Generalized Lorentz Force Equation and Illusions of Gravitomagnetism

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Abstract: In this short note it is shown that the Gravitomagnetism can be misinterpreted and mistakenly identified with the gravitational mass dependence on velocity. The derivations show that a version of Gravitomagnetism can be derived for certain field arrangements from the formula for the mass dependence on velocity. For a one particular choice of the Gravitomagnetic field factor the resulting gravitational wave propagation velocity that follows from such Gravitomagnetism is larger than the speed of light, which is not acceptable. It is thus reasonable to modify the analog of Lorentz force equation instead, which leads to the speed of gravitational waves equal to *c*. Finally, it is found that this Generalized Lorentz force equation can be used to classify the various theories of gravitational force.

Keywords: Gravitomagnetism, gravitational mass dependence on velocity, inertial mass dependence on velocity, speed of gravity, Generalized Lorentz force equation

Introduction: In previous several publications, for example in [1], it was shown that the gravitational mass must depend on velocity as follows:

$$m_g = m_0 \sqrt{1 - v^2 / c^2} \tag{1}$$

This dependence is not recognized by the main stream physics; in particular it is claimed that the gravitational and inertial masses depend on velocity with an identical dependencies equal to:

$$m_i \equiv m_g = \frac{m_0}{\sqrt{1 - v^2 / c^2}} \tag{2}$$

This is not correct, as it was shown previously; the mass dependencies are such that the product of these masses is an invariant independent of velocity or more generally also of a gravitational field.

Derivations: Under certain conditions it is possible to interpret the dependency given in Equation 1 as a Gravitational Electro-Magnetism, in other words as GEM. This most likely leads to a confusion and claims that the GEM actually exists. In order to show this let's consider a case of a small test body with the gravitational mass m_g moving in the gravitational field of intensity E_g and write equation for the force acting on this test mass.

$$\vec{F} = m_g \vec{E}_g = m_0 \vec{E}_g \sqrt{1 - v^2 / c^2} \cong m_0 \left(\vec{E}_g - \frac{1}{2} \frac{\vec{E}_g v^2}{c^2} \right) \tag{3}$$

To be more precise with this equation, it is assumed that the coordinate system to which this equation is referenced to is the stationary coordinate system of the body producing the field.

The second term in Equation 3 can now be modified using the following well known vector identity [2]:

$$\vec{v}\times\left(\vec{E}_g\times\vec{v}\right)=\vec{E}_g v^2-\vec{v}\left(\vec{v}\cdot\vec{E}_g\right) \tag{4}$$

For certain field orientations and motion directions, for example when the field vector and the velocity vector are almost perpendicular as is, for example, in a circular orbit around a mass *M*, or in motion of Galaxy arms, it is possible to neglect the second term in Equation 4 and rewrite Equation 3 as follows:

$$\vec{F}=m_0\left(\vec{E}_g+\frac{1}{2}\frac{\vec{v}\times(\vec{v}\times\vec{E}_g)}{c^2}\right) \tag{5}$$

It is then only necessary to identify the vector product of velocity and the field intensity with a gravitomagnetic field vector B_g as follows:

$$\vec{B}_g=\frac{1}{2}\frac{\vec{v}\times\vec{E}_g}{c^2} \tag{6}$$

where its divergence is equal to zero,

$$\vec{\nabla}\cdot\vec{B}_g=0 \tag{7}$$

the curl is equal to:

$$\vec{\nabla}\times\vec{B}_g=-\frac{2\pi\kappa}{c^2}\rho_g\vec{v} \tag{8}$$

and the mass density ρ_g is satisfying the following Gauss law relation:

$$\vec{\nabla}\cdot\vec{E}_g=-4\pi\kappa\rho_g \tag{9}$$

Equation 5 then transforms into its familiar Lorentz force form with m_0 being the rest mass:

$$\vec{F}=m_0\left(\vec{E}_g+\vec{v}\times\vec{B}_g\right) \tag{10}$$

This equation thus holds true only for the motion directions that are nearly perpendicular to the field intensity and only for small velocities. In typical astronomical motions, for example, planets orbiting our Sun or stars orbiting the galaxy centers, this is the case. As a result many claims are being made that the GEM exists. However, this is not true; it is the gravitational mass dependence on velocity according to Equation 1 that leads to this result. Equation 1 is exact and valid for all the velocities in particular for photons that do not have any m_g. Photons have only inertial mass. This gravitational mass dependence is necessary to avoid any possible relativity theory contradictions.

Unfortunately, one problem with this analogy is the speed of gravity waves that can be derived from these equations when non-static cases are considered and equations are modified accordingly.

However, this problem can also be simply demonstrated by finding analogous relations for the dielectric constant and permeability. From Equation 9 thus follows that for the dielectric constant we can write:

$$\varepsilon_g = \frac{1}{4\pi\kappa} \tag{11}$$

and from Equation 8 follows that for the permeability it is:

$$\mu_g = \frac{2\pi\kappa}{c^2} \tag{12}$$

The speed of gravitational waves then becomes equal to:

$$c_g = \frac{1}{\sqrt{\varepsilon_g \mu_g}} = c\sqrt{2} \tag{13}$$

This result is not reasonable, since it is generally believed that the gravitational waves should propagate with the same velocity *c* as light.

