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RESEARCH ARTICLE

Relativistic Variations in the Permittivity and Permeability of Free Space = Gravitation

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Abstract—This paper describes gravitation in terms of electromagnetism, arguing that the dielectric properties of free space: permeability μ_o and permittivity ϵ_o are not fundamental constants but vary in accordance with Einstein's relativity, adjusting the metrics of *length* and *time* so that all observers measure the speed of light C and the gravitational constant G as fundamental constants; that inertia is the resistance to the change in an accelerating particle's relativistic mass, as it responds to an applied force, keeping its mass-to-energy ratio constant; that curved space is a form of mass/energy where gravitational rest mass and relativistic mass manifest themselves as energy gradients in the dielectric properties of the space that surrounds a particle, such that a slow-moving heavy rest mass particle is equivalent to a fast-moving light rest mass particle.

Keywords: gravitation—electromagnetism—permeability—permittivity—relativity

Equations:

- $E = mC^2$ (1)
- $C = 1/\sqrt{(\epsilon_o \mu_o)}$ (2)
- $m / E = \epsilon_o \mu_o$ from (1) and (2) (3)
- $E = hv$ (4)
- $m / hv = \epsilon_o \mu_o$ from (3) and (4) (5)

Introduction

One aspect of Einstein's relativity tells us that the metrics of *length* and *time* vary so that all observers measure C and G as fundamental constants. Despite the widespread acceptance of relativity, some authors continue to argue that gravitation can be explained in terms of varying dielectric properties of space resulting in a varying refractive index and speed of light. In addition, attempts have been made to argue that G varies in accordance with *Mach's principle* which suggests that the gravitational force is a function of the average mass density in the universe and is affected by distant masses. In 1921, Wilson (1921) made one of the earliest attempts to explain gravitation in terms of varying dielectric properties of space:

> . . . matter is believed to be composed of electrical charges, tends to move through the ether in the direction in which the specific inductive capacity and permeability of the ether increase most rapidly and that this is the cause of gravitation.
>
> It has always been difficult to believe that the ether in a gravitational field contains less energy per unit volume than the ether at a great distance from matter.

Contemporary authors continue to build on Wilson's electromagnetic approach to gravitation:

> . . . the language of classical optics is as suitable as that of Riemannian geometry for the study of electromagnetic phenomena in a gravitational field. (Felice 1971)
>
> . . . the velocity of light *C* in the Lorentz transformation and elsewhere is replaced by the velocity of light in a medium of variable refractive index . . . (Puthoff 2002)
>
> . . . a gravitational field is assigned a variable refractive index . . . (Boonserm, Cattoen, Faber, Visser, & Weinfurtner 2005)
>
> . . . with a variable velocity of light or a variable vacuum refractive index induced by the gravitational matter. (Ye & Lin 2008)

On the subject of a varying gravitational constant, Dicke (1957, 1961) discusses gravitation without a *principle of equivalence*:

> . . . one should not infer that the gravitational acceleration observed in a laboratory moving at high velocity relative to distant matter in the universe would be constant, for such has never been observed.
>
> The motion of the Earth relative to the distant matter . . . could be a factor influencing the locally observed gravitational acceleration. . . .

While all of the aforementioned papers approach the subject differently, using different mathematical techniques to describe the properties of the vacuum, their proposals share in common a varying value of *C* which is diametrically opposed to relativity. Before arguing that it is possible to vary the dielectric properties of space without violating the tenets of relativity, it is instructive to consider the following thought experiment:

Clearly, if a particle could travel at an infinite velocity, the universe would be infinitely big and the particle would be everywhere at once, colliding with every other particle simultaneously, resulting in a universe without cause and effect. An upper limit to velocity creates order out of chaos and leads to the evolution of life. But an upper limit to velocity can be meaningful only if all observers, particle masses included, measure exactly the same value and agree that it is a fundamental constant, otherwise there is no upper limit and the infinite velocity problem remains. Given that observers travel at various velocities when they make their measurement, relativity tells us that the metrics of *length* and *time* vary for each observer as a function of their velocity with respect to *C*, to ensure they all measure the same value of *C*. In addition, relativity tells us that when we accelerate a particle we add energy to the particle's rest mass such that the mass increases toward infinity as it approaches *C*, thereby preventing the particle from traveling faster than *C* and that this additional mass has an equivalent form of energy in accordance with Einstein's equation (1). It therefore seems reasonable to suggest, that in order to have a universe with cause and effect, leading to the formation of fundamental particles which combine to form living creatures, that there has to be a maximum velocity, which we all agree on and if it is not *C* it would have to be some other *constant* value.

