Electromagnetic effects and structure of particles due to special relativity

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That electromagnetic effects are due to special relativity has been confirmed by an exact mathematical result. Due to special relativity, rotation results in a difference velocity which has a maximum value. The maximum difference velocity, transformed by special relativistic effects, is the significant factor in an equation that produces the fine structure constant. The result exactly matches the 11 significant digits of the fine structure constant value recommended by CODATA. The maximum difference velocity is instrumental to quantization of angular momentum and energy. The maximum difference velocity also enables finding the radius of the electron from its known angular momentum. The electron velocity and radius scaled by the square root of the electron-proton mass ratio give the angular velocity and radius of the proton. The proton and electron characteristics thus calculated when applied to structural models lead to the measured neutron and deuteron masses recommended by CODATA within reported uncertainty. The proton g factor also follows from the proton model. Electron and proton are similar in structure, consisting of three mutually orthogonal rotating rings of mass.

There are two different approaches to derive the maximum difference velocity. Both approaches give an identical result.

First derivation

The first derivation of the maximum difference velocity is through Einstein's relativistic equation for the Doppler effect.[1] For an observer moving relative to a distant light source which transmits light with angular frequency ω,

$$\omega' = \omega \frac{1 - l\frac{v}{c}}{\sqrt{1-\frac{v^2}{c^2}}} \tag{1}$$

Einstein noted that when l=0, which is when the observer velocity is perpendicular to a line between the source and the observer, a second order Doppler effect exists.[1] If we let

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

and set $l = 0$, then the first equation can be written as

$$\omega' = \omega \gamma \tag{3}$$

The orientation of light source and observer is shown in figure 1.

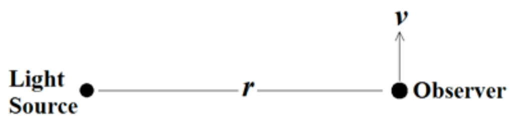

Fig 1. Transverse Doppler Configuration. A line from the source to observer is perpendicular to the observer's velocity vector.

The change in angular velocity is defined as

$$\omega_c = \omega' - \omega \tag{4}$$

The relationship that has been determined to be significant is the difference between ω and ω_c, which we define as

$$\omega_d = \omega - \omega_c = \omega(2 - \gamma) \tag{5}$$

In order to establish a correspondence between observer velocity v and the source light angular velocity ω, we remove the independence of v by requiring $v = r\,\omega$. The observer is still moving with velocity vector v perpendicular to a line drawn from the source to the observer, and is in an inertial frame of reference. This correspondence allows the difference velocity equation to be written as

$$v_d = v(2 - \gamma) \tag{6}$$

The difference velocity as a function of observer velocity is shown in figure 2.

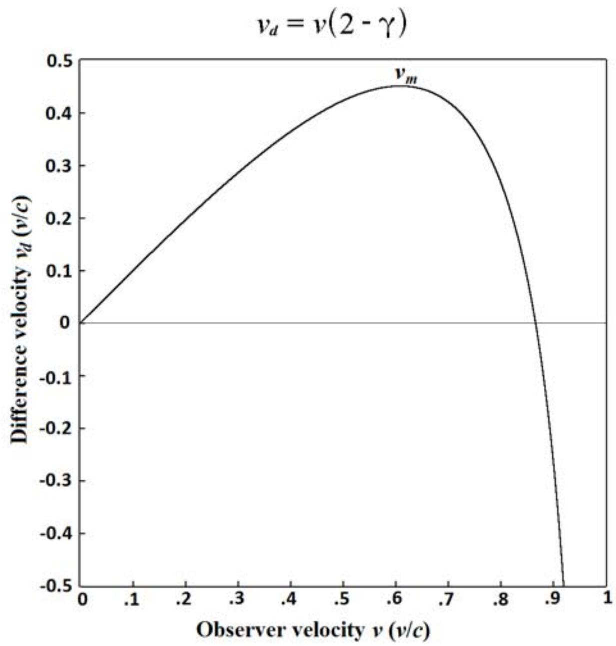

Fig 2. Difference Velocity

The maximum difference velocity is the velocity which leads to the fine structure constant, and is also the velocity of the electron's rotation. When we solve for the maximum value of v_d we find

$$v_m = (2^{2/3}\text{-}1)^{3/2}\, c, \tag{7}$$

where c is the speed of light.

Second Derivation

The second derivation of the maximum difference velocity assumes circular motion, and treats the change in angular velocity as a precession angular velocity. Lecture notes of Nobel prize winning physicist G.F.Smoot give the standard derivation of Thomas precession, arriving at[2]

$$\vec{\omega}_T = \frac{\gamma^2}{\gamma+1}\frac{\vec{v}\times\vec{a}}{2c^2} \tag{8}$$

This is followed later in the notes with a simple derivation of Thomas precession and the equation

$$\frac{\omega_P}{\omega} = \frac{\Delta\theta / T}{2\pi / T} = \gamma - 1 \tag{9}$$

Smoot writes that "This equation, despite the simplicity of the derivation, is the exact expression for the Thomas precession. The equation does not include the oscillating term because the derivation neglected the fact that the front and rear of the inertial bars are not accelerated simultaneously."[2] The equation given above can be rearranged to

$$\omega_P = \omega(\gamma - 1) \tag{10}$$

in which ω_P is analogous to ω_c in the preceding Doppler derivation. Once again a difference equation can be written which is

$$\omega_d = \omega - \omega_P = \omega(2 - \gamma) \tag{11}$$

which is equivalent to the difference equation previously derived through the second order Doppler effect. Note that for a model of particles which consist of three mutually orthogonal rings, each ring is symmetrical, explaining why the simpler Thomas precession equation applies.

