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The quantum origins of gravity

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Abstract

A description of photon wavelength changes in a medium, such as glass, shows it has the same origins as photon wavelength changes, i.e. redshift, in matter free space. Photon trajectories are deflected by changes in electric permittivity. The radial differential of the electric permittivity of space around a massive object gives Newton's inverse square law as a first approximation and Einstein's variation as a second approximation. The exact solution matches known, and predicts unknown, gravity properties. Changes in the electric permittivity of space deflects photons in the same manner as gravity. How particles generate changes in electric permittivity of matter free space is given. It shows why gravity affects all photons and matter particles equally. It indicates that photon deflection by changing electric permittivity generates gravity.

Keywords: gravity, nucleons, electric permittivity, deflection

1) Introduction

In the 17th century CE, the study of gravity was changing from Earth at the centre of the universe, to planets orbiting the Sun [1]. Using his telescope, Galileo [2, 3] confirmed the idea that the planets moved around the Sun and that gravity was responsible for those heavenly motions. He observed that Jupiter had four moons orbiting it. The solar centric model for the motion of the planets around the Sun was firmly established.

Newton [4, 5] placed gravity and gravitational effects on a firm foundation. He introduced his universal law of gravitational attraction between two bodies of masses M and m, through the equation:

$$F_G = \frac{GMm}{r^2} \qquad (1)$$

where F_G is the gravitational attraction between the two bodies, G is Newton's universal gravitational constant, and r is the distance between their centres of mass. Newton also indicated that gravity was responsible for holding everything onto the surface of Earth, and other planets and heavenly bodies. Gravity was universal and affected everything. His gravity field equation was:

$$g = \frac{GM}{r^2} \qquad (2)$$

He gave no mechanism by which gravity caused two masses to attract each other. In Proposition 45 of Principia Volume 1, [5] he worked out that if gravity was weaker than inverse square, a planet would orbit a little further away from the sun and be attracted by a weaker force. It would travel further to return to its perihelion position, which will precess in its orbital direction. Conversely, if gravity was stronger than inverse square, it will orbit a little closer to the sun and be attracted by a stronger force. It will arrive at its perihelion position sooner, which will regress against its orbital direction.

His other predictions on gravity showed it acted as if all the mass of a body was located at its centre of mass. That, his shell theorem and inverse square law of gravity made calculating gravity effects much easier.

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His inverse square law successfully predicted all gravitational observations for almost 200 years. Towards the end of the 19th century CE, it was established that Mercury's orbit had an anomalous precession of 43 arc sec per century (*as/c*) [6, 7].

In 1911, Einstein [8] applied Newton's inverse square law to photons, which he had previously predicted had mass [9]. From that he determined that photons moving away from the sun would be redshifted.

Based on the gravitational field equations associated with his general theory of relativity, Einstein [10, 11, 12] predicted that Mercury should have an anomalous orbital precession of 43 *as/c* [13]. He also made other gravitational predictions including the bending of light rays by massive objects, which includes gravitational lensing, and gravity waves.

Many other attempts were made to explain the origins of gravity. Quantum gravity approaches include gravitons, string and loop quantum gravity theories, among others. A good summary was given in Krasnoholovets [14]. Most, like Einstein's theory, were based upon mathematical calculations and are very much mathematical work in progress.

Einstein's theory of mass distorting space-time was the most successful. Space–time distortion gave a mechanism by which gravity could attract. He gave no indication of the physical properties of space and time that mass distorted.

Through his equation:

$$s^2 = c^2t^2 - x^2 - y^2 - z^2 \qquad (3)$$

Minkowski [15, 16] suggested that space and time were interlinked in a single continuum by the speed of light. In equation (3), *s* is the space–time co-ordinate, *c* is the speed of light in vacuum, *t* is time and *x*, *y* and *z* are the orthogonal space dimensions.

The complexities of Einstein's mathematics made it difficult to understand what the physical principle by which mass distorted space–time was. Some who followed his work "solved" his field equations [17] as:

$$ds^2 = dt^2\left(1 - \frac{\alpha}{r}\right) - \frac{dr^2}{\left(1-\frac{\alpha}{r}\right)} - r^2(d\theta^2 + sin^2\theta d\varphi^2) \quad (4)$$

where $\alpha = \dfrac{2GM}{c^2}$. Equation (4) predicted black holes, bodies so massive that not even light could escape from them. Einstein did not believe they could be derived from his field equations.

For over 100 years after Einstein published the gravitational field equations associated with his general theory of relativity, people knew the mathematics worked, but not the physical principle of mass distorting space–time.

Robinson [18] solved that by pointing out that space–time distortion was photon redshift. That considerably simplified the mathematics of some of the effects Einstein calculated. It also corrected some misconceptions that had developed in those who followed and extended Einstein's gravity calculations. Among those was showing that the exact solution to Einstein's field equations was:

$$ds^2 = \frac{dt^2}{\left(1+\frac{\alpha}{r}\right)} - dr^2\left(1 + \frac{\alpha}{r}\right) - r^2(d\theta^2 + sin^2\theta d\varphi^2) \quad (5)$$

That equation can also be derived from Einstein's 1916 Foundations paper [11], without reference to his field equations, as shown in Appendix 1.

Equation (5) only describes the difference between Einstein's field equations and Newton's inverse square law. Incorporating the dr^2 term from equation (5) to Newton's inverse square law, equation (2) gives

$$g = \frac{GM}{\left(1+\frac{\alpha}{r}\right)r^2} = \frac{GM}{(1+2z)r^2} \qquad (6)$$

where z is redshift.

Einstein's gravity, equation (6), is weaker than Newton's gravity, equation (2). In Proposition 45 volume 1 of his Principia, Newton pointed out that, if gravity was stronger than inverse square, a planet orbiting the sun would have its perihelion and aphelion positions regress against its orbital direction. If gravity was weaker than inverse square, a planet's perihelion and aphelion positions would precess in its orbital direction. The physical reasons were given by Newton, as mentioned above.

Mercury's anomalous orbital motion, i.e., that not predicted by Newtonian gravity, was a precession of ≈ 43 arc seconds per century (as/c). The orbit of star S2 about the massive object in Sagittarius A precesses in its orbital direction [19, 20]. For those to occur, gravity must be weaker than inverse square.

The above points out the advances made by knowing that Einstein's mass distorting space–time is determined by photon redshift. It does not point out how mass distorts space–time to produce that redshift. Einstein gave no indication of the physical properties of space and time that mass distorted to generate gravity. The objective of this presentation are to point out the property of space that mass distorts to produce gravity, and how mass distorts that property.

2) Properties of space and gravity

In his first attempt at calculating the bending of light rays by the sun, Einstein [8] suggested they could be bent by a change in the refractive index of matter free space. Roy and Sen [21] summarised the work of others who also suggested that changes in the refractive index of matter free space could be responsible for some gravitational effects. None continued the calculation to determine how such a change would give rise to gravity.

Maxwell [22] determined that the speed of light in vacuum, *c*, was given by:

$$c^2 = \frac{1}{\varepsilon_0 \mu_0} \qquad (7)$$

where ε_0 and μ_0 are the electric permittivity and magnetic permeability of matter free space.

Huygens [23] suggested that the diffraction of light was caused by changes to the speed of light in different media. It has since been established that the speed of light through a medium m, c_m, was always slower than that in free space. The refractive index, n, of medium m, n_m, was given by $n_m = \frac{c}{c_m}$, where c_m is the speed of light through medium *m*. From that we get $c_m^2 = \frac{1}{\varepsilon_m \mu_m}$, which gives:

$$n_m = \sqrt{\frac{\varepsilon_m \mu_m}{\varepsilon_0 \mu_0}} \qquad (8)$$

The refractive index, n_m, of a medium is always greater than 1. Light passing through a medium with an increased refractive index is slowed and deflected towards the material with the higher refractive index.

