

Toward The Unification Of Gravity And Electromagnetism

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An attempt to unify gravity and electromagnetism in terms of the covariant density distribution of a real average covariant Dirac vacuum built with extended random elements filling flat space-time is presented.

1. Introduction

Although the Newton and Coulomb potentials have similar forms the two theories have developed separately leaving their unification an unsolved problem throughout the history of Modern Science. In the past most attempts at unification have been within a frame associating electromagnetism with new geometrical properties of spacetime [1,2,3]. The aim of this paper is different. Following Puthoff [4], and others, both fields are represented by four-vector field densities A_μ ; where one considers both types of phenomena as different types of motions within the same real physical zero-point field in a flat spacetime, i.e. as two different « vacuum » types of collective perturbations carried by a single « vacuum » field moving in such a space. Our hope is that since this approach suggests new types of experimentation and new interpretations of unexplained effects it could, if confirmed, help to disentangle the present theoretical discussion.

The basis of this model is as follows:

A) The first basis is observational. The universe apparently does not change with distance [15] (as it would for big-bang type theories). This leads to the possibility of a non-Doppler redshift [5] (which suggests a non-zero photon mass $m_\gamma \neq 0$) with the velocity of light isotropic in an absolute inertial frame I_0 , in time.

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B) The second basis is that our essential instrument for distance observation (i.e. electromagnetic waves) is more complex than initially thought. De Broglie and Einstein demonstrated that $E = h\nu = mc^2$ (with $m = m_0 \left(1 - v^2/c^2\right)^{-1/2}$) so that individual massive photon's could be considered as piloted by real non zero-mass Maxwellian waves allowing the electromagnetic field to be represented by a vector density A_μ . As shown by the Aharonov-Bohm effect, this implies that the electromagnetic field is not completely represented by the $\mu\nu$ fields [6,7].

Maxwell's equations [3] conventionally describe Transverse elements denoted as 'EM' waves; by utilizing the Einstein / de Broglie relation one may derive additional degrees of freedom such that Maxwell's equations are not 'cut off' at the vacuum, but lead to Longitudinal wave components and non-zero electric conductivity of the vacuum. Thus our distinct need for the utility of the $\mu\nu$ fields instead of just the standard 'EM'. This also suggests that the photon is 'piloted'. One must 'fix' the coordinates of either the EM field or the $\mu\nu$ field we have chosen the latter. It should be noted that while c is constant in the rest frame and the velocity of massive photons would be frequency dependent~; there is no contradiction because as Dirac himself stated according to coordinate law the pilot wave and the photon decouples [17]. The two sets of coordinates, EM or $\mu\nu$ are exclusive and would generally be independent. It is the aim of this paper to reveal a method for integrating them.

It is well known that the usual form of Maxwell's equations in vacuum (describing zero mass photons) possess infinite families of boundary free exact solutions with Longitudinal electric or magnetic fields; this is the usual $\mu\nu$ theory where $B^{(3)} = 0$ and photon mass = 0. This is also true for the vector potential in the Lorentz gauge according to the equation $A_\mu = 0$. But of interest to the task here, for massive photons there is only one family and one set of boundary conditions!

C) The third basis has its theoretical origin in the introduction by Dirac et al. of a real covariant chaotic physical « aether » which fills space-time, carries real physical observable wave-like and particle like (soliton-like) perturbations or local extended elements, whose four momenta and angular momenta are statistically and evenly distributed on specific hyperbolic surfaces, at each given point, in all given inertial frames. This « vacuum » distribution thus appears, as invariant isotropic chaotic and undetectable (except in specific physical cases) for all inertial observers. The form taken by an aether within Relativity Theory carrying both particles and waves is now discribed in terms of collective motions on the top of a real essentially stochastic covariant background. Such an « aether » theoretically justifies the statistical productions of Quantum Mechanics (in its causal stochastic interpretation) and SED theory, and has a direct experimental justification in the Casimir effect. This implies a background friction (associated with absolute local conservation of total momentum and angular momentum) and collective motions which provide a new interpretation of the observed cosmological red-shift [5, 22] and yields new possibilities to interpret (also in terms of local frictions) the anomalous red-shifts observed by Arp, Tifft and other astronomers [8].

From these bases, section 3, describes the gravitational results of General Relativity in Maxwellian terms. Section 4 develops a possible unification model of both theories. Section 5 ia a brief discusses possible consequences of the preceding attempt. This aether is locally defined by a particular real Poincaré frame I_0 , in which (measured with real physical

instruments) the velocity of light is identical in all directions at all observable frequencies. All observers tied to other frames passing through local inertial motions will see (measure) different space-time properties (associated with their velocity and orientations) defined by the corresponding Poincaré transformations.¹ Local variations of physical properties of the aether correspond to local transitions relating differential inertial frames at neighbouring points.