Effects of the maximum difference velocity

Because of special relativity, the maximum difference velocity calculated above has effects that are seen as electromagnetic. We define two additional constants using the numerical value of v_m, but with different units. We define

$$b \equiv \frac{1}{v_m \frac{s^2}{\sqrt{kg}\,m^2}} \tag{12}$$

where v_m is multiplied by additional units, giving b the characteristic of the square root of energy. We also define

$$d \equiv v_m \frac{m}{s} \tag{13}$$

where v_m is multiplied by m/s to give d units of velocity squared. This transformation of units is extremely unusual, but no less so than the other effects of special relativity, such as time dilation, rest energy, length contraction, and others. The entire edifice of charge, electric field, magnetic field, etc. which were based on the effects of particles, is bypassed to give those effects directly from the structure and special relativistic characteristics of the particles. The magnitude of the force between two charged particles separated by distance r can now be written:

$$F(r) = \left(\frac{\sqrt{3}b^2}{m_e c^2} + \frac{\sqrt{2}d}{c^2} \right) \frac{hc}{r^2} \qquad \text{Force equation (14)}$$

where h is Planck's constant, c is the speed of light, m_e is electron mass, and b and d were defined in equations 12 and 13 above. The fine structure constant can be written in terms of the parenthetical quantity from the force equation, Eq 14, as

$$\alpha = 2\pi\left(\frac{\sqrt{3}b^2}{m_e c^2} + \frac{\sqrt{2}d}{c^2}\right) \tag{15}$$

Since b, d, and c are exact values, the fine structure constant calculated using the above equation has an uncertainty dependent only on electron mass. The value is identical to the currently accepted fine structure constant value which is[3]

$$\alpha = .0072973525664 \tag{16}$$

The reason that there are two terms is not yet known. But the structure of the equation, the relationship of the constants and their derivation, along with the fact that the equation result matches the recommended value of the fine structure constant to 11 significant digits gives credibility to the derivation of the equation. The maximum difference velocity also leads to the structure of the electron and proton, and the structure of those two particles leads to calculated values for the masses of the neutron and deuteron that further confirms the validity of the model. Additionally, the proton g factor follows from the model.

The quantity in parentheses in Eq 14 is a dimensionless scaling factor to force hc/r^2. The term with b is 6 orders of magnitude greater than the term with d. The form of the equation is what might be expected for controlling the strength of electromagnetic interaction. The square of constant b, derived from the maximum difference velocity, in ratio with the rest energy of the electron acts as the primary scaling factor. The equation applies, as does Coulomb's law, to elementary charge including protons and electrons. The reason for the presence of electron mass in the equation is more than interesting, since it may imply that special relativity is relevant in determining the masses of particles. That Eq 14 has two terms will likely lead to further understanding of structure or substructure of particles. The $\sqrt{3}$ in the first term in parentheses may be related to the magnitude of electron spin which is $\sqrt{3}/2$ hbar , and the $\sqrt{2}$ in the second term in parentheses may be related to the magnitude of photon spin which is $\sqrt{2}$ hbar, where hbar is the reduced Planck's constant.

Structure of Particles

Associating maximum difference velocity v_m with the electron, due to the presence of both electron mass and v_m in the force equation, leads to the structure of the electron. The model that has been developed leads to results that confirm it. The electron can be modeled as three mutually orthogonal rings of rotating mass as represented in figure 3.

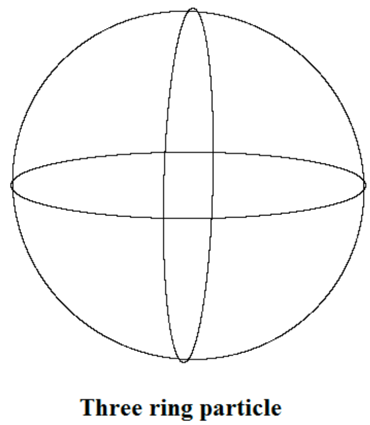

Fig 3. Diagram of particle showing three mutually orthogonal rings of rotating mass.

The electron mass is distributed with 1/3 of the mass around each rotating ring. It is critical to an understanding of the model to realize that the spin angular momentum of particle rings is due to the difference velocity and is not simply due to the rotation velocity. Each ring's angular momentum can vary between hbar/2 and -hbar/2. For convenience of description, we designate the rotation velocity at which the difference velocity is maximum, i.e. where $v_d = v_m$, as v_1, and the rotation velocity at which $v_d = -v_m$ as v_2. We designate the rotation velocity at which $v_d = 0$ as v_0. The range is shown in figure 4.

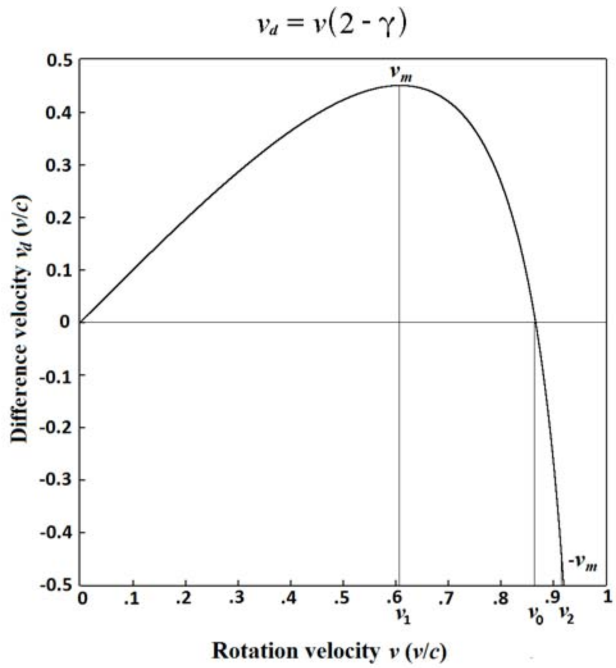

Fig 4. Difference velocity with electron velocity range annotated.

