The electron as a slowed down wave

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Abstract

This paper is based on the creative work done by Niels Bohr and other physicists which gave a lot of information based on experiments and analysis and became the key for a lot of later studies.

Some of the questions regarding wave particle duality, electron structure and shape which are still awaiting precise answers will be discussed in this paper by studying some of the electron's parameters specially within its mass and at its outer surface utilizing the results of some famous experiments like Compton effect, pair production experiment, Larmor precession and some of the undisputed laws in physics like Coulomb's law … etc.

I will show how Compton wave generates electrons and how waves and electrons are quantized into the same elementary particles (which I named phosons).

One of the main findings of this paper is that even waves are quantizes into photons, it is further quantized into smaller elementary particles (phosons) which will help in concluding the electron's shape, structure, and wave behavior.

I will show that the electron has a helical shape with a radius (r_e) and a double of its radius length, the electron length is proportional to its speed such that when it is slowed down, it becomes shorter and vasa versa when accelerated it elongates unit it restores its full original wave shape and properties at the speed of light.

The phoson's charge and mass will be defined and the actual meaning of self-electrostatic charge and energy will be explained.

Many of the electron's parameters will be derived like the spin angular velocity, spin angular momentum, spin angular magnetic moment, magnetic field and flux, internal current, inductance, voltage, impedance, electric field etc..

I will use the electric field at the electron's surface with the produced magnetic field to show how electrons act as electromagnetic waves with calculating its electromagnetic energy density, wave pressure and pointing vector.

I will show how the electron's voltage, internal current and the free space impedance makes an equivalent circuit which has a direct relation with its inductance.

De Broglie's theory will be discussed to show that it is a pure description of the electron's rotational motion around the nucleus assuming that Bohr's orbit circumference length is the wavelength to describe the electron's wave behavior, this will be shown to be not accurate and the actual wave behavior will be explained.

Finally, by the end of this paper, the reader will note that most of the electron's derived formulas and related parameters can be expressed in terms of Compton wavelength and frequency because of its nature of construction leaving no doubt that the electron's mass is just a slowed down Compton wave.

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1.0 Quantization and Electron Generation

• Electrons and Waves are Quantized into the Same Elementary Particles (Electron Generation)

My phoson theory is based on a postulate that light consist of discrete identical mass particles which I named phosons and that beams of light waves consist of streams of phosons' rays, figure 1.1.

Each wave cycle is occupied by one phoson and all phosons carry the same amount of energy, the distance between any two successive phosons in the direction of wave flow is the wavelength and in the transverse direction is intensity dependent.

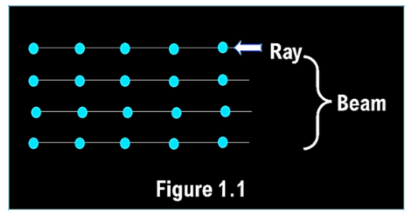

Figure 1.1

Figure 1.2 introduces the idea of this theory, if the incident wave has a wavelength and frequency (λ_i) and (f_i) respectively and the scattered wave has a wavelength and frequency (λ_s) and (f_s) respectively, then the number of phosons involved in generating a new electron is (f_c) where (f_c) is the difference between the aforementioned frequencies

$$f_c = \Delta f = f_i - f_s$$

Each wave cycle represents one energy unit, and the total energy of the incident wave is divided between the scattered wave and the generated electron.

This implies that the incident wave should have a minimum frequency (energy units) of f_c (hf_c= 510,998.95eV) to generate an electron.

In **Compton's effect** experiment, the difference in wavelength ($\Delta\lambda$) varies with the scattering angle θ according to the equation:

$$\lambda_s - \lambda_i = \frac{h}{m.c}(1 - \cos\theta)$$

The maximum ($\Delta\lambda$) happens at ($\theta = 90^o$) where the electron is not only scattered but also generated, in this case ($\cos\ \theta = 0$) and equation the above equation reduces to

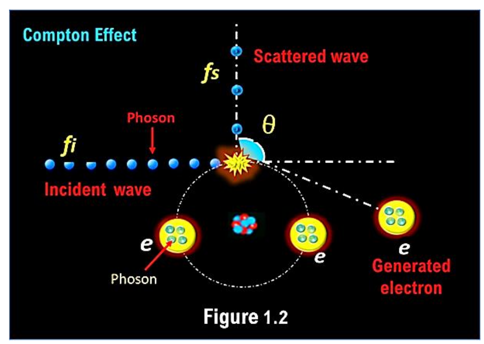

Figure 1.2

$$\lambda_c = \lambda_f - \lambda_i = \frac{h}{m.c} = 2.426310 \times 10^{-12} m$$

The related frequency is

$$f_c = \frac{c}{\lambda_c} = \frac{m.c^2}{h} = \quad 1.23559 \times 10^{20} s^{-1}$$

Considering that each cycle of the wave is occupied by one phoson with energy (h) (joule. s), Then the wave's frequency difference (f_c) is the number of missing (h) energy units from the scattered wave compared with the incident wave which were involved in the electron's generation.

Accordingly, the summation of (f_c) number of (h) energy units represents the accumulated energy units involved in forming the electron's rest energy

$$E = f_c . h = m_e . c^2 \quad 1.1$$

Where (m_e) is the electron's rest mass, (E) is its rest energy and also the energy of the frequency difference (f_c) which was lost from the scattered wave and gained by the electron.

Since the product of this process is an electron, and each energy unit have a mass (m_{ph}) , then the electron's mass is the accumulated phosons' masses

$$m_e = m_{ph} . f_c \quad 1.2$$

$$m_{ph} = \frac{m_e}{f_c} = 7.372497 \times 10^{-51} \text{ (kg. s)} \quad 1.3$$

Also, we conclude from equation 1.3 that

$$h = \frac{m_e}{f_c} . c^2 = m_{ph} . c^2 \quad 1.4$$

from the above we conclude that waves and electrons are composed of same elementary particles with mass (m_{ph}) in $(Kg. s)$ and energy (h) in ($J. s$) .

Any other type of particles like protons, neutrons, quarks … etc. should be composed of same elementary particles as long as it can emit and absorb waves.

In general we can say that matter and waves are composed of the same elementary particles which are the phosons .

The phoson's mass is very small to be measured but when phosons gather as photons or electrons, it becomes easier to measure if the frequency (number of phoson) is known.

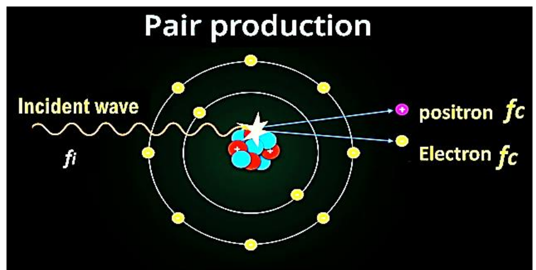

Figure 1.3

In the **pair production** experiment, it was found that the minimum energy of the incident frequency to produce an electron and a positron is 1.022 x 10^6 eV which corresponds to a wavelength 1.2132 x10^{-12} m and a frequency 2.47118 x 10^{20} s^{-1}.

It is obvious that the energy and frequency in the pair production experiment are double those of Compton effect and the wavelength is half Compton wavelength.

Double Compton frequency means double the number of phosons, and two particles of equal mass are generated.

2.0 Electron Structure

• Introduction

Self-electrostatic energy is defined as the energy required to assemble an amount of charge q into a sphere of radius r by bringing charge segments (∂q) from infinity and is used to calculate the classical electron radius where r is the electron radius.

After some assumptions and derivations, it was found that the required self-electrostatic energy in terms of the electron's radius and its self-electrostatic charge to assemble the electron charge is

$$U = \frac{1}{4\pi\epsilon_o}\frac{3}{5}\frac{q^2}{r} \qquad 2.1$$

Because of being a special case of a uniform charge density, the factor ($\frac{3}{5}$) was ignored to set the equation to (U = mc²) . Even the resulted equation is correct but achieved using a poor derivation and a selective choice. In this paper, I will identify the actual meaning of self-electrostatic energy and charge using a different approach.

In his hydrogen atom model, Bohr considered the electron as a point charged particle rotating around the nucleus in a circular orbit of radius (r_b) (figure 2.1.a).

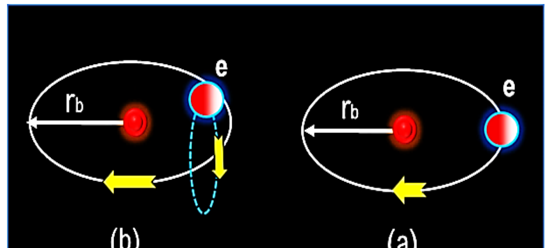

Figure 2-1

The electron experiences two equal and opposite forces during its motion around the nucleus, an electrical centripetal force towards the nucleus and a centrifugal force pushing outwards

$$F = \frac{1}{4\pi\epsilon_o}\frac{q^2}{{r_b}^2} = \frac{mv^2}{r_b} \qquad 2.1$$

Substituting the speed of the electron ($v = \alpha c$) (α is the fine structure constant)

$$\alpha^2(m.c^2) = \frac{1}{4\pi\epsilon_o}\frac{q^2}{r_b} \qquad 2.2$$

Substituting the electron radius (r_e) for Bohr radius (r_b) where ($r_e = \alpha^2 r_b$) in equation 2.2 we get

$$(m.c^2) = \frac{1}{4\pi\epsilon_o}\frac{q^2}{r_e} \qquad 2.3$$

Equation 2.2 gives the potential energy against a force exerted by the nucleus and equation 2.3 gives the electron potential energy against a force exerted by a charge at a distance (r_e) , dividing equation 2.3 by the electron radius we get

$$\frac{mc^2}{r_e} = \frac{1}{4\pi\epsilon_o}\frac{q^2}{r_e^2} \qquad 2.4$$

Equation 2.4 shows that there is a force between the electron as a point charge and an imaginary charge at a distance (r_e) , or simply, equation 2.3, and 2.4 are not just a mathematical substitution but expressing an actual and equivalent force of another type which should be investigated .

The electron as a point particle cannot have a radius, but it can if it has a circular shape, or if it is moving as a point particle in a circular path other than the one around the nucleus.

The above gives a good reason to assume that the electron is a point particle rotating around a transverse orbit with radius (r_e) where its orbit around the nucleus acts as the axis of the transverse orbit (figure 2.1.b). Compton frequency (the number of phosons composing the electron) can be found from equation 2.4 as

$$m.c^2 = hf_c = \frac{1}{4\pi\epsilon_o}\frac{q^2}{r_e} \qquad 2.5$$

$$f_c = \frac{1}{4\pi\epsilon_o}\frac{q^2}{r_e h} \quad 2.6$$

Also, it can be found from the equation used to define the fine structure constant as

$$\alpha = \frac{1}{4\pi\epsilon_o}\frac{q^2}{\hbar c}$$

$$\frac{\alpha\hbar c}{r_e} = \frac{1}{4\pi\epsilon_0}.\frac{q^2}{r_e} \quad 2.7$$

$$\frac{ch}{2\pi\alpha^{-1}r_e} = hf_c = \frac{1}{4\pi\epsilon_0}.\frac{q^2}{r_e}$$

$$f_c = \frac{c}{2\pi\alpha^{-1}r_e} = \frac{c}{\lambda_c} \quad 2.8$$

• How Waves Generate Electrons.

When an incident wave of wavelength (λ_c) passes near to the nucleus of an atom (Figure 2.2), a slowdown of the wave will make the phosons gain charge and bend its route to circular loops in the presence of an external magnetic field produced by the nucleus. If some of the phoson's translational energy is maintained, phosons start to move in a helical path forming together the electron's mass where the phosons' speed of light is divided into two components, one in the transverse direction making the phosons spin around the electron's axis and the other is translational around the nucleus.

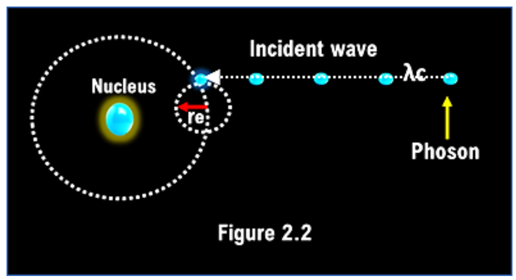

Figure 2.2

The magnetic field is required just to trigger the process, when the first phoson starts to move in a circular path, it produces a magnetic field which will work as an external magnetic field exserted on the next phoson to make it follow the helical path.

Each phoson adds its magnetic field to the previous rotating phosons until the electron's mass is formed. The conditions to make this process happen is the presence of a magnetic field in the starting stage when the wave is slowed down to make it become charged.

Phosons have a very small and very fast varying charge which does not interact with magnetic fields and does not show charge properties as a steady charge, but it can be affected by the nucleus magnetic field if it is prevented from varying for a short time which gives the chance to start the electron generation process.

Each (λ_c) of the involved photon makes circular loops with radius r_e such that the loop circumference is ($2\pi r_e = \alpha\lambda_c$) indicating that each wavelength (λ_c) makes ($\alpha^{-1} \approx 137$) loops causing an increase of α^{-1} in the phosons' angular velocity in the transverse orbit compared to the incident wave angular frequency.

$$\omega_c = 2\pi f_c \quad 2.9$$

Where (ω_c) is Compton's wave angular frequency and

$$c = \lambda_c f_c$$

$$c = (\alpha^{-1}2\pi r_e)f_c = \alpha^{-1}(2\pi f_c)r_e = \alpha^{-1}\omega_c r_e$$

$$c = (2\pi\alpha^{-1}f_c).r_e = \omega_s.r_e$$

$$\omega_s = \alpha^{-1}\omega_c \quad 2.10$$

$$f_s = \alpha^{-1}f_c \quad 2.11$$

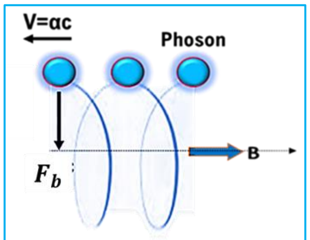

Figure 2.3

(ω_s) is the electron's rotational spin angular velocity and (f_s) is the spinning frequency.

The magnetic field exerts a centripetal force (F_b) on the phosons in their helical path (figure 2.3), causing the phosons to move in circular loops with keeping some of its translational velocity.

Electron's formation happen if a force works against the wave's motion causing the wave's slowdown and compresses it to take a helical shape.

