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Expressions for the normal and the anomalous electron magnetic moments. The hypothetical electron carted charge propelling engine.

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Abstract

This paper makes use of the Planck constant based definition of the Bohr magneton expression and the standard derivation of the magnetic moment of a point-like electron orbiting on a circle with a radius equal to its Compton wavelength. This illustrates the wave-like nature of the normal electron magnetic moment. Additionally, an analytical expression for the so-called electron anomalous magnetic moment is derived by supposing a non-concentric electron charge distribution which give rise to a current circuit with a radius r_c of approximately 0.4478 (fm) inferred from well-established experimental data; this magnetic moment has instead a particle-like behavior. A possible electron spin self-propelling engine based on a pair of shear forces created by a built-in charge-dipole interaction. Finally, a minimalist Planck constant energy-frequency interpretation is disclosed.

Keywords: Electron spin, Bohr magneton, electron Compton wavelength, normal electron magnetic moment, anomalous magnetic moment, carted charge current, Planck constant interpretation

The normal electron magnetic moment

The Bohr magneton, μ_B ($A \cdot m^2$), is given by

$$\mu_B = \frac{e\hbar}{2m_e} = 9.274\ \ 010\ \ 0783 \text{ x } 10^{-24}\ (A \cdot m^2) \quad (1)$$

where e (C) is the electron charge, $\hbar$ (J·s) is the quantum unit of action or Planck constant h divided by 2π, and m_e (kg) is the electron rest mass, respectively, see the NIST Bohr _Magneton page.

Using the electron Compton wavelength definition given by $\lambda_{C,e} = h/m_e/c$ (m), (1) can be written as

$$\mu_{B'} = -e\frac{\lambda_{C,e}}{2\pi}\frac{c}{2} = -e\bar{\lambda}_{C,e}\frac{c}{2}\ (A \cdot m^2) \quad (2)$$

where c (m/s) is the photon speed in vacuum. $\bar{\lambda}_{C,e}$ (m) is known as the reduced electron Compton wavelength. (2) represents (1) as if the Bohr magneton were produced by a point-like electron CCW orbiting in a circle of radius defined by the reduced electron Compton wavelength. A direct derivation of (2) is shown in Fig. 1. Note that the combination of (1) and (2) gives for the electron angular momentum or spin L_e (J·s) the following expression

$$L_e = \frac{\bar{\lambda}_{C,e} m_e c}{2} = \frac{\hbar}{2}\ (J \cdot s) \quad (3)$$

Considering that $\bar{\lambda}_{C,e} = \alpha a_0 = \sqrt{a_0 r_e}$ (m) and $c = v_1/\alpha$ (m/s) where α is the ubiquitous Sommerfeld's or fine-structure constant, a_0 (m) is the H atom radius, r_e (m) the classical electron radius and v_1 is the electron orbit fastest speed, (3) can be transformed into the following expressions

$$L_e = \frac{\sqrt{r_e a_0}\, m_e c}{2} = \frac{a_0 m_e v_1}{2} = \frac{r_e m_e c}{2\alpha} = \frac{eE_e}{2v_1/r_e} = \frac{eE_e}{2c/\bar{\lambda}_{C,e}} = \frac{eE_e}{2\tau_1} = \frac{\hbar}{2}\ (J \cdot s) \quad (4)$$

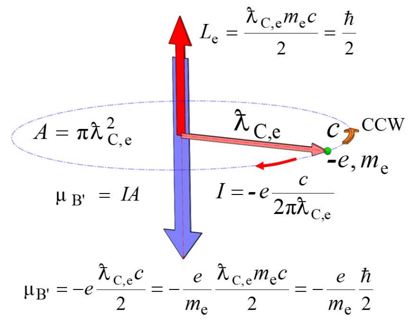

Figure 1. Derivation of the electron magnetic moment in (2) and its angular momentum or spin L_e (J·s).

where eE_e (J) is the electron mass-energy equivalent and τ_1 (cyc·s^{-1}) is a frequency which gives rise to the following handy frequency times energy $\hbar$ equality

$$\hbar = \frac{eE_\mathrm{e}}{\tau_1} \ (\mathrm{J \cdot Hz^{-1}}) \tag{5}$$

with

$$\tau_1 = v_1 / r_\mathrm{e} = c / \bar{\lambda}_\mathrm{C,e} \approx 7.763441\text{x } 10^{20} \quad (\mathrm{cyc \cdot s^{-1}}) \tag{6}$$

Arrows sense in Fig. 1 are determined by the vector nature of the involved parameters. (2) in vector form is

$$\boldsymbol{\mu}_\mathrm{B'} = -e \frac{\boldsymbol{\lambda}_\mathrm{C,e} \times \boldsymbol{c}}{2\pi} \ (\mathrm{A \cdot m^2}) \tag{7}$$

whose sense would be inverted for either a positive charge case or a negative speed, that is, a CW sense orbit is considered; if both changes are involved, the magnetic moment sense would remain as shown. Strictly speaking, inverting the positions of the terms in the vector operation or a negative going radius would also switch the magnetic moment sense.