The traditional way of demonstrating this problem is to add a mass displacement current term to Equation 8 as it is done in the Maxwell theory of EM fields when the fields are time dependent:

$$\vec{\nabla} \times \vec{B}_g = -\frac{2\pi\kappa}{c^2}\rho_g \vec{v} + \frac{1}{2c^2}\frac{\partial \vec{E}_g}{\partial t} \tag{14}$$

and further consider that the curl of the E_g field is equal to:

$$\vec{\nabla} \times \vec{E}_g = -\frac{\partial \vec{B}_g}{\partial t} \tag{15}$$

The factor ½ has to be included in the added term in order to satisfy the continuity equation for the mass current. This can be demonstrated by taking the divergence of Equation 14:

$$0 = \vec{\nabla} \cdot (\rho_g \vec{v}) + \frac{\partial \rho_g}{\partial t} \tag{16}$$

Finally, by taking the curl of Equation 14, the wave equation for the gravitomagnetic field vector $\vec{B}_g$ becomes as follows:

$$\frac{1}{2c^2}\frac{\partial^2 \vec{B}_g}{\partial t^2} - \Delta \vec{B}_g = -\frac{2\pi\kappa}{c^2}\vec{\nabla} \times (\rho_g \vec{v}) \tag{17}$$

This is the well-known wave equation but with the propagation speed of: $c_g = c\sqrt{2}$. An objection could be raised, however, that Equation 15 was selected arbitrarily and if a suitable factor were added to this formula the propagation speed of $\vec{B}_g$ field could be *c*. But there is no other possibility except this choice in order to have the $\vec{E}_g$ field and the $\vec{B}_g$ field propagating with the same velocity. Therefore, in order to satisfy the mass continuity equation and have the both fields propagating with the same velocity the gravitational waves have to propagate with the velocity $c_g = c\sqrt{2}$, larger than *c*.

The above derivations can, of course, be repeated for the mass dependence on velocity according to Equation 2. The only difference would be in the sign in front of the term $\vec{v} \times \vec{B}_g$ in Equation 10. The resulting gravitational wave propagation velocity would then be the same, larger than *c*. It is thus clear that when there is a conviction that *c* is the speed limit of any wave propagation in the vacuum without any evidence otherwise, there cannot be any Gravitomagnetism.

Other definitions of Gravitomagnetic induction vector and the Generalized Lorentz force equation:

In another approach and to avoid the larger than the speed of light wave propagation it is also possible to define the vector $\vec{B}_g$ in Equation 6 as follows:

$$\vec{B}_g = \frac{\vec{v} \times \vec{E}_g}{c^2} \tag{18}$$

Following the same derivation steps as before by using this expression in Equation 5, the result for the Lorentz force equation becomes:

$$\vec{F} = m_0\left(\vec{E}_g + \frac{1}{2}\vec{v} \times \vec{B}_g\right) \tag{19}$$

with the analog of the dielectric constant equal to:

$$\varepsilon_g = \frac{1}{4\pi\kappa} \tag{20}$$

and the gravitomagnetic induction equal to:

$$\mu_g = \frac{4\pi\kappa}{c^2} \tag{21}$$

This finally leads to the sped of gravity equal to *c*.

Furthermore, it is also interesting that in the Gravitomagnetism, as derived for example by Rugiero [3] from Einstein's field equations of General Relativity Theory (GRT), it is possible to modify the definition of the vector $\vec{B}_g$ once more and arrive at the following Lorentz force equation:

$$\vec{F} = m_0\left(\vec{E}_g + 2 \cdot \vec{v} \times \vec{B}_g\right) \tag{22}$$

It thus seems that it is possible to classify the various theories according to the Generalized Lorentz force equation and keep the speed of the wave propagation always equal to *c*:

$$\vec{F} = m_0\left(\vec{E}_g + n \cdot \vec{v} \times \vec{B}_g\right) \tag{23}$$

We thus have for n = 1/2 the scalar theory of gravity with the mass dependence on velocity given by Equation 1, for n = 1 the Maxwell EM field theory where charge is an invariant independent of velocity, and for n = 2 the Einstein GRT with the gravitational mass dependence on velocity the same as the inertial mass dependence on velocity. Some researchers associate this dependency on n with the spin of particles that mediate the field [4]. Of course, it is only the scalar theory and the EM field theory that are compatible with the Special Relativity Theory.

Conclusions: The superficial resemblance and similarity of Equations 7, 8, 9, and 10 with the Maxell-Lorentz equations of Electromagnetic field theory leads many researchers to postulate the existence of Gravitomagnetism. However, this is not correct; there is no Gravitomagnetism [5]. On the other hand those scientists who claim that the Gravitomagnetism exists must now also admit the possibility of correctness of Equation 1 and thus question the correctness of Einstein's general relativity theory that assumes the gravitational and inertial mass exact identity, which is independent of any velocity. About the speed of gravity; there are continuing discussions in the literature on this topic, however, no clear cut convincing measurement or observation has been established yet [6, 7]. Other criticisms of the GRT can be found elsewhere on the internet [8].

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