Electron ring rotation velocity is always between v_1 and v_2. In this range the electron is always coupled to space, angular momentum is exchanged, and photons are emitted or absorbed. Because ring angular momentum is due to the difference velocity and not the rotation velocity, when the rotation velocity is between v_1 and v_0 the angular momentum is positive, and when the rotation velocity is between v_0 and v_2 the angular momentum is negative. At v_m, the ring angular momentum is hbar/2, and at $-v_m$, the ring angular momentum is -hbar/2.

Because the difference velocity of the electron rings remains between $-v_m$ and v_m, there are two results. First is that angular momentum is quantized. Second is that the particle exhibits the characteristics of electric charge. It is always coupled to space such that any change in difference velocity is accompanied by a change in space. A transition from $v_d = -v_m$ to $v_d = 0$ occurs when the electron emits a photon, and a transition from $v_d = 0$ to $v_d = v_m$ occurs with a second photon emission and a spin-flip of the angular momentum. The non-linearity of the curve between $-v_m$ and v_m gives some insight into why the cyclotron emission and anomalous emission are not equal. That the sum of the two emissions divided by 2 is called magnetic moment is problematic because it obscures the physical behavior and has implications that are not applicable.

When not emitting or absorbing a photon, the electron rings rotate at either v_m or $-v_m$, so the radius can be calculated from the equation for per axis angular momentum

$$S_z = rmv \tag{17}$$

Since the difference velocity already includes relativistic effects of the Lorentz transform, γ is not a factor in the equation. The rearranged equation gives electron radius

$$R_e = \frac{\hbar}{2\frac{m_e}{3}v_m} \approx 1.28663582937643*10^{-12}\,m \tag{18}$$

The proton structure is also three mutually orthogonal rotating rings of mass, but the proton ring radius is scaled down by the square root of the proton to electron mass ratio, and the velocity of the proton rings is scaled down similarly.

$$R_p = \frac{R_e}{\sqrt{\frac{m_p}{m_e}}} \approx 3.00262603862771*10^{-14}\,m \tag{19}$$

$$v_{mp} = \frac{v_m}{\sqrt{\frac{m_p}{m_e}}} \tag{20}$$

where R_p is the radius of proton rings, m_p is proton mass, and v_{mp} is the maximum difference velocity of the proton rings. These radii are validated by results calculated for the neutron and deuteron masses. Experiments that may have attempted to measure the particle size previously without knowledge of the structure and characteristics of the particles would not have had correct results. As either proton or electron interact, they emit or absorb photons, and each interaction is accompanied by change, or cycling, of angular momentum.

To summarize the three ring model of electron and proton, it demonstrates quantization of angular momentum, expected per axis angular momentum hbar/2, expected total angular momentum √3hbar/2, asymmetry of spin flip energy, expected order of magnitude size, and rational for effects of charge though masses are different.

Neutron Mass From Structure

The rotation velocity v_1 at which the difference velocity $v_d = v_m$ is

$$v_1 = \frac{\sqrt{2^{2/3} - 1}}{\sqrt[3]{2}} c \tag{21}$$

and the Lorentz factor of this velocity is

$$\gamma_1 = \sqrt[3]{2} \approx 1.259921049395 \tag{22}$$

This Lorentz factor is a constant in a following equation. Having determined the radius of the electron and proton, we can calculate the maximum potential energy of bringing a proton and electron together until they are touching by integrating the force equation. Integration with respect to distance r gives the potential energy equation for two charges separated by distance r

$$E_x(r) = \left(\frac{\sqrt{3} b^2}{m_e c^2} + \frac{\sqrt{2} d}{c^2} \right) \frac{hc}{r} \tag{23}$$

where the subscript x denotes that the two particles are external, separated by at least the sum of their radii. Setting $r = R_e + R_p$ gives

$$E_x(R_e + R_p) = \left(\frac{\sqrt{3}b^2}{m_e c^2} + \frac{\sqrt{2}d}{c^2} \right) \frac{hc}{R_e + R_p} \approx 1.7522168603977166 * 10^{-16}\ \mathrm{J} \qquad (24)$$

The potential energy between a proton and an electron when the proton is inside the electron is

$$E_i(R_e - R_p) = \frac{hc}{\gamma_1 \left(R_e - R_p\right)} \approx 1.254680160323 * 10^{-13}\ \mathrm{J} \qquad (25)$$

where the subscript *i* denotes that the proton is inside the electron, and γ_1 is the Lorentz factor of the rotation velocity v_1 resulting in difference velocity $v_d = v_m$ as shown in the opening paragraph of this section. With the neutron modeled as a proton inside of an electron, the mass of the neutron is equal to the sum of the electron and proton masses, plus the change in mass equivalent of potential energy. This can be written

$$m_n = m_p + m_e + \frac{1}{c^2} \left(E_i(R_e - R_p) - \frac{1}{\sqrt{2}} E_x\left(R_e + R_p\right) \right) \qquad (26)$$

The neutron mass calculated with this equation is

$$m_n = 1.674927478 * 10^{-27}\ \mathrm{kg} \qquad (27)$$

which is well within the standard uncertainty of the CODATA recommended value. The equation for the potential energy between a proton inside an electron was determined empirically, starting with the form of the equation for potential energy between charges separated by distance *r*. That the equation and the model of neutron structure have the form that they do, and the equations result in 9 significant digits of correspondence to the measured neutron mass is further confirmation that the approach of determining structure from the maximum difference velocity v_m is correct.

With the proton inside the electron, the proton rings rotate at $v_0 = \sqrt{3}/2\ c$ and, because $v_d = 0$, have 0 spin angular momentum. The electron rings rotate such that the difference velocity is either + or - v_m, so they have angular momentum of +/- hbar/2. The proton and electron angular momentum sum, giving the neutron the expected per axis angular momentum of hbar/2, and total spin angular momentum of √3/2 hbar. The proton and electron charge effects also add, with the sum is 0, so the neutron is charge neutral. In the discussion section questions about the model presented here as compared to other models will be addressed. A diagram of one ring of the neutron structure is shown in figure 5.

