The Electron and the Quantum Enigma

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Abstract

We show that the wavefunction is associated with a real electromagnetic wave generated by the electron and prove the de Broglie conjecture. This wave creates a space permittivity wave that guides the electron and gives the wavefunction its predictive probabilistic nature.

Key Words**:** Permittivity, Wavefunction, Guiding Mechanism

1 Introduction

In our GeometroDynamic Model of reality – the GDM [1], the elastic space is all there is. In this space there are only two elastic waves – a longitudinal wave and a transversal wave. The electron, as other particles, is a complicated wavepacket of these waves [2], [3]. The electron wavefunction, although it is associated with this wavepacket, does not represent it at all.

The wavefunction with the linear momentum p and kinetic energy U_k of the electron, gives the **probability amplitude** of the electron to be in a specific location at a specific time. This wavefunction, as we show, borrows its features from those of the electron wavepacket. Our goal in this paper is to show that the wavefunction is not merely a mathematical tool, but that it is associated with a real electromagnetic wave, generated by the electron, which creates a space permittivity wave. This permittivity wave, which moves ahead at the speed of light, guides the electron and gives the wavefunction its predictive probabilistic nature.

In the double-slit experiment, this electromagnetic wave creates the interference pattern that modulates spatially the permittivity of space. We assume that this pattern is retained for some time, which is determined by a relaxation time not known to us. This time should be at least the transit time for the electron to move from the slit to the screen.

By generating this electromagnetic wave the electron is supposed to lose energy. The mechanism by which this energy is returned to the electron is not clear.

Without reading our papers, the contentions and discussion in this paper will be considered an absurdity.

This paper complements our paper [6] titled “The Photon and the Quantum Enigma”.

2 The Electron in the GDM

In our GeometroDynamic Model of reality - the GDM [1], the elementary charge of the electron rotates around a geometric center with an angular frequency $\omega = U/\hbar = \gamma\, U_0/\hbar$. For a geometric center at rest $\gamma = 1$, [2] and in motion $\gamma > 1$, [3].

Thus the electron, even at rest, creates a field that can be decomposed to mainly a steady DC field, and a minute AC alternating electromagnetic field. We take the terms AC (Alternating Current) and DC (Direct Current), from the jargon of electrical engineers. This AC electromagnetic field component alternates at the angular frequency:

$$\omega = U/\hbar \tag{1}$$

Note that the GDM model of the electron at "rest", [2], yields the radius and mass of the electron and its anomalous magnetic moment.

Our derivation and calculation of the electron mass gives:

$$M_e = \frac{s^2\sqrt{2}}{\pi(1+\pi\,\alpha)} \cdot \sqrt{G^{-1}\alpha\hbar c^{-3}} \qquad s = 1 \ ([s^2] = L^2T^{-2})$$

A dimensionality check: $[G^{-1}] = ML^{-3}T^2$ $[\alpha] = 1$ $[\hbar] = ML^2T^{-1}$ $[c^{-3}] = L^{-3}T^3$ Thus:

$$M = [s^2\sqrt{G^{-1}\alpha\hbar c^{-3}}\,] = L^2T^{-2}(ML^{-3}T^2\cdot ML^2T^{-1}\cdot L^{-3}T^3)^{1/2} = L^2T^{-2}(M^2L^{-4}T^4)^{-1/2} = L^2T^{-2}ML^{-2}T^2 = M$$

M_e (calculated) = $0.91036 \cdot 10^{-27}$gr

M_e (measured) = $0.910938356(11) \cdot 10^{-27}$gr

Note also that this model of the electron in motion, [3], yields the Lorentz Transformation; in a similar way to Lorentz.

3 Space Permittivity

The electromagnetic field around the electron is affected by the vacuum state polarization [4]. This was verified experimentally [5]. Instead of using the term Vacuum State we use the term **Space Permittivity**, and for the following reason.

The GDM understanding of the Vacuum State is different from the current understanding, in which the Dirac Sea is only one component of the Vacuum State, out of the many ground states of all the fields [4]. We show, [4], [6], that the Dirac Sea is the "sea" of Photoms – Photom Sea, which is the ground state of photons of the electromagnetic field. These photoms are of two types - the positive photom, which carries the oscillating elementary positive charge and the negative photom that carries the oscillating elementary negative charge. In the GDM the Photom Sea is the entire Vacuum State, since the only field that exists is the stress and strain of space, [7].

However, delving into this subject is not crucial for an understanding of this paper.

Thus, AC components, related to internal motions in the electron, generate waves in space permittivity (a wave of density of the photoms).

In the double-slit experiment, the known interference pattern is related to the AC field generated by the electron moving towards the slits. This interference pattern is a pattern in space permittivity that affects the electron motion by a lateral acceleration that deflects it – guides it.

The Doppler Effect causes this field to have a shorter wave-length in front of it. This observation leads us to **a derivation of the de Broglie conjecture**.