The vector form for (3) is

$$\boldsymbol{L}_\mathrm{e} = \frac{\boldsymbol{\lambda}_\mathrm{C,e} \times m_\mathrm{e}\boldsymbol{c}}{4\pi} = \frac{\boldsymbol{h}}{4\pi} \ (\mathrm{J \cdot s}) \tag{8}$$

whose sense implications with respect to $\boldsymbol{c}$ and $\boldsymbol{\lambda}_\mathrm{C,e}$ directions are the same as above.

Using the α expressions given above, the wave nature of (2) can be transformed into a particle nature expression given by

$$\mu_\mathrm{B'} = -ea_0 \frac{v_1}{2} \quad (\mathrm{A \cdot m^2}) \tag{9}$$

whose derivation can be done using Fig. 1 by just changing the new radius and speed terms.

Some noteworthy expressions involving H atom parameters for (2) and (9) are

$$\mu_\mathrm{B'} = -\frac{e^2 v_1 \mathrm{Ry}}{F_\mathrm{C}} = -\frac{e^2 c\alpha \mathrm{Ry}}{F_\mathrm{C}} = -(4\varepsilon_0 v_1 \mathrm{Ry})(\pi a_0^2) = -(0.001054)(\pi a_0^2) \quad (\mathrm{A \cdot m^2}) \tag{10}$$

where Ry (eV) is the Rydberg energy or H ionization energy, F_C (N) is the proton-electron Coulomb force for an a_0 separation, and ε_0 (F/m) is the vacuum permittivity. We will return to this expression further down.

The abnormal electron magnetic moment

On the other side, for the isolated electron, the experimentally determined magnetic moment is

$$\mu_{e} = -9.284\ 764\ 7043\ \text{x}\ 10^{-24}\ (\text{A}\cdot\text{m}^2) \tag{11}$$

as can be obtained from the ElectronMagneticMoment and which, as compared to (2), provides a magnetic moment difference of

$$\Delta\mu_{e,B'} = \mu_{e} - \mu_{B'} = -1.075\ \ 462\ 600\ \ 000\ \ 001\ \text{x}\ 10^{-26}\ \ (\text{A}\cdot\text{m}^2) \tag{12}$$

(12), (11) and (2) give rise to the so-called anomaly of the electron magnetic moment e_MM_a given by

$$a_{e} = \frac{|\mu_{e}|}{\mu_{B}} - 1 = \frac{\Delta\mu_{e,B'}}{\mu_{B'}} = 0.001\ \ 159\ \ 652\ \ 181\ \ 28 \tag{13}$$

The carted electron eccentric current circuit and charge distribution proposed model

(12) can be expressed likewise (2) was derived in Fig. 1 as follows

$$\Delta\mu_{e,B'} = -er_{c}c/2\ \ (\text{A}\cdot\text{m}^2) \tag{14}$$

where an electron current orbital radius, r_c (m), is defined and whose magnitude has to be of

$$r_{c} = \frac{2\Delta\mu_{e,B'}}{ec} = 4.478\ \ 104\ \ 367\ \ 217\ \ 42\ \ \text{x}\ \ 10^{-16}\ \ (\text{m}) \tag{15}$$

Then, (11) can be calculated with

$$\mu_{e} = \mu_{B'} + \Delta\mu_{e,B'} = -e(\lambda\!\!\!^{-}_{C,e} + r_{c})\frac{c}{2} = -e(\alpha a_{0} + r_{c})\frac{c}{2}\quad (\text{A}\cdot\text{m}^2) \tag{16}$$

In order to create a current circuit with an r_c radius, let's consider the electron as having a non-uniform charge density whose geometrical center is not coincident with the particle rotation center. Two charge distribution cases eccentrically rotating while carted by a neutral region hauler are depicted in Fig. 2. A two-sphere charge distribution case is shown in Fig. 3