Magnetic permeability, μ, is defined as 4π x 10^{-7} Henry/m. The speed of light in vacuum, c, is defined as 299,792,458 m/sec. The electric permittivity, ε_0, is derived from them. With magnetic permeability fixed, equation (8) becomes:

$$n_m = \sqrt{\frac{\varepsilon_m}{\varepsilon_0}} \qquad (8a)$$

The speed of light through medium m is given by:

$$c_m = \frac{c}{n_m} = c.\sqrt{\frac{\varepsilon_0}{\varepsilon_m}} \quad (9)$$

The wavelength of light changes inversely with its refractive index. An increase in refractive index slows down the speed of photons, decreasing their wavelength. An increase in wavelength when a photon goes from ε_m to ε_0 is denoted by redshift, z, given by:

$$z = \frac{\lambda_0 - \lambda_m}{\lambda_m} = \frac{\lambda_0}{\lambda_m} - 1 \quad (10)$$

where λ_m and λ_0 are its wavelengths at its origin in medium m and at matter free space respectively.

$$\frac{\lambda_0}{\lambda_m} = n_m = 1 + z \quad (11)$$

Equations (8a) and (11) combine to give $z = n - 1 = \sqrt{\frac{\varepsilon_m}{\varepsilon_0}} - 1$, which simplifies to:

$$\frac{\varepsilon_m}{\varepsilon_0} = (1 + z)^2 \quad (12)$$

Equation (12) applies to any medium. Einstein [8] predicted, and it has been observed that photons are redshifted as they move away from the sun and other massive objects [21 – 23].

Robinson [18] equation (8), showed that gravitational redshift was given by:

$$(1 + z) = e^{\alpha/2r} \quad (13)$$

where $\alpha = \frac{2GM}{c^2}$. The redshift, z, is the same in both calculations. Equating equations (12) and (13) gives:

$$\varepsilon_m = \varepsilon_0 e^{\alpha/r} \quad (14)$$

To avoid confusion, ε_m in space will be referred to as ε_G to indicate its association with gravity. Equation (14) becomes:

$$\varepsilon_G = \varepsilon_0 e^{\alpha/r} \quad (14a)$$

Equations (7) and (8) show that the absolute values of electric permittivity determine the speed of light through a medium. It has been known since Huygens' work that a change in refractive index changes the speed of photons travelling perpendicular to that change. It deflects photons travelling non-perpendicularly to the change.

Since Maxwell's work, it has been known that the refractive index of a medium is governed by its electric permittivity when the value of magnetic permeability is fixed. Electric permittivity determines the refractive index of a medium. Changes in electric permittivity determine the speed and deflection of photons.

Most of the universe is matter free space, where the electric permittivity is ε_0. Equation (14a) shows that ε_0 changes to ε_G as photons approach a mass. The rate of change of electric permittivity from ε_0 to ε_G, is given by the differential of $\frac{\varepsilon_0}{\varepsilon_G}$ with the distance r, namely:

$$\frac{d}{dr}\left(\frac{\varepsilon_0}{\varepsilon_G}\right) = \frac{d}{dr}\left(e^{-\alpha/r}\right) = \frac{-e^{-\alpha/r}}{r^2} = \frac{-1}{r^2 e^{\alpha/r}} \quad (15)$$

Equation (15) gives the rate of change of the electric permittivity with distance from the centre of mass for distances outside the mass. That rate of change determines the deflection, Δ, of photons passing at an angle to that variation. The – sign indicates the deflection is in the opposite direction to the radius. It has the same role as Einstein's $\sqrt{-g} = 1$ in his field equations.

Equation (15) requires a constant of proportionality to be useful. Equation (20) of Robinson [18], derived the equation $g_z = \frac{GM}{r^2 e^{\alpha/r}}$, where g_z is the acceleration due to gravity from redshift considerations. It shows that GM is the constant of proportionality for equation (15). That gives:

$$g = \frac{GM}{r^2 e^{\alpha/r}} \tag{16}$$

as the exact solution to equation (15).

When α<<<r, $e^{\alpha/r} = 1$ and equation (16) becomes $g = \frac{GM}{r^2}$, Newton's equation (2). When α<<r, $e^{\alpha/r} = \left(1 + \frac{\alpha}{r}\right)$ and equation (16) becomes $g = \frac{GM}{\left(1+\frac{\alpha}{r}\right)r^2} = \frac{GM}{(1+2z)r^2}$, equation (6). It adds Einstein's gravity field equation to Newton's gravity. That supports Einstein's theory that mass distorts space-time to produce gravity, even when photon redshift, i.e., space-time distortion, is too small to measure.

Figure 1 shows an object of mass M, containing N nucleons, with a field of varying electric permittivity surrounding it. The white background represents the value ε_0. The intensity of the grey shades represents the increasing value of ε_G as it approaches M. The dotted lines surrounding it are lines of equal electric permittivity. Photons are represented by γ.

Photon A travels across the lines of equal electric permittivity. Its trajectory becomes increasingly deflected the closer it gets to the mass M. After it reaches its point of closest approach, its deflection diminishes as it returns to ε_0. This is illustrated by the differences in the photon's trajectory, full curve, and the dashed lines that extend the photon's initial and final directions back to their crossover at its position of closest approach.

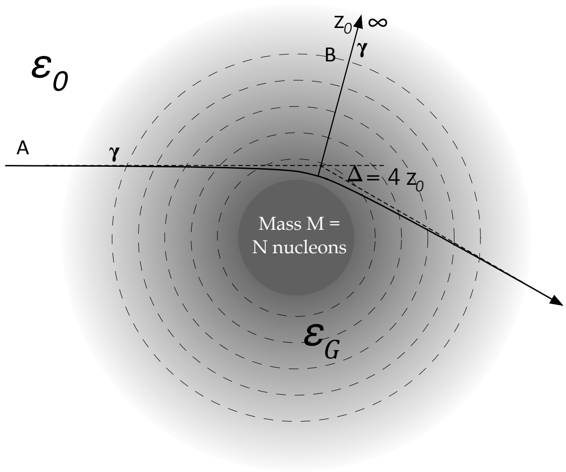

Figure 1: *Schematic illustration of a photon being deflected by an angle Δ as it approaches and departs a massive object composed of N nucleons.*

Using the Schwarzschild radius calculations, the total deflection, Δ, in radians, is 4 times the redshift of photons leaving the position of closest approach and reaching ε_0, the effective infinity [18].

Photon B, travelling perpendicular to the lines of equal permittivity, is not deflected. It starts out in a high electric permittivity zone and travel to a lower electric permittivity zone. Its speed increases, stretching its wavelength. That is the origin of photon redshift. The predicted redshift between the sun and Earth is 2.1 x 10^{-6}. That was the same as Einstein [8] calculated. It has been observed [24 – 26] .

3 Background Information on Particle Structures

The standard model [27, 28] uses nucleons composed of quarks held together by gluons [29]. It has had some successful predictions through the theory of Quantum Chromodynamics [30]. It has many failures. Being based upon mathematics associated with undetected particles, they are hidden behind a wall of great complexity.

Failures show up by their inability to predict much about nuclear physics and the structure of nuclei. Electrons, photons, and neutrinos are treated as point particles to which properties are mathematically attached. All predictions are made mathematically, mostly being to match known properties. Only a few predictions were made in advance and subsequently verified.

