Article

Sagnac Dual-Polarized Ring Laser Interferometric Effects for Microgravimetry on EM-Wave Polarization

Richard L. Amoroso*

Noetic Advanced Studies Institute, Utah, USA

Abstract

Microgravimetric detectors have been studied for about 40 years; recent advances include free-fall gravimeters, spring-based gravimeters, superconducting gravimeters, and atom interferometers. The most recent gravimeter advance, a microelectromechanical system (MEMS) constructed from tiny mechanical structures micro-machined from silicon, evolved from accelerometers used in cell phones to viable miniature gravimeters. Our model uses a different approach, that of measuring gravitational interaction on the polarization of EM-waves by the utility of Sagnac Effect 4-mode dual-photon propagation ring laser apparatus in the context of a Dirac polarized vacuum in terms of Extended Electromagnetic Theory, where the postulated longitudinal $B^{(3)}$ EM-field supports a photon mass anisotropy framework for G-wave detection.

Keywords: Interferometry, EM-wave polarization, microgravimetry, ring laser, Sagnac effect.

1. Overview

The utility of Sagnac Effect 4-mode dual-photon propagation ring laser apparatus for measuring the effects of gravitational interactions on the polarization of an EM-wave is described. The device is designed to study the nature/detection of gravitational waves in terms of Extended Electromagnetic Theory [1-4], where the postulated longitudinal $B^{(3)}$ EM-field supports a photon mass, m_γ anisotropy framework for G-wave detection. The 4 different beams have 4 different phase velocities, dependent upon polarization and propagation direction. Motivation was acquired serendipitously by noticing a disparity in wavepacket dispersion/attenuation for seasonal patterns and periods of no service and intermittent (dropped) service in the region near the operational cutoff range limit of 900 or 1800 MHz telecommunication EM-wave signals, where signal strength attenuates periodically by factors attributed to coupled oscillation between the solar field dynamo (physical process generating Sun's magnetic field) and the Earth's geomagnetic core dynamo - in conjunction with seasonal tilt of the Earth's axis and gravitational changes during sunrise/sunset periods [5]. Since there are no known thermodynamic effects on the propagation of EM-waves, we are left to postulate direct G – EM interaction effects.

*Correspondence: Prof. Richard L. Amoroso, Director of Physics Lab., Noetic Advanced Studies Institute, Utah, USA. https://orcid.org/0000-0003-2405-9034; http://www.noeticadvancedstudies.us E-mail: amoroso@noeticadvancedstudies.us

Experiments conducted by R.M. Kiehn using dual polarized ring lasers verified that the speed of light can have these 4 different phase velocities depending upon direction and polarization; the 4-fold Lorentz degeneracy can be broken with parity and time-reversal symmetry breaking [6-9]. In contrast to large-scale LIGO interferometers (current - L-shaped 4 km arms with 3,000 km separation, proposed - 40 km triangular arm configuration) for detecting cosmic gravitational waves. Our apparatus is tabletop and designed to measure gravitational effects on photon polarization. Current thinking in Geometrodynamics assumes gravitational waves travel at the speed of light, where distance for LIGO interferometry corresponds to a difference in G-wave arrival times of up to 10 milliseconds [10-12].

Our model requiring additional theory, suggests that neither classical EM-theory nor quantum field theory provide a sufficient framework for describing these EM – G-wave polarization interactions; which for us requires a modified dual M-Theoretic topological approach integrating Newtonian instantaneity with Einsteinian relativity as described by a unified field mechanical (UFM) Ontological-Phase Topological Field Theory (OPTFT) able to program space-antispace vacuum least cosmological unit (LCU) cellular automata-like tessellations [13-17].

2. What is gravity?

> *[T]he right-hand side includes all that cannot be described so far in the Unified Field Theory, of course, not for a fleeting moment, have I had any doubt that such a formulation is just a temporary answer, undertaken to give General Relativity some closed expression. This formulation has been in essence nothing more than the theory of the gravitational field which has been separated in a somewhat artificial manner from the unified field of a yet unknown nature"* A. Einstein. $\left[G_{\mu\nu} + \Lambda g_{\mu\nu} = \left(8\pi G / c^4\right) T_{\mu\nu}\right]$.

Generally, gravitational waves are disturbances in the curvature of spacetime, generated by accelerated masses, propagating as waves outward from their source at the speed of light; or according to LIGO - *ripples* in space-time caused by the most violent and energetic processes in the Universe. Einstein predicted the existence of G-waves in 1916 in his general theory of relativity. Einstein's maths showed that massive accelerating objects (neutron stars or black holes orbiting each other) would disrupt space-time in such a way that *waves* of distorted space would radiate from the source (like the movement of waves away from a stone thrown into a pond). Also, these ripples would travel at $v \equiv c$ through the Universe, carrying information of their cataclysmic origins, and clues to the nature of gravity itself.

Most theoretical physicists *believe* the quantum realm is the *basement of reality* and since the three known forces are quantized, gravity *must* be quantized also. In contrast, we believe, following Feynman:

[M]aybe we should not try to quantize gravity. Is it possible that gravity is not quantized and all the rest of the world is? ... Now the postulate defining quantum mechanical behavior is that there is an amplitude for different processes. It cannot be that a particle which is described by an amplitude, such as an electron, has an interaction which is not described by an amplitude but by a probability ... seems that it should be impossible to destroy the quantum nature of fields. In spite of these arguments, we should like to keep an open mind. It is still possible that quantum theory does not absolutely guarantee that gravity has to be quantized [18] - R.P. Feynman. Ontological phase transitions provide such a scenario [13-15].

