dot{G}_{\mu} = 0, \quad \dot{S}_{\alpha\beta} = G_{\mu} v_r - \omega_r v_{\mu}, \quad S_{\alpha\beta} v^{\beta} = 0 \tag{37}$$

which imply the existence of a center of mass $Y_{\mu}(\theta)$ and the clock-like behavior of internal motions with a clock-needle $R_{\mu} = Y_{\mu} - X_{\mu} = S_{\mu\nu}$ with $R_{\mu} G^{\mu} = R_{\mu} \dot{Y}_{\mu} = 0$ which rotates ($\perp$ to *u* and $\dot{X}_{\mu}$) with the Einstein-de Broglie frequency $\Omega=(M/m)\omega/2$, where $M_i^2=G_\mu G^\mu$ and $m=G_\mu \dot{X}_\mu$. Following Dirac, the extended element's charged core part thus rotates twice on itself while X_μ rotates once around X_μ in its rest frame $G_i=0$ $(i=1,2,3)$.

To show that the associated real collective waves satisfy a Feynman-Gell-Mann type equation we follow Battey-Pratt and Racey [31].

1) Connect the tensor definitions of reference [32] which define each element's behavior) with new internal variables defined in terms of two component spinors (*i.e.* rewrite the internal wave equations corresponding to equations for internal and collective core motions; and

2) Add new collective variables (such as a conserved element density) and introduce on each fluid droplet new collective interactions generating de Broglie's and Bohm's Quantum Potential Pilot Wave.

Point 1) immediately results from this well-known fact that any space-rotation of a wave element around $X_\mu(\tau)$ can be represented by a quaternion

$$\phi=\alpha+i\beta+j\gamma+k\delta \tag{38}$$

with $|\phi|=\phi\phi^*=\alpha^2+\beta^2+\gamma^2+\delta^2=1$ where ϕ^* is the quaternionic conjugate. Since one can write

$$\phi=\begin{vmatrix}\alpha+i\delta & -\gamma+i\beta \\ \gamma+i\beta & \alpha-i\delta\end{vmatrix} \tag{39}$$

any representation of a spherical rotation is now a special unitary matrix of order 2 *(i.e.* SU_2) whose operand form (introduced by Dirac) is the 2-component spinor

$$\begin{vmatrix}\alpha+i\delta \\ \gamma-i\beta\end{vmatrix}. \tag{40}$$

The connection with the Darboux-Frenet frame [33-35] is evident. Denoting by $OZ=O_\mu^3$ the instantaneous spin rotation axis in the rest frame of $X_\mu(\psi)$ a spherical rotation starting from the spinor $\begin{pmatrix}1\\0\end{pmatrix}$ can be rotated into $\begin{pmatrix}1\\0\end{pmatrix}$ by the operator $\begin{pmatrix}i & 0\\0 & -i\end{pmatrix}$ which rotates the core of our model by 180° about the *z*-axis, *i.e.* represented in the Lie group space by a quarter turn around a great circle in the 4D hypersphere and goes through the intermediate positions, $\begin{pmatrix}e^{i\theta}\\0\end{pmatrix}$ where θ is the angular displacement along the great circle which now represents a core rotation of 2θ about our *z*-axis. Since our model, as in references [4,14,15], is continuously connected with surrounding space, one must distinguish between inversion by parity *P* and reversal (by time inversion *T*) of spin.

In such an extended rotating core model a rotation that is a linear function of time is referred to as spin [36]. With our notations the corresponding rotation is thus represented by the operator

$$\begin{pmatrix}e^{i\omega t} & 0\\0 & e^{-i\omega t}\end{pmatrix} \tag{41}$$

in the core's rest frame centered on $X_\mu(\tau)$. When the core is moving with a velocity *v* w.r.t. an external observer, Σ the initial condition

$$\begin{bmatrix}\gamma+i\delta\\ \gamma+i\beta\end{bmatrix}=\begin{vmatrix}\Phi_1\\ \Phi_2\end{vmatrix} \tag{42}$$

in its rest frame $\overline{L_0^5}$ appears in the form

$$\Phi=\begin{bmatrix}\Phi_1 e^{\exp\left[-\frac{I\omega\left(t-\overline{v}\cdot\overline{r}/c^2\right)}{\beta}\right]} & 0\\ 0 & \Phi_2 e^{\exp\left[-\frac{I\omega\left(t-\overline{v}\cdot\overline{r}/c^2\right)}{\beta}\right]}\end{bmatrix} \tag{43}$$

to the static observer as a consequence of the Lorentz transformation $t'\to(t-\overline{v}\cdot\overline{r}/c^2)/\beta$ with $\beta=(1-v^2/c^2)^{1/2}$ and

$\bar{v} \cdot \bar{r} = v_x x + v_y y + v_z z$. The observer sees the center x of a contracted core moving past him with a velocity, v and observes a variation of the rotation's phase with time, but also from position to position. This is a straight forward consequence of the chosen $D(\frac{1}{2})$ representation of the Lorentz Group. As a consequence, each particular phase of the motion moves with a velocity $|V| = c^2 / |v|$ in the direction of v (See Fig. 1), as in de Broglie's initial assumption, and regions of constant phase are perpendicular to the motion of the model.

For our external observer, the core rotates around X_μ with an angular velocity $\omega(1 - v^2 / c^2)^{\frac{1}{2}}$ as a consequence of time dilation, and this rotation combined with V produces a decreasing pitch (w.r.t. increasing velocity) since he sees an angular velocity of $\omega / (1 - v^2 / c^2)2$ the helical configuration: a well-known result of the distinction between the contravariant (*i.e.* $\omega(1 - v^2 / c^2)^{\frac{1}{2}}$ and the covariant form (*i.e.* and the covariant form of the rotation energy of the core.

Now as noticed by Battey-Pratt and Racey, [31] the introduction of the preceding new internal spinor variables implies that they are related (for an observer) to the variables X_μ and Y_μ describing locally the core's external motion by a wave equation with $\nabla^2 - (1/c^2)(\partial^2 / \partial t^2)$ we have

$$\Phi = \frac{\omega^2}{c^2} \tag{44}$$

since an immediate calculation yields,

$$\frac{\partial^2 \Phi}{\partial t^2} = -\frac{\omega^2}{\beta^2} \Phi \text{ and } \nabla^2 \Phi = -\frac{\omega^2 v^2}{c^4 \beta^2} \Phi. \tag{45}$$

If we recall that in the single element case showing that $E = Mc^2 = hv$ so that

$$\frac{M^2 c^2}{\hbar^2} = \frac{\omega^2}{c^2} \tag{46}$$

we see that the relation (44) (which represents with new parameters the core's internal rotation) takes the classical form of a Klein-Gordon equation (16)

$$\Phi = \frac{m^2 c^2}{\hbar^3} \Phi \tag{47}$$

an astonishing fact indeed, since we now connect spin with mass in a discreet extended clock-like wave element. This is not all, however. The similarity to the Feynman-Gell-Mann equation appears immediately.

6. Collective Core Motions

The Lagrangian description of a set of core collective motions (waves) evidently implies physical (*i.e.* mathematical) relations between the collective variables and the local average variables describing (locally) individual constitutive set elements in a small 4-volume centered on a point $X_\mu(\tau)$. This can be done in two steps:

1. The local relation (interpretation) of collective spinor parameters describing a real small collective linear pilot wave equation with the local internal variables of their constitutive extended elements.
2. Their relation with the non-dispersive non-linear internal soliton-like solutions representing observed particles in this model.

We start from the assumption that both states' collective motions are described locally by 4-component spinors Ψ_α satisfying the connection and identities (discovered by Pauli [17]) connecting them with the representations $\Phi(\frac{1}{2},\frac{1}{2})$ of the Lorentz group, and therefore satisfying automatically the Pauli identities with the 4x4 matrices γ_μ. . With the usual Bjorken-Drell relations and notations $(\hbar = c = 1)$ we first assume that the pilot-wave Lagrangian without constraints can be written:

$$L = m^2 \overline{\Psi}\Psi - \left(i\hat{\partial} - e\hat{A}^*\right)\Psi \cdot \left(i\hat{\partial} - e\hat{A}\right)\Psi + \frac{1}{4} F_{\mu\nu} F_{\mu\nu} + \mu^2 A_\mu^* A_\mu \tag{48}$$

which yields for the Ψ field Feynman-Gell-Mann type field equations

$$\left[\left(i\hat{\partial}-e\hat{A}^{*}\right)\left(i\hat{\partial}-e\hat{A}\right)-m^{2}\right]\Psi=0 \tag{49}$$

with two conserved currents

$$J_{1\mu}=\frac{1}{m}\mathrm{Re}\left[\bar{\Psi}\left(i\partial_{\mu}-eA_{\mu}\right)\Psi\right] \quad \text{and} \quad J_{2}=\frac{1}{2m}\partial^{\nu}\left[\bar{\Psi}\sigma_{\mu\nu}\Psi\right] \tag{50}$$

along with

$$\sigma_{\mu\nu}={}^{1}\!/_{2}\left(\lambda_{\mu},\gamma_{\nu}\right) \tag{51}$$

and spin vector density

$$S_{\mu}=\frac{1}{m}\mathrm{Re}\left[\bar{\Psi}\gamma;\gamma_{\mu}\left(i\hat{\partial}-e\hat{A}\Psi\right)\right]. \tag{52}$$

We complete this description with two physical constrains (assuming $(\hbar=c=1)$ which reduce the Dirac equation to the Feynman-Gell-Mann equation:

- That Ψ also satisfies the Dirac equation

$$\left(i\hat{\partial}-e\hat{\partial}\right)\Psi=m\Psi \tag{53}$$

- That the invariant $i\bar{\Psi}\gamma_{5}\Psi$ vanishes, *i.e.,*

$$i\bar{\Psi}\gamma_{5}\Psi-0 \tag{54}$$

which imply that Ψ can be built with a two-component spinor W

$$\Psi=\begin{pmatrix}W\\W\end{pmatrix} \quad \text{with} \quad W=\begin{pmatrix}W_{1}\\W_{2}\end{pmatrix} \tag{55}$$

and that Ψ now satisfies the usual Feynman-Gell-Mann equation

$$\left[\left(i\hbar\hat{\partial}-\frac{e}{i}\vec{A}\right)^{2}+\vec{\sigma}\left(\vec{H}+i\vec{E}^{2}\right)\right]\omega=m^{2}c^{2}\omega \tag{56}$$

which we can now analyze in terms of internal and external (collective) variables.

As well known, by analyzing the purely mathematical connection between 4-component spinors, Ψ and the finite dimensional representations of the Lorentz group $D(½,½)$, Pauli showed long ago that one has the following local mathematical identities, *i.e.* (with $\hat{\gamma}_\mu = (1/3\cdot!)\cdot \in_{\mu\nu\alpha\beta} \gamma_\nu\gamma_\alpha\gamma_\beta$): - two invariant $g = \overline{\Psi}\Psi$ and $i\overline{\Psi}\gamma_5\Psi = 0$ in this model; - a current and spin density $J_\mu = i\overline{\Psi}\gamma_\mu\Psi$ and $S_\mu = -\overline{\Psi}\hat{\gamma}_\mu\Psi$ with $J_\mu J_\mu = \rho^2$, $S_\mu S_\mu = \rho^2$ and $J_\mu S_\mu = 0$; an angular momentum density $M_{\mu\nu}$, *i.e.* $M_{\mu\nu} = \frac{1}{2}\overline{\Psi}(\gamma_\mu\gamma_\nu - \gamma_\nu\gamma_\mu)\Psi$ with $\rho\cdot M_{\mu\nu} = -\in_{\mu\nu\alpha\beta} S_\alpha J_\beta$; a momentum density $K_M = i\overline{\Psi}\left[\partial_\mu\right]\Psi$; an energy momentum density $T_{\mu\nu}$ with

$$\rho\cdot T_{\mu\nu} = \rho\cdot\left(-\overline{\Psi}\left[\partial_\mu\right]\gamma_n\Psi\right) = K_\mu\cdot J_\mu\partial_\nu J_\lambda\cdot M_{\mu\lambda} \tag{57}$$

which yields a simple physical interpretation of relation (44) with the constraints (53) and (54). Indeed, if we write

$$W = \rho^{1/2}\cdot e^{iS/\hbar}U \tag{58}$$

and if we now utilize the hydrodynamical interpretation of relation (58) with the help of the quaternion formalism introduced by Battey-Pratt (38), we can physically interpret the terms appearing in relations (57).

First, as already published and discussed in the literature [1,6,17] and without the constraints (53) and (54), the relation (48) associated with waves $\Psi = Q\cdot\omega$ (with $\overline{\omega}\omega = \pm 1$) has been shown to correspond to a quantum potential

$$U = \frac{\Box Q}{Q} - \overline{\omega}\omega\partial_\mu\omega\partial_\mu - \overline{\omega}\partial_\mu\overline{\omega}\omega\partial_\mu\omega \tag{59}$$

and related to the usual quantum calculations.

Now from $L = \left(\hbar c/2\right)\left\{\left(\overline{\Psi}\gamma_\mu\overline{D}_\mu\Psi - \overline{D}_\mu\Psi\varphi_\mu\Psi\right) + 2\chi\overline{\Psi}\Psi\right\} = 0 = \left(\hbar c/2\right)t_{\mu\mu} + \rho m_0 c^2 = 0$ a Lagrangian, the Dirac constraint (53,54) can be derived (reintroducing $\hbar$ and c) (with $\xi = mc^2/\hbar$ and $D_\mu = \left(\partial / \partial x^\mu\right) - \left(ie/c\right) A_\mu$) because as shown by Takabayasi [37], Halbwachs [17], etc., if analyzed in hydrodynamical terms with $\bar{\Psi}\gamma_\mu \Psi = 0$ this yields the Dirac equations $\lambda_\mu D_\mu \Psi = -\chi\Psi$ and $D_\mu \bar{\Psi}\lambda_\mu = \chi\Psi$ so that L = 0. They also yield the conserved current, $\partial_\mu = -i\hbar c \bar{\Psi}\gamma_\mu \Psi = \rho U_\mu$ (with $\partial^\mu j_\mu = 0$, $\rho = \bar{\Psi}\Psi$ and $U_\mu = \partial_\mu / \rho\hbar$) so that $U_\mu Y_\nu = -c^2$. The associated angular momentum, spin and momentum densities take the form $S_{\mu\nu} = \left(i/c\right) \in_{\mu\nu\lambda\alpha} U_\lambda \sigma_\alpha$ with $\sigma_\alpha = \left(\hbar/2\right)\bar{\Psi}_5 \gamma\gamma_\alpha \Psi$ (so that the spin density modulus is just $\sigma_0 \left(\sigma_\alpha \sigma_\alpha\right)^{1/2} = \rho\hbar/2$) and the total impulsion $g_\mu = -\left(1/c^2\right) t_{\mu\nu} v_\mu = \left(i\hbar/2\rho\right)\bar{\Psi}\left[\partial_\mu\right]\Psi$. The energy momentum density corresponding to $L = \rho g_\mu U_\mu + S_{\mu\lambda}\partial_\mu U_\lambda + \rho m_0 c^2 = 0$ yields the energy momentum density $t_{\mu\nu} = g_\mu U_\nu + S_{\mu\lambda}\partial_\mu U_\lambda = g_\mu \cdot U_\nu + \Theta_{\mu\nu}$; with $\partial^\mu t_{\mu\nu} = \dot{g}_\mu + \partial^\mu \Theta_{\mu\nu} \Leftrightarrow$ so that we have $\partial^\mu t_{\mu\nu} = t_{\eta\nu} = 0 = \dot{g}_\mu + \partial^\mu \Theta_{\mu\nu} \Leftrightarrow$ and $\partial^\nu \Theta_\mu$ is the form taken by the quantum potential in that case. The constraint (53) also implies a consequence of angular momentum conservation that the Belinfante tensor $f_{\mu\nu\lambda} = \left(i/4\right)\hbar c \bar{\omega}\lambda_5 \lambda_\alpha \Psi = +\left(i\hbar c/4\right) t_{\mu\nu\lambda\alpha} \bar{\Psi}\hat{\lambda}_\alpha \Psi$ yields the associated angular momentum density $S_{\mu\nu}$ through the relation

$$f_{\mu\nu\lambda} U^\lambda = -\frac{c^2}{2} S_{\mu\nu} = \frac{i\hbar}{2} t_{\mu\nu\lambda\alpha} U^\lambda \sigma^\alpha \tag{60}$$

where σ^α is the spin density.