Another model was proposed in which all matter particles were considered as being composed of confined photons. The original presentation was by Williamson and van der Mark in 1997 [31]. They proposed a model in which an electron was considered as a photon of the appropriate frequency confined by making two complete revolutions per wavelength. That gave electrons the appearance of a toroidal electromagnetic field. Their study was followed by similar proposals by Qui Hong [32] and Robinson [33].

Reference [33] showed how the rotating photon structure automatically generated the special relativity corrections when particles moved. The physical relationship that is $E = mc^2$, is that energy is the photon travelling at c in a straight line, while mass is the same photon making two revolutions per wavelength while still traveling at c. That rotation is also the origin of the spin $J = ½\hbar$.

When Maxwell predicted the existence of electromagnetic waves, he established they were oscillating electromagnetic fields. Between them Planck [34] and Einstein [35] established there was a minimum size to Maxwell's electromagnetic fields. That size was called a photon. It consisted of a single wavelength with the electric and magnetic fields oscillating perpendicularly to each other and the structure travelling at the speed of light.

From their work, it was established that photons had a frequency ν and energy $E = h\nu$, where h is Planck's constant. From Einstein's $E = mc^2$, that gives photons:

mass $m_p =, \frac{h\nu_p}{c^2}$ and frequency $\nu_p = \frac{m_p c^2}{h}$ (17)

The subscript refers to properties of the photon.

When photons rotate to generate electrons, as previously indicated, they retain their properties of mass and frequency [31 – 33]. The subscript p applies equally to the particle that is the rotating photon, as it does to the rotating photon. Equations (17) show that particles have a frequency related to their mass. From Maxwell's work [22], we know that frequency is the oscillating frequency of the electric field.

Rotating photons that are electrons as proposed, have a rest mass of 0.511 MeV/c^2, giving them an oscillating electric field frequency of ≈ 1.236 x 10^{20} Hz. In making two revolutions per wavelength, the electric field oscillates at twice that frequency or 2.472 x 10^{20} Hz. That is an electron's zitterbewegung, ZBW [36].

There is evidence that electrons are photons of the appropriate frequency making two revolutions per wavelength. Physically it is known that collisions of photons of the appropriate energy generate electron/positron pairs. Equally, electron/positron pair annihilations generate two photons, one for each particle.

The simplest physical explanation for this is that both particles are confined photons of the appropriate energy. The simplest confinement is that the photons rotate twice per wavelength to become the particle. Magnetic fields are stronger than electric fields. Photons rotating twice per wavelength means the magnetic fields overlap in charged particles like electrons. That overlap gives stability to charged particles.

That rotating photon structure is also responsible for the special relativity corrections of mass, length and time with increasing particle speed. It adds an additional correction, with its rotation diameter decreasing with increasing speed by the same correction factor. That is why GeV electrons scatter as if their dimension was ≈ 10^{-17} m, while TeV electrons scatter as if they had dimension ≈ 10^{-18} m [33].

Some of the mathematics of electrons composed of photons of the appropriate energy making two revolutions per wavelength has been given by Williamson [37].

The axiom is introduced that this electron model applies to all matter particles, including the nucleons. They, like electrons, are composed of photons of the appropriate frequency making two revolutions per wavelength. The frequency, ν_p, of the photons that are the particles, is given by equation (17).

It is suggested this axiom is somewhat like the introduced axioms of gravitons and string theory. Dirac was credited with re-introducing the term graviton as the quantum of gravity [38]. Susskind [39] is acknowledged as one of the founders of string theory.

Both axioms are hypothetical and have been the subject of significant study. Despite the extensive studies none has shed any significant light on the origins of gravity.

It is suggested this axiom is different for two reasons. One is that, as this study shows, it gives a good explanation of known properties of gravity. Another is that it unites quantum properties of matter with the special relativity theory [33] and the physical origins of gravity – this paper.

As well as uniting quantum properties with relativity, another special relativity correction was added [33]. It also bypasses Einstein's gravity theory from his general relativity theory. In doing so, it removes the approximations he used, considerably simplifies the maths and corrects mathematical errors made by those who tried to solve his complex field equations.

Under this model, all particles will be a photon of the appropriate frequency making two revolutions per wavelength as they become particles. Table 1 lists the matter particles, their masses and frequencies. The zitterbewegung, ZBW, of electrons is the vibration caused by its rotating photon making two revolutions per wavelength. The electric field oscillations are given by their ZBW. They range in frequencies from ≈ 2 x 10^{20} Hz to ≈ 4 x 10^{23} Hz.

Particle	Mass (MeV/c^2	Frequency (Hz)	ZBW
Electron	0.511	1.236 x 10^{20}	2.472 x 10^{20}
Proton	938	1.269 x 10^{23}	4.538 x 10^{23}
Neutron	939	1.269 x 10^{23}	4.539 x 10^{23}

Table 1: List of particles, their masses, frequencies and ZBW

4. Mass Changes the Electric Permittivity of Space

In chapter 31 of volume 1 of his Physics Lectures, Feynman [41] addressed the topic of the refractive index of a material. He indicated that electrons "… behave like little oscillators …". He further indicated the oscillating electric field they produce, would change the refractive index of a medium by changing its electric permittivity.

He developed his approximate equation (31.19) for refractive index of a medium:

$$n = 1 + \frac{N_\rho q_e^2}{2\varepsilon_0 m(\omega_0^2 - \omega^2)} \qquad (18)$$

where $N\rho$ is the electron density, $q_e = e$, unit electric charge, m is the electrons mass, ω_0 is the frequency of the oscillating electrons and ω is the photon frequency. Combining equations (8), $n = n_m = \sqrt{\frac{\varepsilon_m}{\varepsilon_0}}$ and (9), $c_m = \frac{c}{n_m} = c.\sqrt{\frac{\varepsilon_0}{\varepsilon_m}}$, with (18) gives:

$$z = \sqrt{\frac{\varepsilon_m}{\varepsilon_0}} - 1 = \frac{N_\rho q_e^2}{2\varepsilon_0 m(\omega_0^2 - \omega^2)} \qquad (19)$$

Equation (19) applies because the oscillating electrons in the medium affect other electrons. For that reason, the charge and frequency terms are squared. The general principle is that the oscillating electric field, generated by the moving electric charges, change the medium's electric permittivity. Applying the same principle to matter free space means we need only use one unit of charge and one frequency, instead of their square.

The oscillating electric field is generated by electric field variations of the rotating photons that are the nucleons. The electron density is replaced by the total number of oscillating nucleons.

In the denominator of equation (19), the m term refers to the mass of the electrons that respond to the electric field oscillations. With nothing in matter free space to respond to the oscillating electric fields, there is no need for that term. The 2 is used because the electrons both generate a frequency and respond to the frequencies of others. With frequencies only generated and nothing responding, it is not needed.

The strength of the electric field is proportional to $\frac{q_e}{\varepsilon_0}$. With one of the q_e terms removed, the ε_0 term is also removed. The study is about the changes to the electric field permittivity, not its strength. With those modifications, the same principle of a varying electric field affecting the electric permittivity of space, still apply.

Their random nature means the oscillation frequency will continue to increase until a maximum frequency is reached. After that, further oscillations will increase the amplitude. That maximum frequency could be the inverse of Planck's time of ≈ 5 x 10^{-44} sec. Planck's time is associated with the largest frequency that photons can have before they self-collapse into a black hole. It is not a realistic limit.

That does not mean there isn't a maximum frequency, ω_M, below Planck's frequency. With nucleons having a frequency of ≈ 10^{23} Hz, that frequency would be reached with < 10^{26} nucleons, about 1 kg.

