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On the Electron Magnetic Moment "Anomaly"

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INDEX - Electromagnetic mechanics (The 3-Spaces Model)

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On The Electron Magnetic Moment Anomaly

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Abstract:- It can be shown that the difference between the experimental value of the electron magnetic moment and that of the Bohr magneton is due to the magnetic drift of the electron's carrying energy induced at the hydrogen atom ground state gyroradius, corresponding to the electron being forced to constantly change direction as it moves on a closed orbit about the nucleus in an isolated hydrogen atom, instead of moving in a strait line.

Keywords:- Energy density, gyroradius, Bohr magneton, magnetic moment anomaly, circular motion, straight line motion, electron g factor, magnetic drift, first principles, isolated hydrogen atom.

I. Straight Line Motion and Equal Electric and Magnetic Energies Densities

Let us first summarize the various elements that must be considered to address the issue of the long standing still unexplained difference and seen as an anomaly in classical physics, between the theoretically obtained Bohr magneton and the actual experimentally measured so-called "electron magnetic moment".

It was verified in a previous Reference, ([1], Equation (35) and associated footnote), that equal local electric and magnetic energy densities imposes straight line motion to free moving localized photons and also of massive elementary particles, in conformity with Maxwell's theory.

The value of the Bohr magneton (μ_B) is obtained from the electron theoretical gyromagnetic moment equation, that is:

$$\frac{e}{m_o} = \frac{\mu_B}{S_z}, \quad \text{where } S_z = h/4\pi, \quad \text{so} \quad \mu_B = \frac{eh}{4\pi\, m_o} = 9.27400899E-24\ \text{J/T} \qquad (1)$$

We also determined in Reference [1] that the magnetic field of an energy quantum equal to that induced at the Bohr rest orbit ([1], Equation (18)) involves exactly half of the energy induced at this distance from the nucleus ([1], Equations (26) and (27), and associated footnote), which means that the so-called Bohr magneton (μ_B) **cannot possibly be a property of the electron proper**, but is rather a property of its carrying energy as induced at the Bohr gyroradius.

Now, the 3-spaces expanded Maxwellian space geometry [3] reveals that this magnetic energy can only oscillate at its rated energy frequency between an electric state and a magnetic state, a magnetic state whose moment can be experimentally measured.

For straight line motion, either as free photons or carrying-energy for massive particles, this cyclically oscillating energy will completely cross over from one state to the other at each cycle, which is what guarantees equal local density of energy for both electric and magnetic aspects during each cycle in this model, which in turn is the mandatory condition for straight line motion for free moving energy as shown from Maxwell's 4^{th} equation, and also straight line motion for massive charged particles as shown by the Lorentz equation, respectively summarized by the two following equations:

$$c = \frac{\mathbf{E}}{\mathbf{B}} \text{ from Maxwell's } 4^{th} \text{ equation , and } \quad v = \frac{\mathbf{E}}{\mathbf{B}} \text{ from the Lorentz equation} \qquad (2)$$

We also verified ([1], Equation (33)) that the theoretical magnetic field of the energy quantum induced at the Bohr orbit can be calculated with equation:

$$\mathbf{B}_0 = \frac{\mu_0 \pi e c}{\alpha^3 \lambda^2} \qquad (3)$$

and that the relation between this magnetic field and the theoretical Bohr magneton is given by Equation ([1], Equation (25)):

$$\mathbf{B}_0 = E / 2\mu_{\mathbf{B}} = 235051.735 \text{ T} \qquad (4)$$

where energy E is of course the Bohr rest orbit energy (4.35974377E-18 Joules) and the Bohr magneton is of course equal to 9.27400899E-24 J/T as calculated with Equation (1).

II. Circular Motion and the Bohr Magneton

The big question now is:

How is it that the Bohr magneton, theoretically meant to involve an electron **translating on a closed circular orbit** about the nucleus, can thus be equated to the magnetic field of a free electron **moving in straight line** with the same energy?

