RESEARCH

Quantum transitions in GEONs

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Vegt W. Quantum transitions in GEONs. J Pure Appl Math. 2023:7(4); 229-246.

ABSTRACT

The article presents a new theory in physics which explains the interaction between gravity and light with mathematical results close to General Relativity (15 digits beyond the decimal point equal result) and unifies general relativity with quantum physics by the fundamental elementary particle: the GEON. The GEON is a fundamental solution of the relativistic quantum mechanical dirac equation (Quantum physics) and the confinement has been controlled by the fundamental interaction between gravity and light (General relativity). The GEON is the most fundamental elementary particle and can be created by the compression of light into extremely high densities. The GEON appears when an equilibrium has been established between the expanding radiation pressure of light and the confining gravitational force of light. The GEON is the fundamental solution of the relativistic quantum mechanical dirac equation. For this reason, the GEON particle unifies quantum physics with general relativity. The confinement of GEONS is only possible at discrete values. (Quantisation of energy, light and gravity). The GEON carries the mass inside the structures of matter (Elementary particles). The radius of a GEON with the mass of a proton (1.67×10^{-27} kg) equals 310^{-58} (m).

The new theory in physics has been based on the “divergence-free linear 4-dimensional stress-energy tensor in the Minkowski space”. The difference between Einstein’s general relativity and this theory is the different approach. Einstein has deformed (non-linear and non-divergence free) the “4-dimensional stress-energy tensor” by introducing the curved 4-dimensional riemannian manifold to explain the interaction between gravity and light. The new theory describes the interaction between different fields (Electric, Magnetic and Gravitational) by identical interaction terms, generated by the separate divergence and the separate rotation of the different fields. (equation 24) The conclusion of the new theory is that “divergence-free” and “rotation-free” fields do not interact. When Isaac Newton published his 3 famous equations which became the foundation of classical dynamics, he was not aware that he was building the first elemental blocks for the stress-energy tensor in the 4-dimensional Minkowski space. When James Clerk Maxwell published his 4 famous equations which became the foundation for classical electrodynamics, he was not aware that he was building new blocks for the stress-energy tensor in the 4-dimensional Minkowski space. When Paul Dirac published his famous equation which became the foundation of relativistic quantum physics, he was not aware that he was building further on blocks for the stress-energy tensor in the 4-dimensional Minkowski space.

It was Albert Einstein who was one of the first physicists who discovered the importance of the stress-energy tensor to describe in a mathematical way the interaction between electromagnetic radiation and a gravitational field. Because there was no match, Einstein deformed the divergence-free linear “stress-energy tensor” by deforming space and time. Using curved riemannian manifolds, he deformed the fundamental tensor in physics in such a way that he found a very special mathematics to describe the interaction between electromagnetic radiation (Light) and a gravitational field. The theory of general relativity.

This became a fundamental problem in physics. By deforming the fundamental building block in physics (the divergence-free linear “stress-energy tensor), there is no match anymore in the fundamental mainstreams in physics (classical mechanics, electrodynamics, quantum physics and general relativity). Classical mechanics has no match with classical electrodynamics. Classical electrodynamics has no match with relativistic quantum physics. Relativistic quantum physics has no match with general relativity. It is important to distinguish the “Physical reality” from a mathematical description of it (which is in general an approach). The scalar curvature (or the ricci scalar) is a measure of the curvature of a riemannian manifold. Einstein used a curved riemannian manifold to describe “gravitational-electromagnetic interaction”. But the physics beyond this is the interaction between the different fields. It is possible to describe this in different ways. This new theory demonstrates a more direct approach in the force densities acting between different fields expressed by equation (24). This new theory starts with the divergence-free linear “stress-energy tensor” in the 4-dimensional Minkowski space. And from this unique divergence-free “stress-energy tensor” follows classical mechanics, classical electrodynamics, relativistic quantum physics and general relativity. bringing back the necessary unity in physics.

Theories which unify quantum physics and general relativity, like “string theory”, predict the non-constancy of natural constants. Accurate observations of the NASA messenger observe in time a value for the gravitational constant “G” which constrains until ($\left|\dot{G}\right| / G$ to be < 4×10^{-14} per year). One of the characteristics of the new theory is the “constant value” in time for the gravitational constant “G”. A second experiment to test the new theory is the effect of “gravitational redshift”.

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Received: June 12, 2023, Manuscript No. puljpam-23-6513, Editor Assigned: June 15, 2023, Pre-QC No. puljpam-23-6513 (PQ), Reviewed: June 25, 2023, QC No. puljpam-23-6513 (Q), Revised: June 28, 2023, Manuscript No. puljpam-23-6513 (R), Published: July 31, 2023, DOI:-10.37532/2752-8081.23.7(4).229-246.

The "gravitational redshift" between an observatory on earth (R_{adius}=6 10^6 (m)) and a satellite in a galileo orbit (R_{adius}=23222 10^3(m)) according "general relativity":

$$\Delta\, \omega_{GR} = \frac{\Delta\, U}{c^2} = 0.00000000004360137706159641$$

The "gravitational redshift" between an observatory on earth (Radius=6 10^6 (m)) and a satellite in a galileo orbit (Radius=23222 10^3 (m)) according "the proposed theory":

$$\Delta\, \omega_{QLT} = \frac{\Delta\, U_{Rel}}{c^2} = 0.00000000004360134475689392$$

Key Words: *Classical Field Theory; Gravitation; Electromagnetism; General Relativity*

INTRODUCTION

This article describes a new electromagnetic field theory. The foundation of the new theory is the universal 4-dimensional equilibrium in the minkowski space, expressed by the "non-divergence" or "zero-divergence" of the stress-energy tensor: $\partial_b\, T^{ab} = f^a = 0$ in which f^a expresses the density of the electromagnetic force 4-vector in the minkowski space (equation 45) and "a" varies from 1 until 4. Equation (24) describes the Universal Equilibrium for Electromagnetic Waves propagating within time-dependent gravitational fields.

Based on the 4-dimensional equilibrium in the Minkowski space (expressed by the stress-energy tensor = $\underline{0}^4$), Newton's classical dynamics will be unified with Maxwell's electrodynamics, the 4-dimensional relativistic dirac equation (which is the foundation of relativistic quantum physics) represents the classical relativistic Dirac equation (54.1) and equals the 4th component of the density of the force 4-vector in the Minkowski space and Einstein's general relativity.

Extending newton's 3-dimensional equilibrium in classical mechanics into a model of confined electromagnetic energy within a 4-dimensional equilibrium will unify classical mechanics with relativistic quantum physics (4-dimensional Dirac equation) and represents the mathematical solutions (Equation 31) for the in 1955 by J. A. Wheeler already announced concept of gravitational-electromagnetic confined GEONs [1].

The research has been focused to unify the four fundamental theories in physics. Isaac newton's classical mechanics, James clerk Maxwell's electrodynamics, quantum physics (Niels Bohr, Paul Dirac, Werner Heisenberg) and Albert Einstein's theory of general relativity. These four fundamental theories also mark the different periods when they have been created and a fundamentally different way of thinking at those times. To unify these four principles of physics, it is necessary to link electromagnetism and gravitation. Here it is proposed that the 2-dimensional confinement of electromagnetic radiation (a beam of light) creates its own gravitational field, and that field will interact with other gravitational fields. To illustrate the utility of this theory, an example has been discussed with regard to the measured gravitational redshift associated with earth's gravity [2-9]. This theory has been called "Quantum light theory".

The foundation of this theory is the non-zero mass property of photons [10]. In classical physics the mass (inertia) of matter is omni-directional. The weight of an apple on a scale does not change when the apple has been rotated. The mass (inertia) of photons is bi-directional. In the direction of propagation the mass (inertia) of the photon equals zero. In the plane perpendicular to the direction of propagation, the mass (inertia) does not equal zero and has been determined by Einstein's equation for the relationship between mass and energy ($W=mc^2$). For this reason photons are not being accelerated or decelerated when they move towards to- or away from a gravitational field. The speed of light remains constant. However, when the gravitational field directs in the plane perpendicular to the direction of propagation of photons, photons do have mass and interact like other particles with the gravitational field according classical mechanics [11-22].

In the first paragraph the concept of inertia has been introduced into the electromagnetic field equations. Resulting in a unification of classical mechanics and electrodynamics.

The second paragraph introduces the concept of "4-dimensional equilibrium" resulting in the unification of electrodynamics with relativistic quantum physics (Relativistic Dirac equation). The paragraph describes the confinement of electromagnetic radiation due to its own gravitational-electromagnetic field. Wheeler described these confinements in 1955 as GEONs [1]. The mathematical solutions for GEONs are also solutions of the quantum mechanical relativistic Dirac equation (Equations 25, 26, 33, 34 and 50).

The third paragraph introduces the concept of "gravity" into the electromagnetic field equations. Resulting in a unification of electrodynamics with general relativity.

In this paper, a new approach to describe any arbitrary electromagnetic field, has been developed following the concept of universal equilibrium (Stress-Energy Tensor (44), as proposed by Newton for classical mechanics [23-30]. The outcome of which is a single equation based upon stress-energy tensor (44) in 3-dimensional space, between four fundamental force densities: inertia, electric force densities, magnetic force densities and the generation of gravity. The first and last force densities are represented by additional terms in Maxwell's equations, for which the resulting fundamental equation unifies classical mechanics with electrodynamics. These two additional terms account for the electromagnetic-field's inertia and confinement forces within gravitational electromagnetic entities (GEONs) [1]. The approach of James Clerk Maxwell to describe classical electrodynamics is missing two fundamental terms [7].

Extending the 3-dimensional equilibrium between the 4 fundamental forces into a 4-dimensional equilibrium (Energy, time domain) results in the relativistic quantum mechanical Dirac equation, which is the fundamental foundation of relativistic quantum physics.

This article starts with the introduction of the concept of "inertia of electromagnetic radiation", using Newton's second law of motion, expressed in the inertia force density (N/ m^3). This concept has been presented in equation (9) and term B-1 in equation (19).

Then two classical electromagnetic equations (Coulomb and Lorentz) have been used. The same equations which James Clerk Maxwell used to build his theory of electrodynamics,

The coulomb force density (N/m^3) results in Equation 12 and has been expressed as term B-2 in equation 19.

The Lorentz force density (N/m^3) results in equation 17 and has been expressed as term B-5 in equation 19.

The magnetic field terms and the electric field terms are considered to be completely symmetrically. Which results in two extra symmetrical terms. A coulomb force density (N/m^3) expressed as a magnetic force density (term B-4) in equation 19 and a Lorentz force density (N/m^3) expressed as an electric force density (term B-3) in equation 19.

In the second paragraph the sixth term (B-6 in equation 23) has been introduced, presenting the concept "gravity" in light (EMR). The consequence is that light (EMR) creates its own gravitational field, already predicted by John Archibald Wheeler in 1955 in his model of GEONs (Gravitational Electromagnetic Entities) [1]. Wheeler could not find stable solutions for GEONs in general relativity. Equation (23) results in stable solutions for GEONs (equation 25). It follows from (25) that only harmonic functions are possible solutions for GEONs which results in the discrete values (quantum numbers) for the harmonic frequencies for the GEONs depending on the geometry of the gravitational electromagnetic confinement and the corresponding wavelength.

Newton's concept for a 3-dimensional equilibrium has been expanded into a universal 4-dimensional equilibrium in the 4-dimensional Minkowski space. This has been done by applying the 4-dimensional divergence on the 4-dimensional energy-momentum tensor in the 4-dimensional complex Minkowski space (equation 41). This results in the complex 4-dimensioal force-density vector in the Minkowski space (N/m^3). The requirement for the 4-force-density vector (N/m^3) to be zero results in equation (43) as a set of 4 equations. The 3 spatial equations are equal to equation (19) and represent the electromagnetic field equations. The equation in the 4th dimension (space-time domain) in the Minkowski space (equation 43) represents the conservation of electromagnetic energy.

Well-known in wave guides, there exists for harmonic functions a phase shift of 90 degrees between the electric field and the magnetic field for confined (standing) electromagnetic waves. The phase shift of 90 degrees between the electric field and the magnetic field has been expressed in equation (33) and (34) by the complex (imaginary) number "i". Substituting the complex notation for a confined (standing) electromagnetic wave in the law for conservation of energy (32) result in the relativistic Dirac equation [3].

The third paragraph describes the concept "gravitational redshift", the impact of a gravitational field on the intensity and the frequency of light (EMR). Because the light from star constellations can be considered to be plane waves, this has been done by substituting (65) and (66) (the electromagnetic presentation for a plane EMR wave) in equation (56). To calculate the results for the experiments to measure the gravitational redshift due to the gravitational field of the earth, the proportionality between energy and frequency (Planck) has been demonstrated in equation (63). Substituting the gravitational acceleration of the earth for "g" in equation (56) results in values for the gravitational redshift for the experiments, which are equal to 15 digits beyond the decimal point compared to the calculations in general relativity, equations (83) and (84) [2].

Validation of these calculations requires a sensitive and accurate observatory like the JWST or the SKA with observation accuracies better than 10^{-16}.

The linear divergence-free "stress-energy tensor" in electrodynamics

Albert Einstein described with his "theory of general relativity" the interaction between gravity and light (EMR). His starting point was the stress-energy tenor [18]. This new theory starts in a comparable way also with the "stress-energy tensor" (44). The stress-energy tensor (44) describes a universal 4-dimensional equilibrium within the electromagnetic field [19]. The divergence of the "stress-energy tensor" results in the electromagnetic force vector within the electromagnetic field (45). A "universal 4-dimensional equilibrium" within the electromagnetic field requires the force (densities) to be equal zero in the 4-dimensional space-time coordinates (Minkowski space). This results in equation (46). Equilibrium within the 3 spatial coordinates results in equation (22), which describes the electromagnetic field in a more general concept than the 4 Maxwell equations. This more general equation describing the electromagnetic field can also be derived from Newton's third law, second law (inertia) and two classical electromagnetic equations. (Coulomb and Lorentz).

Fields do not interact with particles. Fields only interact with the fields associated with particles. Electric fields only interact with electric fields, Magnetic fields only interact with magnetic fields and gravitational field only interact with gravitational fields.

By Lorentz transformations electric fields can be transformed into magnetic fields and magnetic field can be transformed into electric fields. By Lorentz transformations electric fields interact with magnetic fields which have been transformed by Lorentz transformations into electric fields (Equation 19 term B-3). And by Lorentz transformations magnetic fields interact with electric fields which have been transformed by Lorentz transformations into magnetic fields (equation 19 term B-5).

The effect of a field-field interaction is a force which is exchangeable with electric field interactions, magnetic field interactions and gravitational field interactions. In this way physical boundary conditions can be formulated for the netto total effect of the electric forces, the magnetic forces and the gravitational forces and consequently also for the netto force densities.