Adding those corrections to equation (19) changes it to

$$z \approx fn.N.\left(\frac{e}{\omega_M - \omega}\right) \qquad (20)$$

In equation (20), z is the redshift from ε_M to ε_0, i.e., going from near a mass to infinity; N is the number of nucleons in the mass; e is the unit electric charge, and ω_M is the maximum frequency from the oscillating nucleons. The term *fn* covers all other factors. It is introduced because Feynman's equation, his (32.19) is an approximation. Derivations from it may still be an approximation.

In equation (20) N converts to M, mass in kg, using 6 x 10^{26} nucleons ≈ 1 kg. Charge is the unit electric charge, 1.602 x 10^{-19} C. Setting $\omega_M = 10^{44}$ and deleting ω because $\omega_M >> \omega$, equation (20) becomes

$$z = fn.6x10^{26}M.\frac{1.6\,x\,10^{-19}}{10^{44}} \approx fn.1x10^{-36}M \qquad (21)$$

Conventional redshift measurement, denoted z* and derived from Newtonian mechanics is:

$$z^* \approx \frac{\alpha}{2r} = \frac{GM}{rc^2} \qquad (22)$$

Using the sun's mass $M_\odot \approx 2 \text{ x } 10^{30}$ kg gives $z \approx fn.2\text{x}10^{-6}$ and $z^* = 2.1 \text{ x } 10^{-6}$. z^* has also been measured at 2.1 x 10^{-6}. That suggests that *fn* ≈ 1 and agreement between the two approaches is good.

The agreement between equations (21), which was derived from permittivity considerations, and equation (22), which was derived from measurement and Newtonian mechanics, supports the idea that gravity is caused by changes in the electric permittivity of space, with those changes being induced by oscillating electric fields.

The very small value of e and the large value of ω_M in equation (20) means N must be large to make a significant change in the electric permittivity of space and thus deflect photons according to equation (16). That is why gravity is such a weak force.

The only way gravity can be stronger than inverse square is for the electric permittivity of space to be lower than that of empty space. It is difficult to conceive of any physical mechanism by which that could occur. It cannot be done through accurate mathematics from Einstein's field equations or from equation (16), of which Newton's gravity is a first approximation and Einstein's gravity is a second approximation.

5 How Changing Electric Permittivity Affects Mass.

The first feature to note is that all particles are photons rotating twice per wavelength. Rotating or not, they are still photons. Equation (20) and table 1 show the particle's frequencies are much lower than ω_M, their response to the changing electric permittivity of space will be the same as visible, and all other photons.

The process of comparing equations (21) and (22) was repeated for the planets orbiting the sun. The results are given in table 2. The *fn* terms are the number needed for equation 20 to match equation 21. The gas giants have *fn* ≈ 1. The ice giants have *fn* ≈ 30. The large rock planets have *fn* ≈ 120. The small rock planets have *fn* ≈ 3,600.

The difference between the gas and ice giant ratios is a factor of ≈ 30. That between the ice giants and the large rock planets is ≈ 4. That between the large and small rock planets is ≈ 30. In round figures, the differences between the *fn* terms are within a factor of ≈ 4,000.

The mass difference between the sun, ≈ 2 x 10^{30} kg and Mercury, ≈ 3.3 x 10^{23} kg is ≈ 6 x 10^6. A difference of 4,000 in a weight range of 6 x 10^6 corresponds to a difference of ≈ 0.01%.

Body	z (21)	z* (22)	*fn* (z*/z) ⊙
Sun	2.0×10^{-6}	2.1×10^{-6}	1.1
Mercury	3.3×10^{-13}	1.1×10^{-10}	3×10^{3}
Venus	4.9×10^{-12}	6×10^{-10}	1.2×10^{2}
Earth	6×10^{-12}	7.1×1^{-10}	1.2×10^{2}
Mars	6.4×10^{-13}	1.5×10^{-10}	4.3×10^{3}.
Jupiter	1.9×10^{-9}	2.0×10^{-9}	1.1
Saturn	5.7×10^{-10}	7.3×10^{-10}	1.3
Uranus	8.7×10^{-11}	2.5×10^{-9}	29
Neptune	1.0×10^{-10}	3.1×10^{-9}	31

Table 2: The different redshift calculations, and their ratios, for the major bodies in our solar system.

Newton's gravitational constant, G, is usually stated as 6.67×10^{-11} $m^3.kg^{-1}.s^{-1}$. Several experiments have measured G to an accuracy of an additional 3 significant figures [41, 42]. They reported a difference of ≈ 0.015% between the different results. That difference is approximately the same as the differences over the large mass ratios. Those differences still need to be explained.

Equating equation (20), with N changed to M, and (22) gives :

$$z = fn.1x10^{-36}M.\left(\frac{e}{\omega_M}\right) = \frac{GM}{rc^2} = z* \qquad (23)$$

The c, e and z^* values in equation (23) have been measured and must be treated as accurate. The z term has the variables *fn* and ω_M. Both sides have the same M term, so it cancels out. Treating all terms except ω_M and *fn* as constant, a decrease in ω_M gives an increase in *fn*.

The orbital information from a satellite orbiting a body, e.g., the moon orbiting Earth, gives the product of GM. Measurements of G on Earth gives $G = 6.67 \times 10^{-11}$. That value of G is used for all of the masses, and hence densities, used in table 2. Setting *fn* = 1 gives $\omega_M \approx 10^{42}$ for Earth and Venus.

Body	Mass (kg)	Density (kg/m^3)	ω_M (Hz)
Sun	2×10^{30}	1.4×10^{3}	10^{44}
Mercury	3.3×10^{23}	5.43×10^{3}	3×10^{40}
Venus	4.9×10^{24}	5.24×10^{3}	10^{42}
Earth	6×10^{24}	5.5×10^{3}	10^{42}
Mars	6.4×10^{23}	3.9×10^{3}	2×10^{40}
Jupiter	1.9×10^{27}	1.32×10^{3}	10^{44}
Saturn	5.7×10^{26}	0.69×10^{3}	10^{44}
Uranus	8.7×10^{25}	1.27×10^{3}	3×10^{42}
Neptune	1.0×10^{26}	1.64×10^{3}	3×10^{42}

Table 3: The different mass, density and fn terms, based upon Earth's fn = 1.

The ω_M term is the frequency of the oscillations that leave the mass M. It is well known in spectroscopy that atoms that can emit a frequency can also absorb the same frequency. It is suggested the same principle applies for electric field oscillations. This possibility has not been explored. It is worth noting that if fn depends upon mass, equation (23) shows that G could vary.

Leaving $fn = 1$ for all bodies, the last column in table 3 shows the frequencies the bodies would need for z to equal z* in equation (23). The general trend is the larger and less dense bodies generate higher frequencies than the smaller and more dense bodies. If that is a major factor it means the smaller and denser bodies, rocky planets, generate a greater gravity field for the same mass as the more massive and less dense bodies.

The only variables in equation 17 are fn and ω_M. Although the variations are a factor of about 4,000, spread over a mass range of 6 million, it is less than 0.1%. Although relatively minor errors, they need an explanation. The nucleons are emitting variable electric frequencies, high though they may be. In spectroscopy it is known that particles that can emit a frequency can also absorb at that frequency. That leaves some possibilities.

1) The frequencies emitted by inner nucleons are dampened by outer nucleons. That reduces the output for the same number of nucleons, giving a weaker gravitational effect for the mass.
2) The larger nucleons in closer proximity can reinforce each other, giving a greater amplitude for the same number of nucleons.
3) The large frequency amplitudes generated by an overwhelming mass, e.g., the sun, can influence the output from inner planets and bodies. The sun's gravitational field strength, i.e., radial differential of its electric permittivity, is larger than that on the surface of planets, until Saturn.

If fn is dependent upon mass, including the strong electric permittivity generated by the sun affecting inner planets more than outer planets, it could mean that G varies and the detected masses may not be the same, although it should not change the GM product determined from orbiting satellites or moons.

