Size of the electron speculated from charge formation energy

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Abstract

The classical radius of the electron can be calculated from first principles. The calculated value contradicts with experiments, which does not show any structure for the electron down to about 2×10^{-20} m. In order to be consistent with these experiments the energy required for the charge formation must exceed the rest mass energy of the electron. Based on energy equivalency it is concluded that the energy required for charge formation emerges from rotation, while the energy of mass formation emerges from translation. Assuming that the tangential velocity of the rotation is equivalent with the speed of light reproduces the classical radius of the electron. In order to comply with the known size limit of the electron the tangential velocity must exceed the speed of light. It is proposed that the ratio between the tangential and translation velocity of the electron is α^{-1}, which gives the radius of the electron to $1.50059 \times 10^{-19}\ m$.

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PACS 03.50.De - Classical electromagnetism, Maxwell equations

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Prelude

The Motto of the article is "Vague but exciting". This was the evaluation written on the proposal of Tim Berners-Lee, inventor of World Wide Web, by his supervisor Mike Sendall CERN (1989). The author believes that the presented speculation is very similar "vague, but exciting", and have a possibility to open up completely new perspectives in our understanding of the physical world.

1. Introduction

Based on energy consideration the energy required to form the charge of an electron can be calculated as:

$$U_{electron} = \frac{1}{4\pi\varepsilon_o}\frac{3}{5}\frac{e^2}{r_e} \quad (1)$$

where ε_o is the permittivity of free space, e is the elementary charge, and r_e is the radius of the electron. In this equation it is assumed that the charge has uniform distribution, resulting in the 3/5 multiplier. Assuming that this electrostatic potential energy required for the formation of the electron is same as the rest mass energy of the electron, and neglecting the 3/5 multiplier, gives:

$$U_{electron} = m_e c^2 = \frac{1}{4\pi\epsilon_o}\frac{e^2}{r_e} \quad (2)$$

giving the radius of the electron:

$$r_e = \frac{1}{4\pi\epsilon_o}\frac{e^2}{m_e c^2} = 2.8179403262 \times 10^{-15}\, m\,.[1] \quad (3)$$

This radius is the classical radius of the electron (r_e), which relates to the Compton wavelength of the electron (λ_e), and the Bohr`s radius (a_o) as:

$$r_e = \alpha\frac{\lambda_e}{2\pi} = \alpha^2\, a_o\,, \quad (4)$$

where α is the fine structure constant, defined as:

$$\alpha \equiv \frac{1}{4\pi\varepsilon_o}\frac{e^2}{\hbar c}\,, \quad (5)$$

where c is the speed of light in vacuum, and $\hbar$ is the reduced Planck constant or Dirac constant, given as:

$$\hbar = \frac{h}{2\pi}\,, \quad (6)$$

where h represents the Planck constant.

The calculated classical electron radius is in the range of the size of the nucleus. If the electron has a spatial structure then its magnetic moment should be different than the one calculated by the Standard Model, which assumes a point charge with no spatial extent. The structure of the electron has been probed to10 TeV energies, indicating that the electron does not have any structure or its spatial extent is completely spherical down to about 2×10^{-20} m. [2, 3]. These experimental results contradict with the calculated classical radius of the electron, which has been derived from first principles. In order to comply with the experiments the energy required for the formation of charge must exceed the rest mass energy of the electron. This possibility is investigated in this study.

2. Formation of Mass and Charge

The classical radius of the electron is calculated by assuming that the energy required for the charge formation is the same as the energy required for the mass formation (Eq. 2.). This assumption has never been verified. The formation of a particle requires a photon with energy minimum twice as much as the energy of the rest mass energy of the particle. The absorbed high-energy photon then can creates new particles by pair production. The transferred energy from the photon is used up for the mass formations of the particles, because the energy required for the charge formation cancels out, when the matter and anti matter particles are formed. Thus the energy required for the formation of the charge is not known.

3. Physical description of electromagnetism

The fine structure constant (α), pops out from the principle energy levels derived from the Bohr/De Broglie Hydrogen model as:

$$E_n = -\frac{1}{2}\alpha^2 E_o \frac{1}{n^2} \tag{7}$$

where E_o is the rest mass energy of the electron ($m_e c^2$), n = 1, 2, 3…, and the fine structure constant is defined as given in Eq.5. The aim of the introduced constant was to explain the experimental observations of the spectral lines for the hydrogen atom, not explained by the Bohr's hydrogen atom model [4].

