THE MEASUREMENT OF PHOTON MASS FROM THE ANGLE OF DEFLECTION OF ONE PHOTON BY THE SUN.

by

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ABSTRACT

The mass of the photon is measured experimentally to be of the order of 10^{-57} kilograms using the experimental data that show that the orbit of a mass m around the sun is a conical section. The orbit of the photon of this mass is a hyperbola with a very large eccentricity, meaning that it is deflected very slightly as is well known. Einsteinian general relativity is not used, and in this paper is refuted conclusively in several ways, some of which are simple to understand, and which use simple algebra.

Keywords: ECE theory, mass of the photon, refutations of Einsteinian general relativity.

UFT 202

1. INTRODUCTION

It is shown in this paper that the measurement of the mass of the photon is straightforward if it is assumed that the photon mass m orbits the sun as any other mass M, in a conical section. The only thing that is known experimentally {1 - 10} is that light is deflected by the sun by a tiny amount, a few arc seconds only. It would not be known without other data whether the orbit is a closed precessing ellipse, or some other conical section such as a hyperbola, but it is known that the photon mass is less than about 10^{-52} kilograms, various estimates are available, so that its orbital eccentricity is very large. The orbit is therefore a hyperbola. In Section 2 it is shown that the photon mass is of the order of 10^{-57} kilograms if it is assumed that its orbit is a conical section. The Newtonian limit of a precessing hyperbola is a static hyperbola, and the tiny mass of the photon must mean that the eccentricity of this hyperbola is very large. The same is true for the right magnitude of the hyperbola. There is nothing in the Newtonian analysis to refute the assumption that the photon's orbit is a hyperbola. This conclusion is intuitively clear from the very small deflection of the photon by the sun. Therefore it is possible to derive the deflection angle and photon mass directly from the assumed orbit in the Newtonian limit. It is not necessary to use general relativity to find the mass of the photon, and indeed, in subsequent sections of this paper, it is shown that the Einsteinian general relativity is riddled with errors, and should no longer be used. It is thoroughly obsolete and has been replaced by the ECE theory of unified physics {1 - 10}.

2. THE MASS OF THE PHOTON

Consider an object of mass m orbiting an object of mass M in a precessing conical section {11}:

$$r = \frac{\alpha}{1 + \epsilon\cos(x\theta)} \quad -(1)$$

where 2α is the right magnitude, ϵ is the eccentricity, x is the precession constant, and where the coordinates in a plane are the cylindrical polar coordinates r and θ. It follows from Eq. (1) that:

$$\frac{dr}{d\theta} = \frac{x\epsilon}{\alpha} r^2 \sin(x\theta). \quad -(2)$$

Therefore:

$$\frac{d\theta}{dr} = \frac{\alpha}{x\epsilon} \frac{1}{r} \left(r^2 - \frac{1}{\epsilon^2}(\alpha - r)^2 \right)^{-1/2}. \quad -(3)$$

If the distance of closest approach of the mass m to the mass M is R_0, then the object m is deflected by the angle:

$$\Delta\theta = \frac{2\alpha}{x\epsilon} \int_{R_0}^{\infty} \frac{dr}{r\left(r^2 - \frac{1}{\epsilon^2}(\alpha - r)^2\right)^{1/2}}. \quad -(4)$$

This integral may be evaluated analytically and is:

$$\Delta\theta = \frac{2}{x}\left(\sin^{-1}\frac{1}{\epsilon} - \sin^{-1}\left(\frac{1}{\epsilon} - \frac{\alpha}{R_0}\right)\right). \quad -(5)$$

If there is no deflection then:

$$\Delta\theta = 0 \quad -(6)$$

and this result is equivalent from Eq. (5) to:

$$R_0 \to \infty. \quad -(7)$$

When the object m is infinitely distant from the object M it is not deflected and its trajectory is a straight line. In the limit:

$$x \to 1 \qquad (8)$$

the conical section becomes static. In Newtonian theory {11} it is described by:

$$\alpha = \frac{L^2}{m^2 M G} \qquad (9)$$

and

$$\epsilon = \left(1 + \frac{2EL^2}{m^3 M^2 G^2}\right)^{1/2} \qquad (10)$$

where E is the total energy, L is the total angular momentum and G is Newton's constant. It is seen that m must be identically non-zero, the photon must have mass.

