“Helical Model of the Electron”

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Abstract

A semiclassical model of the electron is presented based on the Principle of Helical Motion (“A free electron always moves at the speed of light following a helical motion, with a constant radius, and with the direction of movement perpendicular to the rotation plane”). This model interprets the Zitterbewegung as a real motion that causes rotation of the electron spin and its magnetic moment. Based on this model, the quantum magnetic flux and quantum Hall resistance are obtained as parameters of the electron and special relativity theory is derived from the helical motion of the electron. Finally, a fix is proposed for the De Broglie’s wavelength that questions the very validity of the Dirac equation.

Introducing

Quantum mechanics (QM) is considered the most accurate physical theory available today; however, from its formulation, QM has been accompanied by controversy. The controversy is not in the results but in the physical interpretation.

The “Copenhagen Interpretation” of QM given by Bohr and Heisenberg was heavily criticized by many physicists who had participated in the development of the theory. The main critic was Albert Einstein himself, who believed that QM was a statistical and probabilistic theory that was only valid for studying the behavior of groups of particles. Einstein believed that the behavior of individual particles must be deterministic (“God does not play dice”). QM applied to individual particles necessarily leads to logical contradictions and paradoxical situations (e.g., “the paradox of Schrodinger’s Cat.”)

Einstein thought that QM was incomplete. Therefore, there must be a deeper theory based on “hidden variables” that allowed explain how subatomic particles individually. Einstein and his followers were not able to find a hidden variable theory that is compatible with QM; thus, the “Copenhagen Interpretation” was imposed as the interpretation of reference.

If we assume that QM is only applicable to groups of particles, it is necessary to develop a new deterministic theory that explains the behavior of individual particles. The aim of this paper is to propose a semi-classical model of free electrons from the known experimental data.

Free electron oscillation

In 1923, Louis de Broglie suggested that Planck's equation (E = hf) could also apply to the particulate matter. If this hypothesis was correct, the particles would be characterized by a "natural frequency." Taking Einstein's equation ($E = mc^2$) and equating the two energies, we obtain the natural frequency of the electron:

$$f = \frac{E}{h} = \frac{mc^2}{h}$$

This resonant frequency matches the value of the "Compton frequency" of the electron and can be observed experimentally in the "Compton effect." The natural frequency of the electron can be understood as the resonant frequency of the electron in its interaction with electromagnetic waves. In addition to a resonance frequency, this frequency could also mean an actual frequency of "oscillation" or "vibration" of the electron.

If the electron is vibrating at a constant frequency, it generates an electric current equal to the electric charge at the frequency (I = ef). According to Maxwell's equations, all electric current generates a magnetic field. Therefore, if the electron actually vibrates, a magnetic moment associated with this oscillation should be experimentally detected. This magnetic moment of the electron has been detected and measured with great precision. The magnetic moment of the electron is approximately the value known as the "Bohr magneton."

$$\mu_e = \mu_B = \frac{e\hbar}{2m}$$

The Bohr magneton is the magnetic moment corresponding to a unitary charge that rotates with angular momentum equal to the reduced Planck constant:

$$L = mrv = \hbar$$

The relationship between the magnetic moment and angular momentum is called the "gyromagnetic ratio" and has the value "e/2m." This value is consistent with the magnetic moment generated by an electric current rotating on a circular surface of radius r.

$$\mu_e = IS = \frac{ev}{2\pi r}(\pi r^2) = \frac{evr}{2} = \frac{e}{2m}(mrv) = \frac{e}{2m}L$$

The gyromagnetic ratio of the electron can be observed experimentally by applying external magnetic fields; for example, in the "Zeeman effect" or in the "Stern-Gerlach experiment."

$$E = gB = \frac{e}{2m}B$$

At first glance, it seems that the electron is a sphere that rotates on itself with a frequency equal to the Compton frequency, generating an angular momentum (spin) equal to the reduced Planck constant and a magnetic moment equal to the Bohr magneton. However, to calculate the necessary speed rotation of the electron, we must obtain a speed many times higher than the speed of light.