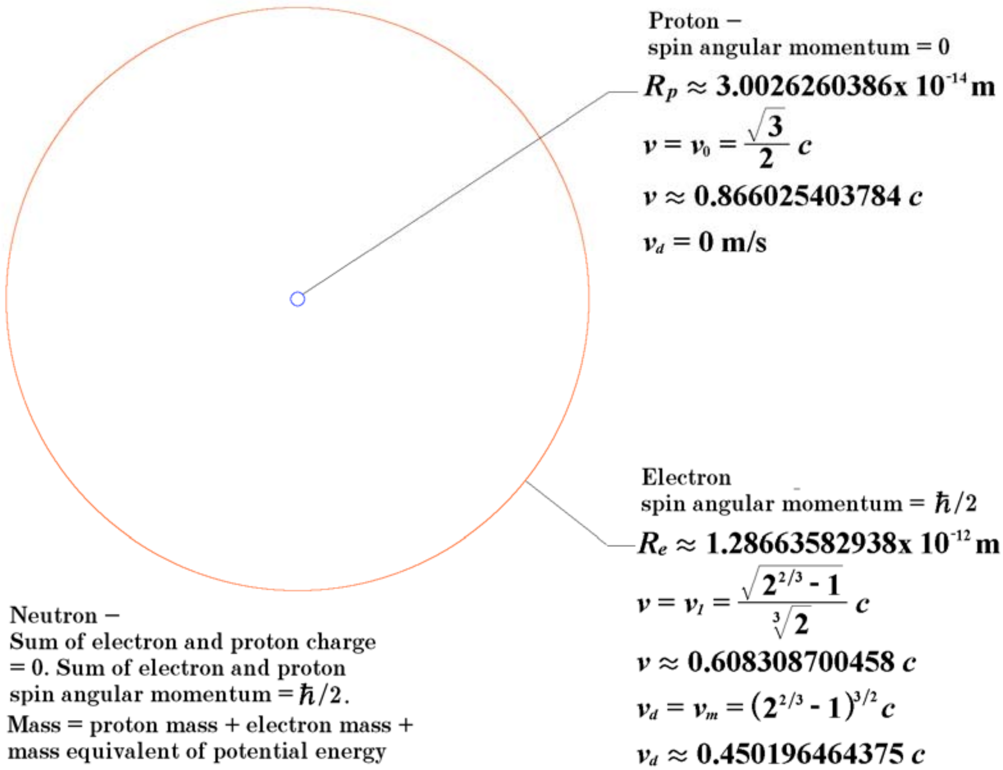

Fig 5. Diagram of neutron showing one of three rings of constituent electron and proton.

Deuteron Mass From Structure

Whereas a free neutron is an unstable particle, the deuteron is the stable nucleus of deuterium, an isotope of hydrogen with a single neutron. Though a neutron's mass is greater than the sum of the proton and electron masses as shown in the previous section, the deuteron's mass is less than the sum of proton and neutron masses. Before proceeding, it is emphasized that the deuteron is the positively charged nucleus and does not include the electron of charge neutral deuterium.

The deuteron mass can be written as

$$m_d = m_n + m_p - \frac{1}{c^2}\left(2\sqrt{2}E_i\left(R_e - R_p\right) + \frac{\gamma_1 c^2\sqrt{2}}{v_m^2}E_x\left(R_e + R_p\right)\right) \tag{28}$$

where γ_1 was defined in the previous section. The deuteron mass calculated with this equation is

$$m_d = 3.343583689*10^{-27}\text{ kg} \tag{29}$$

which is within the standard uncertainty of the CODATA recommended value. The form of the equation compared with the equation for the neutron mass gives insight to the deuteron structure. Whereas the neutron has a proton inside an electron, in the deuteron the second proton also moves inside the electron, and energy is radiated. That the calculated mass matches experimental values to 8 significant digits again confirms the approach. Another confirmation is that the ratio of c^2 to v_m^2 and the Lorentz factor of the rotation velocity v_1 resulting in maximum difference velocity $v_d = v_m$ are in the second term in parentheses.

Charged Particle to Photon Coupling

As described previously, charged particles are continuously coupled to space. The rotation velocity has important characteristics at difference velocity $v_d = v_m$ and at $v_d = 0$. At $v_d = v_m$ the rotation velocity v_1 has a Lorentz factor of $\gamma_1 = \sqrt[3]{2}$, and at rotation velocity $v_0 = \sqrt{3/2}\, c$, the Lorentz factor $\gamma_0 = 2$. Both electron and proton change spin without stopping and reversing, or rolling through π radians, because at rotation velocity $v_0 = \sqrt{3/2}\, c$, where $\gamma_0 = 2$, the difference velocity v_d passes through 0. At rotation velocities lower than v_0, the angular momentum is positive, and at rotation velocities higher than v_0, the angular momentum is negative. The MacLaurin series of the Lorentz factor is

$$\gamma = 1 + \frac{1}{2}\frac{v^2}{c^2} + \frac{3}{8}\frac{v^4}{c^4} + \ldots \tag{30}$$

The series at $v_0 = \sqrt{3/2}$ c is

$$\gamma_0 = 1 + \frac{1}{2}\frac{\frac{3}{4}c^2}{c^2} + \frac{3}{8}\frac{\frac{9}{16}c^4}{c^4} + \ldots \tag{31}$$

Since $\gamma_0 = 2$ at $v_0 = \sqrt{3/2}$ c and the second term evaluates to 3/8, the sum of all subsequent terms is 5/8, so we can write

$$\gamma_0 = 1 + \frac{3}{8} + \frac{5}{8} \tag{32}$$

Where the 3/8 term represents the time dilation for kinetic energy, corresponding to E = 1/2 mv^2, and 5/8 represents time dilation for the remaining energy. We see the 5/8 term in some of the following derivations. The properties of the electron and proton when their spin = 0, that is at $v_0 = \sqrt{3/2}$ c is not yet fully understood. However, the spin-flip energies and photon coupling characteristics may lead to full understanding.

