DETERMINATION OF THE PHOTON MASS FROM COMPTON SCATTERING.

by

M. W. Evans and H. Eckardt,

Civil List and A.I.A.S

(www.webarchive.org.uk, www.aias.us, www.atomicprecision.com, www.upitec.org,

www.et3m.net)

ABSTRACT

Considerations of Compton scattering lead to a photon mass of the order of the electron mass. It is shown that a photon mass of this order travels at c for all practical purposes, and is consistent with the photoelectric effect. It is shown that the classical relativistic theory of particle scattering violates conservation of energy at the most fundamental level, so violates conservation of energy at the quantum electrodynamical level. A new interpretation of mass is suggested in terms of the R parameter of the ECE wave equation, and the Proca equation derived directly from the tetrad postulate.

UFT 244

1. INTRODUCTION

Finite photon mass is implied by the combination of special relativity and the old quantum theory known as the de Broglie Einstein equations {1 - 10}. These were developed extensively in UFT158 to UFT171 of this series, in which several papers have been dedicated to the determination of photon mass. These papers are grouped and reviewed in UFT200 on www.aias.us. This paper, UFT244, is a development of UFT158 to UFT171 and deals with aspects of photon mass. In Section 2, the photon mass is derived straightforwardly from the Compton effect by using the fact that the electron mass is known with precision from standards laboratories, and by using the methods of UFT158 to UFT171 to derive the photon mass. This is the opposite course to the well known theory by Compton in which he derived the electron mass by assuming a zero photon mass. This assumption brings the Compton theory into conflict with the fundamentals of physics because zero photon mass results in an unphysical radiation theory in which the time-like and longitudinal states are missing. Only the transverse states are present if the photon mass is zero. A zero photon mass leads to great difficulties {11} in canonical quantization and also leads to the unphysical E(2) little group of the Poincare group. Zero photon mass leads to numerous refutations of the Einsteinian theory of light deflection by gravitation as discussed in UFT150 to UFT155 and in the review paper UFT200. It is found in Section 2 that the photon mass is of the order of the electron mass. There are two solutions possible for photon mass, one is always real, the other may be imaginary. If it is assumed that the real solution is the physical solution it is of the order of the photon mass, and orders of magnitude heavier than thought. It is found from the same theory that the photon travels at c for all practical purposes, and it is shown that this order of photon mass is compatible with the theory of the photoelectric effect.

However the same theory, based on the de Broglie Einstein equations for equal

mass scattering, is found to violate conservation of energy at the most fundamental level, so by implication it violates conservation of energy at the quantum electrodynamical level. This result means that the de Broglie Einstein equations are not self consistent. This fact was demonstrated in several ways in UFT158 to UFT171, reviewed in UFT200. This self inconsistency cannot be remedied by theories based on a Higgs mechanism, so the Higgs boson is de facto refuted by violation of conservation of energy. The very existence of photon mass and the B(3) field {1 - 10} refutes the Higgs boson immediately, because the latter is incorrectly asserted to be the origin of mass. This assertion violates general relativity, which gives mass to every particle via ECE theory. The heavy hadron and LEP experiments are ones based on electron positron equal mass scattering. A new interpretation is needed of particle scattering theory, one based on ECE theory and the curvature R of the ECE wave equation. Section 3 derives the Proca equation directly from the tetrad postulate of Cartan geometry in order to emphasize the link between Cartan geometry and photon mass. The basics of general relativity lead directly to photon mass, as first shown in early papers of this series. In Section 3 a new and direct method is developed of deriving all aspects of Proca theory from geometry, given the ECE hypothesis. The Proca equation immediately refutes the U(1) gauge invariance of the Higgs boson theory.

Finally in Section 4 the numerical methods of deriving the photon mass are described, and the photon mass tabulated for various scattering angles. Some discussion is given of the meaning of imaginary mass. The latter can be understood in terms of R theory or in terms of superluminal propagation.