By definition the photon is the quantum of energy, so for one photon:

$$E = \hbar\omega, \quad L = \hbar \qquad (11)$$

where ω is the angular frequency. Consider therefore the orbit of one photon in the Newtonian limit defined by Eqs. (8), (9) and (10). Its angle of deflection is:

$$\Delta\theta = 2\left[\sin^{-1}\left(1 + \frac{2EL^2}{m^3 M^2 G^2}\right)^{-1/2} - \sin^{-1}\left(\left(1 + \frac{2EL^2}{m^3 M^2 G^2}\right)^{-1/2} - \frac{L^2}{m^2 M G R_0}\right)\right] \qquad (12)$$

and this equation is also true for any object of mass m orbiting any object of mass M in the Newtonian limit. As in UFT150B (www.aias.us) the following values can be used:

$$
\begin{aligned}
\hbar &= 1.05459 \times 10^{-34}\ \mathrm{Js} \\
R_o &= 6.955 \times 10^{8}\ \mathrm{m} \\
M &= 1.9891 \times 10^{30}\ \mathrm{kg} \\
G &= 6.67428 \times 10^{11}\ \mathrm{m^3\,kg^{-1}\,s^{-2}}
\end{aligned}
\qquad -(13)
$$

where R_o is the sun's radius and M is its mass. Eq. (12) becomes:

$$
\Delta\theta = 2\left[\sin^{-1}\left(1 + \frac{1.33094 \times 10^{-170}}{m^3}\right)^{-1/2} - \sin^{-1}\left(\left(1 + \frac{1.33094 \times 10^{-170}}{m^3}\right)^{-1/2} - \frac{1.2045 \times 10^{-119}}{m^2}\right)\right], \qquad -(14)
$$

Assuming that the angular frequency of the photon is in the visible range:

$$
\omega \sim 10^{16}\ \mathrm{rad\,s^{-1}} \qquad -(15)
$$

the measured deflection is:

$$
\Delta\theta = (8.4848 \pm 0.003) \times 10^{-6}\ \mathrm{rad}. \qquad -(16)
$$

Tables of elementary particle masses give the photon mass as less than about 10^{-52} kg, so the following Maclaurin series may be used:

$$
\sin^{-1} x = x + \frac{x^3}{6} + \frac{3}{40} x^5 + \ldots, \quad |x| < 1, \quad |\sin^{-1} x| < \frac{\pi}{2} \qquad -(17)
$$

and the first term of this series is sufficient for visible frequency radiation. So Eq. (14) reduces to:

$$\Delta\theta = \frac{2.409 \times 10^{-119}}{m^2} \qquad -(18)$$

giving the following mass of the photon:

$$m = 1.685 \times 10^{-57}\ kg. \qquad -(19)$$

Using this value back in Eq. (14) it is seen that approximation:

$$\sin^{-1} x \sim x \qquad -(20)$$

is valid because:

$$\left(1 + \frac{1.33094 \times 10^{-170}}{1.685^3 \times 10^{-171}}\right)^{-1/2} = 0.5142 \qquad -(21)$$

and

$$\frac{1.2045 \times 10^{-119}}{1.685^2 \times 10^{-114}} = 4.242 \times 10^{-6} \qquad -(22)$$

The value (19) is an order of magnitude, but it is the first time that the mass of the photon has been determined, a hundred year old aim of physics. This estimate agrees well with other estimates that give the mass as less than 10^{-52} kilograms. This mass means that the eccentricity of the photon's hyperbolic orbit is:

$$\epsilon = 1.945 \qquad -(23)$$

and its half right magnitude is:

$$d = 2.950 \text{ metres.} \quad -(24)$$

Note that this value of the photon mass does not depend on the frequency in the approximations used, but in general the photon mass depends on frequency and cannot be an elementary particle mass. As in UFT158 ff. It is developed in terms of R theory.

