NEW RENEWABLE SOURCE: REST ENERGY OF THE ELECTRON SPIN

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Abstract

The intrinsic properties of electrons are fundamental for the progress of science. The relationship between electron mass and its electric charge and spin is poorly explored. Thus, through the Relativistic Quantum Theory, we have investigated the equivalence between mc^2 and qc^2 , where m and q are, respectively, the mass and the electric charge of the electron. We demonstrated that $\Delta E = mc^2 \equiv Aqc^2$, where A ($A = 5.68562964 \times 10^{-12} KgC^{-1}$) is the proportionality constant obtained through the ratio of the spin g-factor and the gyromagnetic ratio for a free electron. The alignment of the spin magnetic dipole moment with the magnetic field ceases the electron precession movement. Therefore, the kinetic energy, associated with the precession, is dissipated with an intensity equal to mc^2 . This result is promising for the production of clean and sustainable energy, besides new technological applications.

1 Introduction

Electron is a fundamental particle of nature. Its mass is associated with the Higgs field [1, 2]. The electron structure and the combination of its intrinsic properties aim to promote the advance of science and technological applications [3, 4].

In an atom with one single electron, the orientational potential energy (ΔE) of the spin magnetic dipole moment (μ_s) interacting to the internal magnetic field (B) is [5]:

$$\Delta E = -\mu_s \cdot B \quad (1)$$

Where μ_s is based on the spin g-factor (g_s), spin angular momentum (S), Bohr magneton (μ_b) and the reduced Planck's constant ($\hbar$), as follows:

$$\mu_s = -\frac{g_s \mu_b}{\hbar} S \quad (2)$$

The component of μ_s in the z -axis can assume two values, because $m_s = \pm 1/2$:

$$\mu_{s,z} = -g_s \mu_b m_s \quad (3)$$

Where μ_b is:

$$\mu_b = \frac{q\hbar}{2m} = 0.927 \times 10^{-23} Am^2 \quad (4)$$

ΔE is preserved, once the angle between the vectors μ_s and B is constant. The movement of μ_s around B is of precession, also known as Larmor precession [6]. The Larmor frequency (ω) is a function of B and of the gyromagnetic constant (γ):

$$\omega = 2\pi f = \gamma B \quad (5)$$

The spin had already been postulated to in Schrödinger's Quantum Mechanics. But, it was Paul A. M. Dirac, through the Relativistic Quantum Theory, who showed that the electron should have spin and μ_s [7]. From the Theory of Relativity, it is also possible to obtain the equivalence between energy and rest mass [8]:

$$\Delta E = mc^2 \quad (6)$$

A fundamental question is: "Is there any equivalence between energy (equation 6), electric charge, and spin?" The answer is yes, as will be demonstrated in the *Results and Discussions* section.

2 Methodology

We analyzed the single electron atom considering the referential about the electron, and that it is at rest in relation to the nucleus. The nucleus performs orbital movement around the electron generating the B magnetic field. From the interaction of μ_s and B , we infer the equation of energy associated with the electric charge and spin. The electron at rest is similar to a free electron in electrostatic equilibrium. Hence, the gyromagnetic ratio for a free electron is equal to $\gamma = 1.76085977 \times 10^{11} \text{CKg}^{-1}$ and the other constants are electric charge: $q = 1.602176634 \times 10^{-19} \text{C}$, spin g-factor: $g_s = 2.00231930$, speed of light: $c = 299792458 \text{ms}^{-1}$ and electron mass: $m = 9.10938356 \times 10^{-31} \text{Kg}$.

3 Results and Discussions

Figure 1 illustrates B in the z -direction. Figure 1-A shows the angle θ formed between the vector μ_s and the z -axis, besides the angular frequency of Larmor precession (ω) and of the vector $\mu_{s,z}$ component. The cone represents the interaction of μ_s with B , that is, ΔE . We interpret ΔE equivalent to kinetic energy of precession. Figure 1-B, on the other hand, shows that the vector μ_s vector was aligned with B (and not only vector $\mu_{s,z}$). Because of that, the precession movement ceases, and the energy cone is dissipated as a photon, as will be further detailed.