2. Flat Spacetime And A Real Physical Aether

This model depends on the existence of a real physical vacuum (or zero point field) built with extended wave-like individual elements [9, 10] centered on points in an external flat space-time, where such elements can overlap and interact (i.e. carry) collective motions corresponding to excess (electromagnetic ‘bumps’) or defects (gravitational ‘holes’) in the average density of the local aether elements. The model could be described as a gas of extended elements within flat space-time. These elements can interact locally (i.e. carry collective motions) and the gas’ local scalar density thus carries waves (and solitons) associated with excess (electromagnetic) or defects (gravitational) in density, with respect to the average local vacuum density. One thus defines field variables associated with these two possible (excess or defect) local density variations. The vector fields, for example, in this paper, represent localized excess or density defects w.r.t. the local vacuum density. This model thus implies:

- a) A description of real physical vacuum properties in terms of real extended vacuum elements average behaviour.
- b) A description of the behaviour of its collective excess (above average) associated with recently observed electromagnetic effects.
- c) A description of the behaviour of its collective defects (below average) associated with observed gravitational effects.

Introducing these new concepts into Maxwell’s equations and the description of gravitational fields along the same lines (in terms of vector fields A_μ) suggests a new type of unification of both theories. Instead of looking for a common geometrization of gravity and light (i.e. their unification within a unique form of extended space-time geometry) one could assume the following from Newton and Lorentz :

A) The evolution of extended (fields) and of localized (sources) in terms of 1) vacuum (aether) 2) gravitational fields, 3) the electromagnetic field, reflects the time evolution (motions) and interactions of perturbations of a real material substance moving in a 3-dimensional flat space. This means that all three field and particle sub-elements are localized at given points, at each instant, in this 3-space and move continuously (i.e. locally transform) according to causal laws²

This assumption (distinction of space and fields) is now supported by the existence of a special particular experimental inertial cosmological frame I_0 in which

¹ To quote Kholmetsky « In order to pass from one arbitrary inertial frame I_1 to another one I_2 it is necessary to carry out the transformation from I_1 to the absolute frames I_0 and then from I_0 to I_2 .

² As a consequence of the failure of the geometrical unification program Einstein was still obliged in 1954 to consider the electromagnetic field as filling curved space-time, but never reached a final satisfying model.

- the 2.7°K microwave radiation frame is isotropic and non rotating
- The average distribution of different types of galaxies (spiral, elliptical, Q.S.O's) is isotropic and does not change with distance [15].
- The observable anisotropy of the velocity of light propagation in different directions and around massive objects reflects the real motions of real fields described w.r.t. the I_0 frame in any real inertial Poincaré frame by covariant (local) four-vector scalar chaotic average density $\rho(x_\mu)$ around each absolute space-time point x_μ in I_0 i.e. by average four-vectors $A_\mu^0(x_\alpha)$ where 0 denotes average measures taken in I_0 .³

B) That all real physical observations rest on :

1. The utilisation of real physical apparatus based on electromagnetic fields and gravitational material with charged (or uncharged) particles.
2. On observers also built with the same material i.e. influenced by the said fields and particles.

In other terms all observers (and their observations, inertial or not) are an integral part of fields and particles since they are part of the same overall real field and particle distribution. This fact determines their relation with all real phenomena. A physical theory should explicitly provide (within its context) a definition of the means whereby the quantities with which the theory is built and can be measured. The properties of light rays and massive particles are thus sufficient to provide the means of making basic measurements. Since real clocks and rods are the real instruments utilized in physics, we shall thus first define, for an individual inertial observer, the behaviour of such instruments with respect to each other: since this determines, for every inertial observer possessing them, the behaviour, with respect to I_0 , of the material fields around him.

As a consequence of the covariant distribution character observed in I_0 , the very small resistance to motion and assumed non-zero photon rest mass, real spin of possible extended vacuum sub-elements and their internal possible motions (and associated local interactions) one can describe the four-momenta and angular momenta of all extended subelements passing through a small four-volume with a constant average density on a hyperboloid Σ_0 . The four-momenta and angular momenta of extended elements are distributed at each point $P(x_\mu)$ with constant density $\rho(x_\mu)$ on space-like hyperboloids.