To solve the problem of superluminal rotation speeds, QM defines the electron as a static point charged particle without rotation. Therefore, the magnetic and angular momenta of the electron would have intrinsic values and would not be associated with any real movement. A possible alternative explanation for this apparent contradiction is to assume that the electron is not a sphere.

Ring Electron

In 1915, Alfred Lauck Parson [1] proposed a new theory of the electron with a different geometry. His model assumed that the electron had a ring-shaped geometry and unitary charge circulating in the ring, causing a magnetic field. The electron would behave not only as the unit of electronic charge but also as the unit of magnetic charge or "magneton". Some important physicists of his time, such as David Webster, Lewis Gilbert, and Leigh Page, conducted studies that supported the "Parson magneton" model. The most important of these studies was conducted by Arthur Compton [2], who wrote a series of papers showing that the newfound "Compton Effect" is best explained with Parson's ring electron model, not a spherical electron model. All these studies were compiled in 1918 by H. Stanley Allen in "The Case for a Ring Electron" [3] and discussed at a meeting of the Physical Association. The ring electron model was not widely accepted and was invalidated in 1923 by Schrodinger's wave equation of the electron and quantum mechanics. The ring electron model has been unsuccessfully revisited several times by investigators like Iida [4], Bostick [5], Bergman and Wesley [6], Auvermann [7], Hong and Ryder [8], Gauthier, Charles W. Lucas, and Kanarev.

Other researchers, such as Jennison [9] and Williamson and van der Mark [10] proposed similar ring electron models, with the additional assumption that the electron is actually a photon trapped in a vortex. The collision of an electron with a positron would undo the vortices and release photons. However, none of these authors could adequately explain how an electric charge is generated from a photon, which has no charge.

The ring electron model postulates that the electron has a ring-shaped, extremely thin geometry that is 2000 times larger than a proton. A unitary charge flows through the ring at the speed of light, causing an electric current and associated magnetic field. This model allows us to combine experimental evidence that the electron has an extremely small size (which would correspond to the thickness of the ring) as well as a relatively large size (which would correspond to the circumference of the ring.)

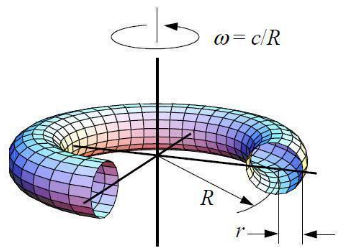


Figure 1: The Spinning Ring Model of the Electron

The circumference of the ring matches the Compton wavelength, while the radius corresponds to the reduced Compton wavelength. Meanwhile, the frequency and angular frequency of the motion match the Compton frequency and reduced Compton frequency, respectively.

$$\lambda_c = 2\pi r = \frac{h}{mc}$$

Substituting the Compton frequency in the formula E = hf, we obtain the same value of energy that provides the formula E = mc^{2}. The movement of the unit of charge around the ring at the speed of light produces an angular momentum (spin) of value:

$$L = mrv = m\frac{\hbar}{mc}c = \hbar$$

The moving charge generates a constant electric current.

$$I = \frac{ec}{2\pi r} = \frac{emc^2}{h} = ef$$

The electric current produces a magnetic field that is induced with a magnetic moment that is equal to the Bohr magneton:

$$\mu_e = IS = \frac{ec}{2\pi r}\pi r^2 = \frac{ecr}{2} = \frac{e\hbar}{2m} = \mu_B$$

The ring acts as a circular antenna. In this type of antenna, the resonance frequency coincides with the length of the circumference. In the case of the electron ring, the resonance frequency coincides with the electron Compton frequency.

This model has problems explaining the nature of the substance that forms the ring as well as its physical characteristics and stability. Any distribution of electric charge of the same sign on a volume involves a huge electromagnetic repulsion force between the parts that would exploit the particle. Actually, the only electrically stable charge distribution is the point charge.