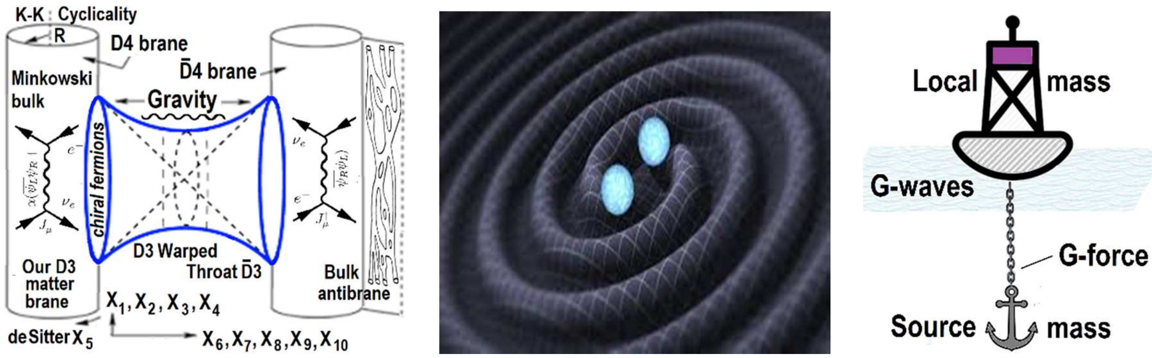

Figure 1. a) M-theoretic brane concept of the origin of gravity in the XD bulk. b) Depiction of LIGO G-wave colliding black holes. Fig. courtesy NASA/C Henze [11]. c) Machian-Vigier inertial G-model, where inertial flux (source mass) is cosmological – Earth, sun, galaxy.

Figure 1a) depicts our extension of the proposal of M-theorists, where we reside on a D3-brane, associated with an antispace mirror symmetric $\bar{D}3$ brane (total 10D). The weakness of gravity is explained by the postulate that matter is embedded in the local 3-brane manifold, whereas gravity is free to move through the bulk. Local 3(4)D $+++-$ Minkowski space, is connected to XD branes through a wormhole-like *warped throat*, that up to the semi-quantum limit entails a manifold of uncertainty (MOU) of finite radius, leading through to a dual Calabi-Yau mirror symmetric brane bouquet bulk. The wormhole connecting deSitter-antideSitter $D4$-$\bar{D}4$ branes opens and closes cyclically. When closed the uncertainty principle is in full force. String/M-theorists postulate the weakness of gravity compared to the other three forces by the statement that *matter is embedded in the 3-brane of our reality and gravity is free to pass between them.*

Recently, de Rham et al. argue that the challenges of understanding space-antispace mirror symmetric D-branes can be resolved by embedding our 3-brane within a succession of higher-dimensional branes, each with their own induced gravity term. They refer to this framework as Cascading Gravity [19]; which we have incorporated a warped throat version of in Fig.1a.

In contrast to the current String/M-theoretic search for a single unique 4D compactification to the Standard Model (SM), in our proposed UFM model, compactification is a continuous process. This scenario is important for embedding Kaluza-Klein (KK) dimensional cyclicality and the Wheeler-Feynman-Cramer standing-wave model of a quantum state or transaction. This additionally allows a de Broglie-Bohm superimplicate order quantum potential to be correlated with the mediating ontological topological coherent force of the UF [13-17].

In Fig. 1c, the Mach-Vigier *anchor model* is symbolically illustrated. The model needs further development, as outlined briefly in Sec. 4 below. To suffice for now, relating Fig. 1a to Fig. 1c; the duality between the Einstein relativistic model, $v \equiv c$ and Newtonian instantaneity, must be understood in terms the structure of extended Dirac-Vigier hypertubes likely to be a (dSAdS) de Sitter-anti de Sitter warped ($D3\text{-}\bar{D}3$ throat) brane topology correlating them [13,16,17].

Reminder on Dirac delta function: a generalized distribution modeling the density of an idealized point mass/charge as a function equal to 0 everywhere except for 0 and where the integral over the entire real line is equal to 1; formally $\delta(t) = \begin{cases} 0 & t \neq 0 \\ \infty & t = 0 \end{cases}$ with $\int_{t_1}^{t_2} dt \delta(t) = 1$ if $0 \in [t_1, t_2]$ (0 otherwise). $\delta(t)$ is *infinitely peaked* at $t = 0$ with total area unity.

The nonlocal connection rests on the idea that particle and wave constitutive elements are not delta functions, but correspond to extended hypertubes (containing real clock-like motions) which can thus carry superluminal phase waves. If the existence of a gravitational field determining this metric is confirmed, gravitational interactions could also correspond to spin-2 phase waves moving at $v > c$ [20].

3. Sagnac Effect and inherent spacetime chirality – interference fringes versus beats

Understanding the proposed Sagnac Effect gravimeter is described in four parts:

1. Fringes in contrast to beats.
2. Conditions related to operation of the Sagnac effect incorporated as a dual polarized ring laser.
3. Cosmological properties of chirality.
4. Constitutive properties of compact domains that lead to non-radiating electromagnetic molecules.

3.1 Fringes versus beats.

In order to understand Sagnac interferometry we review some components. For instance, in regards to fringes or beats

$$\Psi_1 = e^{i(k_1 \cdot r - \omega_1 t)}, \ \Psi_2 = e^{i(k_2 \cdot r - \omega_2 t)} \tag{1}$$

the two outbound waves superimpose (with $k_1 \neq k_2, \ \omega_1 \neq \omega_2$) as $\Delta k = k_1 - k_2$ and $\Delta\omega = \omega_1 - \omega_2$, so $\vec{\Psi}_1 + \vec{\Psi}_2 \sim \exp(\Delta k \cdot r / 2 - \Delta\omega \cdot t / 2) \Psi_1$ or better $\vec{\Psi}_1 + \vec{\Psi}_2 = 2\cos(\Delta k \cdot r / 2 - \Delta\omega \cdot t / 2) \cdot \Psi_1$. A fringe is a measurement of variations in a wave vector, Δk where t remains constant and r varies. Whereas, beats measure frequency variation: $\Delta\omega$ where r remains constant and t varies [6-8].

Contrasting phase and group velocity, firstly, Phase Velocity $=\omega / k = C / n,$ where C is Lorentz velocity and n is the index of refraction; secondly, Group Velocity $= d\omega / dk \sim \Delta\omega / dk \sim \Delta\omega / \Delta k$ and of course, $C / n \neq \Delta\omega / \Delta k$.

Next, contrast outbound phase and inbound phase propagation modes. Note the opposite orientations of wave and phase vectors. There are four phase components: For Outbound $\rightarrow$ Phase we have

$$\begin{aligned} \Psi_1 = e^{i(k_1 \cdot r - \omega_1 t);}\ \Psi_2 = e^{i(-k_2 \cdot r + \omega_2 t)} \\ k = \ \rightarrow \qquad k = \ \leftarrow \end{aligned} \tag{2}$$

For Inbound $\leftarrow$ Phase

$$\begin{aligned} \Psi_3 = e^{i(k_3 \cdot r + \omega_3 t);}\ \Psi_4 = e^{i(-k_4 \cdot r - \omega_4 t)} \\ k = \ \rightarrow \qquad k = \ \leftarrow \end{aligned} \tag{3}$$

For propagation modes, one mixes Eqs. (2,3) outbound or inbound phase pairs for fringes and beats; mixing outbound and inbound phase pairs, produces *standing waves*. For Phase Entanglement, all four modes are mixed. Note each phase mode has a 4-component isotropic spinor representation [6-8].