Manipulating the expression of the fine structure constant (Eq. 5), it can be written as:

$$\alpha\hbar c = \frac{e^2}{4\pi\epsilon_o}\,. \tag{8}$$

According to Bohr`s postulation of the angular momentum of the electron in the Hydrogen atom is

$$L = n\hbar = m_e \alpha c r_n, \tag{9}$$

where n = 1, 2, 3... Substituting

$$\hbar = m_e \alpha c \frac{r_n}{n} \tag{10}$$

into Eq. 8 gives:

$$m_e \alpha^2 c^2 \frac{r_n}{n} = \frac{e^2}{4\pi\varepsilon_o} \tag{11}$$

Replacing $\frac{r_n}{n}$ with the Bohr`s radius (a_o), and dividing both sides of the equation with a_o then Eq. 11 can be rewritten as:

$$\frac{m_e a_o^2 \alpha^2 c^2}{a_o^2} = \frac{e^2}{4\pi\varepsilon_o a_o} \tag{12}$$

Please note that the left side of the equation is the rotational energy of the electron in the Hydrogen atom, because

$$m_e a_o^2 = I_c \tag{13}$$

where I_c is the inertia relating to a hoop or cylindrical shell, and

$$\frac{\alpha^2 c^2}{a_o^2} = \omega^2 \tag{14}$$

where ω is the angular velocity. In the ground sate of the Hydrogen atom (n = 1) the rotational energy of the electron is the same as its ionization energy

$$\frac{1}{2} I_c \omega^2 = \frac{1}{2} \frac{e^2}{4\pi\varepsilon_o a_o} \tag{15}$$

Equation 15 indicates that the Coulomb potential is equivalent with the rotational kinetic energy of the charged particle. This conclusion is consistent with the vector description of electro magnetism, which allows the displacement of a vector without changing its value. In the vector description of electro-magnetism the vector can act

anywhere in space. Thus two vectors are identical if their magnitude and direction are the same, regardless of their line of action. Rotating body can be displaced in space with no energy loss if their rotational axis remains the same. Based on Eq. 15, and the vector description of electromagnetism it is suggested that charge and the electromagnetic field relates to rotational energy as depicted in fig. 1.

5. Size of the electron

From equations 12-15 it can be seen that the rotational energy relating to the Coulomb potential is independent from the radius. In order to be consistent with the experimental limit on the size of the electron, the energy of charge formation must exceed the rest mass energy of the electron.

$$I_c\,\omega^2 = m_e\alpha^{2n}c^2 = \frac{1}{4\pi\varepsilon_o}\frac{e^2}{r_{e-real}} < m_e c^2 \qquad (16)$$

It is assumed that the mass, the charge of the electron, the fine structure constant and the speed of light remain constant, and that the rotational energy can be changed if the tangential velocity of the rotation increases. This increase can be done incrementally by changing the exponent of the fine structure constant.

$$I_c\,\omega^2 = m_e\alpha^{2n}c^2 = \frac{e^2}{4\pi\varepsilon_o r_{e-real}} \qquad (17)$$

The value n = 1 corresponds to the electron in the Hydrogen atom, n = 0 relates to the rest mass energy of the electron. In order to comply with the condition given in Eq. 16, the value of n has to be reduced. Taking the next value n = -1 gives the energy for the charge formation as:

$$U_{e\_charge} = m_e\alpha^{-2}c^2\,, \qquad (18)$$

The radius of the electron ($r_{e\text{-}real}$) then is:

$$r_{e-real} = \frac{1}{4\pi\varepsilon_o}\frac{\alpha^2 e^2}{m_e c^2} = 1.50059 \times 10^{-19}\, m. \quad (19)$$

This calculated value consistent with the experimental constrains. Based on equation 18 the tangential velocity of the rotation exceeds the speed of light by α^{-1} times. Please note that this is an internal velocity and does not relate to the translational velocity of the particle, which is consistent with relativity, and obeys the speed limit of the light.

The energy required for the formation of the mass is derived from translational motion of the particle. Consequently, the energy of mass formation should emerge from translational energy. Gravitational attraction is induced by mass. Thus, the formation of the gravitational field should be related to translational energy. The incompatibility of quantum mechanics and relativity might be rooting in their different forms of energy.

Based on equation 18, the fine structure constant represents the ratio of the translational and tangential velocity of the virtual particles. The square of the constant shows the ratio of mass and charge formation energy as:

$$\alpha^2 \equiv \frac{U_{e_{rest_{mass}}}}{U_{e_c harge}} \quad and \quad \alpha = \frac{v_{translation}}{v_{rotation}}, \quad (20)$$

6. Conclusions

Based on the presented speculation, the following conclusions can be drowning.

