The Concept of Mass as Interfering Photons, and the Originating Mechanism of Gravitation

D.T. Froedge

Formerly Auburn University

Phys-dtfroedge@glasgow-ky.com

V122014

Abstract

For most purposes in physics the concept of mass particles and photons are treated as though they are completely separate and distinct entities having little connection accept through collision interactions. This paper explores the concept of a mass particle being viewed as a pair of trapped photons in a mass-less box demonstrating proper relativistic dynamics, Lorentz covariance, and gravitational properties. The mechanism of trapping of the photons in the particle is not herein defined; however the lack of sufficient spin to properly constitute a photon would be a containment factor. Although this presentation is primarily focused on electrons, presumably it would be applicable to any particle with primary constituents consisting of particles that travel at light speed along null vectors. This illustrates the concept of the equivalence of mass and energy, and why mass velocity cannot exceed the speed of light.

It is asserted and illustrated; that the gravitational effect on particles and photons can be can be effectuated by a simple gradient in the speed of light. This allows the assertion that gravitation is a local alteration of c generated by the presence of matter and could be a QFT effect.

Introduction

The special theory of relative, through the Lorentz transformations, yields the energy velocity relation for photons and particles, one through a shift in frequency, the other through a shift in mass. Considering these particles as different forms of energy, however, bestows a distinction between the forms of energy that is possibly unwarranted. The Lorentz transforms applied to a pair of localized photons can be shown to yield the same results as the transforms applied to a mass particle. A photon constrained to a point as the result of annihilation by the emission of a virtual photon by its opposite going companion, is just the three-dimensional interference of two photons that are somehow spatially constrained to their center of mass, and the properties match very well the dynamics of real mass particles. One may not subscribe to the details of this, but it does give a useful perspective regarding mass, rest mass, energy, and gravitation.

I Momentum

Consider a thought experiment, in which two photons are placed in a perfectly reflecting mass-less container. Presuming that if the two photons are not aligned in the given frame, there has to be some sub-light speed frame of reference, in which the photons are aligned, and in opposite directions, as well as having equal energy and frequency. This frame is thus the rest frame for the center of mass for the two photons

Using the momentum for the photons to be:

$$\vec{P} = M\vec{c} = \left[\frac{h\nu}{c}\right]\frac{\vec{c}}{c} \quad , \tag{1}$$

where we can designate an energy equivalent "mass " for the photon to be $M = h\nu / c^2$. The momentum of the container with respect to a moving frame of reference with velocity v is then:

$$\vec{P} = \left(M_1 + M_2\right)\vec{v} \, . \tag{2}$$

From the perspective of the individual opposite-going photons the momentum is:

$$P = P_1 + P_2 = \frac{h\nu_1 - h\nu_2}{c} = \frac{h\Delta\nu}{c} = \frac{h}{\lambda_B} \, . \tag{3}$$

The wavelength of the difference in the frequency here, or the "beat" frequency, is just the simple deBroglie wavelength.

The total energy, which is the sum of the energy of the photons, and thus sum of the frequencies, yields the simple Compton wavelength:

$$\frac{E_1 + E_2}{c} = \frac{h\nu_1 + h\nu_2}{c} = \frac{h}{\lambda_C} \, . \tag{4}$$

Using the above noted designation for "mass" we can write for the total "mass":

$$M_T = \left(h\nu_1 + h\nu_2\right) / c^2 \, , \tag{5}$$

Defining a mass for photons is not a unique concept and has been used by others [4]

The momentum is then:

$$P = M_T v = (M_1 - M_2)c. \tag{6}$$

Solving for velocity:

$$\frac{v}{c} = \frac{(M_1 - M_2)}{(M_1 + M_2)}. \tag{7}$$

This is notably just the velocity for the center of mass for two opposite going photons.

Since for a particle:

$$M_0{}^2 = M^2\left[1 - \left(\frac{v}{c}\right)^2\right]. \tag{8}$$

Putting in M_T, and v/c and solving gives:

$$M_0{}^2 = (M_1 + M_2)^2 - (M_1 - M_2)^2 = 4M_1M_2. \tag{9}$$

So the square of the rest mass of the particle is four times the product of the "mass" of the individual photons.

II Doppler

This same picture can be viewed from the standpoint of the Doppler shift, on the transformation of velocity coordinates for the two photons.

The relativistic Doppler shift of the photons from one velocity frame to another is:

$$\nu_1{}' = \nu_1\left[\frac{1 - \frac{v}{c}}{1 + \frac{v}{c}}\right] \qquad \nu_2{}' = \nu_2\left[\frac{1 + \frac{v}{c}}{1 - \frac{v}{c}}\right], \tag{10}$$

or using the above noted conventions for energy equivalent mass:

$$M_1{}' = M_1\left[\frac{1 - \frac{v}{c}}{1 + \frac{v}{c}}\right] \qquad M_2{}' = M_2\left[\frac{1 + \frac{v}{c}}{1 - \frac{v}{c}}\right], \tag{11}$$

Multiplying the two relations gives:

$$M_1'M_2' = M_1M_2 = \text{constant}\,, \tag{12}$$

and simple math gets:

$$M_1M_2 = \frac{\left(M_1 + M_2\right)^2 - \left(M_1 - M_2\right)^2}{4}\,, \tag{13}$$

and:

$$\left[1 - \left(\frac{v}{c}\right)^2\right] = \frac{4M_1M_2}{\left(M_1 + M_2\right)^2} = \frac{M_0^2}{M^2}\,, \tag{14}$$

which is the same as the above relation, found for conformance to relativistic kinematics, the model thus transforms properly.