The compression force will set the phosons' to rotate in orbits of radius (r_e), increase the wave frequency and angular velocity accompanied with a reduction in each phoson's translational speed around the nucleus with maintaining the phoson's speed of light in the helical path, this process can be seen as an electron generation or simply as slowing down a wave of wavelength (λ_c) to form an electron.

Compressing the wave against its orbital motion will not change the phoson's spin energy around the electron's axis because a tangential speed equal to c is maintained and the radius of rotation adjusts itself to maintain the relation ($c = \omega_s r_e$) but the reduced translational kinetic energy of each phoson is converted into intrinsic spin energy of the phosons around its own axis which makes the phosons start to have charge.

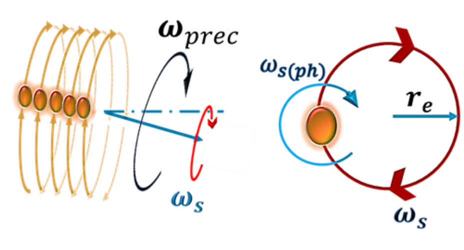

Figure 4.2

The spin energy of the phosons group (the electron) around the electron axis is ($\frac{mc^2}{2}$) where each phoson carries ($\frac{h}{2}$) of this energy.

If the phosons' translational energy is reduced form ($\frac{h}{2}$) to ($\alpha^2\frac{h}{2}$) then its intrinsic spin energy increases to $(1-\alpha^2)\frac{h}{2}$. Referring to figure 2.4, the above can be expressed as:

(Phoson's total kinetic energy equals to its translational kinetic energy plus its intrinsic spin kinetic energy plus its spin kinetic energy around the electron axis)

$$k_{t(ph)} = \alpha^2\frac{h}{2} + (1-\alpha^2)\frac{h}{2} + \frac{h}{2} = h \quad 2.12$$

$$k_{t(ph)} = \frac{1}{2}m_{ph}\alpha^2c^2 + \frac{1}{2}I\omega_{s(ph)}^2 + \frac{1}{2}m_{ph}r_e^2\omega_s^2 = h$$

$$k_{t(ph)} = \frac{1}{2}m_{ph}\alpha^2c^2 + \frac{1}{2}m_{ph}r_{ph}^2\omega_{s(ph)}^2 + \frac{1}{2}m_{ph}r_e^2\omega_s^2 = h \quad 2.13$$

Where $r_{ph}^2\omega_{s(ph)}^2 = (1-\alpha^2)c^2$ and (I) is the phoson's moment of inertia.

Electron's total kinetic energy equals to the number of phosons (fc) multiplied by equation 2.13 or 2.14

$$K_{t(e)} = f_c k_{t(ph)} = f_c h = \alpha^2 f_c\frac{h}{2} + (1-\alpha^2)f_c\frac{h}{2} + \frac{f_c h}{2}$$

$$K_{t(e)} = mc^2 = f_c h = \frac{1}{2}\alpha^2 mc^2 + \frac{1}{2}(1-\alpha^2)mc^2 + \frac{1}{2}mc^2 \quad 2.14$$

Slowing down the wave to form an electron is actually converting its translational energy or part of it into intrinsic spin energy of the phosons. Accordingly the phoson's remaining translational kinetic energy plus the phoson's intrinsic spin kinetic energy is equal to its original translational kinetic energy

$$\frac{h}{2} = \alpha^2 \frac{h}{2} + (1-\alpha^2)\frac{h}{2}$$

$$\frac{1}{2}m_{ph}c^2 = \frac{1}{2}m_{ph}\alpha^2 c^2 + \frac{1}{2}m_{ph}(1-\alpha^2)c^2$$

$$\frac{1}{2}m_{ph}c^2 = \frac{1}{2}m_{ph}\alpha^2 c^2 + \frac{1}{2}m_{ph}v_t^2 \quad 2.15$$

Where $v_t = (1-\alpha^2)c^2 = r_{ph}^2\omega_{s(ph)}^2$ is the tangential speed of the phoson

$$\frac{1}{2}m_{ph}\alpha^2 c^2 = \frac{1}{2}m_{ph}c^2 - \frac{1}{2}m_{ph}v_t^2$$

$$\alpha^2 = 1 - \left(\frac{\frac{1}{2}m_{ph}v_t^2}{\frac{1}{2}m_{ph}c^2}\right) = 1 - \frac{k_s}{k_t}$$

Where (k_s) is the phoson's spinning kinetic energy and (k_t) is the phoson's translational kinetic energy before slowing down the electron.

$$\alpha = \sqrt{1 - \frac{k_s}{k_t}}$$

$$\alpha = \sqrt{1 - \frac{v_t^2}{c^2}} \quad 2.16$$

$$v = \alpha c$$

$$v = \left(\sqrt{1 - \frac{v_t^2}{c^2}}\right) c \quad 2.17$$

The tangential speed (v_t) represents the spin kinetic energy of each phoson which is equal to the reduction in translational kinetic energy due the wave's slowdown.

The relation between the electron's wavelength relative to Compton's wavelength and its tangential velocity which will be discussed later is

$$\lambda_e = \sqrt{1 - \frac{v_t^2}{c^2}}.\lambda_c \quad 2.18$$

By increasing the speed of the phosons, its intrinsic spin tangential velocity, spin angular velocity and spin kinetic energy reduce and its wavelength elongates until it restores its original length, shape and translational speed c, the gained translational kinetic energy is restored from the phosons' stored intrinsic spin kinetic energy i.e. the intrinsic spin kinetic energy works as a potential energy.

Accordingly, phosons have two types of spin, one intrinsic around its own axis which works as a storage of potential energy and the other is around the electron traverse orbit axis which is the electron's spin angular velocity.

Also, it should be noted that considering the electron as a point particle rotating around a traverse axis is equivalent to a group of identical (in mass and charge) phosons of the same total mass doing the same rotation in a helical cylindrical shaped route.

• Electron Spin Angular velocity

The spin angular velocity of the electron (group of phosons) which is equal to the spin velocity of each phoson around the electron's traverse axis can be found as

$$m.c^2 = m.{r_e}^2\omega_s^2 = \frac{1}{4\pi\epsilon_o}\frac{q^2}{r_e} \quad 2.19$$

$$\omega_s = \sqrt{\frac{1}{4\pi\epsilon_0}\frac{q^2}{m\,r_e^3}} = 1.064\,x10^{23}\,rad.s^{-1} \quad 2.21$$

Referring to equation 2.10 and equation 2.11,

$$\omega_s = \alpha^{-1}\omega_c = \left(2\pi\alpha^{-1}f_c\right) = 1.064\,x10^{23}\,rad.s^{-1} \quad 2.22$$

• Forces Acting on the Electron, Spin Angular Momentum and Spin Magnetic Moment

Figures 2.5 shows four forces acting on the electron. The electrical attraction force F_e by the nucleus opposed by the centrifugal force F_c of the electron mass

$$F_e = F_c$$

$$\frac{1}{4\pi\epsilon_o}.\frac{q^2}{{r_b}^2} = \frac{m.v^2}{r_b}$$

This equation can be used to find the electron's spin angular momentum

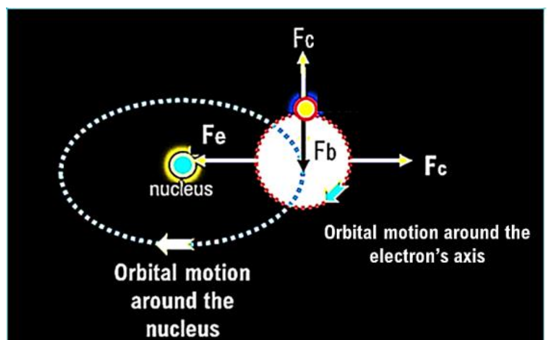

Figure 2.5

$$\frac{1}{4\pi\epsilon_o}\frac{q^2}{c} = m\,\alpha^2 c\,r_b$$

$$S = \frac{1}{4\pi\epsilon_o}\frac{q^2}{c} = m\,c\,r_e \quad 2.23$$

$$S = \frac{U\,r_e}{c} = \frac{\left(mc^2\right)r_e}{c} = \frac{mc^2}{\omega_s} = m\,c\,r_e$$

$$m\,c^2 = hf_c$$

$$S = \frac{hf_c}{\omega_s} = \frac{hf_c}{2\pi\alpha^{-1}f_c} = \frac{\alpha h}{2\pi} = \alpha\left(\frac{h}{2\pi}\right) = \alpha\hbar = \alpha L \quad 2.24$$

Where S is the spin angular momentum of the electron around its own axis and L is its orbital angular momentum around the nucleus. Another approach to derived S is

$$r_e = \frac{c}{\omega_s} = \frac{c}{2\pi\alpha^{-1} f_c} = \frac{ch}{2\pi\alpha^{-1} m.c^2}$$

$$S = r_e m\, c \ = \frac{ch}{2\pi\alpha^{-1} m.c^2}\, m\, c$$

$$S = \alpha\hbar = 7.695582 \times 10^{-37} kg.m^2.s^{-1} \qquad 2.25$$

Also, the spin angular momentum can be found form

$$S = I\omega_s = m\, {r_e}^2 (2\pi\alpha^{-1} f_c)$$

$$S = \ m\, r_e\, (r_e\, \omega_s)$$

$$S = m\, r_e\, c$$

The other two forces acting on the electron are the magnetic force F_b opposed by the centrifugal force F_c.

$$F_b = F_c$$

$$F_b = q(v \times B)$$

$$q\, c\, B = \frac{mc^2}{r_e}$$

Where $(v = c)$, then B can be calculated to be

$$B = \frac{m\, c}{q\, r_e} \qquad 2.26$$

$$B = 6.049 \times 10^{11}\ \text{T} \qquad 2.27$$

Where this formula for magnetic field B is the same of a cyclotron and is the total magnetic field produced by the electron's phosons. The magnetic field exerted on a phoson is working as an external field applied by all other phosons, Using Larmor precession equation we get

$$\omega_s = g\, \frac{q}{2m} B$$

If the g-factor for the electron is approximately equals to 2, then by substituting we get

$$\omega_s = \frac{(2)(1.60217662x10^{(-19)})(6.048615x10^{11})}{(2)\ (9.109383x10^{(-31)})}$$

$$\omega_s = 1.064\ x10^{23} rad.s^{-1} \qquad 2.28$$

This shows that Larmor precession velocity is equal to the spin angular velocity calculated earlier and confirms the value of the magnetic field.

The relation ($F_b = F_e = F_c$) can be used to derive Larmor's formula

$$B\ q\ c = \frac{1}{4\pi\epsilon_o}\frac{q^2}{{r_e}^2} = \frac{mc^2}{r_e}$$

$$B\ q\ c = \frac{1}{4\pi\epsilon_o}\frac{(2\pi\alpha^{-1})\,q^2}{\lambda_c.r_e}$$ using $(r_e = \frac{\lambda_c}{2\pi\alpha^{-1}})$

$$B\ q\ c = \frac{1}{4\pi\epsilon_o}\frac{(2\pi\alpha^{-1}f_c)}{\lambda_c f_c r_e}\ q^2$$ multiplying by $(\frac{f_c}{f_c})$

$$B.q.c = \frac{1}{4\pi\epsilon_o}\frac{q^2}{cr_e}\ \omega_s$$ using $(2\pi\alpha^{-1}f_c = \omega_s)$

$$B.q.c = (m\ c)\omega_s$$ using $(\frac{1}{4\pi\epsilon_o}\frac{q^2}{cr_e} = m\ c)$

$$B = \frac{m}{q}\ \omega_s$$

• Electron Spin Magnetic Moment

The angular spin momentum of the electron in its transverse orbit with radius r_e is

$$S = m\ c\ r_e$$

The spin magnetic moment ignoring the g factor is

$$\mu_s = \frac{q}{2m}S$$

$$\mu_s = 6.7676 \text{ x } 10^{-26}\ J.T^{-1} \qquad 2.29$$

Another method to calculate the spin magnetic moment is

$$\mu_s = IA$$

Where (I) is the current caused by the electron's rotation around the transverse orbit with area A and radius r_e

$$f_s = \alpha^{-1}f_c$$

$$I = qf_s = q\alpha^{-1}f_c$$

then $$\mu_s = \alpha^{-1}qf_c(\pi{r_e}^2) \qquad 2.30$$

$$\mu_s = 6.7676\ x\ 10^{-26}J.T^{-1} \qquad 2.31$$

Thus, the relation between the Spin magnetic moment and Bohr magneton μ_B can be found as

$$\mu_s = \frac{q}{2m}\alpha^{-1}f_c(\pi{r_e}^2)\ 2m$$ multiply equation 2.30 by $(\frac{2m}{2m})$

$$\mu_s = \frac{q}{2m}f_c(2\pi\alpha^{-1}r_e)r_e\ m$$

$$\mu_s = \frac{q}{2m} f_c\, \lambda_c r_e\, m$$

$$\mu_s = \frac{q}{2m} m\, c\, \alpha^2 r_b$$

$$\mu_s = \alpha\left(\frac{q}{2m} m\, \alpha\, c\, r_b\right)$$

$$\mu_s = \alpha\, \mu_B \qquad 2.32$$

The spin magnetic moment can be derived using the electron's volume as a solenoid which is typical to a cylinder

$$V = (2r_e)(\pi r_e^2)$$

$$\mu_s = IA = \frac{1}{\mu_o}(\mu_o I)(\pi r_e^2) = \frac{1}{\mu_o}(\frac{\mu_o I}{2r_e})(\pi r_e^2)(2r_e)$$

$$\mu_s = \frac{1}{\mu_o} B(AL)$$

$$\mu_s = \frac{1}{\mu_0} BV_{ol} \qquad 2.33$$

Magnetic field and electron volume in Equation 2.33 will be discussed later in this paper

• Relation Between Spin Angular velocity and Spin Magnetic Moment.