Photons have an on-axis angular momentum of hbar, and a total angular momentum of $\sqrt{2}$ hbar. Since charged particles transition spin angular momentum by hbar/2 during photon emission, the charge spin and movement can be inferred. Figure 6 shows the necessary conditions for photon emission.

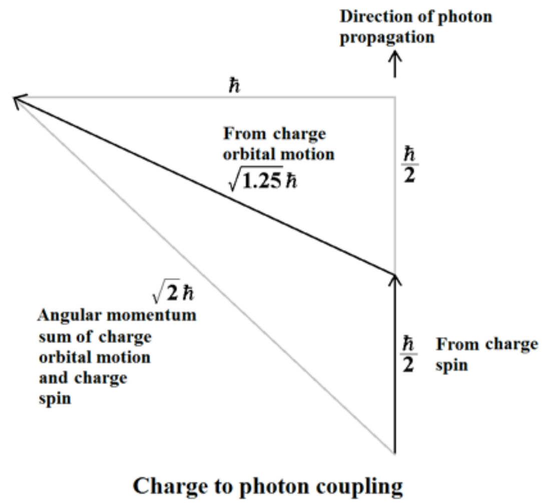

Fig. 6. Charge spin and orbital angular momentum required for photon emission.

Three cases will be examined which involve photon emission, the cyclotron emission of a charge moving in a magnetic field, the proton spin-flip or anomalous photon emission, and an electron coupled to a proton by emission of some of the potential energy between them. The terms "orbital motion" or "orbital velocity" will be used for the bulk movement of a charge and does not refer to rotation of the rings around their center of mass.

Cyclotron Emission

For a charge moving through a magnetic field, the condition for transferring angular momentum from the charge to a photon is met when

$$v = \sqrt{\frac{4\hbar eB}{m^2 \frac{5}{8}}} \tag{33}$$

and

$$r = \frac{\sqrt{1.25}\hbar}{mv} \tag{34}$$

where v is the orbital velocity of the charge, e is the elementary charge, B is the magnetic field strength, m is the mass of the charge, and r is the distance from the charge to the point around which it is rotating. For an electron in a 1 Tesla magnetic field,

$$v(1T) \approx 11415.482434 m/s$$
$$r(1T) \approx 1.1338299889 * 10^{-8} m \qquad \text{(35a,b,c)}$$
$$L(1T) = \sqrt{1.25}\hbar$$

With these values, the orbital angular momentum with $L = rmv$ is $L=\sqrt{1.25}$ hbar.

The orbital kinetic energy is

$$E_k(1T) = \frac{1}{2} mv^2 \approx 5.9353663949 * 10^{-23} J \qquad (36)$$

and the resulting emitted cyclotron photon energy is

$$E_c(1T) = \frac{E_k \frac{5}{8}}{2} \approx 1.854801998 * 10^{-23} J \qquad (37)$$

The cyclotron photon frequency is

$$\omega_c(1T) = \frac{E_c}{\hbar} \approx 175882002360 \qquad (38)$$

The orbital frequency before photon emission, which is not the same as after emission, and is also not the same as the cyclotron photon emission is

$$\omega_o(1T) = \frac{4\omega_c}{\frac{5}{8}\sqrt{1.25}} \approx 1006807330038 \qquad (39)$$

The values calculated above give the expected cyclotron emission energy and also match the required pre-emission orbital angular momentum.

Proton Anomalous Emission

We also find that the proton anomalous, or spin-flip, photon emission energy can be written

$$E_{ap} = \left(\frac{2}{\left(\frac{5}{8}\right)} \frac{\frac{\alpha}{2\pi} + \gamma_1 - 1}{\gamma_1 - 1} \right)^{1/2} E_c \approx 1.792846512 E_c \qquad (40)$$

The proton anomalous energy factor calculated above varies from the value derived from the accepted proton g factor by approximately $8.4*10^{-7}$. Since the form of the equation contains the kinetic energy to cyclotron emitted energy ratio found above, the correspondence seems sufficient for further investigation. As mentioned previously, after cyclotron emission the particle spin is 0 with rotation velocity $v_0 = \sqrt{3}/2$ c. From that velocity, spin angular momentum is either restored from the orbital angular momentum, or a spin-flip occurs and angular momentum becomes -hbar/2.

Electron - Proton Coupling by Potential Energy Emission

For an electron in the vicinity of a proton, the photons that can be emitted due to the potential energy between the proton and electron have a discrete number of values, *n* = 1,2,3,... with 1 being associated with the highest energy, also known as the ionization energy. At each distance *r*(*n*), the orbital angular momentum must equal √1.25 hbar. The equations for velocity and distance are

$$v(n) = \frac{\alpha 2c}{n\sqrt{1.25}} \tag{41}$$

and

$$r(n) = \frac{n\hbar \frac{5}{8}}{\alpha m_e c} \tag{42}$$

For *n* = 1,

$$\begin{aligned} &v(1) \approx 3913461.10177 m/s \\ &r(1) \approx 3.307357566 * 10^{-11} m \\ &E(1) \approx 2.1798723225 * 10^{-18} J \approx 13.60569301 eV \\ &L(1) = r(1) m_e v(1) = \sqrt{1.25}\hbar \end{aligned} \tag{43a,b,c,d}$$

E(1) is the emitted photon energy, and *L*(1) is the orbital angular momentum prior to photon emission.

