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

$$a = 1 - \cos^2\theta,$$
$$b = (\omega'^2 + \omega^2)\cos^2\theta - 2A \qquad -(115)$$
$$A = \omega\omega' - x_2(\omega - \omega')$$
$$c' = A^2 - \omega^2\omega'^2\cos^2\theta$$

where ω' is the scattered gamma ray frequency, ω the incident gamma ray frequency, and where:

$$x_2 = \frac{m_2 c^2}{\hbar}. \qquad -(116)$$

Here $\hbar$ is the reduced Planck constant and c the speed of light in vacuo. The scattering angle is θ . Experimental data on Compton scattering can be used with the electron máss found in standards laboratories:

$$m_2 = 9.10953 \times 10^{-31}\ \mathrm{kg} \qquad -(117)$$

so:

$$x_2 = 7.76343 \times 10^{20}\ \mathrm{rad\,s^{-1}}. \qquad -(118)$$

The two solutions of Eq. (115) for photon mass are given later in this section. 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 thought previously. The other solution can be imaginary valued, and usually this solution would be discarded as unphysical. However R theory means that a real valued curvature can be found as follows:

$$R = mm^*\left(\frac{c}{\hbar}\right)^2 \qquad -(119)$$

where * denotes complex conjugate. It is shown later 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:

$$\gamma' m_1 c^2 = \hbar \omega' \quad -(120)$$

and is c for all practical purposes for all scattering angles (Section 4.3). 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 of "The Enigmatic Photon" in the Omnia Opera of www.aias.us. A photon as heavy as the electron would mean that previous attempts at assessing photon mass would have to be re-assessed as discussed already in this chapter. The Yukawa potential would have to 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:

$$\gamma m_0 c^2 + m_2 c^2 = \gamma' m_0 c^2 + \gamma'' m_2 c^2 . \quad -(121)$$

The de Broglie equation can be used as follows:

$$\hbar \omega = \gamma m_0 c^2 \quad -(122)$$

$$\hbar \omega'' = \gamma'' m_2 c^2 \quad -(123)$$

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

$$\hbar\omega + m_2 c^2 = m_0 c^2 + \hbar\omega'' \quad -(124)$$

where m_0 is the rest mass of the photon. This concept does not exist in the standard model because a massless photon is never at rest. So:

$$m_0 = m_2 + \frac{\hbar}{c^2}(\omega - \omega'') \quad -(125)$$

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

$$m_0 = m_2 \quad -(126)$$

and:

$$\omega = \omega'' \quad -(127)$$

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

If:

$$\omega \neq \omega'' \quad -(128)$$

then:

$$\hbar(\omega - \omega'') = \Phi + (m_0 - m_2)c^2 = \Phi \quad -(129)$$

where Φ is the binding energy of the photoelectric effect. From Eq. (129):

$$\hbar\omega + m_2 c^2 = m_0 c^2 + \hbar\omega'' + \Phi \quad -(130)$$

i.e.:

$$\hbar\omega = \hbar\omega'' + \Phi = E + \Phi \quad -(131)$$

or:

$$E = \hbar\omega - \Phi \quad -(132)$$

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.

A major and fundamental problem for standard physics emerges from consideration of equal mass Compton scattering as described in UFT160 on www.aias.us. It can be argued as follows 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:

$$x^2 + (\omega^2 - x^2)^{1/2} (\omega'^2 - x^2)^{1/2} \cos\theta = \omega\omega' - (\omega - \omega')x \quad -(133)$$

where:

$$x = \omega_0 = \frac{mc^2}{\hbar} \quad -(134)$$

is the rest frequency of the particle of mass m, ω' is 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. (133):

$$\cos^2\theta = \frac{\omega_0^2 + \omega_0(\omega - \omega') - \omega\omega'}{\omega_0^2 - \omega_0(\omega - \omega') - \omega\omega'} \quad -(135)$$

