The Physical Origins of Gravity

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Abstract

This presentation expands on a model of matter that gave a physical description of some individual sub-atomic particle properties. It gives greater details of the model and how it gives those particles some of their quantum properties. These include why individual sub-atomic particles have a spin $\frac{1}{2}\hbar$ and why $E = mc^2$. In an appendix, it also shows why the special relativity corrections of length, time and mass are automatically induced into such particles as they move.

With that as a background, a physical derivation of gravity is given. It combines Feynman's origins of refractive index with the structure of individual nucleons under the proposed model. Each nucleon's mass gives it a very high frequency alternating electric field. It is suggested that high frequency electric field produces a change in the electric permittivity of space. It shows that the differential of the change in electric permittivity matches known gravitational properties such as Newton's mutual attraction, his inverse square law as a first approximation and Einstein's theory of gravity from his general relativity theory. Both gravity theories are derived in the same equation from considerations of the properties of individual nucleons.

Keywords: gravity, electric permittivity, photons, spin, nucleons.

1. Introduction

Einstein [1 – 5] introduced his special and general theories of relativity early in the 20th century. They were derived from mathematical considerations. Observation and experiment verified the accuracy of his calculations. He did not give a physical reason for their origins.

Over a century after his publication, many still express concerns about their reality. What is the physical relationship between energy and matter that gives $E = mc^2$ in preference to any other value? Why is the length travelled by a body at higher speed less than that travelled at a lower speed. A mathematical match does not equate to a physical mechanism.

The mathematical unification of quantum mechanics with special relativity is attributed to Dirac [6, 7]. His equations gave no indication of what was happening physically.

The calculations Einstein used for his general relativity theory were difficult to follow. That has also led many to question their validity. They are generally acknowledged by experts to match every gravitational observation against which has been tested. As such they are believed to be accurate.

Attempts were made to explain the origins of gravity. The more common approaches included quantum gravity and string theory. Some of the quantum gravity approaches were summarized by de Witt and Esposito [8]. A physical summary of aspects of quantum gravity, with an emphasis on black holes, was provided by Susskind [9]. Gravity under string theory depends upon graviton exchange, see for example Giddings [10]. An article by Bjerrum-Bohr [11] covers aspects of string theory and quantum gravity. The main features of those articles were their mathematical complexity and that, after several decades, there is still no theory that explains the physical origins and observed properties of gravity.

Einstein [12,13] explored the influence of Newton's inverse square law of gravity on the propagation of light. In that work, he derived an equation for the redshift of light leaving the sun's surface and being detected at Earth.

Expanding on that explanation, an exact solution to the physical situation in which mass distorted space–time through the redshift it produced in photons, was derived [14]. With that as a background, an evaluation of Einstein's [3] mathematics showed that he introduced approximations in his work. Those approximations were only valid at distances, r, from a massive object, M, when $r \gg \alpha$, its Schwarzschild radius, $\alpha = \frac{2GM}{c^2}$. G is Newton's universal gravitational constant and c is the speed of light in a vacuum. Exact solutions to approximations remain approximations.

No explanation of the redshift origins was given. The objective of this presentation is to explain the physical origins of gravity. That will explain the feature of space–time that mass distorts to produce gravity.

2. Photons as Foundations of all Matter

Searches for the origins of gravity from standard model interpretation of nucleons composed of quarks held together by gluons [15 – 18], have not been successful. It was considered time to go beyond the standard model and explore other possibilities. If individual nucleons were not composed of quarks and gluons, of what else could they be composed? In seeking solutions, the concern was not solely about the properties of the nucleons and other particles. It was about a structure they needed to have to obey the known laws of particle mechanics, including gravity and Einstein's special relativity corrections. One such suggestion was that all individual sub-atomic particles were composed of photons of the appropriate frequency confined by a suitable mechanism.

Williamson and van der Mark [19] published on the possibility of individual electrons being composed of photons of the appropriate energy making two revolutions per wavelength. Others followed [20, 21]. In this presentation, it is suggested that every individual sub-atomic particle is composed of a photon of the appropriate frequency making two revolutions per wavelength. To explain how that model leads to gravity, additional

information about photons and aspects of the model are presented.

The existence of electromagnetic waves was predicted by Maxwell [22]. He showed they could move through free space at the speed of light c, given by

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

where ε_0 and μ_0 are the electric permittivity and magnetic permeability of free space respectively. Magnetic permeability is defined as $\mu_0 = 4\pi. 10^{-7}$ newtons/ampere^2 (N/A^2). The speed of light in matter free space is defined as c = 299,792,458 meter/second (m/s). From those values and equation (1), the electric permittivity of matter free space was calculated to be ε_0 = 8.8541878128 ($\pm$13) x 10^{-12} Farad/meter (F/m).

Between them, Planck [23, 24] and Einstein [25, 26] worked out that Maxwell's electromagnetic waves were quantized into structures now called photons. Although photons have been extensively studied, no proposed model is universally accepted. The two major photon models used are based around the Copenhagen Convention interpretation and that forwarded by Einstein and de Broglie [27].

The Copenhagen Convention interpretation treats photons as massless point particle to which known properties are attached mathematically. That model is useful in mathematical calculations. It does not give any indication about their physical reality. The Einstein-de Broglie model treats photons as a wave function Ψ. No indication of the form of Ψ was given. Einstein [28, 29] determined that photons had mass and transmitted inertia. That was verified experimentally [30 – 33]. Photons with those properties are used in this study.

Photons behave like particles in the photo-electric effect and like waves in diffraction and refraction. The photon model used in this study is based on the Einstein-de Broglie model. An illustration of a model that fits both particle and wave properties is given in figure 1. Its wave properties are shown by the varying electric and magnetic fields. Its particle properties are due to its limited extent. In A and B, the intensities of the field are indicated by the intensity of the colour. The fields are indicated by the labelled colour scheme. It is consistent for all illustrations.

Figure 1 A gives a schematic outline of part of such a plane polarized photon. It starts out from the right-hand side with the positive electric field, E, pointing down the page and the north magnetic field pointing into the page. As the photon travels in the direction indicated by the arrow, their field strengths vary in a sinusoidal manner. Both reach their maximum of E$_0$ and B$_0$ respectively at $\frac{1}{4}\lambda$, before decaying back to zero at $\frac{1}{2}\lambda$. The fields reverse their direction. The positive field points up the page and the north magnetic field points out of the page. They again reach their maximum strengths, E$_0$ and B$_0$ at $\frac{3}{4}\lambda$, before decaying back to zero at the end of the wavelength. The whole assembly moves at the speed of light, c, in the direction perpendicular to both fields, as indicated by the arrow. The dashed lines represent the lines of equal field intensity.

A positive electric field in one direction equates to a negative field in the opposite direction. Similarly, a north magnetic field in one direction equates to a south magnetic field in the opposite direction, as illustrated in figure 1 B. The arrowed line forms the axis about which the electric and magnetic fields oscillate.

Such a structure obeys Maxwell's equations. A change in the electric field in one direction generates a related change in the magnetic field perpendicular to it. Similarly, a changing magnetic field generates a corresponding changing

electric field perpendicular to it. When generated, the structure moves perpendicular to both fields according to equation 1.

As derived by Einstein [28], photons have mass. How electro-magnetic oscillations of the type shown in figure 1 possess mass is found in a definition of mass as its ability to resist inertia. The electric permittivity ε_0 and magnetic permeability μ_0 of free space, store and release energy in a finite time, not instantaneously. That occurs because it takes time for the electric and magnetic fields to spread out from their axis of travel.