From Wolf [21-24], one can also contrast this with spherical waves $\nabla^2\Phi - \left(1/c^2\right)\partial^2\left(\Phi/\partial t^2\right) = 0$ for which there are two solutions which are also in and out wave solutions,

$$\Phi_{\text{out}} = \frac{1}{r}\Phi_{\max}\exp\left(i\omega t - ikr\right),\ \Phi_{\text{in}} = \frac{1}{r}\Phi_{\max}\exp\left(i\omega t + ikr\right), \tag{4}$$

where, Φ is the scalar wave amplitude, $k = mc/h$ = wave number, w = 2πf, r = radius from the wave center, and energy = $E = hf = mc^2$.

At the center, the in-wave continuously rotates to transform it to the out-wave. Superposition of the two amplitudes produces a standing wave that can occur in two ways depending on rotation, CW or CCW. One way is the electron, the other the positron with opposite spin. To see this, the rotation operators are $\mathbf{R}^{\text{CCW}}$ or $\mathbf{R}^{\text{CW}}$. Then the two amplitudes are:

$$\text{The electron} = \text{E}(-) = \left\{- \text{ IN-wave} + \text{OUT-wave}\right\}\ \mathbf{R}^{\text{CCW}} \tag{5}$$

$$\text{The positron} = \text{E}(+) = \left\{+ \text{ IN-wave} - \text{ OUT-wave}\right\}\mathbf{R}^{\mathbf{CW}}. \tag{6}$$

In 1945, Wheeler and Feynman proposed an Absorber Theory as the mechanism for energy transfer by calculating EM-radiation emitted from an accelerated electron. The electron generated outward and inward waves. Cramer's Transactional Interpretation of quantum theory is based on the Wheeler-Feynman Absorber Theory [25]. Wolff further proposed a parallel model where spherical standing-waves created a *particle effect* at their Wave-Center, which he suggests as a solution to the 70-year-old paradox of the Wave-Particle Duality of Matter [21-23].

Which for the programming of spacetime, can be applied to the propagation of Cramer's advanced retarded transaction waves from an emission locus at *x,t* = 0,0 by Eqs. (7) shown in Fig. 2. Which form the advanced-retarded components of a transaction [26]. We may also contrast this with the four components of Cramer's standing-wave transaction,

$$F_{1-\mathrm{Ret}} = F_0 e^{-ikx} e^{-2\pi ift},\ F_{2-\mathrm{Ret}} = F_0 e^{ikx} e^{-2\pi ift},\ F_{3-\mathrm{Adv}} = F_0 e^{-ikx} e^{2\pi ift},\ F_{4-\mathrm{Adv}} = F_0 e^{ikx} e^{2\pi ift} \tag{7}$$

According to Cramer: The transactional interpretation is a nonlocal relativistically invariant alternative to the Copenhagen interpretation. It requires a *handshake* between retarded, (ψ) and advanced waves, (ψ*) for a quantum event which he calls a *transaction* in which energy, momentum, angular momentum, and other conserved quantities are transferred as a hyperspherical (4D) standing wave [26].

In Fig. 2a, a Cramer advanced-retarded transaction emission locus illustrating Eqs. (7) at event point, *x,t* = 0,0 which must be an unknotted Witten string vertex instead of a Euclidean/Minkowski fermionic *knot shadow* singularity for HD parameters to operate [27]. The future-past lightcone is segmented into a dual luminal-superluminal hierarchy. In Fig. 2b, similar to Fig. 2a, taking the next step up the dimensional ladder to reveal one of two mirror symmetric brane topologies governed by the super quantum potential or force of coherence of the putative unified field equation, $F_{(N)} = \pm\aleph / \rho$ guiding its evolution [14,27,28].

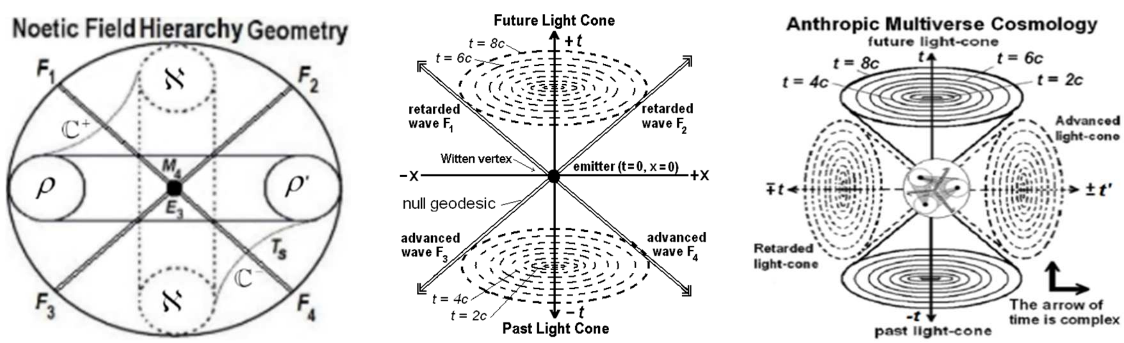

Figure 2. a) Hierarchy of the three regimes of reality. Central black dot; a point in Euclidean (Newtonian) space. Double lines, F_1, F_2, F_3 F_4 (Eq. 7) as future-past components of a Cramer (Quantum) transaction. Four LCU circles representing geometric topology of the UF with UF equation $F_{(N)} = \aleph / \rho$ for coherent control. b) Limited 4D Minkowski lightcone conceptualization of temporal dimensions only in the XD topological backcloth of continuous-state UF Anthropic Cosmology showing a central LCU vertex. It is also representative of a Cramer transaction extended to three temporal dimensions. c) Version with LCU vertex.