2. DERIVATION OF THE PHOTON MASS.

The theory of Compton scattering with finite photon mass was first given in UFT158 to UFT171 and the notation of those papers is used here. The relativistic classical

conservation of energy equation is:

$$\gamma m_1 c^2 + m_2 c^2 = \gamma' m_1 c^2 + \gamma'' m_2 c^2 \quad -(1)$$

where m_1 is the photon mass, m_2 the electron mass, and where the Lorentz factors

are defined by the velocities as usual. The photon mass is given by the equation first derived

in UFT160:

$$m_1^2 = \left(\frac{\hbar}{c^2}\right)^2 \left[\frac{1}{2a}\left(-b \pm (b^2 - 4ac')^{1/2}\right)\right] \quad -(2)$$

$$a = 1 - \cos^2\theta$$
$$b = (\omega'^2 + \omega^2)\cos^2\theta - 2A$$
$$A = \omega\omega' - x_2(\omega - \omega')$$
$$c' = A^2 - \omega^2\omega'^2\cos^2\theta,$$

where γ' is the scattered gamma ray frequency, γ the incident gamma ray frequency,

and where:

$$x_2 = \frac{m_2 c^2}{\hbar}. \quad -(3)$$

Here $\hbar$ is the reduced Planck constant and c the speed of light in vacuo. The scattering angle

is θ. The experimental data on Compton scattering used in this section is that of ref.

{12}. The electron mass is found in any good textbook or tables and is taken to be:

$$m_2 = 9.10953 \times 10^{-31} \text{ kg} \quad -(4)$$

so:

$$x_2 = 7.76343 \times 10^{20} \text{ rad s}^{-1}. \quad -(5)$$

The two solutions of Eq. (2) for photon mass are given in Section 4. One solution is

always real valued, and this root is usually taken to be the physical value of the mass of the photon. It varies with scattering angle but is always close to the electron mass. The photon in this method is much heavier than previously thought. The other solution can be imaginary valued, as usually this solution would be discarded as unphysical. However, R theory means that a real valued curvature can be found as follows:

$$R = m m^* \left(\frac{c}{\hbar}\right)^2 \quad - (6)$$

where * denotes complex conjugate. It is shown in Section 4 that an imaginary valued mass can be interpreted in terms of superluminal propagation.

The velocity of the photon after it has been scattered from a stationary electron is given by the de Broglie equation:

$$\gamma' m_1 c^2 = \hbar \omega' \quad - (7)$$

and is c for all practical purposes for all scattering angles (Section 4). A photon as heavy as the electron does not conflict therefore with the results of the Michelson Morley experiment but on a cosmological scale a photon as heavy as this would easily account for any mass discrepancy claimed at present to be due to "dark matter". Photon mass physics differs fundamentally from standard physics as explained in comprehensive detail {1 - 10} in the five volumes for example of "The Enigmatic Photon". A photon as heavy as an electron means that previous attempts at measuring photon mass have to be re assessed. For example a theory has to be developed to make the precision of the Coulomb law compatible with a photon as heavy as an electron, meaning that the Yukawa potential in electrodynamics must be abandoned or redeveloped.

However the theory of the photoelectric effect can be made compatible with a heavy photon as follows. Consider a heavy photon colliding with a static electron. The

energy conservation equation is:

$$\gamma m_0 c^2 + m_2 c^2 = \gamma' m_0 c^2 + \gamma'' m_2 c^2. - (8)$$

The de Broglie equation can be used as follows:

$$\hbar \omega = \gamma m_0 c^2 \quad - (9)$$

$$\hbar \omega'' = \gamma'' m_2 c^2. \quad - (10)$$

If the photon is stopped by the collision then the conservation of energy equation is:

$$\hbar \omega + m_2 c^2 = m_0 c^2 + \hbar \omega'' \quad - (11)$$

where m_0 is the rest mass of the photon. This concept does not exist in the standard model of physics. So:

$$m_0 = m_2 + \frac{\hbar}{c^2} (\omega - \omega''). - (12)$$

If for the sake of argument the masses of the photon and electron are the same then:

$$m_0 = m_2 \quad - (13)$$

and

$$\omega = \omega'' \quad - (14)$$

i.e. all the energy of the photon is transferred to the electron.