Newton introduced the concept of "stress-energy tensor (44)" in physics, when he formulated in his famous third equation action = -reaction. (Newton's third law). In nowadays math the concept of "stress-energy tensor (44)" has been formulated as:

$$\sum_{i=0}^{i=n} \bar{F_i} = 0 \tag{1}$$

Because the inertia force is a reaction force, the inertia force appears in the equation with a minus sign (Newton's second law).

$$\sum_{i=0}^{i=n} \bar{F_i} - m\,\bar{a} = 0 \tag{2}$$

Equation (2) is a general presentation of Newton's famous second law of motion. In a fundamental way, Newton's second law of motion describes the required electromagnetic equation for the gravitational-electromagnetic interaction in general terms, including Maxwell's theory of electrodynamics published in 1865 and Einstein's theory of general relativity published in 1911 [8-9]. To realize this new "gravitational-electromagnetic equation", the fundamental principle of equilibrium has been divided into 5 separate terms, as described by equation (3). Each one describes a part of the electromagnetic and inertia interaction force densities.

$$\sum_{i=1}^{i=5} \mathbf{B_i} = \mathbf{0} \tag{3}$$

The first term B_1 represents the inertia of the energy (mass-) density, the terms B_2 and B_3 represent the electric force densities, and the terms B_4 and B_5 represent the magnetic force densities, of electromagnetic radiation. Fundamentally, the outcome of (3) recalls the fundamental principle of "stress-energy tensor (44)".

To apply the concept of universal equilibrium within an electromagnetic field, the electric forces $F_i^{Electric}$ the magnetic forces $F_j^{Magnetic}$ and the inertia forces will be presented separately in equation (4):

$$\sum_{i=1,\,j=1}^{i=n,\,j=m} F_i^{Electric} + F_j^{Magnetic} - m\,\bar{a} = 0 \tag{4}$$

<u>The first term (The inertia of light)</u>

Albert Einstein's "general relativity" describes the interaction between "gravity and light". It is impossible to build a framework for the interaction between gravity and light without describing the inertia (mass) of light. Because there can only be interaction between gravity and inertia (mass).

Without inertia (mass) there will be no interaction with gravity. The inertia (mass) of light is very different than the mass of objects we usually describe. The inertia (mass) of objects is always omni-directional. It does not matter in what position we put a mass on a scale, the weight (interaction) between gravity and the object will always be the same. Reducing equation (2) to one single Force, equation (2) will be written in the well-known presentation:

$$\bar{F} = m\,\bar{a} \tag{5}$$

The right and the left term of Newton's law of motion in equation (5) has to be divided by the volume "V" to find an equation for the force density $\bar{f}$ related to the mass density "ρ".

$$\begin{aligned} \bar{F} &= m\,\bar{a} \\ \left(\frac{\bar{F}}{V}\right) &= \left(\frac{m}{V}\right)\bar{a} \\ \bar{f} &= \rho\,\bar{a} \end{aligned} \tag{6}$$

The inertia force $\overline{F_{Inertia}}$ for electromagnetic radiation will be derived from Newton's second law of motion, using the relationship between the momentum vector $\bar{p}$ for radiation expressed by the poynting vector $\bar{S}$:

$$\overline{F_{INERTIA}} = -m\,\bar{a} = -m\frac{\Delta\,\bar{v}}{\Delta\,t} = -\frac{\Delta(m\bar{v})}{\Delta\,t} = -\frac{\Delta\,\bar{p}}{\Delta\,t} = -\left(\frac{V}{c^2}\right)\frac{\Delta\bar{S}}{\Delta t} \tag{7}$$

Dividing the right and the left term in equation (7) by the volume V results in the inertia force density $\overline{f_{Inertia}}$:

$$\begin{aligned} \overline{F_{INERTIA}} &= -m\,\bar{a} = -m\frac{\Delta\bar{v}}{\Delta t} = -\frac{\Delta(m\bar{v})}{\Delta\,t} = -\frac{\Delta\bar{p}}{\Delta t} = -\left(\frac{V}{c^2}\right)\frac{\Delta\bar{S}}{\Delta t} \\ \frac{\overline{F_{INERTIA}}}{V} &= -\frac{m}{V}\bar{a} = -\frac{m}{V}\frac{\Delta\,\bar{v}}{\Delta\,t} = -\frac{1}{V}\frac{\Delta\,\bar{p}}{\Delta\,t} = -\left(\frac{1}{c^2}\right)\frac{\Delta\,\bar{S}}{\Delta\,t} \\ \overline{f_{INERTIA}} &= -\rho\,\bar{a} = -\left(\frac{1}{c^2}\right)\frac{\Delta\,\bar{S}}{\Delta\,t}\ \left[N/m^3\right] \end{aligned} \tag{8}$$

The poynting vector $\bar{S}$ represents the total energy transport of the electromagnetic radiation per unit surface per unit time (J/m^2s). Which can be written as the cross product of the electric field intensity $\bar{E}$ and the magnetic field intensity $\bar{H}$.

$$\begin{aligned} \overline{f_{INERTIA}} &= -\rho a = -\left(\frac{1}{c^2}\right)\frac{\Delta\,S}{\Delta\,t} = -\left(\frac{1}{c^2}\right)\frac{\Delta\left(\bar{E}\times\bar{H}\right)}{\Delta\,t}\left[N/m^3\right] \\ \overline{f_{INERTIA}} &= -\left(\frac{1}{c^2}\right)\frac{\partial\left(\bar{E}\times\bar{H}\right)}{\partial\,t}\ \left[N/m^3\right] \end{aligned} \tag{9}$$

<u>Second and fourth term in "proposed theory" (Term B-2 and B-4)</u>

An example of the coulomb force is the electric force $F_{Coulomb}$ acting on an electric charge Q placed in an electric field E. The equation for the coulomb force equals:

$$\overline{F_{Coulomb}} = \bar{E}\,Q\ \left[N\right] \tag{10}$$

Dividing the right and the left term in equation (10) by the volume V results in the electric force density $\overline{f_{Coulomb}}$:

$$\begin{aligned} \bar{F}_{COULOMB} &= \bar{E}\,Q\ \left[N\right] \\ \frac{\bar{F}_{COULOMB}}{V} &= \bar{E}\,\frac{Q}{V}\left[N/m^3\right] \\ \bar{f}_{COULOMB} &= \bar{E}\,\rho_E\ \left[N/m^3\right] \end{aligned} \tag{11}$$

Substituting Gauss's law in differential form in (11) results in coulombs law for electromagnetic radiation for the electric force density $\overline{f_{Coulomb}}$:

$$\bar{f}_{COULOMB} = \bar{E}\,\rho_E$$
$$\bar{f}_{COULOMB} = \bar{E}\,\rho_E = \bar{E}\left(\nabla \,.\, \bar{D}\right) \tag{12}$$
$$\bar{f}_{COULOMB} = \bar{E}\,\left(\nabla \,.\, D\right) = \varepsilon\;\bar{E}\;\left(\nabla \,.\, \bar{E}\right)\;\left[N/\,m^3\right]$$

In electromagnetic field configurations, there is in general no preference for the electric force densities or the magnetic force densities. In general the equations for the electric field densities are universally exchangeable with the magnetic field densities (Figure 1).

Or the magnetic field densities, equation (12) can be written as:

$$\bar{f}_{Coulomb\,-\,Electric} = \bar{E}\left(\nabla .\, \bar{D}\right) = \varepsilon\;\bar{E}\;\left(\nabla .\, \bar{E}\right)\;\left[N/\,m^3\right]\;\text{(Term B-2)}$$
$$\bar{f}_{Coulomb\,-\,Magnetic} = \bar{H}\left(\nabla .\, \bar{B}\right) = \mu\;\bar{H}\;\left(\nabla .\, \bar{H}\right)\;\left[N/\,m^3\right]\;\text{(Term B-4)} \tag{13}$$

Third and fifth term in "proposed theory" (Term B-3 and B-5)

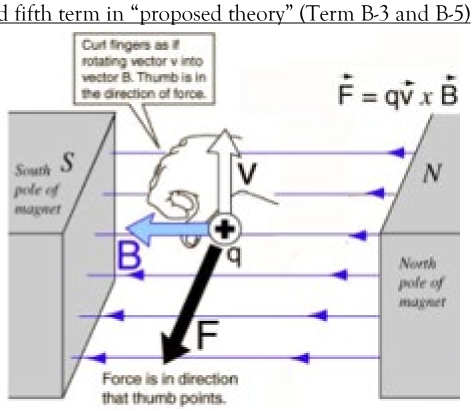

Figure 1) *The Lorentz force equals the cross product of the magnetic induction B and the velocity v of the charge q moving within the magnetic field times the value of the electric charge*

The equation for the Lorentz force equals:

$$\bar{F}_{LORENTZ} = Q\;\bar{v} \times \bar{B}\;\;\left[N\right] \tag{14}$$

Dividing the right and the left term in equation (14) by the volume V results in the Lorentz force density $\overline{f_{Lorentz}}$

$$\bar{F}_{LORENTZ} = Q\;\bar{v} \times \bar{B}\;\;\left[N\right]$$
$$\frac{\bar{F}_{LORENTZ}}{V} = -\;\bar{B} \times \frac{Q\;\bar{v}}{V}\left[N/\,m^3\right] \tag{15}$$
$$\bar{f}_{LORENTZ} = -\;\bar{B} \times \frac{Q\;\bar{v}}{V} = -\;\bar{B} \times \bar{j} = -\,\mu\;\bar{H} \times \bar{j}\;\left[N/\,m^3\right]$$

In which q is the electric charge, v the velocity of the electric charge, B the magnetic induction and j the electric current density. Substituting Ampère's law in differential form in (15) results in Lorentz's Law for electromagnetic radiation for the electric force density $\overline{f_{Lorentz}}$:

$$\bar{f}_{LORENTZ} = -\,\mu\;\bar{H} \times \left(\bar{j}\,\right)$$
$$\bar{f}_{LORENTZ} = -\,\mu\;\bar{H} \times \left(\bar{j}\,\right) = -\,\mu\;\bar{H} \times \left(\nabla\times\,\bar{H}\right)\;\left[N/\,m^3\right] \tag{16}$$

In electromagnetic field configurations, there is in general no preference for the electric force densities or the magnetic force densities. In general the equations for the electric field densities are universally exchangeable with the magnetic field densities. For the electric field densities, equation (16) can be written as:

$$\bar{f}_{Coulomb\,-\,Electric} = -\;\varepsilon\;\bar{E} \times \left(\nabla\times\bar{E}\right)\left[N/\,m^3\right]\;\text{(Term B-3)}$$
$$\bar{f}_{Coulomb\,-\,Magnetic} = -\;\mu\;\bar{H} \times \left(\nabla\,\times\,\bar{H}\right)\left[N/\,m^3\right]\text{(Term B-5)} \tag{17}$$

Fundamental equation for electromagnetic interaction in "proposed theory" (term B-1 + term B-2 + term B-3 + term B-4 + term B-5): Newton's second law of motion applied within any arbitrary electromagnetic field configuration results in the fundamental equation (23) for any arbitrary electromagnetic field configuration (a beam of light):

$$\text{NEWTON: } F_{TOTAAL} = m\,a \text{ represents: } f_{TOTAAL} = \rho\,a$$
$$-\rho\,a \quad + \quad f_{TOTAAL} \quad = 0$$
$$-\rho\,a \quad + \quad f_{ELEKTRISCH} \quad + \quad f_{MAGNETISCH} \quad = 0$$
$$-\rho\,a \quad + F_{COULOMB} \quad + \quad F_{LORENTZ} \quad + \quad F_{COULOMB} \quad + \quad F_{LORENTZ} \quad = 0 \tag{18}$$
$$\underbrace{-\frac{1}{c^2}\frac{\partial\,(\bar{E}\times\bar{H})}{\partial t}}_{B\text{-}1} + \underbrace{\varepsilon_0\;\bar{E}(\nabla .\,\bar{E})}_{B\text{-}2} - \underbrace{\varepsilon_0\;\bar{E}\times(\nabla\times\bar{E})}_{B\text{-}3} + \underbrace{\mu_0\;\bar{H}\;(\nabla .\,\bar{H})}_{B\text{-}4} - \underbrace{\mu_0\;\bar{H}\times(\nabla\times\bar{H})}_{B\text{-}5} = 0$$

Term B-4 is the magnetic equivalent of the (electric) Coulomb's law B-2 and Term B-3 is the electric equivalent of the (magnetic) Lorentz's law B-5.

The universal equation for the electromagnetic interaction for propagating electromagnetic waves (Laser beam) and confined electromagnetic waves (GEONs) has been presented in (19) and expresses the perfect equilibrium between the inertia forces (B-1), the electric forces (B-2 and B-3) and the magnetic forces (B-4 and B-5) in any arbitrary electromagnetic field configuration.

$$\underbrace{-\frac{1}{c^2}\frac{\partial\,(\bar{E}\times\bar{H})}{\partial t}}_{B\text{-}1} + \underbrace{\varepsilon_0\;\bar{E}(\nabla .\,\bar{E})}_{B\text{-}2} - \underbrace{\varepsilon_0\;\bar{E}\times(\nabla\times\bar{E})}_{B\text{-}3} + \underbrace{\mu_0\;\bar{H}\;(\nabla .\,\bar{H})}_{B\text{-}4} - \underbrace{\mu_0\;\bar{H}\times(\nabla\times\bar{H})}_{B\text{-}5} = 0 \tag{19}$$

The integration of Maxwell's theory of electrodynamics in "proposed theory":

The "fundamental equation for electromagnetic interaction" (19) for any arbitrary electromagnetic field configuration can be written in the form:

$$-\frac{1}{c^2}\frac{\partial\,(\bar{E}\times\bar{H})}{\partial t} + \varepsilon_0\;\bar{E}(\nabla .\,\bar{E}) - \varepsilon_0\;\bar{E}\times(\nabla\times\bar{E}) + \mu_0\;\bar{H}\;(\nabla .\,\bar{H}) - \mu_0\;\bar{H}\times(\nabla\times\bar{H}) = 0$$
$$-\varepsilon_0\mu_0\left(\bar{E}\times\frac{\partial(\bar{H})}{\partial t} + \bar{H}\times\frac{\partial(\bar{E})}{\partial t}\right) + \varepsilon_0\bar{E}(\nabla .\bar{E}) - \varepsilon_0\bar{E}\times(\nabla\times\bar{E}) + \mu_0\bar{H}\;(\nabla .\bar{H}) - \;\mu_0\bar{H}\times(\nabla\times\bar{H}) = 0 \tag{20}$$
$$-\left(\underbrace{\varepsilon_0\bar{E}\times\frac{\partial\,(\bar{B}\,)}{\partial t}}_{M\text{-}3} + \underbrace{\mu_0\bar{H}\times\frac{\partial\,(\bar{D})}{\partial t}}_{M\text{-}4}\right) + \underbrace{\bar{E}\,(\nabla .\bar{D})}_{M\text{-}1} - \underbrace{\varepsilon_0\bar{E}\times(\nabla\times\,\bar{E})}_{M\text{-}3} + \underbrace{\bar{H}\;(\nabla .\bar{B})}_{M\text{-}2} - \underbrace{\mu_0\bar{H}\times(\nabla\times\,\bar{H})}_{M\text{-}4} = 0$$

The Maxwell equations are presented in (21):

$$\nabla .\,\bar{D} = \rho \quad \text{(M-1)} \qquad \nabla\times\,\bar{E} = -\frac{\partial\,B}{\partial t} \quad \text{(M-3)}$$
$$\nabla .\,\bar{B} \;=\; 0 \quad \text{(M-2)} \qquad \nabla\times\,\bar{H} \;=\; \frac{\partial\,D}{\partial t} \quad \text{(M-4)} \tag{21}$$

In vacuum in the absence of any electric or magnetic charge density, it follows from (21) that all the solutions for the Maxwell's equations (21) are also solutions for the "fundamental equation for electromagnetic interaction" (20) for the electromagnetic field.