Spin Restoration From Larmor Formula

As mentioned previously, an electron moving with kinetic energy in a magnetic field will undergo cyclotron emission of a photon. During this emission, the electron rotation velocity transitions from v_2 to v_0 in the diagram above, and its difference velocity transitions from -v_m to 0. This is when its spin angular momentum changes from -hbar/2 to 0. Also as shown in another diagram above, before the photon is emitted the electron orbital angular momentum reaches √1.25 hbar so that the total angular momentum is √2 hbar, and the on-axis sum of orbital and spin angular momentum is hbar. This angular momentum is then transferred to a photon. After emitting the photon, unless a spin flip occurs, the force on the electron moving through the magnetic field will cause its angular momentum to be restored to -hbar/2. That this process occurs is confirmed by the Larmor formula for radiated power. The energy emitted is *E*=*hf*, but this can also be written

$$E = \hbar\omega \tag{44}$$

and ω= $eB/(\gamma m_e)$, where e is elementary charge, B is magnetic field strength, γ is the Lorentz factor of the electron velocity through the magnetic field, and m_e is electron mass. Since the on-axis angular momentum of a photon is hbar, the energy carried by the photon is emitted over a time period of $1/\omega$. The photon emission time period is much shorter than the time between photons being emitted. Put another way, the average power emitted in much lower than the emitted energy divided by the photon emission time. During the time between photon emissions electron spin transitions back from 0 to -hbar/2.

The Larmor formula for radiated power while an electron moving in a magnetic field radiates kinetic energy away is:[4]

$$P(\gamma,\theta)=\frac{1}{4\pi\varepsilon_0}\frac{2}{3}\frac{e^4}{m_e^2 c}B^2\left(\gamma^2-1\right)\sin^2\theta \tag{45}$$

The period of emissions can be written as:

$$T(\gamma,\theta)=\frac{3\hbar}{2}\frac{1}{E_x\left(\dfrac{c}{\omega_{ce}}\right)}\frac{1}{B^2\left(\gamma^2-1\right)\sin^2\theta} \tag{46}$$

This equation for the period of emissions makes more apparent that the time is equal to the angular momentum of the three rings divided by the potential energy between the electron and a photon at distance c/ω_{ce}, scaled by the magnetic field strength, a factor for the kinetic energy, and the orientation of the electron in the magnetic field. The Einstein-deHass experiment showed that a magnetic field represented spin angular momentum, which could be transitioned to system level angular momentum. The opposite effect occurs during the time between photon emissions, system level angular momentum is being transitioned to the electron rings spin angular momentum.

We give here an example of applying the Larmor formula and the formula for the period of emissions. For this example, we set B=1T, and let the electron velocity through the magnetic field v = 0.0001357c. We also set $\theta=\pi/2$ for maximum radiated power. Applying the Lorentz transform to v, we have γ = 1.000000009207245127 and $\gamma^2 - 1 = 1.841449034*10^{-8}$. Using these values in the Larmor formula gives

$$P(\gamma,\theta)\approx 2.92248796*10^{-22}W \tag{47}$$

The photon angular frequency is

$$\omega_{ce}=\frac{eB}{\gamma m_e}\approx 175882000740.8 \tag{48}$$

and the photon emission time from $1/\omega_{ce}$ is

$$T_{ce} \approx 5.68563011444008*10^{-12}s \qquad (49)$$

The emission period from the equation above is

$$T(\gamma,\theta) \approx 0.06346654095s \qquad (50)$$

To summarize the behavior of an electron moving with some initial kinetic energy through a magnetic field, the motion of the electron results in forces that transfer system angular momentum to the electron rings spin angular momentum. When the spin angular momentum reaches -hbar/2, and the orbital angular momentum is √1.25 hbar, resulting in the total angular momentum of √2 hbar with an on-axis component of hbar, the angular momentum is transferred to a photon as the electron spin angular momentum transitions to 0. As long as the electron has kinetic energy the process continues, with the emitted photon frequency approaching the cyclotron frequency eB/m_e, and the emission period approaching infinity.

While v_m results in angular momentum being quantized, especially in being carried by photons, charged particles do transition to a spin angular momentum of 0 and either back again or a spin flip occurs. The Larmor radiated power formula shows the asymmetry related to photon emission and spin recovery. The particle model presented here provides all the necessary mechanisms to explain experimental results.

General Applicability of Maximum Difference Velocity

The maximum difference velocity, v_m, was derived by application of special relativity to only velocity and angle. But the presence of electron mass in Eq 14 implies a relationship between v_m and mass. We find consistent and meaningful results by associating v_m with the electron and scaling that velocity by the square root of the electron proton mass ratio to get the proton maximum difference velocity. Using the electron radius scaled by the square root of the electron/proton mass ratio as proton radius, the geometry of combined electron and proton gives accurate results in determining properties of the composite particles neutron and deuteron. The reason that v_m applies directly to the electron and must be scaled by the square root of the electron-proton mass ratio to apply to the proton is not yet fully understood. However, the derivation of v_m gives reason to expect that with or without scaling, it is a universal and fundamental property of space-time.

The derivation of v_m and its accurate application implies that not only particle rings have their properties of charge and possibly even their masses due to v_m, but photon characteristics are due to v_m as well. In particular, during emission or absorption of a photon by a charged particle, the photon behaves as a charge interacting with the charged particle. It further appears that photons have on-axis angular momentum of hbar and total angular momentum of √2 hbar due to v_m.

On the opposite extreme of size and mass from elementary particles, it appears possible that v_m is relevant at the scale of galaxies as well. Galaxies rotate. Stars further from their galactic center orbit faster, up to a maximum velocity. Why there are maximum galactic orbital velocities has been an open question. The maximum velocity varies from galaxy to galaxy, and is only approximately constant, but a rough average maximum orbital velocity may be $2.5*10^5$ m/s +/- $1.0*10^5$m/s. As with v_m applied to the electron and a scaled value applied to the proton, the variation of the maximum orbital velocity between galaxies may be due to mass or mass density and distribution. Because maximum star orbital velocity is not understood by science at this time, and because it appears that v_m should be in some way generally applicable, we hypothesize that v_m is relevant to maximum star velocity around galactic centers.

