Gravitation is a Gradient in the Velocity of Light

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ABSTRACT

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 [1]. It is shown here that a particle defined as a pair of trapped photons in a massless box, having constant energy infalling a conservative gravitational field, is accelerated by a gradient in the velocity of light exactly as a particle in a gravitational potential [2], It is asserted that gravitation is a gradient in c produced by the presence of mass. The symmetry of the Lorentz transform between the change in velocity and the change in c is demonstrated as the mechanism for gravitational acceleration $\Delta v = \Delta c$. Also discussed are the QFT effects that define the total action path of photons which could induce an alteration in the velocity of light in the proximity of a photon path [3], and thus the mechanism for creating the effects of gravitation.

Introduction

This paper on the connection of gravity and the speed of light draws on components other papers by the author. Since there was an early postulation that the energy of a particle infalling gravitation was conserved, it was not clear how the mysterious effects of gravitation could affect this. Recently it was noted that an earlier paper theorizing that modeling mass particles as a pair of photons having opposite going phase velocities trapped in a massless box responded to a gradient in c identically to a massive particle in a gravitational field. The mechanism of inducing the effects of gravitation became apparent, as the same gradient in c that bends the trajectory of photons. A simple Lorentz transform can be shown to transfer the energy from one internal photon to another changing the relative energy and effectuating an increased velocity of the center of mass without a change in particle energy. This can be demonstrated with two photons with opposite phase velocities whether or not they are connected. See Appendix I for a more physical expectation of a physical particle

Speed of light in flat space

Blandford et.al [1], and others [4],[5], have shown that photons operating according to Fermat's principle, in a medium having a speed of light with an index of refraction defined by:

$$c = c_0\left(1 - 2\frac{\mu}{r}\right) \quad , \tag{1}$$

follow a trajectory identical to that of a particle in a gravitation field. This velocity is effected by a projection of the photon path defined in the GR metric tensor, onto flat time Minkowski space

A slightly different, but more symmetric equation is deduced from other work by this author is:

$$c = c_0\left(1 - \frac{\mu}{r}\right)^2 . \tag{2}$$

For the purposes here, either is suitable.

It is argued then that; if gravitation is "only" a gradient in the velocity of light, the photon would have the exact same trajectory. It will be developed here that gravitationally attracted particles, defined above, require no need to postulate that gravitation is anything more than a gradient in c.

Photon Four Momentum Description

For a pair of trapped photons have phase velocities in opposite directions. The center of mass for a pair of particles is along a line connecting the photons and the velocity of the center of mass like any two mass system is:

$$(h\nu_1 + h\nu_2)\mathrm{c} = (h\nu_1 - h\nu_2)\mathbf{v} \tag{3}$$

Nominally $\mathbf{v}$ would be referred to as the velocity of the center mass but in this case could be referred to s the velocity of the center of the energy. Defining the photon mass as $\mathrm{m} = h\nu / \mathrm{c}^2$ has precedents in other publications on photon entrapments [7], and if photons were trapped in a box it would be the velocity of the center of mass.

Photons moving along vector paths in the opposite direction can be described by the null four-momentum in geometric algebra matrix as:

$$\vec{\mathrm{P}}_1 = \frac{\mathrm{h}\nu_1}{\mathrm{c}^2}\left(\gamma^k \mathrm{c}_k + \gamma^0 \mathrm{c}\right), \tag{4}$$

and

$$\vec{\mathrm{P}}_2 = \frac{\mathrm{h}\nu_2}{\mathrm{c}^2}\left(-\gamma^k \mathrm{c}_k + \gamma^0 \mathrm{c}\right) \tag{5}$$

The square of the sum of the two null vectors is necessarily constant and is: (henceforth $h = 1$)

$$(\nu_1 + \nu_2)^2 - (\nu_1 - \nu_2)^2 = 4\nu_1\nu_2 = \nu_0{}^2 \tag{6}$$

The magnitude of each of these null four-momentums is zero by covariance, and the sum of two such moments is invariant. Thus ν_0 must be invariant fixed energy associated with the pair of opposite going photons. If this is defined as a rest energy then it is easy to identify:

$$(\nu_1 + \nu_2), \tag{7}$$

as the total energy.