C) Following an idea of Noether the local analysis of moving fields and extended particles at each point by real observers tied to this point, is defined by local clocks and rods which move with the corresponding element. It is thus locally performed at each point of coordinates $x_\mu(\tau)$ which follows a world-line L . To this point are attached local (in I_0) « internal » variables $b^{(\lambda)}$, which describe its neighbourhoods physical properties and thus depend on τ . The evolution is given by $x_\mu(\dot{x}_\mu)$, $b^\lambda(\dot{b}^\lambda)$, where $\dot{}$ denotes the proper

³ This implies 1) the existence of a basic high density of sub-elements in vacuum, 2) the existence of small density variations above (for light) and below (for gravity) the average density with the possibility of propagating density variation on the top of such a vacuum model as initially suggested by Dirac.

time derivative w.r.t. τ when x_μ describes a world-line L . A scalar Lagrangian thus represents the evolution of the real physical medium in I_0 , which depends on a local Lagrangian L and is thus given by Poisson brackets. This description on I_0 is assumed to correspond to local space-time translations and four dimensional rotations which are determined by a Lagrangian L invariant under the local group of Poincaré transformations (i.e. the inhomogeneous Lorentz group). They contain [15] :

- 1) the operators P_μ of infinitesimal translations of X_μ only and can be described by $P_\mu \cdot X_\lambda = g_{\mu\lambda}$.
- 2) The operators $M_{\mu\nu}$ of infinitesimal four rotations in I_0 which act simultaneously on X_μ and on the internal variables. We have at X_μ :

$$M_{\mu\nu}x_\lambda = x_\mu g_{\nu\lambda} - x_\nu g_{\mu\lambda}. \quad (1)$$

Their action on internal local variables depends on their choice.
3) A choice of L leads to the momenta

$$G_\mu = \frac{\partial L}{\partial \dot{x}_\mu} \quad \text{and} \quad \beta^{(\lambda)} = \frac{\partial L}{\partial \dot{b}^{(\lambda)}} \quad (2)$$

yielding a constant impulsion vector

$$G_\lambda P_\mu x_\lambda = G_\lambda g_{\mu\lambda} = G_\mu \quad (3)$$

and the total angular momentum:

$$M_{\mu\nu} = G_\lambda M_{\mu\nu} x_\lambda + \beta^{(\lambda)} M_{\mu\nu} b^{(\lambda)},$$

so that

$$M_{\mu\nu} = x_\mu G_\nu - x_\nu G_\mu + S_{\mu\nu}, \quad (4)$$

with

$$S_{\mu\nu} = \beta^{(\lambda)} M_{\mu\nu} \beta^{(\lambda)}.$$

These quantities satisfy the Inhomogeneous Lorentz group commutation relations

$$[P_\mu, P_\lambda] = 0$$

$$[M_{\mu\nu}, P_\alpha] = g_{\alpha\beta} P_\nu - g_{\alpha\nu} P_\mu \quad (5)$$

i.e. Poisson Group Relations :

$$[G_\mu, G_\nu] = 0$$

$$[M_{\mu\nu}, G_\alpha] = g_{\alpha\beta} G_\nu - g_{\alpha\nu} G_\mu \quad (6)$$

$$[M_{\mu\nu}, M_{\alpha\beta}] = g_{\mu\alpha} M_{\nu\beta} + g_{\nu\beta} M_{\mu\alpha} - g_{\mu\beta} M_{\nu\alpha} - g_{\nu\alpha} M_{\mu\beta}.$$

With these quantities one can also define local conservation laws for « free » elements i.e.

$$\begin{aligned} \dot{G}_\mu &= 0 \\ \dot{M}_{\mu\nu} &= 0 \\ \dot{S}_{\mu\nu} &= G_\mu \dot{x}_\nu - G_\nu \dot{x}_\mu. \end{aligned} \quad (7)$$

and introduce a constant local mass term M_0 with $G_\mu G_\mu = -M_0^2 \cdot c^2$.

4) An associated center of gravity y_μ is defined by the introduction of the four-vector

$$R_\mu = \left(\frac{1}{(M_0^2 c^2)} \right) \cdot S_{\mu\nu} \cdot G_\nu \quad (8)$$

associated with x_μ i.e.

$$y_\mu = x_\mu - R_\mu; \quad (9)$$

which implies that locally extended real media in I_0 are described by pairs of points as first suggested by Yukawa.

5) An inertial mass (usually not constant) μ_0 defined by

$$-M_0 c^2 = G_\mu \cdot \dot{x}_\mu \quad (10)$$

can also be attributed to x_μ : M_0 being located at y_μ since one has:

$$\dot{y}_\mu = \dot{x}_\mu - \dot{R}_\mu = \dot{x}_\mu - \frac{1}{M_0^2 c^2} (G_\mu \cdot \dot{x}_\nu - G_\nu \dot{x}_\mu) G_\nu = \frac{\mu_0}{M_0^2} \cdot G_\mu \quad (11)$$

so that the motion of y_μ is locally rectilinear and y_μ has a proper time Θ , (with $d\lambda / d\Theta = M_0 / \mu'_0$) and we have :

$$y'_\mu = \dot{y}_\mu \cdot \frac{d\tau}{d\Theta} = G_\mu / M_0 = \text{constant.}$$

and

$$\mu_{\mu\nu} = R_\mu G_\nu - R_\nu G_\mu + S_{\mu\nu}, \quad (12)$$

w.r.t. the center of gravity. Local instantaneous four rotations are described by :