Accepting that *C* is a fundamental constant we might argue that if *C* and *G* are fundamentally linked then *G* must also be a fundamental constant. To argue that for any given *constant* value of *C* there is a correspondingly unique value of *G,* we consider the following thought experiment consisting of a *fast* and *slow* universe. In the fast universe, the value of *C* is a trillion times its actual value and we see from Maxwell's equation (2) that the product $\epsilon_o \mu_o$ has to be much lower in order to obtain this value of *C*. In addition the *m/E* ratio in equation (3) must also be lower as it is equal to $\epsilon_o \mu_o$. We apply a force to a particle and plot its relativistic mass as a function of its velocity with respect to *C* noting that it takes much more work/energy to reach an infinite mass compared to a particle in our universe. We assume that inertia is much less in the *fast* universe and argue that due to the *principle of equivalence* gravity must also be less which leads us to intuitively suspect that *C* and *G* are fundamentally linked.

We consider the *slow* universe, where *C* is one trillionth of its actual value and note that the product $\epsilon_o \mu_o$ is much higher, as is the m/E ratio. Once again we plot the particle's relativistic mass as a function of velocity with respect to *C* noting that inertia and gravity are much greater in the *slow* universe compared with ours. While in principle any pair of values of *C* and *G* might lead to the evolution of life, most physicists would agree that by virtue of the relationship of these constants to others in nature, as discussed by Barrow, Tipler, and Wheeler (1988) in terms of the *anthropic principle*, it is unlikely that life would evolve in the *slow* or *fast* universes described above. We can, however, conclude that there must be some intermediate universe where the value of *C, G,* and $\epsilon_o \mu_o$ are such that life can form and that this is the universe we live in. From the above thought experiment we see that for every value of *C* there appears to be a correspondingly unique value of *G* which leads us to think that inertia, gravitation, and the dielectric properties of space are related to the change in the relativistic mass of an accelerating particle as it maintains a constant *m/E* ratio with respect to *C*.

We see that the mass/energy ratio on the left hand side of equation (3) is representative of Einstein's relativity while the dielectric *constants* of Maxwell's electromagnetism occupy the right hand side, and we wonder if relativity and electromagnetism could actually be two sides of the same coin. We now revisit the thought experiment to consider the physics of what happened when we applied a force to accelerate the particle. First we injected energy into the particle by applying a force, thereby increasing E in equation (3). We know that the product of the dielectric properties of space on the right hand side of equation (3) must remain constant in order to not violate C and consequently the mass must have increased in order to keep the m/E ratio constant. We now consider what mechanism allowed the force to do the work that injected mass/energy into the system and we look to the dielectric properties of space on the right hand side of equation (3) realizing that their product can remain constant while the dielectric values can change reciprocally. Permittivity can decrease as permeability increases or vice-versa, allowing the applied force to introduce energy by doing work on the dielectric properties of space and thereby changing their values and storing energy. We know from electronics that energy can be stored in a capacitor when a voltage is applied to two conductors that are separated by a dielectric, suggesting that the storage of energy in the dielectric properties of a vacuum, in the presence of a mass or fast velocity, may not be unreasonable.