If:

$$\omega \neq \omega'' \quad - (15)$$

then:

$$\hbar(\omega - \omega'') = \Phi + (m_0 - m_2) c^2 \quad = \Phi$$

$$\quad - (16)$$

where $\underline{\Phi}$ is the binding energy of the photoelectric effect. From Eq. (16):

$$\hbar\omega + m_2 c^2 = m_0 c^2 + \hbar\omega'' + \underline{\Phi} \quad -(17)$$

i.e.

$$\hbar\omega = \hbar\omega'' + \underline{\Phi} = E + \underline{\Phi} \quad -(18)$$

or

$$E = \hbar\omega - \underline{\Phi} \quad -(19)$$

which is the usual equation of the photoelectric effect, Q. E. D. The heavy photon does not

disappear and transfers its energy to the electron, and the heavy photon is compatible with

the photoelectric effect.

However, a major fundamental problem for standard physics emerges from the

consideration of equal mass Compton scattering as described in UFT160. In this section it is

seen that equal mass Compton scattering violates conservation of energy. Consider a particle

of mass m colliding with an initially static particle of mass m. If the equations of

conservation of energy and momentum are assumed to be true initially, they can be solved

simultaneously to give:

$$x^2 + \left(\omega^2 - x^2\right)^{1/2}\left(\omega'^2 - x^2\right)^{1/2} \cos\theta = \omega\omega' - \left(\omega - \omega'\right)x$$
$$-(20)$$

where:

$$\omega_0 = x = \frac{mc^2}{\hbar} \quad -(21)$$

is the rest frequency of the particle of mass m, ω' the scattered frequency and ω the

incoming frequency of particle m colliding with an initially static particle of mass m. The

scattering angle is θ, and from Eq. (26):

$$\cos^2\theta = \frac{\omega_0^2 + \omega_0(\omega - \omega') - \omega\omega'}{\omega_0^2 - \omega_0(\omega - \omega') - \omega\omega'}. \quad -(22)$$

In order that:

$$0 \leq \cos^2\theta \leq 1 \quad -(23)$$

then:

$$\omega < \omega'. \quad -(24)$$

The de Broglie equation means that the collision can be described by:

$$\hbar\omega + \hbar\omega_0 = \hbar\omega' + \hbar\omega'' \quad -(25)$$

so:

$$\omega + \omega_0 = \omega' + \omega'' \quad -(26)$$

and:

$$\omega - \omega' = \omega_0 - \omega'' \quad -(27)$$

Therefore:

$$\omega_0 < \omega''. \quad -(28)$$

From Eqs. (24) and (28):

$$\omega + \omega_0 < \omega' + \omega''. \quad -(29)$$

However the initial conservation of energy equation is (26), so the theory violates conservation of energy and contradicts itself. This is a disaster for particle scattering theory because violation of conservation of energy occurs at the fundamental level. Quantum electrodynamics and string theory, or Higgs boson theory of particle scattering are

invalidated.

If two particles of mass m_1 and m_2 collide and both are moving, the initial conservation of energy equation is:

$$\gamma m_1 c^2 + \gamma_2 m_2 c^2 = \gamma' m_1 c^2 + \gamma'' m_2 c^2 \quad - (30)$$

i.e.

$$\hbar\omega + \gamma_2 m_2 c^2 = \hbar\omega' + \hbar\omega'' \quad - (31)$$

Define:

$$x_2 = \gamma_2 m_2 c^2 / \hbar \quad - (32)$$

then:

$$x_2 := \omega_2 = \omega' + \omega'' - \omega \quad - (33)$$

The equation of conservation of momentum is:

$$\underline{p} = \underline{p}_1 + \underline{p}_2 = \underline{p}' + \underline{p}'' \quad - (34)$$

