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EXTENDED EINSTEIN'S THEORY OF WAVES IN THE PRESENCE OF SPACE-TIME TENSIONS

TEORÍA EXTENDIDA DE ONDAS DE EINSTEIN EN LA PRESENCIA DE TENSIONES EN EL ESPACIO-TIEMPO

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RESUMEN

Se propone una modificación a la dinámica de Einstein en presencia de ciertos tipos de tensión del espacio-tiempo. La estructura de las ecuaciones de movimiento para las perturbaciones gravitacionales es muy similar a las ecuaciones de Maxwell para cuerpos quirales micro y macroscópicos caracterizados por T, cuando los operadores de μ y ε son como $\mu(\varepsilon) \rightarrow \mu(\varepsilon)\,(1+T\nabla\times)$. Se discute el límite de unificación del electromagnetismo y la gravitación en el tiempo de Planck. Como aplicación de esta teoría se menciona el efecto de la birrefringencia en sistemas GPS (Global Positioning Systems).

Palabras clave: Tensiones, espacio-tiempo, electrodinámica, quiralidad.

ABSTRACT

A modification of Einstein's dynamics in the presence of certain states of space-time tension is proposed. The structure of the equations of motion for gravitational disturbances is very similar to Maxwell's equations for micro and macroscopic chiral bodies characterized by T, when the operators ε *and* μ *are like* $\mu(\varepsilon) \rightarrow \mu(\varepsilon)\,(1+T\nabla\times)$*. The unification limit between the electromagnetism and gravity is discussed. As an application of this theory we mention the birefringence effect in Global Positioning Systems (GPS).*

Keywords: Tensions, space-time, electrodynamic, chirality.

INTRODUCTION

Electrodynamics is perhaps the most successful theory physicists have constructed. Its theoretical and experimental properties have been simulated and sought for in many others theories, such as the analysis of gravitational phenomena. Much work has been done in this direction and many authors have discussed the resemblance between electrodynamics and gravidynamics [1]. However, it appears to us that it is not difficult to improve the theoretical aspects of this similarity more that has been done I the past. We intend to make a small contribution to this problem here.

In this vein, we shall propose a modification of Einstein's theory of general relativity under certain special states of space-time. Since the brilliant 1916 proposal of Einstein's geometrization of gravitational phenomena, many physicists have discussed alternative models of gravitation. These can be divided into two classes:

i. Geometrical models.
ii. Non-geometrical models.

The first group accepts Einstein's idea of geometrization of gravity but denies (under certain circumstances) the validity of the equations of motion proposed by Einstein's. The second group contains all attempts to construct a model in which gravity has no direct link with the structure of space-time. It is not our intention to discuss these models here. We merely state their existence.

The king of theory we shall advocate here may be classified as being of type **i.** Indeed, we shall assume that gravitational phenomena is described by the structure of space-time. This will be given by means of its metric

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properties – represented by a symmetrical metric tensor $g_{\mu\nu}(x)$ and by two others functions, like operators $\varepsilon(x)$ and $\mu(x)$, which are independent of the metric [2] and intimate characteristics of space-time.

We think it will be convenient, for pedagogical reasons, to limit our considerations in the present paper to the case in which both ε and μ are constants in time, but ε, μ are function of 3-D space. The meaning we would like to propose for these two constants is obtained by a direct analogy with the dielectric and permeability constants of a given medium in electrodynamics like a Born Fedorov approach [4].

However, we shall simplify our model by merely stating that ε and μ can be provisionally identified with the characteristics of certain states of tensions, is free space-time, due to an average procedure on quantum properties of gravitation [3]. This is perhaps not difficult to assume if we can say exactly how the equations of motion of gravity phenomena must be modified by them, as we shall go later. In sec. II we shall describe gravitational interaction by means of a fourth-rank tensor $R_{\alpha\beta\mu\nu}$. We shall set up its algebraic properties and give its dynamics. It is possible to separate this tensor, for an observer moving with four-velocity u^{μ}, into four second-order symmetric trace-free tensors $E_{\alpha\beta}$, $B_{\alpha\beta}$, $D_{\alpha\beta}$ and $H_{\alpha\beta}$. Our principal result is then obtained by showing that we can select a class of observers with velocity u^{μ} in such a way as to have the equations of motion for $B_{\alpha\beta\mu\nu}$. That is, for $E_{\alpha\beta}$, $B_{\alpha\beta}$, $D_{\alpha\beta}$ and $H_{\alpha\beta}$ separated into two groups: one containing only $E_{\alpha\beta}$ and $B_{\alpha\beta}$ (and their derivatives) and the others containing only $D_{\alpha\beta}$ and $H_{\alpha\beta}$(and their derivatives). These equations have the same formal structure of Maxwell's equations in a given general medium. So, we arrived at the conclusion that in our theory there is a class of privileged observers in which gravitational field equations admit the above simple separated form. Any others observers, which is in motion with respect to u^{μ}, mixes the terms $E_{\alpha\beta}$, $H_{\alpha\beta}$, $B_{\alpha\beta}$ and $H_{\alpha\beta}$ into the equations. This situation could be thought of as defining a new type of ether but it is only a preferred frame of observation.