On the other hand, the physical existence of the ring is not necessary. We can assume that the entire electron charge is concentrated in a single infinitesimal point, which we call the Center of Charge (CC), which rotates at the speed of light around a point in space that we call the Center of Mass (CM). With this model of infinitesimal electron rotation, the ring has no substance or physical properties; the ring is simply the path of the CC around the CM.

The CC has no mass, so it can have an infinitesimal size without collapsing into a black hole and scroll to the speed of light without violating the theory of relativity. The electron mass is not a single point but is distributed throughout the electromagnetic field of the electron. This mass corresponds to the kinetic and potential energy of the electron. By symmetry, the CM of the electron corresponds to the center of the ring.

Thus, we replace the geometric static ring electron model with a dynamic electron model that features a perpetual motion loop. In practice, the frequency of rotation is so incredibly high that we can consider that the CC is in all points of the trajectory at the same time. For practical purposes, this dynamic model of the electron is equal to the geometric ring model of the electron.

We can show the principles of this free electron model by making a comparison with the postulates of the Bohr atomic model:

- The CC electron always moves at the speed of light, describing circular orbits around the CM without radiating energy.
- The CC angular momentum equals the reduced Planck constant
- The electron emits and absorbs electromagnetic energy that is quantized according to the formula $E = hf$.
- The emission or absorption of energy implies an acceleration of the CM.

The CC moves constantly without loss of energy, so we can consider the electron as a superconducting ring with a persistent current. Such flows have been experimentally detected in superconducting materials.

With this electron model, the position of the CM of the electron at rest can be established with precision, but it is impossible to establish the position of the CC with an accuracy that is less than the radius of the ring. This feature of the ring electron model is equivalent to the uncertainty principle of QM.

Experimentally, the magnetic moment of the electron is slightly higher than the Bohr magneton. With this model, it is impossible to explain the anomalous magnetic moment of the electron, which leads us to assume that the electron is not really an elementary particle, but there is a substructure. The description of the electron substructure is outside the scope of this electron model.

Quantum LC

By the Biot-Savart Law, the magnetic field at the center of the ring is B = 3.23 x 10^7 Tesla:

$$B = \frac{\mu_o I}{2R}$$

A magnetic field of 30 billion Tesla is gigantic in comparison; the magnetic field of Earth is 0.000005T and the largest artificial magnetic field created by man is only 90T. The magnetic field at the center of an electron is equivalent to the magnetic field of a neutron star!

On the other hand, the electric field in the center of the ring matches the value of the magnetic field multiplied by the speed of light (E = cB = 9.61 x 10^{12} N / C):

$$E = \frac{e}{4\pi\epsilon_0 R^2}$$

Defining a natural frequency for the electron is equivalent to defining a proper time for the electron (T = 1 / f). We can define other parameters of the electron, like the power, which is energy per unit time.

$$P = E/T = Ef$$

The energy of the electron is very low, but the frequency of oscillation is extremely large, which results in a significant power of about 10 gigawatts (P = 1.014 × 10^7 W). In the same line of reasoning, we can calculate the electric potential as the electron energy per unit of electric charge, which gives us a value of approximately half a million volts (5,111 per 10^5 V).

$$V = \frac{E}{e} = \frac{mc^2}{e}$$

We have already calculated the electric current as 20 Amps (I = ef = 19,832 A). Multiplying the voltage by the current, the power is, again, about 10 gigawatts (P = VI).

These calculated values of power, current, voltage, and electromagnetic fields in the center of the ring are extremely high. They could be measured experimentally in the future and serve as a means to validate or disprove this electron model.

