A Connection between Gravitation, the Velocity of Light, and Quantum Field Effects

D.T. Froedge

Formerly Auburn University
Phys-dtfroedge@glasgow-ky.com

V011715
@ http://www.arxdtf.org

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 having constant energy infalling a gravitational potential, and defined as a pair of trapped photons in a massless box, is accelerated by a gradient in the velocity of light exactly as a particle in a gravitational field [2], and thus, is asserted that gravitation is nothing more than a gradient in c produced by the presence of mass. It is also illustrated that QFT effects that define the total action path of photons could induce an alteration in the velocity of light in the proximity of a photon path [3], and could be the mechanism 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 mass particles being composed of opposite going photons or 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 conservative effects of gravitation became apparent, as the same gradient in c that bends the trajectory of photons can induce the energy in opposite going photons to

transfer from one to the other effectuating an increased velocity of the center of mass without a change in particle energy.

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:

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

follow a trajectory identical to that of a particle in a gravitation field. It is argued then that; if gravitation is "only" a gradient in the velocity of light, the photon would behave exactly the same. There is no need to postulate that gravitation has any other effect on a photon other than a gradient in c.

Work done by this author for a model of particles being standing waves, of a opposite going photons, trapped in a massless box, shows that all the covariant relativistic dynamical properties of a particle are matched by this model [2]. If it is shown then that the same gradient in c as in Eq.(1), induces the same effect as gravitation on the center of mass of the two trapped photons, then it is indicative that gravitation is nothing more than a gradient in the speed of light.

III Four Momentum

A pair of photon with a mass as $m = h\nu / c^2$, (Defining the photon mass has precedents in other publications on photon entrapments[7]), moving along vectors paths in the opposite direction can be described by the null four-momentum in geometric algebra matrix as:

$$\overrightarrow{P_1} = m_1\left(\gamma^k c_k + \gamma^0 c\right), \tag{2}$$

and

$$\overrightarrow{P_2} = m_2\left(-\gamma^k c_k + \gamma^0 c\right) \tag{3}$$

Presuming these two photons are co-located, the square of the sum of the two null vectors is necessarily constant and is:

$$\left(m_1 + m_2\right)^2 - \left(m_1 - m_2\right)^2 = 4m_1m_2 = \ {m_0}^2 \tag{4}$$

The magnitude of each of these null four-momentums is zero by covariance, and the sum of two such moments must be constant. Thus m_0 must be invariant fixed quantity associated with the pair of opposite going photons. If this is defined as a rest mass then it is easy to identify:

$$\left(m_1 + m_2\right), \tag{5}$$

as the total mass.

Factoring the total mass from Eq.(4), gives:

$$\left(m_1 + m_2\right)^2 \left[1 - \frac{\left(m_1 - m_2\right)^2}{\left(m_1 + m_2\right)^2}\right] = {m_0}^2 \tag{6}$$

Noting that:

$$\frac{\left(m_1 - m_2\right)}{\left(m_1 + m_2\right)} \tag{7}$$

is the ratio of the velocity of each photon to the velocity of the center of mass then:

$$\left(m_1 - m_2\right)v_c = \left(m_1 + m_2\right)c \tag{8}$$

This makes Eq.(6), the relativistic energy equation for a mass particle.

$$\left(m_1 + m_2\right)^2 \left[1 - \frac{v^2}{c^2}\right] = {m_0}^2 \tag{9}$$

From the relativistic Lagrangian for a particle in a gravitational field:

$$L = m_0 c^2 = \left(mc^2 + m_0 c^2 \frac{\mu}{r} - m\frac{1}{2}v^2 \right) \tag{10}$$

Rearranging and squaring we have:

$$m^2\left(1-\frac{v^2}{c^2}\right)=m_0^2\left(1-\frac{\mu}{r}\right)^2 \tag{11}$$

The right side of this equation is the relativistic mass, and the left which is independent of velocity is the rest mass as a function of the distance from the gravitating body.

Putting in Eq.(1), into Eq.(11), gives:

$$\left(m_1+m_2\right)^2\left(1-\frac{v^2}{c^2}\right)=m_0^2\frac{c}{c_0} \tag{12}$$

(Note that the right side of Eq.(11), and Eq.(1), are, for the purpose here, equivalent.)

In a locally conservative system the energy of the particle is constant, thus as the particle infalls from infinity the rest mass is equal to the total mass [6]. i.e.:

$$\left(m_1+m_2\right)=m_0 \tag{13}$$

From Eq.(4), the rest mass in terms of the masses of the individual photons is:

$$4m_1m_2 = m_0{}^2\frac{c}{c_0} \tag{14}$$

Eliminating m_2 in Eq.(14), by use of Eq.(13), gives:

$$4m_1\left(m_0 - m_1\right) = {m_0}^2 \frac{c}{c_0} \tag{15}$$

Solving for the mass of the mass of one of the single photons, m_1 gives:

$$m_1^2 - m_1 m_0 + \frac{1}{4}{m_0}^2 \frac{c}{c_0} = 0, \tag{16}$$

The quadratic solution of this is:

$$m_1 = \frac{1}{2} m_{01}\left(1 \pm \sqrt{1 - \frac{c}{c_0}}\right) \tag{17}$$

Since the initial mass of the total particle m_{01}, is twice the initial mass of the m_1 photon then the mass change in the internal photon is:

$$\frac{m_{01} - m_1}{m_{01}} = \pm\sqrt{\frac{c_0 - c}{c_0}}, \tag{18}$$

or:

$$\frac{\Delta m_{1,2}}{m_{01}} = \pm\sqrt{\frac{\Delta c}{c_0}} \tag{19}$$

Eq.(13), is the relation between the constant total mass, and the initial rest mass. Eq.(19), is the moving of the energy from one internal photon to another inside the particle as a function of the change in the speed of light. It represents a change in the velocity of the center of mass of the particle without a change in energy. The in-going photon has the + sign and the outgoing is the – sign.