Solving Eqs. (30) and (34) simultaneously leads to:

$$x_2 (\omega - \omega') = \omega\omega' - \left(x_1^2 + (\omega^2 - x_1^2)^{1/2} (\omega'^2 - x_1^2)^{1/2} \cos\theta \right) \quad - (35)$$

For equal mass scattering:

$$\gamma_2 x (\omega - \omega') = \omega\omega' - \left(x^2 + (\omega^2 - x^2)^{1/2} (\omega'^2 - x^2)^{1/2} \cos\theta \right) - (36)$$

where:

$$x = mc^2 / \hbar \quad - (37)$$

By definition:

$$\gamma_2 = \left(1 - \frac{v^2}{c^2}\right)^{-1/2} - (38)$$

so:

$$\left(\omega^2 - x^2\right)^{1/2}\left(\omega'^2 - x^2\right)^{1/2}\cos\theta = \omega\omega' - (\omega - \omega')\left(1 - \frac{v^2}{c^2}\right)^{-1/2}x - x^2$$
$$- (39)$$

For:

$$v \ll c \quad - (40)$$

then:

$$\left(1 - \frac{v^2}{c^2}\right)^{-1/2} \sim 1 + \frac{1}{2}\frac{v^2}{c^2} \quad - (41)$$

so Eq. (39) is approximated by:

$$\left(\omega^2 - x^2\right)^{1/2}\left(\omega'^2 - x^2\right)^{1/2}\cos\theta = -\left(\left(x - \omega'\right)(x + \omega) + \frac{1}{2}\frac{v^2}{c^2}x(\omega - \omega')\right)$$
$$- (42)$$

Therefore:

$$(\omega - x)(\omega + x)(\omega' - x)(\omega' + x)\cos^2\theta$$
$$= (x - \omega')^2(x + \omega)^2 + \frac{v^2}{c^2}x(\omega - \omega')(x - \omega')(x + \omega) + \frac{1}{4}\frac{v^4}{c^4}x^2(\omega - \omega')^2$$
$$- (43)$$

To order $(v/c)^2$:

$$\cos^2\theta = \frac{x^2 + x(\omega - \omega')(1 + v^2/c^2) - \omega\omega'}{x^2 - x(\omega - \omega') - \omega\omega'} \quad - (44)$$

However:

$$0 \leq \cos^2\theta \leq 1 \quad - (45)$$

so:

$$(\omega - \omega')\left(1 + \frac{v^2}{c^2}\right) < -(\omega - \omega') \quad - (46)$$

i. e.:

$$\omega < \omega'. \quad - (47)$$

The conservation of energy equation (30) is:

$$\omega + \omega_2 = \omega' + \omega'' \quad - (48)$$

so:

$$\omega' - \omega = \omega_2 - \omega''. \quad - (49)$$

From Eqs. (47) and (49):

$$\omega_2 < \omega''. \quad - (50)$$

Add Eqs. (47) and (50)

$$\omega + \omega_2 < \omega' + \omega'' \quad - (51)$$

so conservation of energy is again violated at the fundamental level and the whole of particle

scattering theory is refuted, including Higgs boson theory.

3. DERIVATION OF THE PROCA EQUATION.

The Proca equation is the fundamental equation of photon mass theory and was

derived and generalized in early papers of this series from Cartan geometry {1 - 10}. In thid

section it is derived in a few lines from the foundational tetrad postulate of Cartan geometry.

Note carefully that the tetrad postulate always gives a finite photon mass in ECE theory.

