The Electron as a Confined Photon

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Abstract

A new topological study is presented of a semi classical quantized model for the electron, consisting of a circularly bound monochromatic photon. This model for the electron includes a topologically created elementary charge, point-like behavior in high-energy scattering events, half-integral spin, and the magnetic moment of the electron. We will also present evidence for the causes of: 1) the fine structure constant, 2) the magnetic moment anomaly of the electron, 3) the elementary charge, 4) a binding force which allows a photon to be confined to become and electron, 5) the property of inherent inertial mass in the electron, and 6) Relativity. Within this context we propose that all matter is composed of EM waves, and that Relativity and Quantum Mechanics are the simple result of the behavior of those EM waves. For the most part we will use simple scalar mathematics to support this premise, because most of the problems have relatively simple solutions. However we will also submit that new formulations are needed for field equations.

The following gendanken is a “thought experiment” intended to explore the architecture and topology of the electron.

I. Introduction

Toroidal or helical models of the electron have been proposed by many physicists. [1, 2, 3, 4, 10, 11, 27] Few of these authors have considered the wavefront velocity could be higher than c inside the electron even though helical models for the photon shown later, illustrate that this velocity may be $v_{wf} = c\sqrt{2}$. Williamson and van der Mark have proposed an interesting model for the electron which consists of a bound photon with its helical motion converted to the wavefront traversing the helix of the electron at two times the Compton frequency. However they did not adopt the resultant calculated wavefront velocity for the internal velocity of their confined photon’s wavefront. Studies by various authors have been published which explore the creation of charge from fields [14, 15, 16], and the creation of a fermion, electron, from a boson, the photon [2, 17, 27].

The model described herein is similar in topology to the model in [1] but differs, in the use of a sinusoidal monochromatic plane wave instead of a charge ribbon, the model differs in the determination of wavefront velocity, and therefore circulation velocity, and differs in the definition of a confinement force, as well as determination of the elementary charge, determination of the electron magnetic moment, fine structure, and inherent inertial mass.

"It is my opinion that everything must be based on a simple idea. And it is my opinion that this idea, once we have finally discovered it, will be so compelling, so beautiful, that we will say to one another, yes, how could it have been any different."-- John Archibald Wheeler

II. The Photon Model

We will start with a common helical model for the photon which allows for either right or left spin 1 photons, which complete one rotation in one wavelength and travel through the vacuum at the velocity c. We will call this the "twisted ribbon" model for the photon - *Figure 1*.

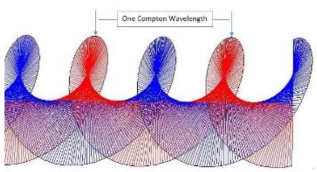


Figure 1

Since E=hf and the photon is a spin 1 particle, then we know that the photon completes one revolution in the time it takes to travel one wavelength at the velocity c (represented by the blue arrows in Figure 1). We therefore know that the angle[1] of the advancing wavefront is 45°. Since the photon is moving forward at the velocity c we know the velocity of the wavefront is therefore $v_{wf} = c\sqrt{2}$.

$$v_{wf} = c\sqrt{2} = 4.239705600007665e + 08 \ m/S \qquad (1)$$

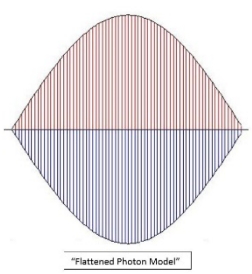


Figure 2

The photon used in our model is helical and has an energy of 0.510998910 MeV because of the well-known electron-positron annihilation reaction. Where upon the annihilation of e+ and e- two gamma ray photons with this energy are released. The photon wavelength at the velocity c is therefore 2.426310e-12m and its Frequency is 1.235589e+20 Hz.

Figure 3 illustrates the shape of the untwisted photon ribbon model we will use. Our photon model is a helical wave so this flattened illustration would be twisted into a helix.

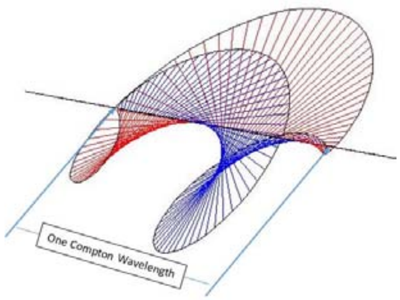


Figure 3

Figure 4 is an illustration of the helical version of our photon model. *Figure 4* is a 3D perspective view projected onto the page.

The reasons we have adopted this specific model for the photon will become evident as we proceed.

III. The Initial Electron Model

Since we are using the photon described above as the building block for our model, the wavefront velocity is $v_{wf} = c\sqrt{2} = 4.239705600007665e + 08 \; m/S$.
The Compton frequency of the particle will remain fixed as in the Compton frequency of the photon so that for the electron $E = \hbar f$. We preserve the Compton frequency f_c here so that the electron can interface directly to spacetime around it with no frequency corrections.
So based upon the velocity v_{wf} defined above, which is the same velocity for that wavefront in the constituent photon, we calculate the corrected Compton wavelength for the wavefront of the confined photon. The result provides for a new wavelength λ_{cc} such that $\lambda_{cc} = \frac{v_{wf}}{f_c}$. The confined photon travels in a closed loop with a radius equal to $R_{oc} = \frac{\lambda_{cc}}{4\pi}$.

So we can write:

$$\lambda_{cc} = \frac{v_{wf}}{f_c} = 3.4313208208095\text{e} - 12\text{m} \tag{2}$$

$$R_{oc} = \frac{\lambda_{cc}}{4\pi} = 2.73055834982988\text{E-}13\text{m} \tag{3}$$

As in [1] the constituent photon fields (for the electron) are oriented so that the positive electric field is always toward the center of radius R_{oc} and the positive magnetic field is always perpendicular to this and pointing 'up' with respect to the plane of rotation. (In the positron the negative portion of the electric field always toward the center.) A simplified illustration in *Figure 5* shows the orientation of simplified field lines for the positive electric field in blue and the negative electric field in red.

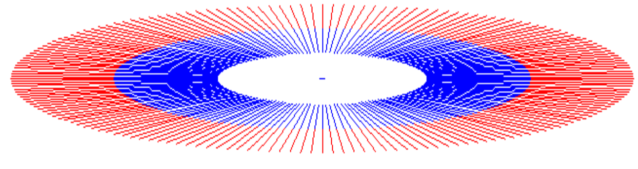


Figure 4

Please note that in this simplified illustration *Figure 5* of the twisted ribbon model in *Figure 1* we cannot see that the photon travels twice around the model in one Compton wavelength.
We will see why the photon is not a smooth charge ribbon as depicted here and that there are sinusoidal components, at least in part because the Compton frequency and wavelength would become meaningless without those artifacts.

We can get a better idea of the nature of the sinusoid by considering the electrical properties of the model. We suggest that the elementary charge is a topologically generated artifact of this ½ integral spin model. To meet the spin requirements, and to complete the λ_{cc} wavelength sinusoid, the photon must make two revolutions to create the full electrically related phenomenon including electric charge. This is a very important issue regarding the topologically generated charge. In order to create the elementary charge the photon must circulate twice around the model.

So from a simple electrical engineering view of the electron we can write the following:

Current $I = e\, f_c$	Amperes	19.7963 A	(4)
Power $W = me\, f_c$	Joules of energy times revolutions/S	10,115,904.58 W	(5)
Volts $V = W\, I$	Energy of the electron in EV	0.51099891 MeV	(6)
Inductance $L = \frac{V \frac{1}{f_C}}{I}$	Inductance in Henrys	2.08910778959e-16 H	(7)
Capacitance $C = \frac{e}{V}$	Capacitance in Farads	3.1353815693e-25 F	(8)
Resistance $R = \frac{V}{I}$	Resistance in Ohms	25.813K Ohms	(9)

Resonant Frequency $F = \frac{1}{\sqrt{L\, C}} = f_c = 1.235589972903622e + 20$ (10)

Resonant frequency of the electron = Compton's frequency.