In that manner, free space provides an inertial resistance to the passage of photons. When photons are absorbed, the energy of the electric and magnetic fields held by the electric permittivity and magnetic permeability respectively, is transferred to the absorbing particle. That gives photons mass and allows them to impart inertia between an emitter and absorber. If energy storage and release were instantaneous, photons would have no mass and travel at infinite speed. The universe would be Euclidean.

Another feature of photons is that those emitted by atoms and nuclei are circularly polarized. Their fields make one complete revolution per wavelength. That gives them a property referred to as spin [34]. Schematic illustrations of circularly polarized photons are shown in figure 1 C, D and E. The arrows indicate the relative strengths and directions of the fields.

Figure 1 C is an oblique schematic illustration of a photon's positive field making six revolutions in three wavelengths. It illustrates how the field starts out from 0 and then twists through 90˚ as it reaches its first maximum at $\frac{1}{4}\lambda$. It twists through a further 90˚ as it goes back to zero intensity at $\frac{1}{2}\lambda$. The positive field continues rotating in the same direction, again reaching a maximum at $\frac{3}{4}\lambda$, before returning to zero intensity at λ. The other fields rotate similarly. The magnetic fields are at 90˚ to the positive field and the negative field is in the opposite direction. Unless the photon is absorbed, its oscillations will continue through
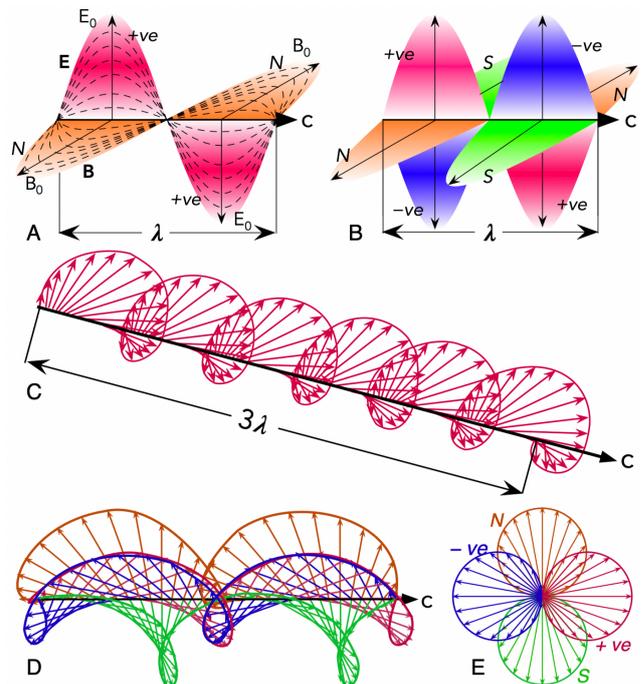

Figure 1 Oblique schematic illustrations of oscillations in the electric, *E*, and magnetic, *B*, fields associated plane and circularly polarized photon.

space. That is shown in figure 1 C with the positive field shown continuing on for another two wavelengths.

Figure 1 D illustrates the situation involving a single wavelength circularly polarized photon. All four fields in figure 1 D are shown twisting through one complete revolution per wavelength. Because each field twists through 180° after each half wavelength, each will commence rising to a maximum on the same side in each half wavelength. This is shown in figure 1 E, an end on view of a photon. Each field always remains on the same side of the photon. Representations of end on images of photons show four lobed structures having a similar appearance to figure 1 E (Mair et al. [35].

There is a lot more to photons than the simple skeletons outlined in figure 1. They were introduced to show that photons have rapidly varying electric and magnetic fields. Each field goes from zero to maximum twice as fast as the photon's frequency.

With that as the background to photon structure, it remains to show how such a structure can make two revolutions per wavelength. The situation of photons of the forms illustrated in figures 1, making two complete revolutions per wavelength is schematically illustrated in figure 2. The different colours represent only segments of the two halves of a wavelength. The top illustrations show a photon in linear form. The bottom illustrations show the rotating photon in phase with the linear photon above it. By the time a linear photon has made a quarter wavelength, i, the rotating photon has turned through 180°. That continues through ii, ½λ, and iii, ¾λ, until it has made two complete revolutions in its wavelength, iv. In both situations, the photon's axis travels at c. The linear photon travels through its next wavelength at a different position in space. The rotating photon still travels at c, but remains in the same position when not moving with respect to an observer.

Under the Einstein-de Broglie model, as predicted by Einstein and observed, photons have mass. It is contained within their oscillating electromagnetic field. A photon of mass m_p will rotate in a circle of radius

$$r = \lambda / 4\pi \qquad (2)$$

There is a special feature associated with a linear structure that makes a 360° twist per length. As shown by Williamson [36], when the ends are joined and the structure released, it forms a double loop with one side of the structure always on the outside. That can be seen in figure 2 B. It shows a flat two-shaded belt, where the loose end was twisted through 360° before being inserted into the buckle. When released, the belt forms into the double loop structure shown in figure 2 B. Also note that only the dark surface appears on the outside. Referring to figure 1 E, it means that the one electric field will always be on the outside. The magnetic fields will always be perpendicular to it and reinforce each other. Because it has a rotating mass, it will have angular momentum, $L = I\omega$, where I is its moment of inertia and $\omega = c/r = 4\pi c/\lambda$ is its angular velocity. It is known that each individual sub-atomic particle has a property called spin, which has a value ½ℏ, where ℏ is Planck's constant divided by 2π. It is suggested the property called spin is angular momentum. Uhlenbeck & Goudsmit [37, 38] indicated that electrons had an intrinsic angular momentum of ½ℏ, to explain the Zeeman effect.

The moment of inertia of a rotating hoop of mass m and radius r is given by $I = mr^2$. In these calculations, it requires that the electric and magnetic fields are equally distributed either side of the axis. That allows this calculation to be made with the centre of
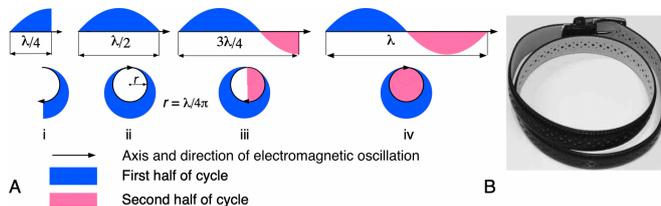
mass located on its rotation axis. Starting with $I\omega = \frac{1}{2}\hbar$ and multiplying both sides by ω gives

$$mr^2 \cdot \frac{c^2}{r^2} = \frac{h}{4\pi} \cdot \frac{4\pi c}{\lambda} = \frac{hc}{\lambda} = h\upsilon = E = mc^2 \qquad (3)$$

Equation (3) shows the physical meaning of $E = mc^2$. Energy E is a photon travelling at c in a straight line. Mass m is the same photon making two revolutions per wavelength, while still travelling at c. The mass m_p of the rotating photon that is the particle is related to its frequency υ through

$$m_p = \frac{h\upsilon}{c^2} \qquad (3a)$$

It has a radius

$$r = \frac{\hbar}{2mc} \qquad (3b)$$

The above does not give any physical reason for a photon to make two revolutions per wavelength. For that we need to look at figures 1 and 2 and the discussion on circularly polarized photons. Circularly polarized photons have spin ℏ. Yang et al. [39] referred to the spin as angular momentum. A linear photon's spin, generated by the 360° twist of the electromagnetic fields, gives it angular momentum $I\omega = \hbar$. Figure 1 shows those fields are off the axis. When the photon twists as shown in figure 1 C and D, the mass contained within the energy fields also twists.