Fundamental Equation for Electromagnetic Interaction

$$-\left(\underbrace{\varepsilon_0\bar{E}\times\frac{\partial(\bar{B})}{\partial t}}_{M\text{-}3} + \underbrace{\mu_0\bar{H}\times\frac{\partial(\bar{D})}{\partial t}}_{M\text{-}4}\right) + \underbrace{\bar{E}\,(\nabla .\bar{D})}_{M\text{-}1} - \underbrace{\varepsilon_0\bar{E}\times(\nabla\times\,\bar{E})}_{M\text{-}3} + \underbrace{\bar{H}\;(\nabla .\bar{B})}_{M\text{-}2} - \underbrace{\mu_0\bar{H}\times(\nabla\times\bar{H})}_{M\text{-}4} = 0 \tag{22}$$

4 Maxwell's Equations

$$\nabla .\,\bar{D} = \rho \quad \text{(M-1)} \qquad \nabla\times\,\bar{E} = -\frac{\partial\,B}{\partial t} \quad \text{(M-3)}$$
$$\nabla .\,\bar{B} \;=\; 0 \quad \text{(M-2)} \qquad \nabla\times\,\bar{H} \;=\; \frac{\partial\,D}{\partial t} \quad \text{(M-4)}$$

Comparing the 4 Maxwell equations (21) with the "fundamental equation for electromagnetic interaction" (20) results in the conclusion that the 4 Maxwell equations show only the 4 parts of the "fundamental equation for electromagnetic interaction" in 4 separate terms and the 4 Maxwell equations are missing the fundamental term for inertia. For that reason it is impossible to calculate the interaction between light and gravity with the 4 Maxwell equations. To find the interaction terms between light and gravity the inertia term B-1 in (19) is necessary.

The linear divergence-free "stress-energy tensor" in "relativistic quantum physics"

Albert Einstein described with his "theory of general relativity" the interaction between gravity and light (EMR). His starting point was the stress-energy tenor [18]. This new theory starts in a comparable way also with the "stress-energy tensor" (44). The stress-energy tensor (44) describes a universal 4-dimensional equilibrium within the electromagnetic field [19]. The divergence of the "stress-energy tensor" results in the electromagnetic force vector within the electromagnetic field (45). A "universal 4-dimensional equilibrium" within the electromagnetic field requires the force (densities) to be equal zero in the 4-dimensional space-time coordinates (Minkowski space). This results in equation (46). Equilibrium within the 3 spatial coordinates results in Equation (22), which describes the electromagnetic field in an more general concept than the 4 Maxwell equations. Stress-energy tensor (44) in the 4th dimension (energy-time domain) results in the quantum mechanical relativistic dirac equation (47 and 49).

In physics the quantization of light has always been related to the quantization of Einstein's concept of photons. In "The proposed theory" the quantization of light has been related to a much broader concept also including Wheeler's concept of GEONs [1].

In general, when waves have been confined, like a sound wave on a guitar string, the phenomenon of "standing waves" (stationary waves) appears with the well-known aspects of nodes and antinodes in all possible modes.

The equation in the proposed theory for confined electromagnetic waves is an equation for "standing waves" (Stationary waves) which appear with the well-known aspects of Nodes and Antinodes in all possible modes, describing the quantization of electromagnetic radiation in GEONs.

<u>The "Quantization of Light" (Electromagnetic Radiation)</u>

In general quantization has been determined by the match of a wavelength on a 3-dimensional geometry. Because only an integer number (natural number) of wavelengths matches the 3-dimensional geometry. The quantization of electromagnetic radiation is only possible when the electromagnetic wave has been confined due to its own gravitational field and the wavelength has to match a 3-dimensional geometry.

This is possible when light "confines" itself in a 3-dimensional stable geometry due to its own gravitational field. According John Archibald Wheeler's "GEON's [1]. (Gravitational electromagnetic entities) and Einstein's relationship ($W=mc^2$) every "confined" energy results in inertia. Inertia results in mechanical mass and mechanical mass results in a gravitational field.

To realize "quantization of light", stable configurations have to be found of confined electromagnetic radiation in which the wavelength of the confined electromagnetic energy matches in natural numbers the 3-dimensional geometry of the confinement.

<u>Realization of a stable electromagnetic confinement in a 3-dimensional configuration matching the wavelength of the confinement in quantum numbers</u>

Newton's third law has been described for the electromagnetic field in 3 spatial dimensions, resulting in the "fundamental equation for electromagnetic gravitational interaction" in the proposed theory:

3 - Dimensional Space Domain

$$\begin{pmatrix} x_3 \\ x_2 \\ x_1 \end{pmatrix} \quad \underbrace{-\frac{1}{c^2}\frac{\partial(\overline{E}\times\overline{H})}{\partial t}}_{\text{B-1}} + \underbrace{\varepsilon_0\,\overline{E}\,(\nabla\,.\,\overline{E})}_{\text{B-2}} - \underbrace{\varepsilon_0\,\overline{E}\times(\nabla\times\overline{E})}_{\text{B-3}} + \underbrace{+\mu_0\,\overline{H}\,(\nabla\,.\,\overline{H})}_{\text{B-4}} - \underbrace{\mu_0\,\overline{H}\times(\nabla\times\overline{H})}_{\text{B-5}} + \underbrace{\frac{1}{2}\left(\varepsilon^2\mu\left(\overline{E}\bullet\overline{E}\right)+\varepsilon\,\mu^2\left(\overline{H}\bullet\overline{H}\right)\right)\overline{g}}_{\text{B-6}} = \overline{0} \tag{23}$$

The boundary conditions for the physical experiment determines the boundary conditions for the theory to be tested. When we put a weight on a scale, the scale will be out of balance. The same effect can be reached by putting an electric charge under one part of the scale or a magnet. The outcome of the experiment gives no information about the origin of the disturbing force (gravitational, electric or magnetic). In equation (24) the mutual electric-, magnetic- or gravitational interaction force densities are exchangeable. The gravitational-electromagnetic confinement for the elementary structure beyond the confinement of light (electromagnetic radiation) has been presented in equation (24).

4 - Dimensional Space Domain

$$\overline{f}^4 = \begin{pmatrix} f_4 \\ f_3 \\ f_2 \\ f_1 \end{pmatrix} = \square \bullet \overline{\overline{T}} = \partial_b\, T^{ab} = f^a = 0$$

3-Dimensional Space Domain (24)

$$\left|\partial_b\, T^{ab}\right|_1^3 = -\frac{1}{c^2}\frac{\partial(\overline{E}\times\overline{H})}{\partial t} + \varepsilon_0\,\overline{E}\,(\nabla\,.\,\overline{E}) - \varepsilon_0\,\overline{E}\times(\nabla\times\overline{E}) +$$

$$+\mu_0\,\overline{H}\,(\nabla\,.\,\overline{H}) - \mu_0\,\overline{H}\times(\nabla\times\overline{H}) + \gamma_0\,\overline{g}\,(\nabla\,.\,\overline{g}) - \gamma_0\,\overline{g}\times(\nabla\times\overline{g}) = \overline{0}$$

in which:

$\varepsilon_0\,(\nabla\,.\,\overline{E}) = \rho_E$ Electric Charge Density $[C/m^3]$

$\mu_0\,(\nabla\,.\,\overline{H}) = \rho_M$ Magnetic Flux Density $[Vs/m^3]$ or $[Wb/m^3]$

$\gamma_0\,(\nabla\,.\,\overline{g}) = \rho_M$ Mass Density (Electromagnetic) $[kg/m^3]$

In which $\overline{g}$ represents the gravitational acceleration (as a function of space and time) expressed in (ms^{-2}) acting on the electromagnetic mass density of the confined electromagnetic radiation and γ_0 = gravitational permeability of vacuum expressed in (kgs^2m^{-3}) [28].

A solution for equation (24), describing a gravitational electromagnetic confinement (GEON) within a radial gravitational field with acceleration $\overline{g}$ (in radial direction), has been represented in (25).

$$\begin{pmatrix} E_r \\ E_\theta \\ E_\varphi \end{pmatrix} = \begin{pmatrix} 0 \\ f(r)\,\mathrm{Sin}(\omega\, t) \\ -f(r)\,\mathrm{Cos}(\omega\, t) \end{pmatrix} \quad \begin{pmatrix} H_r \\ H_\theta \\ H_\varphi \end{pmatrix} = \sqrt{\frac{\varepsilon}{\mu}} \begin{pmatrix} 0 \\ f(r)\,\mathrm{Cos}(\omega\, t) \\ f(r)\,\mathrm{Sin}(\omega\, t) \end{pmatrix} \quad \bar{g} = \begin{pmatrix} \frac{G_1}{4\,\pi\, r^2} \\ 0 \\ 0 \end{pmatrix} \tag{25}$$

$$w_{em} = \left(\frac{\mu_0}{2}(\bar{m}\,.\,\bar{m}) + \frac{\varepsilon_0}{2}(\bar{e}\,.\,\bar{e})\right) = \varepsilon_0\, f(r)^2$$

In which the radial function f(r) equals:

$$f[r] = K\, e^{-\frac{-\frac{G1\,\varepsilon_0\,\mu_0}{r} + 8\,\pi\,\log[r]}{8\,\pi}} \tag{26}$$

The solution has been calculated according Newton's shell theorem.

The fundamental boundary condition for the confinement of electromagnetic radiation (GEONs) is that the energy flow (Poynting vector) $\bar{S} = \bar{E} \times \bar{H}$ equals zero at the surface of the confinement. This is possible at a 90 degrees phase shift between the electric field and the magnetic field.

Introducing the quantum vector function $\bar{\phi}$,

$$\bar{\phi} = \sqrt{\frac{\mu}{2}}\left(\bar{H} + i\,\frac{\bar{E}}{c}\right) \tag{27}$$

Substituting (27) in (25) results in the quantum presentation $\bar{\phi}$, for the GEON:

$$\overline{\Phi(r,\theta,\varphi)} = f(r)\begin{pmatrix} \Phi_r \\ \Phi_\theta \\ \Phi_\varphi \end{pmatrix} = \sqrt{\frac{\mu}{2}}\begin{pmatrix} 0 \\ 1 \\ i \end{pmatrix} f(r)\, e^{i\,\omega\, t}$$

$$\overline{\Phi(r,\theta,\varphi)} = K\, e^{-\frac{G1\,\varepsilon_0\,\mu_0}{8\,\pi\, r}} \begin{pmatrix} 0 \\ 1 \\ i \end{pmatrix} e^{i\,\omega\, t} \tag{28}$$

<u>GEONs with discrete spherical energy levels</u>: A solution for equation (24) describing GEONs dependent of time and radius, presenting discrete spherical energy levels, within a radial gravitational field with acceleration $\bar{g}$ (in radial direction), has been represented in (25).

$$\begin{pmatrix} E_r \\ E_\theta \\ E_\varphi \end{pmatrix} = \begin{pmatrix} 0 \\ f(r)\,\mathrm{Sin}(k\,r)\,\mathrm{Sin}(\omega\,t) \\ -f(r)\,\mathrm{Cos}(k\,r)\,\mathrm{Cos}(\omega\,t) \end{pmatrix} \quad \begin{pmatrix} H_r \\ H_\theta \\ H_\varphi \end{pmatrix} = \sqrt{\frac{\varepsilon}{\mu}} \begin{pmatrix} 0 \\ -f(r)\,\mathrm{Sin}(k\,r)\,\mathrm{Cos}(\omega\,t) \\ -f(r)\,\mathrm{Cos}(k\,r)\,\mathrm{Sin}(\omega\,t) \end{pmatrix} \quad \bar{g} = \begin{pmatrix} \frac{G_1}{4\,\pi\, r^2} \\ 0 \\ 0 \end{pmatrix}$$

$$w_{em} = \left(\frac{\mu_0}{2}(\bar{m}\,.\,\bar{m}) + \frac{\varepsilon_0}{2}(\bar{e}\,.\,\bar{e})\right) = \tag{29}$$

$$f(r)^2\left((\mathrm{Sin}(k\,r)\,\mathrm{Sin}(\omega\,t))^2 + (\mathrm{Cos}(k\,r)\,\mathrm{Cos}(\omega\,t))^2 + \frac{\varepsilon}{\mu}(\mathrm{Sin}(k\,r)\,\mathrm{Cos}(\omega\,t))^2 + (\mathrm{Cos}(k\,r)\,\mathrm{Sin}(\omega\,t))^2\right)$$

In which the radial function f(r) equals:

$$f[r] = K\, e^{-\frac{-\frac{G1\,\varepsilon_0\,\mu_0}{r} + 8\,\pi\,\log[r]}{8\,\pi}} \tag{30}$$

Equation (29) presents a standing (Confined) electromagnetic fields configuration with a phase shift of 90 degrees between the electric field and the magnetic field with the corresponding nodes and antinodes (Figure 2) [13].