In 1909, Samuel Jackson Barnett [4] discovered that if a rod of demagnetized ferromagnetic material is suspended to a thin wire and made to rotate by any mechanical means, the rod becomes magnetized and that the intensity of the resulting macroscopic magnetic field proved to remain directly proportional to the angular velocity of the rod as the velocity was caused to vary!

We analyzed in separate Reference [5] that this could only be due to the momentum energy of the unpaired electrons in the demagnetized rod to all align orthogonally with respect to the rotation axis provided by the supporting thread, which causes the local magnetic fields associated to each momentum energy component that supports circular translational motion of each of these electrons to align parallel to each other perpendicularly to this common direction of motion and consequently add up to become detectable by addition at the macroscopic level, and to logically intensify as their velocity, thus their energy, is increased.

III. Circular Motion and Unequal Fields Energy Density

On the other hand, it is well understood in circular particles accelerators circles ([6], p. 43) that when an electron is forced to move in a magnetic field that is not counterbalanced by an equal energy density electric field, it will start moving in a circle and if the magnetic field is increased further, the radius of that circle will diminish further.

The fundamental relativistic equation used in all existing closed circuit high energy accelerators, including the recently activated LHC, is the following:

$$qv\mathbf{B}_o = \gamma \frac{m_o v^2}{r_o} \tag{5}$$

From which the particle's magnetic orbit radius (named the gyroradius) equation is drawn:

$$r_o = \gamma \frac{m_o v}{q\mathbf{B}_o} \tag{6}$$

The Barnett effect effectively confirms that when electrons are forced to move in a circle, they will generate a magnetic field, which by definition will not be counterbalanced by an equal energy density electric field, since local equal energy density of electric and magnetic fields would mandatorily cause straight line motion of the charges involved, and that this magnetic field will increase as the electron's translation velocity (thus the associate carrying energy) is increased.

So why shouldn't the same Barnett effect also apply to a single electron forced into moving in a circle about an isolated proton (as in an isolated hydrogen atom)?

What do we know about the magnetic moment of the electron besides the Bohr magneton, which is calculated from theory (Equation (1))? We know from experimental measurements that have been extensively carried out since the 1930's that the actual magnetic moment of the electron in the hydrogen atom rest orbital is measurably higher than the Bohr magneton!

What a surprise in light of all of these considerations, that the real magnetic moment of the electron in the hydrogen atom rest orbital would be higher than the Bohr magneton since we verified in Article [1] that the theoretically calculated Bohr magneton implicitly involves equal electric and magnetic energy densities associated to **straight line motion** of an electron having the same energy as the Bohr ground state energy, <u>in blatant contradiction</u> with the state of the actual electron captive in the fundamental state of an isolated hydrogen atom which is **forced to move in a circle**!

The difference between the Bohr magneton value and the experimental value is typically represented by a ratio of the latter over the former. The currently accepted value for this ratio, termed "**The electron magnetic moment anomaly**" ([2], p.1-3) is approximately:

$$\frac{\mu_e}{\mu_B} = 1.001159653 \tag{7}$$

which sets the current value ([2], p.1-3) of the experimentally verified electron magnetic moment to

$$\mu_e = 1.001159653 \times \mu_B = 9.28476362 \text{ E}-24 \text{ J/T} \quad (8)$$

IV. The Electron g Factor

The electron magnetic moment (**μ_e**) is currently calculated from the classical gyromagnetic moment equation previously mentioned (1) modified by the introduction of the **g factor of the electron**, whose definition lies beyond the scope of this text, and whose value, theoretically set at 2, is further ad hoc finely corrected to g/2 =1.001159653 to account as precisely as possible with the experimentally measured value of **μ_e** :

$$\mu_e = \frac{g}{2} \frac{eh}{4\pi m_o} = 9.28476362\text{E}-24 \text{ J/T} \quad (9)$$

Note that this ratio is approximate to a certain extent since it can be measured only very indirectly and involves values for all hyperfine sub-states of the ground state of the hydrogen and deuterium atoms. For example, Julian Schwinger's 1947 paper on this issue [7] rates it at 1.001162.