The relation between the precession speed which is equal to the spin angular velocity of the electron and its magnetic moment can be derived as

$$\mu_s = (\pi {r_e}^2)(q)(\frac{c}{2\pi r_e})$$

$$\mu_s = \frac{r_e q\, c}{2}$$

$$\mu_s = \frac{c}{\omega_s}\frac{qc}{2}$$

$$\mu_s = \frac{q.c^2}{2\omega_s}$$

$$qc^2 = 2\mu_s\, \omega_s \qquad 2.34$$

Energy formula can be derived from equation 2.34 as

$$c^2 q = 2\mu_s \omega_s$$

$$c^2 m = \frac{2\mu_s\, \omega_s\, m}{q}$$

$$mc^2 = \frac{2\mu_s\, c\;\, m}{r_e\, q} \qquad \text{using } \left(\frac{c\, m}{r_e q} = B\right)$$

$$U = mc^2 = 2\,\mu_s\,B \qquad 2.35$$

$$\mu_s B = \frac{mc^2}{2} \qquad 2.36$$

• Spin Magnetic Moment from Coulomb's Law

$$F = m\frac{c^2}{r_e} = \frac{1}{4\pi\epsilon_o}\frac{q^2}{r_e^2}$$

$$mc^2 r_e = m\frac{c^3}{\omega_s} = \frac{1}{4\pi\epsilon_o}q^2$$

$$\frac{c^2}{\omega_s} = \frac{1}{cm}.\frac{1}{4\pi\epsilon_o}q^2 \qquad 2.37$$

Substituting equation 2.37 in equation 2.34 we obtain

$$\mu_s = \frac{1}{2}q(\frac{1}{cm}\frac{1}{4\pi\epsilon_o}q^2)$$

$$\mu_s = \frac{1}{8\pi\epsilon_o}\frac{q^3}{mc} \qquad 2.38$$

$$\mu_s = \frac{\mu_o}{8\pi}\frac{q^3 c}{m} \qquad 2.39$$

$$\mu_s = \frac{q}{2m}\left(\frac{\mu_0}{4\pi}\,q^2 c\right) = \frac{q}{2m}\left(\frac{\mu_0}{4\pi}\,\frac{q^2 c\;\alpha^{-1} f_c}{\alpha^{-1} f_c}\right)$$

$$\mu_s = \frac{q}{2m}(\frac{\mu_o I}{2r_e})\frac{qcr_e}{2\pi\alpha^{-1}f_c} = \frac{q}{2m}B\frac{qcr_e}{\omega_s}$$

$$\mu_s = \frac{q}{2m}\frac{Bqcr_e}{\omega_s} = \frac{q}{2m}\left(\frac{Fr_e}{\omega_s}\right) = \frac{q}{2m}\left(\frac{mc^2}{\omega_s}\right) = \frac{q}{2m}\,\frac{U}{\omega_s}$$

$$\mu_s = \frac{q}{2m}\frac{U}{\omega_s} = \frac{q}{2m}\,S \qquad 2.40$$

Where the potential energy of the electron against the magnetic force which is equivalent to an electrostatic force by an equal and opposite charged particle at the electron's center is ($U_p = F.r_e = mc^2$).

• Relation Between L, μ_B, S, μ_s

From the previous discussion, a relation between Bohr's angular momentum, Bohr's magneton, spin angular momentum and spin magnetic moment can be derived staring with the potential energy derived from coulomb's law

$$\frac{1}{4\pi\epsilon_o}\frac{q^2}{r_e} = mc^2$$

$$\frac{1}{4\pi\epsilon_o} = \frac{c^2\mu_o}{4\pi}$$

$$\frac{c^2\mu_o}{4\pi}\frac{q^2}{r_e} = mc^2$$

$$S = \frac{c\mu_o}{4\pi}q^2 = mcr_e \qquad 2.41$$

$$S = \frac{q}{2}\frac{\mu_o}{2\pi c}(qc^2)$$

$$S = \frac{q}{2}\frac{\mu_o}{2\pi c}.2\mu_s\omega_s$$

$$S = (\frac{q\mu_o}{2\pi c})(\mu_s.\omega_s) \qquad 2.42$$

The term $\left(\frac{q\mu_o}{2\pi c}\right)$ in equation 2.42 can be found from S

$$S = \frac{1}{4\pi\epsilon_o}\frac{q^2}{c} = \frac{mc^2}{\omega_s}$$

$$\frac{q^2}{c}\frac{c^2\mu_o}{4\pi} = \frac{mc^2}{\omega_s}$$

$$\frac{q\mu_o}{2\pi c} = \frac{2m}{\omega_s q}$$

$$\frac{q\mu_o}{2\pi c} = \frac{\frac{h}{2\pi}}{\omega_s(\frac{q}{2m}\frac{h}{2\pi})}$$

$$\frac{q\mu_o}{2\pi c} = \frac{L}{\omega_s\mu_B} \qquad 2.43$$

Substituting equation 2.43 in equation 2.42 leads to

$$S = \frac{\mu_s}{\mu_B}.L$$

$$S.\mu_B = L.\mu_S \qquad 2.44$$

• Electron and Phoson charge and Current

Since the electron is composed of (f_c) phosons, and it takes its shape due to a magnetic force acting on the phosons as charge particles , then its charge is the division of the electron's charge by the number of phosons f_c composing the electron.

$$q_{ph} = \frac{q}{f_c} = 1.296689 \times 10^{-39} \text{ C. s} \qquad 2.45$$

Usually waves do not show any charge behavior and do not interact with magnetic fields due to the continuous varying small charge of the phosons, it gains its steady charge by holding a spinning energy when trapped and slowed down where part or all its translational energy is stored as intrinsic spinning

The current caused by one phoson's rotating around the electron's circumference is

$$i = \frac{q_{ph}}{t} = \frac{q}{f_c}\ \frac{c}{2\pi r_e}$$

$$i = q\,\frac{\lambda_c}{2\pi r_e} = \alpha^{-1} q \qquad \text{measured in } \frac{C.s}{s} \qquad 2.46$$

The total current caused by the rotation of all phosons around the electron axis is

$$I = Ni \quad \text{where} \quad N = f_c \ \ (s^{-1})$$

$$I = \alpha^{-1} f_c q \quad \text{measured in Amperes} \qquad 2.47$$

• Relation between Electrons and Phosons Momentums

The electrical attraction force acting on the electron by another equivalent positive charged particle positioned at its center is just another equivalent expression of the magnetic force generated by the magnetic field of the electron, a field generated by the phosons motion around the electron axis

$$\frac{1}{4\pi\epsilon_o}\ \frac{q^2}{r_e^2} = q.B.c = \frac{mc^2}{r_e} = 29.054 \text{ N} \qquad 2.48$$

Multiplying equation 2.48 by the electron radius gives the potential energy of the electron caused by being in the field of the magnetic force

$$r_e qBc = \frac{1}{4\pi\epsilon_0}\frac{q^2}{r_e} = mc^2 \qquad 2.49$$

The force acting on a phoson by the equivalent charge or the magnetic field is

$$\frac{1}{4\pi\epsilon_o}\ \frac{q_{ph}q}{r_e^2} = q_{ph}.B.c = \frac{m_{ph}c^2}{r_e} = \frac{h}{r_e} \qquad 2.50$$

Multiplying equation 2.50 by the electron radius gives the phoson's potential energy caused by being under the effect of the magnetic force and can be expressed as

$$\frac{1}{4\pi\epsilon_0}\frac{q_{ph}q}{r_e} = q_{ph}Bcr_e = m_{ph}c^2 = h \qquad 2.51$$

Accordingly, we can derive formulas for the phosons' angular momentum around the electron axis and its magnetic moment as

$$S_{ph} = m_{ph}\, c\, r_e = \frac{S}{f_c} \qquad 2.52$$

$$\mu_{ph} = \frac{q}{2m}\,(m_{ph} c\, r_e) = \frac{\mu_s}{f_c} \qquad 2.53$$

$$S = f_c\, S_{ph} \qquad 2.54$$

$$\mu_s = f_c \, \mu_{ph} \qquad 2.55$$

3.0 Slowing Down the Phosons

If a phoson is slowed down from the speed of light at point A to speed αc at point B as shown in figure 3.1, its translational kinetic energy at point B is

$$E_T = \frac{1}{2} m_{ph} \, \alpha^2 c^2 = \frac{\alpha^2}{2} h$$

The total kinetic energy of the phoson at point B is the summation of

$$E_{Total} = E_T + E_s + E_{s(ph)}$$

where $(E_{s(ph)})$ is the phoson's intrinsic spin kinetic energy around its own (x′) axis and (E_s) is its spin kinetic energy around the electron axis x.

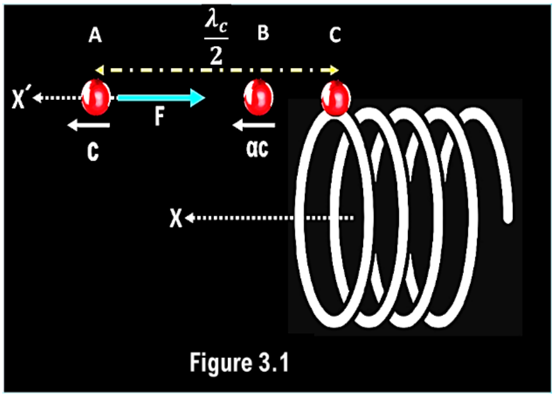

Figure 3.1

Because phosons travel as a wave its speed of light is maintained in the helical path and its spin kinetic energy around the electron axis x is fixed to $(\frac{h}{2})$ maintaining the relation $(c = \omega r_e)$, the energy $(E_{s(ph)})$ is expected to be $(E_{s(ph)} = \frac{h}{2}(1 - \alpha^2))$, accordingly the total energy is

$$E_T = \frac{\alpha^2}{2} h + \frac{h}{2} + \frac{h}{2}(1 - \alpha^2) = h \qquad 3.1$$

The work done to slow down the phoson to (αc) assuming a full slow down to zero velocity in half wavelength can be found as

$$v_f^2 = v_i^2 + 2ad$$

$$\alpha^2 c^2 = c^2 + 2a \frac{\lambda_c}{2} (1 - \alpha)$$

$$(\alpha^2 - 1) \, c^2 = 2a \frac{\lambda_c}{2} (1 - \alpha)$$

$$a = -(1 + \alpha) \, \frac{c^2}{\lambda_c} \qquad 3.2$$

The force required to slowdown the phoson is`

$$F = ma = \frac{-m_{ph}(1+\alpha) \, c^2}{\lambda_c} = -(1 + \alpha) \frac{h}{\lambda_c} \quad \text{(N.s)} \qquad 3.3$$

The work required to slow down the phoson to speed αc is

$$W = f.d = -\frac{(1+\alpha)h}{\lambda_c} \frac{\lambda_c}{2} (1 - \alpha) = -\frac{h}{2} (1 - \alpha^2) \quad \text{(J.s)} \qquad 3.4$$

Considering the full electron, the force and work in equations 3.3 and 3.4 are

$$F = \frac{- m_{ph}\ f_c\ (1+\alpha)\ c^2}{\lambda_c} = -(1+\alpha)\frac{h}{\lambda_c} \quad \text{(N)} \qquad 3.5$$

$$W = -(1+\alpha)\frac{hf_c}{\lambda_c}\ (1-\alpha)\frac{\lambda_c}{2} = -\frac{mc^2}{2}(1-\alpha^2) \ \ \text{N} \qquad 3.6$$

As expected, the work required to slow down the phoson to speed (αc) is equal to its intrinsic spin kinetic energy, in other words the translational kinetic energy lost by the phoson is stored as spin energy. If the phoson is slowed down to zero velocity at point c, we get

$$v_f = v_i + 2ad$$

$$0 = c^2 + 2a\ \frac{\lambda_c}{2}$$

$$a = -\frac{c^2}{\lambda_c} \qquad (\text{ m.s}^{-2}\text{ })$$

$$F = ma = \frac{m_{ph\,c^2}}{2\lambda_c} = -\ \frac{h}{\lambda_c} \qquad \text{(N.s)}$$

$$W = F.d = -\ \frac{h}{\lambda_c}.\ \frac{\lambda_c}{2} = -\ \frac{h}{2} \qquad \text{(J.s)} \qquad 3.3$$

Thus, the spin kinetic energy of the phosons works as a potential energy which can be restored if the phoson is allowed to accelerate to a higher speed.

The energy required by the electron to make a full slow down to rest where it will be just spinning without translational energy is

$$W_e = -\frac{hf_c}{2} = -\frac{mc^2}{2} \qquad 3.4$$

4.0 Inductance, Stored Energy and Magnetic Flux of the Electron

The phosons' helical path is equivalent to a coil of f_c number of turns, its volume as a coil is equal to a cylinder volume of radius (r_e) and length ($2r_e$) figure 4.1, the inductance of the electron is

$$L = \frac{\mu_o.\ A}{L} = \frac{\mu_0\ (\pi\, r_e^2)}{2r_e} = 5.562 \times 10^{-21}\ \text{H} \qquad 4.1$$

The magnetic flux can be found as

$$\phi = L\,.\,I = L\ (qf_c\alpha^{-1}) \qquad 4.2$$

$$\emptyset = \left(\frac{\mu_0\ \pi r_e^2}{2r_e}\right) I = \left(\frac{\mu_0\, I}{2r_e}\right)\pi r_e^2 = BA$$

$$\phi = 1.509 \times 10^{-17}\ \text{weber} \qquad 4.3$$

The stored magnetic field energy in the electron as a coil with inductance L is

$$U_s = \frac{1}{2}\, L.I^2 \;=\; \frac{1}{2}\,\frac{\mu_0}{2r_e}(\pi r_e^2)(q f_c \alpha^{-1})^2 \;=\; \frac{m\,c^2}{4} \qquad 4.4$$