The maximum velocity of the sun's rotation around the Milky Way galactic center may be

$$v_g = \sqrt{2} v_m \frac{\alpha}{2\pi} \tag{51}$$

with the form of the equation generally universally applicable. The foregoing hypothesis is unproven, with the effecting mechanism not yet postulated. However, the hypothesis demonstrates the expectation that a universally applicable v_m should have far reaching application and explanatory power. Inclusion of the hypothesis in this paper is not intended as supporting evidence for the relevance of v_m to charged particles. Rather it is one example illustrating that studying v_m might lead to solutions to additional unsolved problems in science.

Generalization of The Force Equation

In the first section we gave Eq 14 for the magnitude of force between two charged particles in terms derived from the maximum difference velocity. Obviously as an analog to Coulomb's law, this force equation can be generalized to any quantity of particles or total charge.

Now that the significance of v_m has been shown, we can replace the quantity in parentheses in Eq 14 with the fine structure constant divided by 2 pi. When we see the fine structure constant α, we realize that the special relativistic effects of v_m applied to charge structure and photon structure are operating. The force equation can be generalized to

$$F_x(r) = \frac{\alpha}{2\pi} \frac{hc}{r^2} n_a n_b \tag{52}$$

where n_a and n_b are the number of charged particles at each location separated by distance r, and n_a and n_b carry the sign of the charges.

With this equation replacing Coulomb's law, we have a clear connection between the macroscopic and microscopic effects of charge, while the fine structure constant shows the significance of the particle structure.

The force per unit length between two current carrying conductors separated by distance *r* can be written as

$$F_l(r) = 2\frac{\alpha}{2\pi}\frac{hc}{r}\lambda_a\lambda_b\frac{v_a v_b}{c^2} \tag{53}$$

where the force subscript *l* denotes per unit length, λ_a and λ_b denote the charge density in each conductor, and v_a and v_b denote the drift velocity within each conductor. For consistency of resultant force direction, the charge density in number per meter also is assigned the sign of the charge carrier. The direction of the drift velocity of the carriers is also assigned a sign.

With these two equations, the electrostatic and electromagnetic forces are directly attributable to the particles, their structures, and the special relativistic characteristics of velocity, angle, and space. While obviously the equations were valid and could have been formulated without an understanding of why the fine structure constant has the value that it does, it makes sense to move toward a system when that system provides better understanding.

Discussion

Special relativity

Seven years after he published the special theory of relativity, Einstein wrote in his 1912 Manuscript on the Special Theory of Relativity that some of the effects are "astounding" and "surprising".[1] He wrote of time dilation that "This consequence of the theory of relativity appears to many physicists so fantastic that they believe that they must reject the theory of relativity on its account." Many today may not be aware that the acceptance of special relativity was not universal and immediate within the physics community.

Let us also consider what has been called the most famous equation, $E=mc^2$. In Einstein's 1912 manuscript, he applied the Lorentz transform to energy,

$$E = \frac{mc^2}{\sqrt{1-\frac{q^2}{c^2}}} \tag{54}$$

and then expanded it to

$$E = mc^2 + \frac{m}{2} q^2 + ... \qquad (55)$$

The equations 54 and 55 above were numbered 28 and 28' in Einstein's manuscript. The *q* in his equations is velocity. Einstein wrote of the terms of the expanded form, "The second term on the right-hand side is the familiar expression for kinetic energy in classical mechanics. But what does the first, *q*-independent term signify? To be sure, it does not have, strictly speaking, any legitimacy here; for we have arbitrarily omitted an additive constant in (28). But on the other hand, a glance at (28) shows that the term mc^2 is inseparably linked to the second term of the expansion , $m/2\ q^2$."

The most famous equation by one of the greatest scientists of all time, and the mc^2 term is described by Einstein himself as not having strictly speaking any legitimacy in the mathematical derivation. Without fully expounding each term of the Lorentz factor expansion, and in fact only showing the first two terms, Einstein recognized the significance of rest energy and its link to the kinetic energy term.

Rehearsing Einstein's exposition of special relativity serves the purpose here of reminding the reader that a significant physical law may be recognized by its relationships and correspondence to other facts before a complete understanding is attained. The effects of special relativity are astounding again today with discovery of the maximum difference velocity, and the results should again be credited with significance.

Quantization

A question that arose as quantized behavior began to be discovered was "How can an analog world generate quantized effects?" The answer is "Through special relativity." In straight line motion the maximum speed of light leads to the necessity for all the non-linear effects of the Lorentz transform such as time dilation and length contraction. In simple straight line motion, the magnitude of the quantities is affected without affecting the units. At high velocity and right angles, special relativistic effects include transformation of units.

The maximum difference velocity, v_m, is a fundamental characteristic of space time. Without reference to mass or dimension, v_m was derived from velocity and angle. It is so fundamental a part of physics that the structure of matter is related to it. And not matter only, but the structure of energy in the form of photons appears to also be related to it. In particular, the electron difference velocity is exactly v_m, and the proton difference velocity is v_m scaled down by the square root of the proton-electron mass ratio. So quantization of angular momentum and energy levels are very significant characteristics due to v_m, but even beyond that, the structure of matter, charge, and its interaction through photons all appear related to v_m. We have shown in the preceding sections that v_m bounds excursions of the difference velocity, and that angular momentum is not due to rotation velocity but is due to difference velocity.

A plot of electron ring kinetic energy helps visualize quantization as a special relativistic effect.