Consider the tetrad posulate:

$$D_\mu q^a_\nu = \partial_\mu q^a_\nu + \omega^a_{\mu b} q^b_\nu - \Gamma^\lambda_{\mu\nu} q^a_\lambda = 0 \quad - (52)$$

where q^a_ν is the Cartan tetrad, $\omega^a_{\mu b}$ the Cartan spin connection and $\Gamma^\lambda_{\mu\nu}$ the gamma connection. Define:

$$\omega^a_{\mu\nu} = \omega^a_{\mu b} q^b_\nu \quad - (53)$$

$$\Gamma^a_{\mu\nu} = \Gamma^\lambda_{\mu\nu} q^a_\lambda \quad - (54)$$

then:

$$\partial_\mu q^a_\nu = \Gamma^a_{\mu\nu} - \omega^a_{\mu\nu} := \Omega^a_{\mu\nu}. \quad - (55)$$

Differentiate both sides:

$$\partial^\mu \partial_\mu q^a_\nu = \Box q^a_\nu = \partial^\mu \Omega^a_{\mu\nu} \quad - (56)$$

and define:

$$\partial^\mu \Omega^a_{\mu\nu} := -R q^a_\nu \quad - (57)$$

to find the ECE wave equation {1 - 10}:

$$\left(\Box + R \right) q^a_\nu = 0 \quad - (58)$$

and the equation:

$$\partial^\mu \Omega^a_{\mu\nu} + R q^a_\nu = 0 \quad - (59)$$

where the curvature R is:

$$R = -q^\nu_a \partial^\mu \Omega^a_{\mu\nu} \quad - (60)$$

Now use the ECE postulate {1 - 10}:

$$A^a_{\nu} = A^{(0)} q^a_{\nu} \quad - (61)$$

and define the electromagnetic field as:

$$F^a_{\mu\nu} = A^{(0)} \Omega^a_{\mu\nu} \quad - (62)$$

to find:

$$\left(\Box + R \right) A^a_{\mu} = 0 \quad - (63)$$

and:

$$\partial^\mu F^a_{\mu\nu} + R A^a_{\nu} = 0 \quad - (64)$$

These are the two Proca equations, Q.E.D.

The photon mass m is defined by the curvature:

$$R = \left(\frac{mc}{\hbar} \right)^2 \quad - (65)$$

Therefore:

$$\left(\Box + \left(\frac{mc}{\hbar} \right)^2 \right) A^a_{\mu} = 0 \quad - (66)$$

and

$$\partial^\mu F^a_{\mu\nu} + \left(\frac{mc}{\hbar} \right)^2 A^a_{\nu} = 0 \quad - (67)$$

For each state of polarization a these are the Proca equations of the mid thirties. They are not

U(1) gauge invariant and refute Higgs boson theory immediately, because Higgs boson

theory is U(1) gauge invariant. Eq. (62) is a new postulate of ECE theory in which the

electromagnetic field is defined by the connection $\Omega^a{}_{\mu\nu}$. By antisymmetry:

$$F^a{}_{\mu\nu} = -F^a{}_{\nu\mu} \quad - (68)$$

and from the first Cartan structure equation:

$$T^a{}_{\mu\nu} = \partial_\mu q^a{}_\nu - \partial_\nu q^a{}_\mu + \omega^a{}_{\mu\nu} - \omega^a{}_{\nu\mu} \quad - (69)$$

The fundamental postulates of ECE theory are:

$$A^a{}_\mu = A^{(0)} q^a{}_\mu \quad - (70)$$

$$F^a{}_{\mu\nu} = A^{(0)} T^a{}_{\mu\nu} \quad - (71)$$

so:

$$F^a{}_{\mu\nu} = \partial_\mu A^a{}_\nu - \partial_\nu A^a{}_\mu + A^{(0)}\left(\omega^a{}_{\mu\nu} - \omega^a{}_{\nu\mu}\right) = A^{(0)}\left(\Gamma^a{}_{\mu\nu} - \Gamma^a{}_{\nu\mu}\right).$$
$$- (72)$$

By antisymmetry in Eq. (72):

$$F^a{}_{\mu\nu} = 2\left(\partial_\mu A^a{}_\nu + A^{(0)}\omega^a{}_{\mu\nu}\right) - (73)$$

so:

$$F^a{}_{\mu\nu}\left(\text{original}\right) = 2\left(F^a{}_{\mu\nu}\left(\text{new}\right) + A^{(0)}\omega^a{}_{\mu\nu}\right). - (74)$$