To confirm the results in equation 4.1 to 4.4, I will derive known formulas from them starting with Larmor formula

$$U_s = \frac{1}{2} L I^2 = \frac{mc^2}{4} = \frac{1}{2}\frac{\mu_o(\pi r_e^2)}{2r_e}\;\alpha^{-2} q^2 f_c^2$$

$$mc^2 = \mu_o(\pi r_e)\alpha^{-2} q^2 f_c^2$$

4.5

$$\frac{mc^2}{f_c} = \mu_o(\pi r_e)\alpha^{-2} q^2 f_c$$

$$h = \frac{1}{2}\mu_o(2\pi\,\alpha^{-1} r_e)\alpha^{-1} q^2 f_c = \frac{\mu_o}{2}\lambda_c I q$$

$$q = \frac{2h}{\mu_o \lambda_c\, I} = \frac{2mc}{\mu_o I} = \frac{mc}{r_e B} = \frac{m\,\omega_s}{B}$$

$$\omega_s = \frac{q}{m}\; B$$

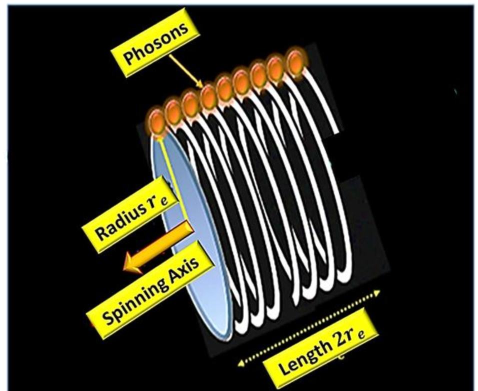

Figure 4.1

The second proof is to derive Coulomb's law starting from equation 4.5

$$\mu_o(\pi\, r_e)(\alpha^{-2} q^2 f_c^2) = mc^2$$

$$mc^2 = \frac{(\pi\, r_e)\,(\alpha^{-2} q^2 f_c^2)}{\epsilon_o\, c^2} = \frac{(\pi\, r_e)(\alpha^{-2} q^2)}{\epsilon_o\, \lambda_c^2} = \frac{(\pi\, r_e)\,(\alpha^{-2} q^2)}{\epsilon_o\, \alpha^{-2}(2\pi\, r_e)^2}$$

$$mc^2 = \frac{(\pi\, r_e)\,(q^2)}{\epsilon_o\, 4\,\pi^2\, r_e^2} = \frac{1}{4\pi\epsilon_o}\frac{q^2}{r_e}$$

• Equivalency Between the Magnetic Field of a Solenoid, a Cyclotron, and an Electron

The cyclotron's magnetic field, solenoid's magnetic field and consequently the electron's magnetic field formulas are the equal, the following derivation is to verify this equality

Cyclotron magnetic field ⇋ solenoid magnetic field ⇋ Electron magnetic field

$$mc^2 = \frac{1}{4\pi\epsilon_0}\frac{q^2}{r_e}$$

$$mc = \mu_0 \frac{q^2}{4\pi r_e} = \frac{1}{c\epsilon_0}\frac{q^2}{4\pi r_e}$$

$$\frac{m}{q}(2\pi) = \frac{\mu_0 q}{2r_e}$$

$$\frac{m}{q}(2\pi\alpha^{-1} f_c) = \frac{\mu_0 \alpha^{-1} q f_c}{2r_e}$$

$$\frac{m}{q}\omega_s = \frac{\mu_0 I}{2r_e}$$

$$\frac{mc}{qr_e} = \frac{\mu_0\, I}{2r_e}$$

$$B = \frac{mc}{qr_e} \leftrightharpoons B = \frac{\mu_0 I}{2r_e}$$

5.0 Behavior as a Solenoid and Similarity with a Current Carrying Wire

The magnetic force and its equivalent static electrical force can be used to derive a formula similar to the one describing a force between two straight wires.

$$F \ = Bqc = \frac{1}{4\pi\epsilon_o}\frac{q^2}{r_e^2} = \frac{m\,c^2}{r_e}$$

$$F = Bq(\alpha^{-1}f_c)\frac{c}{(\alpha^{-1}f_c)} = B(\alpha^{-1}qf_c)\frac{c}{(\alpha^{-1}f_c)}$$

$$F = BI\alpha\lambda_c = BI(2\pi r_e)$$

$$F = (\frac{\mu_o I}{2r_e})(2\pi r_e)\ I \qquad 5.1$$

$$F = BIL \qquad 5.2$$

Equation 5.1 can be rearranged as

$$F = \pi^2(\frac{\mu_o I}{2\pi r_e})(2r_e)\ I \qquad 5.3$$

$$F = \pi^2 BIL \qquad 5.4$$

Equations 5.1 and 5.3 are equal but we know that the magnetic field is the one in equation 5.1 and the electron length is the one in equation 5.3, with the same radius in both, the accurate formula should be

$$F = \pi(\frac{\mu_o I}{2r_e})(2r_e)\ I \qquad 5.5$$

$$F = \pi\mu_0 I^2 \qquad 5.6$$

Equation 5.6 can be derived from the electrostatic force as

$$F = \frac{1}{4\pi\epsilon_o}\frac{q^2}{r_e^2} = \frac{1}{4\pi\epsilon_o}\frac{\alpha^{-2}f_c^2q^2}{\alpha^{-2}f_c^2r_e^2}$$

$$F = \frac{\mu_o c^2}{4\pi}\ \frac{I^2}{\alpha^{-2}f_c^2r_e^2}$$

$$F = \ \mu_o I^2\frac{\pi c^2}{4\pi^2\alpha^{-2}r_e^2f_c^2}$$

$$F = \mu_o I^2 \pi \frac{c^2}{\lambda_c^2 f_c^2}$$

$$F = \pi \mu_o I^2$$

The following derivation is to show the relation of equivalency between the tangential force and the centrifugal force using the current definition and the (k) factor which will be defined next section starting from the potential energy

$$mc^2 = \frac{1}{4\pi\epsilon_0}\frac{q^2}{r_e} = \frac{1}{4\pi\epsilon_0}\frac{4\pi^2 k^2}{r_e} = \frac{\pi k^2}{\epsilon_0 f_c^2 r_e}$$

$$k^2 = \frac{\epsilon_0 f_c^2 r_e m c^2}{\pi} = \frac{f_c^2 r_e mc^2}{\pi \mu_0 c^2} = \frac{m r_e f_c^2}{\pi \mu_0}$$

$$\pi\mu_0 k^2 = m r_e f_c^2$$

$$\pi\mu_0 k^2 (4\pi^2\alpha^{-2}) = m r_e f_c^2 (4\pi^2\alpha^{-2})\frac{r_e}{r_e}$$

$$\pi\mu_0 I^2 = \frac{mc^2}{r_e}$$

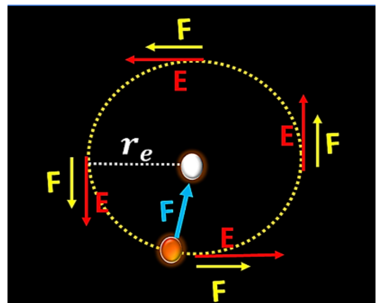

Figure 5.1

Inserting the angular velocity in equation 5.6 leads to

$$F = \pi\mu_o(\alpha^{-2}q^2 f_c^2)$$

$$F = \mu_o q^2 \frac{4\pi^2\alpha^{-2} f_c^2}{4\pi}$$

$$F = \frac{\mu_o}{4\pi}\omega_s^2 q^2 \qquad 5.7$$

After finding the tangential force shown in this section, we can express the three forces exerted on the electron as

Static force = induced tangential force = magnetic force = Centrifugal force

$$F_{static} = \frac{1}{4\pi\epsilon_o}\frac{q^2}{r_e^2} = F_{tang} = \pi \mu_o I^2 = F_{mag} = q.B.c = \frac{mc^2}{r_e} \qquad 5.8$$

• Self-electrostatic energy and charge

While equation 5.1 and equation 5.3 seem to be just a mathematical description of a force between the electron and its equivalent charge as two current carrying wires, the force in equation 5.6 is actual and it is the tangential force produced by the induced electric field which curls the loop of rotation (figure 5.1).

The induced tangential electric field produces a tangential force where both are equivalent to an electric field and force produced by an equal and opposite charged electron at the axes of the electron, the positive charge at the center is not real but came from the equivalency with the magnetic force exerted by the magnetic field.

The magnetic force, the tangential force and the electrostatic force are equal in magnitude, the first two are real while the third one is just an equivalent.

The equivalent electrostatic charge and electric field make the electron gain a potential energy $\left(U_p = mc^2 \right)$ which is actually caused by the magnetic force, this potential energy is equal in magnitude to a torque produced by the tangential force.

Thus, the total potential energies of the phosons composing the helical shaped electron is its self-electrostatic energy and their total charges is its self-electrostatic charge

6.0 Electron's Internal Current (Phosons' Flow)

The flow of phosons around the electron circumference is a current flow, one phoson current is equal to ($\alpha^{-1}q$) in (A.s) or ($\frac{Cs}{s}$) and the total electron current is ($\alpha^{-1}f_c q$) in (A). This current flow can be derived from

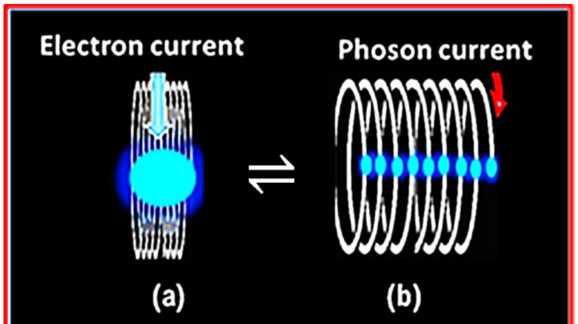

Figure 4.1

$$\mu_s = (\pi r_e^2).I = \frac{q}{2m}(m.r_e.c)$$

$$\pi r_e I = \frac{q}{2}c$$

$$I = \frac{qc}{2\pi r_e}$$

$$I = \frac{\alpha^{-1}qc}{\lambda_c}$$

$$I = \frac{\partial q}{\partial t} = \alpha^{-1}qf_c \qquad 6.1$$

As seen earlier the factor ($2\pi\alpha^{-1}$) is a key factor in describing the electron, examples are the equations ($\omega_s = 2\pi\alpha^{-1}f_c$) , ($\lambda_c = 2\pi\alpha^{-1}r_e$) , ($h = 2\pi\alpha^{-1}S$) etc. similarly, the electron current can be expressed as ($I = 2\pi\alpha^{-1}K$) Where the constant k is equal to (**3.150684**) Amperes .

$$I = f_s q = (\alpha^{-1}f_c)q = 2712.810 = 2\pi\ \alpha^{-1}K \qquad 6.2$$

The following discussion I will show the significance of this factor

• The current Factor K

Starting with equation 6.2 the internal current which is the phosons' motion is

$$I = \alpha^{-1}qf_c = 2\pi\alpha^{-1}k$$

$$2\pi\alpha^{-1}qf_c = 4\pi^2\alpha^{-1}k$$

$$q\omega_s = 2\pi I$$

$$I = \frac{q}{2\pi}\omega_s \qquad 6.3$$

$$q\frac{c}{r_e} = 2\pi I$$

$$\alpha^{-1}qc = (2\pi\alpha^{-1}r_e)I = \lambda_c I \qquad 6.4$$

$$\alpha^{-1}qc^2 = \lambda_c Ic = 2\alpha^{-1}\mu_s\omega_s \text{ (Using equation 2.34)}$$

$$I = \frac{2}{\alpha c\lambda_c}\mu_s\omega_s = \frac{2}{c(2\pi r_e)}\mu_s\omega_s$$

$$I = \frac{1}{\pi}\frac{\mu_s}{r_e^2} \qquad 6.5$$

$$2\pi\alpha^{-1}k = \frac{\mathbf{1}}{\boldsymbol{\pi}}\frac{\boldsymbol{\mu_s}}{\boldsymbol{r_e^2}}$$

$$k = \frac{\mu_s}{2\pi^2\alpha^{-1}r_e^2} = \frac{\mu_s}{\lambda_c(\pi r_e)} = \frac{2\alpha^{-1}\mu_s}{\lambda_c(2\alpha^{-1}\pi r_e)} = \frac{2\alpha^{-1}\mu_s}{\lambda_c^2}$$

$$k = \frac{2\,\mu_B}{\lambda_c^2} \qquad 6.6$$

Bohr magneton in equation 6.6 can be derived in terms of the factor (k) as

$$\mu_B = (\pi r_b^2)(q\frac{\alpha c}{2\pi r_b})$$

$$\mu_B = \frac{1}{2}r_b q\alpha c = \frac{1}{2}\alpha^{-2}r_e q\alpha c = \frac{1}{2}\alpha^{-1}r_e qc$$

$$\mu_B = \frac{(2\pi\alpha^{-1}r_e)\,qc}{4\pi} = \frac{\lambda_c\,qc}{4\pi} = \frac{\lambda_c^2\,qc}{4\pi\,\lambda_c} = \frac{\lambda_c^2}{4\pi}qf_c$$

$$\mu_B = \pi(\frac{\lambda_c}{2\pi})^2 qf_c \quad \text{(Using (} qf_c = 2\pi k \text{))} \qquad 6.7$$

$$\mu_B = \pi(\frac{\lambda_c^2}{4\pi^2})(2\pi K)$$

$$\mu_B = \frac{1}{2}K\,\lambda_c^2 \qquad 6.8$$

The spin magnetic moment of the electron in terms of the (k) factor can be derived as

$$\mu_s = A.I$$

$$\mu_s = (\pi r_e{}^2)(\frac{c}{2\pi r_e})q$$

$$\mu_s = \frac{r_e\,c\,q}{2}$$

$$\mu_s = \frac{r_e\,\lambda_c\,f_c\,q}{2}$$

$$\mu_s = \frac{r_e \lambda_c \,(2k\pi)}{2} \qquad \text{using} \quad (q = \frac{2k\,\pi}{f_c})$$

$$\mu_s = \frac{1}{2}\alpha\, K\, \lambda_c^2 \qquad 6.9$$

The constant K can be derived in terms of the electron radius and Compton wavelength as

$$I = 2\pi\alpha^{-1}k$$

$$I f_c = k\omega_s$$

$$I f_c = \frac{c}{r_e} K$$

$$I \frac{f_c}{c} = \frac{K}{r_e}$$

$$\frac{I}{\lambda_c} = K \frac{1}{r_e}$$

$$I = \frac{\lambda_c}{r_e}\, K \qquad 6.10$$

The following derivation shows where the factor k can be seen clearly

$$\frac{h}{2\pi} = L$$

$$h = 2\pi L = 2\pi\alpha^{-1}S$$

$$hkf_c = 2\pi\alpha^{-1}Skf_c$$

$$\frac{hf_c}{2\pi\alpha^{-1}k} = \frac{Sf_c}{k}$$

$$\frac{mc^2}{I} = \frac{Sf_c}{k} \qquad 6.11$$

Using $mc^2 = S\omega_s = S(2\pi\alpha^{-1}f_c)$

$$Sf_c = \frac{mc^2}{2\pi\alpha^{-1}} \qquad 6.12$$

$$\frac{mc^2}{I} = \frac{mc^2}{2\pi\alpha^{-1}k}$$ (Equation 6.12 is substituted in equation 6.11)

$$I = 2\pi\alpha^{-1}k$$ (Dominators should be equal)

$$mc^2 = S\omega_s = 2\mu_s B = 2AIB \qquad 6.13$$

$$\frac{S\omega_s}{2ABI} = \frac{S(2\pi\alpha^{-1}f_c)}{2ABI} = 1$$

$$\frac{Sf_c}{2AB} = \frac{I}{2\pi\alpha^{-1}} = k = 3.15068 \quad 6.14$$

Equation 6.14 can be analyzed as

$$Sf_c = mcr_e f_c = \frac{h}{\lambda_c} r_e f_c = \frac{mc^2 r_e}{\lambda_c}$$

$$\frac{mc^2 r_e}{\lambda_c} = 2ABK = 2(\frac{\mu_0 I}{2r_e})\pi r_e^2 k$$

$$\frac{mc^2}{\lambda_c} = \pi\mu_0 IK \quad 6.15$$

comparing this equation with the force formula 5.7 derived in section 5 which is

$$\frac{mc^2}{r_e} = \pi\mu_0 I^2 \quad 6.16$$

Dividing equation 6.17 by equation 6.15 we get equation 6.10 again

$$I = K\frac{\lambda_c}{r_e} \quad 6.17$$

Equation 6.15 is double the energy required to slow down the phoson from the speed of light to zero speed.