Operating on the basis that the centre of mass is distributed at distance r' from its central axis, we can calculate the expected distance of the center of mass of the photon's fields from its axis of travel. It is given by $I\omega = \frac{h\upsilon}{c^2} \cdot \frac{c}{r'} = \frac{\hbar}{2\pi}$, which simplifies to $r' = \frac{\lambda}{2\pi}$. Its important feature is that the center of mass of the twisting electromagnetic field is off axis. In circularly polarized photons, the mass of the photon twists about its axis of travel, giving it angular momentum.

It follows from the above that, a photon with angular momentum ℏ, has a preferred status, if available, to make two revolutions within its wavelength. The alignment of the magnetic fields and the natural state of two revolutions per twist, cause the photon to form the more stable structure with a single charge field on the outside and a magnetic field through the middle. It does not need the ends to join because its intrinsic twist angular momentum ℏ will automatically bring them together.

The ends only need to touch each other to give maximum magnetic field strength. Once formed, conservation of both forms of angular momentum, supported by the interlocking magnetic fields and the unit electric field on the outside keeps the structure together. Some of the mathematics of how this is achieved has been described by Williamson [40].

The objective of this presentation is to demonstrate that this rotating photon structure of individual sub-atomic particles can generate the known properties of gravity using known physical mechanisms.

Equation (3) showed that this structure gives the physical relationship between energy and mass through the equation $E = mc^2$. It is believed a better understanding of the physical origins of gravity will be obtained by an understanding of how this model physically explains the origins of Einstein's special relativity theory. That is given in Appendix 1.

3. The Origins of Gravity
3.1 Introduction

Newton [41, 42] was the first to put gravity on a firm foundation. He determined that the gravitational attraction, F_G, between any two bodies, masses M_1 and M_2, with their center of mass separated by distance r, was given by

$$F_G = \frac{GM_1M_2}{r^2} \qquad (4)$$

With that he made several advances in gravity. He showed that gravity, which was known to control the orbit of planets around the sun, was also responsible for holding objects onto the surface of planets and moons in orbit around planets. Gravity was universal. Equation (4) meant that the acceleration due to gravity, g, of a body under gravity was given by

$$g = \frac{GM}{r^2} \qquad (4a)$$

Figure 2 Illustration of structures making two revolutions within their length.

Newton did not determine the value of G. Nor did he give any reason for gravity to act at a distance. He did make a number of other predictions. His equations (4) matched all observations for almost 200 years. Towards the end of the 19th century, it was noticed that Mercury's orbit had an anomalous orbital precession of about 43 arc seconds per century (as/c), beyond that predicted using Newton's equations [43 – 45]. Einstein [2, 3, 5] solved the problem in the publications of his general relativity theory. He formulated the idea that gravity was caused by mass distorting space–time. Using that concept, he developed his gravitational field equations. From them he developed an equation for the anomalous precession of Mercury's perihelion [46], namely

$$\varepsilon = 24\pi^3 \frac{a^2}{T^2 c^2 (1 - e^2)} \qquad (5)$$

Equation (5) predicted Mercury's anomalous precession as 43 as/c.

Other predictions included that a massive object would change the trajectory of a photon passing close to it; photons would experience a redshift as they moved away from a massive object; a moving body would drag space–time with it and that orbiting bodies would emit gravitational waves.

Einstein's prediction that a moving object would drag space–time with it was already being used to calculate the gravitational pull of the other planets on Mercury's additional orbital precession. Kerr [47] calculated that a rotating object would also drag space–time with it.

Einstein's gravitational field equations and their derivation were complex. Some authors changed their format to suit different mathematics. Among those were the Ricci tensor formats derived from Riemannian geometry. They, like Einstein's field equations, derived the difference mass induced in Euclidean geometry. Physicists and cosmologists believed they matched every observation against which they were tested. However, they did not know the physics that underpinned them. Einstein did not explain the property of space–time that mass distorted to produce gravity.

Through his use of field equations, Einstein showed Newton's theory was a first approximation to his theory and Mercury's anomalous orbital precession was a second approximation. In his derivation of Mercury's anomalous orbital precession, Einstein used his field equations to calculate the difference between the gravitational field predictions of his theory and Newton's theory. A previous study [14] showed that difference was due to the detectable photon redshift. Einstein's theory that mass distorted space–time to generate gravity, gave Newton's inverse square law as a first approximation when the redshift was too small to be measured. Deriving the origins of gravity should derive Newton's inverse square law and the redshift factor Einstein introduced.

It was also shown [14] that the detectable photon redshift, z, changed the denominator in Newton's equations (4) from r^2 to $[r(1 + z)]^2$ as an exact solution to the photon redshift calculation. The approximations used by Einstein resulted in the denominator changing to $r^2(1 + 2z)$. The two redshift denominators are barely distinguishable until $z \approx 0.3$. Deriving the origins of gravity means determining how mass generates a redshift in photons.

3.2 Background

Two theories were forwarded for the propagation of light through the vacuum of free space. The first was the ether theory [48 – 50]. It was suggested space was filled with an invisible weightless "ethereal" fluid, ether, which supported light waves as they travelled through space. That suggested the speed of light varied with the direction of travel through space. Michaelson and Morley [51] demonstrated that the speed of light was the same in all directions when observed as Earth travelled through space.

That left the theory developed by Maxwell [22]. The propagation of light through space was supported by its electric permittivity and magnetic permeability, see equation (1). Other researchers established that the speed of light through a material m, c_m, was always slower than that in free space. The refractive index of material m, n_m, was given by $n = \frac{c}{c_m}$, where c_m is the speed of light through material m. From that we get

$c_m^2 = \frac{1}{\varepsilon_m \mu_m}$, which gives

$$n = \sqrt{\frac{\varepsilon_m \mu_m}{\varepsilon_0 \mu_0}} \qquad (6)$$

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

The most common experience of refractive index is light in the 450 to 750 nm wavelength range. As light goes from air, n ≈ 1, to water, n ≈ 1.33, or glass, n ≈ 1.5, its speed slows from c to c/n. It does that because the electric permittivity ε_m of the medium takes longer to store and discharge the photon's energy. That additional time slows down the photon's speed through the medium, compared to the air. Because it travels at a slower speed, its wavelength decreases and its frequency increases. That change in energy is stored in the electric permittivity of the medium. When the photon passes from the medium back to air, the energy stored in the medium's electric permittivity is transferred to the photon and stored in the air's electric permittivity. The photon travels faster, its frequency decreases and its wavelength increases. Those changes give rise to refraction. That is standard refraction mechanism, see for example, Huygens [48].

In his determination of the general expression for the refractive index of materials with n close to 1, Feynman [52] indicated that the fields (affecting refractive index) were produced by the motion of all the charges in the material, such as glass. As the positive charges in nuclei are effectively at rest, that left the motion of the electrons in the material as the source of the field. He indicated the motion of the charges, i.e., electrons, altered the electric permittivity of the space within the material. Feynman went on to calculate an approximate general expression for the refractive index of a material. His equation 31.19,

$$n = 1 + \frac{Nq_e^2}{2\varepsilon_0 m(\omega_0^2 - \omega^2)} \qquad (7)$$

for refractive index was determined by using the electric field generated by moving charges. In it, N is the charge density of the object, q_e and m are the electron's charge and mass respectively, ω_0 is the frequency of the electrons bound in the atom and ω is the frequency of the radiation. He pointed out that it was an approximation and some of the properties he used were not easy to determine. It was useful to point out the principles of refractive index and some properties such as its variation with different wavelengths.