These are simple equations commonly used in electrical engineering, but they give us some valuable insight into the electron and its properties.
The inductance and capacitance values allow us to electrically model an electron equivalent circuit. At resonance the phase relationship between the electrical and magnetic portions of the wave are 90 degrees apart, with the magnetic portion in advance of the electrical portion. Considering the radius, R_{oc} which is the circulation at Zitterbewegung frequency which is twice the Compton frequency, we can clearly see that in the electron model the magnetic and electrical portions of the wave are therefore 180 degrees apart.
These simple engineering equations prove interesting for other reasons as well. For example the computed resistance of our model is equal to the value known as the Quantum Hall Effect.

Additionally we can write:

Momentum	1.0545717e-34	$L = m_e R_{oc}\, v = \hbar\,.$	(11)
Magnetic Flux Quantum	2.0678337e-15 Wb	$\Phi_0 = m_{EV}\, \frac{1}{2f_c}\,.$	(12)
Josephson's constant	4.83597883E+14 Hz/V	$K_J = \frac{1}{\Phi_0}\,.$	(13)

At this point we have created a preliminary model for the electron which already displays many of the detectible properties of the physical electron. After we have addressed the issues of electrical charge generation and magnetic moment we will revisit this model to assure proper accuracy.

IV. Spin

While most of the electron parameters are calculated, spin can be directly measured. The model discussed will exhibit ½ integral spin characteristics about the Z-axis because the full Compton wavelength photon must circulate twice around the model to complete its trajectory and its wave shape. Therefore the photon must traverse the radius through 720 degrees before returning to its original state. This ½ integral spin property is another indication that there must be a sinusoidal component of Compton's wavelength superimposed on the transport radius. Due to the dimensional nature of the circulating fields it is likely the spin ½ property would be evident from all directions.

V. The Creation of Apparent Charge

Here we will discuss the topologically generated charge that this model creates. We will use the same approach used in [1] by analyzing the fields present and comparing those fields to a fictitious elementary charge at the center of rotation.
As in equation (3) our initial radius for charge computation is R_{oc}. If we place our fictitious elementary charge at the center and calculate the resultant field strength at our radius we arrive at:

$$E_1 = \frac{e}{4\pi\varepsilon_0 {R_{oc}}^2} = 1.935784732452970e + 16 \tag{14}$$

When we calculate the field strength of our confined photon using the velocity *v* from our equation (1) the computation yields:

$$E_2 = \sqrt{\frac{6hv}{\pi\varepsilon_0\, {\lambda_{cc}}^4}} = 2.090737505209621e + 16 \tag{15}$$

Then we compare the results to e:

$$q_1 = 4\pi\varepsilon_0 R_{oc} E_1 = 1.602176565E - 19 = e \quad (16)$$

$$q_2 = 4\pi\varepsilon_0 R_{oc} E_2 = 1.730425175e - 19 \quad (17)$$

So our initial apparent charge is very close to, but slightly higher than, the elementary charge:

$$\Delta q = \frac{q_2}{e} = 1.08004649\% \ . \quad (18)$$

We will revisit charge later, to show how the exact value for the elementary charge is created by the model.

VI. Magnetic Moment

Initial calculation of magnetic moment for this model obtains:

$$U_d = \frac{e\, v_{wf}\, R_{oc}}{2} = -9.2740096E - 24 \quad (21)$$

Which is almost exactly the value for the Bohr magneton.

However, for an electron, the measured spin magnetic moment is $U_e =$ -9.28476412E-24.

We will look at the possibility that the effective radius for generating the magnetic field and resultant magnetic moment R_{om} may be very slightly larger than the computed transport radius R_{oc}. We find that the radius $R_{om} = R_{oc}\ multiplied\ by\ (1.00159520996)$ which is within about 0.01% of the value of $\frac{\alpha}{2\pi}$ is the actual effective radius for the magnetic components that will yield an electron magnetic moment of precisely $U_e =$ -9.28476412e-24.

$$U_e = \frac{e\, v_{wf}\, R_{om}}{2} = \text{-9.28476412e-24.} \quad (22)$$

Here, in equation (22) the divide by 2 term, is simply due to the fact that the photon must circulate twice about the radius to generate the elementary electric charge.

We are visiting these issues of effective charge radius and effective magnetic moment radius to be better prepared when we address the specific model topology and sinusoidal components in later sections.

VII. Confining the Photon

In the section "The Initial Electron Model" we discussed the phase relationship between the magnetic and the electric portions of the confined photon. Since we have a circulation frequency which is twice the frequency of the photon, and a 90 degree phase shift at the Compton wavelength, in the model we will see a 180 degree phase shift around the transport radius, between the magnetic and electric portions of the fields. We know the energy in the magnetic portion is half the energy in the confined photon, and similarly the energy in the electric portion is also half the energy of the confined photon.

Due to the magnetic energy being 180 degrees out of phase with the electric energy, we can envision a model for the electric and magnetic fields. In the first look at this we will assume that the photon is one Compton wavelength at the adjusted velocity, and the electric field amplitude will be drawn as the 2 times the wavelength divided by π. We will look first at the resultant electric fields.

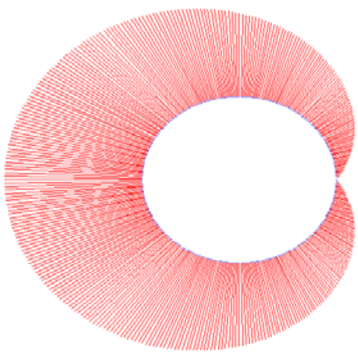


Figure 5

The negative half of the electric field would resemble the image in *Figure 6.* The negative portion of the field is drawn in red. R_{oc} Is the Compton wavelength divided by 4π.

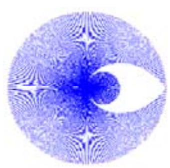


Figure 6

The positive half of the field looks like Figure 7, with the positive electric field drawn in blue.

Note: The shape depicted in *Figure 7* is important because a small portion of the field lines near the center are moving in the opposite direction while they rotate, reducing the effectiveness of the field in generating apparent electric charge.

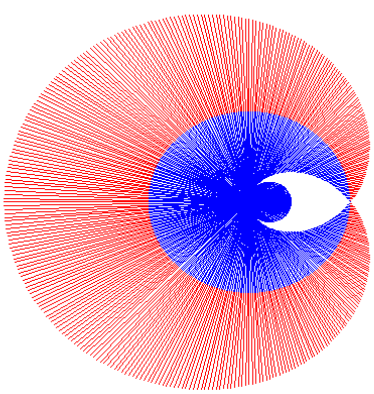


Figure 7

So that the full, closed loop, one wavelength composite of these two images would look like *Figure 8*.

Note: The strange shape of the blue portion is simply the sine function of the field wave modified by the radius R_{oc}. With this topology the negative portion of the E field is always toward the outside of the electron.

Note: The full composite waveform rotates at velocity v_{wf} about the radius R_{oc}.

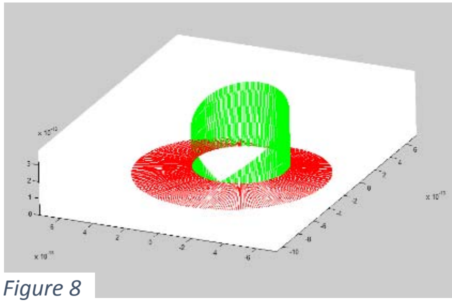
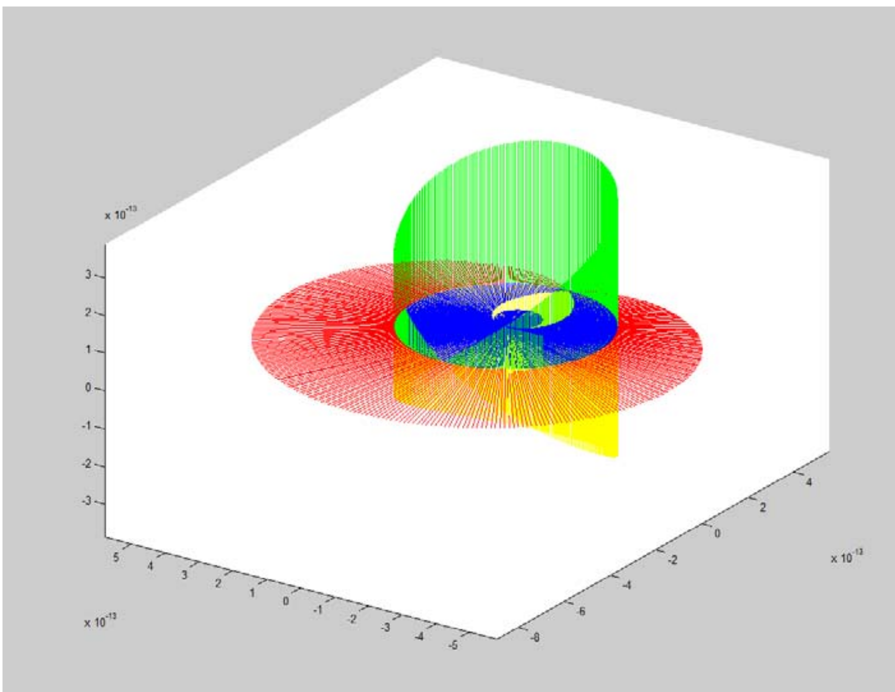