Origin of Gravitation

The above expression, Eq.(19), 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 potential, and thus no energy exchanged, thus gravity is 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 of a particle without contributing energy.

The effect of gravitation on a particle is thus, induced in the particle by the gradient in the speed of light. Newton's apple falls not because of a decrease in energy, but because the speed of light at the branch is higher than the speed of light at the ground.

It has long been known that a photon obeying Fermat's principle, with a speed defined by Eq.(1), exhibits the proper trajectory [1], and from the above development the same change in c induces the proper gravitational motion in particles. The concept of **gravitation thus reduces to: mass altering the local velocity of light in its vicinity.**

It is asserted here that Eq.(19), represents a cause-effect relation between particle motion and the speed of light **and is the mechanism that effects gravitation.**

QFT Origin of Gravitation?

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

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.

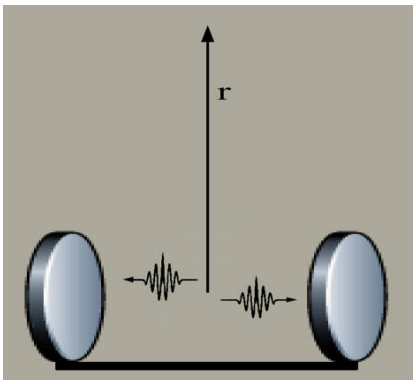

Fig1 *Photons trapped between mirrors of an apparatus increase the mass and thus the gravitational attraction of the apparatus.*

The increase in energy is hv so that the mass increase as a result of a trapped photon is:

$$m = \frac{\hbar\omega}{c^2}, \tag{20}$$

And the gravitational potential due to a photon is:

$$\frac{\mu}{r} = \frac{G\hbar\omega}{c^4 r} \tag{21}$$

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

$$c = c_0\left(1 - 2\frac{G\hbar\omega}{c^4 r}\right) \tag{22}$$

or:

$$\Delta c = 2\frac{G\hbar}{c^3 r}\omega \tag{23}$$

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

$$\Delta c = 2\frac{r_P^2}{r}\omega, \tag{24}$$

which has to be the change in c at a distance r induced by a photon.

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

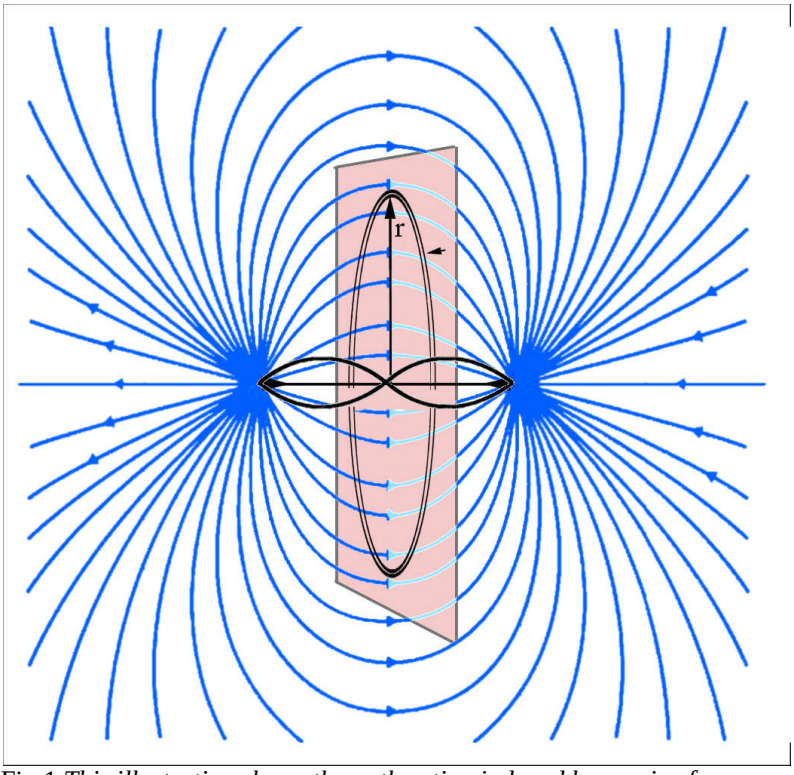

Fig.1 *This illustration shows the path action induced by a pair of oscillating photons.*

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 beam of photons, orders of magnitude greater than a laser, thus Eq.(24), is asserted not to be an unreasonable result.

Conclusion

It has been shown that gravitation can be defined as 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.(24), then gravitation can be identified as a gradient in c induced by QFT.

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