In order that

$$0 \leq \cos^2\theta \leq 1 \quad -(136)$$

then:

$$\omega < \omega' . \quad -(137)$$

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

$$\hbar\omega + \hbar\omega_0 = \hbar\omega' + \hbar\omega'' \quad -(138)$$

so:

$$\omega + \omega_0 = \omega' + \omega'' \quad -(139)$$

and:

$$\omega - \omega' = \omega'' - \omega_0 . \quad -(140)$$

Therefore:

$$\omega'' < \omega_0 . \quad -(141)$$

From Eqs. (137) and (141):

$$\omega + \omega_0 < \omega' + \omega'' . \quad -(142)$$

However the initial conservation of energy equation is (139), 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:

$$\gamma m_1 c^2 + \gamma_2 m_2 c^2 = \gamma' m_1 c^2 + \gamma'' m_2 c^2 \quad -(143)$$

i. e.

$$\hbar\omega + \gamma_2 m_2 c^2 = \hbar\omega' + \hbar\omega'' \quad -(144)$$

Define

$$x_2 = \gamma_2 m_2 c^2 / \hbar \quad -(145)$$

then:

$$x_2 := \omega_2 = \omega' + \omega'' - \omega. \quad -(146)$$

The equation of conservation of momentum is:

$$\underline{p} = \underline{p}_1 + \underline{p}_2 = \underline{p}' + \underline{p}''. \quad -(147)$$

Solving Eqs. (143) and (147) simultaneously leads to:

$$x_2(\omega - \omega') = \omega\omega' - \left(x_1^2 + (\omega^2 - x_1^2)^{1/2}(\omega'^2 - x_1^2)^{1/2}\cos\theta\right). \quad -(148)$$

For equal mass scattering:

$$\gamma_2 x(\omega - \omega') = \omega\omega' - \left(x^2 + (\omega^2 - x^2)^{1/2}(\omega'^2 - x^2)^{1/2}\cos\theta\right) \quad -(149)$$

where

$$x = mc^2/\hbar \quad -(150)$$

By definition:

$$\gamma_2 = \left(1 - \frac{v^2}{c^2}\right)^{-1/2} \quad -(151)$$

so:

$$(\omega^2 - x^2)^{1/2}(\omega'^2 - x^2)^{1/2}\cos\theta = \omega\omega' - (\omega - \omega')\left(1 - \frac{v^2}{c^2}\right)^{-1/2} x - x^2 \quad -(152)$$

For

$$v << c \quad -(153)$$

then:

$$\left(1 - \frac{v^2}{c^2}\right)^{-1/2} \sim 1 + \frac{1}{2}\frac{v^2}{c^2} \quad -(154)$$

so Eq. (152) is approximated by:

$$(\omega^2 - x^2)^{1/2}(\omega'^2 - x^2)^{1/2}\cos\theta = -\left((x - \omega')(x + \omega) + \frac{1}{2}\frac{v^2}{c^2} x (\omega - \omega')\right). \quad -(155)$$

Therefore:

$$(\omega - x)(\omega + x)(\omega' - x)(\omega' + x)\cos^2\theta$$
$$= (x - \omega')^2(x + \omega)^2 + \frac{v^2}{c^2} x(\omega - \omega')(x - \omega')(x + \omega) + \frac{1}{4}\frac{v^4}{c^4} x^2(\omega - \omega')^2. \quad -(156)$$

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

$$\cos^2\theta = \frac{x^2 + x(\omega - \omega')(1 + v^2/c^2) - \omega\omega'}{x^2 - x(\omega - \omega') - \omega\omega'}. \quad -(157)$$

However:

$$0 \leq \cos^2\theta \leq 1 \quad -(158)$$

so:

$$(\omega-\omega')\left(1+\frac{v^2}{c^2}\right) < -(\omega-\omega') \quad -(159)$$

i. e. :

$$\omega < \omega' \quad -(160)$$

The conservation of energy equation (143) is:

$$\omega + \omega_2 = \omega' + \omega'' \quad -(161)$$

so:

$$\omega' - \omega = \omega_2 - \omega'' . \quad -(162)$$

From Eqs. (160) and (162)

$$\omega_2 > \omega'' . \quad -(163)$$

Add Eqs. (160) and (163):

$$\omega + \omega'' < \omega' + \omega_2 \quad -(164)$$

so conservation of energy is again violated at the fundamental level and the whole of particle scattering theory is refuted, including Higgs boson theory.