More recently in Reference [8], that is in 2006, the **g/2 factor** was established at 1.00115965218 with a different method. So any value in this range is likely to physically apply to one or other of the actual states or to a mean value of the ground level state depending on the particular circumstances of measurement.

V. Higher Local Magnetic Energy Density in case of Circular Motion

So this higher measured magnetic moment, coupled with the fact that the isolated hydrogen atom ground state electron can only move in a closed orbit, however uncertain its position may be at any given moment, obviously reveals that the magnetic field of the carrying energy of this electron will involve a magnetic carrying energy density higher than its electric carrying energy density since we know that an equality would mandatorily involve a straight line motion of the electron.

VI. Lower Corresponding Local Electric Field in case of Circular Motion

This means that the energy of the electron carrying energy magnetic field will be increased while that of its corresponding electric field will be diminished in proportion to account for the physical fact that the electron is forced to move in a closed circle, while the mean total amount of carrying energy at the Bohr orbit has to remain invariant given that this total amount is dependent only on the mean distance to the nucleus.

VII. The Electron Magnetic Drift g Factor is an *Ad Hoc* Quantity

Let us emphasize here that the electron g factor, being an ad hoc quantity, **is not calculated from first principles**, since it is established only by comparing the experimentally measured electron magneton with the theoretical Bohr magneton. This in turn means that up to now, no theory has been able to link the observed magnetic drift associated with circular motion of elementary particles to first principles!

However, the 3-spaces model provides ample reasons to conclude that such forced stress drift of energy from the electric state towards the magnetic state of the carrying energy of massive charged particles captives of circular orbits is directly linked to, and varies with, the distance between the interacting charged particles. In other words, in accordance with observation, the tighter a closed circle that an electron is forced into will be, the more extensive will be the drift of its carrier-photon cycling energy from its electrical state towards its magnetic state.

VIII. Magnetic Drift due to Circular Motion, or due to distance to the nucleus, from First Principles

We will see presently that Equation (33b) from previous Reference [**9]** making use of distance related energy levels, or Equation (49) from the same reference making use of corresponding energy wavelengths, allow calculating **from first principles** a value in the proper range without the need for any *ad hoc* corrective factor since both equations have been derived from first principles. Note that Equation (55) derived from Special Relativity in Reference [1] is identical to Equation (49) derived from the 3-spaces model in Reference [9].

Both Equations (33b) and (49) from Article [9] in fact, allow calculating an effective energy drift ratio towards the magnetic state for the whole range of possible interaction distances down to and including those of quarks up and down inside nucleons, thus possibly providing a direct theoretically derived method to explain the drift of the unit charge of the electron to the fractionary charges of quarks up and down ([10], Chapter 17) and the drift ratio of the energy of their local carrying-photons towards their respective magnetic fields, which could allow precise calculation of the observed magnetic moment of nucleons, as we are going to do in coming Reference [12].

Now why should these equations be likely to provide such a ratio?

Let us consider that they already provide a ratio of the actual relativistic velocity of a massive particle over the speed of light, calculated from the absolute wavelength of the energy related to the orbital distance that an electron would cover about an isolated hydrogen nucleus if it orbited at the Bohr radius, which is the mean distance of presence of the orbital occupied by the electron energy in the ground state of the isolated hydrogen atom. Let us consider Equation (49) from Reference [9], for example, that we reproduce her

$$\frac{v}{c} = \frac{\sqrt{\lambda_C(4\lambda + \lambda_C)}}{(2\lambda + \lambda_C)} \tag{10}$$

where λ_C is the electron Compton wavelength and λ will be here the absolute wavelength of the electron carrying energy on the Bohr orbit.