Introducing then the dual of the vector density, σ^α by the definition

$$\hat{\sigma}_{[\alpha\beta\gamma]} = \hat{\sigma}_{[\alpha\beta\gamma]} = \hat{\sigma}_\mu = i t_{\alpha\beta\gamma\mu} \sigma_\mu \text{ with } \mu \neq \alpha, \beta, \lambda \tag{61}$$

and utilizing the Takabayasi projection operator on a plane orthogonal to vector

$$U_\mu \ \textit{i.e.}: \ \eta_{\mu\nu} = \delta_{\mu\nu} + \frac{U_\mu U_\nu}{c^2}. \tag{62}$$

With the definition $W_\mu^{(U)} = \eta_{\mu\nu} W_\nu$ for all vectors we get the expression

$$f_{\mu\nu\lambda} = \frac{1}{2}\delta_{\mu\nu} \cdot U_\lambda + \left\{ ict_{\mu\nu\alpha\lambda}\sigma_\alpha \left(\frac{U_\alpha U_\lambda}{c^2} + \delta_{\alpha\lambda} \right) \right\} = \delta_{\mu\nu} \cdot U_\lambda + \Theta_{\mu\nu\alpha} \tag{63}$$

so that starting as usual from the identity expressing total angular momentum conservation. *i.e.*

$$t_{\mu\nu} - t_{\nu\mu} = 2\partial_\lambda f_{\mu\nu\lambda} = \dot{\delta}_{\mu\nu} + \Theta_{\mu\nu} \tag{64}$$

we get the relation

$$g_\mu U_\nu - g_{\nu\mu} + \left[\delta_{\mu\lambda}\partial_\mu U_\lambda \right] = \dot{S}_{\mu\nu} + \Theta_{\eta\nu} + \tau_{\mu\nu} \,. \tag{65}$$

Any attempt to describe the average internal behavior of a localized particle-like wave packet "piloted" by an external linear wave raises the problem of the physical stability of the particle aspect of matter. If observed extended elements of particles and pilot-waves are extended wave packets, which thus recover internal motions, can one describe them within the frame of the usual linear wave equations or should one add non-linear terms to those equations to endow them with non-dispersive (non-spreading) properties at least during their lifetimes? This problem has already been discussed in the literature by de Broglie *et al.* [38] and we shall only briefly summarize here some established results related to the present model. In order to satisfy observed physical properties of quantum particles, the first property is that if we consider each wave element (in the pilot wave and in the particle-like soliton) as bilocal structures with an internal center of mass around which spirals a point-like center of charge, the average motion of individual particle elements (*i.e.* constitutive pilot-waves and piloted solitons) should be considered as an approximate continuous distribution (defined by the density ρ of a parameter $Y_\mu(\Theta)$ (or X_μ) of their mass centers associated (carrying) spin Vectors $S_\mu(\Theta)$ defining local orbital spin corresponding to local average rotation of their associated centers of charge around $Y_\mu(\Theta)$.

The second property is that if the components of the (average) wave function satisfy the same wave equation a non-linear term can be introduced into it, which would only be effective (big enough) inside the extended soliton part. This would also explain the piloting mechanism.

As a possible solution we shall only present here an extension of the solution proposed by Mackinnon. [39] If we assume:

1) That in the rest frame of its center of mass the extended average element centers at a point $Y_\mu(\Theta)$ at the center of a volume ΔV is associated with the charged point $X_\mu(\tau)$ at a constant distance $R = X_\mu - Y_\mu$;

2) That $Y_\mu(\tau)$ in its rest frame is the origin of an orthogonal set of three axes (where R_μ lies in the *X,Y* plane) represented by a pair of spinor components $\varphi(\varphi_1, \varphi_2)$, where the *X-Z* axis is the rotation axis;

3) That we can leave aside the space-like distance $R_\mu = Y_\mu - X_\mu$ (*i.e.* neglect the corresponding internal oscillations) and work directly in the rest frame of I_0 of X_μ, since X_μ and Y_μ in a free core remain within the same time-like hypertube;

4) That, following Mackinnon [39] we start from the assumption that if we construct in Π_0 at X_μ a system of three orthogonal axes rotating around a vector σ_i and $\dot{X} \cong 0$ then the corresponding phase vibration (of Y_μ w.r.t. X_μ) must be the same for all external observers. It is represented [40] by a two-component spinor $\Psi\left(\Psi_1\left(X_\mu\right), \Psi_2\left(X_\mu\right)\right)$ associated with the representation $D\left(\tfrac{1}{2}, 0\right)$ and $D\left(0, \tfrac{1}{2}\right)$ of the Lorentz group [20]. This implies that if *U* denotes the velocity of X_μ w.r.t. a direction *z* in an inertial frame, the wave packet representing all possible inertial plane waves (on X_μ) with all velocities $\pm c$ in the interval is given by, the non-dispersive wave expression

5)

$$F_{12}(x,t) = K\left\{\exp i\left[\omega(k_0)t - k_0 x\right]\right\}\left\{\sin\frac{\Theta}{\Theta}\right\}\cdot\Phi_{12} \qquad (66)$$

with

$$\Delta k = \frac{m_0 c}{\hbar}\left(1-\beta^2\right)^{-1/2}; \quad k_0 = \frac{m_0 v}{\left(1-\beta^2\right)^{-1/2}};$$
$$\beta = \frac{U}{c}; \quad \Theta = \Delta k\left(z - vt\right); \quad k = \text{constant} \tag{67}$$

A two-component spinor $\Phi\left(\Phi_1, \Phi_2\right)$ then satisfies the wave equation

$$\begin{aligned} F_{1,2} - \frac{m_0^2 c^4}{\hbar^3} F_{1,2} &= \left(c^2 - v^2\right)\exp\left(i\left[\omega\left(k_0\right)t - k_0 x\right]\cdot\nabla\right) \\ &= \lambda \exp\left(i\left[\omega\left(k_0\right)t - k_0 x\right]\right)\cdot\frac{\nabla \sin\Theta}{\Theta} \end{aligned} \tag{68}$$

where λ is a constant. A simple extension of preceding calculation suggests that, adding a solution Θ_N of (xx) to a solution Θ_L of its linear left-hand side with the same phase $S\left(\vec{x}, t\right)$ implies that the soliton (particle) wave Φ_N) is piloted by Φ_L which satisfies the Feynman-Gell-Mann equation.

The assumption of extended particle cores (with internal, R_μ motions) implies, of course, the introduction of different Lorentz frames. Indeed, to describe them one should add to external observer frames Σ (one passes from one frame to another by a Poincaré transformation):

- An instantaneous, comoving inertial frame whose origin, Y_μ is at rest and its Lorentz frame has $a_\mu^4 \simeq dY_\mu / d\Theta,\ a_\mu^3 \cong R_M,$ so that the orbital rotation of X_μ vanishes;
- An instantaneous comoving inertial frame, I_0 whose origin, X_μ is at rest and its Lorentz frame has $b_\mu^4 \cong X_\mu = dX_\mu / d\tau$ and no spin but which rotates with an angular momentum tied to the rotation of $R_\mu = Y_\mu - X_\mu$
- A non-inertial frame, N^a centered on X_μ in which the accelerating electron charge X_μ is at rest and its instantaneous spin is zero;

- A non-inertial reference frame M^a which Y_μ is at rest $(dY/d\Theta = 0)$ and the instantaneous orbital motion of X_μ is zero;
- A non-inertial reference frame N^g supported in a gravitational field. The principle of equivalence implies that $N^a = N^g$ when $a = -g$. The necessity of introducing the preceding frames has been discussed recently (without electron spin) by Petkov [41].

This introduction implies (as will be developed in subsequent work) that at

1) The velocity of light is anisotropic in N^a and N^g;
2) The electric fields in I_0 and N^a are identical;
3) The charged volumes in N^a and N^g are anisotropic;
4) The X_μ's follow local geodetic paths in N^a and N^g in the distorted internal geometry within *R;*
5) Another important point [42] is that if we recall that the point-like charge centered on X_μ rotates twice on itself [6,24] while X_μ undergoes one rotation around Y_μ then one sees that if one assumes that this internal Zitterbewegung resonates with the corresponding external zero-point field to ensure the continuity of Faraday's lines of force on the electrons charged sphere, then one expects that $E = h\nu = mc^2$ and the de Broglie relation $(\omega_c \gamma v)c^{-2} = m_c \gamma v / \hbar = p / \hbar$ defines this gearing pilot mechanism.

In this model internal/core (17) and particle oscillations beat in phase with the external zero-point frequency of the extended pilot wave elements.

7. Divergence of the EM Field

In this chapter our discussion has centered primarily on properties relating to extended electron dynamics; however as discussed in detail elsewhere [14,15] the model applies equally well (as summarized in this and the next section) to internal photon motion and integration of the EM and G fields. A non-vanishing divergence of the electric field given below can be added to Maxwell's equations which results in space-charge distribution. A current density arises in vacuo and longitudinal electric non-transverse

EM terms (i.e. magnetic field components) appears (like $B^{(3)}$) in the direction of propagation.

Both sets of assumptions were anticipated by de Broglie and Dirac. They imply that the real zero-point (vacuum) EM distribution

- Is not completely defined by $F_{\mu\nu}$ but by a four-vector field distribution given by a four-vector density, A_μ associated with a de Broglie-Proca equation i.e.

$$\Box A_\mu(x_\alpha) = -\frac{m_\gamma^2 c^2}{\hbar^2} A_\mu(x_\alpha) \tag{69}$$

and its complex conjugated equation.

- The A_μ field potential equation also contains a gradient term so in vacuum:

$$A_\mu = A_\mu^T + A_\mu^L + \lambda\partial_\mu S \tag{70}$$

with $A_\mu A^* \to 0$ and a small electrical conductivity in vacuo.

8. Possible New Consequences of the Model

Since such models evidently imply new testable properties of EM and gravitational phenomena, we shall conclude this work with a brief discussion of the points where it differs from the usual interpretations and implies new possible experimental tests.

If one considers gravitational and EM phenomena as reflecting different behaviors of the same real physical field i.e. as different collective behavior, propagating within a real medium (the aether) one must start with a description of some of its properties.

We thus assume that this "aether" is built (i.e. describable) by a chaotic distribution $\rho(x_\mu)$ of small extended structures represented by four-vectors $A_\mu(x_\alpha)$ round each absolute point in I_0. This implies:

- the existence of a basic local high density of extended sub-elements in vacuum
- the existence of small density variations $\delta\rho(x_\mu)A_\alpha(x\mu)$ above $\delta\rho > 0$ for light and below $(\delta\rho < 0)$ for gravity density at x_μ.
- the possibility to propagate such field variations within the vacuum as

first suggested by Dirac [43].

One can have internal variations: i.e. motions within these sub-elements characterized by internal motions associated with the internal behavior of average points (i.e. internal center of mass, centers of charge, internal rotations and external motions associated with the stochastic behavior, within the aether, of individual sub-elements. As well known the latter can be analyzed at each point in terms of average drift and osmotic motions and A_μ distribution. Implying introduction of non-linear terms.

To describe individual non-dispersive sub-elements within I_0, where the scalar density is locally constant and the average A_μ equal to zero, one introduces at its central point $Y_\mu(\theta)$ a space-like radial four-vector $A_\mu = r_\mu \exp(iS/\hbar)$ (with $r_\mu r^\mu$ = a^2 = constant) which rotates around Y_μ with a frequency $\nu = m_\gamma c^2 / h$. At both extremities of a diameter we shall locate two opposite electric charges e^+ and e^- (so that the sub-element behaves like a dipole). The opposite charges attract and rotate around Y_μ with a velocity $\cong c$. The +e and –e EM point-like charges correspond to opposite rotations (i.e. ± $\hbar$/2) and A_μ rotates around an axis perpendicular to A_μ located at Y_μ, and parallel to the individual sub-element's four momentum $\partial_\mu S$.

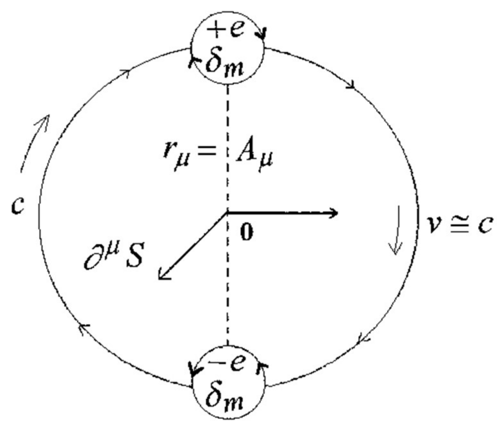

Figure 1. Diagram conceptualizing two oppositely charged sub-elements rotating at v ≅ c around a central point 0 behaving like a dipole "bump" and "hole" on the topological surface of the covariant polarized Dirac vacuum.

Assuming electric charge distributions correspond to $\delta m > 0$ and gravitation to $\delta m < 0$ one can describe such sub-elements as holes ($\delta m < 0$) around a point 0 around which rotate two point-like charges rotating in opposite directions as shown in Fig. 1.