In the remainder of the paper we discuss in some detail a very particular situation of the above tensors, that is, the case in which they can be reduced to two tensors plus two operators: the above ε and μ. The we show that Einstein's theory is obtained from ours for a particular set of values of ε and μ, that is, the case $\varepsilon = \mu = 1$. It is in this sense that we have called our theory a generalization of Einstein's dynamics.

THE R-FIELD

Definitions

Let us define in a four-dimensional Riemannian manifold a fourth-rank tensor $R_{\alpha\beta\mu\nu}$ given in term of four second-order tensors $E_{\alpha\beta}$, $B_{\alpha\beta}$, $D_{\alpha\beta}$ and $H_{\alpha\beta}$ as viewed by an observer with velocity tangent vector (time-like and normalized $u_{\mu}u^{\mu} = +1$). We set

$$R_{\alpha\beta}{}^{\mu\nu} = V_{[\alpha}D_{\beta]}{}^{[\mu}V^{\nu]} + V_{[\alpha}E_{\beta]}{}^{[\mu}V^{\nu]} + \delta^{[\mu}_{[\alpha}E^{\nu]}_{\beta]} - \eta_{\alpha\beta\rho\sigma}V^{\rho}B^{\sigma[\mu}V^{\nu]} - \eta^{\alpha\beta\rho\sigma}V_{\rho}H_{\sigma[\alpha}V_{\beta]} \tag{1}$$

In which the bracket means anti-symmetrization and $\eta^{\alpha\beta\mu\nu} = \sqrt{-g}\,\varepsilon^{\alpha\beta\mu\nu}$; g is the determinant of $g_{\mu\nu}$ and $\varepsilon^{\alpha\beta\mu\nu}$ is the totally anti-symmetric Levi-Civita symbol. The tensors $E_{\alpha\beta}$, $B_{\alpha\beta}$, $D_{\alpha\beta}$ and $H_{\alpha\beta}$ satisfy the following properties:

$$D^{\alpha}{}_{\alpha} = 0, \quad D_{\alpha\beta} = D_{\beta\alpha}, \quad D^{\alpha\beta}V_{\alpha} = 0 \tag{2}$$

$$E^{\alpha}{}_{\alpha} = 0, \quad E_{\alpha\beta} = E_{\beta\alpha}, \quad E^{\alpha\beta}V_{\alpha} = 0 \tag{3}$$

$$H^{\alpha}{}_{\alpha} = 0, \quad H_{\alpha\beta} = H_{\beta\alpha}, \quad H^{\alpha\beta}V_{\alpha} = 0 \tag{4}$$

$$B^{\alpha}{}_{\alpha} = 0, \quad B^{\alpha}{}_{\alpha} = 0, \quad B^{\alpha\beta}V_{\alpha} = 0 \tag{5}$$

We lower and raise the co-ordinate indices by means of the metric tensors $g_{\mu\nu}(x)$. Greek indices run from 0 to 3, in our units we set ≡ velocity of light = 1. We can write $D_{\alpha\beta}$, $E_{\alpha\beta}$, etc, in terms of $R_{\alpha\beta\mu\nu}$ and projections on u^{μ}, by using properties that will be given below.