The new postulate (62) is a convenient way of deriving the two Proca

equations from the tetrad postulate. In so doing:

$$R_0 = \left(\frac{m_0 c}{\hbar}\right)^2 \quad - (75)$$

where m_0 is the rest mass of the photon. More generally define:

$$R = \left(\frac{mc}{\hbar}\right)^2 - (76)$$

where:

$$m = \gamma m_0 \quad - (77)$$

then the de Broglie equation is generalized to:

$$E = \hbar \omega = mc^2 = \hbar c R^{1/2} \quad - (78)$$

and the square of the mass of the moving photon is defined by the curvature:

$$m^2 = \left(\frac{\hbar}{c}\right)^2 R = \left(\frac{\hbar}{c}\right)^2 q^{\tilde{\nu}}_a \partial^\mu \left(\omega^a_{\mu\tilde{\nu}} - \Gamma^a_{\mu\tilde{\nu}}\right). \quad - (79)$$

The Proca equations of about 1935 are:

$$F^{\mu\tilde{\nu}} = \partial^\mu A^{\tilde{\nu}} - \partial^{\tilde{\nu}} A^\mu \quad - (80)$$

and:

$$\partial_\mu F^{\mu\tilde{\nu}} + \left(\frac{m_0 c}{\hbar}\right)^2 A^{\tilde{\nu}} = 0 \quad - (81)$$

and are written in terms of the photon rest mass m_0. In the 1935 equations the following inhomogeneous field equation of standard physics was assumed:

$$\partial_\mu F^{\mu\tilde{\nu}} = \mu_0 j^{\tilde{\nu}} \quad - (82)$$

where $j^{\tilde{\nu}}$ is the charge current density conserved by:

$$\partial_{\tilde{\nu}} j^{\tilde{\nu}} = 0 \quad - (83)$$

So:

$$\partial_{\tilde{\nu}} \left(\partial_\mu F^{\mu\tilde{\nu}}\right) = 0. \quad - (84)$$

It follows from Eqs. (81) and (84) that:

$$\left(\frac{m_o c}{\hbar}\right)^2 \partial_\nu A^\nu = 0 \quad -(85)$$

so for a finite m_o :

$$\partial_\nu A^\nu = 0 \quad -(86)$$

which is known as the Lorenz condition of standard physics. This must be obeyed if the photon mass is not identically zero. So there is no gauge freedom and photon mass theory is incompatible with Higgs boson theory. Gauge freedom asserts that the equations of standard electrodynamics are unchanged under U(1) gauge transform:

$$A^\mu \to A^\mu + \partial^\mu \chi \quad -(87)$$

where χ is arbitrary. In photon mass theory :

$$\partial_\nu \partial^\mu \chi = 0 \quad -(88)$$

so χ is not arbitrary. The Lagrangian for the 1935 Proca equations is:

$$\mathcal{L} = -\frac{1}{4} F_{\mu\nu} F^{\mu\nu} + \frac{1}{2} m_o^2 A_\mu A^\mu \quad -(89)$$

in the reduced units of standard physics, and this Lagrangian is not U(1) gauge invariant. It refutes Higgs boson theory at the foundational level.

Therefore the modified de Broglie Einstein equations are:

$$E = \hbar \omega = mc^2 = \gamma m_o c^2 \quad -(90)$$

$$\underline{p} = \hbar \underline{\kappa} = m\underline{v} = \gamma m_o \underline{v} \quad -(91)$$

$$R = \left(\frac{mc}{\hbar}\right)^2 \quad -(92)$$

and these are discussed further in note 244(3) accompanying this paper.