Equation (6) indicates a change in refractive index was associated with a change in the electric permittivity of a material from ε_0 to ε_m. A changing electric field generates a change in the electric permittivity of space and hence a change in the speed of light through it.

Feynman mentioned the changes in ε_m and n were caused by changes in the electric field oscillations induced into the material by its atomic electrons. In the case of matter free space, there are no electrons that can oscillate. If gravity is caused by mass changing the electric permittivity of space surrounding it, a different origin must be sought.

3.3 Distorting Space–Time to Produce Gravity

Einstein commenced his gravity study with a determination of the influence of Newtonian gravity on the propagation of light [12, 13]. He used equation (4a) to calculate the effect it would have on photons of mass $m_p = \frac{h\nu}{c^2}$. He calculated the expected redshift, z, of photons from the sun. He also suggested that light travelling across a gravitational field will be deflected, attributing it to a change in the refractive index of space caused by the mass of the object.

In diffraction, electromagnetic radiation passing through a material of different refractive index changes its speed. When photons pass between materials of different refractive index, their trajectory is altered at the interface. Einstein [12, 13] considered the possibility that mass could change the refractive index of space. He used it to calculate the deflection of light passing close to the sun's surface. His calculations only included the deflection due to time distortion. He did not include space distortion as well and only got half the answer.

Others proposed that the deflection of light rays could be due to the refractive index of space. A summary of that work was

provided by Roy and Sen [53]. Those studies centred around the effect refractive index would have on photon trajectories. Wilhelm and Dwivedi [54] developed a model in which massless photons, treated as solitons in ether, interacted with gravitons to change refractive index.

It was demonstrated that gravity was related to the redshift of photons [14]. This study expands on that work to show the properties of space–time that mass distorts to give rise to the redshift and hence gravity. It considers the possibility of photon deflection due to a change in refractive index as the cause of gravity.

Matter free space is considered to be flat Minkowski space–time [55, 56]. It is a vacuum free of any matter and significant fields. Its properties of interest are ε_0 and μ_0. They are the properties of nothing. Their existence makes it possible for electric and magnetic fields to pass through space and for photons to travel through it. As long as ε_0 and μ_0 remain unchanged, the properties of photons passing through them remain unchanged. Photons originating from massive objects have been observed to change through redshift [57 – 59]. Those passing by a massive object have been deflected [60 – 61]. Both were due to a gravitational field. Equations (1) and (6) show that the refractive index of a material, including free space, is controlled by its electric permittivity and magnetic permeability.

As mentioned earlier, μ_0 and c have been defined, from which ε_0 has been derived. With magnetic permeability fixed, equation (6) becomes $n = \sqrt{\frac{\varepsilon_m}{\varepsilon_0}}$. The speed of light through medium m is given by

$$c_m = \frac{c}{n} = c\sqrt{\frac{\varepsilon_0}{\varepsilon_m}} \qquad (8)$$

The important feature Feynman [52] pointed out, was that the change in refractive index was due, among other features, to frequencies of the oscillating electric field interacting with photons. In the rotating photon model of matter shown in section 2, every individual nucleon is comprised of a photon making two revolutions per wavelength. From equation (3a) and the mass of the nucleons, $\approx 1.674\ ..\ x\ 10^{-27}$ kg, they have a photon frequency of $\approx 4.5\ x\ 10^{23}$ Hz. At two revolutions per wavelength, their electric fields oscillate at $\approx 9\ x\ 10^{23}$ Hz. For electrons, that oscillating electric field frequency is $\approx 4.7\ x\ 10^{21}$ Hz.

Protons have the opposite charge to electrons, neutralizing overall charge. Protons are about 1837 times more massive than electrons, giving them a much higher frequency. Equation (3b) suggests their radius is smaller than that of electrons by a similar amount. That creates a difference in frequencies and origins of electric field oscillations. It is suggested this difference is sufficient to induce a slight change in the electric permittivity of free space outside a nucleon. It does that by the alternating electric field effect indicated by Feynman. Whether that is the cause, or it is the high frequency oscillating electric fields within the nucleons, the results are similar. Each individual nucleon, i.e., neutron and/or proton/electron combination, will generate a high frequency electric field oscillation that alters the electric permittivity of the space around it.

Matter free space is a vacuum, an absence of anything. The only way the property of nothing can be physically changed is by adding something to it. In this situation, that "something" is a high frequency oscillating electric field. Using Feynman's approach, the high frequency electric field oscillations of the nucleons generate a change in the electric permittivity and hence refractive index of the space surrounding it. The change in electric permittivity induced by an individual nucleon is denoted ξ (xi). The relationship between changing strength and frequency of the electrical field and changes to electric permittivity has not been established. At this stage it is a continuation of Feynman's hypothesis that successfully predicted aspects of refractive index at the quantum level. If it shows this approach matches the observed properties of gravity, it is considered a worthwhile exercise.

The change each nucleon induces in the space surrounding it at distance r, denoted ξ_r, is given by

$$\xi_r = fn(\xi_0) \qquad (9)$$

where ξ_0 is the maximum change associated with each nucleon. With the photons rotating, its change is not introduced from its center. The radius r can never be zero. The total change, ξ, is given by

$$\xi = \oiiint fn(\xi_0)d(r,\theta,\phi) \qquad (10)$$

The effect of a single nucleon changes ε_0 to $\varepsilon_0 + \xi$. Following Feynman [52], (quote) *"the contribution of each charge is not changed by the presence of other charges"*, the effect is linearly cumulative. N nucleons changes ε_0 to

$$\varepsilon_G = \varepsilon_0 + N\xi \qquad (11)$$

where ε_G is the electric permittivity induced into the space surrounding the mass of N nucleons. The suffix $_G$ is used to indicate the change is associated with gravity.

As Feynman pointed out, a change in the electric permittivity of space causes a change in its refractive index, n. A change in refractive index causes a change in the speed of light through the different n. Under standard refraction theory, a change in wavelength, z, is linearly proportional to the change in the speed of light. From equation (8), that gives

$$z = n - 1 = \sqrt{\frac{\varepsilon_G}{\varepsilon_0}} - 1 \qquad (12)$$

It is induced by the high frequency electric field oscillations in the nucleons that comprise the mass of the body. Equation (12) can be rewritten as $\frac{\varepsilon_G}{\varepsilon_0} = (1 + z)^2$. Since $(1 + z) = e^{\alpha/2r}$ [14], it is rearranged as

$$\varepsilon_G = \varepsilon_0 e^{\alpha/r} \qquad (13)$$

The deflection of photons is caused by changes in electric permittivity, not their absolute strength. Gravity requires a continuous change in ε_G, such as indicated in equation (13).

From equations (11) and (13), we get

$$\xi_r = \frac{\varepsilon_G - \varepsilon_0}{N} = \frac{\varepsilon_0}{N}e^{\alpha/r} - 1 = \frac{\varepsilon_0}{N}\left(e^{\left(\frac{2GM}{rc^2}\right)} - 1\right) \qquad (14)$$

Equation (14) indicates a single nucleons' distortion of electric permittivity is exceedingly small. A lot of nucleons are required to induce a small change in electric permittivity of space surrounding them.