Algebraic properties

From definition of $R_{\alpha\beta\mu\nu}$ it is easy to prove the following properties [5]:

$$R_{\alpha\beta}{}^{\mu\nu} = -R_{\beta\alpha}{}^{\mu\nu} \tag{6}$$

$$R_{\alpha\beta}{}^{\mu\nu} = -R_{\alpha\beta}{}^{\nu\mu} \tag{7}$$

$$R^{\alpha}{}_{\beta\alpha\nu} = E_{\beta\nu} - D_{\beta\nu} \tag{8}$$

$$R^{\alpha}{}_{\alpha} = 0 \tag{9}$$

Dynamics

By analogy with Einstein's equations in vacuum we shall impose on $R_{\alpha\beta\mu\nu}$ the equations of motion [4]

$$R^{\alpha\beta\mu\nu}{}_{;\nu} = 0 \qquad (10)$$

(where the semicolon means the covariant derivative).

Now, we shall use the properties given in subsection 1 above for projecting the system of Eq. (10) parallel and orthogonal to the rest frame of a selected observer u^μ from the whole class of v^μ. We impose that the congruence generated by u^μ satisfy the properties:

$$\begin{aligned} u^\mu u_\mu &= +1 && \text{(a)} \\ w_{\alpha\beta} &= \frac{1}{2} h_{[\alpha}{}^{\lambda} h_{\beta]}{}^{\varepsilon} u_{\lambda;\varepsilon} = 0 && \text{(b)} \\ \theta_{\mu\nu} &= \frac{1}{2} h_{[\mu}{}^{\lambda} h_{\nu]}{}^{\varepsilon} u_{\lambda;\varepsilon} = 0 && \text{(c)} \\ \dot{u}^\alpha &= u^\alpha{}_{;\lambda} u^\lambda = 0 && \text{(d)} \end{aligned} \qquad (11)$$

Where $h_{\mu\nu}$ is the projector in the plane orthogonal to u^μ, that is

$$h_{\mu\nu} = g_{\mu\nu} - u_\mu u_\nu \qquad (12)$$

So, the congruence generated by u^μ is geodesic, irrotational, non-expanding and shear-free. The reason for selecting such a particular class of observers will appear clear later. Then, Eq. (10) assumes the form:

$$\begin{aligned} & D_{\alpha\mu;\nu} h^{\mu\nu} h^{\alpha}{}_{\varepsilon} = 0 \\ & \dot{D}_{\alpha\mu} h^{\alpha}_{(\sigma} h^{\mu}_{\varepsilon)} + h^{\alpha}_{(\sigma} \eta_{\varepsilon)}{}^{\nu\rho\tau} u_\rho H_{\tau\alpha;\nu} = 0 \end{aligned} \qquad (13)$$

$$\begin{aligned} & B_{\alpha\mu;\nu} h^{\mu\nu} h^{\alpha}{}_{\varepsilon} = 0 \\ & \dot{B}^{\mu\nu} h_{\mu(\sigma} h_{\lambda)\nu} - h^{\alpha}_{(\sigma} \eta_{\lambda)}{}^{\nu\rho\tau} u_\rho E_{\tau\alpha;\nu} = 0 \end{aligned} \qquad (14)$$

In which a round bracket means symmetrization.

This set of equations has a striking resemblance with Maxwell's macroscopic equations of electrodynamics. Indeed, we can formally understand the above set as being [4]

$$\nabla \bullet \overset{\leftrightarrow}{D} = 0 \qquad (13a)$$

$$\dot{\overset{\leftrightarrow}{D}} - \nabla \times \overset{\leftrightarrow}{H} = 0 \qquad (13b)$$

$$\nabla \bullet \overset{\leftrightarrow}{B} = 0 \qquad (14a)$$

$$\dot{\overset{\leftrightarrow}{B}} + \nabla \times \overset{\leftrightarrow}{E} = 0 \qquad (14b)$$

Where the symbol $\leftrightarrow$ is put over D, E, etc. only to represent its tensorial character; $\nabla\bullet$ and $\nabla\times$ are generalizations of the usual well-known operators $\nabla\bullet$ and $\nabla\times$.

So, we can understand the reason for selecting the above privileged set of observers, given by the tangential vector u^μ. Eqs. (13)-(14) takes the form-only for this class of frame. Any others observer which is in motion with respect to l^μ will mix into the equations of motion the set of tensors $(E_{\alpha\beta}, B_{\alpha\beta})$ with the set $(D_{\alpha\beta}, H_{\alpha\beta})$. So, it is in this sense that there is a natural selection of all observers in the Universe, with respect to the equation of motion satisfied by $R_{\alpha\beta\mu\nu}$.

ε and μ states of tension

A particular class of states of space-time is that in which there is a specific linear function relating the tensors $B_{\alpha\beta}$ with $H_{\alpha\beta}$ and $E_{\alpha\beta}$ with $D_{\alpha\beta}$ by means of two operators, ε and μ.