One experiments with particle inversions (switching electrons to positrons) by changing $(+ \text{ or } -)$ signs in the amplitude equations. To perform a **T**ime inversion, change *t* to – *t*, which converts the positron into an electron. To perform a mirror inversion (**P**arity), imagine that the waves are viewed in a mirror. One sees that a positron is a mirror image of the electron. To change a particle to an anti-particle (**C**harge inversion), switch the in-waves and the out-waves, and the spin direction. Successive **C**,**P**, and **T** inversions returns to the initial state which is a proof of the empirical-theoretical **CPT** rule, now seen to be a property of the wave structure of matter. If one adds the electron amplitude to the positron amplitude, the resulting amplitude is zero or *annihilation* as is well known experimentally.

Its only linear solutions, are a *pair* of spherical in/out waves that form the simple structure of the electron or positron. The waves decrease in intensity with increasing radius, like the forces of charge and gravity. There are only *two* combinations of the two in/out waves. These form electrons and positrons, with opposite phase and spin rotation. Thus, matter is constituted of two *binary* elements.

The wave equation is written (following Wolff [21-23] in spherical coordinates because cosmological space has spherical symmetry. Uniform density of the medium (space) is assumed which yields a constant speed *c* of the waves and *light*. These two solutions describe the *charge waves* of common charged particles including the electron, positron, proton, and anti-proton. They are shown in Eqs. (5) and (6).

These concepts shed more light on how the structure of a (MOU) gating manifold hierarchy might operate:

1) 1st regime: Classical local Euclidean 3-space *x,y,z* fermion vertex with space antispace *zitterbewegung*.
2) 2nd regime: In terms of an extended Cramer standing-wave transaction, is a mid-level future-past complex quantum space of which 3-space is the 'resultant shadow'.
3) 3rd regime: UFM topology governing brane dynamics at the core of the gating mechanism.

We are concerned with the boundary conditions in the region outside the event horizon. The scalar equation in spherical coordinates for wave motion in spacetime which has spherical symmetry.

In the electron wave the sign of the product of energy and time is negative: $-Et/\hbar = -\omega t$. But this is the same as exchanging the *in-wave* with the *out-wave*, which changes the electron into a *real* positron! We see Dirac's numerical result was correct, but the interpretation was wrong without a wave structure theory to guide him. Dirac assumed the electron was a discrete particle instead of a wave structure. This mistaken assumption has plagued physics for a century. Note that the Dirac Equation only describes rotations at the electron center, not the entire Wave Structure of Matter. The work of Batty-Pratt analyzing the rotation of *local* exponential waves, found that these spinors and their rotation produced the Dirac Equation [29].

3.2 Michelson-Morley versus Sagnac interferometry

The Michelson-Morley (M-M) interferometer was designed for the measurement of fringes. In the plane wave approximation, Δk effects are invisible unless the viewing plate is moved in the direction of *k*, the beam wave vector. Alternatively, one can tip the interference fringe viewing plane in order for it not to be orthogonal to the laser beam.

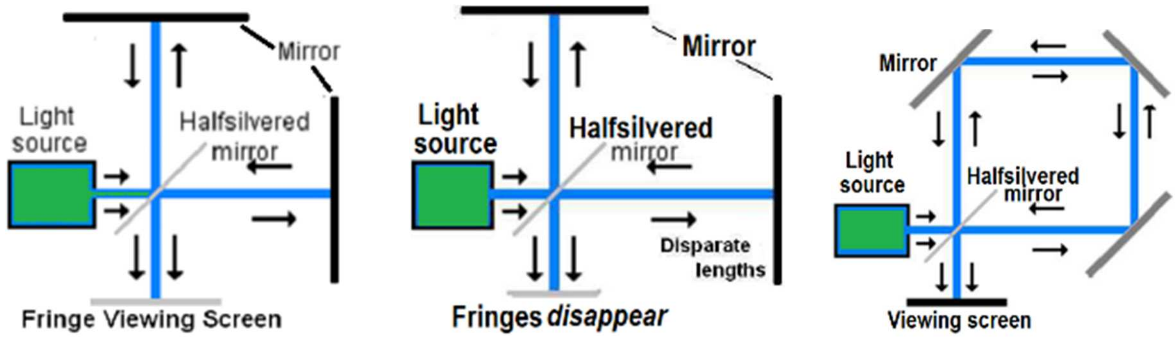

Figure 3. a) The well-known Michelson-Morley optical interferometer. b) Disparate length interferometer. c) A Sagnac interferometer.

The Sagnac interferometer encloses a finite area, The M-M interferometer encloses ~ zero area. The Sagnac interferometer responds to rotation, The M-M interferometer does not. The fringes require that the optical paths are equal to within a coherence length of the photons. $L = C \times$ decay time of ~ 3 meters for Na light, for example. In Fig. 1b, Fringes disappear if arms differ by more than the photon coherence length.

Historical Sagnac clockwise (CW) counterclockwise (CCW) interferometers were designed to measure fringes; Modern Sagnac ring laser interferometers measure beats.

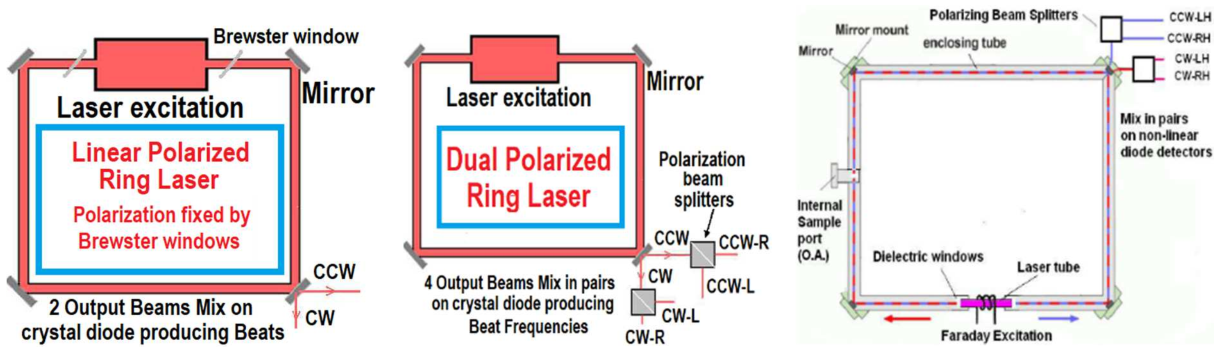

Figure 4. a) 2 beam (CW – CCW linearly polarized) Sagnac Ring with internal laser source. b) 4 Polarized beams – CWLH, CCWLH, CWRH, CCWRH Sagnac Ring with internal laser source. c) Modern dual polarized Ring Laser design. Figures adapted from [6-8].