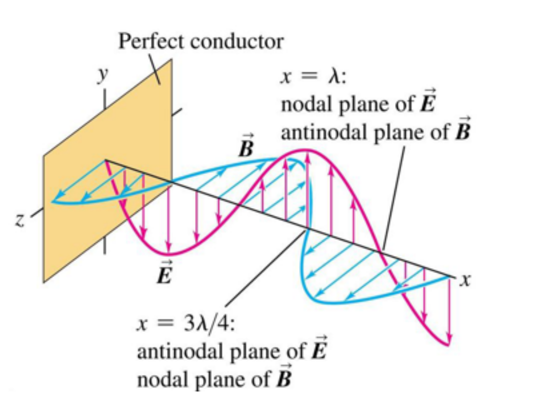

Figure 2) *Nodal and antinodal planes for standing (Confined) electromagnetic waves with a 90 degrees phase shift between the electric field and the magnetic field.*

An essential requirement for the confinement of electromagetic energy is that the poynting vector equals zero at the surface of the confinement. For the confinement within a sphere, a standing electromagnetic wave pattern has been required which exists of concentric spheres, at every sphere an antinodal plane for E (or B) with a radius distance between each sphere of half the wavelength of the confinement (k=nπλ and "n" a natural number and λ the wavelength).

<u>Time and radius dependent GEONs with discrete energy levels. confinements of electromagnetic radiation within spherical regions:</u>
Every concentric sphere represents an anti-nodal surface for the electric field or the magnetic field. The poynting vector at this spherical surface equals zero at any time and at any location at this sphere. The electromagnetic energy remains always within this sphere and the next concentric sphere, where all the concentric spheres have a difference in radius of one-half wavelength of the electromagnetic radiation within the confinement and a different discrete energy level. Every concentric sphere represents an anti-nodal surface of the electric field or the magnetic field (Figure 3, 4).

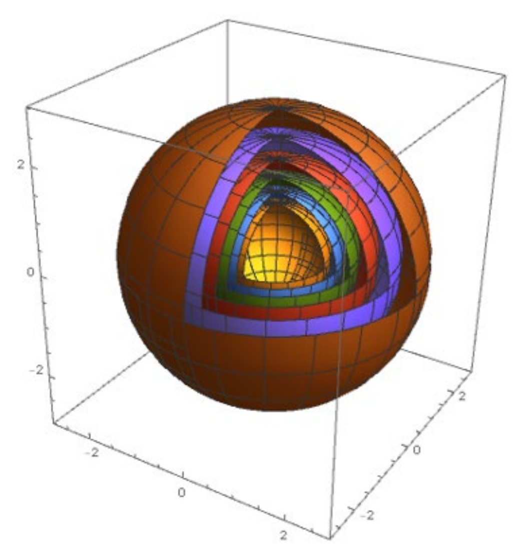

Figure 3) *Nodal and Antinodal Spheres for Standing (Confined) Spherical Electromagnetic waves with a 90 degrees phase shift between the Electric*

field and the Magnetic field. Equation (29)

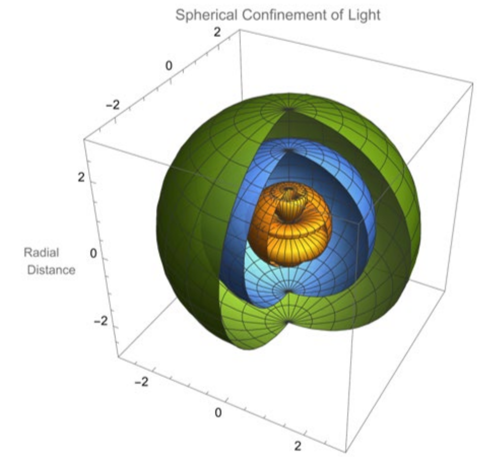

Figure 4) *Nodal- and Antinodal spheres (k = 3) for standing (confined) spherical electromagnetic waves with a 90 degrees phase shift between the electric field and the magnetic field equation (29)*

Equation (31) describes a time and radius dependent GEON.

$$\overline{E} = K\, e^{-\frac{G1\varepsilon0\mu0}{8\pi r}} \begin{pmatrix} 0 \\ \mathrm{Sin}[k\, r]\, \mathrm{Sin}[\omega\, t] \\ -\mathrm{Cos}[k\, r]\, \mathrm{Cos}[\omega\, t] \end{pmatrix}$$

$$\overline{H} = K\, e^{-\frac{G1\epsilon0\mu0}{8\pi r}} \sqrt{\frac{\varepsilon_0}{\mu_0}} \begin{pmatrix} 0 \\ \mathrm{Sin}[k\, r]\, \mathrm{Cos}[\omega\, t] \\ -\mathrm{Cos}[k\, r]\, \mathrm{Sin}[\omega\, t] \end{pmatrix} \tag{31}$$

Equation (31) represents by the function $\mathrm{Sin}[k\, r]$ (k=1,2,3,4....) the confinement of electromagnetic radiation between two concentric spheres (Figure 5) [14].

<u>Time and Polar Angle dependent GEONs:</u>

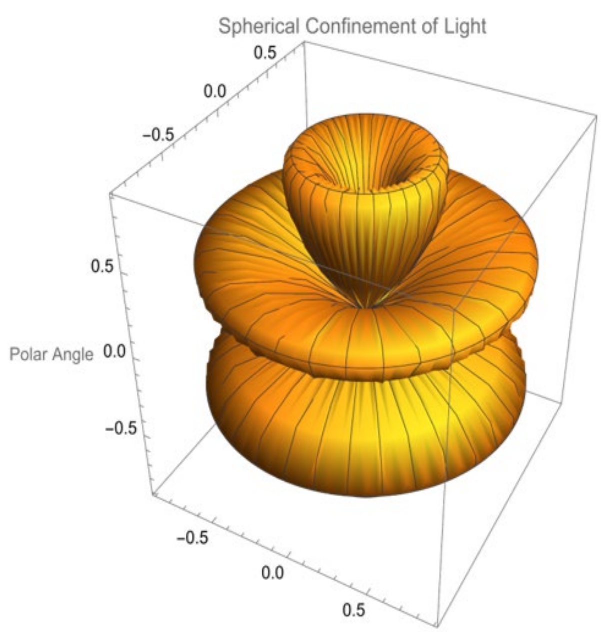

Figure 5) *Nodal- and Antinodal polar angle regions (m = 3) for standing (Confined) spherical electromagnetic waves with a 90 degrees phase shift between the electric field and the magnetic field Equation (29)*

Equation (32) describes a time and "polar angle" dependent GEON

$$\overline{E} = K\, e^{-\frac{G1\varepsilon0\mu0}{8\pi r}} \begin{pmatrix} 0 \\ \mathrm{Sin}[m\, \theta]\, \mathrm{Sin}[\omega\, t] \\ \mathrm{Sin}[m\, \theta]\, \mathrm{Cos}[\omega\, t] \end{pmatrix}$$

$$\overline{H} = K\, e^{-\frac{G1\epsilon0\mu0}{8\pi r}} \sqrt{\frac{\varepsilon_0}{\mu_0}} \begin{pmatrix} 0 \\ \mathrm{Sin}[m\, \theta]\, \mathrm{Cos}[\omega\, t] \\ -\mathrm{Sin}[m\, \theta]\, \mathrm{Sin}[\omega\, t] \end{pmatrix} \tag{32}$$

Equation (32) represents by the function $\mathrm{Sin}[m\, \theta]$ (m = 1,2,3,4.....) the confinement of electromagnetic radiation between two polar angular regions (Figure 6, 7) [15].

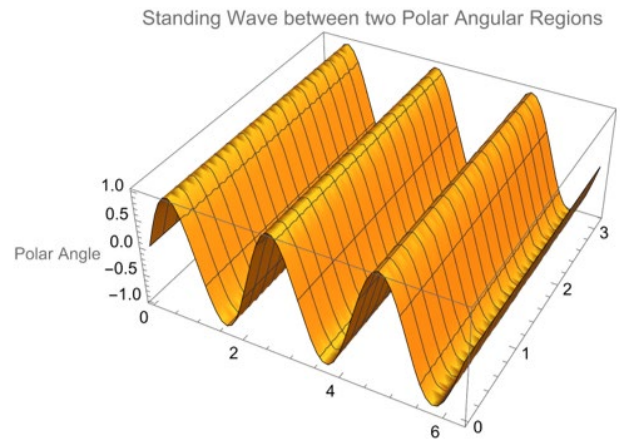

Figure 6) *Nodal- and Antinodal polar angle regions (m = 3) for standing (Confined) electromagnetic waves with a 90 degrees phase shift between the electric field and the magnetic field equation (29)*

<u>Time and Azimuthal angular dependent GEONs</u>

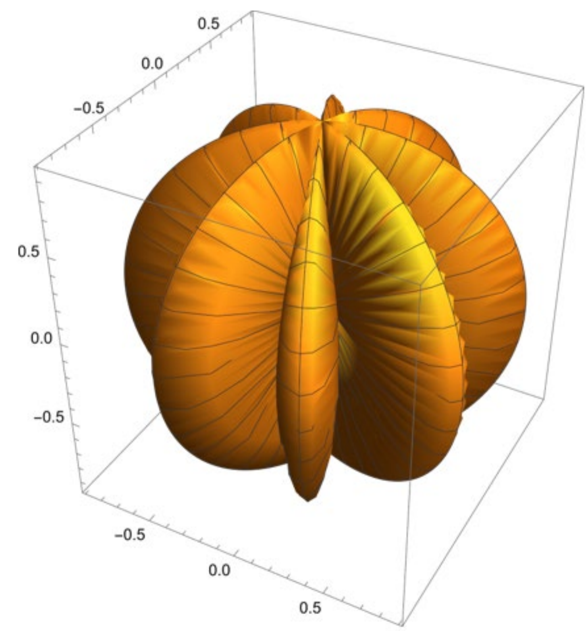

Figure 7) *Nodal- and Antinodal azimuthal angular regions (n = 3) for standing (Confined) electromagnetic waves with a 90 degrees phase shift between the electric field and the magnetic field equation (29)*

Equation (3) describes a time and "polar angle" dependent GEON

$$\overline{E} = K\, e^{-\frac{G1\varepsilon 0\mu 0}{8\pi r}} \begin{pmatrix} 0 \\ \mathrm{Cos}[n\ \varphi]\ \mathrm{Sin}[\omega\ t] \\ \mathrm{Cos}[n\ \varphi]\ \mathrm{Cos}[\omega\ t] \end{pmatrix}$$

$$\overline{H} = K\, e^{-\frac{G1\epsilon 0\mu 0}{8\pi r}} \sqrt{\frac{\varepsilon_0}{\mu_0}} \begin{pmatrix} 0 \\ \mathrm{Cos}[n\ \varphi]\ \mathrm{Cos}[\omega\ t] \\ -\mathrm{Cos}[n\ \varphi]\ \mathrm{Sin}[\omega\ t] \end{pmatrix} \tag{33}$$

Equation (33) represents by the function $\mathrm{Sin}[n\ \varphi]$ (n = 1,2,3,4.....) the confinement of electromagnetic radiation between two azimuthal angular regions (Figure 8) [16].

<u>Time, Polar angular and azimuthal angular dependent GEONs</u>

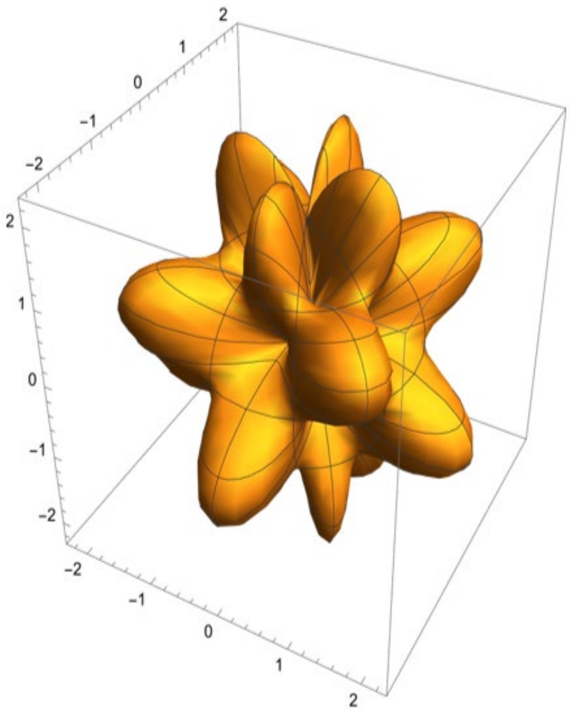

Figure 8) *Nodal- and Antinodal polar angular and azimuthal angular regions (n = 4 and m = 4) for standing (Confined) electromagnetic waves with a 90 degrees phase shift between the electric field and the magnetic field Equation (29)*

Equation (34) describes a time "azimuthal angle" and "polar angle" dependent GEON

$$\overline{E} = K\, e^{-\frac{G1\varepsilon 0\mu 0}{8\pi r}} \begin{pmatrix} 0 \\ \mathrm{Cos}[n\ \varphi]\ \mathrm{Sin}[m\ \theta]\ \mathrm{Sin}[\omega\ t] \\ \mathrm{Cos}[n\ \varphi]\ \mathrm{Sin}[m\ \theta]\ \mathrm{Cos}[\omega\ t] \end{pmatrix}$$

$$\overline{H} = K\, e^{-\frac{G1\epsilon 0\mu 0}{8\pi r}} \sqrt{\frac{\varepsilon_0}{\mu_0}} \begin{pmatrix} 0 \\ -\mathrm{Cos}[n\ \varphi]\ \mathrm{Sin}[m\ \theta]\ \mathrm{Cos}[\omega\ t] \\ \mathrm{Cos}[n\ \varphi]\ \mathrm{Sin}[m\ \theta]\ \mathrm{Sin}[\omega\ t] \end{pmatrix} \tag{34}$$

Equation (34) represents by the function $\mathrm{Cos}[n\ \varphi]$ (n = 1,2,3,4.....) and $\mathrm{Sin}[m\ \theta]$ (m = 1,2,3,4.....) the confinement of electromagnetic radiation between two azimuthal angular regions (Figure 9)[17].