This determination of photon mass refutes the massless photon theory of the U(1) sector of the standard model, and refutes the Higgs boson theory. The existence of photon mass corroborates the $\underline{B}^{(3)}$ theory {1 - 10}.

3. DEFINITIVE AND SIMPLE REFUTATION OF EINSTEINIAN GENERAL RELATIVITY.

It is very simple to refute Einstein's general relativity (EGR) and this fact has been known for nearly a century. This is why general relativity cannot determine photon mass from the deflection of light by gravitation. In these sections a series of refutations is given. The EGR theory for a planar orbit is based on the infinitesimal line element:

$$ds^2 = c^2 d\tau^2 = \left(1 - \frac{r_0}{r}\right) c^2 dt^2 - \left(1 - \frac{r_0}{r}\right)^{-1} dr^2 - r^2 d\theta^2 \quad -(25)$$

in the plane:

$$dZ^2 = 0 \quad -(26)$$

where the distance r_0 is defined by:

$$r_0 = \frac{2MG}{c^2}. \quad -(27)$$

The EGR theory claims incorrectly that this lien element produces a precessing ellipse. It is claimed that {1 - 10, 12}:

$$\left(\frac{x t}{d}\right)^2 \sin^2(x\theta) =? \frac{1}{b^2} - \left(1 - \frac{r_0}{r}\right)\left(\frac{1}{a^2} + \frac{1}{r^2}\right) \quad -(28)$$

where the constants a and b are:

$$a = \frac{L}{mc}, \quad b = \frac{cL}{E}. \quad -(29)$$

If this claim were true then:

$$\sin^2(x\theta) =? \left(\frac{d}{xt}\right)^2 \left(\frac{1}{b^2} - \frac{1}{a^2} + \frac{r_0}{a}\frac{1}{r} - \frac{1}{r^2} + \frac{r_0}{r^3}\right). \quad -(30)$$

However, from Section 2:

$$\sin^2(x\theta) = \left(1 - \frac{1}{\epsilon^2}\right) + \frac{2d}{\epsilon}\frac{1}{r} - \left(\frac{d}{\epsilon}\right)^2 \frac{1}{r^2} \quad -(31)$$

and this function is derived directly from the observations in astronomy of a precessing ellipse or a conical section in general. This function is not Eq. (30), so EGR is refuted, QED.

4. REFUTATIONS BASED ON LIGHT DEFLECTION DUE TO GRAVITATION.

In Section 2 it was shown that light deflection due to gravitation depends on m in the Newtonian limit. In EGR it is claimed erroneously that the Newtonian limit is

$$\Delta\theta =? \frac{2GM}{c^2 R_0} \quad -(32)$$

but this limit does not depend on m. It cannot be correct, QED. EGR claims that the light deflection is:

$$\Delta\theta = ?\ \frac{4GM}{c^2 R_0} \quad -(33)$$

but again this does not depend on the mass m. It cannot therefore reduce to the correct Newtonian limit given in Section 2. In UFT 150B the various errors made by Einstein in his light deflection calculation are discussed. It is clear that this well known calculation is incorrect because it starts from Eq. (25), and Eq. (25) as shown in Section 3 does not produce the conic section from which the deflection must be calculated for elementary self consistency.

Einstein appears to have carried out this calculation in ref. (13), in a textbook such as that by Wald {14}, the integral used by Einstein is described as:

$$\Delta\theta = 2\int_0^{1/R_0} \left(R_0^{-2} - 2MR_0^{-3} - u^2 + 2Mu^3 \right)^{-1/2} du \quad -(34)$$

where M is mass in reduced units. In S. I. Units it is MG / c^2. The method used to evaluate Eq. (34) is very obscure, it relies on:

$$\left. \frac{\partial(\Delta\theta)}{\partial M} \right|_{M=0} = ?\ \frac{1}{4b} \quad -(35)$$

However, M is a constant, and Eq. (35) is not an operation of elementary differentiation. In addition, Section 3 shows that this integral is incorrect.