Or Equation (33b) from the same reference

$$\frac{v}{c} = \frac{\sqrt{4EK + K^2}}{2E + K} \tag{11}$$

where E is the energy captive of the electron rest mass and K is the kinetic energy induced at the distance separating the electron orbit and the nucleus (here, the Bohr radius as a mean distance).

The direct relation of this velocity ratio to electron magnetic moment is that the velocity involved is the actual relativistic velocity that a free electron would have when moving in a straight line, when the energy densities are equal for both the electric and the magnetic fields of its carrying energy, as analyzed in Reference [1], when possessing an energy exactly equal to that induced at any given gyroradius about a hydrogen atom nucleus.

We will see now that dividing either of these equations by $\boldsymbol{2\pi}$ to involve a relation perpendicular to the direction of motion of the electron, as a gyroradius is with respect to the direction of motion of the electron on a circular orbit will provide a ratio in the exact values range of the *ad hoc* electron g factor.

Let us now calculate the mean magnetic drift ratio for the hydrogen ground state with Equation (10), where λ_C = 2.426310215E-12 m is the absolute wavelength of the rest mass energy of the electron and λ = 4.556335256E-8 m is the absolute wavelength of the energy induced in the electron at the Bohr radius (in this example, the Bohr gyroradius energy)

$$\text{magnetic\_drift} = \frac{\delta\mu}{\mu_B} = \frac{\sqrt{\lambda_C(4\lambda + \lambda_C)}}{2\pi(2\lambda + \lambda_C)} = 1.161386535\,\text{E} - 3 \tag{12}$$

By using the proper absolute mean carrying energy wavelength of each orbital that an electron can occupy in any atom, the proper magnetic drift ratio will be obtained for the particular gyroradius considered, which will allow calculating the pertaining local carrying energy's **drifted magnetic field** consistent with that orbital radius and the associated **reduced electric field** of this electron's carrying energy.

$$\mathbf{B}_d = \mathbf{B}_0 \text{ x } (1 + \text{magnetic\_drift}) = 235324.3134 \text{ T} \tag{13}$$

In other words, given that half of the carrying energy of an electron oscillates between the electric and magnetic states during each cycle, part of it will be prevented by the stress due to the closed circuit rotation from completely transferring to the electric state. So that during each cycle, the mean energy making up the local magnetic field of the carrying energy will become equal to **(E/2) x (1 + magnetic drift)** and the mean energy making up the corresponding local electric field will become **E – [(E/2) x (1 + magnetic drift)]**, this difference in the resulting mean energy densities between the local electric and magnetic states then directly relates the magnetic drift to this particular gyroradius.

Alternately, the reciprocal Equation [11] making use of energy can be used to cover the same complete range of possible magnetic drift ratios, where E= 8.18710414 E-14 joules is the energy making up the rest mass of the electron and K = 4.359743805 E-18 joules is the carrying energy of the electron (in this example, the Bohr gyroradius energy)

$$\text{magnetic\_drift} = \frac{\delta\mu}{\mu_B} = \frac{\sqrt{4EK + K^2}}{2\pi(2E + K)} = 1.161386535\,\text{E - 3} \tag{14}$$

Now, the augmented magnetic field ($\mathbf{B}_d$) from Equation (13) that must physically exist at the Bohr radius due to the closed orbit circular motion involved is clearly observed to be increased beyond the value that it would have if the electron was moving in straight line with the same energy. Actually, this increased magnetic field is equal to that of a higher energy free moving photon or carrying photon that would be moving in straight line, in fact, a higher energy of which this magnetic field would constitute exactly half of the total complement of energy of this increased energy photon when moving in straight line

But since calculation of the corresponding electron magnetic moment ($\boldsymbol{\mu}_{\mathbf{e}}$) requires using the energy corresponding to the increased magnetic field and that this energy corresponds to half the energy of that higher energy photon, we need to calculate the energy of that higher energy photon before proceeding.