6 Gravity Influences Everything Equally.

Equation (20) included the term $(\omega_M - \omega)$ in the denominator. It was removed from equation (21) for ease of calculation. Table 3 suggests that ω_M is between 10^{40} and 10^{44} Hz. Table 1 shows ω for nucleons is $\approx 10^{23}$ Hz, for electrons is $\approx 10^{20}$ Hz. For visible photons it is $\approx 10^{14}$ Hz.

The high value of the maximum frequency, $\omega_M \approx 10^{42\pm2}$, Hz is much higher than the frequencies of all particles and photons. Applying Feynman's principle, given in equation (18), his equation (31.19), indicates the lower frequency won't respond differently to the electric permittivity generated by the higher frequency oscillating electric fields. That also justifies its removal from equation (20) to give equation (21).

Figure 1 shows how a changing electric permittivity affects photons travelling through it.

The effect is the same for linear and rotating photons. Linear photons pass rapidly from one value of electric permittivity to another, undergoing small diffractions over nucleon distances of ≈ 1 fm. They pass rapidly through the changed electric permittivity associated with a large mass. The sun, which has 10^{57} nucleons, deflects linear photons that pass close to its surface, by 1.74 arc sec. That is a small amount for such a large mass. Linear photons moving perpendicularly to the sun's surface are redshifted by only 2.1×10^{-6}. They are both very small values for such a large mass.

Part of that is their high speed, $\approx 3 \times 10^8$ km/sec. The strong electric permittivity gradient only affects them over a period of a couple of seconds. That is not long enough to have a significant effect.

The difference with rotating photons, i.e., particles, is they stay in the one place, undergoing the same deflection at the same distance. They are repeatedly subject to the same deflection. An indication of the strength of the effect can be obtained by considering gravity near Earth's surface. It has a mass of ≈ 6 x 10^{24} kg, containing ≈ 4 x 10^{51} nucleons, giving it a value of $g = 9.8$ m/sec^2. We can apply Newton's equation

$$s = ut + ½at^2 \qquad (24)$$

to a nucleon. In equation (24), s is the distance travelled, u is the initial velocity at time $t = 0$ and $a = g$, the particle's acceleration under gravity, Nucleons have a frequency of ≈ 4.5 x 10^{23} Hz. In 2.3 x 10^{-24} sec, the time it takes a nucleon's photon to travel the two rotations it makes in one wavelength, that acceleration causes them to be deflected by ≈ 1.1 x 10^{-48} m.

Table 4 shows the results of applying equation (24) to that deflection over the different times indicated. It shows the displacement is exceedingly small per wavelength cycle. A nucleon has to make ≈ 10^{16} wavelength cycles before it has moved ≈ 1fm, a typical nucleon dimension. It makes ≈ 10^{20} revolutions before it has travelled 1 micron. The displacement per unit time is the same for nucleons and electrons.

Time (sec)	Number of cycles	Displacement (m)
2.3 x 10^{-24}	1	1.1 x 10^{-48}
10^{-20}	4.5 x 10^{3}	4.9 x 10^{-40}
10^{-15}	4.5 x 10^{8}	4.9 x 10^{-30}
10^{-12}	4.5 x 10^{11}	4.9 x 10^{-24}
10^{-8}	4.5 x 10^{15}	4.9 x 10^{-16}
10^{-6}	4.5 x 10^{17}	4.9 x 10^{-12}
10^{-3}	4.5 x 10^{20}	4.9 x 10^{-6}
1	4.5 x 10^{23}	4.9

Table 4: *A list of the displacement individual nucleons will experience in free fall under the influence of Earth's gravity near sea level.*

It does not matter how many nucleons are in an object within the varying electric permittivity, they all undergo the same deflection towards the region with higher electric permittivity. Figure (1) and its associated equations show that the displacement is independent of the direction of travel of the photons. If the object containing the nucleons is unsupported, each time the rotating photons repeat their trajectory, they do so from a slightly different position and velocity towards the increased electric permittivity. That is what gives free particles their acceleration under gravity.

If the object is resting on a support, the deflection will exert a force on the support, converting its mass to its weight. Its mass is fixed. Its weight depends upon the gravitational field strength.

Every object contains nucleons and will generate changes in the electric permittivity of space. The changing electric permittivity by a body of mass M_1 will influence the rotating photon nucleons in another body of mass M_2. In the same manner, the changing electric permittivity of body M_2 will influence the rotating photon nucleons in body M_1. That is the origins of Newton's mutual attraction given in equation (1).

6. Discussion

The very large value of ω_M, $\approx 10^{42}$, means the oscillating electric fields will penetrate anything that tries to screen them out. Its effect can't be screened out. Gravity can't be screened out.

Equation (7) shows that the speed of light is determined by the absolute value of electric permittivity, ε. Equation (15) shows that photon deflection depends upon the electric permittivity's gradient, the rate at which it changes. It is clear that the greater the distance from mass M, the closer ε_G is to ε_0, the electric permittivity of free space. No limit was placed on how far from M would it be before $\varepsilon_G = \varepsilon_0$.

There would be a practical limit. That can be determined by applying Newton's shell theorem to a large number of galaxies giving the space surrounding them an average density ρ. Equation (16) can be applied to a large collection of galaxies of radius r, centred on any point in the universe. That gives $g_r = \frac{4\pi r^3 \rho}{3r^2 e^{\alpha/r}}$.

Substituting for α gives

$$g_r = \frac{4\pi G r^3 \rho}{3r^2 e^{\left(\frac{2G.4\pi r^3 \rho}{3rc^2}\right)}} = \frac{4\pi G r \rho}{3e^{\left(\frac{2G.4\pi r^2 \rho}{3c^2}\right)}} \qquad (25)$$

The numerator in equation (25) increases linearly with r. The denominator increases proportional to e^{r^2}. As $r \to \infty, g_r \to 0$, for any value of ρ. While there is no mathematical limit, equation (25) suggests there is a practical limit.

Inserting $r = 10^9$ light years and $\rho = 10^{-26}$ kg.m^{-3} into equation (25) gives $g \ll 10^{-50}$ m.s^{-2}. It is respectfully suggested that is a practical limit to the extent of gravitational influence. That limit stops an infinite universe from collapsing under the cumulative effect of gravity associated with increasing mass and distance.

Consider the situation of photons in figure 1. As photon A approaches mass M, it is slowed down in the increasing permittivity. As it travels away, the permittivity restores the photon to its original speed, namely c. In that manner, no energy is lost in the photon's deflection.

The same feature occurs when an object, e.g. a comet, approaches a massive object like a planet or sun. Its trajectory will be deflected in the same manner as in figure 1. The comet's total deflection will be more than that for a photon because its speed is much less. The effect given in equation 20 and table 3 will be much larger. The effect is otherwise the same. No energy is lost when it is deflected.

Equation (16) and Einstein's approximation, equation (6) both show that gravity is weaker than inverse square. That makes the existence of black holes physically impossible. The observed precession of Mercury's perihelion and that of star S2 about the massive object in Sagittarius A [19, 20], confirm that gravity is weaker than inverse square.

Appendix 2 shows the solution to the gravity field equations for Schwarzschild metric gravity, Newtonian gravity, the Einstein metric gravity and the equation (16) calculations.

As mentioned earlier, these calculations, like those of Einstein and Feynman are approximations. Those approximations give the right trend, even though the answers vary within a small range. The explanations are that there are unknown variables that are not included in fn, ω_M and/or Newton's G may not be as universal as expected. Consequently, some of the masses may not be as predicted.

