Gravitation is a Gradient in the Velocity of Light, 2nd version

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ABSTRACT

It is well known that a photon moving in a gravitational field has a trajectory that can be defined by Fermat's principle in Minkowski flat space with a variable speed of light and no other gravitational influence.

It can be shown that confined massless lightspeed sub-particles function inertially equivalent to a mass particle and have the same acceleration in a variable index of refraction as a mass particle in a gravitational field. If this is true then it is argued that the internal constituents of all mass depend on the velocity of light for internal propagation of its constituents and are accelerated in a gradient in c just as confined photons. The best evidence for this is that the energy change as the result of a Lorentz velocity transform is the same for particles and photons.

If mass particles are at the core, bound lightspeed particles then there is no need to ascribe any other mechanism to gravitation than a gradient in c.

This makes gravitation an electromagnetic phenomenon, and if QFT can illustrate a gradient in c equivalent to gravitation, can be produced by the internal motion of lightspeed sub-particles then the unification of QM and gravitation becomes more straightforward.*

http://www.arxdtf.org/css/GravAPS.pdf

*It has been asserted by researchers that the quantum vacuum is the origin of the speed of light and there is research on the phenomena, that the passage of a beam of photons can produce a gradient in c. [1][2]

Introduction

There are hundreds of papers on gravitation and a variable speed of light (VLS) some of which preexist General Relativity and many thereafter [3]. All papers so far reviewed by this author assert that gravitation alters the velocity of light as well as providing an attractive potential for mass particles.

It is assumed here and developed in "The Concept of Mass as Interfering Photons"[4] that a pair of bound of lightspeed particles having a mass as defined by $m = E/c$ have the same inertial properties and gravitational properties as a mass particle.

The effect of a gradient in c on such a particle functioning in a variable index of refraction following a trajectory defined by Fermat's principle is developed.

The initial horizontal trajectory of the back and forth motion of lightspeed particles accelerates vertically exactly as a mass particle in a gravitational field. As in previous papers regarding a locally conserved energy principle, flat Minkowski space is presumed. [5]

A simple particle

It is presumed that a simple particle such an electron could be defined bound lightspeed such as a photon, and a neutrino of equal energy having aligned spin and motion reciprocating initially along a common axis. The sum of the spin is ½ and the particles could be held together by a mediating W boson that instantaneously exchanges momentum when the particles exceed the combined particle Compton diameter.

The linear momentum of the light speed particles, developed in [6], can be defined by:

$$\vec{P} = \frac{h\nu}{c^2}\left(\gamma^k c_k + \gamma^0 c \right) \qquad (1)$$

Summing, squaring two particles, and noting the value is Lorentz invariant gives:

$$\frac{(v_1+v_2)^2}{c^2}\left[1-\frac{(v_1-v_2)^2}{(v_1+v_2)^2}\right]=\frac{2v_1v_2}{c_0^2}=\frac{v_0^{\ 2}}{c_0^2} \tag{2}$$

Noting that this expression is the same for the relativistic mass of a particle with $m=(v_1+v_2)/c^2$, and the velocity of the center of mass is:

$$\frac{v}{c}=\frac{(v_1-v_2)^2}{(v_1+v_2)^2}, \tag{3}$$

and the deBroglie frequency is the difference of the photon frequencies.

The motion of the photons can be treated by Fermat's principle in a variable index of refraction. For illustrative purposes it is assumed that the particles are initially moving horizontally along the x axis with the index of refraction gradient along the vertical r axis with the spin being horizontal. As the lightspeed particles move back and forth in the confined volume the acceleration of the vertical component of the trajectories responds to the gradient in c as would a photon in free space.

The acceleration is actually independent of these initial conditions, and thus any configuration of a collection of confined lightspeed particles results in the combined particle center of mass mimicking a real particle in a gravitation field.

