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Calculating the Electron's Magnetic Moment in Simpler Terms

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Abstract

The electron's magnetic moment has traditionally been calculated using a current loop model, assuming a single fundamental charge, *e*, and a static electron radius. However, this approach does not fully capture relativistic effects or the potential internal structure of the electron. In this work, the Light Charge Hypothesis revisits the derivation of the electron's magnetic moment. By incorporating two orbiting light charges of magnitude, $q_p = \sqrt{\varepsilon_o * h * c}$, and considering length contraction, it derives a relativistic corrected expression for the magnetic moment. The result reproduces experimental values and offers new insight into the internal dynamics of the electron.

Keywords

Magnetic Moment, Electron *g*-Factor, Fine Structure Constant, Bohr Magneton, Anomalous Magnetic Moment

1. Introduction

The calculation of the electron's magnetic moment has long stood as a testbed for classical and quantum theories. While early models treated the electron as a point particle or current loop with charge, *e*, such approaches failed to match experimental measurements, necessitating quantum electrodynamics (QED) corrections.

The Light Charge Hypothesis [1] [2] introduces a new framework in which the electron consists of two oppositely charged components, each with magnitude, $q_p = \sqrt{\varepsilon_o * h * c}$, orbiting at the speed of light. This internal structure allows a revisitation of the current loop derivation of the magnetic moment, incorporating relativistic effects via length contraction. This work derives a corrected form of the magnetic moment and demonstrates consistency with observed values.

2. Classical Current Loop Framework

This paper begins by recalling the classical equation for the magnetic moment of a current loop:

$$\mu = I * A$$

where I is the current and A is the area enclosed by the loop. This framework is applicable here since the light charges orbiting at relativistic speeds effectively form a current loop.

Current is defined as:

$$I = \frac{\Delta q}{\Delta t}$$

where Δq is the effective charge and Δt is the period of rotation. For the Light Charge Hypothesis, Δt, is the time it takes one charge to complete an orbit. Assuming the light charge travels at speed, c, and accounting for relativistic length contraction, the contracted radius is

$$r_v = r_o * \sqrt{1 - \frac{v^2}{c^2}}$$

where r_o is the rest-frame radius of the electron. The period is then:

$$\Delta t = \frac{2 * \pi * r_v}{c}$$

The area of the loop is

$$A = \pi * r_v^2 = \pi * r_o^2 * \left(1 - \frac{v^2}{c^2}\right)$$

3. Determining the Effective Charge

To find the effective charge, q_{eff}, we equate Energy under two frames. From the model in [3], each orbiting charge has magnitude, and the energy of the system is $E = q * V$ where $V = k * q / r$.

$$E = \frac{2 * k * q_p^2}{r_o}$$

Under length contraction, the Light Charge Hypothesis reinterprets this as a system with a modified effective charge, q_{eff}, and contracted radius r_v:

$$E = \frac{k * q_{eff}^2}{r_o * \sqrt{1 - \frac{v^2}{c^2}}}$$

Remembering the relation for the fine structure constant:

$$\alpha = \frac{e^2}{2 * \varepsilon_o * h * c} = \frac{e^2}{2 * q_p^2}$$

And equating the two yields:

$$q_{eff} = \frac{e}{\sqrt{\alpha}} * \left(1 - \frac{v^2}{c^2}\right)^{\frac{1}{4}}$$

4. Magnetic Moment Derivation

Substituting into $\mu = I * A$, we have:

$$\mu = \frac{e}{\sqrt{\alpha}} * \left(1 - \frac{v^2}{c^2}\right)^{\frac{3}{4}} * c * r_o * \frac{1}{2}$$

Then from [1] ro can be substituted out.

$$r_o = \frac{h}{2 * \pi * m_{electron} * c}$$

Yielding

$$\mu = \frac{e * h_{bar}}{2 * m_{electron}} * \frac{1}{\sqrt{\alpha}} * \left(1 - \frac{v^2}{c^2}\right)^{\frac{3}{4}}$$

Recognizing that the Bohr magneton is

$$\mu = \frac{e * h_{bar}}{2 * m_{electron}}$$

This paper rewrites:

$$\mu = \mu_B * \frac{1}{\sqrt{\alpha}} * \left(1 - \frac{v^2}{c^2}\right)^{\frac{3}{4}}$$

This matches the QED-style form:

$$\mu = \mu_B * \frac{g}{2}$$

Which implies

$$\frac{g}{2} = \frac{1}{\sqrt{\alpha}} * \left(1 - \frac{v^2}{c^2}\right)^{\frac{3}{4}}$$

Substituting the experimental value $g/2 = 1.00115965218073$, the implied velocity becomes $v = 0.980978935 * c$.

5. Cyclotron Method and Alternate Derivation

An alternative derivation uses the relativistic cyclotron relation. Starting with:

$$\frac{m * v^2}{r} * \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} = q_{effective} * (v \times B)$$

Solving for B, we use:

$$w = \frac{v}{r} = 2 * \pi * f_c * r$$

Combining and solving yields an expression for the Lorentz factor.

$$\sqrt{1-\frac{v^2}{c^2}} = 2*\pi*f_c*m_{electron}*\frac{1}{q_{effective}}*\frac{1}{B}$$

The magnetic moment of a current loop is also expressed as:

$$\mu = \frac{q*v*r}{2}$$

$$\mu = \frac{q_{effective}*c*r_o*\sqrt{1-\frac{v^2}{c^2}}}{2}$$

Substituting in the previous equation gives the following:

$$\mu = \frac{q_{effective}*c*r_o}{2}*2*\pi*f_c*m_{electron}*\frac{1}{q_{effective}}*\frac{1}{B}$$

Which simplifies to

$$\mu = \frac{q_{effective}*c}{2}*\frac{h}{2*\pi*m_{electron}*c}*2*\pi*f_c*m_{electron}*\frac{1}{q_{effective}}*\frac{1}{B}$$

$$\mu = \frac{h}{2}*f_c*\frac{1}{B}$$

Given the experimental values of f = 149 GHz and $g/2$ = 1.00115965218073, solving gives B = 5.316690762164 T, v = 0.980978935c.

Thus, with precise values for f and v, one can derive B and consequently, the magnetic moment using this compact expression.

6. Conclusions

By revisiting the electron's magnetic moment using the Light Charge Hypothesis and incorporating relativistic contraction effects, we derive a closed-form expression that agrees with experimental data.

The result

$$\mu = \mu_B*\frac{1}{\sqrt{\alpha}}*\left(1-\frac{v^2}{c^2}\right)^{\frac{3}{4}}$$

naturally explains the observed deviation in $g/2$ without invoking perturbative QED. Furthermore, the identity

$$\mu = \frac{h}{2}*f_c*\frac{1}{B}$$

Provides a second, experimentally grounded derivation, confirming consistency with cyclotron frequency measurements. These results support the physical plausibility of the Light Charge Hypothesis and offer a promising direction for modeling other elementary particles.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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