$$\frac{mc^2}{2} = (\pi\mu_0 IK)\frac{\lambda_c}{2}$$

$$\frac{mc^2}{2} = \left(mcf_c\right)\frac{\lambda_c}{2} = F\ \frac{\lambda_c}{2} \quad 6.18$$

A relation between the magnetic flux, spin angular momentum and the current factor can be derived as

$$U = \mu_s B = BAI = \frac{mc^2}{2}$$

$$\phi = \frac{mc^2}{2I} = \frac{hf_c}{2I} = BA$$

$$\frac{h}{I} = 2(\frac{mc}{qr_e})\ (\pi r_e^2)\left(\frac{1}{f_c}\right) \quad \text{where} \quad (B = \frac{mc}{qr_e})$$

$$\frac{h}{I} = \frac{2\pi\, m\, c\, r_e}{q\, f_c} = \frac{2\pi\, m\, c\, r_e}{2\pi K} = \frac{m\, c\, r_e}{K} \quad 6.19$$

$$S = K\ \frac{h}{I} \quad 6.20$$

The orbital angular momentum can be derived from equation 6.19 as

$$\frac{h}{I} = \frac{m\, c\, r_e}{K}$$

$$\frac{h}{2\pi\alpha^{-1}K} = \frac{m\, c\, r_e}{K}$$

$$\frac{h}{2\pi} = \alpha^{-1}(m\, c\, r_e) = \alpha^{-1}\, m(\alpha^{-2} r_b)c = m(\alpha c) r_b$$

$$\frac{h}{2\pi} = L \qquad 6.21$$

According to the above discussion, the known formula for magnetic force acting on a charged particle moving in a magnetic field can be derived easily using the electron's current definition and the constant K as

$$F = \pi\mu_0 I^2$$

$$F = \pi(\frac{\mu_o I}{2r_e})(2r_e)(2\pi\alpha^{-1}k) \qquad 6.22$$

$$F = (\frac{\mu_o I}{2r_e})(2\pi\alpha^{-1}r_e)(2\pi k)$$

$$F = \left(\frac{\mu_o I}{2r_e}\right)(\lambda_c)(\, 2\pi k) \qquad \text{using } (\, 2\pi k = q f_c\,)$$

$$F = \left(\frac{\mu_o I}{2r_e}\right)(\lambda_c)(\, q f_c) = qcB \qquad 6.23$$

Equation 6.23 describes the force when the electron has a length $(\, \lambda_c\,)$ and current $(\, \alpha I = 2\pi k = q f_c\,)$ but it is equivalent to equation 6.22

7.0 Magnetic Field, Torque and Potential Energy

The magnitude of the magnetic field required by Compton wave to start generating an electron should by at least $(\frac{B}{f_c})$ which is enough to bend the first phoson.

After the first phoson's circular path is completed, it starts to be the source of external magnetic field for the next phoson, then each added phoson joins the previous ones in producing the magnetic field and the process continues until a full electron is generated, the external magnetic field is required to trigger the process only, after that the magnetic field is fully generated by the phosons where all phosons produce what is considered external field for each phoson which explains why an electron maintains it shape even away from the nucleus.

To confirm the solenoidal shape of the electron, we can calculate the magnetic field as

$$B = \mu_o\, \frac{N}{L}\, i$$

Where $\quad (\, N = f_c\,), (\, L = 2r_e\,) \text{ and } (\, i = \alpha q^{-1}\,)$

$$B = (4\pi \times 10^{-7})(\frac{f_c}{2r_e})(q\alpha^{-1}) = 6.049 \times\, 10^{11}\, T \qquad 7.1$$

But $(\, N = f_c\,)$ is included in the current such that $(\, I = \alpha^{-1} q f_c \text{ and } i = \alpha^{-1} q\,)$, accordingly the magnetic field produced by one phoson is

$$B = \frac{\mu_o i}{2r_e} = \frac{(4\pi\times10^{-7})(q\,\alpha^{-1})}{2r_e} = 4.895 \times 10^{-9}\, T \qquad 7.2$$

And the magnetic field produced by the full electron is

$$B = \frac{\mu_0 I}{2r_e} = \frac{(4\pi\times10^{-7})(qf_c\,\alpha^{-1})}{2r_e} = 6.049 \times 10^{11}\ \mathrm{T} \qquad 7.3$$

The potential energy against the magnetic force which pulls the electron towards its axis can be derived in many ways, but I will show only two, the first is

$$F = \mu_o \pi I^2$$

$$U = \mu_o \pi I^2 r_e$$

$$U = 2(\pi\, r_e^2)(I)(\frac{\mu_o I}{2r_e})$$

$$U = 2\,\mu_s\, B \qquad 7.4$$

Another derivation to find the potential energy U in equation 7.4 is

$$q = I\frac{2\pi r_e}{c}$$

$$F = B.q.c = B(2\pi r_e)(2\pi \propto^{-1} K) = B(2\pi\alpha^{-1} r_e)(2\pi K)$$

$$F = B\lambda_c(2\pi K) = \alpha K \lambda_c^2 \frac{B}{r_e} = \left(\frac{\alpha K\lambda_c^2}{2}\right)\left(\frac{2B}{r_e}\right) = \frac{2\mu_s B}{r_e}$$

$$Fr_e = 2\mu_s B$$

$$U = 2\mu_s B \qquad 7.5$$

The derivation to find the value of energy in equation 7.5 and 7.4 is

$$U = 2AIB$$

$$U = 2(\pi r_e^2)(2\pi\alpha^{-1}K)\left(\frac{mc}{qr_e}\right)$$

$$U = 2(2\pi\alpha^{-1}r_e)(\pi K)\left(\frac{mc}{q}\right)$$

$$U = 2\,\lambda_c \pi\, K\,\frac{mc}{q} = 2\,\lambda_c\,\frac{qf_c}{2}\,\frac{mc}{q}$$ using $(\pi k = \frac{qf_c}{2})$

$$U = mc^2$$

$$\mu_s B = \frac{mc^2}{2} \qquad 7.6$$

The above derivation shows that the potential energy ($mc^2 = 2\,\mu_s\,B$) is against the magnetic force.

Figure 7.1 shows how the electron is precising, keeping in mind that the precision velocity is the angular spinning velocity, precising is actually a result of the phoson's motion in the helical path which is a continuous change in the orientation and inclination of the area enclosed by the rotating phoson and consequently the direction of the magnetic moment or in other words it is the rotation of the magnetic moment vector around the magnetic field vector passing the electron center.

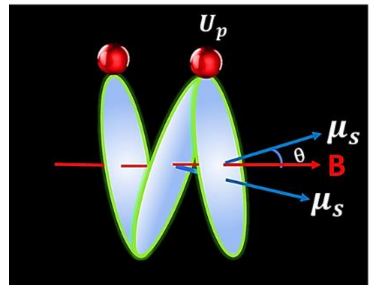

Figure 7.1

The magnetic moment and magnetic field are aligned when the phoson is just spinning without translational motion,

$U_p = \frac{mc^2}{2}$ (Maximum potential energy for the full electron)

$U_p = \frac{h}{2}$ (Maximum potential energy for one phoson)

The potential energy is a scaler quantity given as the dot product of the magnetic moment and the magnetic field

$$U_p = \overline{\mu_s}.\bar{B} = \mu_s B cos\theta$$

And the torque is a vector quantity given as the cross product of the magnetic moment and the magnetic field

$$\tau = \overline{\mu_s} \times \bar{B} = \mu_s B sin\theta$$

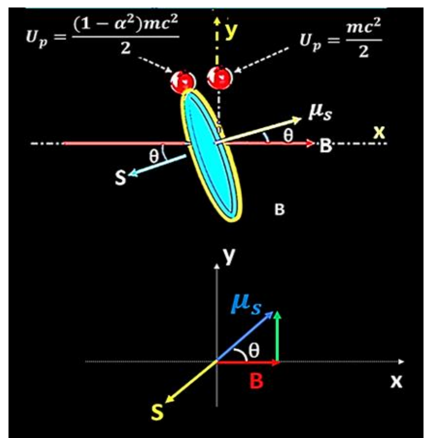

Figure 7.2

Figure 7.2 shows that the potential energy and torque are inversely proportional, when $(\theta = 0)$ potential energy is ($U_p = \frac{mc^2}{2}$) and torque zero while when $(\theta = 90^o)$ torque is ($\tau = \frac{mc^2}{2}$) and potential energy is zero.

Since the units of torque and energy are equivalent (joule = N.m) and based on the previous discussions about the electron's construction, composition and generation, we conclude that the relation between the potential energy and torque is equivalent to a vector summation such that

$$U_p^2 + \tau^2 = (\frac{mc^2}{2})^2$$

$$(\mu_s\,Bcos\theta)^2 + (\mu_s Bsin\theta)^2 = (\frac{mc^2}{2})^2$$

$$(\mu_s^2 B^2)(cos\theta^2 + sin\theta^2) = (\frac{mc^2}{2})^2$$

$$\mu_s B = \frac{mc^2}{2} \qquad 7.7$$

The above is applicable when the potential energy can do work only in the torque direction otherwise torque and potential energy should be treated as completely separate and different parameters

If torque is greater than potential energy the phoson is expected to reduce its spinning and magnetic field which makes it escape and go back to its original wave form, this is expected to happen after a threshold point at an angle ($\theta = 45°$) where the potential energy and torque are equal. Accordingly, the threshold point is

$$U_p = \tau = \frac{mc^2}{2\sqrt{2}} \text{ at } (\theta = 45°) \qquad 7.8$$

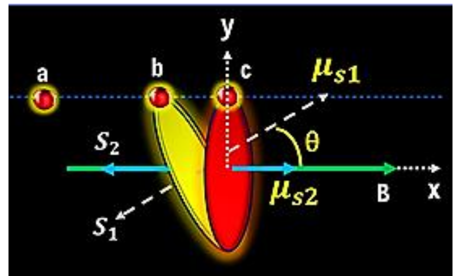

Figure 7.3

Figure 7.3 shows the phoson in three different locations. Point (a) is where the phoson is just part of a wave with no relation to the electron.

At Point b the phoson velocity is reduce to (αc) and at point c its velocity is reduced to zero.

At point b the torque is equal to the translational kinetic energy and the potential energy is equal to difference between the maximum value of their summation minus the torque.

The formula for the full electron is

$$K = \frac{1}{2} m\, \alpha^2 c^2 = \tau = \alpha^2 \frac{mc^2}{2} = \alpha^2 f_c \frac{h}{2}$$

$$U_p = \frac{mc^2}{2} - \alpha^2 \frac{mc^2}{2} = (1 - \alpha^2) \frac{mc^2}{2}$$

Point c is when the phoson velocity is reduced to zero where its full translational kinetic energy is stored as potential energy and the torque is zero.

At point (b) and (c) the phoson is under the effect of two opposite and equal torques, one pushes it to make it leave the electron and the other pushes in the opposite direction to align the magnetic momentum with the magnetic field.

8.0 De Broglie's Theory and Wave -Particle Duality

De Broglie proposed that the electron in the hydrogen atom has a wave behavior with wavelength equals to Bohr orbit length while in higher energy levels, the orbit circumference is a multiple of Bohr orbit length.

$$L = \frac{h}{2\pi} = mvr_b \qquad 8.1$$

$$\lambda = \frac{h}{mv} = 2\pi r_b$$

$$2\pi r = n(2\pi r_b) = \quad n\lambda = n\frac{h}{mv} \qquad 8.2$$

To check this assumption for the hydrogen atom where $v = \alpha c$ we get

$$2\pi r_b = \frac{h}{\alpha c\, m} \text{ which is equivalent } (x = vt)$$

$$\frac{h}{\alpha cm} = vt = \alpha ct$$

$$t = \frac{h}{\alpha^2 m\, c^2} = \frac{1}{\alpha^2 f_c}$$

$$f = \alpha^2 f_c$$

The above can be expressed as

$$(2\pi r_b)(\alpha^2 f_c) = \alpha c \text{ or } \left(\alpha c = \frac{2\pi r_b}{\frac{1}{\alpha^2 f_c}} = \frac{x}{t} \right)$$

Where the wavelength is $\lambda = (2\pi r_b)$ and the frequency ($f = \alpha^2 f_c$) is the number of rotations made by the electron in one second.