Gravitationally Induced Index of Refraction

The index of refraction of light induced by a gravitating mass can be deduced using the defection of starlight by the by the use of Fermat's principle; in addition Blandford & Thorne [7] have shown the same result by projecting the Einstein equations on flat space. That index of refraction is found to be:

$$\eta_\theta=\left(1-2\frac{\mu}{r}\right)^{-1} \tag{4}$$

This result, which is well verified for tangential or angular motion of photons in a gravitational field, is not necessarily the same as the radial value. In fact Karimi, &

Khorasani [8], has illustrated that the Schwarzschild metric yields, for flat space, an index of refraction that is optically anisotropic.

Karimi, & Khorasani [6], have shown that with a more detailed development of the asymmetric aspects of the GR metric, that the index of refraction is actually:

$$\eta = \left(1+\phi\right)^{-1/2}\left(1+\phi\cos^2\theta\right)^{1/2} \quad , \quad \phi = \frac{r_s}{r} = \frac{2\mu}{r} \tag{5}$$

The angle θ is the angle between the wave vector and the radius. By dropping second order terms and simplifying, the velocity becomes:

$$\eta = \left(1-\left(1+\cos^2\psi\right)\frac{\mu}{r}\right)^{-1} \tag{6}$$

θ is the angle between the velocity and the radius vector.

Horizontal Trajectory

The equations for photon movement in a variable index of refraction have long been worked out for lens development. From Evans & Rosenquist [10],[11] the equation for the trajectory of a photon in a variable index medium derived from variational principles based on Fermat's theorem is:

$$\mathbf{r}'' = \eta\nabla\left(\eta\right) \tag{7}$$

With the derivative defined with respect to a stepping parameter, a such that:

$$da = \frac{c_0}{\eta^2}dt \tag{8}$$

And:

$$|\mathbf{r}'| = \left|\frac{d\mathbf{r}}{da}\right| = \eta \tag{9}$$

Inserting Eq.(8), into Eq.(7), and proceeding, the time differential or vertical acceleration is:

$$\frac{d^2r}{dt^2} = \left(\frac{\mathrm{Gm}}{\mathrm{r}^2}\right)\left[1 - \frac{\mathrm{v_r}^2}{\mathrm{c_0}^2}\right]^2 \tag{10}$$

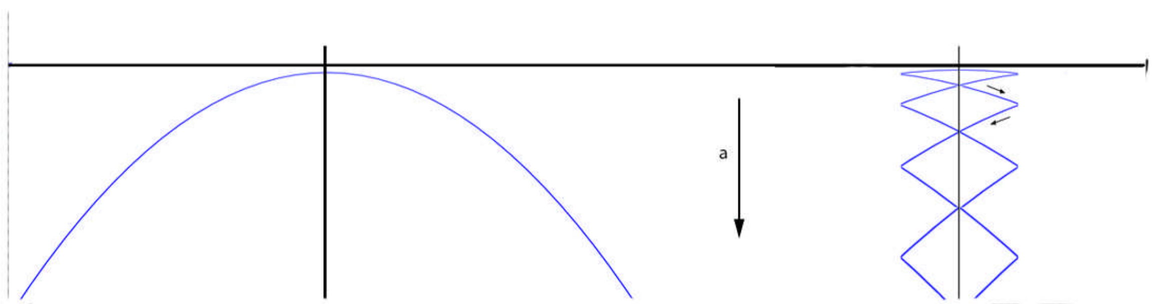
This is the same as the acceleration of a mass particle in gravitation for flat space. (See Appendix I for math details.)

For the horizontal x component of the photon acceleration is:

$$\frac{d^2x}{dt^2} = \left(2\frac{\mathrm{Gm}}{\mathrm{r}^2}\right)\left[1 - \frac{\mathrm{v_x}^2}{\mathrm{c_0}^2}\right]^2 = 0$$

This is initially zero for a particle direction along the x axis. These equations can be solved for the trajectory and is illustrated in Figure 1.

