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Influence of Gravitational Shielding on Time Dilation

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Abstract: This research work investigates the possibility of shielding gravity. The ultimate purpose of this work is to understand the reality behind the concept of Gravitational Shielding (GS) and time dilation. Since the 19th century, scientists have tried to arrive at an understanding of GS via the use of various experiments. Unfortunately, some experiments failed to prove the existence of gravitational shielding, whereas some results proclaimed the possibility of attaining GS. The original phenomenon exhibited by nature cannot easily be understood, but some experiments have demonstrated that the answer may lie behind the mysterious GS. If GS is proved, then in the future, it would be possible to travel across black holes by defying gravity or through any bigger mass having high gravitational field. To unravel the mystery of GS, this work investigates the history of GS and considers the future vision of technologically advanced spacecraft or other warp drive mechanisms with appropriate gravitational shielding. Though the problem is very complex, this research work tries to come to a deeper understanding and explanation of the complexity involved in achieving gravitational shielding.

Keywords: gravitational shielding; Casimir effect; electromagnetic field; gravity

1. Introduction

Newton assumed that the gravity insulation cannot be made by the outer layer of shell with its interior. A number of experiments gave negative results for gravitational shielding [1–4], except that the work by Majorana (1922) posted some marginal effect of positive results on gravitational shielding [5].

Li et al. (1997) as well as Koczor and Noever (1999) reported the negative results on gravitational effect [6,7]. Theoretical analysis of gravitational shielding effect was carried out by Modanese (1996) and Wu (2004) [8,9]. Scientists have since furnished this gravitational shielding problem with several theoretical and empirical evidences. One such piece of evidence is provided by Italian scientist Majorana (1999), who observed that the weight of a body decreases when it is subjected to thick shield of mercury [10]. Furthermore, he formulated a law as in Equation (1) (Majorana, 1999) to depict the gravitational field outside the shell having the absorption coefficient when the material is placed at centre of shell [11].

$$g = \int Gmr^{-2}e^{-h\rho L}dr \quad (1)$$

Although there is no obvious experimental evidence to prove the shielding effect, Unnikrishnan and Gillies [4] reported the upper limit for shielding to be 4.3×10^{-15} m^{2}kg^{-1}. The lower limit of shielding is calculated as 0.6×10^{-15} m^{2}kg^{-1}. A number of researchers claimed that the weight of test masses with various materials varies using various excitations.

2. Casimir Effect

In 1940, Hendrik Casimir, a Dutch physicist, reported a strange behaviour of quantum theory in that there exist quantum fluctuations of the electromagnetic field in the empty vacuum space between ideal conductors [12]. For example, if there are parallel conducting plates close to each other, the plates are bounded by fluctuations which are extremely small i.e. there occurs less pressure between the plates which are pulled together. It is very similar to the effect of water waves, but according to classic electromagnetic theory, there can be no force of attraction or repulsion when they are uncharged. Though the effect contradicted with classical electromagnetic (EM) theory, which was proven experimentally, in 1997 [13]. This experimental evidence further confused the situation because these quantum fluctuations have real energy which will be affected by gravity. Could this solution lead to exotic physical phenomena like wormholes, time travel and warp drive? Consider the following:

The Casimir effect between the attractive Casimir forces between two plates of area A separated by distance L can be calculated as in Equation (2):

$$F = \frac{\pi h c}{480\, L^4} A \tag{2}$$

where h = Planck's constant; L = Separation between the plates; A = area; and c = speed of light.

It is proven that if two metal plates having a thickness of one atom are separated by 1.5 pm, then negative energy can be created in that material. Negative mass can be used to construct the Alcubierre drive and worm-holes [14,15]. In view of gravitational shielding and the Casimir effect, there should be some negative energy if the materials or masses separated at a particular distance. It means that energy can be interpreted as vacuum fluctuations. The vacuum fluctuations may also arise due to the gravitational shielding. Thus, gravitational shielding may be the effect of negative energy.