- A specific « beigrössen » four-frame b_{μ}^{ξ} ($\xi=1,2,3,0$) with

$$\dot{x}_{\mu} = b_{\mu}^4 = \frac{ic}{6} \varepsilon_{\mu\nu\alpha\beta} \cdot \varepsilon^{rst} b_{\nu}^r b_{\alpha}^s b_{\beta}^t, \quad b_{\mu}^{\xi} = (i/2) \varepsilon_{\mu\nu\alpha\beta} \dot{x}_{\nu} S_{\alpha\beta} \quad \text{and}$$

$$S_{\alpha\beta} = I \cdot \dot{b}_{\alpha}^{\xi} \cdot b_{\beta}^{\xi}.$$

- A specific four-frame a_{μ}^{ξ} centered on y_{μ} with $M_{\alpha\beta} = K \cdot \dot{a}_{\alpha}^{\xi} \cdot a_{\beta}^{\xi}$ for a_{μ}^4

along y'_{μ} and $a_{\mu}^3 = (i/2M_0c) \cdot \varepsilon_{\mu\nu\alpha\beta} G_{\nu} \mu_{\alpha\beta}$.

This set of relations must be completed by relations which will define the interactions between the extended elements i.e. the propagation in the aether of collective motions corresponding to observed gravitational and electromagnetic phenomena.

Before the introduction of such interactions one must recall that such proposals have already been made in the past. We only mention here:

- Weysenhof's proposal [9] $S_{\alpha\beta} \dot{x}_{\beta} = 0$ extensively discussed in the literature.
- Nakano's proposal [12] $S_{\alpha\beta} \dot{x}_{\beta} = I \cdot \ddot{x}_{\alpha}$.
- Roscoe's proposal with photon mass [13].

3. General Relativity Represented As A Polarizable Vacuum

Since all observed effects of gravity in distant space rest on light observation (including γ and radio *em* waves coming through space from distant sources) a simple model endows the polarizable vacuum with properties that might account for all the phenomena in terms of distortions. This initial proposal of Wilson and Dicke has been recently revived with astonishing success by Puthoff [5] and Krogh [14]. We first summarize their model and will complete it with a supplementary mass term in electro-magnetism.

One starts from the idea that in flat space the electric field moves in a real « vacuum medium » with a point varying dielectric constant K : so that this D field satisfies the vacuum equation:

$$D = K \cdot \varepsilon_0 \cdot E. \quad (13)$$

This corresponds to a variable fine structure constant

$$\alpha = \frac{e^2}{4\pi\varepsilon_0\hbar c} \cdot \left(\frac{\mu(K)/\mu_0}{K} \right)^{1/2}; \quad (14)$$

so that the vacuum has permittivity and permeability constants given by

$$\varepsilon_0 \rightarrow \varepsilon = K \cdot \varepsilon_0 \quad \text{and} \quad \mu_0 \rightarrow \mu = K \cdot \mu_0, \quad (15)$$

and an impedance $(\mu/\varepsilon)^{1/2} = (\mu_0/\varepsilon_0)^{1/2}$ to satisfy Eötvös-type experiments. The local velocity of light for a given frequency ν varies like $V_{\nu} = c/K$ i.e like $1/(\mu\varepsilon)^{1/2}$. The corresponding principle of equivalence implies that the self energy of a system changes when K changes; so that a flat-space energy E_0 in flat space changes into

$$E = E_0 \cdot (K)^{-1/2}; \quad (16)$$

and one has

$$m = m_0 \cdot K^{3/2}. \quad (17)$$

As a consequence the condition $E = \hbar \cdot \omega$ becomes

$$\omega = \omega_0 (K)^{-1/2} \quad (18)$$

along with the time and length variations Δt and Δr given by the relations:

$$\Delta t = \Delta t_0 (K)^{1/2} \quad \text{and} \quad \Delta r = \Delta r_0 (K)^{-1/2}. \quad (19)$$

These relations are evidently equivalent to a local curvature of space. Indeed a dx_0 length rod shrinks to $d_x = d_{x_0} \cdot (K)^{-1/2}$ and would measure dx_0 , where the rod remains rigid, is now expressed in terms of dx -length rod as $dx_0 = (K)^{1/2} dx$.