Under this model, gravity is produced by, and is hence proportional to, the rate of change of electric permittivity with mass. In flat Minkowski space–time, the electric permittivity of space is ε_0. As mass is approached, it increases to ε_G. From equation (13), the change in electric permittivity due to N nucleons, each of mass m_n, is $\frac{\varepsilon_0}{\varepsilon_G} = e^{-\alpha/r}$. The rate of change of $\frac{\varepsilon_0}{\varepsilon_G}$ with r is given by its differential with respect to r, namely

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

Equation (15) gives the variation of the rate of change of the electric permittivity with distance from the centre of mass for distances outside the mass. In turn, the rate of change of electric permittivity with radius is proportional to the rate at which photons are deflected. It was shown [14] that gravity was directly related to photon redshift. Equation (15) gives the radial dependence of gravity with photon redshift. From that, it follows directly that equation (15) gives the dependence of gravity with radius.

The minus sign (–) plays a similar role to the – sign in Einstein's gravitational field equations, which were conditional upon $\sqrt{-g} = 1$. It indicates gravity acts in the direction towards the center of mass, $M\ (= Nm_n)$. Measurements of r are made away from the centre of mass.

Allowing that gravity acts downwards, equation (15) gives

$$g \propto \frac{M}{r^2 e^{\alpha/r}} \qquad (16)$$

Experimental observation shows the constant of proportionality is Newton's universal gravitational constant G. Equation 16 become

$$g = \frac{GM}{r^2 e^{\alpha/r}} \qquad (17)$$

Equations (15) and (16) were derived from the changes in electric permittivity induced by the structure of individual nucleons, using Feynman's quantum origin of diffraction. In equation (17), G was added to match observation. It derived Newton's inverse square law and Einstein's redshift correction in the one equation. Newton's inverse square approximation works

well when $r \gg \alpha$. It has been shown [14] that Einstein's approximation was good for $r > \approx 3\alpha$.

Equation (17) is the same equation derived [14] from the metric

$$ds_s^2 = dt^2 e^{-\alpha/r} - dr^2 e^{\alpha/r} - r^2(d\theta^2 + sin^2\theta d\varphi^2) \quad (18$$

The match of equations (15) to (17) with both Newton's and Einstein's theories of gravity is the strongest indication gravity is caused by changes in the electric permittivity of space surrounding a massive object. The absence of any other origin indicates the calculations between equations (9) and (14) inclusive are the reason for the varying electric permittivity. Between them, they reconcile both theories of gravity with observation.

Equation (17) has been shown to apply to the redshift of photons and gravitational lensing [12 – 14]. That indicates it works for linear photons. It now needs to be shown how it applies to rotating photons that are matter particles.

Being composed of rotating photons, they will also undergo a deflection when exposed to a varying refractive index. Rotating photons present all angles to the refractive index gradient.

Figure 3 A shows a schematic illustration of a photon, γ, passing from flat Minkowski space–time's electric permittivity, ε_0, through ε_G, produced by an assembly of N nucleons and back to ε_0. For there to be a sufficient change in electric permittivity, it requires that N is a sufficiently large number that the nucleons would noticeably change ε_0 to ε_G.

In figure 3, white represents flat Minkowski space–time, in which the electric permittivity is ε_0. The shades of grey represent the changes in ε_G. The dashed circles represent lines of equal ε_G. The curve ϕ represents the gravitational force. z_0 is the redshift that a photon leaving at the point of closest approach would experience when it reached ε_0. The angle ι (iota) through which the photon would be deflected is $4z_0$ [14]. The important feature of its trajectory is that it presents all angles to the refractive index gradient. Well away from M, it is perpendicular to the lines of equal ε_G. At its position of closest approach, it is parallel to them. The one equation, (18), applies for the whole trajectory [14].

It is suggested the same result would be achieved if the nucleons were randomly oriented and/or the dimensions of their toroidal field were approximately uniformly spread around their rotating axis. In the latter case, the rotating photon's wave front, which occupies the volume of the vibrating torus, would be exposed to the same differential, irrespective of its orientation to the differential.

There is also the question of the conservation of energy as photons or particles move through space. Line B in figure 3 illustrates a photon travelling from C to D in flat Minkowski space–time. Its frequency and trajectory are unaltered between C and D for any distance where ε_0 is not changed. Energy is conserved because it is not changed.

Consider the photon in A. It starts in flat Minkowski space–time, where its velocity is c. As it comes under the influence of the changing electric permittivity it is slowed to c_G, its speed in ε_G. It is deflected towards M. The energy lost by the slowing photon is

stored in the gravitational electric permittivity ε_G. That process continues until the photon reaches its closest approach. After that, its trajectory takes it through decreasing ε_G. The energy that was stored in ε_G passes back to the photon, increasing its speed and decreasing its rate of deflection. Its deflection is always towards the mass. As it passes from ε_G to ε_0, it resumes its former speed c.

That is the manner in which energy is conserved as photons pass through a gravitational field. Photons in a low refractive index material are slowed when they enter a higher refractive index material. Some of the photon's energy is stored in the higher electric permittivity material. As it passes back to the lower refractive index, the higher electric permittivity releases its stored energy back to the photon and it resumes it original speed, although at a different direction. That is standard refraction theory.

In the same manner, a photon leaving the surface of a massive object is emitted in a region of $\varepsilon_G > \varepsilon_0$. The higher value of ε_G gives it a slower speed, compared to ε_0. The additional energy is stored in ε_G. As it moves away, that additional energy is imparted to the photon as it passes through the lower electric permittivity away from the mass. The photon's speed increases. That stretches its wavelength, giving it a redshift.

In operation, the small differences in electric permittivity cause space to have small changes in refractive index. In standard diffraction theory and observation, a different refractive index causes a change in the speed of photons. A change in refractive index deflects a photon's trajectory. With each particle being made of a photon making two revolutions per wavelength, the trajectory of those rotating photons will be slightly displaced by the change in refractive index. Without resistance, that very small deflection will accumulate and cause the rotating photon to move in the direction of increasing refractive index, the effects of which were calculated in equation (15).

As an indication of the strength of the effect, consider gravity near Earth's surface. It has a value of $g = 9.8$ m/sec². We can apply Newton's equation

$$s = ut + \frac{1}{2}at^2 \quad (19)$$

where s is the distance travelled, u is the initial velocity at time $t = 0$ and $a = g$, the particle's acceleration under gravity, to a nucleon. Nucleons have a frequency of $\approx 4.5 \times 10^{23}$ Hz. In 2.3×10^{-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 $\approx 1.1 \times 10^{-48}$ m.

Table 1 shows the results of applying equation (19) to that deflection over the different times indicated. It shows the displacement is exceedingly small per wavelength cycle. A nucleon has to make $\approx 10^{16}$ wavelength cycles before it has moved ≈ 1 fm, a typical nucleon dimension. It makes $\approx 10^{20}$ revolutions before it has travelled 1 micron.