III Four Momentum

Defining the photon mass as in Eq.(5), moving along null vectors in the opposite direction the null four-momentum of two opposite going photons previously defined for the particle in the geometric algebra matrix form is:

$$\overrightarrow{P_1} = m_1\left(\gamma^k c_k + \gamma^0 c\right) \tag{15}$$

$$\overrightarrow{P_2} = m_2\left(-\gamma^k c_k + \gamma^0 c\right) \tag{16}$$

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

$$\left(m_1 + m_2\right)^2 - \left(m_1 - m_2\right)^2 = 4m_1m_2 = {m_0}^2 \tag{17}$$

The magnitude of each of these null four-momentum is zero for 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:

$$(m_1 + m_2)^2 = m_T , \tag{18}$$

as the total mass. Factoring the total mass from Eq.(17), gives:

$$(m_1 + m_2)^2 \left[1 - \frac{(m_1 - m_2)^2}{(m_1 + m_2)^2} \right] = m_0^{\ 2} \tag{19}$$

Noting that:

$$\frac{(m_1 - m_2)}{(m_1 + m_2)} \tag{20}$$

is the ratio of the velocity of each photon to the velocity of the center of mass.

$$(m_1 - m_2) v_c = (m_1 + m_2) c \tag{21}$$

This makes Eq.(19), the relativistic energy equation for a mass particle.

$$m^2 \left[1 - \frac{v^2}{c^2} \right] = m_0^{\ 2} \tag{22}$$

It can thus be asserted that two light speed photons, or other confined zero rest mass particles, have the property of a mass particle, with mass energy equivalent to the energy of the individual particles.

IV Electron-Positron Annihilation

The above relations give the proper Mechanical result for the electron-positron annihilation. That is, as two particles merge the velocity of each increase to c and become two opposite going photons. In a simplistic description as the pair merge, the left going photons in the two particles, and the right going photons in the two particles, constructively and destructively interfere giving two opposite going free photons.

V Gravitation

The paper [1] on a theory of gravitation with locally conserved energy shows a theory in which the total energy of a particle in a gravitational potential is not changed. The kinetic velocity increases at the expense of the rest energy but the total energy remains the same. The dependence of the rest mass on the gravitational potential is:

$$m_{L0}^2 = m_0^2\left(1-\frac{\mu}{r}\right)^2 , \tag{23}$$

where m_0 is the rest mass of a particle in free space and m_{L0} is the local rest mass of that particle in the gravitational potential at a distance r. putting Eq.(23), into Eq.(19), gives:

$$(m_1+m_2)^2\left[1-\frac{(m_1-m_2)^2}{(m_1+m_2)^2}\right] = m_0{}^2\left(1-\frac{\mu}{r}\right)^2 \tag{24}$$

.

or

$$M^2\left(1-\frac{v^2}{c^2}\right) = M_0^2\left(1-\frac{\mu}{r}\right)^2 \tag{25}$$

From that paper and [2] the local speed of light in a locally conserved gravitational field is deduced from Eq.(23), to be:

$$c = c_0\left(1-\frac{\mu}{r}\right)^2 \tag{26}$$

c_0 is the speed of light in free space and c is the local value. This is slightly different from the GR equivalent expression for flat space which is is just the first two terms, [4]. Inserting this into Eq.(25), gives:

$$\left(m_1+m_2\right)^2\left(1-\frac{v^2}{c^2}\right)=m_0^2\frac{c}{c_0} \tag{27}$$

If a particle is falling in a conservative field the total energy remains constant, and if the initial value of the velocity is zero, then the mass remains equal to the initial rest mass. i.e.:

$$\left(m_1+m_2\right)=m_0 \tag{28}$$

From Eq.(17), the rest mass in terms of the masses of the individual photons is:

$$4m_1m_2=m_0{}^2\frac{c}{c_0} \tag{29}$$

Eliminating m_2 in Eq., by use of Eq., gives:

$$4m_1\left(m_0-m_1\right)=m_0{}^2\frac{c}{c_0} \tag{30}$$

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

$$m_1^2-m_1m_0+\frac{1}{4}m_0{}^2\frac{c}{c_0}=0, \tag{31}$$

The quadratic solution of this is:

$$m_1=\frac{1}{2}m_{01}\left(1\pm\sqrt{1-\frac{c}{c_0}}\right) \tag{32}$$

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:

$$\frac{m_{01}-m_1}{m_{01}}=\pm\sqrt{\frac{c_0-c}{c_0}}, \tag{33}$$

or:

$$\frac{\Delta m_{1,2}}{m_{01}}=\pm\sqrt{\frac{\Delta c}{c_0}} \tag{34}$$

Eq.(25), is the relation between the constant total mass, which is the same as the rest mass. Eq.(34), is the change of the mass from one internal photon to another inside the particle as a function of the change in the speed of light. From Eq.(24), it is clear that it represents a change in the velocity 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.(34), 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, but the total energy is not changed.