<u>Spherical confinement of light beween two concentric spheres within GEONs</u>

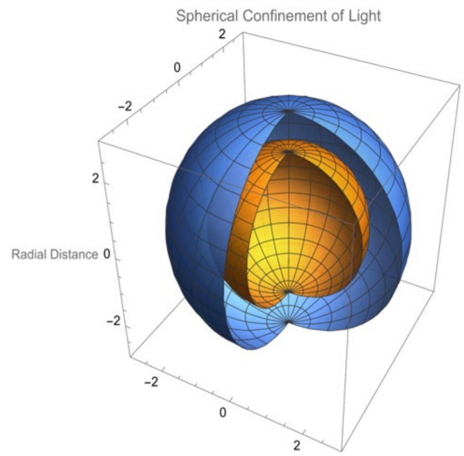

Figure 9) *Nodal- and Antinodal regions for standing (Confined) electromagnetic waves with a 90 degrees phase shift between the electric field and the magnetic field equation (35)*

Equation (35) represents the reflection of the confined electromagnetic energy within the GEON between two concentric spheres while the speed of light, depending on the variable "r", changes in magnitude and direction (Figure 10).

$$\overline{E} = K\, e^{-\frac{G1\varepsilon 0\mu 0}{8\pi r}}\ f\left[t - \frac{\sqrt{\varepsilon_0\ \mu_0}\ \mathrm{Cos}[2\ k\ r]}{2\ k}\right] \begin{pmatrix} 0 \\ \mathrm{Sin}[k\ r]\ \mathrm{Sin}[\omega\ t] \\ -\mathrm{Cos}[k\ r]\ \mathrm{Cos}[\omega\ t] \end{pmatrix}$$

$$\overline{H} = K\, e^{-\frac{G1\epsilon 0\mu 0}{8\pi r}}\ f\left[t - \frac{\sqrt{\varepsilon_0\ \mu_0}\ \mathrm{Cos}[2\ k\ r]}{2\ k}\right] \sqrt{\frac{\varepsilon_0}{\mu_0}} \begin{pmatrix} 0 \\ -\mathrm{Sin}[k\ r]\ \mathrm{Cos}[\omega\ t] \\ -\mathrm{Cos}[k\ r]\ \mathrm{Sin}[\omega\ t] \end{pmatrix} \tag{35}$$

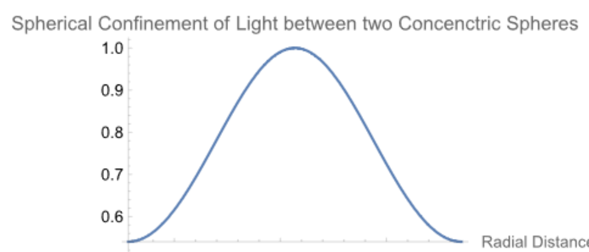

Figure 10) *Nodal- and Antinodal regions for standing (Confined) electromagnetic within two concentric spheres equation (35)*

Universal equilibrium (stress-energy tensor) in the "concept of quantum mechanical probability" in "The proposed theory"

In the 4-dimensional notation of (44), the fourth term of the "Energy-stress tensor" [19] expresses the law of conservation of energy". For an electromagnetic field the law for conservation of energy has been expressed as:

$$\nabla \cdot \overline{S} + \frac{\partial w}{\partial t} = 0 \tag{36}$$

From the equation for the "conservation of electromagnetic energy" (23) the "fundamental equation for confined electromagnetic interaction" in "The proposed theory" will be derived, which equals the relativistic quantum mechanical "Dirac" equation.

The "Fundamental equation for confined electromagnetic interaction" in "The proposed theory" can be considered to be the relativistic version of the quantum mechanical schrödinger wave equation, which equals the quantum mechanical Dirac equation.

Confined electromagnetic energy within a 4-dimensional equilibrium

The physical concept of quantum mechanical probability waves has been created during the famous 1927 5th Solvay conference. During that period there were several circumstances which came just together and made it possible to create a unique idea of "material waves" (Solutions of schödinger's wave equation) being complex (partly real and partly imaginary) and describing the probability of the appearance of a physical object (elementary particle) generally indicated as "**Quantum mechanical probability waves**".

The idea of complex (probability) waves is directly related to the concept of confined (standing) waves. Characteristic for any standing acoustical wave is the fact that the velocity and the pressure (Electric field and magnetic field in QLT) are always shifted over 90 degrees. The same principle does exist for the standing (confined) electromagnetic waves,

For that reason every confined (standing) electromagnetic wave can be described by a complex sum vector $\overline{\phi}$ of the electric field vector $\overline{\mathrm{E}}$ and the magnetic field vector $\overline{\mathbf{B}}$ ($\overline{\mathrm{E}}$ has 90 degrees phase shift compared to $\overline{\mathbf{B}}$).

The vector functions $\overline{\phi}$ and the complex conjugated vector $\overline{\phi}*$ function will be written as:

$$\overline{\phi} = \frac{1}{\sqrt{2\,\mu}}\left(\overline{\mathrm{B}} + i\,\frac{\overline{\mathrm{E}}}{c}\right) \tag{37}$$

$\overline{\mathbf{B}}$ equals the magnetic induction, $\overline{\mathrm{E}}$ the electric field intensity ($\overline{\mathrm{E}}$ has + 90 degrees phase shift compared to $\overline{\mathbf{B}}$) and c the speed of light. The complex conjugated vector function $\overline{\phi}*$ equals:

$$\overline{\phi *} = \frac{1}{\sqrt{2\,\mu}}\left(\overline{\mathrm{B}} - i\,\frac{\overline{\mathrm{E}}}{c}\right) \tag{38}$$

The dot product equals the electromagnetic energy density w:

$$\overline{\phi}\,.\,\overline{\phi *} = \frac{1}{2\,\mu}\left(\overline{\mathrm{B}} + i\,\frac{\overline{\mathrm{E}}}{c}\right).\left(\overline{\mathrm{B}} - i\,\frac{\overline{\mathrm{E}}}{c}\right) = \frac{1}{2}\,\mu\,\mathrm{H}^2 + \frac{1}{2}\,\varepsilon\,\mathrm{E}^2 = \mathrm{w} \tag{39}$$

Using Einstein's equation W = m c^2, the dot product equals the electromagnetic mass density w:

$$\overline{\phi}\,.\,\overline{\phi *}\,\frac{1}{c^2} = \frac{\varepsilon}{2}\left(\overline{\mathrm{B}} + i\,\frac{\overline{\mathrm{E}}}{c}\right).\left(\overline{\mathrm{B}} - i\,\frac{\overline{\mathrm{E}}}{c}\right) = \frac{1}{2}\,\varepsilon\,\mu^2\mathrm{H}^2 + \frac{1}{2}\,\varepsilon^2\,\mathrm{E}^2 = \rho\ [\mathrm{kg/m}^3] \tag{40}$$

The cross product is proportional to the poynting vector [3].

$$\overline{\phi} \times \overline{\phi *} = \frac{1}{2\,\mu}\left(\overline{\mathrm{B}} + i\,\frac{\overline{\mathrm{E}}}{c}\right) \times \left(\overline{\mathrm{B}} - i\,\frac{\overline{\mathrm{E}}}{c}\right) = i\,\sqrt{\varepsilon\,\mu}\;\overline{\mathrm{E}} \times \overline{\mathrm{H}} = i\,\sqrt{\varepsilon\,\mu}\;\overline{\mathrm{S}} \tag{41}$$

This article presents a new "Gravitational-electromagnetic equation" describing electromagnetic field configurations which are simultaneously the mathematical solutions for the quantum mechanical "Schrodinger wave equation" and more exactly the mathematical solutions for the "Relativistic quantum mechanical Dirac equation". The gravitational-electromagnetic confinements, which are mathematical solutions for the "Gravitational-electromagnetic equation" (47) carry mass, electric charge and magnetic spin at discrete values.

The formal mathematical way to describe the force density results from the 4-dimensional divergence of the 4-dimensional energy momentum tensor, resulting in a 4-dimensional Force vector. Dividing the 4-dimensional force vector by the volume results in the 4-dimensional force density vector.

The 4-dimensional electromagnetic vector potential has been defined by:

$$\overline{\varphi}_4 = \begin{pmatrix} \varphi_4 \\ \varphi_3 \\ \varphi_2 \\ \varphi_1 \end{pmatrix} \xrightarrow[\text{Coordinate System}]{\text{Cartesian}} \begin{pmatrix} \varphi_t \\ \varphi_z \\ \varphi_y \\ \varphi_x \end{pmatrix} \xrightarrow[\text{4-Vector}]{\text{Potential}} \begin{pmatrix} i\frac{V}{c} \\ A_z \\ A_y \\ A_x \end{pmatrix} = \overline{\mathrm{A}}_4 \tag{42}$$

In which the term φ_a represents the 4-dimensional electromagnetic vector potential in the "a" direction while the indice "a" varies from 1 to 4. In a cartesian coordinate system the indices are chosen varying from the x,y,z (Magnetic potential A) and t direction (Electric potential V). In which the indice "t" represents the time direction which has been considered to be the 4th dimension. The 4-dimensional electromagnetic "Maxwell tensor" has been defined by:

$$\mathbf{F}_{ab} = \partial_b\,\varphi_a - \partial_a\,\varphi_b \tag{43}$$

where the indices "a" and "b" vary from 1 to 4.

The 4-dimensional electromagnetic "Energy momentum tensor" has been defined by:

$$T^{ab} = \frac{1}{\mu_0}\left[F_{ac}F^{cb} + \tfrac{1}{4}\delta_{ab}F_{cd}F^{cd}\right] \tag{44}$$

The 4-dimensional divergence of the 4-dimensional energy momentum tensor equals the 4-dimensional force density 4-vector f^a :

$$f^a = \partial_b\,\mathrm{T}^{ab} \tag{45}$$

Substituting the electromagnetic values for the electric field intensity "E" and the magnetic field intensity "H" in (71) results in the 4-dimensional representation of Newton's third law (1):

Energy - Time Domain

$$(f_4) \qquad \underbrace{\nabla\,.\,(\,\overline{\mathrm{E}} \times \overline{\mathrm{H}}\,) + \frac{1}{2}\,\frac{\partial\left(\varepsilon_0\,(\,\overline{\mathrm{E}}\,.\,\overline{\mathrm{E}}\,) + \mu_0\,(\,\overline{\mathrm{H}}\,.\,\overline{\mathrm{H}}\,)\right)}{\partial t}}_{\text{B-7}} = 0$$

$$\tag{46}$$

3-Dimensional Space Domain

$$\begin{pmatrix} f_3 \\ f_2 \\ f_1 \end{pmatrix} \quad \begin{aligned} &\overset{\text{B-1}}{-\frac{1}{c^2}\frac{\partial\,(\overline{\mathrm{E}} \times \overline{\mathrm{H}})}{\partial t}} + \overset{\text{B-2}}{\varepsilon_0\,\overline{\mathrm{E}}\,(\nabla\,.\,\overline{\mathrm{E}})} - \overset{\text{B-3}}{\varepsilon_0\,\overline{\mathrm{E}} \times (\nabla \times \overline{\mathrm{E}})} + \\ &+ \overset{\text{B-4}}{\mu_0\,\overline{\mathrm{H}}\,(\nabla\,.\,\overline{\mathrm{H}})} - \overset{\text{B-5}}{\mu_0\,\overline{\mathrm{H}} \times (\nabla \times \overline{\mathrm{H}})} = \overline{0} \end{aligned}$$

In which f_1, f_2, f_3, represent the force densities in the 3 spatial dimensions and f4 represent the force density (energy flow) in the time dimension (4th dimension). Equation (42) can be written as:

Energy - Time Domain

Conservation of Energy

B-7

$$(f_4) \qquad \nabla \cdot \bar{S} + \frac{\partial w}{\partial t} = 0 \qquad (47.1)$$

(47)

3-Dimensional Space Domain

B-1 B-2 B-3

$$\begin{pmatrix} f_3 \\ f_2 \\ f_1 \end{pmatrix} \quad -\frac{1}{c^2}\frac{\partial(\bar{E}\times\bar{H})}{\partial t} + \varepsilon_0\,\bar{E}\,(\nabla\cdot\bar{E}) - \varepsilon_0\,\bar{E}\times(\nabla\times\bar{E}) + \underbrace{+\mu_0\,\bar{H}\,(\nabla\cdot\bar{H})}_{B\text{-}4} - \underbrace{\mu_0\,\bar{H}\times(\nabla\times\bar{H})}_{B\text{-}5} = \bar{0} \qquad (47.2)$$

The 4[th] term in equation (45.1) can be written in the terms of the Poynting vector "S" and the energy density "w" representing the electromagnetic law for the conservation of energy (Newton's second law of motion).

The 4-dimensional "Equation for gravitational-electromagnetic interaction" equals the 4-Dimensional relativistic quantum mechanical Dirac equation

Substituting (40) and (41) in equation (47.1) results in the 4-dimensional equilibrium equation (48):

$$(x_4) \quad -\frac{i}{\sqrt{\varepsilon_0\,\mu_0}}\nabla\cdot(\bar{\phi}\times\bar{\phi}^*) = -\frac{\partial\bar{\phi}\cdot\bar{\phi}^*}{\partial t} \qquad (48.1)$$

(48)

$$\begin{pmatrix} x_3 \\ x_2 \\ x_1 \end{pmatrix} \quad -\frac{1}{c^2}\frac{\partial(\bar{E}\times\bar{H})}{\partial t} + \varepsilon_0\,\bar{E}\,(\nabla\cdot\bar{E}) - \varepsilon_0\,\bar{E}\times(\nabla\times\bar{E}) + \mu_0\,\bar{H}\,(\nabla\cdot\bar{H}) - \mu_0\,\bar{H}\times(\nabla\times\bar{H}) = \bar{0} \qquad (48.2)$$

The fourth term (x_4) equals the relativistic Dirac equation (49.2) which equals equation (102) [3].

Equation (45.2) represents the relativistic quantum mechanical Dirac equation where ψ represents the quantum mechanical probability wave function. The mathematical evidence for the equivalent for (45.1) has been published in 1995 in the article: "A continuous model of matter based on AEONs". Equation (1) to equation (102) [3].

The electromagnetic law for the conservation of energy (47.1) and the relativistic Dirac equation (47.2) are **identical** but written in a different form.

The law of conservation of electromagnetic energy can be written in an electromagnetic form (49.1) or in an identical way in a quantum mechanical form (49.2):

Energy - Time Domain

Conservation of Energy

B-7

(49)

$$(f_4) \qquad \nabla\cdot(\bar{\phi}\times\bar{\phi}^*) = -\frac{i}{c}\frac{\partial\bar{\phi}\cdot\bar{\phi}^*}{\partial t} \qquad (49.1)$$

$$(x_4) \qquad \left(\frac{i\,m\,c}{h}\,\bar{\beta} + \bar{\alpha}\cdot\nabla\right)\psi = -\frac{1}{c}\frac{\partial\psi}{\partial t} \qquad (49.2)$$

The disadvantage in the quantum mechanical relativistic Dirac equation (49.2) is that the Dirac equation is a 1-dimensional equation which is not able to describe the 4-dimensional real physical world. While equation (46) represents a 4-dimensional electromagnetic vector equation.