Determination of the Photon Mass from Compton Scattering

M. W. Evans[*], H. Eckardt[†]

Civil List, A.I.A.S. and UPITEC

(www.webarchive.org.uk, www.aias.us,
www.atomicprecision.com, www.upitec.org)

4 Computational methods

The photon mass is given by Eq.(2) of this paper. It can be calculated, if the scattering angle θ, the frequency of incident light ω and the frequency of scattered light ω' are known. We used experimental data of Compton scattering as reported in [12]. The results are similar to those already obtained in UFT papers 158 and 160 with different experimental data sets. Photon mass comes out to be highest near to zero angle scattering, i.e. in direction of the incident beam.

The velocity of photons should deviate from the value c because of their rest mass. Using the mass dedtermined by Eq.(2), the velocity can be found from the de Broglie relation

$$\gamma \, m_1 \, c^2 = \hbar \omega'. \tag{93}$$

This leads to

$$1 - \frac{v^2}{c^2} = \left(\frac{m_1 \, c^2}{\hbar \, \omega'} \right)^2 \tag{94}$$

from which we obtain by resolving for v^2 and taking the square root:

$$v = c \sqrt{1 - \left(\frac{m_1 \, c^2}{\hbar \, \omega'} \right)^2}. \tag{95}$$

The complex-valued masses deserve some more discussion. There are several options to interpret them:

1. ignore as unphysical,

2. take the modulus of them,

3. give them a new physical interpretation.

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[*]email: emyrone@aol.com

[†]email: mail@horst-eckardt.de

Most interesting is to look for a new interpretation. We look at Eq.(93) anew. This equation not only holds for photons but also for particles of any type and describes the de Broglie relation between mass and frequency, with parameters m and ω independent of scattering processes:

$$\gamma \, m \, c^2 = \hbar \omega. \tag{96}$$

Defining the rest energy

$$E_0 = m \, c^2 \tag{97}$$

and total energy

$$E = \hbar \, \omega \tag{98}$$

then Eq. (95) reads

$$v = c \, \sqrt{1 - \frac{E_0^2}{E^2}}. \tag{99}$$

The corresponding ratio v/c becomes imaginary for $v > c$ as shown in Fig. 1. This case appears for $E < E_0$. Velocity values start at $imag(v) = 0$ and are not bound when E approaches zero. It remains open what this means and, in paticular, what an imaginary velocity means. Sometimes particles with these hypothetical properties are called Tachyons. It should be noticed that a negative mass does not change anything of this pictures since mass appears squared in the formula.

A different picture arises if we assume that the mass of particles is imaginary as suggested by the results of the Compton experiment. Then, with

$$E_0 = i \, m \, c^2, \tag{100}$$

the sign in the second term of the square root of Eq.(95) changes, leading to

$$v = c \, \sqrt{1 + \frac{E_0^2}{E^2}}. \tag{101}$$

This changes the characteristics of v/c completely, resulting in the graph shown in Fig. 2. There is always $v/c > 1$; the limit for $E \to 0$ is similar as in Fig. 1, but v remains real-valued and the curve is differentiable everywhere. This is the more familiar view of Tachyons. Compton scattering would allow to produce such particles. There is a claim that such particles should generate Cherenkov radiation which is not observed.

The velocity of photons has been calculated from the masses given in Table 1 and is also presented there in the last two columns. Because the photons - according to this theory - are heavy-weighted particles, their velocity deviates significantly from c. Where the mass is imaginary, we have $v > c$ as explained above. This is obviously in disagreement of experimental findings and is an additional point where standard physics disintegrates. Compton experiments show that energy is not conserved, mass and photon velocities are not constant. All this has been shown on basis of relativistic de Broglie theory and energy / momentum conservation, the keystones of twentieth century physics.

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	$\cos(\theta)$	$\omega'[10^{21}/s]$	m_1	m_2	v_1/c	v_2/c
	0.8	0.780	1.005	0.417 i	0.00209	1.08254
	0.6	0.663	0.849	0.049	0.11074	0.99834
0	0.4	0.571	0.700	0.147	0.30509	0.97979
	0.2	0.498	0.517	0.119	0.59223	0.98256
	0.0	0.440	0.073	0.073	0.99162	0.99162
	-0.2	0.396	0.076	0.589 i	0.98890	1.52696
	-0.4	0.360	0.075	0.958 i	0.98691	2.29437

Table 1: Compton scattering angles and computed photon masses. Frequency of incident light was $\omega = 1.006 \cdot 10^{21}/s$.