It is obvious that this is a pure rotational motion description of the electron as a particle not as a wave and that's why it can be easily expressed in terms of angular momentum. This theory has many weaknesses, but I will mention only the following example starting with De Broglie Wavelength

$$\lambda = \frac{h}{mv}$$

$$mv = \frac{h}{\lambda}$$ multiply both sides by the speed of light c

$$mcv = \frac{hc}{\lambda}$$ but $\frac{c}{\lambda} = f$

$$mcv = hf$$

$$E = hf \neq mcv$$

The previous result contradicts with ($E = hf = mc^2$)

We can re- express these equations in a wave form as

$$(2\pi r_b)(\alpha^2 f_c) = \alpha c$$

$$(2\pi r_e)(f_c) = \alpha c$$

$$(2\pi r_e)(\alpha^{-1} f_c) = c \quad 8.3$$

Where $$\lambda_e = 2\pi r_e = \alpha\, \lambda_c \quad 8.4$$

$$f_e = \alpha^{-1} f_c \quad 8.5$$

From equation 8.3 the electron's spin tangential velocity can be derived as

$$(r_e)(2\pi\alpha^{-1} f_c) = c$$

$$r_e . \omega_s = c$$

Thus, it is equation 8.3 which describes the wave behavior of the electron while De Broglie's formula describes its rotational motion, the actual wavelength is

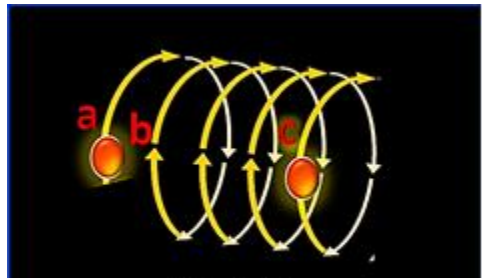

Figure 8.1

$$2\pi r_b = \frac{h}{\alpha cm}$$

$$\frac{2\pi r_e}{\alpha^2} = \frac{h}{\alpha cm}$$

$$2\pi r_e = \frac{\alpha^2 h}{\alpha cm}$$

$$\lambda = 2\pi r_e = \frac{\alpha^2 h}{m\alpha c}$$

Substitute v for αc we get

$$\lambda = 2\pi r_e = \frac{\alpha^2 h}{mv} \quad 8.6$$

Figure 8.1 describes the electron as a wave, it shows only two phosons out of f_c phosons, the distance between any two successive phosons along the helical path is Compton wavelength (length between point a and c), each wavelength is composed of α^{-1} loops where the length of each loop is $2\pi r_e$ (length between point a and b).

From the electron wave equation 8.3 we can find the relation between its momentums

$$(2\pi r_e)(\alpha^{-1} f_c) = c$$

$$c = 2\pi\alpha^{-1} r_e \frac{m.c^2}{h}$$

$$h = 2\pi\alpha^{-1} r_e mc$$

$$\frac{h}{2\pi} = \alpha^{-1} S$$

$$L = \alpha^{-1} S \quad 8.7$$

9.0 Induced Electric Field and Induced Voltage

The flow of charged phosons generates a magnetic field, for each phosons the magnetic field produced by all other phosons works as an external magnetic field, the change of magnetic flux of this field caused by the phosons' helical motion in the electron besides the motion of the full group produces an electrical field tangential to the circular orbits and perpendicular to the magnetic field, the tangential field is equivalent to a static electric field by the assumed positive charge at the center of the electron, accordingly, we have two electric fields to be investigated

• Tangential Induced Electric Field

Since the phosons' motion at the speed of light is itself the current and the generator of the magnetic field, both the induced electric field and the change in magnetic flux occurs because of the other. We can say in this case that the magnetic flux is induced by the electric field and visa versa, I will refer to the electric field as induced for clarity. The induced electric field can be derived as

$$c = \frac{E}{B} = \omega_s r_e = \frac{\omega_s \, 2\pi r_e^2}{2\pi r_e}$$

$$E_{ind}(2\pi r_e) = 2B(\pi r_e^2)\omega_s = 2BA\omega_s$$

$$E_{ind}(2\pi r_e) = 2\emptyset\omega_s = 2\emptyset(2\pi\alpha^{-1}f_c) \quad 9.1$$

$$Er_e = 2\emptyset\alpha^{-1}f_c$$

$$E_{ind} = \frac{2}{r_e}\frac{d}{dt}\emptyset \quad 9.2$$

Where ($E_{ind} = \frac{2}{r_e}BA\alpha^{-1}f_c$), ($\frac{\partial\emptyset}{\partial t} = \frac{\partial BA}{\partial t} = AB\alpha^{-1}f_c$), and $(\partial\, t = \frac{1}{\alpha^{-1}f_c})$, equation 9.2 can be written as

$$\oint_0^{2\pi r_e} E.\partial l = \frac{2}{r_e}\frac{d}{dt}\emptyset \quad 9.3$$

the force produced by this induced electric field is the tangential force found earlier in this paper which is

$$F = qE = \frac{2}{r_e}BA\alpha^{-1}qf_c$$

$$F = \frac{2}{r_e}(\frac{\mu_0 I}{2r_e})(\pi r_e^2)I$$

$$F = \pi\mu_0 I \quad 9.4$$

• The Equivalent Radial Static Electric Field

The radial electrostatic electric field produced the equivalent electrostatic charge at the electron axis is

$$mc^2 = Fr_e = \frac{1}{4\pi\epsilon_o}\frac{q^2}{r_e}$$

$$Er_e = \frac{mc^2}{q} = \frac{1}{4\pi\epsilon_o}\frac{q}{r_e} \quad 9.5$$

$$E = \frac{1}{4\pi\epsilon_o}\frac{q}{r_e^2} \quad 9.6$$

The tangential electric field is the actual one, but the equivalency with the radial field can be seen in equation 9.6

$$E = (\frac{\mu_o c^2}{4\pi})(\frac{q}{r_e^2})(\frac{\alpha^{-1}f_c}{\alpha^{-1}f_c}) = \frac{1}{r_e}(\frac{\mu_o I}{2r_e})(\frac{c^2}{2\pi\,\alpha^{-1}f_c})$$

$$E = B\frac{c^2}{r_e\omega_s} = Bc$$

The equivalency between equation 9.1 and 9.6 can be used to derive the magnetic field of the electron as a solenoid

$$\frac{1}{4\pi\epsilon_o}\frac{q}{r_e^2}\,(2\pi r_e) = 2\omega_s B(\pi r_e^2)$$

$$\frac{1}{4\pi\epsilon_o}\frac{q}{r_e^2} = \omega_s r_e B = cB$$

$$B = \frac{1}{4\pi\epsilon_o}\left(\frac{q}{c\,r_e^2}\right) = \left(\frac{\mu_o\,c^2}{4\pi}\right)\left(\frac{q}{c\,r_e^2}\right) = \frac{\mu_o\,c\,q}{4\pi r_e^2}$$

$$B = \frac{\mu_o\,c\,q\,(4\pi^2\alpha^{-2})}{4\pi\,\lambda_c^2} = \frac{\mu_o\,(\alpha^{-1}qf_c)(\pi\alpha^{-1})}{\lambda_c}$$

$$B = \frac{\mu_o\,I\,(\pi\alpha^{-1})}{\alpha^{-1}(2\pi\,r_e)} = \frac{\mu_o\,I}{2\,r_e} \qquad 9.7$$

The two electric fields are related as

static electric filed = Induced electric field

$$E_{static} = \frac{1}{4\pi\epsilon_o}\frac{q}{r_e^2} = E_{ind} = \frac{2}{r_e}\frac{d}{dt}\emptyset \qquad 9.8$$

• Electron Voltage

The electron has three types of voltages which are.

(1) The potential voltage difference in putting the phosons (or the full electron) in its location at a radial distance r_e from the electrostatic charge at the electron's center

$$E = \frac{1}{4\pi\epsilon_o}\frac{q}{r_e^2}$$

$$V = Er_e = \frac{Fr_e}{q} = \frac{1}{4\pi\epsilon_o}\frac{q}{r_e} = \frac{mc^2}{q} \qquad 9.9$$

(2) The induced tangential electric field which was clear in deriving equation 9.2

$$V_{ind} = 2\,BA\alpha^{-1}f_c$$

$$V_{ind} = E_{ind}\,r_e = 2\frac{d}{dt}\emptyset \qquad 9.10$$

$$V_{ind} = 2BA\alpha^{-1}f_c$$

$$V_{ind} = 2\left(\frac{\mu_0 I}{2r_e}\right)(\pi r_e^2)(\alpha^{-1}f_c)\left(\frac{q}{q}\right)$$

$$V_{ind} = \frac{1}{q}(\pi\mu_0 I^2)r_e \qquad 9.11$$

$$V_{ind} = \frac{1}{q}(\pi\mu_0 I^2)r_e = \frac{Fr_e}{q} = \frac{mc^2}{q} \qquad 9.12$$

As a conclusion the induced electric field can be described by combining equations 9.10 and 9.12 as

$$V_{ind} = E_{ind}\, r_e = 2\frac{d}{dt}\emptyset = \frac{mc^2}{q} \qquad 9.13$$

(3) The voltage across the electron as an inductor which can be derived as below

$$U_s = \frac{1}{2}LI^2 = \frac{mc^2}{4}$$

$$LI^2 = \frac{mc^2}{2}$$

$$L = \frac{mc^2}{2I^2} = \frac{mc^2}{2q\alpha^{-1}f_c\, I}$$

$$L = \frac{mc}{q}\frac{\pi c}{\omega_s I} = \frac{mcr_e}{q}\frac{\pi}{I} = \frac{\pi}{I}\frac{S}{q}$$

$$L = \frac{\omega_s}{2I^2}\, S = \frac{1}{2I^2}mc^2 = \left(\frac{1}{2I}\right)\left(\frac{mc}{q}\right)\left(\frac{c}{\alpha^{-1}f_c}\right) \qquad 9.14$$

$$L = \left(\frac{mc}{qr_e}\right)\left(\frac{\pi r_e^2}{I}\right) = \frac{BA}{I}$$

$$L\, I = \emptyset$$

$$LI\alpha^{-1}f_c = \emptyset\, \alpha^{-1}f_c$$

$$V_L = L\frac{\partial I}{\partial t} = \frac{\partial \emptyset}{\partial t} \qquad 9.15$$

Comparing equation 9.15 with equation 9.13 we get

$$V_L = L\frac{\partial I}{\partial t} = \frac{\partial \emptyset}{\partial t} = \frac{mc^2}{2q} \qquad 9.16$$

The following derivation is to prove that the voltage across the electron's radius due to the assumed static charge is equal to the voltage across the electron's free space impedance using the equivalency between the static force, the tangential force and the electron's current definition formula

$$V = \frac{mc^2}{q} = \frac{1}{4\pi\epsilon_0}\frac{q}{r_e}$$

$$V^2 = \left(\frac{mc^2}{q}\right)^2 = \left(\frac{1}{4\pi\epsilon_0}\right)^2\frac{q^2}{r_e^2}$$

$$V^2 = \left(\frac{mc^2}{q}\right)^2 = \frac{1}{4\pi\epsilon_0}F \qquad 9.17$$

$$V^2 = \left(\frac{mc^2}{q}\right)^2 = \frac{1}{4\pi\epsilon_0}(\pi\mu_0 I^2) = \frac{\mu_0\, I^2}{4\epsilon_0} = \frac{I^2}{4\epsilon_0^2 c^2} = \frac{4\pi k^2\alpha^{-2}}{4\epsilon_0 c^2}$$

$$V = \frac{mc^2}{q} = \frac{\pi k \alpha^{-1}}{\epsilon_0 c}$$ using ($Z = \frac{1}{\epsilon_0 c}$) and multiply by ($\frac{2}{2}$)

$$V = \frac{mc^2}{q} = \frac{1}{2} ZI \qquad 9.18$$

The voltage is equation 9.18 in terms of the electron's inductance is

$$V = \frac{1}{2}\left(\frac{2\omega_s L}{\pi}\right) I = \frac{1}{\pi}(2\pi\alpha^{-1} f_c)\, LI = 2L(\alpha^{-1} f_c I)$$

$$V = 2L\frac{\partial I}{\partial t} \qquad 9.19$$

Equation 9.19 shows that the voltage across the free space impedance which is equal to the free space impedance voltage is double the voltage across the electron as an inductor.

• Electron Equivalent Circuit

The voltage and current in the circular direction and in the longitudinal direction across the electron combined with its impedance make the equivalent to a circuit that can be expressed as

$$\text{Voltage} = (\text{impedance})(\text{current})$$

$$\frac{mc^2}{2q} = \frac{Z}{4} I \qquad 9.20$$

$$\frac{mc^2}{q} = \frac{Z}{2} I \qquad 9.21$$

Where ($Z = \mu_o c = \frac{E}{H}$) Z is the free space impedance and H is the magnetic field strength . Equations 9.17 and 9.18 are equal but the first represents the equivalent circuit in the circular direction (figure 9.1.a) while the second equation represents the electron's equivalent circuit in the longitudinal direction (figure 9.1.b) .

The free space impedance is related to the inductance of the electron as

$$Z = \mu_o c = \mu_o \frac{2\pi r_e^2}{2\pi r_e^2}\, c$$

$$Z = 2\left(\frac{\mu_o \pi r_e^2}{2r_e}\right)\frac{\omega_s}{\pi}$$

$$Z = \frac{2}{\pi} L\, \omega_s \qquad 9.22$$

$$\frac{L\omega_s}{\pi} = \frac{Z}{2} \qquad 9.23$$

The power in the electron's impedance is derived using the equivalency between radial and tangential forces

$$U = mc^2 = Fr_e = (\pi\mu_o I^2)r_e$$

$$P_z = \frac{U}{t} = (\pi\mu_o I^2)\, r_e\alpha^{-1}f_c = \frac{1}{2}\,\mu_o I^2 r_e(2\pi\alpha^{-1}f_c)$$

$$P_z = \frac{1}{2}\,\mu_o I^2 r_e\omega_s$$

$$P_z = \frac{1}{2}\,\mu_o I^2 c = \frac{Z}{2}\,I^2 \qquad 9.24$$

Using the tangential force formula, the voltage across the electron's free space impedance can be derived

$$mc^2 = Fr_e$$

$$mc^2 = (\mu_o I^2\pi)r_e$$

$$mc^2 = \mu_o I\alpha^{-1}qf_c\pi r_e$$

$$mc^2 = \frac{\mu_o I}{2}\,(2\pi\alpha^{-1}r_e)(qf_c) = \frac{\mu_o I}{2}\,\lambda_c f_c q = \frac{\mu_o Icq}{2}$$

$$mc^2 = \frac{Z\,I\,q}{2}$$

$$V = \frac{mc^2}{q} = \frac{Z}{2}\,I \qquad 9.25$$

To Verify that the voltage difference across the electron's free space impedance is ($v = \frac{m\,c^2}{q}$) and is equal to radial potential voltage difference by the static charge we derive the relation as