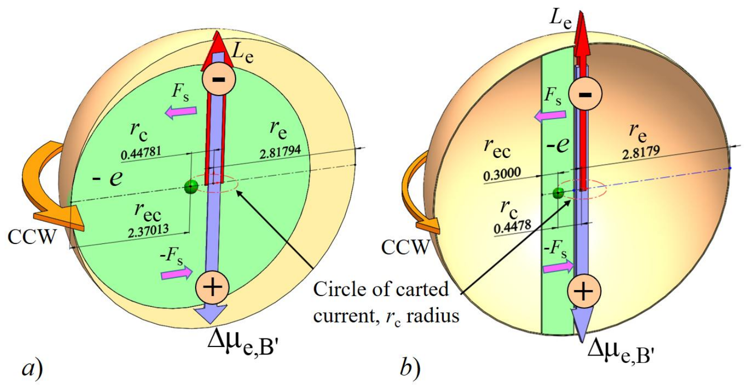

Figure 2. An sphere, *a*), and a cylinder, *b*), electron charge distributions carted along an eccentric circle of r_c radius able to produce a magnetic moment of $\Delta\mu_{e,B'}$ as in (12). Dimensions are in fermis. Possible spin propelling magnetic shear forces are indicated.

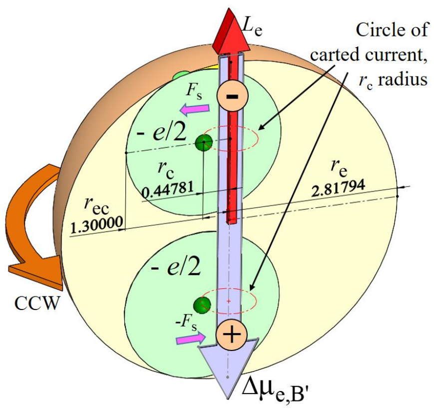

Figure 3. Two spheres electron charge distributions carted along an eccentric circle of r_c radius able to produce a magnetic moment of $\Delta\mu_{e,B'}$ as in (12) . Again, possible spin propelling magnetic shear forces are shown.

Fig. 4 portrays the representation of the involved terms in (16).

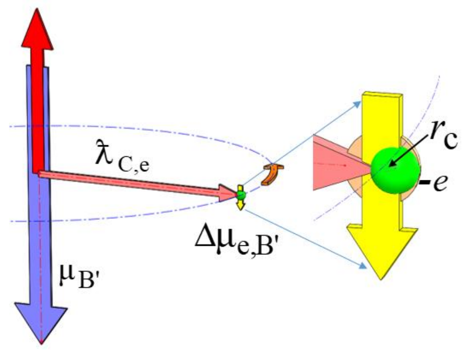

Figure 4. Representation of the electron magnetic moment terms in (16).

On regards to the proposed presence of electron self-propelling shear charge-dipole interaction forces mentioned in Figures 2 and 3, the authors manifest that their conjecture is based only on considering that the equivalent expression for (10) associated to the magnetic moment $\Delta\mu_{e,B'}$ in (12) is

$$\Delta\mu_{e,B'} = -(17071.72)\,(\pi r_c^2) \quad (\mathrm{A}\cdot\mathrm{m}^2) \tag{17}$$

which, current wise, is over seven orders of magnitude stronger than the current for the magnetic moment of the H atom.

Finally, elaborating on (16), it can obtained

$$\frac{1}{\alpha} = \frac{e a_0 c}{2\mu_e + e c r_c} = 137.035\ \ 999\ \ 084\ \ 049 \tag{18}$$

which has a relative standard uncertainty of -3.56382E-13 with respect to the numeric value recommended by the 2018 CODATA [1] inv alpha NIST.

Useful information on this topic can be found on [2,3,4].

Conclusions

A plausible explanation of the anomaly of the electron magnetic moment was disclosed based on the assumption that the electron charge distribution is not uniform in such a way that its geometrical center is located a characteristic r_c distance away of the center of the particle. This creates an eccentrically hauled charge rotation on a circle of r_c radius which was shown to produce a magnetic moment equal in magnitude to the one associated to the referred anomaly. A supposed electron spin propelling feature based on the presence of charge-dipole shear forces was expressed. An expression for the inverse Sommerfeld's constant was derived.

Notification

The authors state that any possible conflict of interest exists on regards to the authorship and publication of this article.

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