These charges themselves rotate with a velocity c at a distance $r_\mu = A_\mu$ (with $r_\mu r_\mu$ = Const.). From 0 one can describe this by the equation

$$\Box A_\mu - \frac{m_\gamma^2 c^2}{\hbar^2} \cdot A_\mu = \frac{\left[\Box(\mathrm{A}_\alpha^* \mathrm{A}_\alpha) \right]^{1/2}}{(A_\alpha^* A_\alpha)^{1/2}} \cdot A_\mu \tag{71}$$

with $A_\mu = r_\mu \cdot \exp[iS(x_\alpha)/\hbar]$ along with the orbit equations for e^+ and e^- we get the force equation

$$m \cdot \omega^2 \cdot r = e^2 / 4\pi r^2 \tag{72}$$

and the angular momentum equation:

$$m_\gamma \cdot r^2 \cdot \omega = \hbar / 2 \tag{73}$$

Eliminating the mass term between (31) and (33) this yields

$$\hbar\omega = e^2 / 2r \tag{74}$$

where $e^2/2r$ is the electrostatic energy of the rotating pair. We then introduce a soliton-type solution

$$A_\mu^0 = \frac{\sin \cdot K \cdot r}{K \cdot r} \cdot \exp[i(\cot - K_0 x)] \tag{75}$$

where

$$K = mc/\hbar, \quad \omega = mc^2/\hbar \quad \text{and} \quad K_0 = mv/\hbar \tag{76}$$

satisfies the relation (31) with $r = ((x - vt)^2 \cdot (1 - v^2/c^2)^{-1} + y^2 + z^2)^{1/2}$ i.e.

$$\Box A_\mu^0 = 0 \tag{77}$$

so that one can add to A_μ^0 a linear wave, A_μ (satisfying $\Box A_\mu = (m_\gamma^2 c^2 / \hbar^2) A_\mu)$ which describes the new average paths of the extended wave elements and piloted solitons. Within this model the question of the interactions of a moving body (considered as excess or defect of field density, above or below the aether's neighboring average density) with a real aether appears immediately[2].

As well known, as time went by, observations established the existence of unexplained behavior of light and some new astronomical phenomena which led to discovery of the Theory of Relativity.

In this work we shall follow a different line of interpretation and assume that if one considers particles, and fields, as perturbations within a real medium filling flat space time, then the observed deviations of Newton's law reflect the interactions of the associated perturbations (i.e. observed particles and fields) with the perturbed average background medium in flat space-time. In other terms we shall present the argument (already presented by Ghosh et al. [44]) that the small deviations of Newton's laws reflect all known consequences of General Relativity.

9. New Background Conditions of the Dirac Vacuum

Assuming in conjunction with the de Broglie-Bohm-Vigier Causal Stochastic Interpretation (CSI) of quantum theory [18,45-47] that de Broglie matter-waves describe a wave-particle duality built up with real extended space structures with internal oscillations of particle-like spin, Bohr's physical assumptions are justified predicting new properties of a real Dirac covariant polarized vacuum [10,45].

Bohr's major contribution to modern physics was the model of photon emission-absorption in Hydrogen in terms of random energy jumps between stable quantum states and atomic nuclei. This discovery was one of the starting points for the Copenhagen Interpretation of quantum theory.

---

[2] According to Newton massive bodies move in the vacuum, with constant directional velocities, i.e. no directional acceleration, without any apparent relative "friction" or "drag" term. This is not true for accelerated forces (the equality of inertial and gravitational masses are a mystery) and apparent absolute motions proposed by Newton were later contested by Mach.

We suggest this structural-phenomenology by general covariance applies equally as well to the symmetry conditions of the Dirac vacuum backcloth also; but as one knows the purely random description of quantum jumps suggested by Bohr is obviated by the CSI of quantum mechanics [18,45,46,48] suggesting this interaction is piloted. We feel the CSI interpretation is required for our exciplex model to work because it is the internal motion of a massive photon that enables coupling to the Dirac vacuum.

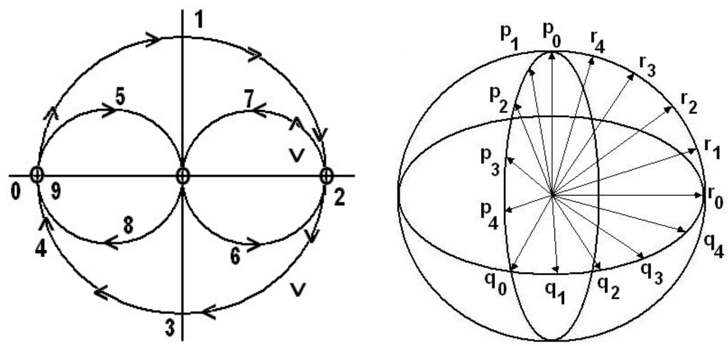

Figure 2 a) 2D simplistic view of 3D Dirac rotation map. b) 2D rendition of 4D view of Dirac hyperspherical rotation for raising and lowering Dirac-type topological advanced-retarded annihilation-creation vectors.

Some experimental evidence has been found to support this view [48,49] showing the possibility that the interaction of these extended structures in space involve real physical vacuum couplings by resonance with the subquantum Dirac ether. Because of photon mass the CSI model, any causal description implies that for photons carrying energy and momentum one must add to the restoring force of the harmonic oscillator an additional radiation (decelerating) resistance derived from the EM (force) field of the emitted photon by the action-equal-reaction law. Kowalski has shown that emission and absorption between atomic states take place within a time interval equal to one period of the emitted or absorbed photon wave. The corresponding transition time corresponds to the time required to travel one full orbit around the nucleus. Individual photons are extended spacetime structures containing two opposite point-like charges rotating at a velocity near *c*, at the opposite sides of a rotating diameter with a mass, $m_\gamma \simeq 10^{-65} g$ and with an internal oscillation

$E = mc^2 = h\nu$. Thus, a new causal description implies the addition of a new component to the Coulomb force acting randomly and may be related to quantum fluctuations. We believe this new relationship has some significance for our model of vacuum C-QED blackbody absorption/emission equilibrium [4].

The result from real causal interactions between the perturbed local background "ether" and its apparently independent moving collective perturbations imply absolute total local momentum and angular momentum conservation resulting from the preceding description of vacuum elements as extended rigid structures.

10. Introduction to the Dimensional Conundrum

Protocols utilizing Yang-Mills Kaluza-Klein (YM-KK) equivalence as a path to verifying XD-LSXD) is suggested [50-56]. Riemannian KK manifolds, M with horizontal and vertical subspaces in the tangent bundle (M = X x G) defined by the YM connection are orthogonal with respect to the KK metric, where X is a 4D spacetime and G an arbitrary gauge Lie group; the corresponding YM theory, M is a trivial principle G-bundle [52,57]. This suggests orthogonal XD, changing the meaning of the concept of dimensionality [58,59]. This method validates M-Theory by tabletop-low energy UFM *cross section* alternatives for *viewing* putative brane topologies in a trans-dimensional 'slice' rather than supercollider cross section particle spray techniques.

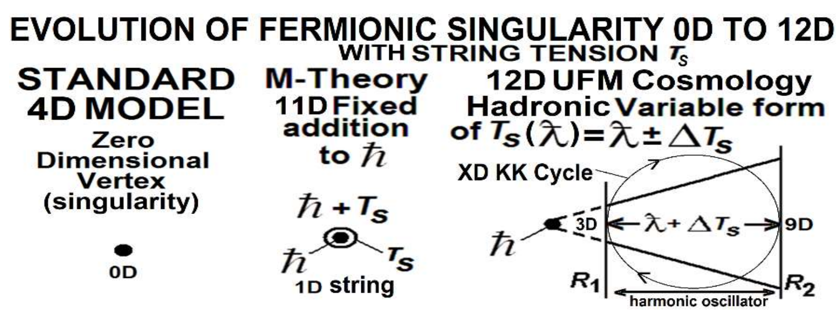

Figure 3. a) Usual 4D SM consideration of a fermion, the fundamental object of physics, as a 0D singularity. b) The current 1D basis of string theory, a fixed length, string tension T_S added to the Planck length, $\hbar + T_S$. c) UFM M-theoretic model reverting to the original hadronic form of string theory with variable T_S, for continuous-state cyclical compactification.

Two special processes emerge for modelling XD: 1) Duality, where dimensions are fundamentally different in character, and 2) Anti-commutativity, where they are fundamentally the same [59,60]. Rather than the current iteration of String/M-Theory this work is based on a radical extension of the original, hadronic form of the theory because of corresponding key elements such as virtual tachyon/tardon interactions (allowing more than one temporal dimension [51,61,62) and a variable concept of string/brane tension, T_S yielding experimental design parameters for accessing additional dimensionality (XD) [51,63,64].

It is generally known that KK modeling makes correspondence to the SM through YM Gauge Theory [62,65-67**]; **now extended to an 11D M-Theory with Calabi-Yau mirror symmetric brane topology [68]. M-Theory has been severely criticized until now by the inability to perform experimental tests [69].

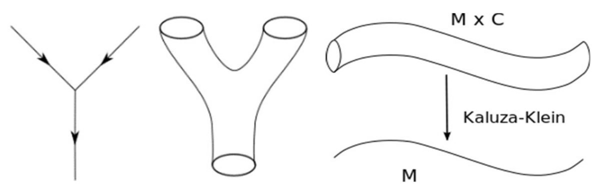

Figure 4. a) Interacting 0D fermionic point particle world line. b) M-Theory world sheet 1D string; extended to $M_{12} = M_4 \times C_8$ brane topology model where $(C_8 = \pm C_4)$. c) KK space, $M \times C$ compactified over set C; KK decomposition produces a field theory over M. A tangent bundle M (M = X x G) defined by the YM connection orthogonal to a KK metric.

A salient feature of YM-KK correspondence as a path for extending the SM is the utility of the additional degrees of freedom allowed by dimensionality beyond the 4D of the SM. That a mathematical YM-KK correspondence exists is reasonably obvious [65-73] and not under overt dispute; what is questioned is whether or not extended real physical correlations exist. We list formulations briefly here:

A correspondence path to unified theory began in 1919, but not until the 1940's was KK theory completed. Kaluza's 1921 invariant 5D line element is $ds^2 \equiv \tilde{g}_{ab} dx^a dx^b = g_{\mu\nu} dx^\mu dx^\nu + \phi^2 \left(A_\nu dx^\nu + dx^5 \right)^2$ where $\tilde{g}_{ab}$ is the 5D metric and $g_{\mu\nu}$ the 4D spacetime metric; ϕ is the associated scalar field at a 5[th] diagonal, and A the Electromagnetic (em) vector potential from which the equations of both General Relativity (GR) and em can be derived [74-76].

It is possible to have supersymmetry in alternate dimensions because spinor properties change dramatically with dimensionality. For example, in d dimensions, spinor size is ~ $2^{d/2}$ or $2^{(d-1)/2}$. The maximum supersymmetries, is said to be 32; thus, the greatest number of dimensions in which a supersymmetric theory can exist is 11D. An SU(3) x SU(2) x U(1) gauge symmetry group can describe all known particle interactions. Following Witten, [68,73] the minimum number of dimensions of a manifold with this symmetry is 7D. Gauge fields arise in SU(3) x SU(2) x U(1) group symmetry in a gravitational field as components of more than 4D. This forms a reality of at least four non-compact and seven compact spacetime dimensions, $M^4 \times S^7 = 11\text{D}$, which Witten [78] calls a '*remarkable numerical coincidence*' because this 11D supergravity maximum is the minimum for SU(3) x SU(2) x U(1) symmetry which for symmetry reasons observed in nature is in practicality the largest group one could obtain from KK theories in seven XD.

Following Sundrum, [77] for 5D GR the Einstein action is $\ni \partial_\mu$ or $\partial_5 Gr^0_{MN}(x) \to 0$ for XD fluctuations $ds^2 \ni Gr_{55}\left(dx^5\right)^2 = Gr_{55}R^2 d\theta^2 \Rightarrow$ $Gr^{(0)}_{55}(x) \equiv$ dynamical XD radius. Randall and Sundrum [47,48] found an HD method for solving the hierarchy problem utilizing 3-branes with opposite tensions, $\pm\sigma$ residing at the orbifold fixed points which together with a finely tuned cosmological constant form a source for 5D gravity.

The various Randall-Sundrum models utilize a 5D warped geometry to describe reality as an anti-de Sitter (AdS^5) space with elementary particles residing on a localized 3 + 1 4D brane (D3 Planck brane) and an additional separated gravity brane. The Randall-Sundrum warped AdS^5 XD postulate aligns sufficiently with our finite radius manifold of uncertainty [58] to give a semblance of credibility to each. Technological access to XD-LSXD requires a new group of transformations beyond the Galilean-Lorentz-Poincairé.

As a reminder, a Galilean transformation occurs between the absolute space and time coordinates of two Newtonian (non-relativistic) reference frames, (*x, y, z, t*) and (x', y', z', t') equated as $x' = x - vt,\quad y' = y, z' = z, t' = t$. The common form of the Lorentz transformation for special relativity, is a velocity confined to the *x*-direction, with $t' = \gamma\left(t - \left(vx/c^2\right)\right), x' = \gamma\left(x - vt\right), y' = y, z' = z,$ where γ is the Lorentz factor, $\left(\sqrt{1-\left(v^2/c^2\right)}\right)^{-1}$ and (x, y, z, t) and (x', y', z', t') are the coordinates for an event in two reference frames.

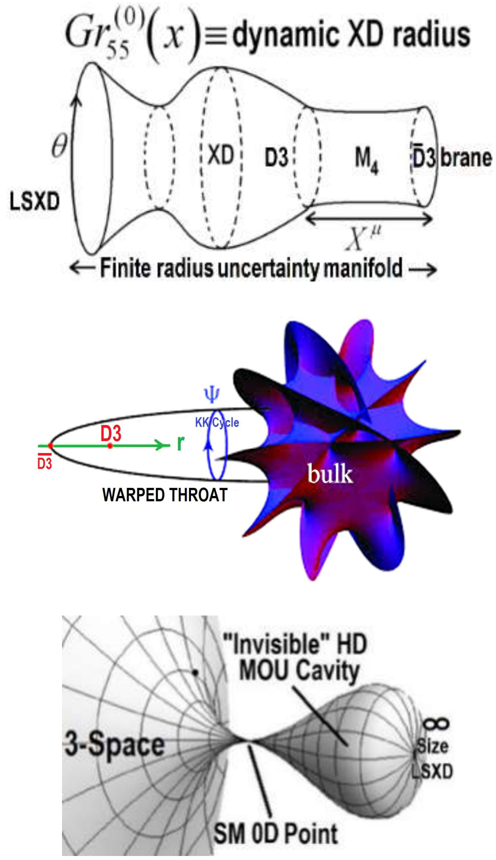

Figure 5. a) Randall-Sundrum model of dynamic GR radius for LSXD fluctuations, where X^μ are the Lorentz coordinates. Redrawn from [77]. b,c) Additional XD throat models.