A feature of table 3 is that it predicts that ω_M varies with the composition of bodies massive enough to generate gravity. That shows that Newton's universal gravitational constant, G, may not be universal. Equation (23) shows that a variation in fn can alter G and give different values of M than those currently used.

Measurements of G on Earth have produced results varying by up to 0.015%. The ω_M variation is about 3,000 in a mass range of ≈ 3 x 10^6, gives a variation of ≈ 0.01%. Newton's 1687 prediction of G as a universal constant was made with no knowledge of the mass of Earth, moon or sun. An accuracy of 3 significant figures those hundreds of years ago, and applicable to Earth, is a remarkable achievement. It may seem a little optimistic to believe that the same figure applies to densities ranging between ≈ 1,000 kg/m^3 (gas giants) to over 10^{17} kg/m^3 (neutron stars) and masses from ≈ 10^2 kg, laboratory experiments, to ≈ 10^{39} kg, mass in the centre of galaxy M87.

There are some significant differences between this presentation and Einstein's 1916 Foundations paper. His complex field equations only derive the difference between his theory and Newton's theory. Equation (15)'s differential and its solution, equation (16) are derived from considerations of the changing electric permittivity of space. It derives Newton's inverse square law as a first approximation and the full solution to Einstein's gravity as a second approximation.

Einstein suggested that gravity was caused by mass distorting space-time. This presentation shows that mass alters the electric permittivity of space around it. The changing electric permittivity gives photon redshift, which is the distortion of space-time mentioned by Einstein. Space-time distortion, i.e., photon redshift, does not cause gravity.

Gravity is produced by mass changing the electric permittivity off space. It is the changed electric permittivity that distorts space-time through redshift. Space-time distortion is produced by gravity generated by the electric permittivity of space. It does not produce gravity.

7. Conclusion

A presentation was given of how changes in the electric permittivity of matter free space deflect photons and change their frequency. Higher electric permittivity slows photons. Changes in electric permittivity deflects them. Both have the same effect on photons, be they linear or rotating, i.e., particles. It gives a strong indication that gravity is photon deflection and electric permittivity is space-time distortion.

It requires that all matter particles are composed of photons of the appropriate energy making two revolutions per wavelength. This gives them high frequency alternating electric fields, like the known electron zitterbewegung. Feynman's work showed that high frequency electric fields change the electric permittivity of space. Vast numbers of nucleons are required to make small changes to the electric permittivity of the space around a massive object. It is higher near the massive object and lower as the distance increases. That requirement is also necessary for photons and particles to respond equally to gravity.

Linear photons pass rapidly through the changed electric permittivity around a massive object. Their deflection is small. Rotating photons, i.e., particles, are subjected to the same deflection. Staying in the same place means the deflection effect is cumulative.

If they are unsupported, the deflection of each rotation increases their speed towards the massive object. That gives them their acceleration under gravity. If they are supported, each rotation deflection exerts a force on the supporting body. That converts their mass to weight!

The results show that over the ≈ 10^6 range in masses within the solar system, the differences between theory and observation were about 0.01%. The differences in the measurements of G on Earth are about the same.

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Appendix 1:

Direct Path to Solve Einstein's Gravity Theory

Abstract

A solution to Einstein's gravity theory is derived directly from his 1916 paper. It uses the four dimensional tensor differential he cited, expands it to the 16 terms and fills them in from Einstein's work. That is followed by converting from Cartesian to polar co-ordinates, citing Schwarzschild's paper for its derivation.

Introduction

Einstein published his gravity field equations in 1916 [A1]. paper. He suggested it would be difficult to determine their solution. Within a year Schwarzschild [A2] published a paper giving a solution to his field equations. Schwarzschild introduced approximations to obtain his solution.

To overcome that, some authors went on to derive their own solution, removing Schwarzschild's approximation. [A3]. The generally accepted format of their solution is:

$$ds^2 = dt^2\left(1 - \frac{\alpha}{r}\right) - \frac{dr^2}{\left(1 - \frac{\alpha}{r}\right)} - (r^2 d\theta^2 + sin^2 d\theta d\phi^2) \quad \text{(A1)}$$

where s is the space-time co-ordinate and $\alpha = \frac{2GM}{c^2}$ is the Schwarzschild radius. The remaining terms are those customarily used.

The equation (A1) solution, like Einstein's paper deriving them, are complex and difficult for most people to follow. The topic is left to experts. This presentation suggests it was not necessary for Einstein to derive his field equations. It goes directly from his work prior to his field equations, to the exact solution to the gravity effects he was describing earlier. It is the solution to his gravity theory without the need for his field equations.

Derivation

In his § 8 (of 22 §s), Einstein introduced the standard four dimension spatial tensor differential equation:

$$ds^2 = g_{\mu\nu} dx_\mu dx_\nu \quad \text{(A2)}$$

Here the $g_{\mu\nu}$ terms are the gravitational fields in the μ and ν directions. The dx terms are their differentials. He repeated it in § 22. It uses the normalization of setting the speed of light, c = 1. His first derived field equations were his equations (47) in § 14. This presentation goes from equation (A2) above, extracted from his § 8 to exact the exact solution.

Expanding $g_{\mu\nu}$ gives:

$$g_{\mu\nu} = \begin{matrix} g_{xx} & g_{xy} & g_{xz} & g_{xt} \\ g_{yx} & g_{yy} & g_{yz} & g_{yt} \\ g_{zx} & g_{zz} & g_{zz} & g_{zt} \\ g_{tx} & g_{ty} & g_{tz} & g_{tt} \end{matrix} \quad \text{(A3)}$$

Einstein interchangeably used the notation $x = 1, y = 2, z = 3$ and $t = 4$. The $\mu\mu$ terms are the μ term squared. Equation 3 can be re-written as:

$$g_{\mu\nu} = \begin{matrix} g_{x^2} & g_{xy} & g_{xz} & g_{xt} \\ g_{yx} & g_{y^2} & g_{yz} & g_{yt} \\ g_{zx} & g_{zy} & g_{z^2} & g_{zt} \\ g_{tx} & g_{ty} & g_{tz} & g_{t^2} \end{matrix} \qquad \text{(A4)}$$

Adding the differential terms gives:

$$g_{\mu\nu}d_{x\mu}d_{x\nu} = \begin{matrix} g_x{}^2dx^2 & g_{xy}d_{xy} & g_{xz}d_{xz} & g_{xt}d_{xt} \\ g_{yx}d_{yx} & g_y{}^2d_y{}^2 & g_{yz}d_{yz} & g_{yt}d_{yt} \\ g_{zx}d_{zx} & g_{zy}d_{zy} & g_z{}^2d_z{}^2 & g_{zt}d_{zt} \\ g_{tx}d_{tx} & g_{ty}d_{ty} & g_{tz}d_{tz} & g_t{}^2d_t{}^2 \end{matrix} = ds^2. \qquad \text{(A5)}$$

Calculating the individual $g_{\mu\nu}$, and $d_{x\mu}d_{x\nu}$ is difficult. However, gravity is spherically symmetric for a massive body, see figure A1. In that situation, $g_x = g_y = g_z = g_1$, making $g_{\mu\mu} = g_{11} = g_x{}^2 = g_y{}^2 = g_z{}^2$. Equation (A5) is re-written as:

$$ds'^2 = \begin{matrix} g_1{}^2dx^2 & A & B & C \\ D & g_2{}^2d_y{}^2 & E & F \\ G & H & g_3{}^2d_z{}^2 & J \\ K & L & M & g_4{}^2d_t{}^2 \end{matrix} \qquad \text{(A6)}$$

where *ds'* is the differential term in Cartesian co-ordinates. It is the same *ds* term used in the polar co-ordinate solution of equation (A1). It is used only to show the Cartesian format is different from the polar format. All $\mu\nu$ components have been replaced by *A* to *M* respectively.