Figure 8

Figure 9 illustrates the negative portion of the electric field of the confined photon and the relationships between electric and magnetic fields when we add the magnetic field lines with a 180 degree phase shift, perpendicular to the electric field lines. The positive magnetic field lines are shown in green.

Figure 10 illustrates the composite electric and magnetic field lines of one full Compton wavelength structure wrapped around R_{oc}. Of the many possible structure configurations, this one is chosen to markedly illustrate the wavelength in the model.



The energy in the EM fields in this configuration remains constant due to the rotation of the entire composite set of fields around its radius.

Figure 9

The full composite waveform rotates as a unit so the energy remains constant. The electrical properties of the electron clearly indicate the presence of a phase shift between the E and M fields and the value of 180 degrees in the ½ integral spin configuration with $R_{oc} = \frac{\lambda_{cc}}{4\pi}$.

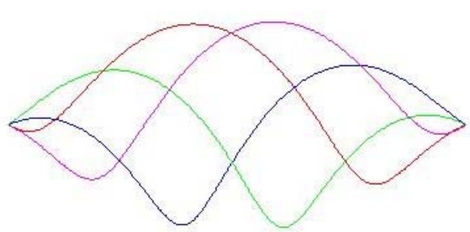
So we have a model for the EM wave structure of the electron which has equal and opposite electric and magnetic components on opposite sides of the model diameter 2 R_{oc}. For simplicity it can be argued that these equal and opposite E and M fields would attract each other and form a natural confinement for the photon in this model. Especially since these fields are fully evolved to their spatial extents at maxima removing most of the task of computing propagation times for the attractive force between them. But let’s check this assumption before we proceed.

VIII. Understanding EM confinement forces

For this confinement force study we ignore Maxwell's equations and use simple geometric models and momentum to find field forces for the photon. Returning to first principals here, to see if there needs to be an extension to our understanding of Maxwell's equations at the particle level, and to help derive another means to make such corrections if necessary. We use the photon to understand and derive the forces that are present in the EM wave of the photon, to demonstrate that sufficient confinement forces for the electron model presented exist in nature.

a. Forces inside photons

We don't generally think about the forces inside a photon. But a photon has momentum and spin, as well as E and M fields, so there are likely a set of balanced forces which preserve the integrity of the photon. These forces would serve as a quantization mechanism. To model the reaction of spacetime to electromagnetic fields we need to be able to express the fields geometrically in units of length, and we need to be able to convert these length units to energy, and eventually force. The expression E=hf, energy in joules equals Planck's constant times frequency, can give us some insight into a solution which allows us to express the fields in units of distance. Photon topology and geometry can be generalized by understanding that a spin one photon will make one revolution about the longitudinal axis in one wavelength. This requires an angle θ of helical rotation at 45°. So that the ***dimensional*** RMS value of the total field may be estimated using the expression $r_p = \frac{\lambda}{2\pi}$. Where $\lambda = wavelength = \frac{E}{h}$. So in this photon model, the photon helix is moving forward at the velocity c and spinning about the longitudinal axis at radius r_p at the velocity c. The wavefront velocity internal to the photon is therefore $\frac{1}{\cos(\theta)}$ c which is equivalent to the velocity $\sqrt{2}$ c.



If we calculate the 'centripetal' force from momentum, that is to say, separate the longitudinal momentum and the angular momentum components of the photon, and then calculate the centripetal force of the angular momentum component, we can know the twisting force or photon spin force, and therefore find the total forces for the photon EM fields. The twist will lead us again to E=hf.

The twist force must act against EM wave momentum to cause the helix topology described above. Since the angle of rotation θ is 45°, the angular force will be the twist force at r_p. Then the twisting force times $\sqrt{2} = \frac{1}{\cos(\theta)}$ will yield the total photon mutual EM field force. In this manner we can create expressions which allow us to relate the mutual force between the fields to spatial dimensions.

First let us find the momentum L that the twist force must act against:

$$L = \frac{h}{\lambda} \quad (25)$$

Now let us calculate the twist force required:

$$F_{tw} = \frac{L\,c}{r_p} \quad (26)$$

Total mutual force F_{tp} between E and M fields is then $\frac{1}{\cos(\theta)} F_{tw} = \sqrt{2}\, F_{tw}$.

Radius rp is the action distance for this field force F_{tp}.

Due to the spatial distribution of the fields and the fact they are perpendicular, there will be an RMS value for rp. These are not point charges or infinitely small fields so the action distance will not be zero but will be rp. In our analysis the field vector units are chosen so that we can represent them in the geometry of the photon. The values are an RMS approximation expressed in units of distance. Therefore the RMS action distance for the photon would be:

$r_p = \frac{\lambda}{2\pi}$ Where $\lambda = wavelength = \frac{E}{h}$

b. Confinement force for the electron

In the electron model, preserving the wavefront velocity $\sqrt{2}$ c, the action distance for the force would then be found as follows: We will set the energy in this gamma photon to the electron energy.

$E =$ 8.18710478684500E-14J

$E = hf$ and $\lambda = wavelength = \frac{E}{h}$ so the frequency of the confined photon is:

$f =$ 1.23558997290369E+20Hz

And the wavelength at c is: $\lambda =$ 2.42631022082086E-12m

So the helical radius of the photon is: $r_p = \frac{\lambda}{2\pi} =$ 3.86159265118028E-13m

And the electron transport radius: $r_e = \sqrt{2}\,\frac{\lambda}{4\pi} =$ 2.73055834982987E-13m

Since the electron is a spin ½ particle, this r_e electron transport radius, is a smaller action distance than that of the photon r_p. If we assume that the total mutual force follows the inverse square rule, which seems reasonable, we can estimate the E and M confinement forces for the electron model by using the ratio of the square of the photon radius over the square of the electron radius: $\frac{{r_p}^2}{{r_e}^2}$

$F_E = \frac{F_{tp}}{2}\frac{{r_p}^2}{{r_e}^2}$ And $F_m = \frac{F_{tp}}{2}\frac{{r_p}^2}{{r_e}^2}$. Where F_E is the electrical contribution to the force, and F_m is the magnetic contribution.

When simplified, this expression shows that the **total mutual confinement force** of the electron F_{te} is:

$$F_{te} = 2F_{tp} = 0.59966525068799 \text{ Kg} \tag{27}$$

Then we find the **required confinement force** F_{ce} for the electron model using the photon angular momentum L at the velocity $\sqrt{2}\,c$.

Preserving wavefront velocity $\sqrt{2}c$, the momentum for the confined photon in the electron model is:

$$L = \sqrt{2}\,\frac{h}{\lambda} = 3.86211004218299\text{E-22} \tag{28}$$

So the **binding force required** is: $F_{ce} = \frac{L\sqrt{2}\,c}{r_e} = \frac{m_e\,{v_{wf}}^2}{r_e} = 0.59966525068799$ (28)

Which equals the calculated confinement force providing a stable balance of forces.