Using the same argument for dt and dt_0 we find that one can write:

$$dS^2 = c^2 dt_0^2 - (dx_0^2 + dy_0^2 + dz_0^2) \quad (20)$$

which transforms into

$$dS^2 = \frac{1}{K} c^2 dt^2 - K(dx^2 + dy^2 + dz^2): \quad (a)$$

i.e.

$$(21)$$

$$dS^2 = g_{ij} \dots dx^i dx^j, \quad (b)$$

with

$$g_{00} = 1/K, \quad g_{11} = g_{22} = g_{33} = -K \quad \text{and} \quad g_{ij} = 0 \quad \text{for} \quad i \neq j.$$

In the case of a spherically symmetric mass distribution one writes

$$\begin{cases} K = e^{2G \cdot M / rc^2} \\ K = 1 + 2 \frac{G \cdot M}{rc^2} + \frac{1}{2} \left(\frac{2GM}{rc^2} \right)^2 + \dots \end{cases} \quad (22)$$

where G is the gravitational constant, M the mass and r the distance from its origin located at the center of mass. Puthoff [5] has recently shown that this model accounts (sometimes with better precision) for all known experimental tests of General Relativity in a simple way i.e. one can describe

- The gravitational redshift given by $\omega = \omega_0 / (K)^{1/2}$ (so that $\Delta\omega / \omega \cong (GM / R^2 c^2) h$ has a 1/100 precision).
- The bending of light rays by the sun and stars.
- The advance of the Perihelion of Mercury.

He has also shown that one can derive the form of (22) from a general Lagrangian with a variable K i.e. leaving aside vacuum interaction,

$$L = - \left[\frac{m_0 c^2}{K^{1/2}} \left(1 - \left(\frac{v}{c/K} \right)^2 \right)^{1/2} + q \cdot \phi - q \cdot \vec{A} \vec{V} \right] \delta^3(r - \vec{r}) - \frac{1}{2} \left(B^2 / (K \cdot \mu_0) - K (\epsilon_0 E^2) \right) - \frac{\lambda}{K^2} \left[(\nabla K)^2 - \frac{1}{(c/K^2)} \left(\frac{\partial K}{\partial t} \right)^2 \right] \quad (23)$$

in I_0 .

This association of gravitational theory with electromagnetic theory based on the introduction of a variable dielectric « vacuum » constant K has recently been made more explicit by Krogh [14]. Noting that:

a) Electromagnetic theory implies the effects of electromagnetic vector four-potential vectors A_μ on the phases S of quantum mechanical waves so that one has

$$\Delta S = \frac{q}{h} \int \phi dt - \frac{q}{hc} \int \vec{A} \cdot d\vec{S} \quad (24)$$

for charged particles moving under the influence of the four vector, A_μ .

b) If $m_\gamma \neq 0$ (m_γ is the mass term introduced into Maxwell's equation) the force on charged particles takes the form

$$F = q \left(E + \frac{V \times B}{c} \right) + q \cdot V \quad (25)$$

where the first term is the usual transverse Poynting force on currents and the second a longitudinal force along currents (resulting from non zero photon mass) recently observed by Graneau [11] and Saumont [16].

c) One can describe gravity with a four-vector density A_μ^g so that the gravitational (Newton) and electromagnetic (Coulomb) potentials have the same form, but different coupling constants. This suggests that both wave fields and singularities are just different aspects of the same fundamental field.

4. Maxwell's Equations Extended

This discussion opens the possibility to test new types of extensions of Maxwell's equations in the laboratory. Since this has already been attempted some results (derived within the frame of the model) are given here:

a) From a non-zero vacuum conductivity coefficient $\sigma \neq 0$ [6] we have in vacuum $\text{div } E = 0$ with $\text{curl } H = \sigma E + \epsilon_0 \chi_0 \partial E / \partial t$ and $\text{div } H = 0$ with $\text{curl } E = -\mu_0 \chi_m \partial H / \partial t$.

b) From an associated non-zero photon mass term ($m_\gamma \neq 0$) (with $A_\mu A_\mu \rightarrow 0$ where A_μ denotes the total four-potential density in Dirac's aether model. This introduces a non-zero fourth component of the current $J_\mu = \sigma E, j_0$ (where $j_0 \neq 0$) into the vacuum

corresponding to a real detectable space. With present technology this implies that the present <<vacuum>> really carries space-charge currents [17] (so that the divergence of the electric field is different from zero <<in Vacuo>>) and the corresponding existence of a displacement current (i.e. a curl of the magnetic field) and its associated current density⁴.

4.1 The Infinitesimal Mass Of Photons

Unifying massive spin 1 photons piloted by electromagnetic waves built with massive extended sub-elements has been developed in a series of books by Evans, Vigier et al. [6] The model implies the introduction of spin and mass with an associated energyless magnetic field component $B^{(3)}$ in the direction of propagation and a small electrical conductivity in the Dirac vacuum also implying a new <<tired light>> mechanism [6, 22]. Corresponding equations will be given below.