Free Trajectory **Trapped Between Two Vertical Mirrors**



Free lightspeed particles trajectory Bound lightspeed particle trajectory

Fig. 1.The vertical acceleration for both bound photons traveling at light speed, and free particles in a variable index of refraction.

The initial conditions of a stationary center of mass and a horizontal trajectory are not necessary for the results.

Vertical Trajectory

The above illustrates the particles being initially aligned along the horizontal axis, but it is easy to show that the same result applies to any initial condition.

A more direct approach developed in earlier papers, [4], and easily shown, Eq. (3), the velocity of the center of mass, or "center of energy" for two photons, or speed of light particles, is:

$$\frac{\vec{\mathbf{v}}}{c} = \frac{\left(v_1 \frac{\vec{c}_1}{c} + v_2 \frac{\vec{c}_2}{c}\right)}{\left(v_1 + v_2\right)} \tag{11}$$

Presuming the particles initially of the same energy and are moving opposite directions along a vertical axis with a gradient in c, Fig 2, the acceleration of the center of mass of the two particles as the result of a gradient in c is:

$$\frac{dv}{dt} = \frac{d}{dt}\left[c\frac{\lambda_0}{2}\left(\frac{1}{\lambda_1} - \frac{1}{\lambda_2}\right)\right], \tag{12}$$

With $\lambda_0 = \lambda_1 + \lambda_2$. Inserting the wavelength dependence on index of refraction from EQ.(6), foe a vertical trajectory, this becomes

$$\frac{dv}{dt} = \frac{c}{2}\left(\left(1 - \frac{\mu}{r_1}\right) - \left(1 - \frac{\mu}{r_2}\right)\right) \tag{13}$$

Since the particles are moving in opposite directions $c = dr_1 / dt = -dr_2 / dt$, the vertical acceleration of the center of mass of the two lightspeed bound particles is:

$$a = \frac{dv}{dt} = \frac{Gm}{r^2} \tag{14}$$

This is exactly as above Eq.(10), for the vertical acceleration of a bound system of two light speed particles, and the same for a massive particle moving in a gravitational field.

Particle Trajectories for Bound Particles Vertical Trajectories

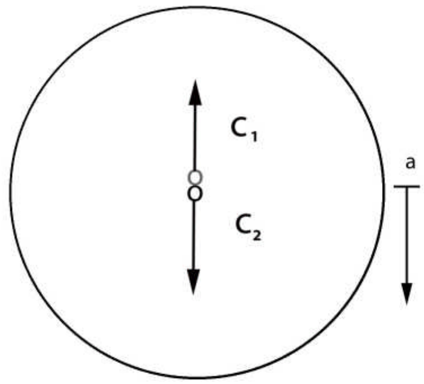


Figure 2

The Argument

1: A photon trapped between two reflectors whether mirrors or in a black box cavity represents rest mass. From the outside the photon is part of the total energy and cannot be ignored as part of the proper mass.

2: A photon reflecting between two parallel vertical mirrors accelerates vertically in a gradient in c exactly as a mass particle in a gravitational field.

3: If a trapped photon is mass then a photon oscillating between two mirrors must generate gravitation the same as a mass particle of the same energy.

4: An energetic photon can by virtue of QFT generate a gradient in c in its path vicinity.

Therefore; if the simplest form of mass, a trapped photon, can respond to a gradient in c as if it is in a gravitation field, and can generate a gradient in c equivalent to that produced by gravitation, why is there a necessity ascribe any other attribute to gravitation.

Conclusion

It has been shown that the effects of gravitation attraction of mass particles can be effectuated on a mass defined by a confinement of lightspeed particles by a gradient in the speed of light without need of any other mechanism. Since there are well-known processes defined in QFT and path integral formulations of QM, that alter the velocity of light in the proximity of moving photons,[1][2] it is speculated in appendix II, that the processes of QFT could be the progenitor of gravitation.