The displacement per time unit remains the same, irrespective of the mass. It is the same displacement as would be experienced by a linear photon passing through the same space. Linear photons move through the different regions of space at c. They pass rapidly through the zone of maximum refractive index and back to $n = 1$.
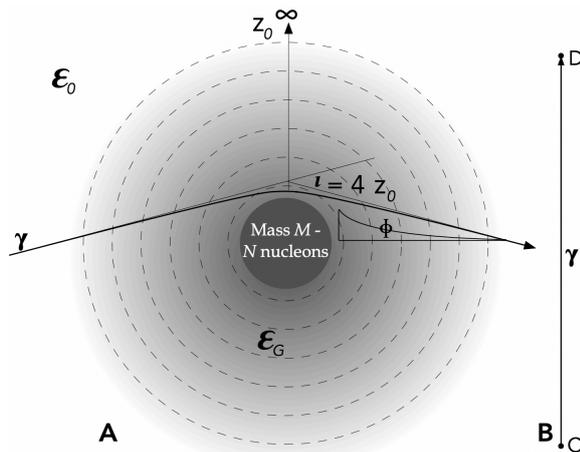

Figure 3 Schematic illustration of a photon being deflected by an angle ι (iota) as it approaches and departs a massive object composed of N nucleons.

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

Table 1 A list of the displacement individual nucleons will experience in free fall under the influence of earth's gravity at approximately sea level.

The total deflection of a photon passing from $-\infty$ to $+\infty$ close to a massive object is $2\alpha/r$ [14]. For Earth's surface, $r \approx 6380$ km, giving a photon a deflection of $\approx 2.73 \times 10^{-12}$ rad. Linear photons pass quickly through the different zones of refractive index change and receive almost no deflection. Rotating photons are subject to the same deflection as linear photons at the same point. Photons confined by rotation, are continually subject to the same deflection.

When a nucleon is prevented from moving, its rotating photon will still experience the same deflection per wavelength. Even though it doesn't move, it exerts a slight force on its support mantle. Unlike the distance travelled by the unsupported nucleons, it is not reinforced per cycle. The accumulated effect of the displacement of all the individual nucleons converts the mass of the object into its weight.

The weak extent of that effect is determined from the ratio of the gravitational attraction of two protons compared to their electric repulsion. It is given by

$$\frac{F_G}{F_E} = \frac{Gm_P^2}{4\pi\varepsilon_0 e^2} \approx 8 \times 10^{-37} \tag{20}$$

where F_G is their gravitational attraction, m_P is the mass of a proton, F_E is their electric repulsion and e is the unit electric charge.

This study deals with gravity in space outside matter. Only the change to the electric permittivity outside the N nucleons was considered. The best that can be said about the nucleons within the structure is, as Feynman [52] indicated, they will all experience the field generated by all the other charges. It is so small that it takes a large number of nucleons before it generates a significant effect.

5. Discussion

This approach differs from the current standard model. The standard model starts out with known properties of matter particles and fits them together to get useful physics. It has no physical explanation for the origins of gravity. This model starts out with a proposed structure of sub-atomic particles and some of their quantum properties. From them it derives the mechanics of gravity, matching both Newton's and Einstein's predictions in the one equation.

The objective of section 2 was to show that the rotating photon model of matter was feasible. Reasons for photons to travel in said manner included photons having an intrinsic spin $\hbar$. Treated as twist angular momentum, it showed a photon could form a double loop oscillation. Its electric and magnetic fields reinforce each other and give the particle angular momentum $I\omega = \frac{1}{2}\hbar$. It was suggested such a structure is more stable than linear photons, in which the electric and magnetic fields do not support each other. The rotating photon structure is held together by the conservation of its intrinsic twist angular momentum $\hbar$ bringing the ends together, its $\frac{1}{2}\hbar$ rotational angular momentum, the magnetic fields reinforcing each other and only one electric field on the outside.

That does not necessarily exclude other photon models from achieving the same result. This principle of gravity requires each individual sub-atomic particle is composed of a photon making two revolutions per wavelength.

Section 4 showed that model, combined with Feynman's quantum origins of refractive index, gave an explanation of the origins of gravity that matched its observed properties.

In this interpretation of Feynman's work, the electric field oscillations are generated by the high frequency of the rotating photons that are the nucleons. Following Feynman's work, it was hypothesized that the rapidly varying electric fields produced by the rotating photon structure of the nucleons generates a change in the electric permittivity of matter free space. The oscillations' high frequencies mean they have the same influence on all photons.

No indication is given to distinguish between electric permittivity being caused by the nucleons alone, or by the differing frequencies of the proton and electron frequencies. It is suggested such may be possible if materials with the same number of proton/electron combinations were tested for G and compared against the measurements of G for materials with a different ratio of protons to neutrons. Suitable materials would be ^{112}Sn and ^{124}Sn. No difference would mean the electric permittivity originated

entirely within the nucleons themselves. A difference would indicate the electrons also played a role in changing the electric permittivity of the space surrounding the mass.

The above demonstrated that the mechanism applied to linear photons. It also showed why rotating photons responded similarly, giving the gravitational effect we all experience. The very high frequencies of the nucleons' oscillations are far too high to be shielded by atomic electrons. The gaps between atomic nuclei are so large they pose no barrier to the passage of the $\approx 10^{24}$ Hz electric field oscillations. Although gravity is an electromagnetic phenomenon, its effect can't be screened out.

The electric permittivity of the space around a massive object is changed by the collective high frequency oscillations of its constituent nucleons. That changed electric permittivity changes the refractive index of space. A photon entering from flat Minkowski space–time is slowed down and altered by the changing electric permittivity. In turn the permittivity stores the energy of the slower moving photon. In that process, the photon's frequency is increased. As the photon leaves ε_G and enters ε_0, that energy is returned to the photon. Its energy has been conserved even though its trajectory has been altered.

That explains why photons are redshifted as they move away from a massive object. Photons emitted in a gravitational field are emitted with $c_G = \frac{c}{n_G} = c\sqrt{\frac{\varepsilon_0}{\varepsilon_G}}$. As the photon moves from ε_G to ε_0, energy stored in ε_G is released and the photon travels faster. Its faster speed stretches the photon's wavelength, giving it redshift.

That is also why local observers will always get the same value for the speed of light in vacuum. No matter what the value of electric permittivity, be it ε_0 or ε_G, it automatically determines times and distances so that local c is always measured at $c = 299,792,458$ m/sec. It is only when observations are made in a different gravitational field strength that the external observer will notice there is a difference between the behaviour of known photons between the two locations.

Newton's gravity theory was that two masses attracted each other proportional to the product of their masses and the inverse square of the distance between their centre of mass. It has three components, see equations (4). Consider the mutual attraction of two bodies towards each other. Under this mechanism, each mass generates its own variation in electric permittivity and through that a change in refractive index. Two masses M_1 and M_2, both distort the refractive index of the space around them. The nucleons in M_2 experience the changed refractive index generated by M_1. Through the mechanism mentioned above each nucleon in M_2 will be deflected towards M_1. In the same manner, $M_2's$ generated variations in refractive index will cause nucleons in M_1 to be deflected towards M_2. That is the mutual attraction of both masses to each other.

The derivative of $e^{-\alpha/r}$, equation (15), shows Newton's inverse square law applies when $r \gg \alpha$. Then, for all practical purposes, $e^{\alpha/r} = 1$ and the redshift $z = 0$. That does not mean that redshift plays no part in Newtonian gravity. Gravity depends upon $\frac{d}{dr}\left(\frac{\varepsilon_0}{\varepsilon_G}\right)$, which also generates redshift. When the redshift is too small to be measured, gravity is detected as varying according to Newton's inverse square law.