The impedance of the electron can be obtained by Ohm's Law, dividing the voltage by the current. The obtained value (25,812 Ohms) matches the value of the quantum Hall effect (QHE). This value is quite surprising, since it is observable at the macroscopic level and was not discovered experimentally until 1980.

$$R = \frac{V}{I} = \frac{h}{e^2}$$

Moreover, according to Faraday's Law, voltage is the variation of the magnetic flux per unit time. So, in a period of rotation,

$$V = \frac{\phi}{T}$$

$$\phi = VT = \frac{mc2}{e}\frac{h}{mc2} = \frac{h}{e}$$

which coincides with the value of the quantum magnetic flux, another macroscopically observable value. This value was expected since, in this model, the electron behaves as a superconducting ring, and it is experimentally known that the magnetic flux in a superconducting ring is quantized.

The natural frequency of the electron implies an oscillatory motion of the charge. This motion of the electron generates a current and associated voltage. This causes the particle to behave as a quantum LC circuit. We can calculate the coefficients of self-inductance (L) and capacitance (C) of the electron, obtaining values L = 2.084 x 10^{-16} H and C = 3.135 x 10^{-25} F:

$$L = \frac{\phi}{I} = \frac{h^2}{mc^2e^2}$$
$$C = \frac{e}{V} = \frac{e^2}{mc^2}$$

Applying the formulas of the LC circuit, we can obtain the values of impedance and resonance frequency, which coincide with the previously calculated values of impedance and natural frequency of the electron.

$$Z = \sqrt{\frac{L}{C}} = \sqrt{\frac{h^2/mc^2e^2}{e^2/mc^2}} = \frac{h}{e^2}$$
$$f = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{(h^2/mc^2e^2)(e^2/mc^2)}} = \frac{mc2}{h} = f$$

The energy of the particle oscillates between electric and magnetic energy, the average value being:

$$E = \frac{LI^2}{2} + \frac{CV^2}{2} = \frac{hf}{2} + \frac{hf}{2} = hf$$

The above calculations are valid for any elementary particle with a unit electric charge, a natural frequency of vibration, and its own energy, which meets the Planck equation (E = hf).

From this result, we can infer that the electron is formed by two indivisible elements: a quantum of electrical charge and a quantum of magnetic flux, whose product is equal to Planck's constant. The magnetic flux of the electron is simultaneously the cause and the consequence of the circular motion of the electric charge.

$$e\phi = h$$

Zitterbewegung

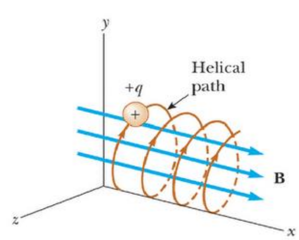
Analyzing possible solutions to the Dirac equation, in 1930, Schrödinger found a term that represents an unexpected oscillation whose amplitude is equal to the Compton wavelength, which he called "Zitterbewegung."

In 1953, Kerson Huang [11] gave a classical interpretation of the Dirac equation, according to which the Zitterbewegung is the mechanism that causes the angular momentum of the electron (spin), and this angular momentum is the cause of the electron's magnetic moment. Bunge [12], Barut [13,14], Zhangi, Bhabha, Corben, Weyssenhoff, Pavsic, David Hestenes [15,16], and Martin Rivas [17] have published many papers interpreting the Zitterbewegung as a real oscillatory motion of the electron hidden in the Dirac equation.

These mathematical analyses attempt to interpret the Dirac equation from the point of view of classical physics, showing hidden electron geometry in the Dirac equation. Hestenes calls this model the "Zitter Electron Model." Each author presents important variations in this model, so we should really call them "Zitter models." These Zitter models are mathematically compatible with quantum mechanics.

Zitter models differ from each other, but all come to the same conclusion, which could be summarized in the Principle of Helical Motion: "A free electron always moves at the speed of light following a helical motion, with a constant radius, and with the direction of movement perpendicular to the rotation plane."

This helical motion of the electron is analogous to the observed motion of an electron in a homogeneous external magnetic field.