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Appendix I

Calculations

The presumption is that the initial motion of the lightspeed particle is tangential to the gradient in the velocity of light. With axis such that r is vertical and the velocity is orthogonal and along the x axis.

From above, the gravitational equivalent index of refraction for a speed of light particle along the r , and θ directions are:

$$\eta_r = \lambda_0 \left(1 - 2\frac{\mu}{r}\right)^{-1/2} \tag{1.1}$$

$$\eta_\theta = \left(1 - 2\frac{\mu}{r}\right)^{-1} \tag{1.2}$$

From [10] the motion of a speed of light particle in a variable index of refraction is:

$$\mathbf{r}'' = \frac{d}{da}\frac{d\mathbf{r}}{da} = \mathrm{grad}\left(\frac{\eta^2}{2}\right) \tag{1.3}$$

With the stepping parameter a defined as:

$$da = \frac{c_0}{\eta^2} dt \qquad \text{and} \qquad |\mathbf{r}'| = \left|\frac{d\mathbf{r}}{da}\right| = n \tag{1.4}$$

To express Eq.(1.3), in time dependent acceleration the stepping parameter can be replaced with Eq.(1.4), giving for the tangential motion along the r axis:

$$\frac{d}{da}\left(\frac{dr}{da}\right) = \frac{d}{da}\left(\frac{\eta^2}{c_0}\frac{dr}{dt}\right) = \frac{\eta^2}{c_0}\frac{d}{dt}\left(\frac{n^2}{c_0}\frac{dr}{dt}\right) = \frac{\eta^2}{c_0}\frac{d}{dt}\left(\frac{\eta^2}{c_0}\right) + \frac{\eta^2}{c_0}\frac{\eta^2}{c_0}\frac{d}{dt}\frac{dr}{dt} \tag{1.5}$$

Thus:

$$\mathbf{a} = \frac{d}{dt}\frac{d\mathbf{r}}{dt} = \frac{c_0^{\ 2}}{\eta^4}\,\mathrm{grad}\left(\frac{\eta^2}{2}\right) - \frac{c_0}{\eta^2}\frac{d}{dt}\left(\frac{\eta^2}{c_0}\right) \tag{1.6}$$

For the radial component of the acceleration is:

$$\frac{d^2r}{dt^2} = c_0^{\ 2}\left(\frac{\mu}{r^2}\right)\left(1-\frac{\mu}{r}\right)^{-1} - v_r^{\ 2}\left(\frac{2\mu}{r^2}\right)\left(1-\frac{\mu}{r}\right)^{1} \tag{1.7}$$

or

$$\frac{d^2r}{dt^2} = \left(\frac{\mathrm{Gm}}{r^2}\right)\left[1-\frac{v_r^{\ 2}}{c_0^{\ 2}}\right]^2 \tag{1.8}$$

Similarly the horizontal x component of the photon acceleration is:

$$\mathbf{a}_x = \frac{d^2x}{dt^2} = \left(2\frac{\mathrm{Gm}}{\mathrm{r}^2}\right)\left[1-\frac{v_x^{\ 2}}{c_0^{\ 2}}\right]^2 = 0 \tag{1.9}$$

The radial or vertical acceleration is exactly equivalent to the acceleration of a relativistic particle in flat space under the influence of a gravitational field.

These equations can be solved for the trajectory of the photon experiencing a gradient in c. See Evans [11] for the procedure.

Appendix II

It has been demonstrated above that the effect of gravitation can be mimicked on the dynamics of photons and particles by a gradient in c. It is certainly true for the dynamics of photons and confined photons. Given this; a demonstration that a photon reciprocating in a cavity generates a gradient in c, of the proper value, in the surrounding space by methods of QFT, would transform gravitation form a distinct force, to electromagnetic phenomena.