4 The de Broglie Conjecture

In his Ph.D. thesis, de Broglie conjectured the existence of a periodic phenomenon (internal clock) in the electron, which is of **unknown nature** and is associated with its energy (in analogy to the photon):

The self-energy of a moving electron is:

$$U = \gamma U_0 \tag{2}$$

The angular frequency of the AC component created by the moving electron is thus:

$$\omega = U/\hbar = \gamma U_0/\hbar \tag{3}$$

where $\omega_0 = U_0/\hbar$.

The wavelength of this AC component is, however, shortened by the Doppler Effect and the angular frequency is increased to become ω_D. For $v << c$ we get the approximated relationship:

$$\omega_D = \omega\,(1+ v/c) \tag{4}$$

The source of the electrons creates, on average, an AC component which is similar to that of the moving electron due to internal motions. Thus their ω is approximately the same.

If space response is non-linear the AC components, of the source and the moving electron, create new $\omega_D \pm \omega$ AC components in front of the moving electron. Of interest to us is the component with the minus sign. Using equation (4) we get:

$$\omega_D - \omega = U/\hbar\,(v/c) = Mc^2/\hbar\,(v/c) = (M\,v/\hbar)\,c = (p/\hbar)\,c\ .$$

The frequency of this component is:

$\upsilon = (\omega_D - \omega)/2\pi = (p/h)c$ and since $\lambda\upsilon = c$ the wavelength of this component is:

$\lambda = p/h$ **de Broglie Wavelength** (5)

This is, in a way, a proof of the conjecture.

This wave moves at the speed of light, enters the slits in the interference experiment and creates the spatial interference pattern between the slits and the screen.

5 On the "Wavefunction" Spread in Space and its Energy

5.1 The Spread

In a typical experimental setup with electrons [6]:

An electron beam with energy of 600 eV was generated with a thermionic tungsten filament and several electrostatic lenses. ...

...The individual slits are 50 nm ($5\cdot10^{-6}$cm) *wide ′ 4 μm tall with a 150 nm support structure midway along its height, and separated by 280 nm* ($2.8\cdot10^{-5}$cm). ....

$U = 600\ eV = 600\cdot1.6\cdot10^{-12}erg\ \sim 10^{-9}erg$ (1)

Since $U = 1/2\ M_e v^2$, (1) and $M_e = 10^{-27}$gr give:

$v \sim 10^9\ cm\ sec^{-1}\ \ (\sim 0.03c)$ (2)

Hence the momentum $p = M_e v$, using M_e and (2), is:

$p = 10^{-18}\ gr\ cm\ sec^{-1}$ (3)

The de Broglie wavelength:

$\lambda = h/p$ (h Planck constant) (4)

is:

$\lambda \sim 6\cdot10^{-9}cm$ (5)

Thus the number of λ units that can enter a slit is:

$(Slit\ width / \lambda) = 5\cdot10^{-6}cm/ 6\cdot10^{-9}cm \sim 10^3$ (6)

The **number of λ units** between the slits is:

(Slit separation / λ) $= 2.8\cdot10^{-5}\text{cm}/6\cdot10^{-9}\text{cm} \sim 5\cdot10^{3}$ (7)

To create the interference pattern a wavefunction created by a particle must spread in space around it to cover both slits. This zone of space should contain many orders of magnitude of λ units, and its linear dimension is determined by the boundary at which the energy density of the wave equals the energy density of the vacuum energy density (fluctuations).

5.2 On the Energy

A quant of energy of the wave in the example above, using (5), is:

$U = h\upsilon = hc/\lambda \sim 3\cdot10^{-8}\text{erg}$ (8)

This energy is about 0.03 times the self-energy of the electron, which is $\sim 10^{-6}$erg.

We ignore the possibility that in creating the wave the particle exchanges (emits and absorbs) such amounts, (8), of energy.

6 The Vacuum State as a Dielectric Fluid

6.1 A Dielectric Fluid

In **quantum field theory**, the **vacuum state** is the quantum state with the lowest possible energy for each and every physical field. Additional related terms for the vacuum state are **Zero-point Energy** and **Zero-point Fluctuations**.

In our GeometroDynamic Model of reality – the GDM [7] we consider space to be the only fundamental entity that exists. We show that the vacuum state contains **only** the ground state space quantized vibrations, which are the ground state photons - the photoms [4].

We also show, [8], that the ground state gravitons – the gravito**m**s, are identical to the photo**m**s. Since the core of the positive and the negative photoms are the oscillating bivalent elementary charges [4] the GDM ground state can be looked upon as the **Dirac Sea** [4]. This Dirac Sea is a **dielectric fluid** responsible for **space polarization** [9].

6.2 The Dielectric Fluid Patterning by the Wavefunction

The Wavefunction being an electromagnetic wave creates density waves of photoms, which are actually waves of a dielectric fluid. The interference behind the slits creates spatial patterning of the dielectric fluid. This is a spatial interference pattern of permittivity.