Non-reciprocal Media – Electronic Media can generally be divided into reciprocal and nonreciprocal magnetoelectric materials. As a simple example, reciprocity implies that antennas work equally well as transmitters or receivers, and specifically that an antenna's radiation and receiving patterns are identical. Specifically, suppose that one has a current density J_1 that produces an electric field E_1 and a magnetic field H_1, where all three are periodic functions of time with angular frequency ω, and in particular they have time-dependence $\exp(-i\omega t)$. Suppose that we similarly have a second current J_2 at the same frequency ω which (by itself) produces fields E_2 and H_2. The Lorentz reciprocity theorem then states, under certain simple conditions on the materials of the medium described below, that for an arbitrary surface S enclosing a volume, V [30]:

$$\int_V \left[\mathrm{J}_1 \cdot \mathrm{E}_2 - \mathrm{E}_1 \cdot \mathrm{J}_2 \right] dV = \oiint_S \left[\mathrm{E}_1 \times \mathrm{H}_2 - \mathrm{E}_2 \times \mathrm{H}_1 \right] \cdot \mathrm{dS} \tag{8}$$

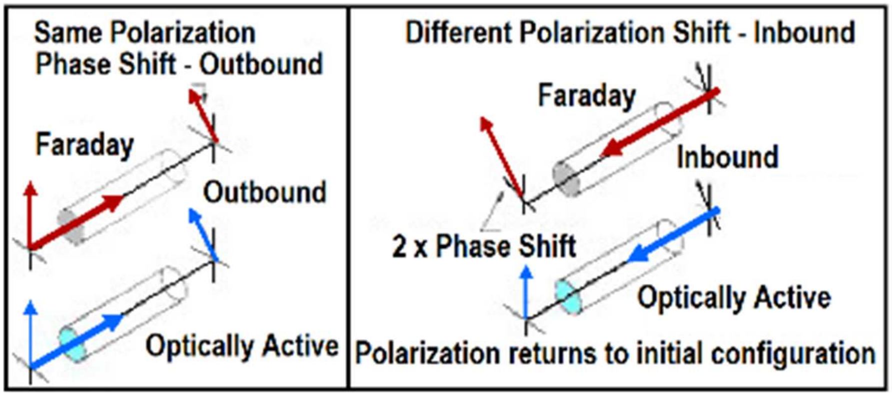

Figure 5. The Faraday effect, rotation of the polarization of light due to an applied magnetic field, and dispersion, which is the variation in refractive index as a function of wavelength of light, are related to each other through their basis in the phenomenon of absorption. Figure redrawn from Kiehn [7,31].

As well-known, the speed of light can differ for different states of polarization. Less appreciated is: in Non-Reciprocal media, the speed of light not only depends upon polarization, but also depends upon the direction of propagation [31]!

Faraday rotation or Fresnel-Fizeau: The Fresnel–Fizeau effect is a special relativistic effect that makes the speed of light dependent on the velocity of a transparent, moving medium. Consider linearly polarized light passing through Faraday or Optically Active media, The Faraday Ratchet can accumulate tiny phase shifts from multiple to-and-fro reflections. The hope was that such a device would reveal the tiny effect of gravity on the polarization of the photon. It was soon determined that classical EM-theory would not give an answer to EM-gravity polarization interactions, leading to the modern interferometer design in Fig. 4c. Then with a new technique: Tune to a single mode. If no intra-Optical Cavity effects, then one gets a single beat frequency due to Sagnac Rotation [9].

If Optical and Faraday effects are combined in the Optical Cavity, then one gets 4 beat frequencies. Kiehn's conclusion: The 4 different beams have 4 different phase velocities, dependent upon polarization and propagation direction, which was tested experimentally in 1977 [31], using dual polarized ring lasers verifying that the speed of light can have 4 different phase velocities depending upon direction and polarization. The 4-fold Lorentz degeneracy can be broken. Such solutions to the Fresnel-Maxwell theory, are subject to a gauge constraint [8]. After Kiehn filed US patents [7], the full theory of singular solutions to Maxwell's equations without gauge constraints was published in Physical Review [6]. Kiehn's theory shows the exact solution for the Fresnel-Kummer singular wave surface for combined Optical Activity and Faraday Rotation. Generalized Fresnel analysis of singular solutions to Maxwell's equations (propagating photons) [32,33]. Theoretical existence of 4-modes of photon propagation as measured in the dual polarized Ring Laser correspond to: 1) Outbound LH polarization, 2) Outbound RH polarization, 3) Inbound LH polarization, and 4) Inbound RH polarization.

These concepts stimulated a search for apparatus which could measure the effects of gravity on the polarization of an EM wave, and ultimately to practical applications of a dual polarized ring laser. Kiehn summarized his model for possible gravimetry: Electromagnetic waves with multiple polarization and for propagation direction modes, in the form of laser waves, are modulated by means of force responsive devices such as amorphous quartz elements. The application of force or acceleration to the modulator creates a difference in frequency of two of the modes. That frequency difference is a function of the force or acceleration being measured. The two signals are combined and their difference is detected in a beat detector. Preferably, the electromagnetic waves are configured as a ring laser operating with plural circular polarization modes. Each polarization mode exists in one of the counter-directional laser beams. The modulator, a quartz cylinder is located in the laser cavity. The force is applied as a torque tending to twist the cylinder about its longitudinal axis. The device provides a high degree of sensitivity and a wide range in the measurement of force and acceleration which could be used in gravimeters [7].

4. Future foundational developments - Realization of m_γ photon polarization gravimeters

Vigier claims: The most important development expected in the near future concerning the foundations of quantum physics is a revival, in modern covariant form, of the ether concept of the founding fathers of the theory of light (Maxwell, Lorentz, Einstein, *etc.*). This crucial question, it now appears that the vacuum is a real physical medium which presents surprising properties (superfluid, *i.e.* negligible resistance to inertial motions) so that the observed material manifestations correspond to the propagation of different types of phase waves and different types of internal motions within the extended particles themselves. The transformation of particles into each other would correspond to reciprocal transformations of such motions. The propagation of phase waves on the top of such a complex medium first suggested famously by Dirac in 1951 [34] yields the possibility to bring together relativity theory and quantum mechanics as different aspects of motions at different scales.