There is nothing in the above that alters Newton's calculations that the action of gravity originates from the centre of mass of the attracting object.

Einstein's theory was that mass distorted space–time to produce gravity. He did not define the property of space–time that mass distorted. It was shown that space–time distortion was determined by the redshift of photons [14]. Equations (6) and (12) show that the redshift was related to the refractive index induced by the frequency oscillations of the nucleons in a massive object. The space–time distortion that causes gravity is the variations in the electric permittivity caused by the high frequency oscillations of the rotating photon structure of nucleons. That produces a refractive index gradient that deflects photons. With particles composed of rotating photons, the deflection causes the particle to move in the direction of higher electric permittivity.

An additional feature of this presentation is that it is not physically possible to take anything away from nothing. It is not physically possible for ε_G to be less than ε_0. However, if $\varepsilon_G < \varepsilon_0$ were possible, equation (6) means the refractive index would be less than 1 and the speed of light would be greater than c. Photons moving from a high gravitational field to ε_0 would be compressed and a photon blue shift would be observed. The observation of a blue shift would mean lengths appeared shorter. That is a necessity for gravity to be stronger than inverse square law, a requirement for black holes to exist. Newton [41, 42] showed that gravity stronger than inverse square law also means the aphelion and perihelion of elliptical orbits would regress against the direction of travel. To date there has been no detection of either gravitational blue shift away from mass, or orbital regression.

It has been shown [14] black hole predictions were due to mathematical errors by those who proposed them. The above confirms the physical non-existence of black holes. It also showed that equation (17) automatically led to the toroidal structure detected by the Event Horizon Telescope collaboration [62, 63].

This presentation also physically shows why gravity moves at the speed of light. That is the rate of passage of electric fields. Although that was an essential feature of Einstein's gravity, some perceptions of Newtonian gravity, often expressed in textbooks, were that its effect was instantaneous [64, 65]. Haug [66] provided a mathematical reason why that interpretation was not correct. He did not give any physical reason for Newtonian gravity to be limited to the speed of light. This presentation of the physical origins of gravity shows why gravity propagates at the speed of light. That Newton inverse square law is a first approximation does not mean that it eliminated gravity's finite speed.

Gravity is a very live and dynamic phenomenon. A large number of nucleons, each generating a high frequency electric field, $\approx 10^{24}$ Hz, alter the electric permittivity in the space surrounding them. In turn, that variation deflects photons that experience it according to the differential of that variation with the distance from its centre. With all matter particles being composed of rotating photons, they are deflected by that differential.

The electromagnetic forces are attractive and repulsive. The above has described gravity as an electromagnetic effect. Gravity is not a force like electricity and magnetism. It is a deflection caused by changes in the electric permittivity of space. Those changes are induced by the high frequency oscillations of the nucleons that make up the mass of all matter. The deflection effect is so weak that it requires large numbers of nucleons have any noticeable effect. It is linear with the number of nucleons.

6. Conclusions

A model of matter was proposed in which each individual sub-atomic particle is composed of an Einstein-de Brogile model photon of appropriate frequency making two rotations per wavelength. Some of the physical mechanisms that gave rise to that feature were presented. It was shown that such a particle explained the relationship between energy and mass given by $E = mc^2$. Energy is the photon travelling in a straight line. Mass is the same photon making two rotations per wavelength.

The same model was used to derive the physical origins of gravity. The high frequency alternating electric field of the nucleons generates a change in the electric permittivity of space, similar to the mechanism proposed by Feynman. It was shown that proposed mechanism matched the known properties of gravity through the differential of the ratio of the electric permittivity of matter free space over that of space near matter. That differential in electric permittivity generates a differential in refractive index, which deflects in the trajectory of photons. With all matter particles composed of rotating photons, deflection gives rise to gravity. That differential explains Newton's inverse square law and Einstein's field equations.

In this presentation, the properties of gravity were derived from sub-atomic and quantum properties of matter. It goes beyond the standard model, uniting quantum and sub-atomic particle properties

with gravity. Appendix 1 shows it does the same for Einstein's special relativity theory.

Appendix 1

Einstein's Special Relativity Corrections

This appendix is added to show that the rotating photon model of sub-atomic particles can also give a physical explanation of Einstein's special relativity corrections [1, 4]. Apart from showing another useful aspect of the model, it is intended to close concerns readers may have about the validity of his relativity theory calculations.

Consider what happens when a particle under this rotating photon model moves. Figure A1 A illustrates the axis of a hoop moving along its plane of rotation, like a spinning hoop moving freely along its plane of rotation. Classically it could be considered as moving as indicated, with the photon travelling at different speeds. With c constant, that motion is difficult. Figure A1 B illustrates the same hoop moving along its axis of rotation perpendicular to that plane of rotation. All other possible motions should be considered as a combination of those two. In this study, only the path shown in figure A1 B, in which the rotating photon spirals helically through space, is considered. That requires each particle of this type to orient itself such that the direction of rotation of the photon would always be perpendicular to the direction of travel of the particle. If the predictions match observation it is considered that this is the way particles move.

It is not considered that the rotating photons are the hoops portrayed in in this presentation. As indicated by Williamson and van der Mark [19], they are toroidal electromagnetic fields. Similarly, the rotating axis will not move in the smooth manner illustrated. They will interact with other rotating electromagnetic fields, causing them to vibrate. The following calculations describe the average of all orientations along their average axial trajectories.

A feature of photons is that they cannot move sideways. The only way such a structure can move is to spiral a helical path. Figure A1 also shows images of the axis of a rotating photon at rest, C, and moving, D. In C and D, i, ii and iii represent the rotating photon viewed end on, obliquely and parallel to the plane of rotation respectively. Figure A1 D ii shows it travels in a helix. Viewed end on, as the particle approaches the observer, it is seen as a circle, as shown in figure A1 D i. Side on, see figure A1 D iii, it is shown as a "saw tooth" wave. It is actually a helix, see figure A1 D ii.

The front still travels distance ct in time t, given by

$$(2\pi r_v)^2 + (vt)^2 = ct^2 \tag{A1}$$

where r_v is the radius at velocity v. Equation (5) can be rewritten as

$$\frac{(2\pi r_v)^2 + (vt)^2}{(2\pi r_0)^2} = \frac{ct^2}{(2\pi r_0)^2}$$

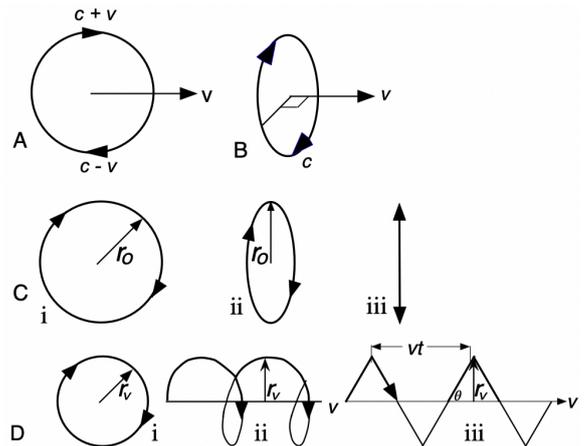Since $2\pi r_0 = ct$, that simplifies to

Figure A1   Schematic illustration of the motion of the axis of a rotating electromagnetic oscillation as it moves.

$$\frac{(2\pi r_v)^2}{(2\pi r_0)^2} + \frac{(vt)^2}{(ct)^2} = 1$$

which can be rewritten as

$$\frac{r_v^2}{r_0^2} + \frac{v^2}{c^2} = 1$$

for which one solution is

$$r_v = r_0\sqrt{1 - \frac{v^2}{c^2}} \tag{A2}$$

In this rotating photon model, a particle will contract laterally as it moves. The degree of lateral contraction is given by equation (A2).