We have all the pieces to formulate a new UF transform group, but are not yet sufficiently aware of topological restrictions to make a formal attempt; it is not clear in this case, whether experiment or theory will drive discovery. Because of the importance of this condition, we take liberty to speculate, hypothetically outlining the plethora of required components. As noted above our version of UFM M-theory reverts to an original hadronic form of string-theory having a tachyon (considered nonphysical) and variable string tension. Both these concepts become relevant in the UFM scenario where the present instant is a standing-wave of the future-past. Indeed the 1945, Wheeler-Feynman absorber theory,

$$T_{\text{tot}}\left(\mathrm{X},t\right)=\sum_{n}\left(E_{n}^{\text{ret}}\left(\mathrm{X},t\right)+E_{n}^{\text{adv}}\left(\mathrm{X},t\right)\right)/2+ \\ \sum_{n}\left(E_{n}^{\text{ret}}\left(\mathrm{X},t\right)-E_{n}^{\text{adv}}\left(\mathrm{X},t\right)\right)/2=\sum_{n}E_{n}^{\text{ret}}\left(\mathrm{X},t\right) \qquad (78)$$

describes radiation as a standing wave [80].

Cramer's transactional interpretation (TI) of quantum mechanics [81] (based on Wheeler–Feynman absorber theory), also describes quantum interactions as standing waves formed by retarded (forward-in-time) and advanced (backward-in-time) waves. Many consider Cramer's TI standing-waves too primitive; but a 1D oscillating string is only the basic concept. In reality, when extended to Calabi-Yau mirror symmetric dual 3-tori, a 6D hyperspherical standing wave M-theoretic topological interaction; the model can be made to work (Fig. 6d).

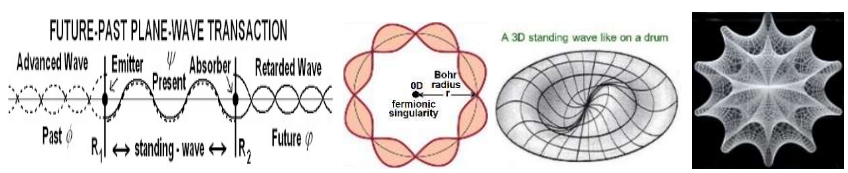

Figure 6. Cramer's Transactional Interpretation showing 1D, 2D, 3D and 6D hypercomplex standing waves respectively.

Additional complexity appears in continuous-state spin-exchange parallel transport dimensional reduction compactification process. Because there must be holophote entry of the UF force of coherence (cannot be continuous) UF generator of 3D reality of the observer (flatlanders) [58].

A *Lorentz boost* is a *Lorentz transform* not involving rotation. Lorentz boosts are well-known; superluminal Lorentz boots (SLB) less so [82-84]. In a SLB a spatial dimension is transformed into a temporal dimension. This not a substance of space; we do not know what space is other than to name it extension (Einstein's term). We can consider it a substance of spacetime. Below we will consider additional boosting.

Lorentz boosts (no rotation) in *x,y,z*-directions respectively, for coordinates (*t,x,y,z*) and $\beta = v/c$:

$$\begin{bmatrix} \gamma & -\beta\gamma & 0 & 0 \\ -\beta\gamma & \gamma & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \gamma & 0 & -\beta\gamma & 0 \\ 0 & 1 & 0 & 0 \\ -\beta\gamma & 0 & \gamma & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \gamma & 0 & 0 & -\beta\gamma \\ 0 & \gamma & 0 & 0 \\ 0 & 0 & 1 & 0 \\ -\beta\gamma & 0 & 0 & 1 \end{bmatrix} \tag{79}$$

For boosts in any direction the values of γ and β change as follows

$$\gamma = 1/\sqrt{1-\left(v_x^2+v_y^2+v_z^2 \big/ c^2\right)};\ \ \beta_x = \frac{v_x}{c}, \beta_y = \frac{v_y}{c}, \beta_x = \frac{v_y}{c} \tag{80}$$

and the boost matrix for $v = \left(v_x, v_y, v_z\right)$ is

$$\begin{bmatrix} L_{tt} & L_{tx} & L_{ty} & L_{tz} \\ L_{xt} & L_{xx} & L_{xy} & L_{xz} \\ L_{yt} & L_{yx} & L_{yy} & L_{yz} \\ L_{zt} & L_{zx} & L_{zy} & L_{zz} \end{bmatrix}. \tag{81}$$

$L_{tt} = \gamma;\ \ L_{ta} = L_{at} = -\beta_a\gamma;\ \ L_{ab} = L_{ba} = \left(\gamma-1\right)\left(\beta_a\beta_b / \beta_x^2+\beta_y^2+\beta_z^2\right)+\delta_{ab} =$ $\left(\gamma-1\right)\left(v_a v_b / v^2\right)+\delta_{ab}$, and where *a* and *b* are *x,z* or *z*.

$$\delta_{a,b} = \begin{cases} 0 & \text{if } a \neq b, \\ 1 & \text{if } b = a, \end{cases} \tag{82}$$

where the Kronecker delta, δ_{ab} is a piecewise function of *a* and *b*; for example $\delta_{1\,2} = 0$, but $\delta_{3\,3} = 1$ [85,86]. This is the stepping-stone, at the semi-quantum limit, in terms of making correspondence to a new UFM XD transform dynamics.

Again, we will make no serious attempt at derivation here, only introducing simplistically some of the required tools necessary that relate to Kronecker stepping functions. We will later on, again only briefly, show

how Kronecker products related to coquarternion and octonions will be a valuable tool in discovering the UFM M-theoretic transform.

Typically, the Kronecker delta is restricted to positive integers; for space-antispace, future-past annihilation-creation topological phase transitions we will also require negative integers to fully utilize the cyclical elements in quaternions and octonions. For example, $\delta_{(-1)(-5)} = 0$ and $\delta_{(-3)(-3)} = 1$. The Kronecker delta is said to have (changing notation) a *sifting* property for $j \in \mathbb{Z}$: $\sum_{i=-\infty}^{\infty} a_i \delta_{ij} = a_j$. If the integers are considered to be a counting measure space, this property is coincident with a defining property of Dirac's delta function, $\int_{-\infty}^{\infty} \delta(x-y) f(x)\, dx = f(y)$, important in some sequences [85].

Briefly, following [87], coquaternionic, *C* and quaternionic, *Q* Kronecker products are derived. The distinguishing difference is in the inverse of *C* and *Q* respectively,

$$C^{-1} := \frac{1}{|w|^2 - |z|^2} \begin{bmatrix} \overline{w} & -z \\ -\overline{z} & w \end{bmatrix}; \;\; \mathrm{Q}^{-1} := \frac{1}{|w|^2 + |z|^2} \begin{bmatrix} \overline{w} & -z \\ \overline{z} & w \end{bmatrix}. \qquad (83)$$

The inverse of *C* only exists if $|w|^2 - |z|^2 \neq 0$, but Q has an inverse so long as $Q \neq 0$. The salient difference regards which elements are noncommutative or commutative [87].

Leaving this for now, with the additional mention of combining these functions with relative work of Kauffman on the concept of iterant algebra to formation of basic Clifford algebras reconstructing the complex numbers in terms of a formalization of temporal process. Kauffman's iterant algebra includes all of matrix algebra and a representation of the SU(3) Lie algebra for the Standard Model and a construction of the Dirac Equation, making it clear how solutions arise from nilpotent elements in a Clifford algebra, and how Fermion algebra including the algebra of Majorana Fermions emerges in this context. Kauffman continues a formulation of the original Majorana Dirac Equation in terms of Clifford algebra in the context of his iterants [88,89].

Why is the Kauffman Interant of interest? The simplest discrete system corresponds directly to $\sqrt{-1}$, when $\sqrt{-1}$ is seen as an oscillation between ± 1. Generally, starting with a discrete time series of positions, one immediately has a non-commutativity of observations which can be encapsulated in an iterant algebra which is used to formulate the Lie algebra *SU*(3) for the Standard Model for particle physics and Majorana Fermion Clifford algebra. This Majorana Dirac equation is $\left(\partial/\partial t+\hat{\eta}\eta\partial/\partial x+\varepsilon\partial/\partial y+\hat{\varepsilon}\eta\partial/\partial z-\hat{\varepsilon}\hat{\eta}\eta m\right)\psi=0$, η and ε are the simplest generators of iterant algebra, $\eta^2=\varepsilon^2=1$ and $\eta\varepsilon+\varepsilon\eta=0$, and $\hat{\varepsilon},\hat{\eta}$ forming a commuting copy of this algebra. This combination of the simplest Clifford algebra with itself underlies the structure of Majorana Fermions, forming the underlying structure of all Fermions! Kauffman also includes the Kronecker delta in his *SU*(3) and Gell-Mann matrices discussion [88,89].

As well-known Hamilton had to sacrifice commutativity in order to close the quaternion algebra. In finding the formalism for Noetic UFM group of transformations, closure must be periodically broken; this cyclical process is key to empirically accessing the brane bulk. A Kauffman-Kronecker continuous-discrete cycle iterant algebra (commutative-anticommutative) will aid discovering the topological phase.

In addition to the mentioned boosts, rotations, standing-wave future-past annihilation-creation and various topological phase transitions; the nature of dimensionality also undergoes transformation in the new UFM M-theoretic group. In our mindset we dwell too much on the concept of dimensionality as a spatial construct, and not its complete physical meaning. Here we review firstly, the well-known Superluminal Lorentz Transformations (SLT) that changes real quantities into imaginary; how a SLT transforms a spatial dimension into a temporal dimension.

Following Cole [83] & Rauscher [82,90] we illustrate the transformation of complex spatial dimensions into temporal dimensions by orthogonal superluminal boosts (SLB). For example an SLB in the x direction with velocity $v_x \pm \infty$ the SLT is $x' = \pm t,\ y' = -iy,\ z' = -iz,\ t' = x$. To clarify the meaning of imaginary quantities in an SLT time is represented as a 3D vector; with t defined as $t = t_x\hat{x} + t_y\hat{y} + t_z\hat{z}$, in expanded form is $t_x = t_{x\mathrm{Re}} + it_{x\mathrm{Im}}$,

$t_y = t_{y\mathrm{Re}} + it_{y\mathrm{Im}}$, $t_z = t_{z\mathrm{Re}} + it_{z\mathrm{Im}}$. Finally, for the SLB with velocity $v_x \pm \infty$ along x, the transformations are

$$x'_{\mathrm{Re}} + ix'_{\mathrm{Im}} = t_{x\mathrm{Re}} + it_{x\mathrm{Im}},\ \ y'_{\mathrm{Re}} + iy'_{\mathrm{Im}} = y_{\mathrm{Im}} - iy_{\mathrm{Re}},\ \ z'_{\mathrm{Re}} + iz'_{\mathrm{Im}} = z_{\mathrm{Im}} - iz_{\mathrm{Re}}$$
$$t'_{x\mathrm{Re}} + it'_{x\mathrm{Im}} = x_{\mathrm{Re}} + ix_{\mathrm{Im}},\ \ t'_{y\mathrm{Re}} + it'_{y\mathrm{Im}} = t_{y\mathrm{Im}} - it_{y\mathrm{Re}},\ \ t'_{z\mathrm{Re}} + it'_{z\mathrm{Im}} = t_{z\mathrm{Im}} - it_{z\mathrm{Re}} \quad (84)$$

where the SLT in *x* of M_4 spacetime transforms real components into imaginary, and imaginary complex quantities into real quantities as one major property of the periodic nature of noetic anthropic multiverse spacetime [82,90,91].

UFM postulates how boundary conditions transform the dimensionality of space and time along with the energy covering (de Broglie-Bohm super-quantum potential) of the UF by $D_S \rightarrow D_t \rightarrow D_e$; i.e. space $\rightarrow$ time $\rightarrow$ energy (UFM) [90,91]. In complex Minkowski space the coordinates are $z^u = x^u_{\mathrm{Re}} + ix^u_{\mathrm{Im}}$ where z is complex and $X_{(\mathrm{Re})}$ and $X_{(\mathrm{Im})}$ are real and the index u runs over 0,1,2,3. Using classical notation for simplicity $t = t_{\mathrm{Re}} + it_{\mathrm{Im}}$, $x = x_{\mathrm{Re}} + ix_{\mathrm{Im}}$, $y = y_{\mathrm{Re}} + iy_{\mathrm{Im}}$, $z = z_{\mathrm{Re}} + iz_{\mathrm{Im}}$.

11. Space-Antispace

The nilpotent condition for the two vector spaces can be made from arbitrary scalar values and be represented by the 5 generator objects E, p_x, p_y, p_z, m to form the two commuting vector spaces by,

$$\left(\mathrm{K}E + i\mathrm{Ii}p_x + i\mathrm{Ij}p_y + i\mathrm{Ik}p_z + i\mathrm{Jk}m\right)\left(\mathrm{K}E + i\mathrm{Ii}p_x + i\mathrm{Ij}p_y + i\mathrm{Ik}p_z + i\mathrm{Jk}m\right) = 0 \,. \quad (85)$$

Which becomes the nilpotent condition, $E^2 - p_x^2 - p_y^2 - p_z^2 - m^2 = 0$. The bracketed object above has squared to zero, the duality is identical and defines the principle of a point in either space as a norm 0 crossover between them. Physics is mediated by the concept of space, requiring a dual space to ensure that the fundamental condition of the universe is a zero totality. The real space of observation is defined by quaternions as *i, j, k* [55,59]. The dual space, I,J,K not accessed as a physical quantity (until now) is called `vacuum space', or `antispace' because it combines with real space to produce a nilpotent zero totality. The creation of nilpotent structures zeroing all higher terms and the perfect group symmetry allowing a complete cancellation ensure that Nature exhibits zero totality in all of its aspects, material and conceptual, and it does this via a fundamental principle of duality [55-57].

Another way to look at this is to say the fermion always exists in the two spaces from which it is constructed, real space and vacuum space, and the non-classical *zitterbewegung* motion, Schrödinger found in the solution to the free-particle Dirac equation [92], represents the switching between these spaces which makes it possible to define the fermion as creating a point singularity through the intersection of two spaces. We can here apply a reverse argument from topology. The creation of a particle singularity using its `intersection' with a dual space can be seen as the creation of a multiply-connected space from a simply-connected space through the insertion of a topological singularity.

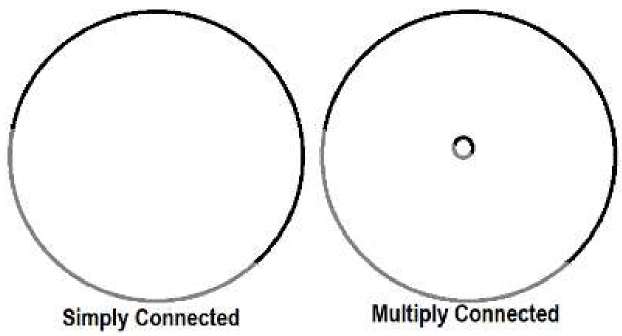

Figure 7. Simply and multiply-connected spaces effect parallel transport (One of our UFM generators of topological switching) differently.