This ether, built from spin 1/2 ground-state extended elements undergoing covariant stochastic motions, is reminiscent of old ideas at the origin of classical physics proposed by Descartes and anciently by Heraclitus himself. The statistics of quantum mechanics thus reflects the basic chaotic nature of ground state motions in the Universe. Such a model also implies the existence of non-zero mass photons, m_γ as proposed by Einstein, Schrödinger, and de Broglie. Experimental confirmation would necessitate a complete revision of present cosmology [35]. The associated *tired-light* models could replace the so-called expanding/inflationary Universe models. Non-velocity redshifts could explain anomalous quasar-galaxy associations [15]; the Universe would be infinite in time in an absolute spacetime frame corresponding to the observed 2.7K microwave background Planck distribution. Absolute 4-momentum and angular momentum conservation would be valid at all times and at every point in the Universe [20].

4.1 Dirac's extended electron with inherent local-nonlocally entangled hypertubes

In the *Classical theory of radiating electrons* [36], 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* [37]. 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 [15-17,20,27]. 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. 1a,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 untested assumptions that seem logical in some frameworks, but are nevertheless based on incorrect conclusions for others.

4.2 The Vigier hypertube model and the de Broglie-Bohm-Vigier causal interpretation

The Vigier model [38] 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) [39] are interpreted as being due to a *random subquantum level of matter*, in the sense of Dirac's *aether* or de Broglie's *hidden thermostat* [40]. This idea reflects Einstein's viewpoint according to which quantum statistics should be due to a real subquantum physical vacuum alive with fluctuations and randomness.

The notion of an extended particle, as introduced by Bohm and Vigier in 1954 (see also Ref. [41]) 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 [42,43]).

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* [38]. Here, the relativistic extension of the continuity equation, namely, $\partial_\mu j_\mu = 0$, is shown to be equivalent to the set of two (forward and backward) Fokker- Planck equations

$$\frac{\partial \rho}{\partial \tau} + \nabla\left(\nu \pm \rho\right) \pm D \Box \rho = 0, \quad \left(\rho = R^2\right) \tag{9}$$

where the diffusion coefficient, D is obtained in the same form, $D = \hbar/(2m)$, as in Furth [44]. Lastly, the notion of *superluminal propagation of the quantum potential* was introduced in the Vigier model [38]. Specifically, for a particle of rest mass m, the quantum potential Q, is defined by $Q = \log M$ with

$$M = \left[m^2 + \frac{\hbar^2}{c^2} \frac{\Box \rho^{1/2}}{\rho^{1/2}} \right]^{1/2}, \tag{10}$$

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* [45] is considered to be a *true stochastic potential* [46].

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 nonlocal hidden-variable theories. Therefore, it does not necessarily 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* [47,48].

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 [14-16,27], as demonstrated in EPR experiments. Additionally, 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, connects the semi-quantum limit (finite radius manifold of uncertainty, MOU) to Large-Scale Additional Dimensionality (LSXD) of M-theoretic brane topological interactions in the bulk, associated with an Einsteinian Unified Field (UF) model [14,16,27]. We have also proposed a battery of experimental protocols for falsifying the model [27].

There are already in existence numerous gravimetric technologies in a variety of developmental stages able to measure tiny variations in 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 [49-59]. 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 [60].

4.2 Additional theory required to complete the 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 [61], 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 [5,13-17,27]. This new theory, stated simplistically is a modified form of string/M-theory without G-quantization.

Hopefully this theory will be completed in an ensuing paper. The new model, completing the description of additional principles needed for developing Sagnac dual-polarized ring laser interferometric effects for microgravimetry on EM-wave polarization requires extending the process of Kaluza-Klein cyclicality to all levels of XD M-theoretic compactification modes (cyclic or continuous manner). This mandates extension of the Dirac hypertube model of the electron [62-64] with utility of the Randall-Sundrum warped throat model [65-67] in order to open the LSXD arena to the unification of gravity with a 3rd regime of natural science – that of a long sought Einsteinian unified field. The stumbling block has been understanding how to formulate a new set of Einstein-like UFM transformations beyond the current 4D SM limit of the Galilean-Lorentz-Poincaré sets of transforms [13-17,27] which must supervene the uncertainty principle and define parameters of nonlocal instantaneity in a satisfactory manner.

5. Summary/Conclusions

We have briefly outlined the recent LIGO detection of G-waves and the current status of gravity theory, claimed that gravity is not quantized, and that the regime of integration with the other known forces is under the panoply of a more evolved M-theoretic brane bulk model of an Einstein-like unified field theory. We mentioned the vast array of current developments in gravimeters and that our gravity detection model is different – based on the effects of gravity on photon polarization. As a starting point, we gave an in-depth description of work by Kiehn on Sagnac Effect dual-polarized ring laser interferometric effects with four phase components [6-9]. We showed in prior work the effects of gravity on EM-waves [5,68,69].

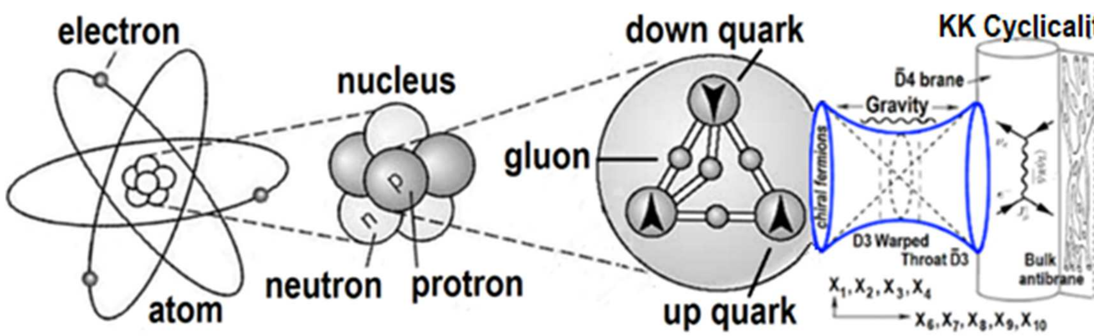

Figure 6. Unified field – M-theoretic model of matter. Atom $\rightarrow$ nucleus $\rightarrow$ quarks on a D3 brane (Fig. 1a-left cylinder). At the semi-quantum limit tunneling occurs through an XD warped throat to the antispace $\bar{D}3$ brane bulk with LSXD brane topology.