4.5 PHOTON MASS AND LIGHT DEFLECTION DUE TO GRAVITATION.

In papers of 1923 and 1924 (L. de Broglie, Comptes Rendues, 77, 507 (1923) and

Phil. Mag., 47, 446 (1924)) Louis de Broglie used the concept of photon mass to lock together the Planck theory of the photon as quantum of energy and the theory of special relativity. He derived equations which are referred to as the de Broglie Einstein equations in this book. He quantized the photon momentum, producing wave particle dualism, and these papers led directly to the inference of the Schroedinger equation. In UFT 150B and UFT 155 on www.aias.us , photon mass was shown to be responsible for light deflection and time change due to gravitation and the obsolete methods of calculating these phenomena were shown to be incorrect in many ways. This is an example of a pattern in which the ECE theory as it developed made the old physics entirely obsolete. Photon mass emerged as one of the main counter examples to standard physics - the Higgs boson does not exist because of finite photon mass, which also implies that there a cosmological red shift without an expanding universe. Therefore photon mass also refutes Big Bang, as does spacetime torsion {1 - 10}. The red shift can be derived from the original 1924 de Broglie Einstein equations without any further assumption and the de Broglie Einstein equations can be derived from Cartan geometry (chapter one).

The existence of photon mass can be proven as in UFT 157 on www.aias.us with light deflection due to gravitation using the Planck distribution for one photon. The result is consistent with a photon mass of about 10^{-51} kgm for a light beam heated to 2,500 K as it grazes the sun and this result is one of the ways of proving photon mass, inferred by the B(3) field. Prior to this result, estimates of photon mass had been given as less than an upper bound of about 10^{-52} kgm, and many methods assumed the validity of the Yukawa potential. These methods have been criticized earlier in this chapter. The Einsteinian theory of light deflection due to gravitation used zero photon mass and is riddled with errors as shown in UFT 150B and UFT155. Therefore the experimental data on light deflection due to gravitation were thoroughly re interpreted in UFT 157 to give a reasonable estimate of photon mass. Once photon mass is accepted it works its way through in to all the experiments that originally signalled the onset of quantum theory in the late nineteenth century: black body radiation, specific heats, the photoelectric effect, atomic and molecular spectra, and in the nineteen twenties, Compton scattering. As already argued in the context of the Proca equation, photon mass indicates the existence of a vacuum potential, which can be amplified by spin connection resonance to produce energy from spacetime.

The de Broglie Einstein equations are valid in the classical limit of the Proca wave equation of special relativistic quantum mechanics. It has already been shown that the Proea equation is a limit of the ECE wave equation obtained from the tetrad postulate of Cartan geometry and the development of wave equations from the tetrad postulate provides the long sought for unification of gravitational theory and quantum mechanics. The ECE equation of quantum electrodynamics is:

$$(\square + R) A^a_\mu = 0 \qquad (165)$$

where R is a well defined scalar curvature and where:

$$A^a_\mu = A^{(0)} q^a_\mu . \qquad (166)$$

Here $A^{(0)}$ is the scalar potential magnitude and q^a_μ is the Cartan tetrad defined in chapter one. Eq. (165) reduces to the 1934 Proca equation in the limit:

$$R \to \left(\frac{mc}{\hbar}\right)^2 \qquad (167)$$

where m is the mass of the photon, c is a universal constant, and $\hbar$ is the reduced Planck constant. Note carefully that c is not the velocity of the photon of mass m, and following upon the Palermo memoir of Poincare, de Broglie interpreted c as the maximum velocity available in special relativity.