Factoring the total energy from Eq.(6), gives:

$$\left(\nu_1+\nu_2\right)^2\left[1-\frac{\left(\nu_1-\nu_2\right)^2}{\left(\nu_1+\nu_2\right)^2}\right]=\nu_0{}^2 \tag{8}$$

Noting that from Eq.(3):

$$\frac{\mathbf{v}}{\mathrm{c}}=\frac{\left(\nu_1-\nu_2\right)}{\left(\nu_1+\nu_2\right)} \tag{9}$$

V is the velocity of the center of mass or energy, using $\mathrm{m}=h\nu/\mathrm{c}^2$, Eq.(8) , could be written as the relativistic mass velocity relation:

$$\mathrm{m}^2\left(1-\frac{\mathrm{v}^2}{\mathrm{c}^2}\right)=\mathrm{m}_0{}^2 \tag{10}$$

Rewriting Eq.(3), and Eq(9).,

$$\mathrm{p}=\frac{\left(\nu_1+\nu_2\right)\mathbf{v}}{\mathrm{c}^2}=\frac{\left(\nu_1-\nu_2\right)}{\mathrm{c}} \tag{11}$$

This is just the relation between the momentum of the particle and the total momentum of the photons.

$$\mathrm{p}_{\mathrm{C}}=\mathrm{p}_1-\mathrm{p}_2 \tag{12}$$

Taking the differential of this yields the change in the momentum of the center of mass:

$$\mathrm{dp}=\frac{\left(\nu_1+\nu_2\right)}{\mathrm{c}^2}\mathbf{dv}=\frac{\left(\mathrm{d}\nu_1-\mathrm{d}\nu_2\right)}{\mathrm{c}} \tag{13}$$

It can now be shown that the change in velocity of the center of mass as a change in energy of the photons is equivalent to the change in energy as the result of a Lorentz velocity transform of the observer.

Applying a Lorentz transform of the observer's velocity to a photon by way of the relativistic Doppler shift:

$$\nu = \nu_0 \left[\frac{1 - \frac{\mathbf{v}}{\mathrm{c}}}{1 + \frac{\mathbf{v}}{\mathrm{c}}} \right]^{1/2} \tag{14}$$

Letting v/c be small, this can be written as:

$$\nu = \nu_0 \left(1 - \frac{\mathbf{v}}{\mathrm{c}} \right) \tag{15}$$

or:

$$\frac{\nu_{10} - \mathrm{v}_1}{\nu_{10}} = \frac{\mathbf{v}}{\mathrm{c}} \tag{16}$$

Again, letting the change in velocity be small:

$$\frac{\mathbf{dv}}{\mathrm{c}} = \frac{\mathrm{d}\nu}{\nu} \tag{17}$$

Since the change in frequency in the direction of the velocity is opposite the change in frequency for the photon having opposite phase velocity:

$$\frac{\mathbf{dv}}{\mathrm{c}} = \frac{\mathrm{d}\nu_1}{\nu_1} = -\frac{\mathrm{d}\nu_2}{\nu_2}, \tag{18}$$

and:

$$\mathrm{d}\nu_1 = \frac{\mathbf{dv}}{\mathrm{c}} \nu_1 = \qquad \mathrm{d}\nu_2 = -\frac{\mathbf{dv}}{\mathrm{c}} \nu_1 \tag{19}$$

Substituting these values into Eq.(13), gives:

The equality:

$$\mathrm{dp} = \frac{(\nu_1 + \nu_2)}{\mathrm{c}^2} \mathbf{dv} = \frac{(\nu_1 + \nu_2)}{\mathrm{c}} \frac{\mathbf{dv}}{\mathrm{c}} \tag{20}$$

This proves that a Lorentz velocity transform $\mathbf{dv}$ applied to the two opposite going internal photons induces the exact same change in energy that the particle requires for that same change in the velocity of the center of mass.

Equivalence of a change in velocity and change in c

A change in velocity $\mathbf{dv}$ has the same change in the relative energy for the internal photons as a change in the velocity of light $\mathrm{dc}=\mathbf{dv}$. A particle moving in a gradient in c from higher to a lower speed of light will not have a constant velocity, but will experience an increase in velocity.