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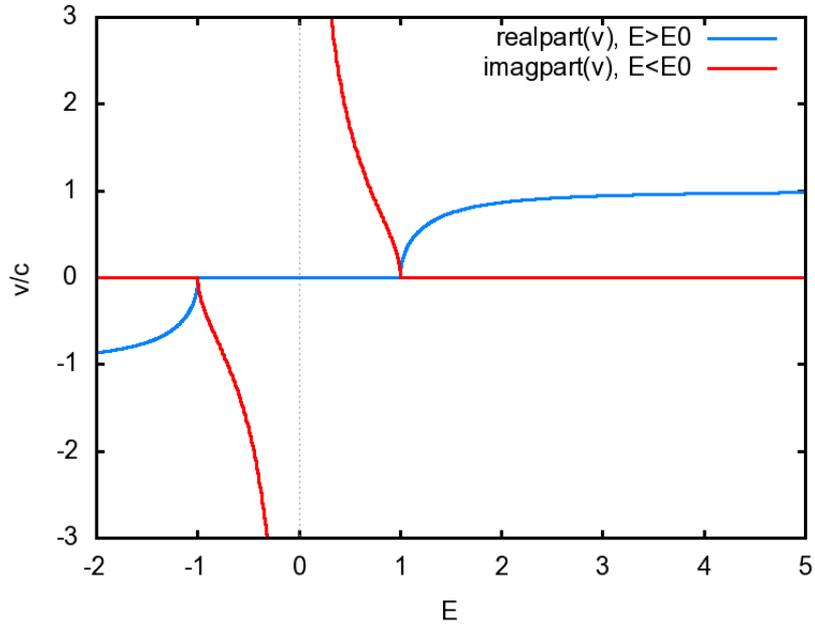
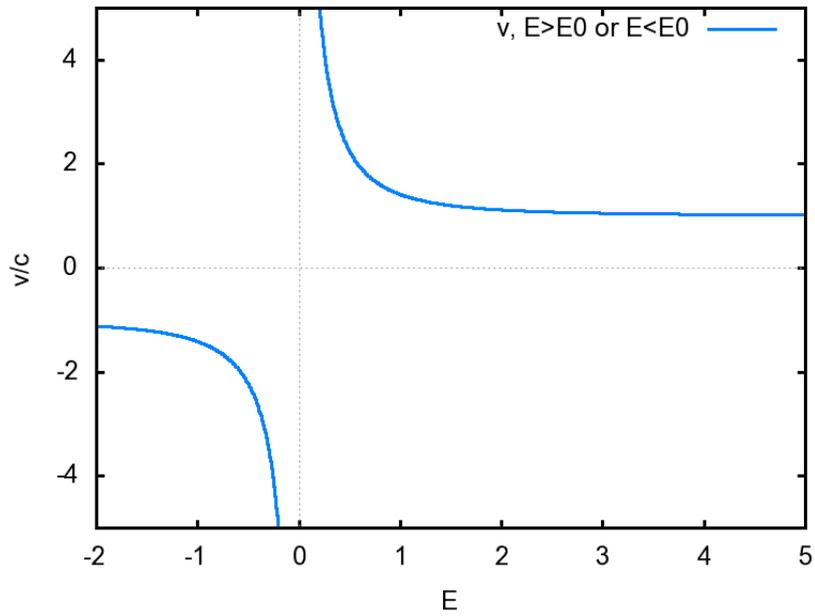Figure 1: Energy dependence of v/c, real and imagnary parts for $m = c = E_0 = 1$.

Figure 2: Energy dependence of v/c for imaginary mass, $m = c = E_0 = 1$.

4. COMPUTATIONAL METHODS

Section by Dr. Horst Eckardt

ACKNOWLEDGMENTS

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