In this brief exercise, starting by simply calculating the forces required in a photon to satisfy spin and momentum, we have found an EM field binding force for the electron at rest, which exactly equals the required binding force.

c. Relativistic treatment for binding force

To begin, we will substitute an updated version of the relativistic energy for the electron $E = \gamma mc^2$ where γ is the result of the updated Lorentz equation: This new Lorentz equation is based on the wavefront velocity we found in the section "The Photon Model" and is clearly an implied velocity with any spin 1 photon model.

$\gamma = \frac{1}{\sqrt{1-\left(\frac{v^2}{{v_{wf}}^2}\right)}}$ Where v is the particle velocity and v_{wf} is the wavefront velocity.

$$E_e = \gamma mc^2 \tag{32}$$

Then we will compute a Compton frequency for the electron: $f = \frac{E_e}{h}$

Next we find the resultant wavelength: $\lambda_e = \frac{v_{wf}}{f}$ (33)

Then we find the transport radius: $r_e = \frac{\lambda_e}{4\pi}$ which is for the spin ½ electron. (34)

The electron momentum is then: $L_e = \frac{\sqrt{2}\, h}{\lambda_e}$ (35)

Now we model a photon with the same energy and compute the photon forces:

The photon frequency is: $f_p = \frac{E_e}{h}$ and wavelength is: $\lambda_p = \frac{c}{f_p}$ (36)

We find the photon radius: $r_p = \frac{\lambda_p}{2\pi}$ (37)

And we find the photon longitudinal momentum: $L_p = \frac{h}{\lambda_p}$ (38)

Now we are ready to calculate the photon force at the photon radius: $F_p = \sqrt{2}\, \frac{L_p\, c}{r_p}$ (39)

So for a photon with energy E_e which is the relativistic energy of our confined photon, F_p is the total EM force at the photon radius.

Let us now calculate the **binding force** for the relativistic electron at the electron transport radius:

$$F_e = F_p \frac{{r_p}^2}{{r_e}^2} \quad (40)$$

We can now calculate the required force to bind and confine the photon:

The electron momentum is found by finding the total momentum of the photon which is:

$$L_t = \sqrt{2}\, \frac{h}{\lambda_p} \quad (41)$$

The required total EM field force for confinement at the electron radius is therefore:

$$F_b = \sqrt{2}\, \frac{L_t v_{wf}}{r_e} \quad (42)$$

And we find that: $F_e = F_p \frac{{r_p}^2}{{r_e}^2} = \sqrt{2}\, \frac{L_t v_{wf}}{r_e} = F_b$ (43)

Which provides for balanced confinement forces from rest up to just less than the velocity c.

The modified Lorentz factor $\gamma = \frac{1}{\sqrt{1 - \left(\frac{v^2}{{v_{wf}}^2}\right)}}$ is apparently only valid for the internal terms in the spin ½ particle, due to the change in configuration of the EM wave in the confined photon. The values above are internal to the electron. This appears to be the only instance where

$\gamma = \frac{1}{\sqrt{1-\left(\frac{v^2}{v_{wf}{}^2}\right)}}$ Must be used instead of the conventional $\gamma = \frac{1}{\sqrt{1-\left(\frac{v^2}{c^2}\right)}}$.

As we have seen, for instances of transformation external to the particle, the speed of light is a limit, and the conventional transformation holds.

IX. The Resultant Model

a. Exploring the Fine Structure Constant

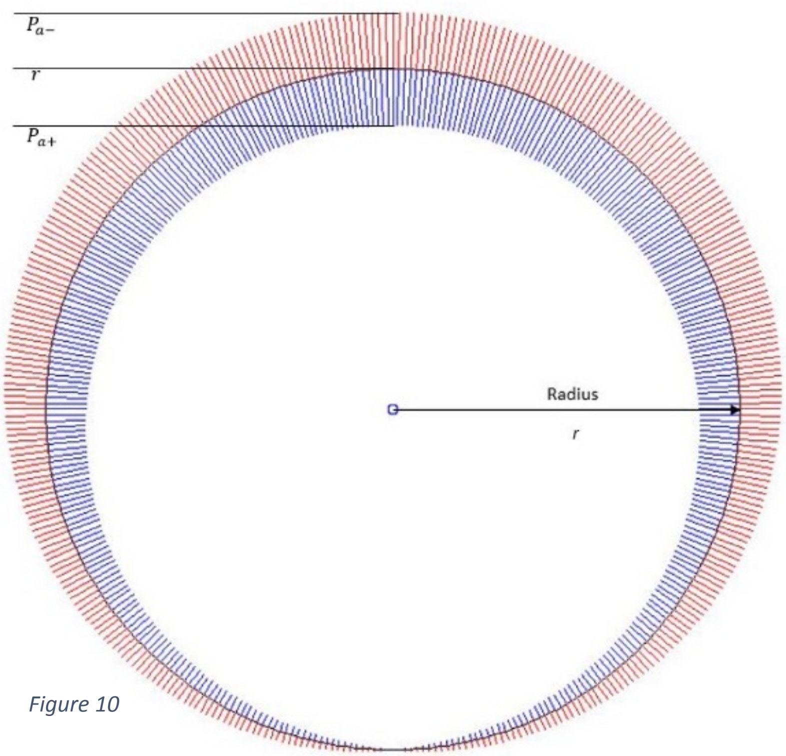


Figure 10

The illustration in Figure 11 is for the purpose of defining a sinusoidal component which is responsible for the fine structure constant and the magnetic moment anomaly of the electron. It is not to be confused with the actual model illustrations for the electron in Figures 6 through 10 above.

Before proceeding with a description of the proposed model, some explanatory foundation is required.
The fine structure constant α is an interesting observable artifact. We can now begin to propose a geometric cause for the fine structure constant.
If you start with a simple circle and superimpose a sine wave, with a wavelength equal to two times the circumference of the circle, as in *Figure 11,* and then measure the relationship between the area of the sine wave outside the radius and the area of the sine wave inside the radius you can begin to see some very interesting relationships. Our example, in *Figure 11,* assumes the negative portion of the sine wave is outside the radius. In this configuration the sine wave component is distorted by the curvature of the radius it traverses, making the positive half of the wave smaller in area than the negative half.

In our example illustrated in *Figure 11* we will compare the superimposed sinusoidal component's amplitude P_a to the radius r.

The peak amplitude of the sinusoidal component for this example will be set to:

$$P_a = r * 0.0011596521807404 \quad (44)$$

Therefore the displacement from center for the peak of the negative (red) portion of the wave is:

$$P_{a-} = P_a + (P_a * r) = r * 1.00115965218074 \quad (45)$$

And the displacement from center for the peak of the positive (blue) portion of the wave is:

$$P_{a+} = P_a - (P_a * r) = r * 0.99884034781926 \quad (46)$$

In one half wavelength the sine wave is of course defined by π radians but the area the wave occupies is distorted by the curvature of the radius. So to compute a factor for this distortion for both the negative and positive portions of the wave we write:

$$D_{a-} = \pi - (\pi * P_{a-}) = \underline{\mathbf{0.007290534335842920} \approx \alpha} \quad (47)$$

$$D_{a+} = \pi + (\pi * P_{a+}) = 0.007282084751091490 \quad (48)$$

Comparing the distortions of the negative and the positive portions, we obtain:

$$D_t = 2\left(\frac{D_{a-} - D_{a+}}{D_{a-} + D_{a+}}\right) = \underline{\mathbf{0.0011596521807135}} \approx \left(\frac{U_e}{U_b} - 1.0\right) \quad (49)$$

In this simple exercise, we have found reasonable first order approximations for both the *magnetic moment anomaly* of the electron, and the *fine structure constant* ,just by exploring the sinusoidal waveform when distorted by the curvature of a circular path that is one half of the wavelength. In this electron model the negative portion of the wave is the external exposed portion. The value for the area relationship of this portion of the wave D_{a-} is within 0.094% the value of α, the fine structure constant.

The value of $D_t = 0.0011596521807135$ which explores the difference in area of the negative and positive portions of the wave is within 0.000000001421763% of the measured value for the magnetic moment anomaly.