We expressed our view that Sagnac Effect interferometry on photon polarization is likely to become the most efficient and sensitive form of G-wave detection; but that this technology will only mature with the completion of gravitational theory by the advent of an M-theoretic Einstein-like UF-theory. To operate such a device, bulk universal quantum computing is required, which entails a new set of transformations beyond the Galilean-Lorentz-Poincairé [13-17,27].

Most importantly, for progress to be made in G-wave detection is a revival of the Dirac electron hypertube model with an inherent duality of local luminal and nonlocal instantaneous tunneling connectivity in the context of a Dirac polarized vacuum (ether) with m_γ anisotropy allowing experimental access to the LSXD brane bouquet by incursive resonant interferometry [27].

Received March 26, 2021; Accepted April 11, 2021

References

1. Proca, A. *Compt. Rend.* **1936**, *202,* 1420.
2. Roy, S. and Lehnert, B. *Extended Electromagnetic Theory Space Charge in Vacuo and the Rest Mass of the Photon* **1998** Singapore: World Scientific
3. Lehnert, B. New developments in electromagnetic field theory, in R.L. Amoroso, G. Hunter, M. Kafatos and J-P Vigier, Eds. *Gravitation and Cosmology From the Hubble Radius to the Planck Scale* **2002** Dordrecht: Kluwer Academic.
4. Lehnert, B. Electromagnetic theory with space-charges in vacuo, in G. Hunter, S. Jeffers and J-P Vigier Eds. *Causality and Locality in Modern Physics* **1998** Dordrecht: Kluwer Academic.
5. Amoroso, R.L. and Dunning-Davies, J. 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. Eds. *Physics of Reality Space Time Matter Cosmos* **2014** London: World Sci. 239-248.
6. Kiehn, R.M. Kiehn, G.P. and Roberds, B. Parity and time-reversal symmetry breaking, Singular solutions
and Fresnel surfaces *Phys Rev A* **1991** *43* 5165-5671.
7. Kiehn, R.M. Electromagnetic wave modulation and measurement system and method, **1974** US Patent 3786681;
https://patentimages.storage.googleapis.com/a6/55/36/c3e46d1786b5f7/US3786681.pdf.
8. Schultz, A.K. Kiehn, R.M. Post, E.J. and Roberds, J.B. Lifting of the four-fold EM degeneracy and PT asymmetry *Physics Letters A* **1979** *746* 384-386.
9. Kiehn, R.M. The Sagnac effect and the chirality of space time, in *The Nature of Light What Are Photons?* **2007** 6664 66640L, International Society for Optics and Photonics.
10. Carbone, L. et al. Sensors and actuators for the Advanced LIGO mirror suspensions, *Class Quantum Gravity* **2012** *29*, 115005.
11. Abbott, B.P. et al. GW170814 A three-detector observation of gravitational waves from a binary black hole coalescence LIGO scientific collaboration and Virgo collaboration *Phys Rev Lett* **2017** *119,* 141, 101.
12. Abbott, B.P. Abbott, R. Abbott, T.D. Abernathy, M.R. Acernese, F. Ackley, K. Adams. C. et al. Binary black hole mergers in the first advanced LIGO observing run *Phys. Rev. X* **2016** *6* **4** 041015.
13. Amoroso, R.L. 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, and P. Rowlands Eds. *Unified Field Mechanics II Preliminary Formulations and Empirical Tests 10th Symposium in Honor of Jean-Pierre Vigier* **2017** Hackensack: World Scientific.
14. Amoroso, R.L. Fundaments of ontological-phase topological field theory, in R.L. Amoroso, G. Albertini, L.H. Kauffman and P, Rowlands Eds. *Unified Field Mechanics II Preliminary Formulations and Empirical Tests, 10th Symposium in Honor of Jean-Pierre Vigier* **2017** Hackensack: World Scientific.
15. Amoroso, R.L. On the possibility of relativistic shock-wave effects in observations of quasar luminosity, in R.L. Amoroso and E.A. Rauscher, *The Holographic Anthropic Multiverse, Formalizing the Complex Geometry of Reality* **2009** Hackensack: World Scientific.
16. Amoroso, R.L. Einstein/Newton duality, An ontological-phase topological field theory, in *IOP J. Phys.Conf. Series.* **2018** 1051 *1* 012003.
17. Amoroso, R.L. Unified geometrodynamics A complementarity of Newton's and Einstein's Gravity, in *The Physics of Reality Space Time Matter Cosmos* **2013** 152-163 Hackensack: World Scientific.
18. Feynman, R.P. Morinigo, F.B. and Wagner, W.G. *Lectures on Gravitation* **1962/63** Ca. Inst. Tech.