According to a well-known argument, parallel transporting a vector round a complete circuit in a multiply-connected space will produce a phase shift of π or 180° in the vector direction, whereas transporting it round a simply-connected space will not, and so, in the first case, the vector will be required to do a double circuit to return to its starting point [56,93]. This is exactly what happens with a spin ½ fermion, which, as a point-singularity, can be regarded as existing in its own multiply-connected space. We can interpret this as meaning that the fermion requires a double circuit because, just as in *zitterbewegung*, it spends only half of its time travelling in the real space of observation.

12. Matter as Continuous-State Calabi-Yau Brane Bouquet Transformations

M-theory currently remains silent in any attempt to configure a bouquet of resonant strings into a model of a fermion. The googolplex of possibilities, essentially 10^{∞} for deriving a single unique compactification of the 11D bulk producing the 4D Standard Model has remained elusive. While we have been able to derive a unique vacuum utilizing an alternative derivation of string tension in a continuous-state cosmology [91], our anthropic UFM model, provides feasibility of such modeling on the horizon; success would be elusive without the new noetic UFM group of transformations.

All matter appears to observation as a singularity. In wave-particle duality, the quantum field is like the clothing of the particle. Physical science has no idea of what the fundamental nature of a field is; we put a metric in its proximity and measure salient properties. Likewise, we do not know what space is, other than to apply Einstein's definition, that it is extension. Our observations of matter in Euclidean-Minkowski-Riemann space are considered geometric. The additional 8D of the M-theoretic bulk are considered topological, with attempts underway to provide topological field theories [58,94].

Wave-particle duality, yes, is a probabilistic Heisenberg potentia given either wave or particle depending on measurement conditions. This QM regime is only an oasis in the combinatorial hierarchy of reality [58,90,91,94]. However, in passing beyond the Copenhagen wall of QM exclusion/ uncertainty, the inherent processes of existence are a continuous cycle of this duality and its extended mirror symmetric partners. Anthropic reality depends on this. Assuming (not yet proven) Descartes is correct in his dualism postulate, the dynamic propagation of 3-space (observation) manifold embedded in the M-theoretic Bulk of the UF, must be, in terms of the *injected* (ontologically topologically switched) coherence force of the UF, holophotic, not continuous, otherwise, the *flatlander* cannot abide his 2D existence. His eyes, by subtractive interferometry, would see 12D and he would fall through the floor (pass through like the 3-sphere visitor to Flatland) out of temporal existence. However, many degrees of freedom we define SM temporality with, localized realism is limited. The UFM nonlocal holographic ∞ has all degrees of freedom. As well-known, Einstein claimed, if one put a saddle on a photon, one could circumnavigate the universe without the passage of time. This is not all; its observation pertains to the nonlocal instantaneity where temporal dimensions are transformed by annihilation. As a metaphorical SM mantra: if one assumes matter is a vector gluon, the leading lightcone singularity is modulated by a phase of the quark gluon field. We attempt upgrade to UFM: If one assumes that reality is a tensor psychon, the superimplicate order is an evanescent ontology of the UFM noeon field.

In this section, we attempt to provide some insight into the nature of topological brane dynamics in the bulk. It is radically different than the string communities current thinking, primarily because compactification is continuous. We will not argue this point now, other than to propose in passing, that the reason is anthropic. Einstein himself stated that his long sought UF could explain living systems.

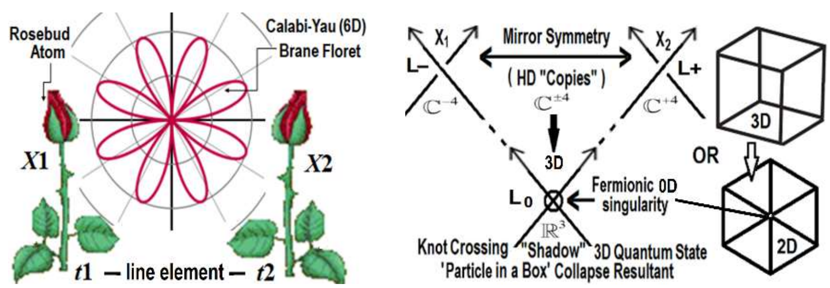

Figure 8. 12D UFM models of matter. a) Consider $X_1(t_1)$ and $X_2(t_2)$ as ends of a line element between two atoms depicted in 3-space as rosebuds. For a space-antispace configuration, X would only represent the knot shadow, fermionic singularity of observation in b) with Euclidean coordinates *x,y,z*. b) An oriented left-right (over-strand, under-strand) crossover link diagram; each component has a preferred direction as shown by the arrow. For a given crossing L_+, L_-, resultants L_0 and $\mathbb{R}^3$ change the diagram as proposed. Braid elements in the HD complex, $\mathbb{C}^{\pm 4}$ brane world become a knotted shadow when projected onto Euclidean space, $\mathbb{R}^3$. c) Illustrating how a crossing shadow reduces dimensionality.

Fermionic matter can no longer be considered 0D point particles (electrons) or as rigid Mass-charge quark microspheres (nucleons), as treated by vector algebra or quantum field theory, embedded in (3)4D (+,+,+,-) Minkowski-Riemann manifold; but must now be devised as a compactification of 6D D-brane mirror symmetric Calabi-Yau florets cyclically driven by de Broglie-Bohm-Cramer piloted matter-wave XD brane topology-phase transitions. The generator design's multiphasic concatenation requires utilization of a unique interpretation of M-Theory, the modified model of matter, albeit incorporating relevant *off-the-shelf*, parameters currently incorporated into the vast panoply of thinking comprising String Theoretic parameters; especially those related to T-Duality D-brane mirror symmetry, because as generally known, T-duality interrelates two theories with different spacetime geometries. Thus, allowing correspondence with usual notions of classical atomic geometry, quantum field theory or our radically different UFM formulation of T-duality.

Figure 8a **is** simplistic in that the rosebud is only illustrated for an x coordinate; whereas it is proposed that a quaternionic space-antispace mirror symmetric representation, $\pm\, i, j, k$ would entail six buds continuously blooming (Calabi-Yau brane topology) and compactifying into the 3-space knotted shadows. A knot projected onto a plane casts a shadow. A small change in the angle of projection shows if it is one-to-one except at the crossings, where a 'shadow' of the knot crosses itself once transversely. Analogously, knotted surfaces in 4-space can be related to immersed surfaces in 3-space.

The knot crossing shadows in Figs, 8b,9 in the next step are illustrated as trefoil knots. In work in progress, we show that the topology of the Dirac spinor is a trefoil in HD; a fact hidden from observation, until now, by the uncertainty principle.

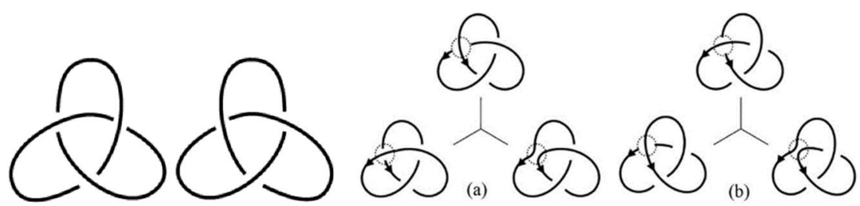

Figure 9. a) Left and right-handed trefoil knots are mirror images of each other. b) Raising and lowering of trefoil over and under crossings allows a variety of topological moves.

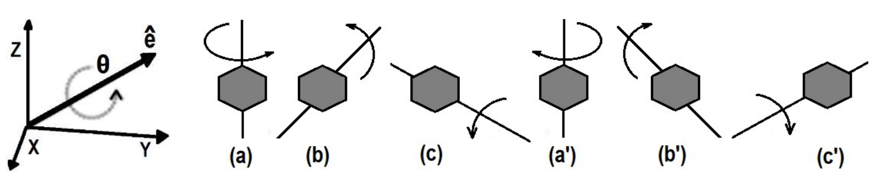

Figure 10. Regarding Fig, 9, unknotting the crossover links during parallel transport allows rotations to be added to the topological phase transitions.

Topological moves (phase transitions) are richly endowed. We attempt to illustrate the battery of parameters useful in describing the operation of a UFM transformation group. We address these elements in an introductory manner primarily to give an overview of the requirements as seen at this point in time in the hopes of engendering interest in development of experimental protocols [95].

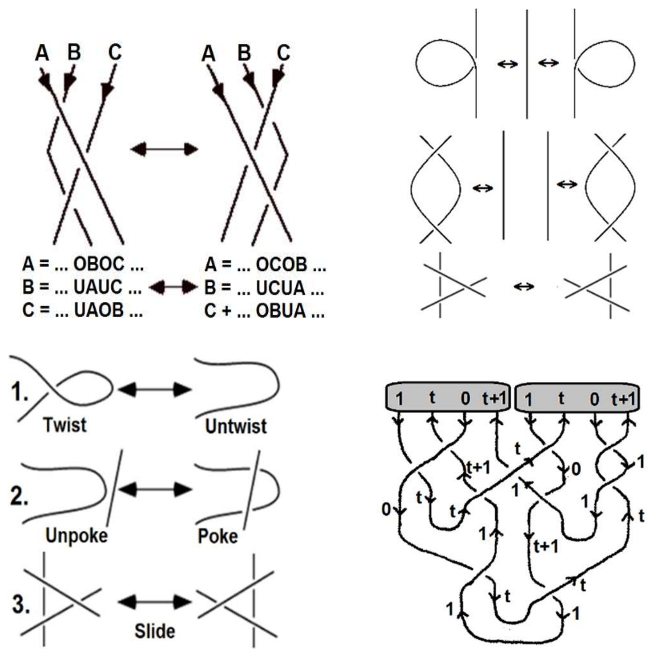

Figure 11. a,b,c) Varieties of Reidemeister moves. d) A roll spun knot.

The local SM component corresponds to 4D quantum Field Theory wherein Copenhagen aspects are replaced by resultant Cramer Transactional and extended de Broglie-Bohm piloted implicate order causality with a corresponding nonlocal duality of Large-Scale Additional Dimensionality (LSXD) in the bulk described by an Ontological-Phase Topological Field Theory developed as a 12D form of cyclic Kaluza-Klein theory initially introduced by Yang-Mills Kaluza-Klein correspondence to include a fundamental Least Cosmological Unit (LCU), the primary requirement for an Einsteinian Unified Field Theory as the tessellation of space/spacetime [51,62,63,67,96].

To fully represent matter up to and beyond space-antispace, three oriented rosebuds *X,Y,Z* would be required mirror symmetrically designated with quaternion notation, $Y = i, j, k$ and $Z = -i, -j, -k$. In addition, the space-antispace configuration would be represented as in the center of a) as rose petals in bloom. *X,Y,Z* undergo Dirac spinor rotation, where a rotation through antispace takes 720º rather than the 360º needed for a 3-space rotation to return to the starting position. Because this only represents the penultimate compactification to 3-space, *X,Y,Z* are represented by a trefoil configuration of three sets of quaternions. This fact has been hidden from observation as an element of the Dirac spherical rotation by the quantum uncertainty principle. To complete the UFM line element cycle the rose petal symmetry (Calabi-Yau topological brane interactions), continues through a continuous 12D KK cycle. The mirror image of the space-antispace mirror image is causally free of the knot crossing shadow in 16b), which is realized or the collapsed resultant of the local 3(4)D Euclidean/Minkowski quantum *particle in a box*.

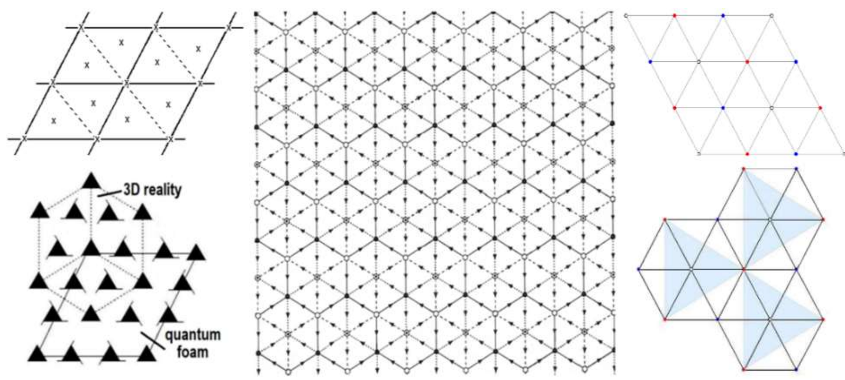

Figure 12. a) 2D and projected 3D view of LCU tiling, giving rise to higher dimensionality (1 sphere in Fig. 5b,c,d in spacetime backcloth. LCU spacetime loses its stochasticity at the semi-quantum limit; and becomes more ordered by coherent control at the upper (HD) limit of the *manifold of uncertainty* by coherence of the UF. b) Least-unit exciplex C-QED backcloth tessellating space, able to accommodate any geometry and any transform by topological switching. Fig. adapted from [97]. c-bottom) P and H domains of Dixon functions for sm *z*, Fig. adapted from [98].

In Fig**.** 12a-bottom, the triangles with tails represent the trefoil knots in Fig. 7 and the naked triangles the resultant cyclic point or fermionic vertex quantum state in 3-space.

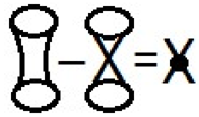

Figure 13. The Dirac mobius transforms to an HD trefoil to tunnel through the finite radius semi-quantum limit. Tunneling $\equiv$ wormhole or warped D-brane throat.

Our proposal that Dirac spherical (spinor) rotation (360º-720º) for SM particle physics in Minkowski/Riemann space 3(4) +,+,+,- includes hidden trefoil crossover topology in the semi-quantum interface requires further discussion on the parametrization of the trefoil surface in relation to the Dirac Mobius. Because of the existence of HD-LSXD duality, hidden (until now) from observation by the uncertainty principle, takes the form of a mirror symmetric trefoil with utility of its over/under crossings for parallel transport in both simply and multiply-connected topologies. This scenario is required to describe the UFM transform and operation of HD M-theoretic bulk reality.

Firstly, the Trefoil, ***T*** has polar equation $r^3 = 2A\cos(3\theta)$ and Cartesian coordinates $\left(x^2+y^2\right)^3 = A\left(2x^3-6xy^2\right)$. Following Langer & Singer's [98] description of the trefoil as a sextic curve with exceptional properties, such as a genus-1 Platonic surface with 18 equilateral triangle faces that may be exchanged and rotated like the faces of an icosahedron (dual of dodecahedron).