Conceptually, this seems simple accept that there is no work done on the particle as the particle enters the potential, no energy exchanged, and thus gravity is not a force at all. The velocity 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.(26), exhibits the proper trajectory [3], and from this development the same change in c induces the proper gravitational motion in particles. The concept of **gravitation thus reduces to the presence of a gravitating mass, altering the velocity of light in its vicinity, and is not a force at all.**

It is asserted that Eq.(34), represents a cause-effect relation between particle motion and the speed of light that **constitutes the origin of gravitation.**

Implications

If there is no energy exchanged by gravitating particles, then there is, as pointed out earlier, no quantization of gravitational energy, and no gravitons or gravitational radiation. This is consistent with the fact that despite exceptional effort there has been no detection of gravitational radiation, and from this development it would be difficult to envision how a gradient in c could be propagated.

It is well known and experimentally verified, however that gravitating masses do lose orbital energy. If it is as asserted here, not possible for gravitational waves to carry the energy away from the system, then the search for gravitationally transmitted energy should be conducted in the electromagnetic spectrum.

QFT Origin of Gravitation?

Consider a thought experiment in which here is a cavity with opposing mirrors. If photons are injected and trapped between the mirrors, from the conservation of energy, the mass of the apparatus has increased. It is not without precedent that photons oscillating in a cavity are noted as having mass [4]. The photons thus having mass, must originate gravitation, but being just photons bouncing back and forth from one mirror to another in a cavity having no ascribed interaction, how does this result?

It has been asserted here that gravity is generated by an alteration of the speed of light. The possible mechanism for this in the vicinity of oscillating photons is by mechanisms of quantum electrodynamics. From the work of D. Kharzeeva, et.al, [5] it is shown that for an intense laser beam the QFT effects related to electron–positron loops induce vacuum “self-focusing” which can be interpreted as a slowing down in the vacuum speed of light in the vicinity of the beam. The photons reflecting back and forth in the here discussed particle, constitute an intense repetitive beam orders of magnitude greater than a laser, and as such have path action that can find the photons having a path probability far outside the trapped zone [6]. It is asserted that this slow down of c in proximity of oscillating light speed particles, could be the mechanism that generates the effect of gravitation between massive particles.

“If” the reduction in c in the vicinity of photons oscillating in a massless box can be found by methods of QFT to be:

$$c = c_0\left(1 - G\frac{\hbar\omega}{c^4 r}\right)^2 \tag{35}$$

then the gravitational constant is calculated, and the riddle of gravitation is solved.

It could be argued that the photons are not observed outside the massless box, and thus unable to affect c, but as in the case of the Aharonov–Bohm effect the underlying coupling of the electromagnetic potential with the complex phase illustrates the effect of the probability path action of a particle is non local and present outside the local area even if the particle presence is shielded [7].

Conclusion

The concurring points of similarity of the opposite going photons in a massless box model and the particles are consistent with:

1) The deBroglie wavelength.
2) The Compton wavelength
3) The zero velocity rest mass
4) The total energy
5) Velocity transforms
6) Local conservation of Gravitation

Using a reflecting container is somewhat artificial, but as in the case of the transformation of momentum between velocity frames, the gross mechanics do not depend on the internal structure. All of the real internal constraints such as spin, energy, etc, which may be important to the actual mechanics of holding a particle together are not necessary to understand the concept. The dynamics of the center of mass of the two photons is the same whether the photons are confined or not, and it is easy to understand from this model why mass particles do not exceed the speed of light. A mechanism for producing the effects of gravitation on such a particle has been offered that could lie within the scope of the effects generated by QFT.

http://www.arxdtf.org/

References:

1. DT Froedge, Scalar Gravitational Theory with Variable Rest Mass ,V020914, http://www.arxdtf.org/css/grav2a.pdf

2. DT Froedge, The Velocity of Light in a Locally Conserved Gravitational Field, V101914, http://www.arxdtf.org/css/velocity.pdf

3. Roger Blandford, Kip S. Thorne, in Applications of Classical Physics, (in preparation, 2004), Chapter 26 http://www.pma.caltech.edu/Courses/ph136/yr2002/chap26/0226.1.pdf

4. Alex KruchkovBose-Einstein condensation of light in a cavity http://arxiv.org/pdf/1401.0520v2.pdf

5. D. Kharzeeva, K. Tuchinb, Vacuum Self–Focussing of Fery Intense Laser Beams, arXiv:hep-ph/0611133v2

6. Feynman, Hibbs, 1965, Quantum Mechanics and Path Integrals McGraw-Hill pp 24,

7. Chambers, R.G. (1960). "Shift of an Electron Interference Pattern by Enclosed Magnetic Flux". *Physical Review Letters* **5**: 3–5.Bibcode:1960PhRvL...5....3C (http://adsabs.harvard.edu/abs/1960PhRvL...5....3C)