The Mass Structure of Electron

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Abstract

In this paper, the formula of electron mass is deduced theoretically. According to it, we know the internal structure of electron. We find that there is a capacitance in the charge center of the electron, which is composed of two circular currents, and there is a large amount of magnetic field passing through between the two circular currents. The mass of electron is created by this structure. We also made a simple diagram of the internal structure of the electron based on it.

Introduction

Derivation of the mass formula for the electron

This paper begins with the derivation of the classical charge radius of the electron, as follows:

$$\frac{e^2}{4\pi\varepsilon_0 r_e} = \mathrm{M}c^2 \tag{1}$$

Where e is the basic charge; ε_0 is the vacuum permittivity; r_e is the classical radius of the electron; M is the rest mass of the electron; c is the speed of light in vacuum; π is the pi.

The left side of the Equation (1) is the electrostatic potential energy of the electron, and the right side is its rest energy. According to $c^2 = 1/\varepsilon_0\mu_0$, where μ_0 is the vacuum permeability, we simplify Equation (1) and obtain:

$$\mathrm{M} = \frac{\mu_0 e^2}{4\pi r_e} \tag{2}$$

Generally, it is difficult to expand Equation (2) at this step. Here we can start with the charge e. When a conductor is superconducting, the charge of the electron has the following relationship with the magnetic flux quantum it generates [1]:

$$\Phi = \frac{h}{2e} \tag{3}$$

Where Φ is the magnetic flux quantum; h is the Planck constant.

Now, according to Equation (3), we can get $e = h/2\Phi$, substituting it into Equation (2), we get:

$$\mathrm{M} = \frac{\mu_0}{4\pi r_e}\left(\frac{h}{2\Phi}\right)^2 = \frac{\mu_0}{16\pi r_e}\frac{h^2}{\Phi^2} \tag{4}$$

It can be seen from the Compton wavelength formula of the electron: $h = Mc\lambda_e$, where λ_e is the Compton wavelength of the electron. We put it into Equation (4):

$$\mathrm{M} = \frac{\mu_0}{16\pi r_e}\frac{(Mc\lambda_e)^2}{\Phi^2} = \frac{16\pi r_e}{\mu_0}\frac{\Phi^2}{c^2\lambda_e^2} \tag{5}$$

Since $\lambda_e = 2\pi r_e/\alpha$, where α is the fine-structure constant. Substituting this equation into Equation (5) is:

$$\mathrm{M} = \frac{16\pi r_e}{\mu_0}\frac{\Phi^2}{c^2(2\pi r_e/\alpha)^2} = \frac{4}{\mu_0}\frac{\Phi^2\alpha^2}{c^2\pi r_e} \tag{6}$$

According to the formula of magnetic flux: $\Phi = BS$, B is the magnetic field, namely the magnetic induction intensity; S is the area through which the magnetic field passes. Substituting them into Equation (6) are:

$$\mathrm{M} = \frac{4}{\mu_0}\frac{\Phi\Phi\alpha^2}{c^2\pi r_e} = \frac{4}{\mu_0 c^2}\frac{BS\Phi\alpha^2}{\pi r_e} \tag{7}$$

Where the product of the magnetic field B and the electron ' s spin magnetic moment μ_e is equal to the electron ' s rest energy, that is, $B \cdot \mu_e = \mathrm{M}c^2$.