- The experimentally defined size of the electron can only be explained if the energy of the charge formation exceeds the rest mass energy of the electron
- The energy required for charge formation is not known because the pair production of the particles cancels it out

- The energy of charge formation emerges from rotational energy
- The electric field induced by the charge transmits the rotation of the charge to the virtual particles, while the magnetic field produced by their spin
- The energy required for the mass formation derived from translational energy
- Consequently gravity should be generated by the translational motion of the virtual particles
- The radius of the electron has been deduced from first principles, giving the value of 1.50059×10^{-19} m.
- The square of the fine structure constant represents the energy ratio required for the mass and charge formations.

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Fig. 1/a

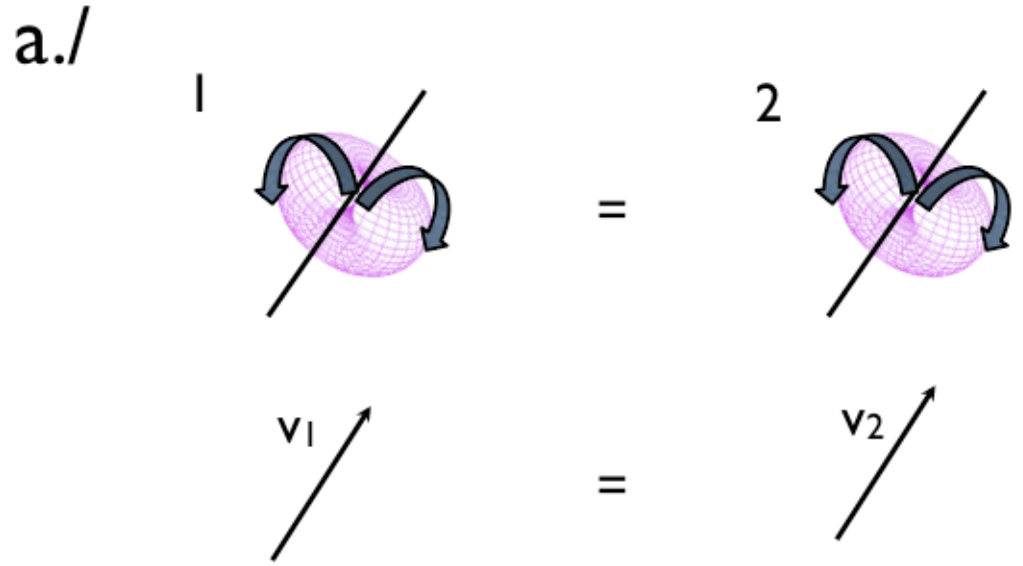
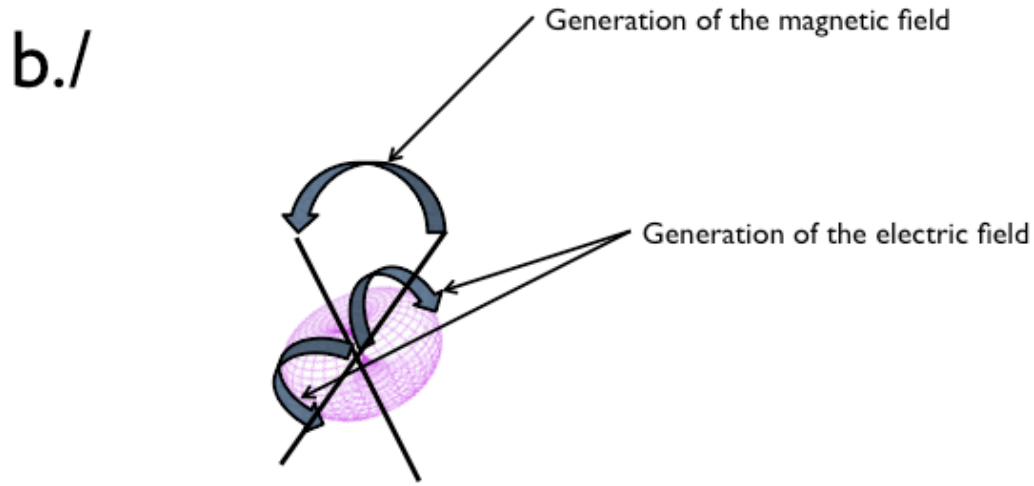


Fig. 1/b



Legend:

Fig. 1: Depicted virtual particles forming electric and magnetic field. (a) The equivalency of the "electric field" with the vector description of rotation is shown. The electric field is generated by the organized rotation of the virtual particles. If the

axis of the virtual particle remains the same then there is no change in the “electric field” and “magnetic field” is not generated. (b) When the axis changes then “magnetic field” is generated, which is perpendicular to the plane of the rotating axis.