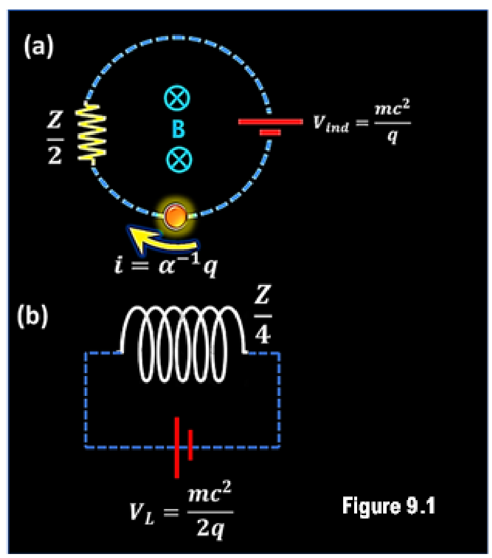

Figure 9.1

$$q = \frac{2\pi r_e}{c}I$$

$$2cq = I(4\pi r_e)$$

$$\frac{I}{2c} = \frac{q}{4\pi r_e}$$

$$\frac{Ic}{2c^2\epsilon_0} = \frac{q}{4\pi\epsilon_0 r_e}$$

$$\frac{1}{2}\mu_o cI = \frac{1}{4\pi\epsilon_0}\frac{q}{r_e}$$

$$V = \frac{Z}{2}I = \frac{1}{4\pi\epsilon_0}\frac{q}{r_e} = \frac{mc^2}{q} \qquad 9.26$$

The relation of equation 9.23 with rate of change of magnetic flux can be found as

$$V = \frac{1}{4\pi\epsilon_0}\frac{q}{r_e}$$

$$VI = \frac{1}{4\pi\epsilon_0}\frac{qI}{r_e} = \frac{\mu_0 c^2}{4\pi}\frac{qI}{r_e} = B\left(\frac{c^2 q}{2\pi}\right) = B(\frac{2\mu_0\omega_s}{2\pi})$$

$$\frac{mc^2}{q}I = \frac{B\mu_s\omega_s}{\pi}$$

$$\frac{mc^2}{q} = \frac{BA\omega_s}{\pi} = \frac{\emptyset}{\pi}2\pi\alpha^{-1}f_c = 2\emptyset\alpha^{-1}f_c$$

$$V = \quad 2\frac{\partial\emptyset}{\partial t}$$

To show that the induced voltage is double the rate of change of magnetic flux using equation 9.19 we find

$$\frac{mc^2}{2q} = \frac{1}{4}ZI = \frac{1}{4}\,\mu_o cI = \frac{1}{4}\left(\frac{\mu_o I}{2r_e}\right)(2r_e)c$$

$$\frac{mc^2}{2q} = \frac{1}{4}\,B(2\pi r_e^2)\frac{c}{\pi\, r_e} = \frac{1}{2}\,B(\pi r_e^2)c\,\frac{2\pi\alpha^{-1}}{\pi\,\lambda_c}$$

$$\frac{mc^2}{2q} = B(\pi r_e^2)\alpha^{-1}f_c$$

$$V = \frac{mc^2}{q} = 2B\,(A)\alpha^{-1}f_c = 2\,\phi\,\alpha^{-1}f_c$$

$$V = \frac{1}{\pi}\emptyset\omega_s$$

$$V = 2\,\frac{\partial\emptyset}{\partial t} \qquad 9.27$$

The following derivation is to show that the voltage across the electron's free space impedance is double the voltage across the electron as an inductor

$$c = \omega_s r_e$$

$$Ic = 2\pi\alpha^{-1}f_c r_e I$$

$$\mu_0 Ic = 4(\frac{\mu_0\,\pi r_e^2}{2r_e})I\alpha^{-1}f_c$$

$$\frac{1}{2}ZI = 2L\frac{\partial I}{\partial t} \qquad 9.28$$

The following derivation is to show that the voltage difference across the free space impedance is double the rate of change of the magnetic flux

$$c = \omega_s r_e$$

$$\mu_0 Ic = 4(\frac{\mu_0 I}{2r_e})\pi r_e^2\alpha^{-1}f_c$$

$$\mu_0 I c = 4BA\,\alpha^{-1} f_c$$

$$\frac{1}{2} Z I = 2\frac{\partial \emptyset}{\partial t} \quad 9.29$$

Comparing equation 9.25 with equation 9.23 we get

$$L\frac{\partial I}{\partial t} = \frac{\partial \emptyset}{\partial t} = \frac{mc^2}{2q} \quad 9.30$$

All the previous derivations can be summerized as (Induced voltage = static voltage = 2 x voltage across the electron as an inductor)

$$V_{ind} = 2\frac{d}{dt}\emptyset = V_{static} = \frac{1}{4\pi\epsilon_o}\frac{q}{r_e} = \frac{mc^2}{q} \quad 2.31$$

$$V_L = \frac{d}{dt}\emptyset = L\frac{\partial I}{\partial t} = \frac{mc^2}{2\,q} \quad 2.32$$

$$V_{ind} = \frac{Z}{2} I \quad 9.33$$

$$V_L = \frac{Z}{4} I \quad 9.34$$

10.0 Energy Density and Pointing Vector of the Electron's Electromagnetic fields.

• Energy Density

The electron is just a slowed down wave which kept most of its wave properties. One of the wave properties is the relation between the electric field and the magnetic field, this can be seen in the force formula

$$F = B\,c\,q$$

$$E = \frac{F}{q} = B\,c$$

Where $$E = \frac{1}{4\pi\epsilon_o}\frac{q}{r_e^2} = 1.813 \text{ x } 10^{20}\ \text{NC}^{-1} \quad 10.1$$

$$B = \frac{E}{c} = 6.049 \text{ x}10^{11}\ \text{T} \quad 10.2$$

Usually if a coil moves in an external magnetic field it induces current, voltage and electric field. In the electron case, motion of the phosons is the current which generates a magnetic field and the change in magnetic flux with time caused by rotation induces an electric field, the phosons motion resembles current flow with induced voltage.

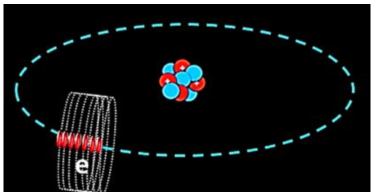

Figure 10.1

The magnetic field through the helical electron induces an electrical field tangential to the orbit of rotation (curling the loop), the electric field at the electron circumference is constant in magnitude but changing in direction with the rotating phosons keeping its direction always perpendicular to the magnetic field.

The electromagnetic energy density of the electromagnetic fields of the electron is derived as

$$F = \frac{mc^2}{r_e} = \frac{1}{4\pi\epsilon_0}\frac{q^2}{r_e^2}$$

$$mc^2 = \frac{\mu_0 c^2}{4\pi}\frac{q^2}{r_e}$$

$$q^2 = \frac{4\pi\, r_e m}{\mu_0}$$

$$q = \sqrt{\frac{4\pi\, r_e m}{\mu_0}}$$

$$F = Bcq$$

$$\frac{mc^2}{r_e} = Bc\sqrt{\frac{4\pi r_e m}{\mu_0}}$$

$$\frac{m^2c^4}{r_e^2} = B^2c^2(\frac{4\pi r_e m}{\mu_0})$$

$$mc^2 = (\frac{4\pi r_e}{\mu_o})B^2 r_e^2$$

$$U_{em} = \frac{B^2}{\mu_o} = \frac{mc^2}{2(\pi r_e^2)(2r_e)} = \frac{mc^2}{4\pi r_e^3} \qquad 10.3$$

The electromagnetic energy density is given in equation 10.3 ($U_{em} = \frac{B^2}{\mu_o}$), but I will derive it also from the right side of the equation

$$U_{em} = \frac{m\,c\,\omega_s}{4\pi\, r_e^2} = \frac{mc\,(\,2\pi\alpha^{-1}f_c)q}{4\pi\, r_e^2\, q} = \left(\frac{mc}{qr_e}\right)\frac{\alpha^{-1}\,qf_c}{2r_e} = \frac{B\,iN}{2r_e}$$

$$U_{em} = \frac{\mu_0\, iN}{2r_e}\,(\frac{iN}{2r_e})$$

$$U_{em} = \frac{\mu_o\, i^2N^2}{4r_e^2} = \frac{\mu_o\, I^2}{4r_e^2} \qquad 10.4$$

$$U_{em} = \frac{1}{\mu_0}\frac{\mu_0^2\, I^2}{4r_e^2} = \frac{1}{\mu_0}B^2$$

$$U_{em} = 2.912 \times 10^{29}\ \text{J.m}^{-3} \qquad 10.5$$

Where ($i = \alpha^{-1}q$), ($I = Ni = f_c i = \alpha^{-1}qf_c$) and $N = f_c$. The electromagnetic energy density in terms of the electric field is

$$U_{em} = \frac{B^2}{\mu_o} = \frac{1}{\mu_o}\left(\frac{\mu_o^2 I^2}{4r_e^2}\right) = \frac{\mu_o I^2}{4r_e^2} = \mu_o \frac{\alpha^{-2} q^2 f_c^2}{4r_e^2} = \frac{1}{\epsilon_o c^2}\frac{\alpha^{-2} q^2 f_c^2}{4r_e^2}$$

$$U_{em} = \frac{1}{4\epsilon_0}\frac{\alpha^{-2} q^2 f_c^2}{\omega_s^2 r_e^4} = \frac{1}{4\epsilon_o}\frac{\alpha^{-2} q^2 f_c^2}{(4\pi^2\alpha^{-2} f_c^2) r_e^4} = \frac{1}{16\pi^2 \epsilon_o}\frac{q^2}{r_e^4}$$

$$U_{em} = \epsilon_o \left(\frac{1}{4\pi\epsilon_o}\frac{q}{r_e^2}\right)^2 = \epsilon_o E^2 \qquad 10.6$$

The magnetic and electric fields energy densities are

$$U_e = \frac{1}{2}\epsilon_o E^2 = \frac{1}{2}(8.854 \, x \, 10^{-12})(1.813 \times 10^{20})^2$$

$$U_e = \frac{U_{em}}{2} = 1.456 \times 10^{29} \, \mathrm{J.m^{-3}} \qquad 10.7$$

$$U_m = \frac{1}{2}\frac{B^2}{\mu_0} = \frac{1}{2}\frac{1}{\mu_o}(6.048 \times 10^{11})^2$$

$$U_m = \frac{U_{em}}{2} = 1.456 \times 10^{29} \, \mathrm{J.m^{-3}} \qquad 10.8$$

The relation between the electromagnetic energy and energy density is derived as

$$F = \pi\mu_0 I^2 = \pi\left(\frac{\mu_0 I}{2r_e}\right)(2r_e)\left(\frac{\mu_0 I}{2r_e}\right)\left(\frac{2r_e}{\mu_0}\right)$$

$$F = 4\pi r_e^2\left(\frac{B^2}{\mu_0}\right) = 4\pi r_e^2 U_{em} \qquad 10.9$$

Where (U_{em}) is the electromagnetic energy density in J.m^{-3} , Using the electron's volume as a solenoid which is ($V_{ol} = (2r_e)(\pi r_e^2)$) we get

$$F = 4\pi r_e^2 U_{em}$$

$$F = 2(2\pi r_e^3)\left(\frac{U_{em}}{r_e}\right) = 2 V_{ol}\left(\frac{U_{em}}{r_e}\right)$$

$U_p = F r_e = mc^2 = 2 V_{ol} U_{em}$ (Potential energy at the electron circumference)

$$U_{em} = \left(\frac{mc^2}{2}\right)\frac{1}{V_{ol}} \qquad 10.10$$

Equation 10.10 shows that an electromagnetic energy $\left(\frac{mc^2}{2}\right)$ is distributed in the electron's cylindrical volume. Half this energy is electrical, and the other half is stored in the electron magnetic field as an inductor which is

$$U_m = \frac{U_s}{V_{ol}} = \frac{\frac{1}{2} L I^2}{(2r_e)(\pi r_e^2)} = \frac{1}{2}\frac{\mu_o(\pi r_e^2) I^2}{(2r_e)(2r_e)(\pi r_e^2)} = \frac{\mu_o I^2}{8r_e^2} \qquad 10.11$$

$$U_m = \frac{1}{2\mu_0}\left(\frac{\mu_0 I}{2r_e}\right)\left(\frac{\mu_0 I}{2r_e}\right) = \frac{1}{2\mu_0}B^2 = 1.456 \times 10^{29} \, \mathrm{J.m^{-3}}$$

• Pointing Vector and Power

The pointing vector which is the transported power in the front area of the electron is

$$S_{pv} = \frac{1}{\mu_o} \mid E \times B \mid = \left(\frac{1}{\mu_o}\right)\left(\frac{\mu_o c\, I}{2r_e}\right)\left(\frac{\mu_o I}{2r_e}\right) = \frac{1}{\mu_o} B^2 c \qquad 10.12$$

$$S_{pv} = U_{em}\, c = \frac{E\,B}{\mu_o} = 8.729 \times 10^{37}\ \mathrm{W.m^{-2}} \qquad 10.13$$

Equation 10.12 can be written as

$$S_{pv} = \frac{B}{\mu_o}\frac{Z\,I}{2r_e} \qquad 10.14$$

• Power and Energy

The power of the electron's free space impedance as part of the electron's equivalent circuit is

$$P_z = \frac{1}{2} Z\, I^2 = \frac{1}{2}\, \mu_o I^2 c \qquad 10.15$$

$$P_z = \frac{1}{2}\frac{(\,\mu_0 \pi\, I^2\,)}{\pi} c = \frac{1}{2\pi} F c$$

$$U_z = P_z t = \frac{1}{2\pi}\frac{F\,c}{\alpha^{-1} f_c} = \frac{F\,c}{\omega_s} = F r_e = mc^2 \qquad 10.16$$

It is obvious that equations 10.15 and 10.16 are describing the potential energy of the electron which is the summation of energies of each phoson resulting from being in its orbit under the effect of the magnetic force.

$$mc^2 \omega_s = F\, c$$

$$P_z = \frac{mc^2}{t} = \frac{1}{2\pi} F c = \frac{1}{2\pi} mc^2 \omega_s = mc^2 \alpha^{-1} f_c \qquad 10.17$$