Dixon elliptic functions, based on the curves $x^3+y^3-3axy=1$ and the trefoil make a perfect fit. Our interest is in the Fermat cubic, $x^3+y^3=1$, for which when $a=0$, the Dixon functions display a unique hexagonal symmetry; a simpler curve with the same projective symmetry group as ***T.*** Especially as the Dixon sine sm *z* can be used to map a regular hexagon onto a Riemann sphere, where the hexagon interior is conformally mapped onto the complement of the three rays joining ∞ to a cube root of unity. In this sense, arc length parameterization provides the trefoil's structure as a genus-one Platonic surface, whose 18 equilateral-triangular faces may be arbitrarily exchanged and rotated, like the faces of an icosahedron [98].

The trefoil has many noted features. The Dixon sine equation $\mathrm{sm}\, z = \tan\frac{p}{2}e^{i\lambda}$ correlates the hexagon point with complex coordinate $z=x+iy$ with the point in the sphere of latitude $\pi/2-p$ and longitude

λ. The function $w = \mathrm{sm}\, z$ defines real z by $z = \int_0^w dx \Big/ \left(1 - x^3\right)^{2/3}$, and $\mathrm{cm}\, z$ by $\mathrm{sm}^3 z + \mathrm{cm}\, z = 1$. Then interestingly, sm (0) = 0, cm (0) -1, and $\frac{d}{dz}\mathrm{sm}\, z = \mathrm{cm}^2 z$, $\frac{d}{dz}\mathrm{cm}\, z = s\mathrm{m}^2 z$. In 1896, Caley finally paved the way for formalizing sm z and cm z as elliptic functions.

Since sm z and cm z have periods $p_1 = 3K$ and $p_2 = 3\omega K$, with $\omega = -1 + i\sqrt{3}/2$ as a cube root of unity: $\mathrm{sm}\left(z + 3\omega^j K\right) =$ sm z, $\mathrm{cm}\left(z + 3\omega^j K\right) =$ cm z, $j = 0,1,2$. As for any elliptic functions, one can describe the values of sm z and cm z, $z \in \mathbb{C}$, via a tiling of the plane by copies of a `period parallelogram' P with edges corresponding to the pair of periods. There is a corresponding triangulation of P by 18 equilateral triangles (Fig. 12c-top). One may also define rotational and quasiperiodic translational symmetries [98].

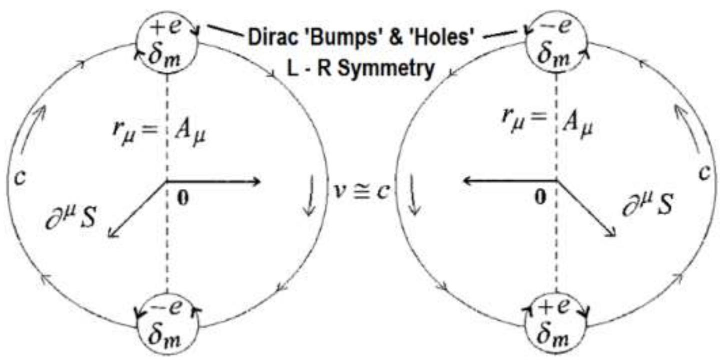

Figure 14. Oppositely charged sub-elements rotating at v ≅ c around center 0 behaving as dipole bumps and holes on the surface of a covariant polarized Dirac vacuum, allowing Sagnac interferometric rf-modulation.

The tiling of sm z and cm z trefoil properties to the vacuum are an entry point for applying micromagnetics to the Dirac polarized vacuum. When a static electric dipole d is placed in front of an ideally conducting wall, it interacts with its mirror image. In historical terms, this Casimir–Polder (CP) result, gives the interaction potential between a ground state atom and a mirror as obtained within the cQED (cavity-QED) framework known to be valid for any separation z between the atom and the mirror and results from modification of vacuum fluctuations by the mirror.

Recent experiments have given clear evidence for the existence of retardation terms in the atom-wall problem, in good agreement with Casimir-Polder predictions. We extend these parameters in our 3rd regime M-theoretic UFM approach in order to enable aspects of the Static-Dynamic (S-D) Casimir Effect in relation to topological charge inherent in cyclical (KK-like T-duality) brane interaction dynamics mediated by a super quantum potential of the unified field. The UFM interaction is an Ontological (energyless) transfer of information, not phenomenological (quantal) as in quantum field theory.

The dynamics of micromagnetics becomes part of LCU vacuum programming by resonant pulsed external fields. The magnetic domains in Dirac LCU vacuums act as an aggregate of spins. There are four applicable magnetic forces, magnetostatic, exchange, anisotropic and external which can be programmed to act on the other three. These phenomena work in conjunction with topological invariants such as winding, wrapping and linking numbers. Toffoli states, emergent structures of micromagnetics do not constitute a motley collection of features, rather, they are arranged in a dimensional hierarchy (respectfully 3, 2, 1, and 0 dimensions) interconnected with topological constraints [97].

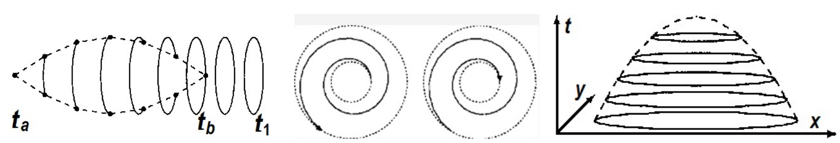

Figure 15.. a) Two Bloch points created as a pair at $t > t_0$, move apart and subsequently come together (dashed), annihilating at $t < t_1$. Moving in space they leave a trail of twisted magnetization (solid) eventually closing on itself but still hovering in space even after the Bloch points disappear. b) Path described by a Vertical Bloch Wall (VBL) lying on the wall of an expanding bubble (left). Dotted lines indicate the bubble's initial and final sizes. As the wall slowly moves outwards, the VBL slides along it at a speed much larger than the wall itself (here ~10); compound VBL motion (radial and tangential) is a logarithmic spiral. When the magnetic field changes in opposite direction the wall retreats, the VBL spirals inwards (right). c) As a bubble is made to shrink until it disappears, its boundary (circles) generates a surface (paraboloid-like figure) having the topology of the disk. Figures modified from [97].

Of extreme importance to the duality required to surmount the uncertainty principle for quantum computing is the application of topological phase transitions to the finite radius manifold of uncertainty beginning at the semi-quantum limit; this takes the form of topological switching between the regime of micromagnetics and HD brane topology. The LCU tessellated spacetime network of signals and nodes representing information transactions. The nodes are partitioned into triangular sublattices. The transition between lattice states entails the collapse of a hexagonal lattice into a triangular lattice which is a form of symmetry breaking. In the schema of topological switching, perfect symmetry is everywhere extant relative to the force of coherence mediating the UF, wherein the hexagonal lattice is a programmable metastable state which can be cyclically protected from decoherence [58,97,99,100].

13. Dirac's Extended Electron with Inherent with Local-Nonlocally Entangled Hypertubes

In his *Classical theory of radiating electrons*, Dirac proposed (in the framework of classical theory) a self-consistent schema describing the interaction of electrons with radiation. The electron treated as a point charge led to the difficulties of infinite Coulomb energy. Dirac avoided this using a procedure of subtracting divergent terms similar to that used in positron theory. The equations obtained, had the same form as those currently used, but their physical interpretation for *the final size of the electron took on a new sense*. Namely, the interior of the electron appeared as a region of space through which signals could be transmitted *faster than light*. Dirac concluded *the interior of the electron* was *a region of failure, not of the field equations of EM theory, but of elementary properties of spacetime* [101]. We now know that spacetime is not fundamental, but emergent. One may readily accept that spacetime is quantized; but quantized spacetime does not necessitate the quantization of gravity.

Phrased in terms of Dirac's theory, nonlocality holds that particle and wave constitutive elements correspond to *extended hypertubes* (with real clock-like motions) which thus carry superluminal phase waves. If the existence of a gravitational field determining the metric is confirmed, gravitational interactions could also correspond to spin-2 phase waves moving faster than light [102-106]. Interestingly, contrary to often-expressed opinion, Einstein himself did not deny the existence of the ether; in his 1920 Leyden lecture, he stressed, *the negation of ether is not necessarily required by the principle of special relativity. We can admit the existence of ether, but we have to give up attributing it to a particular motion . . . The hypothesis of the ether as such does not contradict the* *theory of special relativity.* What Einstein did reject completely was the existence of the *absolute frame of reference*.

It is now an experimental fact that gravity generates waves that cause the matter in spacetime to oscillate; this does not however, confirm in any way the existence of a graviton, quantized or otherwise. General Relativity is a classical theory. In pondering Figs. 12a,c, it is easy to realize M-theoretic parameters must be built into any G-theory before we can have a complete model. M-theory is fraught with many assumptions that may seem logical in some frameworks, but are nevertheless incorrect.

14. The Vigier Hypertube Model and the De Broglie-Bohm-Vigier Causal Interpretation

The Vigier model [107] is an advanced implementation of the Bohm-Vigier approach which suggests a solution to the problem of quantum nonlocality. This model is essentially relativistic. In Vigier's representation, the irregular fluctuations of the Bohm-Vigier model (1954) [108] are interpreted as being due to a *random subquantal level of matter*, in the sense of Dirac's *aether* or de Broglie's *hidden thermostat* [109]. This idea reflects Einstein's viewpoint according to which quantum statistics should be due to a real subquantal physical vacuum alive with fluctuations and randomness.

The notion of an extended particle, as introduced by Bohm and Vigier in 1954 (see also Ref. [110]) has been developed further by Vigier. If Dirac's picture of an extended electron is accepted, then the motion of the core of the electron should be represented in 4-spacetime not by a line, but by a time-like hypertube lying inside the light cone. Accordingly, in the Vigier model particles are regarded as *extended time-like hypertubes* that "move along time-like paths and can only transmit superluminal information localized within their internal structure" (see [111,112]).

In Vigier's model, the stochastic jumps introduced by Bohm and Vigier (1954) as a mechanism to carry particles from one line of flow to another, are interpreted as *stochastic jumps on the light cone*, meaning that *the stochastic fluctuations occur at the velocity of light* [107]. Here, the relativistic extension of the continuity equation (1), namely, $\partial_\mu j_\mu = 0$, is shown to be equivalent to the set of two (forward and backward) Fokker-Planck equations

$$\frac{\partial\rho}{\partial\tau}+\nabla\left(\nu\pm\rho\right)\pm D\square\rho=0,\quad\left(\rho=R^2\right) \tag{86}$$

where the diffusion coefficient, D is obtained in the same form, $D=\hbar/(2m)$, as in Furth [113]. Lastly, the notion of *superluminal propagation of the quantum potential* was introduced in the Vigier model [107]. Specifically, for a particle of rest mass m, the quantum potential Q, as defined by $Q = \log M$ with

$$M=\left[m^2+\frac{\hbar^2}{c^2}\frac{\square\rho^{1/2}}{\rho^{1/2}}\right]^{1/2}, \tag{87}$$

is a function of the density $\rho=\left(\psi^*\psi\right)^{1/2}$ alone, and propagates with superluminal velocities within the drift current. The quantum potential is *a real interaction among the particles and the subquantal fluid polarized by the presence of the particles* [114] is considered to be a *true stochastic potential* [115].

It is important to note that the quantum potential is essentially *nonlocal*, so that Vigier's model, like Bohm's theory, appears as a particular implementation of non-local hidden-variable theories. Therefore, it does not conflict with Bell's inequalities. An essential feature of Vigier's model is that it preserves Einstein's causality in experiments of the EPR type, while at the same time explaining quantum mechanical nonlocality through a *nonlocal superluminal information* transfer. The latter is not brought about by individual particles, but rather is due to the propagation of collective excitations (considered real and physical) on top of the *material vacuum* [116,117].

Since the time of Dirac, Vigier, de Broglie and Bohm's writings, we have independently uncovered similar parameters relating to electron (fermionic) hypertubes; but with variations; hypertube connectivity is not superluminal, but instantaneous [103,106]. Additionally, in our postulate of a close-packed Least Cosmological Unit (LCU) tessellating space/spacetime, with an inherent duality (like Dirac's electron hypertube) of a warped throat connecting the semi-quantum limit (finite radius manifold of uncertainty) to Large-Scale Additional Dimensionality (LSXD) of M-theoretic brane topological interactions in the bulk, associated with an Einsteinian Unified Field (UF) model [103,106]. We have also proposed a battery of experimental protocols for falsifying the model [106].

There are already in existence numerous gravimetric technologies in a variety of developmental stages able to measure tiny variations in the local gravitational acceleration. Some applications are, detection of hidden hydrocarbon reserves, magma build-up before volcanic eruptions, and locating subterranean tunnels; they are called *free-fall gravimeters*, spring-based gravimeters, superconducting gravimeters, and atom interferometers. Most gravimeters have limitations of high cost. Recently developed microelectromechanical system (MEMS) devices can be used to measure the Earth tides. MEMS accelerometers found in most smart phones can be mass-produced cheaply, but none are stable enough for gravimetry [121-131]. One recent MEMS device has made the transition from accelerometer to gravimeter with many possible applications in gravity mapping; its developers claim it could be mounted on a drone for distributed land surveying and exploration, deployed to monitor volcanoes, or built into multi-pixel density-contrast imaging arrays [132].

15. Added Theory Required to Complete Understanding of Gravity

The quest to quantize gravity is nearly universal among physicists; indeed, great strides are believed to have been made in terms of quantum entanglement and black hole modeling. Although much of the motivation for this scenario arises because quantum mechanics is considered *the basement of reality* and the fact that the other *three known forces are quantized*; this does not mean that gravity must also be quantized. M-theory, although more troubled recently, is still considered the best theory for quantizing gravity. Applying conditions recently introduced by Susskind [133], a method can be demonstrated for removing fundamental conditions for quantization and modifying the mass of a particle, by field interactions. When this is applied to topological phase transitions in Calabi-Yau mirror symmetric brane interactions in an ontological (energyless) form of topological switching (information transfer) rather than as a phenomenological (quantized) manner of field interaction, it can be shown that there is a *virtual quantization* of matter up to a semi-quantum limit beyond which in the higher dimensional space of M-theory gravity make correspondence with an Einstein Unified Field as the regime of integration in terms of an ontological-phase topological field theory

[102-104,106,118,119]. This new theory, stated simplistically is a modified form of string/M-theory without quantization.

This theory will be completed in an ensuing paper. The model, completing description of the principles for developing Sagnac dual-polarized ring laser interferometric effects for microgravimetry on EM-wave polarization additionally requires extending the process of Kaluza-Klein cyclicality to all levels of M-theoretic compactification modes (cyclic or continuous manner), extension of the Dirac hypertube model of the electron [120,134,135] and utility of the Randall-Sundrum warped throat model [136-139] in order to open the arena for the unification of gravity to the 3rd regime of natural science – that of a long sought Einsteinian unified field.