Since there are well-known processes defined in QFT and path integral formulations of QM, that alter the velocity of light in the proximity of moving particles,[10] ,[11] it is speculated that these processes could be the progenitor of the gravitational phenomena. It is a bit of speculation, but not farfetched with respect to known QFT phenomena.

It has long been known that a photon entering a gravitational potential follows a path identical to that of a photon in a variable speed of light defined by the Shapiro velocity for Minkowski flat space [7]. A spatially variable speed of light is implicitly present in General Relativity, and in fact has a long history starting in the pre GR efforts of Einstein and others. The difference in the approach taken in this author's paper is not that gravitation changes the speed of light, but that gravitation **is a change in the speed of light.** Newton's apple falls not because of an increase in energy, but because the speed of light at the branch is higher than the speed of light at the ground.

Simplifying the Discussion

First; it is observed that a photon confined in a reflective cavity constitutes rest mass. If to an empty cavity having a given mass is added a number of photons, the energy is increased, and for an outside observer the increase though small, constitutes an inertial or rest mass increase. For a black body cavity containing black body radiation the effect may be small, but in the case of an atomic nucleon the addition of a gamma ray is quite measurable. It must be concluded that the radiation confined in a black body cavity must contribute to the rest mass of the cavity and must be included in its inertial mass.

Second; if confined photons must be included in the rest mass, then the presence of the photons must also generate gravitational attraction. It must be concluded that a single photon bouncing back and forth between two reflectors is somehow generating the effect of gravitation, and in the view of this author a gradient in c.

Consider an apparatus having a cavity with opposing mirrors and having photons trapped between the mirrors. From conservation of energy the apparatus has more mass and generates more gravitational attraction than the cavity without the photons. There is not speculated an interaction between the photons, so the photons that are bouncing back and forth must be generating gravitation.

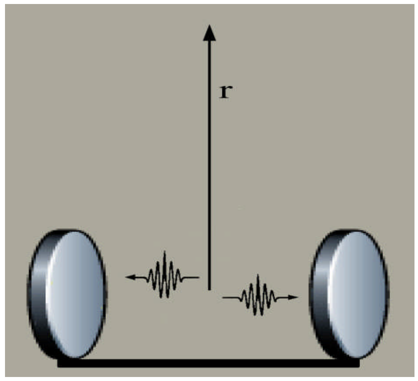

Fig1 *Photons trapped between mirrors of an apparatus increase the mass and thus the gravitational attraction of the apparatus.*

The increase in energy of the system is**Error! Objects cannot be created from editing field codes.** so the mass of the apparatus increase as a result of a trapped photon is:

Error! Objects cannot be created from editing field codes. (2.1)

The gravitational potential due to a confined photon is then:

Error! Objects cannot be created from editing field codes. (2.2)

Putting this into the radial value for the index of refraction [13] of light in flat space yields:

$$c = c_0\left(1 - \frac{G\hbar\omega}{c^4 r}\right) \tag{2.3}$$

or:

$$\Delta c = \frac{G\hbar}{c^3 r}\omega \tag{2.4}$$

Noting that the square of the Planck radius is **Error! Objects cannot be created from editing field codes.** this can be stated as:

$$\Delta c = \frac{r_P^2}{r}\omega , \tag{2.5}$$

From our premise; “if” the motion of the photons generates a gradient in c, equivalent to Eq.(2.5), then the effect on other particles is equivalent that of gravitation.

The fact that the Planck radius is the constant in the equation is quite curious.

By the methods of path integrals noted by Feynman the probability for the particle moving from point a to point b, exist throughout spaces, it has already been shown by the methods of Quantum Electrodynamics that a photon beam induces a change in the velocity of light in the vicinity of the beam. [2], if this is the value then the conjecture will be proven.