19. de Rham, C. Khoury, J. Tolley, A.J. Flat 3-brane with tension in cascading gravity, *Phys. Rev. Let.* **2009** *103* 161601; arXiv:0907.0473v2 hep-th.
20. Vigier, J-P Fundamental problems of quantum physics, Montreal: *Apeiron* **1995** *2* **4** 114-115.
21. Wolff, M. Microphysics, fundamental laws and cosmology, Invited paper 1st Sakharov Conf. Phys. Moscow 1131-1150 *Proceedings Nova Sci. Publ.* **1991** New York.
22. Wolff, M. Fundamental laws microphysics and cosmology *Physics Essays* **1993** *6* 181-203.
23. Wolff, M. *Exploring the Unknown Universe* **1990** Manhattan Beach: Technotran Press.
24. Wolff, M. *Schrödinger's Universe* **2008** Colorado: Outskirts Press.
25. Wheeler, J.A. and Feynman, R. *Rev. Mod. Physics* **1945** *17* 157.
26. Cramer, J.G. *Reviews of Mod Physics* **1986** *58* 3 647-687.
27. Amoroso, R.L. *Universal Quantum Computing: Surmounting Uncertainty Supervening Decoherence* **2017** Hackensack: World Scientific.
28. Amoroso, R.L. and Rauscher, E.A. *The Holographic Anthropic Multiverse Formalizing The Complex Geometry of Reality* **2009** London: World Scientific.
29. Batty-Pratt, E. and Racey, T. Geometric model for fundamental particles *Int. J. Theor. Phys.* **1980** *19* 437-475.
30. Landau, L.D. and Lifshitz, E.M. *Electrodynamics of Continuous Media* **1960** Addison-Wesley.
31. Kiehn, R.M. Optical vortices faraday rotation optical activity **2001**; https://pdfs.semanticscholar.org/3457/53bceb37b7338010dba230c8cd4ca0059c32.pdf.
32. Sanders, V.E. and Kiehn, R.M. Dual polarized ring-lasers *J. Quant. Electr.* **1977** 739-45.
33. Post, E.J. *Formal Structure of Electromagnetics General Covariance and Electromagnetics* North-Holland Publishing **1962;** or **1997** New York: Dover.
34. Dirac, P.A.M. Is there an aether? *Nature* **1951** *168* 4282 906.
35. Vigier, J-P New non-zero photon mass interpretation of the Sagnac effect as direct experimental justification of the Langevin paradox *Phys Let A* **1997** *234* 2 75-85.
36. Dirac, P.A.M. Classical theory of radiating electrons *Proc Roy Soc* **1938** *167A*, 148.
37. Chebotarev, L. 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* **2000** Montreal: Aperion.
38. Vigier, J-P *Lett Nuovo Cimento* **1979** *24* 258 265.
39. Bohm, D. and Vigier, J-P *Phys. Rev.* **1954** *96* 208.
40. de Broglie, L. *La Thermodynamique de La Particule Isolee* **1964** Paris.
41. Bohm, D. and Vigier J-P *Phys Rev* **1958** *109* 882.
42. Selleri, F. and Vigier, J-P *Lett Nuovo Cimento* **1980** *29* 1.
43. Vigier, J-P *Lett Nuovo Cim* **1980** *29* 467.
44. Furth, R. *Z. Physik* **1933** *81* 143.
45. Petroni, N.C. and Vigier, J-P *Lett Nuovo Cimento* **1979** *26* 149.
46. Petroni, N.C. Droz-Vincent, Ph. and Vigier, J-P *Lett Nuovo Cimento* **1981** *31* 415.
47. Vigier, J-P Possible consequences of an extended charged particle model in electromagnetic theory *Physics Letters A* **1997** *235* p419-31.
48. Vigier, J-P 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 *Found. Phys.* **1994** *241* 61-83.
49. Jiang, Z. et al. Relative gravity measurement campaign during the 8th international comparison of absolute gravimeters, *Metrologia* **2009** *49* 95–107 2012.
50. Goodkind, J.M. The superconducting gravimeter, *Rev Sci Instrum* **1999** *70* 4131–4152.
51. de Angelis, M. et al. Precision gravimetry with atomic sensors, *Meas. Sci Technol* **2009** *20* 022001.

52. Krishnamoorthy, U. et al. In-plane MEMS-based nano-g accelerometer with sub-wavelength optical resonant sensor, *Sens Actuat A* **2008** 145–146; 283–290.
53. Lainé, J. and Mougenot, D. A high-sensitivity MEMS-based accelerometer *Leading Edge* **2014** *33* 1234–1242.
54. Pike, W.T. et al. A self-levelling nano-g silicon seismometer in *Proc IEEE Sensors 2014* **2014** 1599–1602; http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=6985324.
55. Battaglia, M. Gottsmann, J. Carbone, D. and Fernandez, M. *J 4D Volcano Gravimetry Geophysics* **2008** *73* WA3–WA18.
56. Peterson, J. Observations and modeling of seismic background noise, *US Geological Survey* **1993** USGS Report 93-322; http://www.mtmllr.com/ADS/DATA/peterson_usgs_seismic_noise_ofr93-322.pdf.
57. Romaides, A.J. et al. A comparison of gravimetric techniques for measuring subsurface void signals, *J Phys D* **2001** *34* 433–443.
58. Butler, D.K. Microgravimetric and gravity gradient techniques for detection of subsurface Cavities, *Geophysics* **1984** *49* 1084–1096.
59. Kirkendall, B. Li, Y. and Oldenburg, D. Imaging cargo containers using gravity gradiometry *IEEE Trans Geosci Remote Sens* **2007** *45* 1786–1797.
60. Middlemiss, R.P. Bramsiepe, S.G. Douglas, R. Hild, S. Hough, J. Paul, D.J. Samarelli, A. Rowan. S. and Hammond, G. D. Microelectromechanical system gravimeters as a new tool for gravity imaging *Philosophical Trans Roy Soc A: Math Phys and Eng Sci* **2018** *376* 2120 20170291.
61. Susskind, L. Demystifying the Higgs boson **2012**; https://www.youtube.com/watch?v= JqNg819PiZY.
62. Dirac, P.A.M. Proc Royal Soc **1962** *268A* 57.
63. Gnadig, P. Kunszt, Z. Hasenfratz, P. Kúti, J. Dirac's extended electron model *Hungarian Academy of Science* **1978**; https://inis.iaea.org/collection/NCLCollectionStore/Public/10/435/10435160.pdf.
64. Chebotarev, L.V. The de Broglie–Bohm–Vigier approach in quantum mechanics Basic concepts of the causal stochastic interpretation of quantum mechanics, in *Jean-Pierre Vigier and the Stochastic Interpretation of Quantum Mechanics* **2000** Montreal: Aperion 1-18.
65. Randall, L. and Sundrum, R. *Phys Rev Lett* **1999** *83* 3370; hep-ph/9905221; *Phys Rev Lett* **1999** *83* 4690; hep-th/9906064.
66. Cvetic, M. Duff, M.J. Liu, T, Lu, H. Pope, C.N. and Stelle, K.S. Randall-Sundrum brane tensions **2000**; arXiv:hep-th/0011167v1.
67. Bao, R. Lykken, J. Randall-Sundrum with AdS(7) **2005;** arXiv:hep-ph/0509137v2.
68. Vigier, J-P and Amoroso, R.L. Can one unify gravity and electromagnetic fields? in R.L. Amoroso, G. Hunter, M. Kafatos and J-P Vigier Eds. *Gravitation and Cosmology From the Hubble Radius to the Planck Scale* **2002** Dordrecht: Kluwer Academic (now Elsevier).
69. Vigier, J-P and Amoroso, R.L. Comparison of near and far field double-slit interferometry for dispersion of the photon wavepacket, in R.L. Amoroso, G. Hunter, M. Kafatos and J-P Vigier Eds. *Gravitation and Cosmology from the Hubble Radius to the Planck Scale* **2002** Dordrecht: Kluwer Academic (now Elsevier).