In the « absolute » inertial frame I_0 all massive particles are governed by a gravitational potential four-vector $\phi_g, \vec{A}_g / c$, associated with a small mass m_g which can be decomposed into transverse, longitudinal and gradient potentials.

We can thus associate the relations

$$\sim \phi = -\frac{\rho}{\varepsilon_0} + \mu\phi \quad \text{and} \quad \sim \vec{A} = -\vec{d}_0 / \varepsilon_0 c + \mu\vec{A} \quad (26)$$

which represent the electromagnetic field in vacuum in any inertial frame Σ_0 the relations:

$$\sim \phi_g = 4\pi G m \rho_\mu + \mu_g \cdot \phi_g \quad \text{and} \quad \sim \vec{A}_g = 4\pi \cdot G \cdot \vec{j}_m + \mu_g \vec{A}_g, \quad (27)$$

which represent the gravitational field in the same vacuum; where ρ_μ refers to mass density, j_m to mass current and μ and μ_g to electromagnetic and gravitational mass (both very small $\cong 10^{-65}$ grams) and $\rho \cdot c_0$ in the \sim terms ($\sim = \nabla^2 - (1/c_0^2)\partial/\partial t^2$) represents the corresponding wave velocities (which except in I_0 depend on the directions in flat space-time) so that one has:

$$c_0 = c \cdot e^{2\phi_g/c^2}; \quad (28)$$

where c is the value in the absence of a gravitational potential A_μ^g . In this model, one assumes, with Sakharov, that the gravitational field corresponds to local depressions in the immensely positive energy of the zero-point field; and gravitational fields represent regions of diminished energy (i.e. that their momentum gravity corresponds to « holes » in vacuum energy or local defects of vacuum elements). Their effective momentum is thus opposite and corresponding gravitational forces are attractive.

Such an association also suggests that although measuring devices (observations) in local inertial Poincaré frames are altered by gravitational potentials (they are part of the same real physical background in this model). There is no effect on the geometry of flat

⁴ Such attempts have been recently published in a book by Lehnert & Roy [18] so we shall only present a summary of some results and assumptions.

space and time. For any given real inertial local Poincaré frame Σ_0 real space is Euclidean and one uses Poincaré transformations between Σ_0 and I_0 to describe real motions which include consequences of gravitational potentials. For example a reduction of the velocity of quantum mechanical waves, including light, is taken as a fundamental effect of gravitational potentials. Clocks are slowed and measuring rods shrink in such potentials by a factor e^{ϕ_g/c^2} .

4.2 Divergence Of The Electromagnetic Field

A non-vanishing divergence of the electric field given below, can be added to Maxwell's equations which results in space-charge distribution. A current density arises in vacuo and longitudinal electric non-transverse electromagnetic terms (i.e. magnetic field components) appears (like $B^{(3)}$) in the direction of propagation.

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

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

$$\sim A_\mu(x_\alpha) = -\frac{m_\gamma^2 c^2}{\hbar^2} A_\mu(x_\alpha) \quad (29)$$

and its complex conjugated equation.

- the A_μ field potential equation also contains a gradient term so one has in vacuum (20):

$$A_\mu = A_\mu^T + A_\mu^L + \lambda \partial_\mu S \quad (30)$$

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

5. Some Possible New Consequences Of The Theory

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

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

We thus assume

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

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

- the possibility to propagate such field variations within the vacuum as first suggested by Dirac [17].

One can have internal variations: i.e. motions within these sub-elements characterized by internal motions associated with the internal behaviour of average points (i.e. internal center of mass, centers of charge, internal rotations : and external motions associated with the stochastic behaviour, within the « aether », of individual sub-elements. As well known the latter can be analyzed at each point in terms of average drift and osmotic motions and A_μ distribution. It implies the introduction of non-linear terms. Tysis has been developed by MacGregor [4], Guerra and Pusterla and Smolin.

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

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

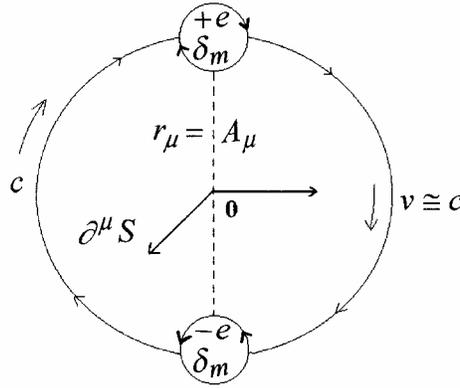


Figure 1. Diagram conceptualizing two oppositely charged subelements rotating at $v \cong c$ around a central point 0 behaving like a dipole « bump » and « hole » on the topological surface of the polarized Dirac vacuum.