3. Gravity and Electromagnetic Field

According to Coulomb's law, the force of attraction or repulsion is given by Equation (3).

$$F = k\frac{q_1 q_2}{r^2} \tag{3}$$

The force of attraction or repulsion depends on the charges and the separation between them. If q_1 is positive charge and q_2 is negative charge, then it exhibitsa force of attraction butthere is no force of attraction when there are like poles/charges.This is not the case with gravitational force (Equation (4)).

$$F = G\frac{m_1 m_2}{r^2} \tag{4}$$

If there exist two "positive" masses, there is no force of repulsion. The only difference between equation between Equations (3) and (4) is that the positive and negative charges exist in EM Theory but in gravitational theory there is no such thing. Moreover, the theory of electromagnetic interactions does not consider how big the charges are. The evidence lies in finding negative-mass-equivalent in gravitational field theory to that which would correlate with EM theory, noting that Einstein's gravitational field theory of space–time curvature is absolutely elegant when compared to Newton's viewpoint of gravity being a force due to mass. There exists a huge chasm between the EM and gravity theories to this day.

4. Gravitational Shielding by Scalar Field

The Kaluza Klein model [16,17] attempts to unify electromagnetism and gravity by introducing an extra dimension, in addition to the 3 spatial and 1timedimension, thereby extending General Relativity to the 5th dimension (5D)

According to the Kaluza Klein theory 5D equations of motion of matter are described as below (Equation (5)).

$$g = \frac{c^2}{2\varphi}\left(\frac{d\varphi}{dr} + \varphi\frac{d\vartheta}{dr}\right)e^{\vartheta-\lambda} \quad (5)$$

The fully covariant metric and scalar field solutions of 5D, as given by the Kaluza-Klein theory are as follows (Equations (6)–(11)).

$$e^{\vartheta} = \Psi^2\varphi^{-2} \quad (6)$$

$$e^{\lambda} = \left(1 - \frac{\beta^2}{r^2}\right)^2\Psi^{-2} \quad (7)$$

$$\varphi^2 = -\alpha^2\Psi^4 + \left(1+\alpha^2\right)\Psi^{-2} \quad (8)$$

$$\Psi = \left(\frac{r-\beta}{r+\beta}\right)^{\frac{1}{\sqrt{3}}} \quad (9)$$

$$B = \frac{G_0M}{\sqrt{3(1+\alpha^2)c}^2} \quad (10)$$

$$\alpha = \frac{Q}{2\sqrt{G_0M}} \quad (11)$$

$$g = g_N\left(1 - \frac{14\,G_0M}{3c^2r}\right) \quad (12)$$

From the results, it is shown that the gravitational field is reduced by the scalar field. For instances, the gravitational field is shed by ~10% (or the percentage of weight loss for a sample object) at $r = 100B$; by ~20% at $r = 35B$; by ~40% at $r = 15B$; by ~80% at $r = 5B$; and ~100% at $r = B$. Therefore, for a weak field, the relative difference of the field is small and thus the shielding effect is negligible [18].

5. Gravitational Time Dilation

The general theory of relativity enunciates that an object moving in a gravitational field can be compared to an object moving with uniform acceleration. However, this theory expresses the basic concept of the space–time fabric and time dilation phenomenon; that wherever space–time bends and creates a curvature, like a big mass placed on a stretched-out rubber sheet, it then creates a gravitational time dilation. The expression for the gravitational time dilation is shown in Equation (16).

$$t_f = \frac{t_0}{\sqrt{1 - \frac{2Gm}{Rc^2}}} \quad (13)$$

6. Gravitational Shielding and Time Dilation

$$t_0 = t_f\left(\sqrt{1 - \frac{2Gm}{Rc^2}}\right) \quad (14)$$

Squaring both sides and then rearranging Equation (14) obtains Equation (15):

$$\left(\frac{t_0}{t_f}\right)^2 = 1 - \frac{2gR}{c^2} \quad (15)$$

Further simplification of Equation (15) so as to obtain a common denominator yields Equation (16):

$$\left(\frac{t_0}{t_f}\right)^2 = \frac{c^2 - 2gR}{c^2} \quad (16)$$

$$c^2\left(\frac{t_0}{t_f}\right)^2 = c^2 - 2gR \tag{17}$$

$$2gR = c^2 - c^2\left(\frac{t_0}{t_f}\right)^2 \tag{18}$$

$$2gR = c^2\left(1 - \left(\frac{t_0}{t_f}\right)^2\right) \tag{19}$$

$$2g = \frac{c^2}{R}\left(1 - \left(\frac{t_0}{t_f}\right)^2\right) \tag{20}$$

$$2g = \frac{c^2}{R}\left(\frac{t_f^2 - t_0^2}{t_f^2}\right) \tag{21}$$

From Majorana's approximation:

$$g = \int GMR^{-2}e^{-h\rho L}dR \tag{22}$$

Substituting the expression of g (Equation (22)) in Equation (21), upon rearranging the terms, yields Equation (23):

$$\frac{2R}{c^2}\int GMR^{-2}e^{-h\rho L}dR = \frac{t_f^2 - t_0^2}{t_f^2} \tag{23}$$

$$\frac{2t_f^2}{c^2}\int GMR^{-1}e^{-h\rho L}dR = t_f^2 - t_0^2 \tag{24}$$

$$t_0^2 = t_f^2 - \frac{2t_f^2}{c^2}\int \frac{GM}{R}e^{-h\rho L}dR \tag{25}$$

$$t_0^2 = t_f^2\left(1 - \frac{2GM}{c^2}\int \frac{e^{-h\rho L}}{R}dR\right) \tag{26}$$

$$t_0^2 = \frac{t_f^2}{c^2}\left(c^2 - 2GM\int \frac{e^{-h\rho L}}{R}dR\right) \tag{27}$$

$$t_0 = \frac{t_f}{c}\left(c^2 - 2GM\int \frac{e^{-h\rho L}}{R}dR\right)^{1/2} \tag{28}$$

Thus, the final time would be:

$$t_f = \frac{ct_0}{\left(c^2 - 2GM\int \frac{e^{-h\rho L}}{R}dR\right)^{1/2}} \tag{29}$$

where R is the distance (radius) of shield; h-screening constant $h \cong 10^{-22}\mathrm{m^2kg^{-1}}$; L = thickness of shield; ρ = density of shield; and M is the reduced/effective mass.

Now let us apply the obtained expression for the dilated time, Equation (29), in an actual model and try to obtain the result for the particular case.

We choose the solar eclipse model where the Sun acts as the gravitating body while the Moon, considering it to be a total solar eclipse and at the instant where the umbra of the eclipse is perfectly normal to the surface of the earth, acts as the shield for the Earth, as depicted in Figure 1. The density of the moon, ρ_{moon} is very small when compared to the shielding constant, so the term can be sufficiently approximated to 1.

However, since $e^{-h\rho L} \rightarrow 1$ *and* $h \approx 10^{-22}\text{m}^2\text{kg}^{-1}$ then substituting in to Equation (29) we obtain Equation (30) as below:

$$t_f = \frac{c\, t_0}{\left(c^2 - 2GM \int \frac{dR}{R}\right)^{1/2}} \quad (30)$$

and further simplification leads to Equation (31):

$$t_f = \frac{c\, t_0}{\left(c^2 - 2GM \ln R\right)^{1/2}} \quad (31)$$

since $M = \frac{m_1 m_2}{m_1 + m_2}$, but here $m_1 >> m_2$, $\frac{m_1 m_2}{m_1} \approx m_2$.

On substituting $m_2 = m_A 5.972 \times 10^{24}$ kg; $c = 3 \times 10^8$ ms^{-1}; G = 6.674× 10^{-11} Nm^{2}kg^{-2}; R = 3.84×10^8 m; into Equation (31) and upon calculating, yields the following result:

$$t_f = 1.04875\, t_0 \quad (32)$$

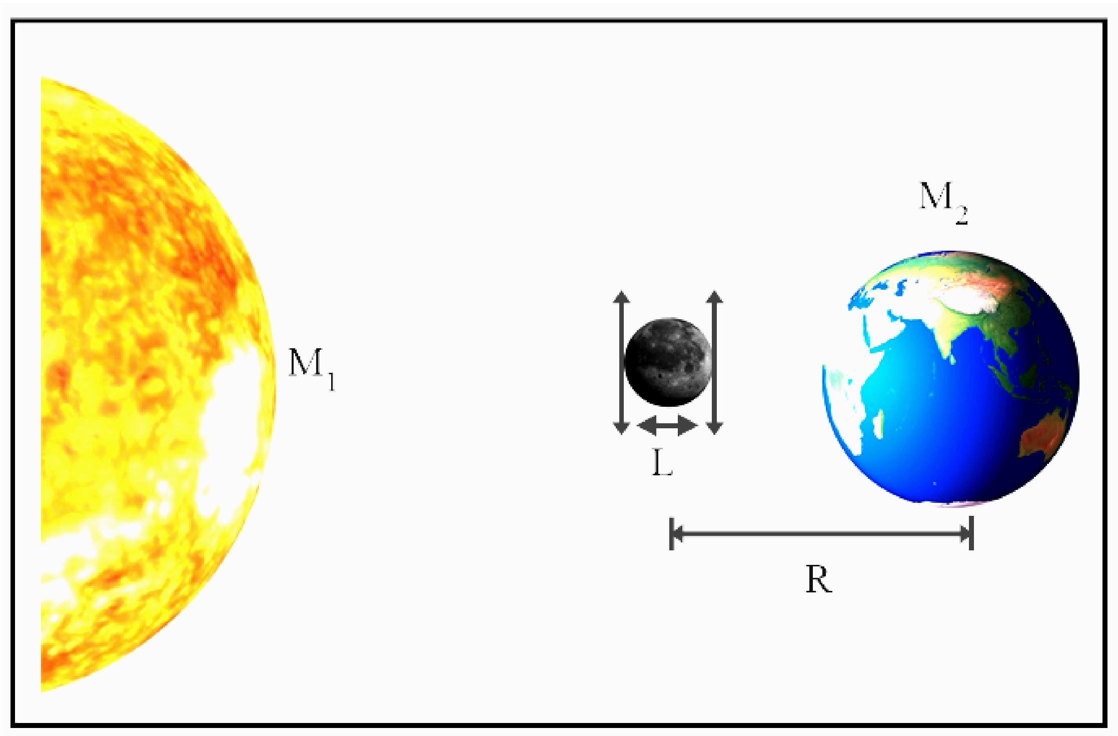

Figure 1. Solar Eclipse Model where ρ= density of shield $(\rho_{moon}) = 3.34 \times 10^3$ kgm^{-3}, L = thickness of shield $(L_{moon}) = 3.474 \times 10^6$ m, R is the distance (radius) of shield; h-screening constant $h \cong 10^{-22}$ m^{2}kg^{-1}; and M_1 is the mass of sun and M_2 be the mass of earth.

7. Discussion

According to the solution obtained from the case study, final time deviates from original time by very few seconds, even for higher amount of gravitational shielding. Thus, the amount of shielding depends entirely on the mass of the object. In the case of binary star systems such as Alpha Centauri the shielding thickness is greater, which means it can increase the effect of time dilation to a much more significant extent.

Gravitational shielding seems to be quite contradictory to the general notion of physics because it violates the conservation of energy in a similar way to superconductors, which violate Ohm's law. If gravitational shielding is possible as per discussions above, as stated from the experiments, it should have some negative gravitational potential to manage the imbalance in the conservation laws.

Antigravity is different from gravitational shielding. Where there is a mass, there exists gravity. Mass is the result of a particle's interaction with Higgs field. Thus, stronger interactions result in greater mass.

Gravitons are the hypothesized quanta of gravity that mediate the gravitational force between bodies, thereby in a sense, causing it. It is similar to the weak nuclear force generated by W and Z Bosons. Strong nuclear force is caused by gluons and electromagnetic force by the exchange of photons. In the absence of any experimental evidence to prove gravitons, it is almost impossible to verify or measure gravitational shielding precisely and accurately.

CERN is trying to create antigravity using antimatter, but antimatter is the costliest thing on Earth. In theory, we could create an antimatter rocket which can produce a specific impulse, which will be about 1million to 10 million times more efficient when compared to solid, liquid or gaseous fuelled or pulsed rocket engines [19]. Antimatter has the opposite charge to that of matter which means it can create negative gravitational fields which could help in proving the effects of gravitational shielding.

Space researchers are also observing large magnetic fields feeding super massive black holes at the centre of galaxies. NASA's flying telescope, the Stratospheric Observatory for Infrared Astronomy (SOFIA) studied the active galaxy Cygnus A, whose magnetic field dust feeds the super massive black hole. Cygnus A which is 600 light years away is surrounded by the disk of dust and gas that feeds the black hole due to the influence of its magnetic field. Scientists are interested in studying the magnetic field of the black holes and their observations evidently proves that there exists a relationship which governs and also claims that gravity and magnetic field can coexist with each other under certain physical conditions as exhibited in the picture of Universe. If the existence of negative gravitational fields is proven, then it can be comfortably linked with the above hypothesized effects of gravitational shielding thereby opening a new avenue in the field of theoretical physics.

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