The electron model that we present in this paper (which we call **"**Electron Helical Model") has much in common with the Zitter models of Barut and Hestenes, but differs in some important concepts:

- The Zitter models claim to be complete and mathematically formalize the dynamics of the electron with external electromagnetic fields. By contrast, this helical model is restricted to the case of the free electron in the absence of external electromagnetic fields. To treat the electron that is bound to an atom requires the incorporation of additional features into the present model.

- The Zitter models postulate that the electron is an elementary particle, while this helical model assumes the possibility of a substructure of the electron to explain the anomalous magnetic moment.

- The Zitter models assume that the Dirac equation is correct. They develop and interpret the equation in order to find a physical model of the electron. On the contrary, this helical model ignores the Dirac equation and does not assume its validity.

- The Zitter models are relativistic, since they start from the Dirac equation, which is relativistic. On the other hand, this helical model obtains the Lorentz transformation equations of the theory of special relativity as a consequence of the helical motion of the electron.

Theory of Special Relativity

As proposed by TS Natarajan [18], if we start from the helical motion of the electron and assume that the electron is a particle that always travels at the speed of light, it is possible to derive the Lorentz transformations of the theory of special relativity (SRT) as a consequence of this model.

Electron helical motion can be decomposed into two orthogonal components: a rotary motion and a translational motion. The velocities of rotation and translation are not independent, but are constrained by the tangential velocity of the electron, which should be constant and equal to the speed of light.

At the electron at rest, the rotational velocity is equal to the speed of light, as we have discussed above. As you increase the translational velocity, the rotational velocity will decrease. The translational velocity shall not at any time exceed the speed of light.

In the Pythagorean Theorem, the relationship between the three velocities is:

$$c^2 = v_r^2 + v_t^2$$

As the rotational velocity of the moving electron is:

$$v_r = c\sqrt{1-(v/c)^2} = c/\gamma$$

Where gamma is the coefficient of the Lorentz transformation, the base of the SRT is:

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

We multiply the three components by the same factor:

$$(\gamma mc)^2c^2 = (\gamma mc)^2v_r^2 + (\gamma mc)^2v_t^2$$

Substituting the value of the rotational velocity and linear momentum (p), we obtain the relativistic energy formula:

$$E^2 = (\gamma mc^2)^2 = (mc^2)^2 + (pc)^2$$

The rotation period of the electron acts as an internal clock of the electron. As a result, although there is no absolute time in the universe, each electron can always set its proper time. This proper time is relative to the reference frame of the electron and its velocity relative to other inertial reference frames.

As we calculated, the period of rotation of the electron depends on the translation velocity of the electron. The translation velocity is not absolute but, rather, is relative to the inertial reference system. This implies that the proper time of the electron is also relative to the inertial reference system.

The rotation period of an electron at rest is:

$$T = \frac{R}{v_r} = \frac{R}{c}$$

Assuming the electron radius (R) and tangential velocity (v = c) are invariant for any inertial observer, the rotational velocity depends on the translational velocity (v) with respect to the inertial reference frame. The rotation period calculated in the inertial reference frame is:

$$T' = \frac{R}{v_r} = \frac{R}{c/\gamma} = \gamma T$$

What can be interpreted as time expands in proportion to the relative translational velocity. The frequency of the electron is affected inversely:

$$f' = \frac{1}{T'} = \frac{1}{\gamma T} = \frac{f}{\gamma}$$

Furthermore, the distance traveled by the particle is equal to the tangential velocity divided by time. For resting electrons, distance traveled per unit time is:

$$X = \frac{c}{T}$$

For an inertial observer, the tangential velocity remains equal to the speed of light, but the time will be different. What can be interpreted as distances shrink proportionally to its relative speed:

$$X' = \frac{c}{T'} = \frac{c}{\gamma T} = \frac{X}{\gamma}$$

Finally, the angular momentum of the electron at rest is:

$$L = mRv = mRc$$

If we assume that the radius of the electron and the angular momentum are invariant with respect to the inertial observer (R = R ‘, L = L’), the mass must necessarily be relative to the reference system. For the inertial observer moving at a translational velocity (v):

$$L' = m'R'v' = m'R'\frac{c}{\gamma}$$
$$m' = \gamma m$$

which can be interpreted as the electron mass increases proportionally to the relative translational velocity.