We simplify Equation (7) according to $c^2 = 1/\varepsilon_0\mu_0$, then:

$$\mathrm{M} = 4\varepsilon_0\frac{BS\Phi\alpha^2}{\pi r_e} = B\Phi\frac{4\varepsilon_0 S\alpha^2}{\pi r_e} \tag{8}$$

Since electron has an anomalous magnetic moment, Equation (8) needs to add an electron's spin g-factor g_e, as follows:

$$M = B\Phi \frac{4\varepsilon_0 S\alpha^2 g_e}{\pi r_e} \tag{9}$$

From the parallel plate capacitance formula, it can be seen that $4\varepsilon_0 S\alpha^2 g_e/\pi r_e$ is a capacitance in Equation (9), let it be equal to the capacitance C, then $C = 4\varepsilon_0 S\alpha^2 g_e/\pi r_e$, substitute it into Equation (9), then we can get the mass formula of the electron:

$$M = B\Phi C \tag{10}$$

So far, we have derived the mass of electronic formula. From Equation (10), we can see that the essence of the electron mass is a capacitance with a magnetic field, and the mass is a medium filled in the middle of the capacitor. B, Φ, they are all magnetic fields. C is a capacitance, which produces an electric field. It can be found that this medium is composed of electromagnetic fields. Mass is more like the energy and information stored in the capacitor.

In Equation (10), the capacitance C is composed of two circular currents. Since the electron carries only one charge, the charge in the two circular currents is the same, so they will be mutually exclusive. However, since the moving directions of these two circular currents are the same, the magnetic fields generated by them will attract each other. Coupled with the anomalous magnetic moment, the attraction generated by the magnetic field between the two circular currents will be greater than the repulsion generated by the electric field, so that the two circular currents are firmly attracted together to form the electron mass, and the charge is dispersed outside the electron mass.

Inside the electron, the relationship between the electric field force F_e and the magnetic field force F_B between two circular currents is as follows:

$$\frac{F_e}{F_B} = \frac{\pi}{g_e^2} \tag{11}$$

According to the previous derivation, we have drawn **a diagram of the internal structure of the electron**, as shown in Figure 1.

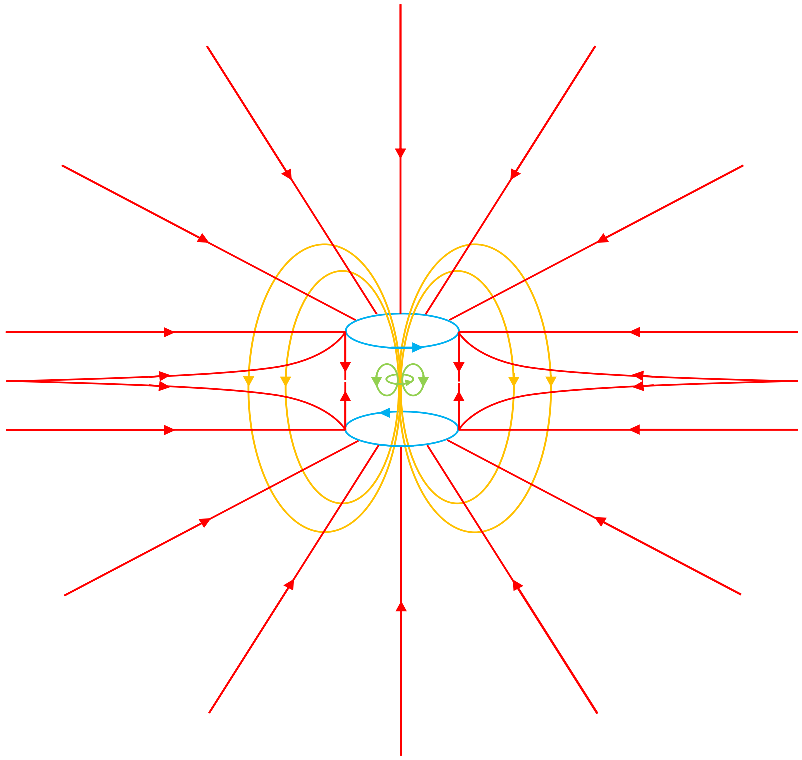

Figure 1: The red lines are the electric field lines. The yellow circles are the magnetic induction lines, that is, the magnetic fields. The blue circles are the circular currents. The green circles are the anomalous magnetic moments. The arrows indicate the directions.

References

[1] 2018 CODATA Value: magnetic flux quantum