16. Conclusions and Discussion

We conclude this model with three remarks.

1. If one assumes elementary particles are extended in space, then one enters a new field of research, since one should describe (in such a frame) their internal motions and connect them with observable properties of their external motions.

2. Such attempts evidently violate the limits imposed on physical models by the Copenhagen interpretation (believed to be incomplete), since one thus assumes the existence of some still unobservable properties only justified by their indirect physical consequences and their internal motions occur in distorted space-time geometry like the Einstein energy dependent spacetime metric, $\hat{M}_4$ [140] which in terms of new thinking should be extended to an HD string theoretic vacuum that takes into account the parameters of a covariant Dirac polarized vacuum.

3. The model proposed in this work (albeit too simple) suggests a similarity between the proposed internal periodic motions of electrons and the periodic motions, at much larger scale, of atoms and molecules, *i.e.* extends to internal particle motions some of the concepts suggested by the causal stochastic interpretation of Quantum Mechanics. Whether this is true or not will be settled by the future development of microscopic physics [141].

16.1 Discussion

1. Electron theory is addressed in the context of questions about the size of the electron in relation to its point-like behavior, the problem of the nature of electron spin and its EM self-interaction, the problem of the contribution of the electron charge to the electron mass, and the problem of the anomalous magnetic moment.

2. The chapter bases its modeling on the assumption that the vacuum is a physical medium built of a covariant polarized distribution of EM waves. In this model, each individual element moves within a time-like hypertube.

3. Certainly if one assumes that elementary particles are extended in space, then one should describe their internal motions and connect these with observable properties from the outside. This makes this sort of modeling a challenge to the pure symmetry approach to elementary particles where the particle is identified with its external quantum symmetry group. In this context it is legitimate to assume that there is associated with a particle a distinction of geometric type in the ambient three-dimensional space. Of course, it is also possible to articulate this distinction in terms of internal spaces of higher dimensions as occurs in string theories and earlier in Kaluza-Klein theory. At this point we reach an interface between the topology of embedded manifold structures in three-dimensional space and corresponding structures in higher dimensions. If hypertubes appear from the outside as tangled knotted and woven structures, this must be compared with their interior view that will contain the geometry and topology of the interior spaces.

4. The remarks in 3, lead mathematically to new notions about knots and links in 3D space that can generalize the role of knots and links in both string theory and in Chern-Simons theory. In both of these cases the embeddings of one-dimensional manifolds (tubes about one-dimensional manifolds) are augmented by extra structure that is called out as internal structure or the structure of a gauge field on a bundle over the three-dimensional space. In all these cases it is the relationship among these structures that is of consequence for particle properties and particle interactions. What we need to think about on the mathematical side is how to hold the context of a knot with extra structure when this structure has global complexity as does a gauge field or a string quantization. The notion of external/internal that is challenged here will potentially lead to new mathematics and new physics.

5. The point of view taken here also challenges the strict notion of measurement in the Copenhagen/von Neumann school of quantum mechanics. Particles being field structures should not have their measurements treated as an idealized projection to an eigenstate, but rather, the entire context of the measurement should be taken into account as a quantum field theoretic phenomenon. This is more complex, that a simple projection and it is more realistic, more geometrical and more topological. It will be worth the effort to find this richer formulation of measurement in relation to geometric/topological particle structure.

16.2. Final remarks

The chapter describes a model of particle structures extended in space-time, with structural features incorporating 'hidden' parameters which describe 'the local collective motions of the corresponding pilot-waves'. This is part of a long-term project by Vigier in applying the pilot wave model of de Broglie to overcoming some of the problems inherent in the Copenhagen interpretation of quantum mechanics. The conclusion to the paper says that the semi-classical model proposed is 'too simple', but that it suggests a way of linking particles with proposed internal structures with atoms and molecules which are known to have such structures.

Present experimental evidence is consistent with a point-like structure for fundamental particles; data from Penning traps suggests that the radius of the electron, if it exists, must be less than 10^{-22} m. String / membrane theory, however, has proposed that fundamental particles can be represented in some sense as extended objects, which would help to overcome the problem of infinite self-energy needing to be removed by renormalization, and the finite size is linked to the HD brane concept in the abstract of this paper.

A point-like structure for particles does not mean that the particles will behave as point-like in a *classical* way. There are aspects of particle behavior which generate properties akin to extension, even in a point-like particle – for example, vacuum polarization, *Zitterbewegung* and the related Lamb shift. There is also the classical radius, relating mass and charge, and the Compton radius, a measure of the particle's mass. And, of course, Heisenberg uncertainty means that a point-like particle cannot be located at a classical point. In addition, aspects of quantum systems can often be usefully modeled by semiclassical approaches, e.g. the Bohr theory. So, even assuming a Copenhagen interpretation of quantum mechanics and a strictly point-like structure for a fundamental particle, it is relevant to ask how far a *model* of an extended structure can encompass such intrinsically quantum properties as *Zitterbewegung*. The value of such a model, therefore, does not necessarily require us to prove it to be true, but depends on the extent to which we can use it to generate results, especially numerical ones, for experimental investigation and extension of theory into new areas.

Equation (5) p. 3, $W_H \cong 2\mu^2 / 3R_M^3$ is of interest because the factor 2/3 makes it close to the expression that Heaviside obtained for the mass (*m*) produced by a sphere of radius *r*, with a charge **e** uniformly distributed through it:

$$\frac{e^2}{4\pi\varepsilon_0 r} = \frac{2}{3}mc^2 \qquad (88)$$

I have always thought that, for an electron, the radius

$$r = \frac{3}{2}\frac{e^2}{4\pi\varepsilon_0 m_e c^2} \qquad (89)$$

was more important than the 'classical radius' [142] (*Zero to Infinity*, p. 612), and certainly with respect to the polarized vacuum, *Zitterbewegung*, etc. (Something like this or the classical radius connects directly with the electron mass, which derives from *Zitterbewegung*. This is also true of the Compton wavelength.) Of course, an electron is not a diffused sphere of charge, but this is not a totally inaccurate expression of *vacuum*, which, from the electron's point of view is a series of 'virtual' positron-electron pairs. Vacuum is nonlocal and so fits in with a picture of a diffused concept of charge rather than a localized one.

The nilpotent formulation of quantum mechanics defines the uniqueness of fermions solely through the instantaneous direction of the spin axis, which contains all the information that is known about a fermionic state (*Zero to Infinity*, p. 144 [142]). The nilpotent formulation derives from a double vector space, one space being defined as ordinary, observable, space, the other as unobservable, vacuum, space (see the accompanying paper, P. Rowlands, *Dual Vector Spaces and Physical Singularities*). The uniqueness of axis is in both spaces.

A particle model with + and – charges rotating round each other at the speed of light has a vacuum that is made up of a lattice of electron-positron pairs. I think of both of these as being a kind of model of *Zitterbewegung*, which I have as occurring at a particle 'singularity', on the boundary between real and vacuum spaces. (See P. Rowlands, *Dual Vector Spaces* *and Physical Singularities*) So I think of an extension in structure in real space as being like a 'physical' semiclassical model of the more abstract and quantum mathematical structure of a dual vector space (the 'vacuum' space being a mathematical combination of all the unobservable parameters in physics – mass, time, charge). This also fits with the string / membrane concept, in principle, though it rules out any of the individual string models as being ultimately or fundamentally true. (P. Rowlands, *Dual Vector Spaces and Physical Singularities*)

Fundaments of the dynamic hyperstructure of the Randall-Sundrum D-brane warped throat have remained elusive. Inspiration arises in the obvious similitude to notions Dirac conceived in his electron hypertube model.

We now prepare to propose a variety of experimental protocols for surmounting the uncertainty principle enabling exploration of inherent dualities at the semi-quantum limit.

References

[1] M. Evans et al., (1994) The Enigmatic Photon, Kluwer,
[2] Vigier, J-P (1990) Evidence for nonzero mass photons associated with a vacuum-induced dissipative redshift mechanism, IEEE Trans Plasma Sci, 18:1;64-72.
[3] Amoroso, R.L., Kafatos, M. & Ecimovic, P. (1998) The origin of cosmological redshift in spin exchange vacuum compactification and nonzero rest mass photon anisotrophy, in G. Hunter, S. Jeffers & J-P Vigier (eds.) Causality and Locality in Modern Physics, Dordrecht: Kluwer.
[4] Amoroso, R.L & Rauscher, E.A. (2009) The Holographic Anthropic Multiverse, Singapore: World Scientific.
[5] Barnes, A. & Scargle, J.D. (1975) Improved upper limit on the photon mass, Phys Rev. 35: 17; 1117-1120.
[6] J.P. Vigier, Phys. Lett. A 235 (1997) 419.
[7] Roy, S. & Lehnert, B. (1998) Extended Electromagnetic Theory; Space Charge in Vacuo and the Rest Mass of the Photon, Singapore: World Scientific.
[8] Lehnert, B. (2002) New developments in electromagnetic field theory, in R.L. Amoroso, G. Hunter, M. Kafatos & J-P Vigier (eds.) Gravitation & Cosmology: From the Hubble Radius to the Planck Scale, Dordrecht: Kluwer Academic.
[9] Lehnert, B. (1998) Electromagnetic theory with space-charges in vacuo, in G. Hunter, S. Jeffers & J-P Vigier (eds.) Causality and Locality in Modern Physics, Dordrecht: Kluwer Academic.
[10] Dirac, P.A.M. (1952) Nature (London) 169, 702.
[11] Petroni, N.C & Vigier, J-P (1983) Dirac's aether in relativistic quantum mechanics, Foundations of Physics, 13:2; 253-285.
[12] Amoroso, R.L. (2002) Developing the cosmology of a continuous state universe, in R.L. Amoroso, G. Hunter, M. Kafatos & J-P Vigier (eds.) Gravitation & Cosmology: From the Hubble Radius to the Planck Scale, Dordrecht: Kluwer Academic.
[13] M.H. Mac Gregor, (1992) The Enigmatic Electron, Kluwer Academic Publishers.
[14] Vigier, J-P, and Amoroso, R.L. (2002) Can one unify gravity and electromagnetic fields? in R.L. Amoroso, G. Hunter, M. Kafatos & J-P Vigier (eds.) Gravitation and Cosmology: From the Hubble Radius to the Planck Scale, Dordrecht: Kluwer Academic.
[15] Amoroso, R.L. & Vigier, J-P (2004) Toward the unification of gravity and electromagnetism, in V.V Dvoeglazov & A.A. Espinoza Garrido (eds) Relativity, Gravitation, Cosmology, NY: Nova.
[16] G. Hunter, The Bohr model of the photon (Invited Paper) 2005 Proceedings of SPIE - The International Society for Optical Engineering 5866
Geoffrey Hunter, Marian Kowalski, Camil Alexandrescu
[17] F. Halbwachs, *Theorie relativiste des fluides* a *spin,* Gauthier-Villars, 1960.
[18] Bohm, D. & Vigier, J-P (1954) Model of the causal interpretation of quantum theory in terms of a fluid with irregular fluctuations, Phys Rev 96:1; 208-217.
[19] P.A.M. Dirac, Nature 1968 (1951) 906.
[20] L. Mackinnon, Found. of Physics 81 (1978) 157 and 11(1981) 910.
[21] V.K. Ignatovich, Foundations of Physics 8 (1978) 565.
[22] M. Faraday, Phil. Trans. Royal. Soc. (1832) 25 and (1852) 25.
[23] O'Hara, J. G. (1975) George Johnstone Stoney, F.R.S., and the Concept of the Electron, Notes and Records of the Royal Society of London. 29 (2) 265–276.

[24] Stoney, G. J. (1894) Of the "Electron", or Atom of Electricity, Philosophical Magazine. Series 5. 38: 418–420.
[25] Barrow, J. D. (1983) Natural Units Before Planck, Quarterly Journal of the Royal Astronomical Society 24: 24.
[26] GJ Stoney (1881) On the physical units of nature, Phil. Mag. 11, 381-391.
[27] D. Bohm and J.P. Vigier, Phys. Rev. 109 (1958) 1882.
[28] P. Beckmann, Einstein Plus Two, Golem Press, 1987.
[29] P. Hillion and J.P. Vigier, II Nuovo Cimento XVIII (1960) 205.
[30] P.A.M. Dirac, Nature 1968 (1951) 906 and 169 (1952) 702.
[31] Battey-Pratt and T.J. Racey, Int. J. Th. Phys. 19 (1980) 437.
[32] Ph. Guereit et al., Phys. Lett. 107A (1985) 379.
[33] G. Darboux (1918) Bull. Amer. Math. Soc. 24, 394-403. 1
[34] G. Darboux (1917) *Principles de Geometrie Analytique*, Paris: Gauthier-Villars.
[35] VB Matveev (1991) Darboux Transformations and Solitons, Berlin: Springer-Verlag.
[36] N. Cufaro-Petroni, Ph. Gueret and J.P. Vigier, II Nuovo Cimento 81 (1984) 243.
[37] T. Takabayasi (1979) Relativistic mechanics of confined particles: The bilocal case, Prog. Theor. Phys. 67, pp. 1-68.
[38] L. de Broglie (1953) La physique quantique indeterministe, Paris, Gauthier-Villard.
[39] Mackinnon, L. Lett. al. Nuov. Cim. 42 (1985) 362.
[40] A. Einstein (1912) Energy dependent spacetime metric
[41] V. Petkov (2000) Acceleration dependent electromagnetic self-interaction effects as a basis for inertia and gravitation, in press.
[42] B. Haisch and A. Rueda, Phys. Lett A (in press).
[43] D. Bohm et al., II Nuovo Cimento XVIII (1960) 209.
[44] A. Ghosh (Origin of Inertia (1999) Aperion, 2:1, 33-39.
[45] Vigier, J-P (2000) selected papers, in S. Jeffers, B. Lehnert, N. Abramson, & L. Chebotarev (eds.) Jean-Pierre Vigier and the Stochastic Interpretation of Quantum Mechanics, Montreal: Aperion.
[46] Vigier, J-P (1997) Possible consequences of an extended charged particle model in electromagnetic theory Physics Let A, 235:5; 419-431; R. L. Amoroso, L. H. Kauffman, E. A. Rauscher, P. Rowlands, and J.-P. Vigier (2010) “Hidden” Parameters Describing Internal Motion Within Extended Particle Elements, AIP Conference Proceedings 1316, 1; https://doi.org/10.1063/1.3536434
[47] de Broglie, L. & Vigier, J-P (1972) Phys. Rev. L. 28, 1001-1004.
[48] Kowalski, M. (1999) Photon Emission from Atomic Hydrogen, Phys Essays, Vol.12, 312-331.
[49] RL Amoroso, P. Rowlands, S. Jeffers (2010) Search for Fundamental Theory, VIIth Intl Symposium Honoring French Mathematical Physicist Jean-Pierre Vigier, AIP Conf Proc 1316.
[50] Amoroso R L and Di Biase F 2013 Empirical protocols for mediating long-range coherence in biological systems *J Consc Explor Res* 4 9 955-976
[51] Amoroso R L and Rauscher E A 2010 Empirical protocol for measuring virtual tachyon tardon interactions in a Dirac vacuum AIP Conf Proceed 1316 99
[52] Amoroso R L 2016 Yang-Mills Kaluza-Klein equivalence An empirical path extending the standard model of particle physics (http://vixra.org/pdf/1511.0257v1.pdf) address given at: (http://www.ntu.edu.sg/ias/PastEvents/2015/Yang-Mills60/Pages/default.aspx); (https://www.youtube.com/watch?v=ecu86GY7Xt8)