Helical Motion

When the translational velocity is uniform, the electron moves along a helical path. The position of the particle is defined by the function r(t), where w is the angular frequency of the electron. The velocity and acceleration are obtained by differentiating the function r(t):

$$r(t) = (Rcos(wt), Rsen(wt), vt) \qquad |r'(t)| = c$$

$$r'(t) = (-v_r sen(wt), v_r cos(wt), v) \qquad |r''(t)| = v_c^2/R$$
$$r''(t) = (-\frac{v_r^2}{R}cos(wt), -\frac{v_r^2}{R}sen(wt), 0)$$

As expected, the magnitude of the velocity corresponds to the speed of light and the acceleration module corresponds to the centripetal acceleration motion.

If the electron is in uniform rectilinear (v = constant), the trajectory of the particle is a cylindrical helix. The geometry of the helix is defined by two constant parameters: the radius of the helix (R) and the “helical pitch” (H). The helical pitch is the spacing between two turns of the helix.

The radius of the helix corresponds to the reduced Compton wavelength. The helical pitch is calculated by multiplying the translational velocity (v) by the time (T). At the same time (T), the helix will be given a complete turn to the rotation velocity.

$$v_t T = H \qquad v_r T = 2\pi R = \lambda_c$$

Equating both times, we obtain the value of the helical pitch:

$$H = \lambda_c \frac{v_t}{v_r} = \lambda_c \frac{v_t}{c/\gamma} = \lambda_c \frac{\gamma v}{c}$$

Finally, we get the rest of parameters representative of a cylindrical helix, such as the curvature and torsion. Depending on Lancret's theorem, the necessary and sufficient condition for a curve to be a helix is that the ratio of curvature to torsion must be constant. This ratio is equal to the tangent of the angle between the plane of osculation with the axis of the helix:

$$h = \frac{H}{2\pi} = \frac{v}{w} = \frac{\gamma R v}{c}$$
$$\kappa = \frac{R}{R^2 + h^2} = \frac{1}{\gamma^2 R}$$
$$\tau = \frac{h}{R^2 + h^2} = \frac{1}{\gamma R}(\frac{v}{c})$$
$$tan\alpha = \frac{\kappa}{\tau} = \frac{R}{h} = \frac{v_r}{v} = \frac{c}{\gamma v}$$

The helical motion can be interpreted as a wave motion with wavelength equal to the helical pitch and a frequency equal to the natural frequency of the electron. Multiplying the two factors, we obtain the translational velocity of the electron:

$$\lambda = H = \gamma \lambda_c (v/c)$$

$$f' = \frac{f}{\gamma} = \frac{mc^2}{\gamma h}$$

$$\lambda f' = (\gamma \lambda_c \frac{v}{c})(\frac{mc^2}{\gamma h}) = (\gamma \frac{h}{mc}\frac{v}{c})(\frac{mc^2}{\gamma h}) = v$$

De Broglie's wavelength

By rearranging the terms, we can express the value of helical pitch, depending on the De Broglie's wavelength:

$$H = \lambda_c \frac{v}{c/\gamma} = \lambda_c \frac{\gamma v}{c}\frac{hm}{hm} = \lambda_c \frac{h}{mc}\frac{\gamma m v}{h}$$

$$\lambda_B = \frac{h}{\gamma m v} \qquad H = \frac{\lambda_c^2}{\lambda_B}$$

This result is surprising and has important implications. Basically, the helical model establishes that the electron wavelength is proportional to the translational velocity, while De Broglie's hypothesis established a wavelength that is inversely proportional to the translation velocity. If we multiply this wavelength by the natural frequency of the electron, we obtain the translation velocity; whereas, if we multiply the De Broglie wavelength by the natural frequency of the electron, we obtain a superluminal speed (!).