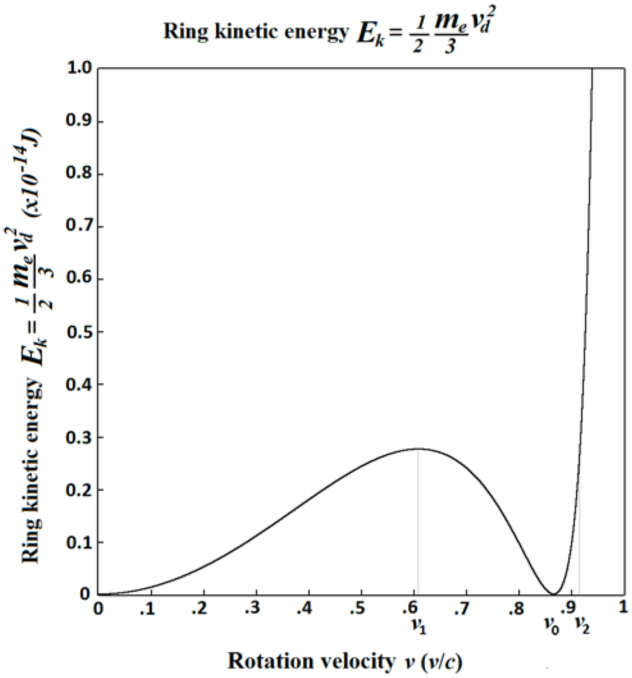

Fig 7. Electron ring kinetic energy.

Referencing figure 7, electron rotation velocity remains between v_1 and v_2 due to v_m thus resulting in quantized angular momentum. Once again we emphasize that angular momentum and kinetic energy are due to the difference velocity v_d, and not rotation velocity v. For this reason at $v_0 = \sqrt{3}/2\ c$, angular momentum is 0. Special relativity has historically extended our understanding of physics from the straight line low velocity behavior that our senses experience into the high velocity behaviors that are not intuitive. This latest discovery of special relativity extends our understanding from low velocity orthogonal behavior to high velocity orthogonal behavior where we find the fundamental basis for charge and particle structure.

Experimental Results

The model presented herein matches very well with basic experimental results. But the accumulated body of experimental data is enormous, and there is a significant amount of work remaining to evaluate previous experiments in light of the current model. Not in all cases would experiments performed without knowledge of the current model be expected to provide correct results. The model detailed here matches experimental results of per axis angular momentum, total angular momentum, quantization of energy levels, and spin flip behavior or magnetic moment and g factor.

Other Models

Over the past few decades, a number of physical models of elementary and composite particles and particle interaction have been proposed. These ranged from the electron as a black hole to the electron being a composite of many neutrinos. Some modeled the electron as a resonant electromagnetic structure. However, without the difference velocity and its maximum, v_m, the quantization of angular momentum and energy, explanation of spin-flip, and the physical basis for the effects of charge, the models were missing significant components. The model presented here has in common with some other models the underlying premise that particles exhibiting the behavior of the electron and proton must occupy space and incorporate rotation. The model is a physical model describing physical properties and structure. The model does not involve mathematical or philosophical abstracts, but actual energy and matter that occupies non-zero space and time.

Remaining Work and Effects

The model and results presented here provide a framework for completely modeling all electromagnetic interactions and very likely the structure of all matter. However there is still significant work to be done.

1) The force equation scaling factor consists of two terms. If proton mass m_p is substituted into the force equation in place of electron mass m_e, then proton maximum difference velocity v_{mp} can be used to form a b_p to replace b in the force equation. Thus the ratio $\sqrt{3}b^2/(m_e c^2) = \sqrt{3}b_p^2/(m_p c^2)$. But the second term contains d which is not scaled by mass. This second term is roughly 6 orders of magnitude smaller than the first term. Clarifying the source of the terms is an important objective. As mentioned previously, the second term may be due to the photon interface between charges. However, the question also arises of whether the force between positive charges and negative charges is exactly equal, or if the second term is scaled there would be a small difference between forces due to positive charges and forces due to negative charges.

2) If an electron emits a cyclotron photon, and that photon is treated as a charge at distance of the photon radius, then there is a potential energy between the electron and the photon. This potential energy is nearly the magnitude of the spin-flip, or anomalous, photon energy. It appears that due to the shape of the difference velocity curve between v_m and - v_m, the electron anomalous emission behaves differently than the proton anomalous emission. The proton difference velocity varies much more linearly around 0 with an excursion $\sqrt{(m_e/m_p)}$ times that of the electron. Developing more detail of the electron and proton behavior during spin-flip is an important goal.

3) When charged particle rings rotate at $\sqrt{3}/2 * c$, their difference velocity is 0 with a resultant angular momentum of 0. At this velocity the energy that had been kinetic energy at v_m appears to be rest energy. The rotation velocity of $\sqrt{3}/2 * c$ appears to be, from the particle frame of reference, stationary. Also at this velocity, the time dilation can apparently be characterized as 3/8 due to a kinetic energy term, with the balance equaling 5/8. It remains to be detailed in what way these proportions are related to the 5/8 and $\sqrt{1.25}$ hbar that are involved with photon angular momentum during emission.

4) Empirically the force between a proton and electron when the proton is inside the electron has been determined as described in the section on the neutron. In this

configuration, the scaling ratios involving v_m are not present. This appears to be due to the geometry of the interface. This requires more development.

5) The geometry and energy of the deuteron has been modeled and the resultant mass matches the experimental value. However, more work needs to be done in comparing this result with other experimentally determined characteristics.

Providing a theoretical physical basis for the effects of charge, and a model of elementary particles that follows naturally from v_m, will enable development of highly detailed deterministic models of atoms and their electromagnetic interactions. Most chemical properties, as seen with the table of elements, are derived from the electromagnetic characteristics of the atoms. So while there is a significant amount of work to be done, the framework is now in place that can lead to detailed modeling of atoms, electromagnetic interactions, and chemical properties.

The improved understanding of the physical properties of matter from these deterministic models leads beyond simulation to synthesis of materials. This will enable technological advances in superconductivity, photo-electric devices, microelectronics, magnetics, heat transfer, strength of materials, and many others.

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