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

$$\sim A_\mu - \frac{m_\gamma^2 c^2}{\hbar^2} \cdot A_\mu = \frac{\left[\prod (A_\alpha^* A_\alpha) \right]^{1/2}}{(A_\alpha^* A_\alpha)^{1/2}} \cdot A_\mu \quad (31)$$

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

$$m \cdot \omega^2 \cdot r = e^2 / 4\pi r^2 \quad (32)$$

and the angular momentum equation:

$$m_\gamma \cdot r^2 \cdot \omega = \hbar / 2 \quad (33)$$

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

$$\hbar \omega = e^2 / 2r \quad (34)$$

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

$$A_\mu^0 = \frac{\sin \cdot K \cdot r}{K \cdot r} \cdot \exp[i(\cot - K_0 x)] \quad (35)$$

where

$$K = mc / \hbar, \quad \omega = mc^2 / \hbar \quad \text{and} \quad K_0 = mv / \hbar \quad (36)$$

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

$$\sim A_\mu^0 = 0 : \quad (37)$$

so that one can add to A_μ^0 a linear wave A_μ (satisfying $\sim A_\mu = (m_\gamma^2 c^2 / \hbar^2) A_\mu^0$) which describes the new average paths of the extended wave elements and piloted solitons.

Within this model the question of the interactions of a moving body (considered as excess or defect of field density, above or below the « aether's » neighbouring average density) with a real « aether » appears immediately⁵.

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

In this work we shall follow a different line of interpretation and assume that if one considers particles, and fields, as perturbations within a real medium filling flat space time,

⁵ According to Newton massive bodies move in the vacuum, with constant directional velocities, i.e. no directional acceleration, without any apparent relative « friction » or « drag » term. This is not true for accelerated forces (the equality of inertial and gravitational masses are a mystery) and apparent absolute motions proposed by Newton were later contested by Mach.

then the observed deviations of Newton's law reflect the interactions of the associated perturbations (i.e. observed particles and fields) with the perturbed average background medium in flat space-time. In other terms we shall present the argument (already presented by Ghosh et al. [19]) that the small deviations of Newton's laws reflect all known consequences of General Relativity

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

6. Extending Newton's Model With Inertia And Vacuum Drag

Starting from an « aether » built with moving small extended structures with an average real distribution isotropic in an inertial frame I_0 (i.e. examining the effects in a given inertial frame I centered on a point Y_μ of the real vacuum distribution on a test particle moving with absolute velocity V^0 and angular momentum $\omega_{\alpha\beta}^0$) one can evaluate more precisely, the collective interactions carried by this « aether » between two extended neighbouring regions centered on points A and B with two centers of mass situated at X_A and X_B .

If we start with $\delta\rho < 0$ i.e. gravitational effects, it appears immediately

- if one assumes the gravitational potential is spherical in the rest frame I_B of its source B ,
- that the motion of A undergoes a velocity dependent inertial induction w.r.t. A i.e. a friction depending on the velocity v of A w.r.t. B
- that this motion is also submitted to an acceleration dependent inertial w.r.t. I_B i.e. also an acceleration depending on its acceleration a measured in I_B .
- possible terms depending on higher order time derivations which we will neglect in the present analysis we can write (19) the force on A due to B in I_B in the form $F = F_S + F_v + F_a$ where

$$F = -G \cdot \frac{m_A \cdot m_B}{r^2} - G' \frac{m_A \cdot m_B}{c^2 r^2} \cdot v^2 \cdot f(\theta) \hat{U}_r - G'' \cdot \frac{m_A \cdot m_B}{c^2 r} \cdot a f(\phi) \hat{U}_r \quad (38)$$

The terms G , G' , G'' are scalars possibly dependent on v . The terms m_A and m_B are the gravitational masses in I_B , \hat{U} , is the unit vector along r . $f(\theta)$ and $f(\phi)$ must have the same form i.e. $1/2 \cos \phi$ or $\cos \phi |\cos \phi|$. If we also accept the preceding velocity dependent analysis for contracting rods and retarded clocks then we should write $G = G'$ in (38) and take $f(\theta) = \cos \theta |\cos \phi|$ as done by Ghosh [19]. Moreover, if we compare the form given by Weber to the repulsion of two electric charges of the same sign :

$$F_{AB}^e = \frac{e_A \cdot e_B}{4\pi\epsilon r^2} \cdot \left[1 - \frac{1}{c^2} \left(\frac{dr}{dt} \right)^2 + \frac{2r}{c^2} \cdot \frac{d^2 r}{dt^2} \right] \quad (39)$$

corresponding to electromagnetism, with the recent form given by Assis [18] to attracting interacting masses m_A and m_B i.e.