Arriving at the values for these two otherwise puzzling, elusive, and well known parameters from a simple first order planar model is a strong indication that the topology for the model is evolving along the correct path to eventually accurately reflect the actual physical principles which create and govern the electron.

This exercise causes us to consider that there may need to be a modification to our understanding of EM wave behavior at the subatomic scale. It may prove useful to explore the possible topological causes for the subtle imposition of sinusoidal functions on the EM waves within particles.

b. Constructing the Electron Model – the next step

By following the steps we have addressed so far, we have gathered sufficient information to propose an improved model of the electron as a confined photon.

We will discuss a model which has an effective transport radius with the value of $\mathrm{R_{oc}}$.

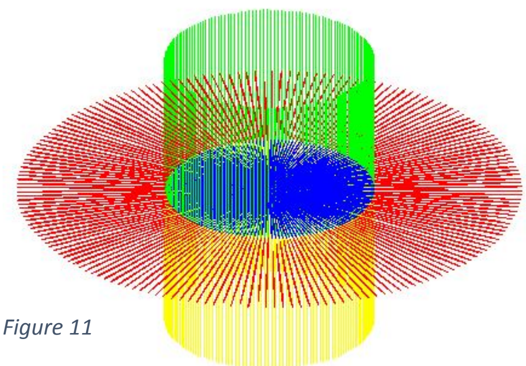


Figure 11

Our confined photon circulates this radius at the same velocity it has in the unconfined photon which is the velocity $v_{wf} = c\sqrt{2}$. The wavelength of the confined photon is $\lambda_{cc} = \frac{v_{wf}}{f_c}$.

So if we could take a snapshot of this electron model, with a shutter speed of $2/f_c$ seconds (the time it takes the wavefront to travel around $\mathrm{R_{oc}}$ twice) we would see a completely circular model: as illustrated in *Figure 12*.

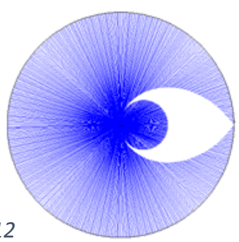


Figure 12

Another intrinsic sinusoidal component is already in the model which causes the mean radius of the electric field $\mathrm{R_{oe}}$ to appear *larger* than the transport radius $\mathrm{R_{oc}}$. A first order approximation of the derivation of that artifact follows:

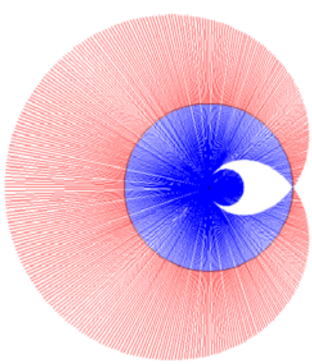


Figure 13

In the section "Confining the Photon" we presented illustrations (*Figures 6, 7 and 8*) for the electric field lines of the confined photon. Let us look now at the implications of *Figure 7*. *Figure 13* shown here is similar except there is a small black dot at the center of rotation. The small principally circular form just to the right of the center dot is an area where the field lines are the reverse of the major portion of the field lines due to rotation about the center (black dot), such that ***the field direction is reversed for this small feature,*** since the positive end of the lines in this feature are pointing away from the center. In all other portions of the trajectory the positive end of the field lines point toward the center. This is a wave interference phenomenon and will reduce the efficiency of the field lines in creating apparent electric charge. When we compare the sum of the magnitudes of the reversed portions of the field lines to the sum of the magnitudes of all field lines we have:

$$Correction = \frac{S_{fl}}{S_{fl}-S_{rfl}} = 1.082102222033963\% \qquad (50)$$

This 1.082102222033963% is a first approximation of the effect, but still gets us within about 0.002% of the required Efficiency correction 1.08004649% calculated in formula (18). We will therefore study this issue further. This will also have the effect of shifting the effective electrical field radius outwards making it larger. So within this one artifact of reverse (interfering) fields, we have found a mechanism which makes the apparent magnetic radius larger, and the electric field efficiency smaller, which is exactly the requirement for the correct charge and magnetic moment of the electron.

c. Constructing the Model – a proposed solution

A version of the model can now be created which principally accommodates the measured electric charge and magnetic moment for the electron.

In simulation we found the effective mutual charge radius for the E and M fields R_{oe} is 2.733724710523004E-13m which is slightly larger than the transport radius R_{oc}, as is anticipated above discussing *Figure 13*.

When we consider that the fields are affected by the efficiency reduction in the electric field due to internal wave interference, we can understand that we will arrive at a new, larger effective electromagnetic field radius. $R_{oe} = 2.733724710523004\text{E} - 13\text{m}$ Using this radius our topologically generated charge is 1.602176565e-19C which is *the exact value for the elementary charge.*

The corrected model's magnetic moment is 9.28476376999241e-24 after first order corrections for the changes in field efficiency and radius. ***This value is also accurate to within 12 significant digits of the measured magnetic moment of the electron.***

The physical transport radius R_{oc}, for this electron model is 2.730558349828513e-13m, the ratio of the two radii is 1.001159601916102, which is of course very close to the CODATA value for the electron magnetic moment anomaly 1.00115965218073. Our magnetic moment is however exactly that of the experimentally measured magnetic moment of the electron and this radius difference is simply caused by the effective EM radius being slightly larger than the transport radius due to internal wave interference (cancellation).

In the section on "Modeling the Photon" we took the liberty to express field magnitudes in units of distance, to aid in the construction of an understandable geometric model. The confinement radius of the electron is smaller than the photon radius, which gives us an *increased energy density* in the electron, which in turn confines the electric field more than we see in the photon. So that the peak amplitude A_p , expressed in units of distance, for the photon is 5.46111669965974E-13m, while, due to *increased energy density, and therefore increased field confinement*, the peak amplitude A_e for the electron, expressed in similar units is 3.919522693345939e-13m.

In this exercise so far, we have found that *confined photon EM self-interference* may clearly explain the fine structure, the electron magnetic moment anomaly, and the value for the elementary charge.

The possibility then arises that all spin ½ particles will therefore have "confined photon EM self-interference" at their center of rotation, due to the required geometry of the confined photon and the balance of forces at the confinement radius.

Prior to this causal study, QED was the only known theory to explain the electron magnetic moment with such precision. But QED does not explain all of the properties of the electron that this model addresses.

Computing the effect the small interference region near the center, has on the model:

First we find an interference correction factor: $C_f = 1 + \left(\left(\frac{A_e - \mathrm{R_{OC}}}{\mathrm{R_{OC}}}\right)^2 \left(\frac{A_e - \mathrm{R_{OC}}}{\mathrm{R_{OC}}}\right)\right)$

The total charge is then: $q_t = \left(\frac{1}{2\pi}\right)\sqrt{3\varepsilon_0 \hbar v_{wf}}$

And the effective charge is: $q_e = \frac{q_t}{C_f}$

This geometric model displays the correct value for electric charge, and the correct value for the magnetic moment of the electron.

X. De Broglie Wavelength

The confined photon has been transformed from a free helical photon with electric and magnetic fields principally in phase, to a planar monochromatic wave structure circulating at approximately twice the Compton frequency with the electric and magnetic fields about 180 degrees out of phase at this frequency. However due to conservation of energy and momentum it still displays the same Compton frequency in its planar sinusoidal from as it circulates the double loop. In order to derive the de Broglie wavelength we principally follow the same steps as in "The Charged-Photon Model of the Electron, the de Broglie Wavelength, and a New Interpretation of Quantum Mechanics" (Richard Gauthier)[13].