Eq. (165) in the classical limit is the Einstein energy equation:

$$p^\mu p_\mu = m^2 c^2 \quad -(168)$$

where:

$$p^\mu = \left(\frac{E}{c}, \underline{p} \right) \quad -(169)$$

and where m is the mass of the photon. Here E is the relativistic energy:

$$E = \gamma m c^2 \quad -(170)$$

and $\underline{p}$ is the relativistic momentum:

$$\underline{p} = \gamma m \underline{v}_g \quad -(171)$$

The factor γ is the result of the Lorentz transformation and was denoted by de Broglie as:

$$\gamma = \left(1 - \frac{v_g^2}{c^2} \right)^{-1/2} \quad -(172)$$

where v_g is the group velocity:

$$v_g = \frac{\partial \omega}{\partial \kappa}. \quad -(173)$$

The de Broglie Einstein equations are:

$$p^\mu = \hbar \kappa^\mu \quad -(174)$$

where the four wavenumber is:

$$\kappa^\mu = \left(\frac{\omega}{c}, \underline{\kappa} \right) \quad -(175)$$

Eq. (174) is a logically inevitable consequence of the Planck theory of the energy quantum of light later called "the photon", published in 1901, and the theory of special relativity. The standard model has attempted to reject the inexorable logic of Eq. (174) by rejecting m. Eq. (174) can be written out as:

$$E = \hbar\omega = \gamma m c^2 \quad -(176)$$

and:

$$\underline{p} = \hbar \underline{\kappa} = \gamma m \underline{v}_g \quad -(177)$$

In his original papers of 1923 and 1924 de Broglie defined the velocity in the Lorentz transformation as the group velocity, which is the velocity of the envelope of two or more waves:

$$v_g = \frac{\Delta\omega}{\Delta\kappa} = \frac{\omega_2 - \omega_1}{\kappa_2 - \kappa_1}, \quad -(178)$$

and for many waves Eq. (173) applies. The phase velocity v_p was defined by de Broglie as:

$$v_p = \frac{E}{p} = \frac{\omega}{\kappa}, \quad -(179)$$

$$v_g v_p = c^2,$$

which is an equation independent of the Lorentz factor γ and universally valid. The standard model makes the arbitrary and fundamentally erroneous assumptions:

$$m =? \, 0, \quad v_g = v_p =? \, c. \quad -(180)$$

In physical optics the phase velocity is defined by:

$$v_p = \frac{\omega}{\kappa} = \frac{c}{n} \quad -(181)$$

where $n(\omega)$ is the frequency dependent refractive index, in general a complex quantity (UFT 49, UFT 118 and OO 108 in the Omnia Opera on www.aias.us). The group velocity in physical optics is:

$$v_g = c\left(n + \omega\frac{dn}{d\omega}\right)^{-1} \quad -(182)$$

and it follows that:

$$v_p v_g = c^2 = \frac{c^2}{n\left(n + \omega\frac{dn}{d\omega}\right)} \quad -(183)$$

giving the differential equation:

$$\frac{dn}{d\omega} = -\frac{n}{2\omega}. \quad -(184)$$

A solution of this equation is

$$n = \frac{D}{\omega^{1/2}} \quad -(185)$$

where D^2 is a constant of integration with the units of angular frequency. So:

$$n = \left(\frac{\omega_0}{\omega}\right)^{1/2} \quad -(186)$$

where ω_0 is a characteristic angular frequency of the electromagnetic radiation. Eq (186) has been derived directly from the original papers of de Broglie {1 – 10} using only the equations (181) and (182) of physical optics or wave physics. The photon mass does not appear in the final Eq. (186) but the photon mass is basic to the meaning of the calculation. If ω_0 is interpreted as the emitted angular frequency of light in a far distant star, then ω is the angular frequency of light reaching the observer. If:

$$n > 1 \quad -(187)$$

then:

$$\omega < \omega_0 \quad - (188)$$

and the light has been red shifted, meaning that its observable angular frequency (ω) is lower than its emitted angular frequency (ω_0), and this is due to photon mass, not an expanding universe. The refractive index $n(\omega)$ is that of the spacetime between star and observer. Therefore in 1924 de Broglie effectively explained the cosmological red shift in terms of photon mass."Big Bang" (a joke coined by Hoyle) is now known to be erroneous in many ways, and was the result of imposed and muddy pathology supplanting the clear sciénce of de Broglie.