Where $(mc^2 \alpha^{-1} f_c = \frac{\partial U}{\partial t})$

The power of the free space impedance also can be found to be

$$P_z = \frac{1}{2}\left(\frac{2\omega_s L}{\pi}\right) I^2 \qquad \text{(Using } Z = \frac{2\omega_s L}{\pi}\text{)}$$

$$P_z = \left(\frac{\omega_s L}{\pi}\right) I^2 \qquad 10.18$$

The stored energy can be derived as

$$mc^2 = F r_e = (\pi \mu_o I^2) r_e$$

$$\frac{mc^2}{2} = \left(\frac{\mu_o \pi r_e^2}{2r_e}\right) I^2$$

$$\frac{mc^2}{4} = \frac{1}{2} L\, I^2 \quad 10.19$$

The power transported by the electron electromagnetic wave is

$$P_{emt} = S_{pv} A = \frac{1}{\mu_0} B^2 c(\pi r_e^2)$$

$$P_{emt} = \frac{1}{\mu_0} \frac{\mu_0^2 I^2}{4 r_e^2} c(\pi r_e^2) = \frac{(\mu_0 \pi I^2) c}{4} = \frac{F\, c}{4} = \frac{F \omega_s r_e}{4}$$

$$P_{emt} = \frac{mc^2}{4} \omega_s \quad 10.20$$

The relation between the transported power and the stored energy is

$$P_{emt} = \frac{mc^2}{4} \omega_s = \frac{1}{4} F r_e \omega_s = \frac{1}{4} (\pi \mu_0 I^2) r_e \omega_s$$

$$P_{emt} = \frac{1}{2} \left(\frac{\mu_0 \pi r_e}{2 r_e} \right) I^2 \omega_s = (\frac{1}{2} L I^2) \omega_s$$

$$P_{emt} = U_s \omega_s \quad 10.21$$

The relation between the transported power and the electron's free space impedance power is

$$\frac{P_{emt}}{P_Z} = \frac{mc^2 \omega_s}{4} \frac{2\pi}{mc^2 \omega_s} = \frac{\pi}{2} \quad 10.22$$

Or it can be derived as

$$P_{emt} = \frac{1}{\mu_0} B^2 c A = B \left(\frac{I}{2 r_e} \right) c(\pi r_e^2) = B \frac{I c\, \pi r_e}{2}$$

$$P_{emt} = \frac{\mu_0 I}{2 r_e} \frac{I c\, \pi r_e}{2} = \frac{\pi}{2} \left(\frac{1}{2} Z I^2 \right) = \frac{\pi}{2} P_Z \quad 10.23$$

$$P_{emt} = \frac{\pi}{2} \left(\frac{\omega_s L}{\pi} \right) I^2 = \frac{1}{2} \omega_s L I^2 \quad 10.24$$

According to the above equations the pointing vector can be expressed as

$$S_{pv} = \frac{P_{emt}}{area} = \frac{\frac{mc^2}{4} \omega_s}{\pi\, r_e^2} \quad 10.25$$

$$S_{pv} = \frac{\left(\frac{\pi}{2}\right)\left(\frac{1}{2} Z\, I^2\right)}{\pi r_e^2} = \frac{Z\, I^2}{4\, r_e^2} \quad 10.26$$

$$S_{pv} = \frac{\frac{1}{2} \omega_s L\, I^2}{\pi r_e^2} = \frac{1}{2\pi\, r_e^2} \omega_s L\, I^2 \quad 10.27$$

$$S_{pv} = \frac{Z}{\mu_o} U_{em} \qquad 10.28$$

• EM Pressure

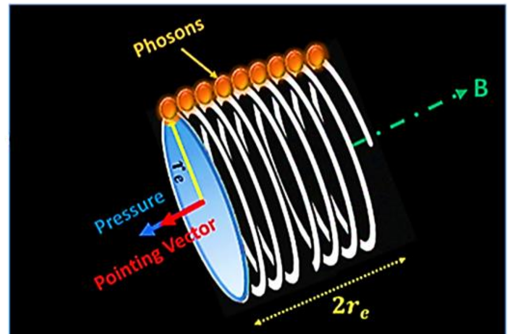

Figure 10.2

The pressure of the electron's electromagnetic wave on the electron's front area can be derived as

$$E = \frac{F}{q}$$

$$U = \epsilon_o \frac{F^2}{q^2} = \frac{\epsilon_o}{q^2} \mu_o^2 \pi^2 I^4$$

$$U = (\epsilon_o \mu_o)(\mu_o \pi I^2)(\frac{\pi I^2}{q^2})$$

$$U = F \frac{\pi I^2}{c^2 q^2} \qquad 10.29$$

The term ($\frac{\pi I^2}{c^2 q^2}$) in equation 10.29 can be found to be

$$\lambda_c = 2\pi\alpha^{-1} r_e$$

$$\alpha^2 \lambda_c^2 = \alpha^2 (4\pi^2 \alpha^{-2} r_e^2) = 4\pi^2 r_e^2$$

$$4\pi r_e^2 = \frac{\alpha^2 \lambda_c^2}{\pi}$$

$$4\pi r_e^2 = \frac{1}{\alpha^{-2}} \frac{c^2}{f_c^2} \frac{q^2}{q^2} \frac{1}{\pi} = \frac{c^2 q^2}{\pi I^2} \qquad 10.30$$

Substituting equation 8.30 in equation 8.29 we obtain

$$P_{pr} = \frac{F}{4} \frac{1}{\pi r_e^2} = \frac{F}{4} \frac{1}{area} \qquad 10.31$$

Also, the electron electromagnetic fields wave pressure can be related to the pointing vector as

$$P_{mom} = \frac{U_{emt}}{c}$$

$$P_{pr} = \frac{F}{A} = \frac{1}{A} \frac{\partial P_{mom}}{\partial t} = \frac{1}{cA} \frac{\partial U_{emt}}{\partial t} = \frac{1}{c} \frac{P_{emt}}{A}$$

$$P_{pr} = \frac{1}{c} S_{pv} \qquad 10.32$$

Where (P_{mom}) is the wave momentum, (A) is the area, ($\frac{\partial U_{emt}}{\partial t} = P_{emt}$) is the electromagnetic transported power and (P_{pr}) is the wave pressure. The wave pressure also can be found using the definition of the transported power

$$P_{emt} = \frac{\partial U_{emt}}{\partial t} = \frac{\pi}{2}(\frac{1}{2} Z I^2)$$

$$P_{pr} = \frac{1}{cA}\frac{\partial U_{emt}}{\partial t} = \frac{1}{c\pi r_e^2}(\frac{\pi}{4}\mu_o c I^2)$$ Using $(F = \pi\mu_o I^2)$, to get

$$P_{pr} = \frac{1}{c\pi r_e^2}\left(\frac{\pi}{4}\mu_o c I^2\right) = \frac{F}{4}\frac{1}{\pi r_e^2} \qquad 10.33$$

• Relation Between Electromagnetic and Non-Electromagnetic Parameters

The purpose of this section is show the relation between electron's parameters and to show that some electromagnetic parameters can be expressed by purely non-electromagnetic parameters, I will start the derivation with Ohms law

$$mc^2 = \frac{1}{4\pi\epsilon_o}\frac{q^2}{r_e} = \frac{\mu_o c^2}{4\pi}\frac{q^2}{r_e}$$

$$m r_e c = \frac{\mu_o\, c\, q^2}{4\pi}$$

$$S = \frac{q^2}{4\pi} Z \qquad \text{(S is spin angular momentum)} \qquad 10.34$$

$$S = \frac{q^2 Z}{4\pi}(\frac{\pi}{\pi}\frac{\alpha^{-2} f_c^2}{\alpha^{-2} f_c^2}) = \frac{\pi\, I^2 Z}{\omega_s^2}$$

$$S = \frac{2\pi P_z}{\omega_s^2} = \frac{4P_{emt}}{\omega_s^2} \qquad 10.35$$

$$P_{emt} = \frac{\pi}{2} P_z = \frac{1}{4} S\omega_s^2 \qquad 10.36$$

$$P_{emt} = \frac{1}{2}\left(\frac{1}{2} I\omega_s^2\right)\omega_s = \frac{1}{2} K_s\omega_s \qquad 10.37$$

Where (I) is the moment in inertia and (K_s) is the electron's spin kinetic energy. Rearranging equation 10.36 gives

$$S\omega_s^2 = 4P_{emt} = 4(\pi r_e^2)\, S_{pv}$$

$$S_{pv} = \frac{1}{4\pi r_e^2} m r_e c\omega_s^2$$

$$S_{pv} = \frac{1}{4\pi} m\omega_s^3 \qquad 10.38$$

$$S = \frac{2\pi P_z}{\omega_s^2} = \frac{2\pi\,(\frac{1}{2} Z\, I^2)}{\omega_s^2} = \frac{\pi\,\mu_o I^2 c}{\omega_s^2} = \left(\frac{\mu_o\, I}{2 r_e}\right)\left(\frac{2 r_e \pi I c}{\omega_s^2}\right) \qquad 10.39$$

$$S = B\left(\frac{2 r_e \pi c\,(\,\alpha^{-1} f_c q\,)}{\omega_s^2}\right) = B\,\frac{(2\pi\alpha^{-1} r_e)(c f_c q)}{\omega_s^2}$$

$$S = B\frac{\lambda_c(cf_cq)}{\omega_s^2} = \frac{B(\ c^2q\ )}{\omega_s^2}$$

$$S = \frac{B(2\mu_s\omega_s)}{\omega_s^2}$$ (Using equation 2.34) 10.40

$$S\omega_s = 2\mu_sB = mc^2$$

$$\frac{1}{2}I\omega_s^2 = \frac{1}{2}mc^2 = \mu_sB$$ (Using ($S = I\omega_s$)) 10.41

The upper right term in equation 10.40 is

$$2\mu_s\omega_sB = 2I(\pi r_e^2)\omega_s\left(\frac{\mu_{0I}}{2r_e}\right) = (\pi\mu_0I^2)r_e\omega_s = Fr_e\omega_s$$

$$2\mu_s\omega_sB = mc^2\omega_s = 4P_{emt}$$

$$P_{emt} = \frac{1}{2}\mu_s\omega_sB$$ 10.42

11.0 Conclusions

Since most of the ideas in this paper are new, summarizing the conclusions will be about 40% of the full paper length or at least 20 pages, accordingly only major conclusions and notes will be mentioned here, new equations will be shown in blue color, for full conclusions the reader should go to paper body,

Major conclusions and notes

1) If the frequency of a wave is Compton frequency or its multiples, it can generate electrons because waves and electrons are quantized into the same tiny elementary particles which I named phosons where the Compton wave photon and the electron contain the same number of these phosons.
   Each phoson has a mass $\left[\ m_{ph} = \frac{m_e}{f_c}\ \ (kg.s\ )\right]$ and an energy equals to $h\ (J.s)$.
2) The key relation between the electron and Compton wave other than its wavelength and frequency is ($\omega_s = 2\pi\alpha^{-1}f_c$) which relates the wave's phase frequency to the electron's spin velocity.
3) The forces acting on the electron are the magnetic force, the induced tangential force, the centrifugal force, and their equivalent static force by an assumed positive charged electron at the electron axis.
4) The tangential force produced by the induced electric field is ($F = \pi\mu_0I^2$) which is equal to the magnetic force and equivalent to the static force.
5) Compton wave takes a compressed helical shape when it is slowed down to form the electron, the helical shape of the electron is typical to a cylinder shape having a radius (r_e) and a length ($2r_e$).The electron length is inversely proportional to its speed.

6) Slowing down the wave makes the phosons store its reduced translational kinetic energy as a potential intrinsic spinning kinetic energy which makes it gain a steady charge that can interact with other charged particles and magnetic fields (charge and spin are conjoined twins).

7) The electron having its phosons flow as current is equivalent to a current carrying helical conductor which has a magnetic field and flux, inductance, volage, electric field etc. and all are discussed in the paper body.

8) The magnetic field produced by the phosons motion generates a magnetic force, induced electric field and induced voltage which are equivalent to static electric field, force, and voltage produced by an assumed positive charged electron located at the electron's axis where the actual meaning of the self-electrostatic charge and energy can be obtained, the self-electrostatic energy is the total potential energies of the phosons against the magnetic force which keeps the electron's helical shape and the self-electrostatic charge is the total charge of all the phosons forming the electron.

9) The tangential induced electric field and the magnetic field give the electron its electromagnetic properties as an electron and a wave, its pure electromagnetic wave properties can be restored if it is accelerated to the speed of light.

10) The accurate formula to describe the electron's wave – particle duality is $\{(2\pi r_e)(\alpha^{-1} f_c) = c\}$, the one derived by De Broglie is a description of its rotational motion.

11) I am currently doing three researches in three related topics which will give the full idea about my theories and will be accomplished in the near future which are :
   a- A similar model for the proton (proton is typical to the electron but with minor differences which came from its positive charge and location in the nucleus)
   b- A model to describe the waves behavior as particles
   c- A review and restudy of special relativity considering the impact of my theories.

12.0 - List of new parameters

Electron Magnetic Field	B	6.048776 X 10^{11} T
Phoson Magnetic Field	$B_{ph} = Bf_c^{-1}$	4.895456 X 10^{-9} T
Phoson Mass	m_{ph}	7.372497 X 10^{-51} Kg
Electron Spin Angular Velocity	ω_s	1.063871 X 10^{23} rad.s^{-1}
Electron Magnetic Flux	Ø	1.508971 X 10^{-17} Wb
Electron Inductance	L_{in}	5.562391 X 10^{-21} H
Electron Spin Magnetic Moment	μ_s	6.76757 X 10^{-26} J.T^{-1}
Electron Spin Angular Momentum	S	7.695582 X 10^{-37} Kg.m^2.s^{-1}
Electric Field Energy Density	U_e	1.455778 X 10^{29} J.m^{-3}
Magnetic Field Energy Density	U_m	1.455778 X 10^{29} J.m^{-3}
Electromagnetic Energy Density	U_{em}	2.911556 X 10^{29} J.m^{-3}
Pointing Vector	S_{pv}	8.7286255 X 10^{37} W.m^{-2}
Electron Volume	Vol	1.405967 X 10^{-43} m^3
Electron Internal Current	I	2712.810341 A
Phoson Current	i	2.195559 X 10^{-17} A.s
Phoson Charge	$q_{ph} = qf_c^{-1}$	1.296689 X 10^{-39} C.s
Induced Electric Field	E	1.813377 X 10^{20} N.q^{-1}
Force	F	29.053509 N
Electromagnetic Transported Power	P_s	2,177,505,762 W
Electron Free Space Impedance Power	P_z	1,386,243,223 W

12.- REFERENCE

Sine all my ideas in this paper are new, I referred only to references of physics fundamentals

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