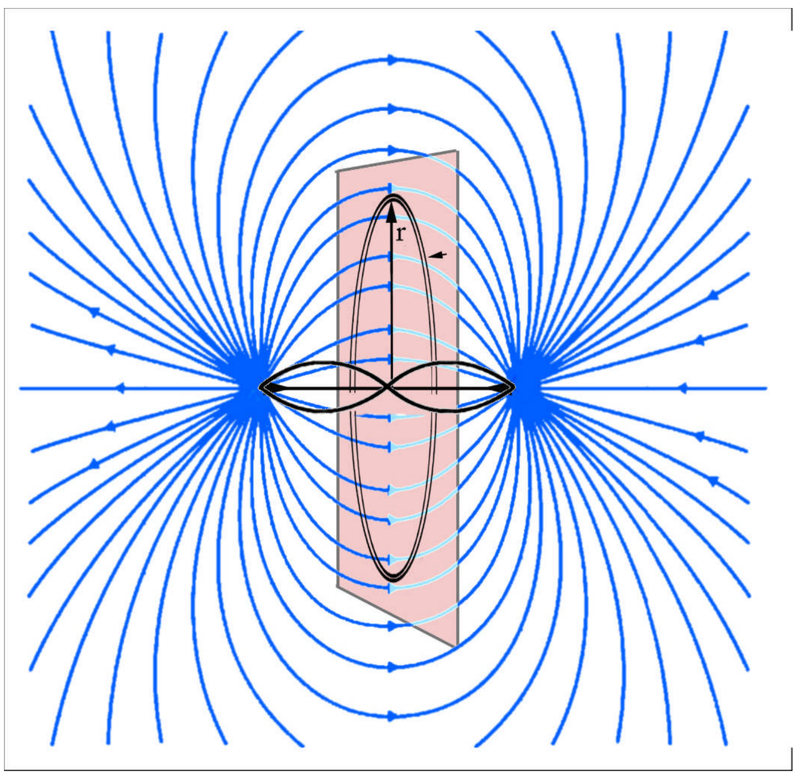

Fig.2.This illustration shows the path actions induced by a photon oscillating between two reflectors.

From the work of D. Kharzeeva, et.al, [2] it is shown that for an intense laser beam the QFT effects related to electron–positron loops induce vacuum “self-focusing” which is a vacuum alteration of the index of refraction in the speed of light in the vicinity of the beam

A particle model being reciprocating bosons in a massless box, as asserted here, constitutes an intense, highly energetic back and forth reciprocal motion, orders of magnitude greater than a laser.

It is suggested here that the multiple path integration of the photon action over all space would alter the velocity of light near the path as a function of r, and if Eq.(2.5), is realized the connection between gravitation and QFT would be established.

* More succinctly the anisotropic gravitational induced velocity of light is $c = c_0\left(1-\left(1+\sin\theta\right)\mu / r\right)$, with θ being the angle between the velocity and the radius vector [12]

$$\eta = \left(1+\phi\right)^{-1/2}\left(1+\phi\cos^2\psi\right)^{1/2} \quad , \quad \phi = \frac{r_s}{r} = \frac{2\mu}{r}$$

(2.6)

The angle ψ ins the angle between the wave vector and the radius.

By dropping second order terms and simplifying, this becomes the same expression as was developed from experimental considerations in [].

$$c = \left(1-\left(1+\cos^2\psi\right)\frac{\mu}{r}\right) \tag{2.7}$$

Due linearising of the gravitational potential in GR:

$$\left(1-\frac{\mu}{r}\right)^2 \rightarrow \left(1-2\frac{\mu}{r}\right), \tag{2.8}$$

the Karimi expression Eq.(2.6), is not correct for a conservative field in which photons do not transfer energy to the field.

The propagation expression used in the original presentation was:

$$c = \left(1-\frac{\mu}{r}\right)^2 \text{ (2.9)}$$

The expression for the asymmetric propagation of light near a gravitational radius used in the ray projections in this presentation is:

$$c = \left(1 - \frac{\mu}{r}\right)^{\left(1+\cos^2\psi\right)} \tag{2.10}$$