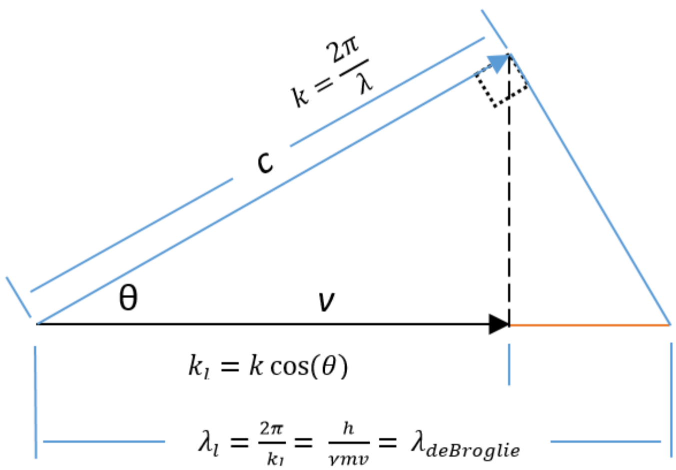
The relativistic energy for the electron as a confined photon is of course $E = \gamma mc^2$ where γ the Lorentz transformation is: $\gamma = \frac{1}{\sqrt{1-\left(\frac{v^2}{c^2}\right)}}$ where *v* is the particle velocity and *c* is the speed of light.

For the photon, $E = hf$. Therefore the associated frequency for the confined photon in the electron is: $hf = \gamma mc^2$ or $f = \frac{\gamma mc^2}{h}$. The wavelength associated with this frequency is $\lambda =$

$\frac{h}{\gamma mc}$. Therefore the wavenumber for the photon is $k = \frac{2\pi}{\lambda}$. The photon's rotation about the electron confinement radius makes an angle θ with the perpendicular longitudinal motion of the electron such that $\cos(\theta) = \frac{v}{c}$. The confined planar photon's wave vector has a longitudinal component in the direction of travel of the electron $k_l = k\cos(\theta)$ and the resultant longitudinal wavelength associated with k_l is therefore:

$$\lambda_l = \frac{2\pi}{k_l} = \frac{h}{\gamma mv} = \lambda_{deBroglie}. \tag{51}$$

See *Figure 15*.



Note: In the section "Relativity" we address issues which may cause us to have to recalculate a few of the conventional assumed values we use for relativistic transformations and this might yield slightly different results for values of the de Broglie wavelength, mass increase at relativistic speeds, and a few others.

Figure 14

XI. Point Like Behavior at High Energies

Since $E = hf$ the frequency of our model at 10TeV is 2.418E+27Hz which yields a wavelength λ = 1.2398E-19m, and therefore a radius $r = \frac{\lambda}{4\pi}$ is 9.866E-21m, which is in agreement with experimental results at 10TeV setting the calculated upper limit for the radius of the electron at $r < 2.0\text{E} - 20$.

XII. Relativity

If particles are made up of EM waves which principally obey the known properties of EM radiation, it is reasonable to assume the relativistic transformations will be a natural consequence of the propagation of these waves inside of particles.

We have introduced a maximum velocity for the wavefront in a helical photon $v_{wf} = c\sqrt{2}$. This value may have some implications regarding relativistic velocity transformations. If there is not another limiting set of principles at work, the new longitudinal relativistic transformation internal to the particle would become:

$$\gamma = \frac{1}{\sqrt{1-\left(\frac{v^2}{{v_{wf}}^2}\right)}} \tag{52}$$

The possible implication is that some types of particles with near zero rest mass may be able to travel slightly faster than *c*, (*neutrinos may be examples of slightly faster than c particles*) and that with a tremendous expense in acceleration energy, small spin ½ mass carrying particles might be able to travel slightly faster than *c*.

However it is also possible that the microscopic properties of EM waves, forces, and spacetime at these scales work to prevent θ, from ever becoming greater than 45 degrees.

$$\cos(\theta) = \frac{v}{v_{wf}} \tag{53}$$

Which is analogous to the formula $\cos(\theta) = \frac{v}{c}$ in the section "de Broglie Wavelength".

XIII. Possible Transport of a Photon at Faster than Light Speed

The distance across this electron model at rest is $2\mathrm{R_{oe}}$. The time it takes light to travel this distance is $t = \frac{c}{2\mathrm{R_{oe}}}$. The time it takes to traverse ½ the circumference at v_{wf} is $\frac{v_{wf}}{\pi \mathrm{R_{oe}}}$ which allows for a maximum possible transport speed of a photon across this electron model at rest about 11.07% faster than light. So this electron model does not shed much light on FTL quantum tunneling unless the velocity of the Coulomb field plays a role in the transport of a photon through a barrier in quantum tunneling.

XIV. Inertial Mass

We normally only see inertial rest mass in spin ½ particles. Which indicates there is something about the topology which engenders the inertial mass property.

In the section on "Confining the Photon" we assumed the model at rest has a mass of m_e which is of course the measured mass of the electron. Then we computed the binding force which balances the centripetal force that the measured mass of the electron would generate at the transport radius and velocity of rotation.

Inertial mass is a property that requires force be applied, in order to accelerate the particle which is to say that energy must be applied or added to a particle. This applied energy does several things. For non-relativistic particle velocities two important items are affected: Application of energy increases the energy in the EM wave, and the applied energy changes the circular propagation of the confined photon, elongating the circle in the Z axis (the direction of motion), which changes the planar circle into a helical trajectory. Once these changes are made to the particle the electron will remain in this configuration – due to conservation of energy and momentum, and due to the velocity limit v_{wf} – until the added energy is removed by applying an equal and opposite force thereby removing energy from the particle.

From the section "Understanding EM confinement forces", we have observed the EM wave structure in this electron model has the capability to exhibit forces equal to the binding force required for the mass of the electron spinning at velocity v_{wf} at the radius $\mathrm{R_{oe}}$. Clearly, from the speed of light, spacetime imposes a limit on the velocity of the free, unbound, linearly propagating photon. From the perspective of this treatise, this speed limit *c* imposed by spacetime on the free photon is one of the foundations which allow the spin ½ model presented here to display the property of inertial mass. The velocity of the wavefronts in the confined photon for the model presented here are limited to v_{wf} , for reasons explained by equation (1), and v_{wf} *is deemed to be a hard limit imposed by spacetime, for the wavefront propagation velocity vector of any EM wave in the vacuum*.

For several reasons, including the experimental behavior of accelerated electrons in magnetic fields, the electron model presented here can only be accelerated in the +/- Z axis, and the electron will, quite quickly, upon acceleration, orient itself with the Z axis principally parallel to the direction of motion. In most circumstances the force required to orient the electron's Z-axis parallel to the direction of travel is insignificant, for the free electron. Since the balance of forces will attempt to keep the distance between the E and M fields constant, and therefore the shape of the electron in the local XY plane principally circular, force applied in any direction on the local XY plane will immediately cause the electron to rotate so that the Z axis is aligned with that force. This rotation requires very little energy as it does not require any significant change to the distance between fields.

Since the photon is already in a closed confined path, and already moving at the maximum allowable velocity, the only thing which can allow movement of the electron, is to change the trajectory of the photon in the confined path. However the confined photon will strongly resist this change, and any movement of the electron, because the photon is already moving at its confined limit, and held at that limit by equal and opposite forces, of an amazing magnitude for the electron, about $0.599665250688026\mathrm{Kg}$. That is 1.322036 pounds of force, confining a particle which is only 5.46E-13m in diameter at rest. Just to illustrate the "solidity" of the electron, let's look at the ratio of the electron's mass to confinement force. The ratio is an astounding 6.582940656021913e+29 to 1.

The wavefront velocity must remain fixed at all times, so that due to the balance of forces, the **only** way to change the electron's trajectory is to change the energy in the EM wave, allowing a helical path with a longitudinal component. Which causes a smaller radius. The smaller radius offsets the increased dimensional changes of the longitudinal motion component at the new energy level. Therefore there are topological, geometric and force changes, with acceleration, which naturally produce a balance of internal forces for the electron. Here we speak of topology being the overall shape of the electron, circular or helical when in motion, and geometry being the distances between fields or features.

Due to the rigidity or stiffness of the of the electron EM wave topology, brought about by such large forces, any external force applied, to accelerate the electron, results in geometry changes, and energy changes in the EM field required to maintain internal force balance. So we can see that, in principal, you must add energy (which adds mass) to the EM wave in electron in order to cause acceleration. Due to the conservation of energy and momentum, the electron will retain that full configuration, until acted upon by another force. These behaviors are exactly what is required for inertial mass.
The energy in the EM wave is **directly changed** by the application of an accelerating force. The **only** way we have of interacting with this particle is through fields incident upon the particle. So **any acceleration forces are applied directly to the EM wave** which makes up our confined photon. All of the energy of the electron is contained in this EM wave. The confined wave harvests the acceleration energy from an incident wave or field, and adds that energy to the existing confined wave energy to cause acceleration. This changes the circular planar rotation into a helix, which is propagating through space, instead of remaining in a stationary circular pattern.