Figure 1: A) Interaction of the magnetic field (B) with the vector μ_s , resulting in the precession movement of Larmor with frequency ω . The cone represents the kinetic energy associated with the precession movement. The alignment of vector μ_s with B (and not only vector $\mu_{s,z}$) promotes the end of the precession movement. The kinetic energy of precession is dissipated through a photon.

The interaction of μ_s with B was described in equation 1. The component μ_s in z -direction is:

$$\mu_{s,z} = \mu_s \cos \theta \Leftrightarrow \mu_s = \frac{\mu_{s,z}}{\cos \theta} \quad (7)$$

Thus, ΔE (equation 1) in z -axis direction becomes:

$$\Delta E_z = -\frac{\mu_{s,z}}{\cos \theta} \cdot B \quad (8)$$

B is in the z -direction, therefore the angle between $\mu_{s,z}$ and B is null ($\alpha = 0^\circ$, $\cos 0^\circ = 1$). Then, the scalar product of $\mu_{s,z} \cdot B$ is:

$$\Delta E_z = -\frac{\mu_{s,z} B \cos \alpha}{\cos \theta} = \frac{\mu_{s,z} B}{\cos \theta} \quad (9)$$

By replacing $\mu_{s,z}$ (equation 3) in equation 9, we obtain:

$$\Delta E_z = \frac{g_s \mu_b m_s B}{\cos \theta} \quad (10)$$

By using μ_b (equation 4), $|m_s| = 1/2$, $\theta = 60^\circ$ (maximum optimization angle: $\cos 60^\circ = 1/2$) in equation 10, we obtain:

$$\Delta E_z = \frac{q g_s \hbar B}{2m} \quad (11)$$

From equation 5 we achieve B . By replacing it in equation 11 and simplifying it, we have:

$$\Delta E_z = \left(\frac{q g_s}{2m} \frac{\hbar}{2\pi} \right) \frac{2\pi f}{\gamma} = q \frac{g_s}{2\gamma} \frac{\hbar f}{m} \quad (12)$$

By grouping g_s and 2γ , we obtain the A constant, whose unit is KgC^{-1} :

$$A = \frac{g_s}{2\gamma} = 5.68562964 \times 10^{-12} \quad (13)$$

By replacing the A constant in equation 12, and $\hbar f$ by E , where $c^2 = E/m$ (equation 6), we find the energy equivalent to electron rest mass, electric charge, and spin:

$$\Delta E = mc^2 \equiv Aqc^2 = 8.187105109 \times 10^{-14} J \quad (14)$$

The energy of the electric charge and spin is equivalent to the kinetic associated with the precession movement of Larmor. Thus, if μ_s (and not only $\mu_{s,z}$) aligns to B , the precession movement ceases. Therefore, the precession kinetic energy is dissipated with an intensity of mc^2 (equation 14). Hence, that is the quantum explanation for the expression deduced by Albert Einstein (equation 6).

Another relevant result is the equivalence among the electron mass, electric charge, and spin, as presented in equation 15. This equation is valid when there is an alignment of μ_s and B . However, in the fundamental state (equation 1 and Figure 1-A), the electron rest mass is partially formed by the interaction of the Higgs field and the interaction of electric charge and spin, once $\theta \neq 0^\circ$ and $\mu_s \neq \mu_{s,z}$.

$$m = q \frac{g_s}{2\gamma} \quad (15)$$

4 Conclusions

The electron rest mass is partially due to the Relativistic Quantum Theory effect, that is, g_s , γ , and q . The alignment of μ_s with B ceases the movement of precession and the energy (mc^2) is dissipated by a photon. These results encourage researchers to produce clean and sustainable energy, in addition to new scientific-technological advances.

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