Equation (3) provides us with the key to this calculation since the only variable involved is the wavelength of the increased magnetic field. So

$$\text{From } \mathbf{B}_d = \frac{\mu_0 \pi e c}{\alpha^3 \lambda^2} \text{ we define } \lambda = \sqrt{\frac{\mu_0 \pi e c}{\alpha^3 \mathbf{B}_d}} \tag{15}$$

And since E=hc/λ , we can write

$$E = h\sqrt{\frac{c\,\alpha^3\,\mathbf{B}_d}{\mu_0\,\pi\,e}} \tag{16}$$

So, from theory, and without using any ad hoc constant, we now obtain for the magnetic moment of the electron at the Bohr radius the following value:

$$\mu_{er_0} = \mu_B \times 1.00116138653 = 9.284779694\,E - 24\,J/T \tag{17}$$

which stands barely outside the rated standard relative 4.0E-6 uncertainty factor of the measured value of 9.28476362 E-24 J/T.

As a final observation, we observe that the phrase "**electron magnetic moment**" is quite a misnomer since its value specifically pertains to the specific mean carrying energy of the electron in the ground state of the isolated hydrogen atom, that is, the energy of its carrier-photon, and should be renamed accordingly

IX. Deriving the Fine Structure Constant (α) From Theory

Better yet, the currently recognized first principle derivation of the so-called *electron anomalous magnetic moment* was initially established by Julian Schwinger in 1948 as being equal to the fine structure constant divided by **2π** [7], but was not related at the time to the magnetic drift being described in this article:

$$\text{magnetic\_drift} = \frac{\alpha}{2\pi} = 1.161409727\,E - 3 \tag{18}$$

This established the *anomalous electron magnetic moment* as being a constant, while we just found out that it is only one of many possible values, this one being the specific *variable magnetic drift* of the magnetic energy of the electron carrier-photon at the specific gyroradius of the mean rest orbital of the hydrogen atom.

Comparing the value obtained from Equation (18) with the latest experimental value obtained in 2006 [11], that sets the g/2 factor at 1+ 1.15965218E-3, we can observe that the value obtained from this entirely different approach from electromagnetic Equations (12) and (14) of 1.161386535E-3 is practically identical to that obtained by Schwinger, that is, standing within 2.319211E-8 of α/2π. But the difference between these values obtained from theory and the actual experimental measurement still remains to be explained.

What this identity of Schwinger's result with that of Equations (12) and (14) means is, in fact, that when the electron Compton wavelength and the wavelength of the adiabatic energy induced for the electron at the mean rest orbital in an isolated hydrogen atom are used to resolve Equation (10), we obtain the exact value of the fine structure constant:

$$\alpha = \frac{\sqrt{\lambda_C(4\lambda + \lambda_C)}}{2\lambda + \lambda_C} = 7.297206813E-3 \quad (19)$$

Similarly, when the energy of the electron rest mass and the carrying energy of the electron on the mean ground state orbital of an isolated hydrogen atom are used to resolve Equation (11), we also obtain the exact same result:

$$\alpha = \frac{\sqrt{4EK + K^2}}{2E + K} = 7297206813E-3 \quad (20)$$

Since the electron Compton wavelength is a constant related to the invariance of the electron rest mass energy, the level of adiabatic energy in excess becomes the only variable in the equation, and can *de facto* represent the energy level of any orbital in an atom, to allow calculating its specific magnetic drift with Equation (12) or else with Equation (14).

X. Conclusions

As a final observation, we observe that the phrase “**electron magnetic moment**” is quite a misnomer since its value specifically pertains to the specific mean carrying energy of the electron in the ground state of the isolated hydrogen atom, that is, the energy of its carrier-photon, and should be renamed accordingly

There is thus ground to conclude that the so-called magnetic moment "of the electron" is only one discrete state of the whole range of all possible carrying-energy magnetic moments that depend directly on the electron gyroradius within atoms.

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