With the equations (40) and (41) follows from (48) the 4-Dimensional vector-Dirac equation (50). This equation is a 4-dimensional vector equation and is coherent with the 4-dimensional physical reality.

$$\begin{aligned} &(x_4) \quad \nabla\cdot(\bar{\phi}\times\bar{\phi}^*) + \frac{i}{c}\frac{\partial\bar{\phi}\cdot\bar{\phi}^*}{\partial t} = 0 \\ &\begin{pmatrix} x_3 \\ x_2 \\ x_1 \end{pmatrix} \frac{i}{c}\frac{\partial(\bar{\phi}\times\bar{\phi}^*)}{\partial t} - \left(\bar{\phi}\times(\nabla\times\bar{\phi}^*) + \bar{\phi}^*\times(\nabla\times\bar{\phi})\right) + \left(\bar{\phi}\,(\nabla\cdot\bar{\phi}^*) + \bar{\phi}^*\,(\nabla\cdot\bar{\phi})\right) = 0 \end{aligned} \qquad (50)$$

In which the quantum mechanical complex probability vector function $\bar{\phi}$ and the complex conjugated vector function $\bar{\phi}^*$ equals:

$$\begin{aligned} \bar{\phi} &= \bar{B} + \frac{i}{c}\,\bar{E} = \mu\,\bar{H} + \frac{i}{c}\,\bar{E} \\ \bar{\phi}^* &= \bar{B} - \frac{i}{c}\,\bar{E} = \mu\,\bar{H} - \frac{i}{c}\,\bar{E} \end{aligned} \qquad (51)$$

The 4-dimensional Dirac equation (46) and (48) represents the "4-dimensional equilibrium" in the 4-Dimensional Minkowski space en has been represented by 4 separate equations. The first one represents the well-known relativistic quantum mechanical Dirac equation in the time-energy domain x_4. This represents the energy equilibrium in the time-domain (Conservation of energy). The 3 quantum mechanical equations in the space-momentum domain represents the "Electromagnetic equilibrium" for the force densities in the space domains (x_1, x_2, x_3)

$$\begin{aligned} &(x_4) \quad \nabla\cdot(\bar{\phi}\times\bar{\phi}^*) + \frac{i}{c}\frac{\partial\bar{\phi}\cdot\bar{\phi}^*}{\partial t} = 0 \\ &\begin{pmatrix} x_3 \\ x_2 \\ x_1 \end{pmatrix} \frac{i}{c}\frac{\partial(\bar{\phi}\times\bar{\phi}^*)}{\partial t} - \left(\bar{\phi}\times(\nabla\times\bar{\phi}^*) + \bar{\phi}^*\times(\nabla\times\bar{\phi})\right) + \left(\bar{\phi}\,(\nabla\cdot\bar{\phi}^*) + \bar{\phi}^*\,(\nabla\cdot\bar{\phi})\right) = 0 \end{aligned}$$

Newton's second law (Inertia of Light) — Lorentz — Coulomb (52)

$$\frac{1}{c^2}\,\bar{\phi}\cdot\bar{\phi}^* = \rho \ [\mathrm{kg/m^3}]$$

(Specific mass of Light)

4-dimensional Equilibrium in Space and Time

Equation (50) represents the Newtonian equilibrium in equation (1) in a 4-dimensional space-time continuum.

To transform the electromagnetic vector wave function $\bar{\phi}$ into a scalar (spinor or one-dimensional matrix representation), the pauli spin matrices σ and the following matrices (Equation 99 [3]) are introduced:

$$\bar{\alpha} = \begin{bmatrix} 0 & \sigma \\ \sigma & 0 \end{bmatrix} \quad \text{and} \quad \bar{\beta} = \begin{bmatrix} \delta_{ab} & 0 \\ 0 & -\delta_{ab} \end{bmatrix} \qquad (53)$$

The equations (52) and (53) can be written as the 4-Dimensional relativistic quantum mechanical Dirac equation:

$$(x_4) \quad \left(\frac{i\,m\,c}{h}\,\bar{\beta} + \bar{\alpha}\cdot\nabla\right)\psi = -\frac{1}{c}\frac{\partial\psi}{\partial t} \qquad (54.1)$$

(54)

$$\begin{pmatrix} x_3 \\ x_2 \\ x_1 \end{pmatrix} \quad -\frac{1}{c^2}\frac{\partial(\bar{E}\times\bar{H})}{\partial t} + \varepsilon_0\,\bar{E}\,(\nabla\cdot\bar{E}) - \varepsilon_0\,\bar{E}\times(\nabla\times\bar{E}) + \mu_0\,\bar{H}\,(\nabla\cdot\bar{H}) - \mu_0\,\bar{H}\times(\nabla\times\bar{H}) = \bar{0} \qquad (54.2)$$

THE LINEAR DIVERGENCE-FREE "STRESS-ENERGY TENSOR IN "GENERAL RELATIVITY"

To define the "Fundamental equation for electromagnetic gravitational interaction", an extra term (B-6) has been introduced in equation (58). The term B-6 represents the force density of the gravitational field acting on the electromagnetic mass density.

$$F_{GRAVITY} = m\,\bar{g} \ [N]$$

Dividing both terms by the Volume V:

$$\frac{F_{GRAVITY}}{V} = \frac{m}{V}\,\bar{g} \ [N/m^3] \qquad (55)$$

Results in the force density:

$$f_{GRAVITY} = \rho\,\bar{g} \ [N/m^3]$$

The specific mass "ρ" of a beam of light follows from Einstein's equation:

$$W = m\,c^2$$

Divinding both terms by the Volume V results in:

$$\frac{W}{V} = \frac{m}{V}\,c^2$$

which represents the energy density "w" and the specific mass "ρ" of the electromagnetic radiation: (56)

$$w = \rho\,c^2$$

which results for an expression of the specific mass ρ:

$$\rho = \frac{1}{c^2}\,w = \varepsilon\,\mu\,w$$

The energy density "w" follows from the electric and the magnetic field intensities:

$$w = \frac{1}{2}\,\varepsilon\,E^2 + \frac{1}{2}\,\mu\,H^2$$

$$w = \frac{1}{2}\left(\varepsilon\,E^2 + \mu\,H^2\right) = \frac{1}{2}\left(\varepsilon\left(\bar{E}\,.\,\bar{E}\right) + \mu\left(\bar{H}\,.\,\bar{H}\right)\right) \qquad (57)$$

Substituting equation (57) in equation (56) results in the gravitational force density $f_{GRAVITY}$ acting on an arbitrary electromagnetic field configuration (a beam of light) with mass density ρ.

$${}_{GRAVITY} = \rho\,\bar{g}$$

$$f_{GRAVITY} = \rho\,\bar{g} = \varepsilon\,\mu\,w\,\bar{g} = \frac{1}{2}\left(\varepsilon^2\mu\left(\bar{E}\,.\,\bar{E}\right) + \varepsilon\,\mu^2\left(\bar{H}\,.\,\bar{H}\right)\right)\bar{g} \qquad (58)$$

Substituting equation (56) in equation (19) results in the fundamental equation describing the electromagnetic-gravitational interaction for any arbitrary electromagnetic field configuration (a beam of light):

$$\text{NEWTON: } \bar{F}_{TOTAAL} = m\,\bar{a} \ [N]$$

$$\text{NEWTON: Expressed in force densities: } \bar{f}_{TOTAAL} = \rho\,\bar{a} \ [N/m^3]$$

$$-\rho\,\bar{a} + \bar{f}_{TOTAAL} = \bar{0}$$

$$-\rho\,\bar{a} + \bar{f}_{ELEKTRISCH} + \bar{f}_{MAGNETISCH} + \bar{f}_{GRAVITY} = \bar{0} \qquad (59)$$

$$\bar{f}_{INERTIA} + \bar{f}_{COULOMB} + \bar{f}_{LORENTZ} + \bar{f}_{COULOMB} + \bar{f}_{LORENTZ} + \bar{f}_{GRAVITY} = \bar{0}$$

$$\underbrace{-\frac{1}{c^2}\frac{\partial(\bar{E}\times\bar{H})}{\partial t}}_{B\text{-}1} \underbrace{+\varepsilon_0\,\bar{E}\,(\nabla.\bar{E})}_{B\text{-}2} \underbrace{-\varepsilon_0\,\bar{E}\times(\nabla\times\bar{E})}_{B\text{-}3} \underbrace{+\mu_0\,\bar{H}\,(\nabla.\bar{H})}_{B\text{-}4} \underbrace{-\mu_0\,\bar{H}\times(\nabla\times\bar{H})}_{B\text{-}5} \underbrace{+\frac{1}{2}\left(\varepsilon^2\mu\left(\bar{E}\,.\,\bar{E}\right)+\varepsilon\,\mu^2\left(\bar{H}\,.\,\bar{H}\right)\right)\bar{g}}_{B\text{-}6} = \bar{0}$$

Term B-1 represents the inertia term of the electromagnetic radiation. Term B-4 is the magnetic representation of the (electric) coulomb's force B-2 and Term B-3 is the electric representation of the (magnetic) Lorentz Force B-5. Term B-6 represents the electromagnetic-gravitational interaction of a gravitational field with field acceleration $\bar{g}$ acting on an arbitrary electromagnetic field configuration (a beam of light) with specific mass ρ.

The universal equation for the electromagnetic field (free electromagnetic waves and confined electromagnetic fields) within a gravitational field with gravity field intensity $\bar{g}$ has been presented in (60) and expresses the perfect equilibrium between the inertia forces (B-1), the electric forces (B-2 and B-3), the magnetic forces (B-4 and B-5) and the gravitational force (B-6) in any arbitrary electromagnetic field configuration.

$$\underbrace{-\frac{1}{c^2}\frac{\partial(\bar{E}\times\bar{H})}{\partial t}}_{B\text{-}1} \underbrace{+\varepsilon_0\,\bar{E}\,(\nabla.\bar{E})}_{B\text{-}2} \underbrace{-\varepsilon_0\,\bar{E}\times(\nabla\times\bar{E})}_{B\text{-}3} \underbrace{+\mu_0\,\bar{H}\,(\nabla.\bar{H})}_{B\text{-}4} -$$

$$\underbrace{-\mu_0\,\bar{H}\times(\nabla\times\bar{H})}_{B\text{-}5} \underbrace{+\frac{1}{2}\left(\varepsilon^2\mu\left(\bar{E}\,.\,\bar{E}\right)+\varepsilon\,\mu^2\left(\bar{H}\,.\,\bar{H}\right)\right)\bar{g}}_{B\text{-}6} = \bar{0} \qquad (60)$$

Planck's constant in "Confined electromagnetic radiation"

The fundamental relationship in the interaction between gravity and light is the proportionality between energy and frequency. This effect becomes measurable in "Gravitational red/blue-shift.

To describe the "proportionality between energy and frequency (Planck's constant) for confined electromagnetic waves, an example has been chosen of an electromagnetic wave (light) confined between two 100 % reflecting mirrors (Figure 11).

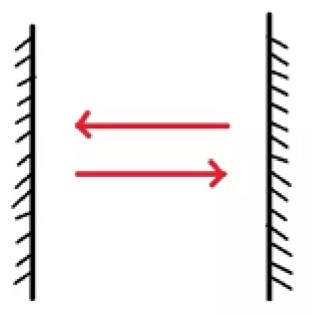

Figure 11) *Confined electromagnetic radiation between two 100 % reflecting mirrors*

Figure 8 represents confined electromagnetic radiation with amplitude E_0 and frequency ω_0. A general property of confined electromagnetic waves is the proportionality between energy and frequency. As an example, the confinement of light between two perfect reflecting mirrors with surface A has been chosen. When both mirrors are being moved towards each other over a distance $\Delta\,x$, the work $\Delta\,W$ has been delivered:

$$\Delta\,W = p\,\left(A\,\Delta\,x\right) \qquad (61)$$

In which "A" equals the surface of the mirrors and "p" equals the radiation pressure:

$$p = w = \frac{1}{2}\,\varepsilon\,E^2 + \frac{1}{2}\,\mu\,H^2 \ [N/m^2] \qquad (62)$$

The electromagnetic "Work $\Delta\,W$" which has been delivered equals:

$$\Delta\,W = w\,A\,\Delta\,x \qquad (63)$$

When over a time "Δt "one mirror move towards the other with a velocity "v", then the distance " Δx " passed over a time interval Δt equals:

$$\Delta x = v \Delta t \quad [m] \tag{64}$$

Substituting (62) in (61) results in:

$$\Delta W = w A \Delta x$$

$$\Delta W = w A v \Delta t = \frac{W}{V_{Volume}} A v \Delta t \tag{65}$$

In which "W" equals the total energy involved in the transformation of mechanical energy into the electromagnetic energy.

When an observer moves slowly (not at a relativistic speed) towards a beam of light, a doppler frequency shift appears:

$$\Delta f = f_0 \left(\sqrt{\frac{1+\frac{v}{c}}{1-\frac{v}{c}}} - 1 \right) = f_0 \left(-1 + 1 + \frac{v}{c} + \frac{1}{2}\left(\frac{v}{c}\right)^2 + \frac{1}{2}\left(\frac{v}{c}\right)^3 + \frac{3}{8}\left(\frac{v}{c}\right)^4 + \right) \approx \frac{v}{c} f_0 \tag{66}$$

The same happens for the moving mirror. A shifted frequency will be reflected. The total effect of the displacement of the distance Δx will be a frequency shift in the confined electromagnetic radiation which equals:

$$\begin{aligned} &\Delta f = \frac{v}{c} f_0 \\ &v = \frac{\Delta f}{f_0} c \\ &\Delta W = \frac{W}{V_{Volume}} A v \Delta t = \frac{W}{V_{Volume}} A \frac{\Delta f}{f_0} c \Delta t \\ &\left(\frac{\Delta W}{\Delta f}\right) = \left(\frac{W}{f_0}\right) \frac{(c \Delta t) A}{V_{Volume}} = \left(\frac{W}{f_0}\right) \frac{n \lambda A}{V_{Volume}} = \hbar_{EM} \end{aligned} \tag{67}$$

In which λ represents the wavelength of the confined radiation and "n" the number of wavelengths of compressions. The term $\hbar_{EM}$ represents an electromagnetic equivalent for Planck's constant.