To show this Eq.(15), can be written as:

$$v = v_0 \left(\frac{\mathrm{c} - \mathbf{v}}{\mathrm{c}} \right) \tag{21}$$

If the initial value of c is c_0 and the value of c is $\mathrm{c} \to \mathrm{c} - \mathbf{v}$ then:

$$\frac{v}{v_0} = \frac{\mathrm{c}}{\mathrm{c}_0} \tag{22}$$

or:

$$\frac{\mathrm{d}v}{v_0} = \frac{\mathrm{dc}}{\mathrm{c}_0} \tag{23}$$

Noting the relation in Eq.(17):

$$\frac{\mathbf{dv}}{\mathrm{c}} = \frac{\mathrm{dc}}{\mathrm{c}} \tag{24}$$

This is the equivalence between the change in the relative energy of the internal photons as a result of a velocity change, or a change in the velocity of light. Thus a particle moving through a gradient in c results in acceleration.

Particle velocity speed of light relation

The relation between velocity of the particle and the velocity of light can be determined from the relativistic Lagrangian for a particle in a gravitational field:

$$L = m_0 c^2 = \left(mc^2 + m_0 c^2 \frac{\mu}{r} - m\frac{1}{2}v^2 \right) \tag{25}$$

Rearranging and squaring we have:

$$m^2\left(1-\frac{v^2}{c^2}\right)=m_0^2\left(1-\frac{\mu}{r}\right)^2 \tag{26}$$

For a particle falling from infinity with the mass equivalent to the initial rest mass, using Eq.(3), the expression becomes:

$$\left(1-\frac{v^2}{c^2}\right)=\frac{c}{c_0} \tag{27}$$

or:

$$\frac{v}{c} = \sqrt{1-\frac{c}{c_0}} \tag{28}$$

This is the velocity of a particle accelerating in a gradient in c as defined in Eq.(1), or Eq.(2),

Origin of Gravitation

The above, may not seem all that impressive, but does have profound implications, the change in the kinetic energy of a particle is effectuated by the gradient of the velocity of light the same as if the particle is in a gravitational potential.

There is no work done on the particle as the particle enters the field, and thus no energy exchanged, gravity is thus properly not a force, conveys no energy, and does no work. The kinetic mass has increased at the expense of the rest mass. The change in c provides the mechanism by which a conservative gravitational potential effectuates a change in the velocity.

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.

QFT Origin of Gravitation?

This section is a bit of speculation, but indicated by the state of the art.

From the above discussion: **Gravitation reduces to: Mass altering the local velocity of light in its vicinity.**

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 asserted to be interaction between the photons, so the photons that are bouncing back and forth must generate gravitation.

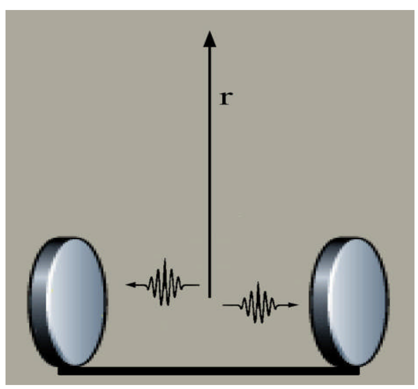

Fig1 *Photons trapped between mirrors of an apparatus increase the mass and thus the gravitational attraction of the apparatus.*

The increase in energy is $h\nu$ so that the mass increase as a result of a trapped photon is:

$$m = \frac{\hbar\omega}{c^2}, \tag{29}$$

And the gravitational potential due to a photon is:

$$\frac{\mu}{r} = \frac{G\hbar\omega}{c^4 r} \tag{30}$$

Putting this into Eq.(1), then gives:

$$c = c_0\left(1 - 2\frac{G\hbar\omega}{c^4 r}\right) \tag{31}$$

or:

$$\Delta c = 2\frac{G\hbar}{c^3 r}\omega \tag{32}$$

Noting that the square of the Planck radius is $G\hbar / c^3$ this can be stated as:

$$\Delta c = 2\frac{r_P^2}{r}\omega \ , \tag{33}$$

which has to be the change in c at a distance r induced by a photon if QFT can induce a change in c equivalent to 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, and 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.