We set

$$B_{\alpha\lambda} = \mu H_{\alpha\lambda}\ , \quad D_{\alpha\lambda} = \varepsilon E_{\alpha\lambda} \qquad (15)$$

If we put expressions (15) into definition (1) of $R_{\alpha\beta\mu\nu}$, a straightforward calculation shows that it is possible to write $R_{\alpha\beta\mu\nu}$ in terms of the Weyl tensor $C_{\alpha\beta\mu\nu}$ and its "electric" and "magnetic" parts $E_{\alpha\beta}$ and $\hat{H}_{\alpha\beta}$, if we identify the tensor $E_{\alpha\beta}$ with $\hat{E}_{\alpha\beta}$ and $H_{\alpha\beta}$ with $\hat{H}_{\alpha\beta}$.

$$\begin{aligned} & \hat{E}_{\alpha\mu;\nu} h^{\mu\nu} h^{\alpha}{}_{\varepsilon} = 0 && \text{(a)} \\ & \varepsilon \dot{\hat{E}}_{\alpha\mu} h^{\alpha}_{(\sigma} h^{\mu}_{\varepsilon)} + h^{\alpha}_{(\sigma} \eta_{\varepsilon)}{}^{\nu\rho\tau} u_\rho \hat{H}_{\tau\alpha;\nu} = 0 && \text{(b)} \end{aligned} \qquad (16)$$

$$\begin{aligned} & \hat{H}_{\alpha\mu;\nu} h^{\mu\nu} h^{\alpha}{}_{\varepsilon} = 0 && \text{(a)} \\ & \mu \dot{\hat{H}}_{\alpha\mu} h^{\alpha}_{(\sigma} h^{\mu}_{\varepsilon)} + h^{\alpha}_{(\sigma} \eta_{\varepsilon)}{}^{\nu\rho\tau} u_\rho \hat{E}_{\tau\alpha;\nu} = 0 && \text{(b)} \end{aligned} \qquad (17)$$

By the same argument that guided us to Eqs. (13)-(14) we see from the above set that we can identify ε as being the gravitational analogue of the dielectric constant of electrodynamics, and μ as being the permeability of space-time.

Now, we recognize in Eqs (16)-(17) Einstein's equations for the free gravitational field for the particular case in which $\varepsilon = \mu = 1$. [4]

So, we propose to interpret Eqs (16)-(17) for the general case (ε, μ different from unity) as the equations for the gravitational fields for states of space-time that are characterized macroscopically (in the sense discussed in the introduction) by the operators ε and μ.

GRAVITATIONAL ENERGY IN AN ε-μ STATE OF TENSION

There have been many discussions, since Einstein's 1916 paper, concerning the definition of the energy of a given gravitational field. We do not intend to comment hare on this subject but we shall limit ourselves to considering one reasonably successful suggestion of Bel [3] for the form of the energy-momentum tensor of gravitational radiation.

The point of departure come from the supposed resemblance of gravitational and electromagnetic effects. So, he defines a fourth-rank tensor $T^{\alpha\beta\mu\nu}$ given in terms of quadratic components of the field (identified with the Riemann tensor) and written in terms of the Weyl tensor $C^{\alpha\beta\mu\nu}$.

Bel's super-energy tensor takes the form:

$$T^{\alpha\beta\mu\nu} = \frac{1}{2}\left\{ C^{\alpha\rho\mu\sigma} C^{\beta}{}_{\rho}{}^{\nu}{}_{\sigma} + \overset{*}{C}{}^{\alpha\rho\mu\sigma} \overset{*}{C}{}^{\beta}{}_{\rho}{}^{\nu}{}_{\sigma} \right\} \tag{18}$$

Where the definitions of the dual $\overset{*}{C}_{\alpha\beta\mu\nu}$ is the usual:

$$\overset{*}{C}_{\alpha\beta\mu\nu} = \frac{1}{2}\eta_{\alpha\beta\rho\sigma} C^{\rho\sigma}{}_{\mu\nu} \tag{19}$$