"Gravitational redshift/ blueshift in "Light (EMR)" due to "Electromagnetic gravitational interaction"

The "Stress-energy tensor (44) equation" for electromagnetic waves interacting with a gravitational field with acceleration $\overline{g}$ has been presented in equation (64)

$$\begin{aligned} &-\frac{1}{c^2}\frac{\partial(\overline{E}\times\overline{H})}{\partial t} + \varepsilon_0 \overline{E}(\nabla \cdot \overline{E}) - \varepsilon_0 \overline{E}\times(\nabla\times\overline{E}) + \mu_0 \overline{H}(\nabla\cdot\overline{H}) \\ &-\mu_0 \overline{H}\times(\nabla\times\overline{H}) + \frac{1}{2}\left(\varepsilon^2\mu\left(\overline{E}\bullet\overline{E}\right) + \varepsilon\,\mu^2\left(\overline{H}\bullet\overline{H}\right)\right)\overline{g} = \overline{0} \end{aligned} \tag{68}$$

A fundamental solution for equation (64) within a gravitational constant gravitational field $\overline{g}$ in the z-direction, equals for the electric field [6]:

$$\overline{E} = \begin{pmatrix} e_x \\ e_y \\ e_z \end{pmatrix} = \begin{pmatrix} e^{-\frac{1}{2} g z \mu_0 \varepsilon_0}\, h\left[\omega\, e^{-\frac{1}{2} g z \mu_0 \varepsilon_0}\left(t - \sqrt{\varepsilon\,\mu}\, z\right)\right] \\ 0 \\ 0 \end{pmatrix} \tag{69}$$

And for the magnetic field:

$$\overline{H} = \begin{pmatrix} H_x \\ H_y \\ H_z \end{pmatrix} = \begin{pmatrix} 0 \\ \frac{1}{\sqrt{\varepsilon_0\,\mu_0}} e^{-\frac{1}{2} g z \mu_0 \varepsilon_0}\, h\left[\omega\, e^{-\frac{1}{2} g z \mu_0 \varepsilon_0}\left(t - \sqrt{\varepsilon\,\mu}\, z\right)\right] \\ 0 \end{pmatrix} \tag{70}$$

The term $\hbar_{EM}$ (Electromagnetic equivalent for Planck's constant) defines a proportionality between the energy density and the frequency ω. The solutions (65) and (66) represent a "Constant speed of Light" "c". The "Gravitational red-shift" equals:

$$\omega_{\text{Gravitational Redshift}} = \omega_0\, e^{-g z \mu_0 \varepsilon_0} \tag{71}$$

In which ω_0 equals the original frequency of the beam of light propagating in the direction of the constant gravitational field in the z-direction and the exponential term demonstrates the gravitational redshift when the beam of light moves away from the gravity source (Solar system or black hole). Including the "Doppler redshift the total frequency shift equals:

$$\omega_{\text{Gravitational Redshift}} = \omega_0\, e^{-g z \mu_0 \varepsilon_0} \sqrt{\frac{1+\frac{v}{c}}{1-\frac{v}{c}}}$$

Gravitational Redshift Doppler Redshift (72)

Equation (72) represents the "Gravitational redshift" for a constant gravitational field (with a constant gravitational acceleration "g"). The "Electromagnetic equilibrium equation" (60) in "The proposed theory" represents possible solutions for all "Time and space depending gravitational fields" and equation (60) is the fundamental equation to be "tested" relative to Einstein's theory of general relativity. measurements of "Gravitational red-shift/ blue-shift from world-wide observatories could falsify or confirm "The proposed theory".

For simplicity 3 distinguishments have been made for the different kinds of gravitational fields. The first one is a function with a linear increment to the source of the gravitational field (The center of the of the milky way galaxy to the edge of the milky way galaxy) in which the gravitational acceleration "g". and the corresponding solution for equation (60) have been presents in equation (73.1). The second gravitational field is proportional to $1/r^2$ (The gravitational field around the edge of the milky way galaxy) in which "r" equals the distance (Equation 73.2). The third type of gravitational field is a constant gravitational field over long distances far away from sources of gravity like black holes (73.3).

Mathematical calculations for gravitational redshift/ blueshift

When a ball is thrown upwards from earth, its kinetic energy is converted into a potential energy, the higher it goes the kinetic energy reduces according to the ball's inertia and the planet's gravitation. Accounting for EMR inertia if a beam of light (e.g., a laser beam) is directed radially away from the earth's surface, something comparable happens. The EM field intensity becomes exponentially lower (the higher the beam shines upwards) but the speed of light does not change. The speed of light remains constant. For a laser beam shining downwards on earth, the opposite happens. The intensity becomes (exponentially) higher and the observed frequency higher (Blue shift).

Equation (71) represents 3 solutions for 3 different kinds of gravitational fields. The Gravitational Redshift (GRS) term in QLT depends on the type of gravitational field:

$(\omega_{RS} = \omega_{GRS}\ \omega_{Doppler})$

Gravitational Field Type 1

$$g = G_1\ z$$

$$\omega_{RS} = \omega_0\ e^{-\frac{1}{2} G_1 z^2 \varepsilon_0 \mu_0} \sqrt{\frac{1+\frac{v}{c}}{1-\frac{v}{c}}} \qquad (73.1)$$

Gravitational Field Type 2

$$g = \frac{G_1}{z^2} \qquad (73)$$

$$\omega_{NLGR} = \omega_0\ e^{-\frac{G_1 \varepsilon_0 \mu_0}{z}} \sqrt{\frac{1+\frac{v}{c}}{1-\frac{v}{c}}} \qquad (73.2)$$

Gravitational Field Type 3

$$g = G_1$$

$$\omega_{NLGR} = \omega_0\ e^{-g z \mu_0 \varepsilon_0} \sqrt{\frac{1+\frac{v}{c}}{1-\frac{v}{c}}} \qquad (73.3)$$

The mathematical solutions for the gravitational redshift term in the proposed theory (GR_{QLT}) differ from the Gravitational Redshift in General Relativity (GRGR) with a factor α . Within a constant gravitational field over a distance of 36000 (km) (average satellite height) and an estimated gravitational acceleration of ((g = 9.8)m s^{-2}) [2].

$$\alpha = \left(GR_{QLT}\right) - \left(GR_{GR}\right) = -\frac{1}{2}\ g\, \varepsilon\, \mu \approx -2\ 10^{-9} \qquad (74)$$

The mathematical solutions (73) for equation (60) have been calculated [5]. The mathematical solutions in equation (60) for a gravitational field proportional to z^n, equals:

Gravitational Field Type z^n

$$g = G_1\ z^n$$

$$(75)$$

$$\omega_{NLGR} = \omega_0\ e^{\frac{-G_1 z^{1+n} \varepsilon_0 \mu_0}{2(1+n)}} \sqrt{\frac{1+\frac{v}{c}}{1-\frac{v}{c}}}$$

In general the mathematical solutions for equation (60) can be represented as:

Gravitational Field as a function "h(z)" along the z-axis between "object" and observer

$$g = G_1\ g[z]$$

$$\omega_{NLGR} = \omega_0\ e^{-\frac{1}{2}\varepsilon_0 \mu_0 G_1 \int_0^z g(h)\, dh} \sqrt{\frac{1+\frac{v}{c}}{1-\frac{v}{c}}} \qquad (76)$$

frequency being observed	original frequency	Gravitational Redshift	Doppler Redshift

Deviations in gravitational redshift calculated in general relativity and the proposed theory

The mathematical solutions for the gravitational redshift term in the proposed theory (GR_{QLT}) differ from the Gravitational Redshift in General Relativity (GR_{GR}) with a factor α .

In general relativity the frequency change in gravitational redshift is proportional to the change of the electromagnetic (Potential energy) U of the radiation

$$\Delta f \sim \frac{\Delta U}{c^2} \qquad (77)$$

An accurate way to test "General relativity" and "The proposed theory" theory is the "Gravitational redshift" within a well-known gravitational field like the gravitational field of the earth. Both theories give different outcomes in the values for the "Gravitational redshift" within the gravitational field of the earth between an observatory on earth (R_{adius} = 6 10^6 (m)) and a Satellite in a Galileo Orbit (R_{adius} = 23 222 10^6 (m)). The galileo space segment comprises a constellation of a total of 30 Medium Earth Orbit (MEO) satellites, of which 3 are spares, in a so-called Walker 27/3/1 constellation.

"Gravitational redshift" between an observatory on earth (R_{adius} = 6 10^6 (m)) and a satellite in a galileo orbit (R_{adius} = 23222 10^3 (m)) according "General relativity":

$$\Delta\, \omega_{GR} = \frac{\Delta U}{c^2} = 0.000000000004360137706159641 \qquad (78)$$

"Gravitational redshift" between an observatory on earth (R_{adius} = 6 10^6(m)) and a satellite in a galileo orbit (R_{adius} = 23222 10^3(m)) according "The proposed theory":

$$\Delta\, \omega_{QLT} = \frac{\Delta U_{Rel}}{c^2} = 0.000000000004360134475689392 \qquad (79)$$

In "The proposed theory" the result of the calculations has been based on a "Perfect equilibrium in space and time, taking into account the effect of the change in electromagnetic mass due to the potential energy level.

In a factor α has been defined which presents the measured deviation α between the predicted gravitational redshift by general relativity and the measured gravitational redshift [2].

$$\alpha = \Delta\, \omega_{MEASURED} - \Delta\, \omega_{GR} = (2.2 \pm 1.6) \times 10^{-5} \qquad (80)$$

A comparable factor α can be used to determine which theory (GR or QLT) has the closest approach to the experimental data. Highly accurate measuring experiments are required with an accuracy higher than 16 digits beyond the decimal point (78 and 79).

Experiments to test "The linear divergence-free "Stress-energy tensor

Experiments are required to validate "The proposed theory" in relation to the fundamental theories: Electrodynamics, quantum physics and general relativity.

Experiments to test the mew theory:

A fundamental experiment to test any arbitrary theory related to electrodynamics is the projection of a slide on a screen. The projection of a slide (or a film) in the z-direction, represents an arbitrary intensity division f(x,y) in the (x,y) plane perpendicular to the z-axis (axis of propagation):

$$\overline{E} = \begin{pmatrix} f[x,y]\ g[z - c\ t] \\ 0 \\ 0 \end{pmatrix}$$

$$\overline{H} = \sqrt{\frac{\mu}{\varepsilon}} \begin{pmatrix} 0 \\ f[x,y]\ g[z - c\ t] \\ 0 \end{pmatrix} \tag{81}$$

The force density in the 3 spatial directions for this electromagnetic field configuration equals:

$$\overline{f} = \begin{pmatrix} f_x \\ f_y \\ f_z \end{pmatrix} = -\frac{1}{c^2}\frac{\partial(\overline{E}\times\overline{H})}{\partial t} + \varepsilon_0\ \overline{E}(\nabla.\ \overline{E}) - \varepsilon_0\ \overline{E}\times(\nabla\times\overline{E}) + \mu_0\ \overline{H}\ (\nabla.\ \overline{H}) - \mu_0\ \overline{H}\times(\nabla\times\overline{H}) \tag{82}$$

Substituting (79) in (80) and when the propagation speed c equals:

$$c = \sqrt{\frac{1}{\varepsilon\ \mu}} \tag{83}$$

The resulting force density equation (82) equals:

$$\overline{f} = \begin{pmatrix} f_x \\ f_y \\ f_z \end{pmatrix} = -\frac{1}{c^2}\frac{\partial(\overline{E}\times\overline{H})}{\partial t} + \varepsilon_0\ \overline{E}(\nabla.\ \overline{E}) - \varepsilon_0\ \overline{E}\times(\nabla\times\overline{E}) + \mu_0\ \overline{H}\ (\nabla.\ \overline{H}) - \mu_0\ \overline{H}\times(\nabla\times\overline{H}) = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix} \tag{84}$$

Exactly at the speed of light a perfect equilibrium exists in the x-, y, and z-direction. This represents the required evidence that any arbitrary slide can be projected on a screen because the electromagnetic field configuration is always a solution of the electromagnetic field equation in "The proposed theory" for any arbitrary function f(x,y). The only requirement in (82) is that the light propagates exactly with the speed of light $C = \sqrt{\frac{1}{\varepsilon\ \mu}}$.

The projection of a slide (or a film) in the z-direction on a screen, represents an arbitrary intensity division f(x,y) in the (x,y) plane perpendicular to the z-axis. An infinite amount of functions f(x,y) is not divergence free. And for that reason not a solution of the Maxwell equations (83-a) and (83-b).

$$\nabla.\ \overline{D} = \rho \quad \text{(a)} \qquad \nabla\times\overline{E} = -\frac{\partial B}{\partial t} \quad \text{(c)}$$

$$\nabla.\ \overline{B} = 0 \quad \text{(b)} \qquad \nabla\times\overline{H} = \frac{\partial D}{\partial t} \quad \text{(d)} \tag{85}$$

There is no slide (intensity division proportional to the arbitrary function $f(x,y)^2$) which cannot be projected. It is a fundamental requirement for any electromagnetic field equation that the arbitrary function f(x,y) is part of the solution set for this electromagnetic field equation.

The electromagnetic field equation (82) fulfils this essential requirement. The Maxwell equations (83-a) and (83-b) do not fulfil that essential requirement and for that reason cannot be used to describe an electromagnetic field configuration QED.

Experiments to test the proposed theory

The 4-dimensional equilibrium equation represents the relativistic quantum mechanical Dirac equation in the 4th dimension (Energy time domain):

$$\left(x_4\right) \quad \left(\frac{i\,m\,c}{h}\ \overline{\beta} + \overline{\alpha}\ .\ \nabla\right)\psi = -\frac{1}{c}\ \frac{\partial\psi}{\partial t} \qquad (86.1)$$

$$\begin{pmatrix} x_3 \\ x_2 \\ x_1 \end{pmatrix} \quad -\frac{1}{c^2}\frac{\partial(\overline{E}\times\overline{H})}{\partial t} + \varepsilon_0\ \overline{E}\ (\nabla\ .\ \overline{E}) - \varepsilon_0\ \overline{E}\times(\nabla\times\overline{E}) + \mu_0\ \overline{H}\ (\nabla\ .\ \overline{H}) - \mu_0\ \overline{H}\times(\nabla\times\overline{H}) = \overline{0} \qquad (86.2)$$

(86)

Every electromagnetic confinement has to be part of the solution set of equation (86). GEONs (Electromagnetic confinements by gravitational electromagnetic interaction) are part of the solution set and are for that reason part of the solution set for the Dirac equation. Like elementary particles, GEONs carry mass, charge and spin in discrete values (the wavelength of the confinement has to match the geometry of the confinement in discrete values) and have common properties with elementary particles. Further research is required to investigate the relationship between elementary particles and GEONs.

Experiments to test the proposed theory with general relativity

An accurate way to test "General relativity" with the proposed theory is the "Gravitational redshift" within a well-known gravitational field like the gravitational field of the earth. Both theories give different outcomes in the values for the "Gravitational redshift" within the gravitational field of the earth between an observatory on earth (R_{adius} = 6 10^6 (m)) and a satellite in a galileo orbit (R_{adius} = 23 222 10^6 (m)). The galileo space segment comprises a constellation of a total of 30 Medium Earth Orbit (MEO) satellites, of which 3 are spares, in a so-called Walker 27/3/1 constellation.