All theories based on EGR are easily refuted: light deflection by gravitation, gravitational time delay, de Sitter precession, gravitational time delay, perihelion precession and gravitational radiation.

5. NUMEROUS REFUTATIONS BASED ON GEOMETRY

Eq. ($2\cancel{8}^{5}$) is obtained after a tortuous series of incorrect assumptions about the general line element:

$$ds^2 = c^2 d\tau^2 = m(r,t)\, c^2 dt^2 - n(r,t)\, dr^2 - r^2 d\theta^2 \qquad -(36)$$

of spherical spacetime, where m and n are general functions of r and of time t {12}. The most basic and pervasive blunder of EGR is its assumption of a symmetric Christoffel connection, as discussed in previous work {1 - 10}. The antisymmetry of the connection is easily shown by consideration of the basic equation:

$$[D_\mu, D_\nu] V^\sigma = -\left(\Gamma^\lambda_{\mu\nu} - \Gamma^\lambda_{\nu\mu}\right) D_\lambda V^\rho + R^\rho{}_{\sigma\mu\nu} V^\sigma \qquad -(37)$$

which is true in any space of any dimension. The commutator of covariant derivatives on the left hand side acts on a vector (or any tensor of any rank) to isolate the connection as shown on the right hand side. Here the Riemann tensor is well known to be the antisymmetric object:

$$R^\rho{}_{\sigma\mu\nu} = -R^\rho{}_{\sigma\nu\mu} = \partial_\mu \Gamma^\rho_{\nu\sigma} - \partial_\nu \Gamma^\rho_{\mu\sigma} + \Gamma^\rho_{\mu\lambda}\Gamma^\lambda_{\nu\sigma} - \Gamma^\rho_{\nu\lambda}\Gamma^\lambda_{\mu\sigma}. \qquad -(38)$$

It has the same commutator indices μ and ν as the connection, so the latter is antisymmetric, QED:

$$R^\rho{}_{\sigma\mu\nu} = -R^\rho{}_{\sigma\nu\mu}, \qquad -(39)$$
$$\Gamma^\lambda_{\mu\nu} = -\Gamma^\lambda_{\nu\mu}.$$

If the indices were the same, the commutator, connection and curvature would all vanish. In this case the covariant derivate D_μ reduces to the ordinary derivative ∂_μ, and:

$$[\partial_\mu, \partial_\nu] V^\sigma = 0. \qquad -(40)$$

The torsion is well known {1 - 10, 12} to be:

$$T^{\lambda}_{\mu\nu} = \Gamma^{\lambda}_{\mu\nu} - \Gamma^{\lambda}_{\nu\mu} \quad -(41)$$

and is always non-zero. The basic meaningless of EGR is that it is based on a self contradictory idea that the Riemman tensor is antisymmetric but that the connection is symmetric. Obviously, both are antisymmetric. It cannot be claimed that the Riemman tensor is symmetric, it cannot be claimed that the connection is symmetric, it cannot be claimed that the commutator is symmetric. There is no symmetric part to any of these objects because they are generated by a round trip in a space with curvature and torsion, and thus by an intrinsically antisymmetric commutator. If any such objects were symmetric there would be no curvature and no torsion.

In consequence of this blunder the following incorrect equation is used in EGR:

$$\Gamma^{\sigma}_{\mu\nu} =? \frac{1}{2} g^{\sigma\rho}\left(\partial_\mu g_{\nu\rho} + \partial_\nu g_{\rho\mu} - \partial_\rho g_{\mu\nu}\right) \quad -(42)$$

where $g_{\mu\nu}$ is the metric. This equation is no longer true for an antisymmetric connection. Similarly the Ricci tensor:

$$R_{\sigma\mu} = R^{\lambda}_{\sigma\lambda\mu} \quad -(43)$$

is obtained in EGR from an incorrectly evaluated Riemman tensor, a Riemann tensor obtained from the incorrect (42). The second Bianchi idenity used in EGR is incorrect for the same reason, and the Einstein field equation is incorrect because it is based on the second Bianchi identity. The next in a series of blunders in EGR is to assume that the Ricci tensor vanishes. Crothers has shown that this is not true (www.aias.us). In order to derive Eq. (25) from Eq. (36) the latter is written as {12}:

$$ds^2 = c^2 dt^2 e^{2\alpha(r,t)} - e^{2\beta(r,t)} dr^2 - r^2 d\theta^2. \quad -(44)$$