Due to the symmetric properties of the Weyl tensor, we have $C_{\alpha\beta\overset{*}{\mu}\nu} = C_{\overset{*}{\alpha}\beta\mu\nu} = \overset{*}{C}_{\alpha\beta\mu\nu}$. This property does not hold for $R_{\alpha\beta\mu\nu}$. This is related to the lack of symmetry: $R_{\alpha\beta\mu\nu} \neq R_{\mu\nu\alpha\beta}$. Indeed, we have

$$R_{\alpha\beta\overset{*}{\mu}\nu} u^{\beta} u^{\nu} = \overset{*}{C}_{\alpha\beta\mu\nu} u^{\beta} u^{\nu} = \hat{H}_{\alpha\mu}$$
$$R_{\overset{*}{\alpha}\beta\mu\nu} u^{\beta} u^{\sigma} = \mu \hat{H}_{\alpha\varepsilon}$$

This $T^{\alpha\beta\mu\nu}$ tensor has properties very similar indeed to the Minkowski energy-momentum tensor of electrodynamics.

The scalar constructed with $T^{\alpha\beta\mu\nu}$ and the tangent vector u^{μ}, for instance, takes the form

$$u_{(T)} = T^{\alpha\beta\mu\nu} u_{\alpha} u_{\beta} u_{\mu} u_{\nu} \tag{20}$$

And gives the 'energy' of the field

$$u_{(T)} = \frac{1}{2}(\hat{E}^2 + \hat{H}^2) \tag{21}$$

Where

$$\begin{aligned} \hat{E}^2 &= \hat{E}_{\alpha\beta}\hat{E}^{\alpha\beta} \quad &(a) \\ \hat{H}^2 &= \hat{H}_{\alpha\beta}\hat{H}^{\alpha\beta} \quad &(b) \end{aligned} \tag{22}$$

In the context f our theory, for a space-time in the states ε–μ of tension, we propose to modify $T^{\alpha\beta\mu\nu}$ into $\theta^{\alpha\beta\mu\nu}$ defined in an analogous manner by

$$\theta^{\alpha\beta\mu\nu} = \frac{1}{2}\left\{ R^{\alpha\rho\mu\sigma} C^{\beta}{}_{\rho}{}^{\nu}{}_{\sigma} + R^{\overset{*}{\alpha}\rho\mu\sigma} \overset{*}{C}{}^{\beta}{}_{\rho}{}^{\nu}{}_{\sigma} \right\} \tag{23}$$

Then, the energy $U_{(\varepsilon,\mu)}$ as viewer by an observer u^{μ} will be given by

$$U_{(\varepsilon,\mu)} = \theta^{\alpha\beta\mu\nu} u_{\alpha} u_{\beta} u_{\mu} u_{\nu} = \frac{1}{2}(\varepsilon\hat{E}^2 + \mu\hat{H}^2) \tag{24}$$

in complete analogy with the electrodynamical case in a general medium.

We would like to make an additional remark by presenting to special properties of $\theta^{\alpha\beta\mu\nu}$

$$\begin{aligned} \theta^{\alpha}{}_{\beta\alpha\mu} &= \frac{1}{2}(1-\varepsilon)\hat{E}^{\rho\sigma} C_{\beta\rho\mu\sigma} \quad &(a) \\ \theta &= \theta^{\alpha\mu}{}_{\alpha\mu} \quad &(b) \end{aligned} \tag{25}$$

Property (25a) states that not all traces of $\theta^{\alpha\beta\mu\nu}$ are null for a general states of tension of space-time that the non-null parts of the contracted tensor are independent of the 'permeability' μ. The second property (25b) states that the scalar obtained by taking the trace of $\theta^{\alpha\beta\mu\nu}$ twice is null, independent of the states of tension of the space-time.

`THE VELOCITY OF PROPAGATION OF GRAVITATIONAL WAVES IN ε–μ STATES OF TENSION

In order to know the velocity of gravitational waves in ε–μ states of space-time let us perturb the set of equations (15) and (16). The perturbation will be represented by the map:

$$\begin{aligned} \hat{E}_{\mu\nu} &\to \hat{E}_{\mu\nu} + \delta\hat{E}_{\mu\nu} \qquad (a) \\ \hat{H}_{\mu\nu} &\to \hat{H}_{\mu\nu} + \delta\hat{H}_{\mu\nu} \qquad (b) \end{aligned} \tag{26}$$