The "Gravitational redshift" between an observatory on Earth (R_{adius} = 6 10^6 (m)) and a satellite in a galileo orbit (R_{adius} = 23222 10^3(m)) according "General relativity":

$$\Delta\ \omega_{GR} = \frac{\Delta\ U}{c^2} = 0.000000000004360137706159641 \tag{87}$$

The "Gravitational redshift" between an observatory on earth (R_{adius} = 6 10^6 (m)) and a satellite in a galileo orbit (R_{adius} = 23222 10^3 (m)) according "The proposed theory":

$$\Delta\ \omega_{QLT} = \frac{\Delta\ U_{Rel}}{c^2} = 0.000000000004360134475689392 \tag{88}$$

In "The proposed theory" the result of the calculations has been based on a "Perfect equilibrium in space and time, taking into account the effect of the change in electromagnetic mass due to the potential energy level $\Delta\ U_{Rel}$.

In (Gravitational redshift test using eccentric galileo satellites, Sven Herrmann, Felix Finke, Martin Lülf, Olga (et. al.), 2018) a factor α has been defined which presents the measured deviation between the predicted gravitational redshift by general relativity and the measured gravitational redshift [2].

$$\alpha = \Delta\ \omega_{MEASURED} - \Delta\ \omega_{GR} = \left(2.2 \pm 1.6\right) \times 10^{-5} \tag{89}$$

A comparable factor α can be used to determine which theory (GR or QLT) has the closest approach to the experimental data. Highly accurate measuring experiments are required with an accuracy higher than 17 digits beyond the decimal point (80 and 81).

The weight of light (Photons) calculated with gravitational redshift

In this thought experiment two identical boxes, with at the inside 100 % reflecting mirrors, have been placed on a balance scale. One box has been filled with light (Electromagnetic radiation) with energy density "w" and the other box is empty and has not been filled with light. With gravitational redshift the weight of the Light will be calculated (Figure 12).

Figure 12) *In a "Thought expiriment": Measuring the weight of confined light (Electromagnetic radiation) in one of both boxes with 100 % reflecting mirrors at the inside*

The radiation pressure of the confined light (Electromagnetic radiation) equals:

$$p = w \ [N/m^2] \tag{90}$$

Inside the box with 100 % reflecting mirrors (with dimensions: Width x Length x Height) the upwards oriented force F_U equals:

$$F_U(z+H) = p(z+H) \times A = w(z+H) \times W \times L \ [N] \tag{91}$$

The downwards oriented force F_D equals:

$$F_D(z) = p(z) \times A = w(z) \times W \times L \ [N] \tag{92}$$

The energy density of the confined electromagnetic radiation is proportional to the frequency (Equation 67)

$$\omega_{GR} = \omega_0 \ e^{-g L \mu_0 \varepsilon_0}$$
$$w_{GR} = w_0 \ e^{-g L \mu_0 \varepsilon_0} \tag{93}$$

According equation 71.3 the weight (Gravitational force: F_{GRAV}) of the confined light (Electromagnetic radiation) with energy density w[z] in the box within a constant gravitational field equals:

$$\begin{aligned} F_{GRAV} &= F_D - F_U = \left(w(z) - w(z+H)\right) W L \\ F_{GRAV} &= \left(w[z] - w[z] e^{-g H \mu_0 \varepsilon_0} \right) W L \\ F_{GRAV} &= w[z]\left(1 - e^{-g H \mu_0 \varepsilon_0} \right) W L \end{aligned} \tag{94}$$

Applying series development on the exponentional function results in:

$$\begin{aligned} F_{GRAV} &= w[z]\left(1 - e^{-g H \mu_0 \varepsilon_0} \right) W L \\ F_{GRAV} &= w[z]\left(1 - \left(1 - g H \mu_0 \varepsilon_0 + \frac{1}{2}(g H \mu_0 \varepsilon_0)^2 - \frac{1}{6}(g H \mu_0 \varepsilon_0)^3 + \dots\dots\dots \right) \right) W L \end{aligned} \tag{95}$$

Which results in a first order approach into Einstein's well-known equation W=mc^2: [21-22]

$$\begin{aligned} F_{GRAV} &= w[z]\left(g H \mu_0 \varepsilon_0 - \frac{1}{2}(g H \mu_0 \varepsilon_0)^2 + \frac{1}{6}(g H \mu_0 \varepsilon_0)^3 + \dots\dots\dots \right) W L \\ F_{GRAV} &\approx w[z]\, g \mu_0 \varepsilon_0 H W L = \frac{1}{c^2} W g = m g \end{aligned} \tag{96}$$

Quantum transitions in GEONs

GEONs can drop back in a lower energy state under the emission of light of a specific frequency or jump to a higher energy level under the absorption of light of a specific frequency.

According equation (67) the energy level of GEONs has been related to the fundamental frequency of the GEON:

$$\begin{aligned} \Delta f &= \frac{v}{c} f_0 \\ v &= \frac{\Delta f}{f_0} c \\ \Delta W &= \frac{W}{V_{Volume}} A v \Delta t = \frac{W}{V_{Volume}} A \frac{\Delta f}{f_0} c \Delta t \\ \left(\frac{\Delta W}{\Delta f}\right) &= \left(\frac{W}{f_0}\right) \frac{(c \Delta t) A}{V_{Volume}} = \left(\frac{W}{f_0}\right) \frac{n \lambda A}{V_{Volume}} = \hbar_{EM} \end{aligned} \tag{97}$$

According equation (35) for GEONs:

$$\begin{aligned} \overline{E} &= K e^{-\frac{G 1 \varepsilon 0 \mu 0}{8 \pi r}} \begin{pmatrix} 0 \\ \mathrm{Sin}[k r] \mathrm{Sin}[\omega t] \\ -\mathrm{Cos}[k r] \mathrm{Cos}[\omega t] \end{pmatrix} \\ \overline{H} &= K e^{-\frac{G 1 \epsilon 0 \mu 0}{8 \pi r}} \sqrt{\frac{\varepsilon_0}{\mu_0}} \begin{pmatrix} 0 \\ -\mathrm{Sin}[k r] \mathrm{Cos}[\omega t] \\ -\mathrm{Cos}[k r] \mathrm{Sin}[\omega t] \end{pmatrix} \end{aligned} \tag{98}$$

When an GEON drops back to a lower energy level, the radius of the sphere will become smaller with a lower frequency (Figure 13-15).

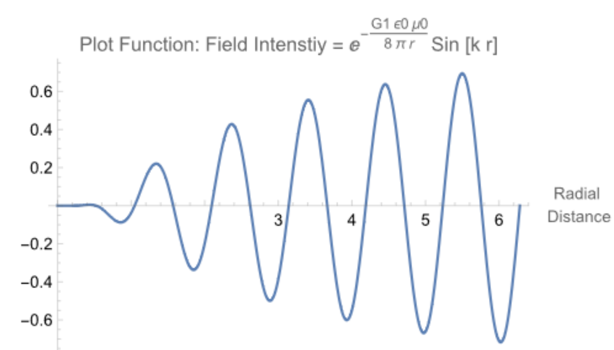

Figure 13) *Plot of the function:* $\overline{H} = e^{-\frac{G 1 \epsilon 0 \mu 0}{8 \pi r}} \mathrm{Sin}[k r]$ at $t = \pi / 2 \omega$

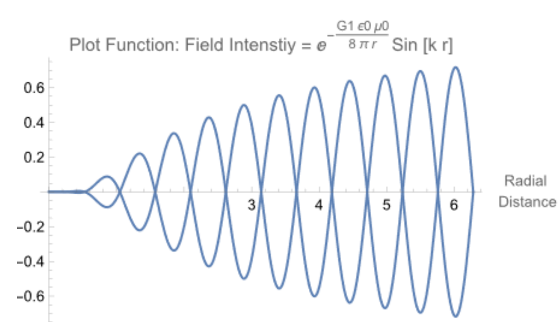

Figure 14) *Plot of the function:* $\overline{E} = e^{-\frac{G 1 \epsilon 0 \mu 0}{8 \pi r}} \mathrm{Sin}[k r]$ at $t = \pi / 2 \omega$ and at $t = 3 \pi / 2 \omega$

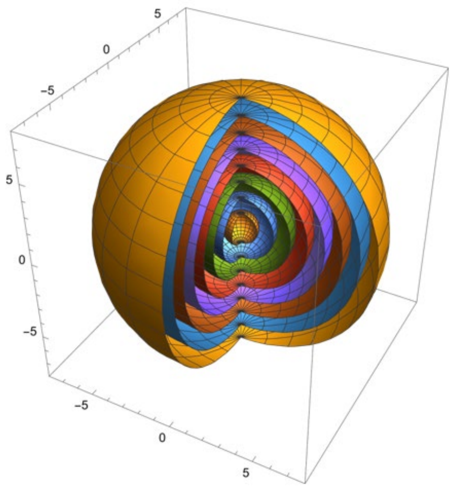

Figure 15) *Plot of the concentric spherical areas of anti-node of the gravitational-electromagnetic confinements (Standing spherical waves) of the electromagnetic energy.*

When a GEON drops back to a lower energy level, the discrete amount of energy, confined between 2 concentric spheres (orange area of confinement between two concentric spheres) will be emitted as a single electromagnetic wave package (photon) (Figure 16).

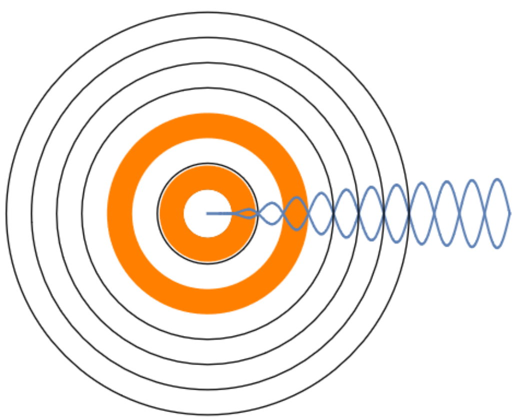

Figure 16) *2-dimensional plot of the concentric spherical areas of anti-node of the gravitational-electromagnetic confinements (Standing spherical waves) of the electromagnetic energy during an energy transition of a GEON.*

Gravitational lensing

Calculating the refraction index for a lens has been based on the different propagating speeds of light in the separate materials the lens has been built of. The lens equation expresses the quantitative relationship between the object distance (do), the image distance (di), and the focal length (f). The different speeds of light in the different materials has been caused by the separate electromagnetic interactions between the light and the separate materials. The electromagnetic fields close around the atoms interact with the passing beam of light and creates extra electromagnetic mass which slows down the speed of light. For this reason materials only slow down the speed of light. There are no materials with a refraction index smaller than 1.

To calculate "Gravitational lensing" it is important to calculate the speed of light depending on the local gravitational field [29]. The speed of light is a function of the total "Electromagnetic gravitational interaction" according equation (24) in which the properties of vacuum (electric permittivity, magnetic permeability and gravitational permeability) depend on the intensity and direction of the local gravitational field:

4-Dimensional Space Domain

$$\overline{f}^4 = \begin{pmatrix} f_4 \\ f_3 \\ f_2 \\ f_1 \end{pmatrix} = \square \bullet \overline{\overline{\mathrm{T}}} = \partial_b \, \mathrm{T}^{ab} = f^a = 0 \tag{99}$$

3-Dimensional Space Domain

$$\left|\partial_b \, \mathrm{T}^{ab}\right|_1^3 = -\varepsilon_0(x,y,z)\,\mu_0(x,y,z)\frac{\partial\,(\overline{\mathrm{E}}(x,y,z,t)\times\overline{\mathrm{H}}(x,y,z,t))}{\partial t} + \varepsilon_0(x,y,z)\,\overline{\mathrm{E}(x,y,z,t)}\,(\nabla\,.\,\overline{\mathrm{E}(x,y,z,t)}) - \varepsilon_0(x,y,z)\,\overline{\mathrm{E}(x,y,z,t)}\times(\nabla\times\overline{\mathrm{E}(x,y,z,t)}) +$$

$$+\mu_0(x,y,z)\,\overline{\mathrm{H}(x,y,z,t)}\,(\nabla\,.\,\overline{\mathrm{H}(x,y,z,t)}) - \mu_0(x,y,z)\,\overline{\mathrm{H}(x,y,z,t)}\times(\nabla\times\overline{\mathrm{H}(x,y,z,t)}) + \gamma_0\,\overline{\mathrm{g}(x,y,z)}\,(\nabla\,.\,\overline{\mathrm{g}(x,y,z)}) - \gamma_0\,\overline{\mathrm{g}(x,y,z)}\times(\nabla\times\overline{\mathrm{g}(x,y,z)}) = \overline{0}$$

in which:

$$\varepsilon_0\,(\nabla\,.\,\overline{\mathrm{E}}) = \rho_E \quad \text{Electric Charge Density } [\mathrm{C/\,m^3}]$$

$$\mu_0\,(\nabla\,.\,\overline{\mathrm{H}}) = \rho_M \quad \text{Magnetic Flux Density } [\mathrm{Vs/\,m^3}] \text{ or } [\mathrm{Wb/\,m^3}]$$

$$\gamma_0\,(\nabla\,.\,\overline{\mathrm{g}}) = \rho_M \quad \text{Mass Density (Electromagnetic) } [\mathrm{kg/\,m^3}]$$

CONCLUSIONS

Based on the assumption of the zero-rest mass of photons, general relativity describes the interaction between gravity and light within a 4-dimensional curvature in space and time due to a gravitational field. Light follows a path defined by this curved 4-dimensional space and time geometry.

The proposed theory presented here, describes a bi-directional separation between mass and inertia for light (photons). Inertia only in the direction of propagation of the beam of light (photons) which determines the speed of light. Mass of the beam of light (photons) only in the plane perpendicular to the direction of propagation, which determines the deflection of a beam of light (photons) by a gravitational field in the plane perpendicular to the direction of propagation.

GEONs (Gravitational-electromagnetic confinements) are fundamental solutions of the relativistic quantum mechanical Dirac equation. The inertia of light has been represented by term (1) and the non-zero rest-mass has been presented by term B-6 in equation (23).

Within a 4-Dimensional equilibrium and taking into account the inertia and the gravitational force densities within the electromagnetic field configurations, gravitational electromagnetic confinements (GEONs) are a physical reality and are solutions of the relativistic quantum mechanical Dirac equation and present spherical confinements with discrete separate energy levels.

To test the proposed theory with general relativity, an experiment has been required which measures the interaction between gravity and light within a well-defined gravitational field like the gravitational field of the earth. The difference between the calculation for gravitational redshift, within the gravitational field of the earth, in "General relativity" and "The proposed theory" is smaller than 10^{-16} and cannot be determined with present observation equipment (maximum accuracy of 10^{-10} for GRS). Validation of both theories requires a very sensitive and accurate observatory like the JWST or the SKA.

DATA AVAILABILITY

All the data and all the calculations to provide evidence to "The proposed theory" have been published at: https://quantumlight.science/

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