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Unraveling the Mystery of 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 carrying energy induced at the hydrogen ground state gyroradius, corresponding to the electron having to move in a circle about the nucleus.

Let us first summarize the various elements that must be considered to address the issue of the long standing "anomaly" observed in comparing the experimentally measured so called "electron magnetic moment" with that obtainable from theory.

It was verified in a previous paper ([1]) that equal local electric and magnetic energy density for free electromagnetic energy implies straight line motion[1] of free moving energy, in conformity with Maxwell's theory. Let us also recall that the Bohr magneton is traditionally calculated with the gyromagnetic moment equation:

$$\frac{e}{m_o} = \frac{\mu_B}{S_z}, \text{ where } S_z = h/4\pi, \qquad \text{so} \qquad \mu_B = \frac{eh}{4\pi m_o} \tag{1}$$

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

[1] See ([1], equation (35)) and associated footnote.

Now, the 3-spaces expanded Maxwellian geometry of space model ([3]) reveals that this magnetic energy can only oscillate at the rated energy frequency between an electric state[2] and a magnetic state, a magnetic state however whose moment can be experimentally measured.

For self sustaining 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 in this model equal local density of energy for both electric and magnetic aspects during each cycle, which in turn is the mandatory condition for self sustaining straight line motion for free moving energy as shown by Maxwell's 4th equation, and also straight line motion for massive charged particles as shown by the Lorentz equation, respectively summarized by these equations:

$$c = \frac{\mathbf{E}}{\mathbf{B}} \text{ for Maxwell's } 4^{th} \qquad \text{and} \qquad v = \frac{\mathbf{E}}{\mathbf{B}} \text{ for Lorentz}$$

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

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

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

$$\mathbf{B}_0 = E / 2\boldsymbol{\mu}_{\mathbf{B}} = 235051.735 \text{ T} \qquad (3)$$

Where energy E is of course the Bohr rest orbit energy (4.35974377E-18 Joules) and the theoretical Bohr magneton is of course equal to 9.27400899E-24 J/T.

The big question now is:

How is it then that the Bohr magneton, theoretically meant to involve an electron **translating on a closed circular orbit** about the nucleus, can thus be associated 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 be directly proportional to the angular velocity of the rod as the velocity was caused to vary!

We analyzed in a separate paper ([5]) that this could only be due to the unpaired electrons in the demagnetized rod to align orthogonally with respect to the rotation axis provided by the supporting thread, which causes the local magnetic field associated to the carrying energy that supports this circular translation motion of each of these electrons to align and become detectable by addition at the macroscopic level, and to logically intensify as their velocity, thus their energy, is increased.

On the other hand, it is well understood in circular accelerators circles ([6], p.43) that when an electron is caused to move in a magnetic field that would not be 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.

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[2] Neutral in the case of carrying energy and free moving photons, and whose explanation is beyond the scope of the present paper.

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

$$qvB_o = \gamma \frac{m_o v^2}{r_o} \tag{4}$$

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

$$r_o = \gamma \frac{m_o v}{qB_o} \tag{5}$$

The Barnett effect effectively also 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[3], 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 be valid for a single electron forced to move in a circle about an isolated proton (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? We know from experimental verification that has been extensively carried out since the 1930's that the actual magnetic moment of the electron on the hydrogen rest orbital is effectively 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 it can be verified ([1]) that the Bohr magneton must actually be associated to **straight line motion** of an electron having the same energy as the Bohr ground state energy, since it is calculated from theory in a manner that mandatorily assigns equal energy density to both electric and magnetic aspects, in blatant contradiction with the state of the actual electron captive in the rest state in 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]) is about

$$\frac{\mu_e}{\mu_B} = 1.001159653 \tag{6}$$

which sets the current value ([2]) of the experimentally verified electron magnetic moment to

$$\mu_e = 1.001159653 \times \mu_B = 9.28476362\,E-24\,J/T \tag{7}$$

The electron magnetic moment (μ_e) is currently calculated from the classical gyromagnetic moment equation (1) previously mentioned modified by the introduction of the so-called g factor of the electron, whose definition lies beyond the scope of this paper, but whose value, theoretically set to 2 for other purposes, is further adjusted after the fact, so to speak, to g/2 =1.001159653 to account correctly for the experimentally measured value of μ_e :