$$F_{AB}^g = -G \cdot \frac{m_A \cdot m_B}{r^2} \left[1 + \frac{6}{c^2} \left[r \cdot \frac{d^2 r}{dt^2} - \frac{1}{2} \left(\frac{dr}{dt} \right)^2 \right] \right] \quad (40)$$

We see they have exactly the same form; the difference of their coefficients being compatible (within our interpretation) since they correspond to opposite variations of the average vacuum density. Their interpretation in terms of $\delta\rho > 0$ (for electromagnetism) and $\delta\rho < 0$ (for gravitation) also explains (at least qualitatively) why extended depressions repel or attract when they rotate through parallel or antiparallel directions and only attract when $\delta\rho < 0$. This also explains why a reduction of attraction between two masses has been observed when one puts another mass between them (the LAGEOS satellite). In this model this similarity is indeed comparable to similar behaviours of vortices for gravitation and Tsunamis for electromagnetism on an ocean surface.

If one assumes the absolute local conservation of four-momentum and angular momentum in regions containing the preceding « aether » carrying its associated collective electromagnetic and gravitational motions one can evaluate the effects of their interactions. With a real physical « aether » there is no such thing as « free » electromagnetic or gravitational phenomena. Drag theories (described as « inertial induction ») are always present and responsible for Casimir type effects in the microscopic domain. Real consequence of the « aether » appear, at various levels, in the macroscopic and cosmological domains... as has already been suggested in the literature and tested in laboratory or astronomical phenomena. We only mention here:

- 1) Possible consequences of modifying and testing the Newton and Coulomb forces.
- 2) The redshift and variable velocity of electromagnetic waves which results from the rotational inertial drag of extended photons moving in vacuum: an effect already observed in light traversing around the earth [20].
- 3) The possible measurable existence of the redshift of transverse gravitational waves... possible in the near future.
- 4) Observational redshift variations of light emitted by Pioneer close to the solar limb i.e. also of photons grazing a massive object [20].
- 5) The observed anisotropy of the Hubble constant in various directions in the sky [20] associated with various galactic densities.
- 6) Observed torques on rotating spheres in the vicinity of large massive bodies. This also appears in some experiments, i.e.:
 - a) Secular retardation of the earth's rotation.
 - b) Earth-moon rotation in the solar system etc.
- 7) Apparent evolution with time of angular momentum in the solar-planetary system.
- 8) Different variation of redshift of light travelling up and down in the Earth's gravitational field... Which also supports existence of photon mass.

7. Summation And Conclusions

This model exploits as stated in the introduction :

- a) the analogy (underlined by Puthoff) between the four vector density representation of gravity and electromagnetism in flat space-time [4]

- b) the possibility of describing the causality of quantum mechanical phenomena in terms of extended solitons piloted i.e. by quantum mechanical potentials, by real guiding collective waves on a chaotic, polarizable Dirac-type aether - both moving in a flat space-time [20].
- c) the representation of this « real vacuum » (Dirac aether) in terms of the chaotic distribution of real extended elements moving in the flat space-time.
- d) the introduction of internal motions within extended sub-elements and their relation with local collective motions i.e. the $E = mc^2 = h\nu$ relation
- e) the representation of the electron (and its associated pilot-wave) in terms of extended elements with a point-like charge rotating around a center of mass [20].

These assumptions yield realistic physical characteristics to known empirical properties and predict new testable relations besides known properties of elementary particles. The present model must thus be extended, by associating new internal motions to these known properties and interpret them in terms of new strong spin-spin and spin-orbit interactions.

Our attempt is justified by the existence of electromagnetic phenomena not explained by Maxwell's equations. Barrett [21] has stated that Maxwell's theory does not explain the Aharonov-Bohm (AB) effect and Altshuler-Aharonov-Spivak (AAS) effects. It does not cover the topological phase question i.e. the Berry-Aharonov-Anandan, Pancharatnam and Chio-Wu phase-rotation effects. An inclusion of Stoke's theorem is necessary and results of Ehrenberg and Siday must be analysed. The quantum results of Josephson, Hall, de Haas and van Alphen Sagnac-type experiments also need clarification.

The integration of gravity and electromagnetism however, is not finished, because unification is so far only accomplished in terms of « bumps » and « holes » rotating on the stochastic surface of the polarized Dirac Vacuum. Unification must also occur in terms of the richer Higher Dimensional (HD) structure of vacuum topology where one would show the geometric origin of charge and how « bumps » and « holes » transform into each other through quasi-particle like transitions « piloted » by advanced and retarded potentials of the fundamental unitary field itself.

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