[53] Amoroso R L 2015 Introduction to unified field mechanics Formalizing the protocol (http://vixra.org /pdf/1511.0175v1.pdf)
[54] Amoroso R L 2015 Unified field mechanics A brief introduction (http://vixra.org/pdf/1511.0176v1.pdf)
[55] Rowlands P 2013 Space and antispace in R L Amoroso L H Kauffman and P Rowlands (eds) The Physics of Reality Space Time Matter Cosmos World Sci 29-37
[56] Rowlands P 2014 A dual space as the basis of quantum mechanics and other aspects of physics in J C Amson and L H Kauffman (eds) Scientific Essays in Honor of H Pierre Noyes on the Occasion of His 90th Birthday World Scientific 318-338
[57] Rauscher E A Rowlands P and Amoroso R L 2015 Dirac equations in nilpotent quaternionic space-antispace and eight dimensional (8D) complex Minkowski space Unified Field Mechanics 66-87 (https://www.worldscientific.com/doi/abs/10.1142/ 9789814719063 0006)
[58] Amoroso R L 2017 Universal Quantum Computing: Surmounting Uncertainty Supervening Decoherence Hackensack World Scientific
[59] Rowlands P 2015 How many dimensions are there? In R L Amoroso LH Kauffman and P Rowlands (eds) Unified Field Mechanics: Natural Science Beyond the Veil of Spacetime Hackensack World Scientific
[60] Rowlands P 2014 *The Foundations of Physical Law* Singapore World Scientific
[61] Bailin D and Love A 1987 Kaluza-Klein theory *Rep Prog Phys* 50 1087-1170
[62] Becker K Becker M and Schwartz J H 2007 String Theory and M-theory A Modern Introduction Cambridge Cambridge Univ Press
[63] Amoroso R L 2013 Shut the front door Obviating the challenge of large-scale extra dimensions and psychophysical bridging in R L Amoroso L H Kauffman and P Rowlands (eds) The Physics of Reality Space Time Matter Cosmos, London, World Sci
[64] Amoroso R L 2010 Simple resonance hierarchy for surmounting quantum uncertainty, in RL Amoroso P Rowlands and S Jeffers (eds) AIP Conf Proc 1316 1 185-193
[65] O'Raifeartaigh L 1997 The Dawning of Gauge Theory Princeton Univ Press
[66] Chivukula RS Dicus DA and He HJ 2002 Unitarity of compactified five-dimensional Yang–Mills theory *Phys Let B* 525 1 175-182
[67] Reifler F and Morris R 2007 Conditions for exact equivalence of Kaluza-Klein and Yang-Mills theories (arXiv:0707.3790 [gr-qc])
[68] Witten E 1997 Solutions of four-dimensional field theories via M-theory Nuclear Physics B 500 1-3 3-42
[69] Banks T 2003 A critique of pure string theory Heterodox opinions of diverse dimensions (arXiv: hep-th/0306074)
[70] Martin SP 2011 A supersymmetry primer (arXiv:hep-ph/9709356v6)
[71] Gogberashvili M 1999 Four dimensionality in non-compact Kaluza-Klein model (ArXiv:hepph/9904383v1)
[72] Overduin J M and Wesson P S 1997 Kaluza-Klein gravity Phys Report 283 303-378
[73] Witten E 1981 Search for a realistic Kaluza-Klein theory Nuc Phys B 186 412-428
[74] Klein O 1926 Quantum theory and five-dimensional relativity theory *Zeit Phys* 37 895
[75] Klein O 1926 The atomicity of electricity as a quantum theory law *Nature* 118 516
[76] Kaluza T 1921 *Zum Unitätsproblem in der Physik Sitzungsber Preuss Akad Wiss Berlin Math Phys* 966-972

[77] Sundrum R 2005 SSI lecture notes part 2 (http://www.slac.stanford.edu/econf/ C0507252/lecnotes/Sundrum2/sundrum2.pdf)
[78] Randall L and Sundrum R 1999 An alternative to compactification *Phys Rev Let* 83 4690-4693; ([hep-th/9906064])
[79] Randall L 2005 Warped Passages New York Harper-Collins
[80] Wheeler J A and Feynman R P 1945 Interaction with the absorber as the mechanism of radiation *Rev Mod Phys* 17 2–3 157–181
[81] Cramer J G 1986 Transactional interpretation of quantum mechanics *Rev Mod Phys* 58 3 647
[82] Rauscher EA 2002 Non-Abelian gauge groups for real and complex Maxwell's equations in RL Amoroso G Hunter S Jeffers and M Kafatos (eds) Gravitation and Cosmology From the Hubble Radius to the Planck Scale Dordrecht Kluwer
[83] Cole E A B 1977 *Il Nuovo Cimento* 40 2 171-180
[84] Hansen R O and Newman ET 1975 *Gen Rel and Grav* 6 216
[85] Frankel T 2012 The Geometry of Physics An Introduction 3rd ed Cambridge Univ Press
[86] Spiegel E O'Donnell C J 1997 Incidence algebras Pure Applied Maths 206 Marcel Dekker
[87] Janovska´ D and Opfer G 2013 Linear equations and the Kronecker product in coquaternions *Mitt Math Ges Hamburg* 33 181–196
[88] Kauffman L H 2016 Iterants braiding and the Dirac Equation in R L Amoroso G Albertini L H Kauffman and P Rowlands (eds) Unified Field Mechanics II, Xth Vigier Symposium, London World Sci
[89] Kauffman L H 2019 Iterants and the Dirac equation in R L Amoroso D M Dubois L H Kauffman and P Rowlands (eds) Advances In Fundamental Physics Prelude to Paradigm Shift XI Vigier Symposium IOP J Physics Conference Series London
[90] Rauscher E A and Amoroso R L 2011 Orbiting the Moons of Pluto: Complex Solutions to the Einstein Maxwell Schrödinger and Dirac Equations London. World Sci
[91] Amoroso R L and Rauscher E A 2009 The Holographic Anthropic Multiverse Formalizing the Complex Geometry of Reality London World Scientific.
[92] Schrödinger E 1930 *Über die kräftefreie bewegung in der relativistischen quantenmechanik Sitz Preuss Akad Wiss Phys-Math Kl* 24 418 28
[93] Berry M V 1984 Proc R Soc Lond A 392 45 57
[94] Amoroso R L 2018 Einstein/Newton duality: An ontological-phase topological field theory XX Intl Meeting Physical Interpretations Relativity Theory (PIRT) 3–6 July 2017 Moscow Russian Federation J Phys Conf Series 1051 open access (https://iopscienceioporg/article/101088/1742-6596/1051/1/012003)
[95] Amoroso, RL (2010) Simple Resonance Hierarchy for Surmounting Quantum Uncertainty, AIP Conference Proceedings 1316, 185; https://doi.org/10.1063/1.3536432
[96] Sung JC 1993 *Pixels of Space-Time* Woburn Scientific Publications
[97] Kotigua R P and Toffoli T 1998 Potential for computing in micromagnetics via topological conservation laws *Physica D* 120 1-2 139-161
[98] Langer J C and Singer D A 2013 The trefoil *Milan J Math* 99 9999 1-23
[99] Chang H (ed) 1975 *Magnetic Bubble Technology* IEEE Press New York
[100] O'Dell T H 1973 The dynamics of magnetic bubble domain arrays Philos Mag 27 596-606
[101] Chebotarev L 2000 The de Broglie–Bohm–Vigier approach in quantum mechanics Basic concepts of the causal stochastic interpretation of quantum mechanics in S Jeffers

B Lehnert N Abramson and L Chebotarev (eds) Jean-Pierre Vigier and the Stochastic Interpretation of Quantum Mechanics Montreal Aperion
[102] Amoroso RL 2009 On the possibility of relativistic shock-wave effects in observations of quasar luminosity in RL Amoroso and EA Rauscher The Holographic Anthropic Multiverse Formalizing the Complex Geometry of Reality London, World Sci
[103] Amoroso RL 2018 July Einstein/Newton duality An ontological-phase topological field theory in IOP J Phys Conf Series 1051 1 012003
[104] Amoroso RL 2013 Unified geometrodynamics A complementarity of Newton's and Einstein's gravity in The Physics of Reality Space Time Matter Cosmos 152-163 Hackensack World Sci
[105] Vigier J-P 1995 Fundamental Problems of Quantum Physics Apeiron 2 4 114-115
[106] Amoroso R L 2017 Universal Quantum Computing Surmounting Uncertainty Supervening Decoherence Hackensack World Scientific
[107] Vigier J-P 1979 *Lett Nuovo Cimento* 24 258 265
[108] Bohm D and J P Vigier J-P 1954 *Phys Rev* 96 208
[109] de Broglie L 1964 *La Thermodynamique de La Particule Isol ´EE* Paris
[110] Bohm D and J P Vigier J-P 1958 *Phys Rev* 109 882
[111] Selleri and F Vigier J-P 1980 *Lett Nuovo Cimento* 29 1
[112] Vigier J-P 1980 *Lett Nuovo Cim* 29 467
[113] Furth R 1933 *Z Physik* 81 143
[114] Petroni N C and Vigier J-P 1979 *Lett Nuovo Cimento* 26 149
[115] Petroni N C Droz-Vincent Ph and Vigier J-P 1981 *Lett Nuovo Cimento* 31 415
[116] Vigier J-P 1997 Possible consequences of an extended charged particle model in electromagnetic theory, Physics Letters A 235 p419-31
[117] Vigier J-P 1994 Possible test of the reality of superluminal phase waves and particle phase space motions in the Einstein-de Broglie-Bohm causal stochastic interpretation of quantum mechanics Foundations of Physics 241 61-83
[118] Amoroso R L and Dunning-Davies J 2014 A scintilla of unified field mechanics revealed by a conceptual integration of new fundamental elements associated with wavepacket dispersion in R L Amoroso et al The Physics of Reality Space Time Matter Cosmos 239-248
[119] Amoroso RL 2017 Newton-Einstein G-duality and Dirac-Majorana fusion modeling as mediated by ontological-phase topological field theory in R L Amoroso G Albertini L H Kauffman P Rowlands (eds) Unified Field Mechanics II Preliminary Formulations and Empirical Tests 10th Symposium in Honor of Jean-Pierre Vigier Hackensack World Scientific
[120] Dirac PAM 1962 Proc Royal Soc 268A 57
[121] Jiang Z et al 2009 Relative gravity measurement campaign during the 8th international comparison of absolute gravimeters Metrologia 49 95–107 2012
[122] Goodkind J M 1999 The superconducting gravimeter Rev Sci Instrum 70 4131–4152
[123] de Angelis M et al 2009 Precision gravimetry with atomic sensors Meas Sci Technol 20 022001
[124] Krishnamoorthy U et al 2008 In-plane MEMS-based nano-g accelerometer with sub-wavelength optical resonant sensor *Sens Actuat A* 145–146 283–290
[125] Lainé J and Mougenot D 2014 A high-sensitivity MEMS-based accelerometer *Leading Edge* 33 1234–1242

[126] Pike W T et al 2014 A self-levelling nano-g silicon seismometer in *Proc IEEE Sensors 2014* 1599 1602 (http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber =6985324)
[127] Battaglia M Gottsmann J Carbone D and Fernandez 2008 J 4D Volcano Gravimetry Geophysics 3 WA3–WA18
[128] Peterson J 1993 Observations and modeling of seismic background noise US Geological Survey USGS Report 93-322 (http://www.mttmllr.com/ADS/DATA/ peterson_usgs_seismic noise ofr93-322.pdf)
[129] Romaides A J et al 2001 A comparison of gravimetric techniques for measuring subsurface void signals J Phys D 34 433–443
[130] Butler D K 1984 Microgravimetric and gravity gradient techniques for detection of subsurface cavities *Geophysics* 49 1084–1096
[131] Kirkendall B Li Y and Oldenburg D 2007 Imaging cargo containers using gravity gradiometry *IEEE Trans* Geosci Remote Sens 45 1786–1797
[132] Middlemiss R P Bramsiepe S G Douglas R Hild S Hough J Paul D J Samarelli A Rowan S and Hammond G D 2018 Microelectromechanical system gravimeters as a new tool for gravity imaging Philosophical Trans Roy Soc A: Math Phys and Eng Sci 376 2120 20170291
[133] Susskind L 2012 Demystifying the Higgs boson (https://www.youtube.com/ watch?v=JqNg819PiZY)
[134] Gnadig P Kunszt Z Hasenfratz P Kúti J 1978 Dirac's extended electron model Hungarian Academy of Science; (https://inis.iaea.org/collection/ NCLCollectionStore/ Public/10/435/10435160.pdf)
[135] Chebotarev L V 2000 The de Broglie–Bohm–Vigier approach in quantum mechanics Basic concepts of the causal stochastic interpretation of quantum mechanics Jean-Pierre Vigier and the Stochastic Interpretation of Quantum Mechanics Montreal Aperion 1-18
[136] Randall L and Sundrum R 1999 Phys Rev Lett 83 3370 (hep-ph/9905221); Phys Rev Lett 83 4690 (hep-th/9906064)
[137] Cvetic M Duff M J Liu T Lu H Pope C N and Stelle K S 2000 Randall-Sundrum brane tensions; (arXiv:hep-th/0011167v1)
[138] Bao R Lykken J 2005 Randall-Sundrum with AdS(7) (arXiv:hep-ph/0509137v2)
[139] R.L. Amoroso, L.H. Kauffman, E.A. Rauscher, P. Rowlands & J-P Vigier (2010) "Hidden" Parameters Describing Internal Motion Within Extended Particle Elements, AIP Conference Proceedings 1316, 1; https://doi.org/10.1063/1.3536434
[140] A. Einstein (1912) Energy dependent spacetime metric
[141] R L Amoroso, LH Kauffman, P. Rowlands, EA Rauscher, (2012) Search For Fundamental Theory, London: Oxford Academic Press, in process.
[142] Rowlands, P (2007) Zero to Infinity, The Foundations of Physics, Series on Knots and Everything, Vol 41, London: World Scientific