Figure 2

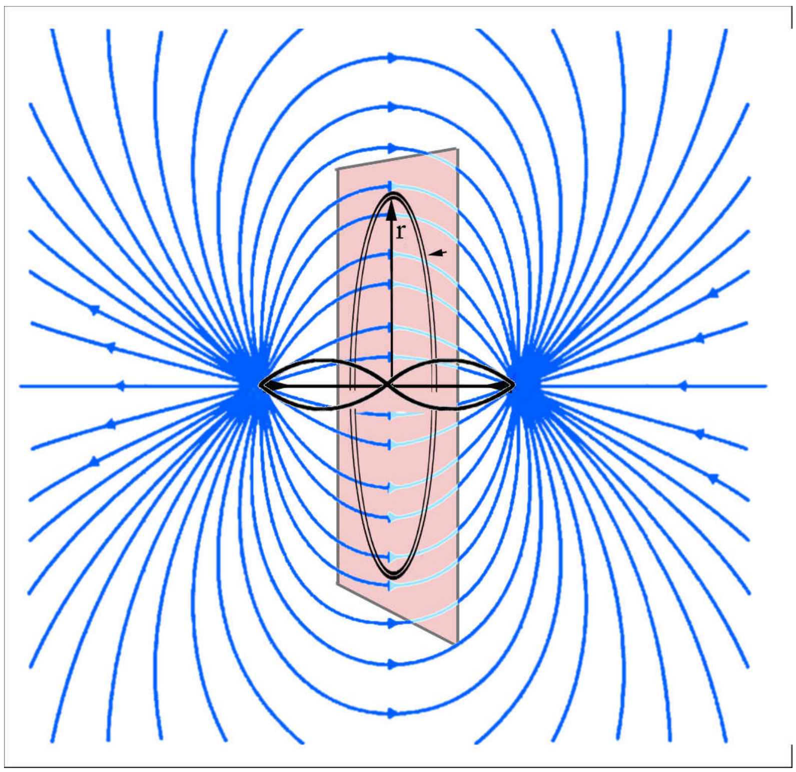

Fig.1 *This illustration shows the path action induced by a pair of oscillating photons.*

From the work of D. Kharzeeva, et.al, [3] 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 particles model being reciprocating photons in a massless box, as asserted here constitutes an intense, highly energetic back and forth motion of photons, orders of magnitude greater than a laser, thus Eq.(33), is not an unreasonable result.

Conclusion

It has been shown that gravitation can be effectuated by a gradient in the speed of light.

If it can be shown by quantum field effects that a photon moving along a path induces a change in the velocity of light c in accordance with Eq.(33), then gravitation can be identified as a gradient in c induced by QFT.

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Appendix I

Physical Model Appearance

The mechanism of containment of the light speed constituents need not be addressed for the purpose of this paper, nothing really requires it. The mathematical mechanisms are the same whether the particles are confined or not, and posing a massless box that contains the particles is as good as any other physical mechanism for the purposes here.

A presumed appearance for particle such as an electron modeled by a pair of trapped opposite photons is not exactly a pair bouncing back and forth. For the simple electron, in the rest frame it is more likely the model is spherical, with a path that is continuous helix with an x, y projection of a figure eight and a projection along the spin axis of a circle.. If the frame of an observer is set to moving toward the particle in the direction of the spin, then the internal wave in the same direction will see a decreased frequency and the internal wave in the direction against the velocity would see an increased frequency. Though technically not, if each of those motions are defined as photons then the center of mass of the two directions would have to be moving toward the observer. Since the direction of the observer's velocity can be arbitrary the defining of what constitutes separation into the forward and backward photons from a continuous energy loop has to do with the fact that the any direction has two quantum values of energy, the same as for spin. Presumably the lack of sufficient spin of the internal constituents prevents escape of the energy as photons.

Obviously complete photons are not the constituents of particles otherwise the particle would disintegrate. Presumably, however the constituents are light speed, such as leptons, quarks, gluons, etc, and are confined with a quantum division of energy divided along the axis of motion.