[3] Since local equal energy density of electric and magnetic field mandatorily causes straight line motion of charges.

$$\mu_e = \frac{g}{2}\frac{eh}{4\pi m_o} = 9.28476362\,E-24\ J/T \qquad (8)$$

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 atom. For example, Julian Schwinger's 1947 paper on this issue ([7]) rates it at 1.001162.

More recently ([8]), in 2006, the g/2 factor was established at 1.00115965218085 with a different method. So any value in that range is likely to physically apply to one or other of the actual states or to a mean value of the ground level in the particular circumstances of measurement.

So this higher observed magnetic moment, coupled with the fact that the isolated hydrogen atom ground state electron can only move in a circle, 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 higher magnetic carrying energy density than electric carrying energy density since we now know that equality would involve straight line motion of the electron.

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

It must be realized here that the electron g factor, being an ad hoc quantity, **is not calculated from first principles**, but established by comparing experimental measurements with the theoretical Bohr magneton with the actually measured electron 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.

Actually, the 3-spaces expanded geometry model provides ample reasons to conclude that such stress drifting of energy from electric state towards magnetic state of the carrying energy of massive particles captives on circular orbits is directly linked to, and varies with, the distance between interacting charged particles.

We will see presently that equation (55) from paper ([1]) derived from the gamma relativistic factor does allow calculating **from first principles** a value in the proper range without the use of any ad hoc corrective factor. Moreover, an equation reciprocal to (55) from paper ([1]) but making use of corresponding energy levels ([3], Chapter **From Classical to Relativistic Mechanics via Maxwell**) instead of wavelength, also provides the exact same value.

Both equations in fact, for reasons outside the scope of the present paper allow calculating an effective energy drift ratio towards magnetic state for the whole range of possible interaction distances down to and including those of quarks up and down inside nucleons, thus providing a direct theoretically derived method of explaining the drift of the unit charge of the electron to the partial charges of quarks up and down and the drift ratio of their local carrying energy, which could allow precise calculation of the observed magnetic moment of nucleons. This however is outside the scope of the present paper, but is addressed in a separate article ([9], Section III).

Now why should these equations provide such a ratio?

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 orbital distance of an electron about a hydrogen nucleus. Consider equation (55) from paper ([1]) for example that we reproduce here:

$$\frac{v}{c} = \frac{\sqrt{\lambda_C(4\lambda + \lambda_C)}}{(2\lambda + \lambda_C)} \tag{9}$$

Where λ_C is the electron Compton wavelength and λ is the absolute wavelength of the electron carrying energy.

Or equation (15) from ([3], Chapter **From Classical to Relativistic Mechanics via Maxwell**)

$$\frac{v}{c} = \frac{\sqrt{4EK + K^2}}{2E + K} \tag{10}$$

Where E is the energy captive of the electron rest mass and K is the kinetic energy related to the distance between the electron orbit and the nucleus.

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 will have moving in straight line, when energy density is equal for both carrying electric and magnetic fields as explored in a previous paper ([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 2π to involve a relation normal 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 range of the ad hoc electron g factor.