In which $\delta\hat{E}_{\mu\nu}$, $\delta\hat{H}_{\mu\nu}$ are null quantities. Then, Eqs. (15) and (16) go into the perturbed set of equations:

$$\begin{aligned} \delta\hat{E}_{\alpha\ ;\beta}^{\ \beta} &\approx 0 \qquad (a) \\ \varepsilon\delta\hat{E} + \frac{1}{2}h_{(\alpha}{}^{\lambda}\eta_{\mu)}{}^{\rho\sigma\tau}u_{\rho}\delta\hat{H}_{\tau\lambda;\rho} &\approx 0 \quad (b) \end{aligned} \tag{27}$$

$$\begin{aligned} \delta\hat{H}_{\alpha\ ;\beta}^{\ \beta} &\approx 0 \qquad (a) \\ \mu\delta\hat{H} - \frac{1}{2}h_{(\alpha}{}^{\lambda}\eta_{\mu)}{}^{\rho\sigma\tau}u_{\rho}\delta\hat{E}_{\tau\lambda;\rho} &\approx 0 \quad (b) \end{aligned} \tag{28}$$

Where the covariant derivative is taken in the background and we limit ourselves to the linear terms of perturbation.

Now, let us specialize the background to be a Minkowaki (flat) space-time with $\mu(\varepsilon) \to \mu(\varepsilon)(1 + T\nabla\times)$ In this case the covariant derivatives are the usual derivatives and we can use the commutative property in order to write:

$$\varepsilon(1 + T\nabla\times)\delta\ddot{\hat{E}}_{\alpha\beta} + \frac{1}{2}h_{(\alpha}{}^{\lambda}\eta_{\beta)}{}^{\rho\sigma\tau}u_{\sigma}\delta\dot{\hat{H}}_{\tau\lambda;\rho} \approx 0 \tag{29}$$

By taking the derivative of Eq. (27b) projected in the privileged direction u^{μ}.

Now, multiplying Eq. (27b) by the factor

$$\frac{1}{2\mu}h_{(\alpha}{}^{\nu}\eta_{\beta)}{}^{\sigma\tau\gamma}u_{\tau}\frac{\partial}{\partial x^{\sigma}}$$

We find

$$\frac{1}{2}h_{(\alpha}{}^{\nu}\eta_{\beta)}{}^{\sigma\tau\gamma}u_{\tau}\delta\hat{H}_{\gamma\nu;\sigma} - \frac{1}{4\mu}h_{(\alpha}{}^{\nu}\eta_{\beta)}{}^{\sigma\tau\gamma}u_{\tau}u_{\rho}h^{\varepsilon}{}_{(\gamma}\eta_{\nu)}{}^{\psi\rho\psi}\delta\hat{E}_{\rho\varepsilon|\psi|\sigma} \approx 0 \tag{30}$$

Subtituting Eq. (30) in (29) and using (28b) we finally find

$$(1 + T\nabla\times)^2\delta\ddot{\hat{E}}_{\alpha\mu} - \frac{1}{\varepsilon\mu}\nabla^2\delta\hat{E}_{\alpha\mu} = 0 \tag{31}$$

Where ∇^2 is the Laplacion operator defined in the three-dimensional space orthogonal to u^{μ}.

In the same way an analogous wave equation can be obtained for $\hat{H}_{\alpha\mu}$. From Eq. (31) we obtain the expected result: the velocity of propagation of gravitational waves in ε–μ states of tension of space-time is equal to $1/\sqrt{\varepsilon\mu}$ when $T \to 0$. Thus we are shown that the point of departure, from the supposed resemblance of gravitational and electromagnetic effects turns a truly unification when $T \to \hbar/2M_{P}c$ (Planck limit) [6], where $R_{\mu\nu} \equiv T_{\mu\nu}^{\max well}\Big|_{\hat{E}=i\eta\hat{H}} = 0$.

At the Planck scale both EM and gravity have the same equations. Because of the ultra strong nature of EM fields at the Planck scale, self-cancellation occurs and the equations for both gravity and EM are the vacuum equations:

$$G_{\mu\nu} = R_{\mu\nu} - \frac{1}{2}Rg_{\mu\nu} = 0 \tag{32}$$

But the zero is a result of cancelling terms,

$$G_{\mu\nu} = 8\pi G/c^4(A_{\mu\nu} - T_0 g_{\mu\nu}) \tag{33}$$

where $A_{\mu\nu}$, is the first part of the Maxwell stress tensor, which we will call the action stress, and where T_0 is the normalization stress scalar. The tensor $T_0 g_{\mu\nu}$, will be called the reaction stress. We can calculate the value of T_0 approximately:

$$T_0 = M_p c^2/(2\pi^2 r_p^3) = c^4\Lambda/8\pi G$$

where we have defined the "cosmological constant" $\Lambda = \sim r_p^{-2} \sim T_p^{-2}$, which was first proposed by Einstein**.** Since at this scale we have $g_{\mu\nu} = Ag_{\eta\nu}/T_0$, we can simplify the vacuum equation: $G_{\mu\nu} = \Lambda g_{\mu\nu} - \Lambda g_{\mu\nu}$) This equation is of the form first proposed by Einstein [7] with the cancellation of terms first proposed by Zeldovich [8]. At the Planck scale the first "action" term and the second "reaction" term cancel exactly to make a vacuum equation. It is here that the GEM splitting occurs; the terms cease to cancel with the parameters of the reaction term changing. We have then a splitting into two equations, the first being the action term equation

$$G_{\mu\nu} = \Lambda T_{\mu\nu} / T_0 \quad (34)$$

which becomes the standard non vacuum equation of GR:

$$G_{\mu\nu} = 8\pi G / c^4 T_{\mu\nu}$$

where $T_{\mu\nu}$, is now the stress tensor due to presence of electrons and protons that have now appeared due to splitting. The second equation, the reaction portion with its negative sign will become the EM equation. It splits again to form two equations of the form $G_{\mu\nu} = -\Lambda' T_{\mu\nu}/T'_0$. The new parameters Λ' and T'_0 are no longer quantities associated with the Planck scale but a new scale associated with particles such that $T'_0 = q^2/8\pi r_0^4$ and $\Lambda' = r_0^{-2}$ where q is a particle charge and r_0 has changed from the Planck length to a particle classical radius.

In the chiral approach we have $\partial / \partial t \rightarrow \partial / \partial t(1 + T\nabla\times)$ so we have

$$\left[\nabla^2 + \omega^2 (1 + T\nabla\times)^2 \varepsilon^2 - 2i\omega(1 + T\nabla\times) G \cdot \nabla\right] \hat{E}^{\pm}_{\alpha\mu} = 0 \quad (32)$$

the solution of the wave equation can give relative retardation of right- and left-handed circularly polarized waves like was observed in the experiments with "Pioneer-6", whereas in the case of linearly polarized waves the effect was practically zero. If such birefringent effects like polarisation dependent bending of light by the Sun, the Earth or time delay of pulsar signals are observed with other measurements, they will signal new physics beyond Einstein's gravity [5-7].

As application of this theory in the future, will be the potential designs to improve the Global Positioning System (GPS). The variety of GPS applications is astonishing. In addition to the more obvious civilian and military applications, the system's uses include synchronizing of power-line nodes to detect faults, very-large-baseline interferometry, monitoring of plate tectonics, navigation in deep space, time tamping of financial transactions, and tests of fundamental physics. Two years ago, the value of the GPS to the general community had already become so great that USA turned off "selective availability"-the system by which the highest GPS precision was available only to the military. At the Arecibo radio telescope in the 1970s and 1980s, Joseph Taylor and colleagues verified the general-relativistic prediction for the loss of energy by a binary pulsar through gravitational radiation. Their exquisitely precise long-term timing measurements made use of the GPS to transfer time from the Naval Observatory and NIST to the local reference clock at Arecibo. The GPS constellation of highly stable clocks in rapid motion will doubtless provide new opportunities for tests of relativity. More than 50 manufacturers produce more than 500 different GPS products for commercial, private, and military use. More than 2 million receivers are manufactured each year. New applications are continually being invented.

Relativity issues are only a small –but essential– part of this extremely complex system. Numerous other issues must also be considered, including ionospheric and tropospheric delay effects, cycle slips, noise, multipath transmission, radiation pressure, orbit and attitude determination, and the possibility of malevolent interference. Relativistic coordinate time is deeply embedded in the GPS. Millions of receivers have software that applies relativistic corrections. Orbiting GPS clocks have been modified to more closely realize coordinate time. Ordinary users of the GPS, though they may not need to be aware of it, have thus become dependent on Einstein's conception of space and time.

CONCLUSION

This theory deserves further investigation. In any case, the model we are proposing on gravitational interaction has many intriguing consequences that should be carefully examined. Among these, we would like to point out the possibility of avoiding collapse either locally (starts) or globally (the Universe).

The gravitational optic approximation should be changed accordingly and many qualitatively new gravitational phenomena are to be expected to appear. We intend to come black to these problems elsewhere.

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