The amount of energy required to perform this change from circular at rest and accelerate an electron to 0.2 c is 9.66356634304671E-15 Joules. Due to the balanced forces and fixed velocity of the EM wavefront in the electron model, if you add 9.66356634304671E-15 Joules of energy to the EM wave the electron model will become a helix configuration moving at 0.2c. Given the natural constraints, the only way to accelerate the model is to add energy to the EM wave. We cannot "stretch" the geometry, because the ratio of the internal force to the mass or momentum of the electron is so great that the confining balanced forces will always dominate.

The small area of wave interference discussed in the section "Constructing the Electron Model – the next step" and illustrated in *Figure 14*, plays a role in the stabilized transport radius of the electron at all velocities. As the velocity increases and the wavelength of the electron changes, so does the interference area. This changes the field efficiency and causes the model to slightly adjust the transport radius due to the slightly less efficient E field, which again results in a balance of forces in the model. We have established in simulations, that the energy required to accelerate the electron model, is the energy we calculate for accelerating an object with the mass of the electron. This indicates inherent inertial mass in this, and probably all, spin ½ particles.

We will now calculate, using some simple first order approximations, the force required for accelerating the confined photon electron model:

We will start with Newton's famous $F = ma$ where *F* = force, *m* = mass and *a* = acceleration, and will use this mass term in the instantaneous sense during our analysis. This is done because, as we apply force, adding energy, we increase the energy in the electron increasing the mass of the electron, so the mass term will evolve with acceleration. Using the Lorentz equation

$$\gamma = \frac{1}{\sqrt{1 - \left(\frac{v^2}{c^2}\right)}}$$

Such that $m_r = m_e \, \gamma$ where m_r is the relativistic mass of the electron and m_e is the electron rest mass.

We must do work to accelerate the particle, so we update the equation $F = m \, a$ to $F = m_r \, a$ as one step in providing the correct relationship between accelerating force, and the resultant acceleration. However acceleration must also be subject to a relativistic transformation for us to eventually arrive at the correct value for the work required. The conventional formula for the acceleration "boost" transform is $a' = a \, \gamma^3$. So our force formula becomes $F = m_r a \gamma^3$.

Work is equivalent to energy used, and our work equation is simply $E = F \, D$ where E is work or energy consumed, F is force, and D is distance.

For our model we have already established that $E_e = \gamma mc^2$.

If we start from 0.01 *c* and accelerate our electron to 0.02 *c* we increase the energy in our particle from 8.18751417278854E-14J, the relativistic energy of the electron at 0.01 *c* to, 8.18874269919246E-14J the relativistic energy of the electron at 0.02 *c,* according to the formulae $E_e = \gamma mc^2$ and $\gamma = \frac{1}{\sqrt{1 - \left(\frac{v^2}{c^2}\right)}}$.

This is an energy increase of 1.22852640391951E-17J.

Using the same example, starting from 0.01 *c* and accelerating our electron to 0.02 c, requires a force of $F = m_r a \gamma^3 =$ 2.73133389035729E-24N through a distance of 4497111.7425m, or work (energy) of 1.22831137108838E-17J.

So, based on simple first order approximations, and without a full integration of the relativistic treatment, the force required to accelerate our electron with inherent inertial mass, from 0.01 *c* to 0.02 *c* is 0.0175% higher than expected. But this simple exercise clearly illustrates the ability of a spin ½ particle built from a confined EM wave, to contain its own inherent property of inertial mass.

XV. List of Predicted Properties for this Electron Model

a. Spin of ½ ħ, Up or Down
b. Zitterbewegung of the electron
c. Heisenberg uncertainty
d. Exact Electron Magnetic Moment
e. Exact Elementary charge
f. The de Broglie wavelength for the electron
g. Point-like behavior in high energy scattering experiments
h. Relativistic behavior
i. A topological derivation of the fine structure constant
j. A derivation of the electron magnetic moment anomaly
k. Prediction of the electron's antiparticle the positron.
l. Prediction of inherent inertial mass

XVI. The Coulomb Field and its Velocity – Non Locality and Pilot Waves

Particles exhibit wavelike properties, implied herein by the waves that constitute the particles. But that is not the whole story. There still seems to be a "pilot wave" for particles which has not yet been discussed here. Experimental evidence suggests that the Coulomb field itself propagates much faster than *c* and much faster than our wavefront velocity. One such experiment is reported in "Measuring Propagation Speed of Coulomb Fields" [7]. One possible explanation is that the Coulomb field is actually propagating very quickly. This does not necessarily violate Relativity because information transfer may not be possible using this phenomenon. Let us suppose for a moment that this experimental data and the data presented in "Bounding the speed of 'spooky action at a distance'" [6] are due principally to the same cause, the velocity of the Coulomb field. If that is the case then we might be able to detect a 'pilot' wave nature for waves which contain an electric field or EM waves -- and non-locality may be simply due to the particles affected being almost perfectly 'in phase' and therefore susceptible to influences from this superluminal coulomb field.

XVII. Implications

This model implies that "there are no charges, there are only fields". If this approach is correct it will have many implications for understanding the physical foundations which caused the principle of Relativity and it will offer a valuable basis for understanding the quantum nature of matter. It is evident that if matter is made of EM waves that mater will exhibit a quantum nature based on the harmonic resonances, and balanced forces, in these small confined, resonant waveforms. Also evident is the principle that the velocity limit for the motion of the wavefronts, and therefore the velocity limit for propagation of light, will cause relativistic effects.

The basic approach presented here implies also that there are at least localized preferred rest frames in spacetime, and that there may be a larger *preferred rest frame for spacetime*. If localized rest frames are a valid part of spacetime, it is assumed that mass contributes to frame dragging creating these localized preferred rest frames.

The model may predict some very slight differences for de Broglie frequency and some other subtle changes. We will continue searching for testable differences predicted by the model so that the theory may be tested.

The model explores the property of inherent inertial mass, without the need for the Higgs mechanism to generate mass for spin ½ particles. It is again the Occam's razor argument. It seems a simplified and accurate method for explaining inherent inertial mass in spin ½ particles would be preferred.

Note: The model of the electron discussed so far is postulated because, among other things, it illustrates a means for a confined photon in a spin ½ particle to become electrically charged. There are of course other models which could accomplish at least this criteria. One such possible model is a complex torus with the photon traveling a curved helical path within the boundaries of the torus. The cross section of the complex torus could be similar to *Figure 16*.

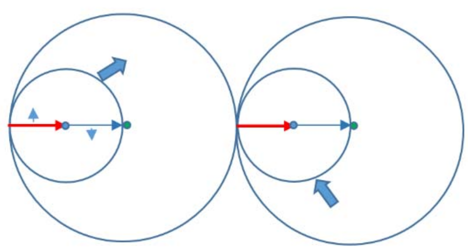


Figure 15

The large circles represent the torus and the extent of the photons curved helix. The photon is like a free linearly propagating photon except that confinement imposes an additional helical motion and a circular motion around the electron's radius. The mean radius of photon circulation in the electron is the green dot, the photon's normal rotation is about the blue dot.

The negative end of the photon's E field is always toward the circumference of the major torus. This would expose a negative field to all points outside the torus. This topology would also make the spin ½ property very clearly apparent from all directions. Confinement has not been verified for such a model, nor have the parameters for radius of the torus, or the frequency of the helical motion of the photon inside the torus. More exploration for this topology is in order.

This complex torus model does not yet appear as capable of explaining the fine structure, magnetic moment anomaly, the balance of forces, and perhaps a few other details. As mentioned, this topology does however, offer another explanation of how an uncharged photon could become a charged photon for creating the electron.