In a universe populated with moving masses, space can never be perfectly flat and Maxwell's equations are not the complete story. Maxwell's equation (2) describes flat space, making no predictions as to the bending of light or the changing of its frequency in the presence of a mass. Given that light does bend as it passes a mass leads us to ask how a photon senses the curvature of space if space has no properties which can be curved. A particle gaining energy in a gravitational field leads us to wonder where the gravitational potential energy was stored before it was absorbed by the particle as kinetic energy. An atomic clock knows how much to slow down in a gravitational field or inertial reference frame. Because the photon, particle, and clock are interacting with space, then the properties of *space* must store the energy and control the metrics of *length* and *time*. Clearly *space* knows how much energy to impart to a particle and how much it must slow down an atomic clock as a function of the velocity of the reference frame and gravitational intensity with respect to C and G. Moreover, one part of space must be able to differentiate its properties from another part of space such that it agrees with the inverse square law ($1/R^2$). In all the aforementioned examples the properties of space seem to play a fundamental role, and unless space has some other properties that we are not aware of then it must be the changes in permittivity and permeability that store the energy and adjust the metrics of *length* and *time* such that an atomic clock dilates and a ruler measures the Lorentz contraction. Maxwell's equations have the electric and magnetic vectors at right angles, resulting in the speed of light propagating at right angles to both alternating vectors and in a straight line with no work being done. If the electric and magnetic vectors of free space are distorted such that their attributes are changed by the space in which they are imbedded, work may be carried out on a photon's frequency as it interchanges energy with the distorted properties of curved space and this may be permitted by equation (5).

But why should the dielectric constants of space vary when most textbooks and physics dictionaries list them as fundamental constants? It is interesting that in Maxwell's equation (2) there are supposedly three fundamental constants with no variables. Because permeability and permittivity contain the units of *length* and *time*, it is arguable that these so-called *constants* should vary in accordance with relativity, otherwise relativity becomes questionable. The units of permittivity (farads per meter) are a measure of the resistance of a dielectric material to the passage of an electric flux in response to an applied electric field. The units of permeability (volt seconds per amp meter) provide a measure of the generation of a magnetic field from a changing electric field. If relativity is correct then the dielectric properties of space must be variables.

Modern quantum physics tells us that space is a sea of virtual particles which are constantly being created and destroyed, as discussed by Urban, Couchot, and Sarazin (2011), and this agrees with the proposal that curved space can store energy. If curved space can store energy then space must be an equivalent form of mass with properties such as linear and angular momentum, and it should not be surprising that particles can be created from the energy–mass stored within space curvature. Another thought experiment allows us to create a recipe for creating a menu of particles from the dielectric properties of curved space: Take a quantized volume of spinning curved space and polarize its dielectric properties to point inward or outward so that it is either negatively or positively charged (a zero-charged particle would result from zero polarization). Allow the particle's surface to introduce a discontinuity, in proportion to its rest mass, with the dielectric properties of the surrounding space so that an energy gradient is formed which decreases in accordance with Newton's gravitational inverse square law. Create a second particle in close proximity to the first particle and take note of any forces that result between the particles. We might find that there are two distinct forces between the particles. The first (electromagnetic) force might result from the two charged particles trying to orient the dielectric properties of their surrounding space in the opposite sense to each other. The second (gravitational) force might arise from the discontinuity that each particle forms between its surface and the dielectric properties of the surrounding space, resulting in two overlapping inverse square energy gradients. The overlapping energy gradients cause an overall asymmetry which space tries to reduce by accelerating the two particles toward each other in order to reduce its asymmetrical curvature. The particles appear to attract because the curvature of space that each particle introduces to the space between the particles cancels out, allowing the curvature of space on the opposite sides of the particles to reduce curvature by accelerating the particles toward each other, thereby imparting kinetic energy to the particles. Similarly it is the dielectric curvature of space that is increasing as it decelerates the masses as they move away from each other, thereby absorbing and reducing their kinetic energy. This explains why a light rest mass particle traveling at a high velocity can have the same dielectric values as a slower moving heavier rest mass particle and why inertial and gravitational mass lead to the *principle of equivalence*. Although the recipe for particle creation, developed from our thought experiment, is somewhat oversimplified, it illustrates how quantum physics could create particles and forces simultaneously from the dielectric properties of space.

There is the possibility that enormous amounts of energy can be stored in the dielectric properties of space, and with infinitesimally small distances quantum physics may impose restrictions on position, momentum, time, and distance as a consequence of the presence of Planck's constant in equation (5). There are a number of hypothetical, but as yet unproven theories associated with gravitation: extra dimensions, zero point energy; vacuum energy; dark energy and the graviton. The proposal presented above does not postulate any new physics but simply argues that if permittivity and permeability vary in accordance with relativity, in the presence of mass or an inertial reference frame, then energy can be interchanged between particles and space, adjusting the metrics of *length* and *time* so that all observers agree that C and G are fundamental constants and this explains why masses appear to attract each other.

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