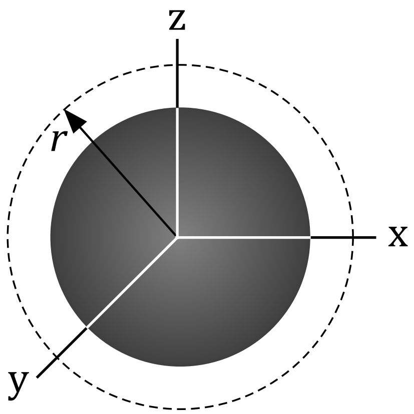

Figure A1 *Schematic illustration of the symmetry of gravity associated with a massive object.*

Einstein used the nomenclature that *x*, *y*, and *z* refer to the three orthogonal space dimensions and *t* is time. As such, the only two important dimensions are $x = g_1$ and $t = g_4$. In his § 22, Einstein derived:

$$g_{11} = -\left(1 + \frac{\alpha}{r}\right) \qquad \text{(A7)}$$

giving

$g_{22} = g_{33} = -\left(1 + \frac{\alpha}{r}\right)$ (A7a)

The question arises: "From where did Einstein get his α term?" It is inferred it in his 1911 paper "On the Influence of Gravitation on the Propagation of Light [A4]. It was derived by using Newtonian gravity on packets of electromagnetic energy, i.e., photons, that he described as having mass in his 1905 paper "Does the Inertia of a Body Depend upon its Energy Content?" [A5].

Its origin is not clearly referred to in his 1916 Foundations paper. However, it is apparent from his work, and that of others who followed, that he was using the $\alpha = \frac{2GM}{c^2}$ used in equation (A1). He used the notation that $-1 = g_{11}dx_1^2$. Re-arranged that gives:

$dx_1 = -\frac{1}{\sqrt{g_{11}}}$. (A8)

In the spherically symmetric situation of gravity associated with a massive object, *x* and *r* are interchangeable, see figure A1. So are their derivatives. Inserting equation (A7) into equation (A8) gives:

$dx = \frac{1}{\left(1+\frac{\alpha}{2r}\right)}$ (A9)

when $\alpha \ll r$. Einstein went on to state "*it follows that, correct to a first order of small quantities,*

$dx = 1 - \frac{\alpha}{2r}$" (Einstein's equation 71)

That is, $\frac{1}{(1+x)} \approx 1 - x$ when x << 1. That approximation is only valid for *r* >> α. Einstein regularly used that approximation in in his 1916 "Foundations" paper. As such, exact solutions to his field equations will always be approximations.

Staying with his original solution of $dx = \frac{1}{\left(1+\frac{\alpha}{2r}\right)}$, gives:

$dx^2 = \frac{1}{\left(1+\frac{\alpha}{r}\right)}$ when $\alpha \ll r$. (A10)

Multiplying equations (A7) and (A10) gives:

$g_{11}dx^2 = -\left(1 + \frac{\alpha}{r}\right) . \frac{1}{\left(1+\frac{\alpha}{r}\right)} = -1$ (A11)

In a radially symmetric solution, his equation $g_{11} = g_{22} = g_{33} = g_1{}^2 = g_2{}^2 = g_3{}^2 = -\left(1 + \frac{\alpha}{r}\right)$. In a set gravitational field, the speed of light is constant. A change in length results in a negative inverse change in time. That gives:

$g_{44} = \frac{1}{\left(1+\frac{\alpha}{r}\right)}$ (A12)

In his equation 70, Einstein approximated it to

$g_{44} = 1 - \frac{\alpha}{r}$

In the same manner, that gives $dt = \left(1 + \frac{\alpha}{2r}\right)$ and $dt^2 = \left(1 + \frac{\alpha}{r}\right)$. That gives:

$$g_{tt}dt^2 = \frac{1}{\left(1+\frac{\alpha}{r}\right)} \cdot \left(1+\frac{\alpha}{r}\right) = 1 \qquad \text{(A13)}$$

Inserting equations (A11) and A(13) into equation (A6) gives:

$$ds'^2 = \begin{array}{cccc} -1 & A & B & C \\ D & -1 & E & F \\ G & H & -1 & J \\ K & L & M & +1 \end{array} \qquad \text{(A14)}$$

Equation (A14) informs us only that time is different from space. Beyond that, it is difficult to work out what is happening. That invokes what Einstein considered one of his greatest thoughts. An internal observer cannot tell the difference between free falling under gravity or being in a gravity free zone. Nor could an observer tell the difference between being at rest in a gravitational field or being accelerated in gravity free space.

In order to work out what is happening, it is necessary to fix one of them. Fixing the derivatives means the positions are fixed and we can determine the gravitational fields at that position. Fixing g is the equivalent of uniform acceleration. Fixing the derivatives means fixing a point in space where Newton's g has a fixed value. Fixing them at 1 allows the result to be multiplied by any value of Newton's g in future calculations.

That makes it apparent that Einstein's field equations deal with the difference between his gravity theory and Newtonian gravity. His calculations do not determine absolute gravity values.

Using equations (A7) and (A12), equation (A14) becomes:

$$ds'^2 = \begin{array}{cccc} -\left(1+\frac{\alpha}{r}\right) & A & B & C \\ D & -\left(1+\frac{\alpha}{r}\right) & E & F \\ G & H & -\left(1+\frac{\alpha}{r}\right) & J \\ K & L & M & \frac{1}{\left(1+\frac{\alpha}{r}\right)} \end{array} \qquad \text{(A15)}$$

Converting from Cartesian to polar co-ordinates is virtually a look up equation. It was done by Schwarzschild in his 1916 paper. Such conversion gives:

$$ds^2 = \frac{dt^2}{\left(1+\frac{\alpha}{r}\right)} - dr^2\left(1+\frac{\alpha}{r}\right) - (r^2 d\theta^2 + sin^2 d\theta d\phi^2) \quad \text{(A16)}$$

The *A* to *M* values can be determined by calculating back from equation (A16), if desired.

Equation (A16) is the exact solution to Einstein's field equations. It differs from the accepted Schwarzschild solution because those who removed Schwarzschild's approximation did not remove the approximations Einstein made. Those approximations come in two forms.

His choice of tensors limited the accuracy of his work to second order tensors. That limited his whole study to approximations. It was good for r > ≈ 3α, a justifiable approximation.

The second approximations came through approximating $\frac{1}{\left(1+\frac{\alpha}{r}\right)} \approx .\left(1-\frac{\alpha}{r}\right)$. When $\frac{\alpha}{r} \approx 10^{-8}$, that is a valid approximation. It does not apply when *r* approaches α. Einstein mentioned his use of approximations several times. They can also be picked up by following his equations. Exact solutions to approximations always remain approximations.

Equation (A16)'s ds^2 solution is the variation in gravitational fields between that predicted by Newtonian mechanics and that predicted by Einstein's theory. The total gravitational field strength is determined by replacing the normalized gravitational field strength by Newton's gravitational field strength of $g_N = \frac{GM}{r^2}$. That holds for any value of r and M. It gives the total gravity field strength under Einstein's theory, g_E as [A6]:

$$g_E = \frac{GM}{\left(1+\frac{\alpha}{r}\right)r^2} \qquad \text{(A17)}$$

Equation (A17) shows that Einstein's gravity is a slight modification to Newton's theory. His use of approximations mean that calculations pertaining to extend his results are only valid for $r \gg \alpha$. It is well known, although derived again [A6], that redshift $z = \frac{\alpha}{2r}$, giving:

$$g_E = \frac{GM}{(1+2z)r^2} \qquad \text{(A18)}$$

when $r \gg \alpha$.