XVIII. Conclusion

We have used simple principles to present a causal model for the electron, which displays the known properties of the electron. Over the many years of research regarding the electron, the author has reviewed and studied in detail many electron models, some are cited in this article. Those models have not been able to accurately model the electron with all of its basic established properties. Presented here is a confinement force sufficient to confine the electron, a cause for the fine structure, a cause for the magnetic moment anomaly, a cause for the elementary charge, and a cause for inertial mass. We are not aware of any other topological model for the electron which complies with or comparably explains all these principles and properties.

Along the way we have discovered artifacts of this proposed model which work together to naturally explain the observed properties of the electron. We did not expect to find simple EM sinusoidal solutions for the fine structure constant and the electron magnetic moment anomaly, but discovered some plausible explanations during the endeavor. We found an EM wave interference region near the center of the model which helps to explain the fine structure constant, the exact value of the elementary charge, the electron magnetic moment anomaly, the apparent difference in the transport and magnetic moment radii and a cause for that apparent difference.

We also found that by simply analyzing the spin force of the photon against the photon momentum, we can define a confinement force, allowing a photon to be confined, to make an electron.

Natural development of Relativity and quantum behavior remains a compelling part of an EM wave approach.

Understanding the electron in a causal, topological manner, allows us to understand the foundations upon which QM is built. It can help us to improve and refine QM so that we understand the constraints. We can remove the ambiguities, infinities, and singularities from our theories when we have a basis upon which to build.

XIX. Future Work

This scalar view of the electron as a confined photon needs a full treatment at the vector and tensor levels. The formulation of all aspects will probably require a full Clifford algebra, similar to $C\ell(1, 3)$ [25,26].

Creating models of nucleons or their constituents, from confined photons is a natural step in the evolution of this work.

Also, as mentioned, for the electron at rest, the electric field model explored so far is planar, however there is evidence that a free electron, away from fields, will have a tendency to tumble due to the small remnant of spin force which will likely be present after photon confinement. This will cause the free electron to appear spherical and similarly would make the free electron appear to have no magnetic moment.

There are also arguments which may support a model with the photon confined in a toroidal boundary, instead of planar, which we will explore in at another time.

XX. Acknowledgements

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This work is built upon a foundation of work of so many preceding authors with some additional components. The most important of those predecessors begin Einstein, Bohr, Dirac, de Broglie, Compton, Bohm, Maxwell, and Schrodinger, and more recent works from Hestenes, John Williamson, Martin van der Mark, and Richard Gauthier.

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[27] Robinson, VNE "A Proposal for the Structure and Properties of the Electron"

Notes:

1) We arrive at this angle 45˚ by using a simple derivation which allows us to graphically represent the field vectors in units which coincide with the dimensions of the model. Since the wave circulates around the helix once in one wavelength, we know it travels one wavelength around the circumference while traveling one wavelength longitudinally. This leads us to graphically representing the field amplitude vectors in units which correspond to the spatial dimensions of the photon and electron. It also appears that the actual RMS radius values of the field vectors fit mechanically into these models and match the units chosen in this manner.

2) We know from the Standard Model that there are wave solutions for particles. We now can begin to understand the causal details. John Williamson [25] and Niels Gresnigt [26] have proposed new Clifford algebras for advancing and extending our understanding of field equations beyond Maxwell's equations. Their work also allows us to begin to understand the Pauli Exclusion Principle, the cause of spin, and the foundations of quantization. Too many clues indicate the validity of this line of work for us to ignore this avenue of research. The section on "Understanding EM confinement forces" provides an indication that such work is required for fully defining wave confinement in fermions.

3) Many of the illustrations used above are simplified versions to make the concepts easier to see and understand. Included here are more accurate illustrations, showing the full wavelength of the photon wrapped around the electron radius, as it would be in this model. In the following illustrations the negative end of the E field is red and the positive end is blue. The magnetic fields are drawn in green and yellow. The black lines are the effective envelope extents for the confined photon E fields and the resultant magnetic fields (Figures 17 through 19). Figure 20 is the confined photon, removed and drawn flat, showing the result of the wave interference at the center of the electron, on the effective field of the photon.

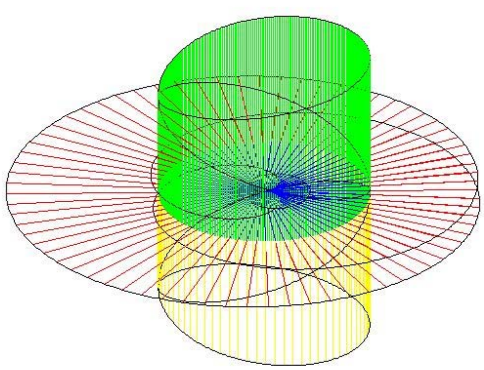

Figure 17

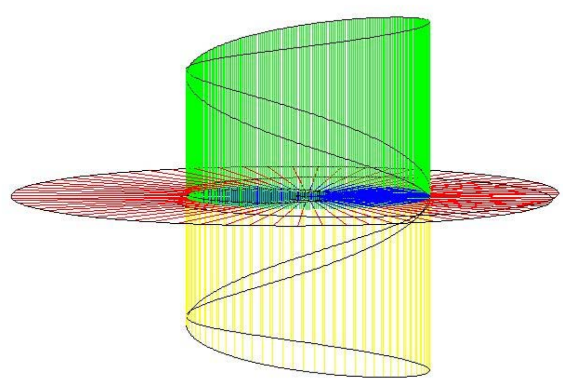

Figure 16

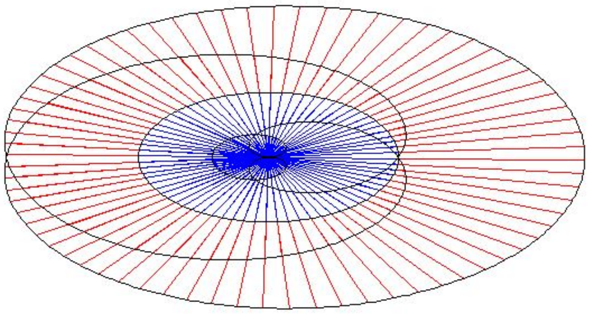

Figure 19

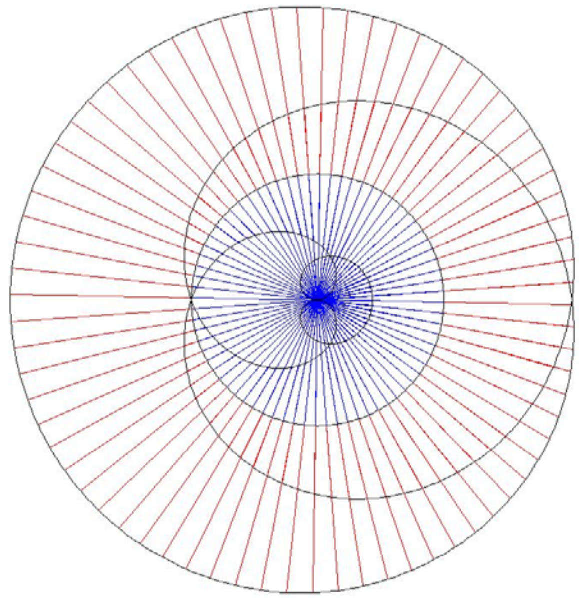

Figure 18

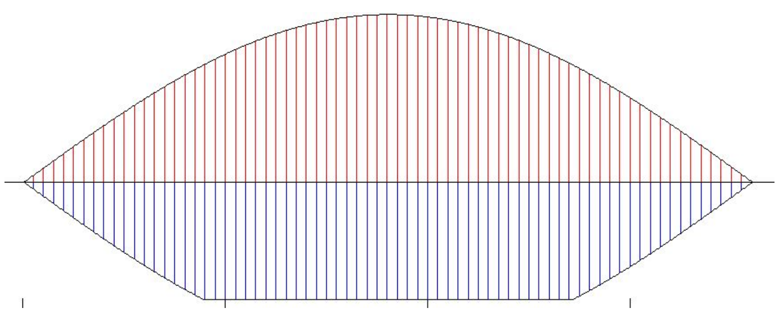

Figure 20