Let us now calculate the mean magnetic drift ratio for the hydrogen ground state with equation (9) where λ_C = 2.426310215E-12 m, which is the absolute wavelength of the rest mass energy of the electron and λ = 4.556335256E-8 m, which is the absolute wavelength of the energy of the orbiting electron (in this example, that of the Bohr gyroradius energy)

$$\text{magnetic\_drift} = \frac{\delta\mu}{\mu_B} = \frac{\sqrt{\lambda_C(4\lambda + \lambda_C)}}{2\pi(2\lambda + \lambda_C)} = 1.161386535\,\text{E} - 3 \tag{11}$$

By using the proper absolute 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 **drifted magnetic field** consistent with that orbital radius and the associated **reduced electric field**.

$$\mathbf{B}_d = \mathbf{B}_0 \text{ x } (1+\textbf{magnetic\_drift}) = 235324.3134 \text{ T} \tag{12}$$

In other words, as an electron's carrying-energy oscillates between electric and magnetic states, part of it will be prevented by the stress due to closed circuit rotation from completely transferring to the electric state at each cycle. So during each cycle, the mean energy making up the local magnetic field of the carrying energy will be equal to **(E/2) x (1+magnetic_drift)** and the mean energy making up the corresponding local carrying energy electric field will be **E – ((E/2) x (1+magnetic_drift))**, this difference in the resulting mean energy density between local carrying energy electric and magnetic states directly explaining the translation in circle of the electron at this particular gyroradius.

Alternately, the reciprocal equation (10) making use of the energy levels can be used to cover the same complete range of possible magnetic drift ratios, where E= 8.18710414 E-14 Joules is the energy contained in 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

$$\text{magnetic\_drift} = \frac{\delta\mu}{\mu_B} = \frac{\sqrt{4EK + K^2}}{2\pi(2E + K)} = 1.161386535\,E - 3 \tag{13}$$

Now, the drifted magnetic field (**B**$_d$) from equation (12) that must physically exist at the Bohr radius due to the circular motion involved is clearly seen 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 photon or carrying photon that would be moving in straight line.

But since calculation of the corresponding electron magnetic moment (**μ**$_e$) requires using the energy corresponding to the increased drifted 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. 2

Equation (2) provides us with the key to this calculation since the only variable involved is the wavelength of the drifted magnetic field. So

$$\text{From } B_d = \frac{\mu_0 \pi e c}{\alpha^3 \lambda^2} \text{ we define } \lambda = \sqrt{\frac{\mu_0 \pi e c}{\alpha^3 B_d}} \tag{14}$$

And since E=hc/λ , we can write

$$E = h\sqrt{\frac{c\,\alpha^3\,B_d}{\mu_0\,\pi\,e}} \tag{15}$$

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

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

which stands barely outside the rated standard relative 4.0E-10 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 energy of the electron hydrogen ground state energy, and should be named accordingly.

Conclusion

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

References

[1] **Field Equations for Localized Individual Photons and Relativistic Field Equations for Localized Moving Massive Particles**, International IFNA-ANS Journal, No. 2 (28), Vol. 13, 2007, p. 123-140, Kazan State University, Kazan, Russia. Also available at the following Internet location http://www.wbabin.net/science/michaud.pdf

[2] David R. Lide, Editor-in-chief. **CRC Handbook of Chemistry and Physics**. 84th Edition 2003-2004, CRC Press, New York. 2003.

[3] André Michaud. **Expanded Maxwellian Geometry of Space**. 4th Edition 2005, SRP Books.

[4] S.J. Barnett. **Gyromagnetic and Electron-Inertia Effects**. Rev.Mod.Phys. Vol 7, 129 (1935).

[5] André Michaud. **On the Einstein-de Haas and Barnett Effects**, The General Science Journal 2007. http://www.wbabin.net/science/michaud3.pdf

[6] Stanley Humphries, Jr.. **Principles of Charged Particle Acceleration**, John Wiley & Sons, 1986.

[7] Julian Schwinger. **On Quantum-electrodynamics and the Magnetic Moment of the Electron**. Phys. Rev. 73, 416-417 (1948).

[8] B. Odom, D. Hanneke, B. D'Urso and G. Gabrielse. **New Measurement of the Electron Magnetic moment Using a One-Electron Quantum Cyclotron**. Phys. Rev. Let. 97, 030801 (2006).

[9] André Michaud. **On the Inverse Cube Magnetostatic Interaction**, The General Science Journal 2006. http://www.wbabin.net/science/michaud2.pdf