Einstein's space–time distortion is photon redshift. It is still the cause of Einstein's gravity, even when photon redshift is too small to measure. Equations (A17) and (A18) predict that gravity is weaker than Newtons' inverse square law.

Conclusion

This study has shown that equation (A16), the exact solution to Einstein's gravity, could be determined without his field equations. Equations (A17) and (A18) are the complete gravity field equations for gravity under Einstein's approximations. They are much easier to use and provide exact solutions to the gravity field equations he derived. There is nothing in the above that wasn't available after 1916. As such there is no reason why others could not take the same approach. This suggests that excessive maths complexity has led to incorrect an understanding of what is otherwise a "relatively" simple topic.

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[A6] Robinson V N E, 2021; *J. Phys. Commun.* **5** 035013 https://doi.org/10.1088/2399-6528/abee2f

Appendix 2

Physical presentations of the four gravity metrics

It is suggested it is easier to understand an effect if it can be visualized. Figure A2 illustrates the gravitational field strengths for the different Metrics.

The horizontal axis is the distance from the centre of a massive object, O. It is expressed as a multiple of the Schwarzschild radius. It is drawn for an object so massive its Schwarzschild radius is much larger than its physical radius.

The vertical axis is the relative gravitational field strengths. The actual values are obtained by multiplying the value by GM. They represent the gravitational field strengths outside an object.

Each set of curves, g_S, g_N, g_E and g_Z, represent a 2D slice through the 3D gravitational field for the different metrics. Each metric is indicated on the upper left of figure A2. The formulae used to calculate them are in the upper right. Their derivations were given in the main text. In particular, the Newton and Einstein metrics were approximations to the redshift metric. The Schwarzschild metric came from incorrect understandings of Einstein's gravitational field equations.

The solution to the Schwarzschild metric, equation (4) is the difference between the g_N and g_S curves. The solution to the correct answer to Einstein's field equations, equation (5) is the difference between g_N and g_E.

The curves were obtained by plotting the four equations into one quadrant. That quadrant was rotated 180˚ about the vertical, r = 0, axis. The assembly was rotated 180˚ about the horizontal, g = 0, axis.

The diagram represents a 2 dimensional slice through the three dimensional field that can be visualized by rotating the curves through 180˚ about the vertical, r = 0, axis. It applies for distances outside the massive object.

No attempt was made to determine the gravitational field strengths inside the massive body. Newton's shell theorem indicates it will be zero for any mass.

The g_Z and g_E curves remain approximately equal until $r < \approx 4\alpha$. This indicates his approximation of not using tensors of higher than second order, were quite accurate. It is not seriously in error until $r < \approx 3\alpha$.

The redshift gravity g_Z reaches a maximum at $r = ½\alpha$. At lesser distances, the electric permittivity gradient term, $e^{-\alpha/r}$, dominates the inverse square law.

Incoming particles will reach maximum speed at that distance. Those passing through it will be attracted back to $r = ½\alpha$. That will be the region where maximum energy is emitted by particle collisions. The toroidal image below O shows the expected intensity of the radiation that would be emitted by colliding, infalling particles. Such shapes have been observed at the centres of galaxies M87 and Milky Way. They would be associated with any massive object in which its physical radius was significantly smaller than its Schwarzschild radius.

Figures (A1) and (A2) and equation (16) indicate a good relationship between gravity and variations in the electric permittivity of space.

Their equations are on the right. The Schwarzschild gravity was obtained by incorporating equation (4) into equation (2), the Newtonian metric. The full Einstein metric is equation (6). The redshift metric is equation (16). The Newtonian field was obtained directly from equation (2).

It should be noted that Einstein's gravity field equations, of which

$$\frac{\partial \Gamma^{\alpha}_{\mu\nu}}{\partial x_\alpha} + \Gamma^{\alpha}_{\mu\beta}\Gamma^{\beta}_{\nu\alpha} = 0 \qquad \text{(Einstein 47)}$$
$$\sqrt{-g} = 1$$

and

$$\frac{\partial}{\partial x_\alpha}\left(g^{\sigma\beta}\Gamma^{\alpha}_{\mu\beta}\right) = -\kappa\left(t^{\alpha}_{\mu} - ½\delta^{\alpha}_{\mu}t\right) \quad \text{(Einstein 51)}$$
$$\sqrt{-g} = 1$$

are two variations, predict only the differences between g_N and g_E. That difference is all that is needed to determine Mercury's anomalous orbital precession. In 1911, Einstein calculated the bending of light rays by the sun by considering half the effect of Newtonian gravity on photons. His field equations incorporated the other half.

The g_N and g_Z curves were determined from first principles. The g_N curve was also derived as a first approximation to the g_Z curve. The g_E curve was derived as a second approximation to the g_Z curve. The g_Z curve was derived from the radial differential of the electric permittivity induced by a large number of nucleons.

Gravity is not caused by mass distorting space-time, as Einstein suggested. It is caused by mass altering the electric permittivity of space. Einstein's mass distorting space-time is photon redshift. It is a consequence of the electric permittivity that nucleons induce into space, not the cause.

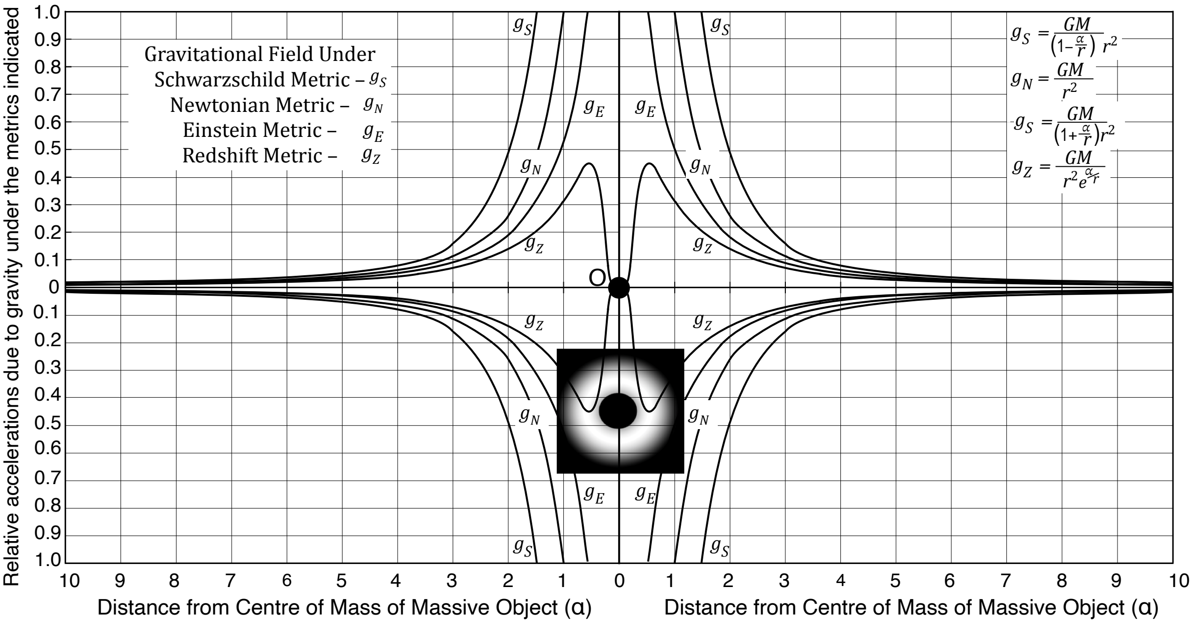

Figure A2: Two-dimensional slice through a 3 D representation of the various gravity fields