Similar ideas have already appeared in the literature, see S. Colin and W. Struyve, [12]: A Dirac sea pilot-wave model for quantum field theory (2007)

The Dirac sea pilot-wave model can be seen as a possible continuum generalization of a lattice model by Bell. It can also be seen as a development and generalization of the ideas by Bohm, Hiley and Kaloyerou, who also suggested the use of the Dirac Sea for the development of a pilot-wave model for quantum electrodynamics.

7 The Guidance Mechanism

In a double-slit experiment the electron travels through one slit. The AC waves, created by the moving electron and the electrons in the source, pass through both slits and interfere. As the electron exits a single slit, the direction it travels is altered by the permittivity wave, created by the interference. The electron is attracted to space zones with larger concentrations of photoms [3]. This attraction, by the permittivity wave, is the guidance mechanism, see Section 8.

In the year 2011 it was shown [16] in a "Weak- Experiment" [17] that a single photon, in the Double-Slit experiment, goes all the way from the source to the screen through only one slit. The photon follows a trajectory known as the D. Bohm trajectory [18].

Experiments with other elementary particles, atoms, molecules and even microscopic bodies should give similar results.

8 The Guiding Mechanism – Numerical Estimations

In the experiment presented in Section 3, the electron moves a distance d ~30cm from the slits to the screen, with the velocity:

$$v \sim 10^{9}\ \text{cm sec}^{-1} \quad (\sim 0.03c) \qquad (2)$$

The time to cross the distance d is:

$$t = d/v = 3\cdot10^{-8}\text{sec} \qquad (13)$$

In the following example, the electron is deflected by ~1mrad in the zone between the slits and the screen. In this case the electron hits the screen perpendicular to the original direction of motion, a distance d'= 0.03cm. The central acceleration needed to cause this deflection is:

$$g = 2\cdot d'/t^{2} = 2\cdot0.03/9\cdot10^{-16} \sim 6\cdot10^{13}\text{cm sec}^{-2} \qquad (14)$$

This acceleration, (14), should be caused by an induced positive image of the electron in the anisotropic permittivity sea around it. This anisotropy is created by the interference of the relevant waves coming from the slits. The force between the created image, which is of the same absolute elementary charge, for a distance d''< 0.003cm from the electron is:

$$F = Q^{2}/d''^{2} \sim 2.5\cdot10^{-14}\ \text{dyn} \qquad (15)$$

And the acceleration is:

$$F/M = 2.5\cdot10^{-14}/10^{-27} = 2.5\cdot10^{13}\text{cm sec}^{-2} \qquad (16)$$

The calculated accelerations (14) and (16) agree.

Thus a change in the permittivity causes a major central acceleration that deflects the electron.

In atomic orbits the AC wave propagation forwards and backwards creates a standing wave. The guiding mechanism of this wave keeps the electron stable in its orbit.

9 Double-Slit Experiments with Large Neutral Molecules

Interference has been demonstrated with photons, electrons, neutrons, atoms and large neutral molecules. An example for a large molecule is the soccer-ball-shaped Fullerene molecule with 60 carbon atoms. Another example is an organic molecule with 810 atoms in a single particle exceeding a mass of 10000 amu [11]. This subject, however, is out of the scope of this paper.

10 The Electron Wave Function

We consider the **Electron Wave Function** to be related to the **Permittivity Wave** created by the electron (Section 4):

$\psi = A\cos(2\pi/\lambda - \omega t)$ with $2\pi/\lambda = 2\pi p/h = k$ (p the electron momentum)

The angular frequency is: $\omega = \hbar\omega/\hbar = U/\hbar$.

U is the quant of energy of the wavy permittivity field. It is, however, related to the kinetic energy of the electron, as we show in Section 4.

We express the wave function in a complex form, as: $\psi = A\, e^{i(kx - \omega t)}$

The **momentum connection** is: $\partial\psi/\partial x = ik\,\psi = ip/\hbar\,\psi$ (17)

The **energy connection** is: $\partial\psi/\partial t = -\,i\omega\,\psi = -\,iU/\hbar\,\psi$ (18)

When an **operation** on a function returns the function times a constant, that constant is called an **eigenvalue**, and the function is an **eigenfunction**.

For the electron:

$p_{operator} = -i\hbar\,\partial/\partial x$

$U_p = ½\,Mv^2 = p^2/2M$

For a wave ($U = U_w$):

$U_{operator} = i\hbar\, \partial/\partial t$

$U = \hbar\omega$, but $\lambda \cdot \upsilon = h/p \cdot U/h = U/p$ and since $\lambda \cdot \upsilon = c$ the energy of our wavefunction is thus:

$$U = pc \tag{19}$$

For our electron $U = Mvc = 10^{-27} \cdot 0.03c \cdot c = 3 \cdot 10^{-8}$erg, ~30 times **smaller** than the self-energy of the electron: $U_e \sim 0.8 \cdot 10^{-6}$erg .

11 Summary

Delving into Quantum Mechanics (QM), a theory with "point-like and structureless" photons and electrons cannot yield a resolution of its enigma. To solve the QM enigma, as we have done, requires good models of the photon, the electron and the vacuum state

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