When this type of particle moves at increasing speed, its radius contracts while its angular momentum, $I\omega$, remains constant. None has been either added or subtracted. Thus, angular momentum $I\omega$ remains constant at $\frac{1}{2}\hbar = mr^2 \cdot \frac{c\sin\theta}{r}$ for all velocities. θ is the angle between the direction of travel of the particle and the angle traversed by the spiralling photon, as shown in figure A1 D iii. The $\sin\theta$ term comes about because the motion of the photon is now no longer completely circular, some of the velocity c is in the direction of the propagation of the particle and some in the direction of rotation. It is only the component $\sin\theta$, in the direction of rotation, which contributes to the angular momentum. That gives $m_0 r_0 = m_v r_v \sin\theta$, where m_0 and r_0 are the rest mass and rest radius of the electron and m_v and r_v are its mass and radius at velocity v. In this rotating photon model of a particle, the photon cannot spin faster. To match angular momentum, its mass must increase. As such, $m_v = \frac{m_0 r_0}{r_v \sin\theta}$

Since $\sin\theta$ is given by $\frac{r_v}{r_0}$, this gives $m_v = m_0 \cdot \frac{r_0^2}{r_v^2}$, which simplifies to

$$m_v = \frac{m_0}{\left(1 - \frac{v^2}{c^2}\right)} \tag{A3}$$

Equation (A3) means that, as the velocity of a particle of this type increases, its mass would increase at a rate faster than allowed under the previously derived relationship $E = mc^2$. That is at odds with the principle of conservation of mass-energy. That can be avoided if the rotation rate of the particle's photon slows down. Then equation (A3) can be re-written as

$$m_v = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}} \cdot \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{A3a}$$

indicating that the correction required is

$$\frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{A4}$$

In the above description of the rotating photon, classical concepts of length and time have been used. If time on the moving particle were to slow down according to equation (A4), the mass would increase at the slower rate given by

$$m_v = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{A5}$$

That agrees with predictions from Einstein's special theory of relativity. This rotating photon model requires time interval t_v at velocity v to slow down according to the relationship

$$t_v = \frac{t_0}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{A6}$$

which also agrees with the special theory of relativity and experimental observation. With the photon's rotation rate slowed down, yet the photon still required to travel at c, it must now have a linear forward travel component in its motion. This is shown in figure A2.

The thicker lines in A2 A, B and C are meant to indicate that portion of the spiral is out of the plane of the page, with the thinner lines indicating the spiral is into the page. All show the photon making three spirals, travelling 1½ wavelengths. A2 A shows a side on view of the photon. The dashed lines show the spiraling photon without the "forward slip". The pale "slip" travel line shows the introduced forward motion. The full dark spiral and slip travel line shows the trajectory the photon takes as it travels.
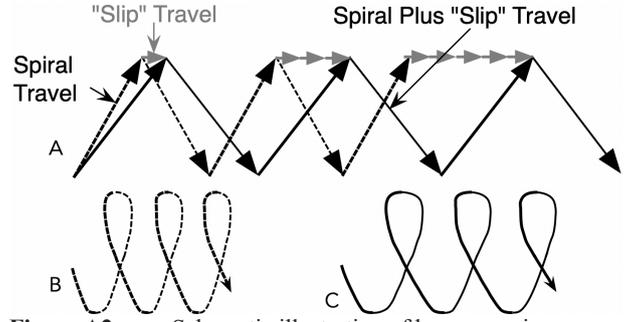

Figure A2 Schematic illustration of how a moving particle's photon has to both spiral, as well as having an additional forward movement as it travels.

It is not that the spiralling photons move sideways as indicated in figure A2 A. Figure A2 B shows the equivalent of the spiral travel indicated by the dotted line in figure A2 A. The forward slip motion has the effect of stretching the helical travel, as shown in A2 C. The rotating photon is still spiralling forward. Each stretched spiral travels a little further than the rotating spiral would were it not for the necessity for its rotational speed to slow down.

If the particle were to helically spiral its way through space, it would travel the total distance as seen by a stationary observer. When it has a forward linear motion, it does not have to make the same number of spiral revolutions to go from one position to another. Making fewer revolutions means that it spirals through a shorter distance to reach its destination. As can be seen from equation (A4), the correction factor for this forward slip motion is $\frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$.

This results in the distance travelled by the rotating photon moving at velocity v, being apparently shortened according to the well-known relativistic correction for distance, namely

$$\ell_v = \ell_0 \sqrt{1 - \frac{v^2}{c^2}} \tag{A7}$$

In order to increase the velocity of a particle, it must be given energy, i.e., photons. The rotating photon absorbs the incoming photon and increases its mass. But this is not a simple increase in mass that decreases its radius. As it goes faster and its mass increases, it has to slow down the rate at which it rotates. The slowing down in rotation rate makes it look to an external observer as if time is slowing down on it. It still has to travel at the same speed, so it takes on a forward motion in the whole structure. The photon still spirals its way forward as it rotates, but it slides forward at the same time.

Figure A2 shows that the special relativity corrections are not imposed on matter by some mathematical means. The constant speed of light means they an automatic consequence of this rotating photon structure of matter. Length appears to be less, as if the distance has shortened, because a particle does not have to spiral the whole distance. Einstein calculated his equations entirely from mathematical reasoning based upon the speed of light being constant. This model does it from the rotating photon model for the structure of matter and the constant speed of light. From the above, it can be seen that this rotating photon model of the structure of a particle automatically derives the major features of the special theory of relativity, namely

$$E = mc^2 \tag{3}$$

$$m_v = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{A4}$$

$$t_v = \frac{t_0}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{A6}$$

$$\ell_v = \ell_0 \sqrt{1 - \frac{v^2}{c^2}} \tag{A7}$$

It also gives a physical reason for those corrections, based purely upon the structure of individual particles. The reason is that the circumferential speed of a rotating photon spiralling through space remains constant at the speed of light c. The radius must be altered to suit their motion. This automatically results in time slowing down, mass increasing and the distance spiralled

decreasing. Unlike the Einstein /Lorentz [1, 49] corrections, this rotating photon model also predicts a contraction in the width of an individual sub-atomic particle such as an electron according to:

$$r_v = r_0 \sqrt{1 - \frac{v^2}{c^2}} \qquad (A2)$$

This has been detected, but not recognized as such. According to equation (2), the electron's rest mass gives it a rest radius of $\approx$ 1.93.. x 10^{-13} m. It is quite small, but much larger than measurable dimensions. Electrons have been accelerated to over 29 GeV [67]. That adds over 50,000 times the electron's mass, getting it to travel close to the speed of light. They found that electrons behaved as if they were point particles, having dimensions under 10^{-17} cm. On that basis, measurements with electrons accelerated to TeV energies would show collision cross sections of less than 10^{-18} m.

It should be pointed out that it is only the width of individual sub-atomic particles that contract. This contraction does not apply to the lateral dimensions of space as a whole. They are unaltered. Space is foreshortened in the direction of travel of the particle, not in the other directions.

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