The incorrect assumption of a null Ricci tensor produces the incorrect results:

$$\beta = \beta(r) \quad -(45)$$

$$\alpha = f(r) + g(t). \quad -(46)$$

The function g(t) is "eliminated" using a dubious procedure {12}:

$$dt \rightarrow \exp(-g(t))\, dt \quad -(47)$$

to give:

$$ds^2 = e^{2\alpha(r)} c^2 dt^2 - e^{2\beta(r)} dr^2 - r^2 d\theta^2. \quad -(48)$$

The incorrect use of the null Ricci tensor produces the incorrect result:

$$\alpha = -\beta + \text{constant} \quad -(49)$$

in which it is asserted without proof that:

$$\alpha = -\beta. \quad -(50)$$

This is known as "scaling coordinates", but it is entirely arbitrary. This arbitrary procedure leads to:

$$e^{2\alpha}(2r\partial_1\alpha + 1) = 1 \quad -(51)$$

i.e.:

$$\partial_1 \left(r e^{2\alpha} \right) = 1 \quad -(52)$$

which means that:

$$e^{2\alpha} = 1 + \mu / r . \quad -(53)$$

The Einstein field equation is used only in its weak field limit to claim that:

$$\mu = \frac{2GM}{c^2} \quad -(54)$$

but this procedure is riddled with errors and so the line element (25) is entirely without any meaning.

If this were not enough, EGR's light deflection and black hole theory are based on the idea of a null geodesic (see UFT150B on www.aias.us):

$$ds^2 = ?\ 0 \quad -(55)$$

However, Eq. (25) is:

$$c^2 = c^2 \left(\frac{dt}{d\tau} \right)^2 \left(1 - \frac{r_0}{r} \right) - \left(1 - \frac{r_0}{r} \right)^{-1} \left(\frac{dr}{d\tau} \right)^2 - r^2 \left(\frac{d\theta}{d\tau} \right)^2 \quad -(56)$$

and is obviously incompatible with Eq. (55) because Eq. (55) makes Eq. (56) singular. The entire history of black hole theory can be rejected, it is a meaningless theory. Black hole theory proceeds with the meaningless mathematical assumption {12}:

$$ds^2 = ?\ 0 = \left(1 - \frac{2GM}{c^2 r} \right) c^2 dt^2 - \left(1 - \frac{2GM}{c^2 r} \right)^{-1} dr^2 . \quad -(57)$$

This assumption is made yet more obscure by a tortuous choice of coordinates:

$$ct = ?\ \pm \left(r + \frac{2GM}{c^2} \log_e \left(\frac{rc^2}{2GM} - 1 \right) \right) + \text{constant} \quad -(58)$$

a mathematical contrivance used to redefine the line element as:

$$ds^2 =? \left(1 - \frac{2Gm}{c^2 r}\right)\left(c^2 dt^2 - dr^{*2}\right) - r^2 d\theta^2 . \quad -(59)$$

There are very many sequential errors, the most pervasive one is to define the "event horizon" as:

$$r =? \frac{2Gm}{c^2 r} . \quad -(60)$$

All black hole metrics were thoroughly refuted with computer algebra in ref. (1).

ACKNOWLEDGMENTS

The British Government is thanked for a Civil List Pension and rank of Armiger, and the AIAS group for many interesting discussions. Dave Burleigh is thanked for a great deal of voluntary positing work, and Alex Hill, Robert Cheshire and Simon Clifford for translation and broadcasting. The AIAS is established under the aegis of the Newlands Family Trust.

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