De Broglie wanted to avoid real superluminal speeds. He defined this superluminal speed as the "phase velocity" of the wave, and he took various approaches to obtain a "group velocity" equal to the translational velocity of the electron. De Broglie's wave model of the electron is a complex wave that is formed by the superposition of two waves: a carrier wave and a modulated amplitude wave (also known as a "wave packet").

This Helical Electron Model contradicts De Broglie's electron model. In this model, there is no superluminal speed wave or phase-modulated wave, and the De Broglie's wavelength does not correspond with any real length.

It is possible to experimentally test the two theories and see which one is correct. You could emit electrons toward a crystal surface where the theoretical wavelength of the electron coincides with the separation between atoms in the crystal. Such interaction should result in some kind of resonance or interference pattern that could be detected. The big difference between the two theories is the necessary kinetic energy. In the case of the De Broglie wavelength, this energy is about 50 eV; while, in the case of the helical model, the energy required would be about 80 MeV (one million times).

The first experiment was successfully conducted in 1927 by Davisson and Germer. Thus, De Broglie's hypothesis was confirmed. De Broglie and Davisson received the Nobel Prize for these discoveries. The second experiment was never carried out, due to technical limitations of time and the lack of interest in testing alternative theories.

In 2005, Michel Gouanère [20] conducted an experiment in identifying the second wavelength's energy at about 80 MeV. The experiment has not had too much significance, as it contradicts one of the basic pillars of quantum mechanics. However, both David Hestenes [20] and Martin Rivas [21] say that the experiment is very important and provides experimental evidence consistent with the Zitter models of electron. But what about the Davisson-Germer experiment? We think that it is simply an incorrect interpretation of the experimental data. The Davisson-Germer experiment was accepted very quickly because the experiment confirmed the theories of both Einstein and Bohr. Nobody seriously considered other explanations for the results, although certain experimental data disagreed with the theory. However, there are alternative explanations to this experiment. For example, the Alfred Phillips Jr. Source Institute [22] proposes a different explanation: "the incident electrons cause plasma oscillations in the crystal structure that is reflected on the surface as a wave."

Schrodinger based the definition of his equation on De Broglie's hypothesis; so, if the De Broglie's wavelength is incorrect, the Schrodinger and Dirac equations should also be incorrect. How is it possible that equations based on incorrect assumptions enable correct results?

Curiously, if we substitute the translation velocity with the rotation velocity, the De Broglie equation becomes the equation of angular momentum and the diameter of the electron orbit corresponds to its wavelength. Thus, an incorrect interpretation of an incorrect equation allows us to obtain correct results.

Conclusions

If subatomic particles have “spin,” necessarily, “something must be rotating about something.” An electron cannot spin, as it would imply a rotational speed much higher than the speed of light. An alternative is to assume that the electron rotates about a point in space to the speed of light at a distance of the order of the electron’s Compton wavelength, forming a ring-shaped path. The electron magnetic moment is caused by the rotation movement of the unitary charge. By analyzing the Dirac equation and interpreting the Zitterbewegung as an actual rotational motion of the electron, we reach a similar conclusion. Similar semiclassical theories have been raised many times by more than a hundred researchers from the likes of Arthur Compton (1927 Nobel Prize) and David Hestenes (2002 Oersted Medal).

Analyzing the helical motion of the electron obtains the same results as the theory of special relativity. By considering the electron as a resonant LC circuit, the Compton frequency is obtained as resonance frequency and related parameters appear as the quantum Hall resistance and the quantum magnetic flux.

The motion of the electron follows a helical path with a radius equal to the Compton wavelength and a helical pitch inversely proportional to the De Broglie wavelength. This model implies that De Broglie’s hypothesis about the wavelength of the electron is incorrect, raising doubts about the validity of the Schrodinger and Dirac equations, or at least of their interpretation.

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