A unified formula for the anomalous magnetic moment of electron, muon, and tauon

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Abstract

We put forward a new viewpoint that there are two magnetic moments inside the charged leptons, namely dominant magnetic moment and recessive magnetic moment. The recessive magnetic moment produces the anomalous magnetic moment of the charged lepton, and we believe that the recessive magnetic moment is related to the mass of muon, tauon, proton, and neutron. Based on this viewpoint, we created a unified formula that describes the anomalous magnetic moments of three charged leptons. Their calculations matched well with the recommended value of 2018 CODATA. Especially for the difference in the anomalous magnetic moment of the muon, the formula in this article gives a very simple explanation. At the same time, it also tells us that there are more complex structures inside the charged lepton.

Introduction

We put forward a new viewpoint: There are two magnetic moments inside the charged leptons, namely **dominant magnetic moments** and **recessive magnetic moments**. For this viewpoint, its specific process is as follows: the dominant magnetic moment refers to the spin magnetic moment of a charged lepton. The recessive magnetic moment refers to the magnetic moment produced by other masses present inside the charged lepton, which are composed of the masses of muons, tauons, protons and neutrons, which interact in different ways Produce. The magnetic moments they produce can cancel each other out, leaving the remaining amount involved in the composition of the anomalous magnetic moments of charged leptons. For the different combinations of their magnetic moments, we call the **recessive magnetic moment modes**, different modes of recessive magnetic moments correspond to different anomalous magnetic moments, and different modes of recessive magnetic moments can switch between each other, of course, provided that under certain conditions. When the mode of the recessive magnetic moment of a charged lepton is switched, its spin magnetic moment will also change.

For the recessive magnetic moment, we can also understand in this way, it is in addition to the magnetic moment generated by the mass of the particle itself, there are other masses inside the particle generated magnetic moment, these other masses of the magnetic moment we call the recessive magnetic moment. The recessive magnetic moment is combined with the single-ring contribution of the anomalous magnetic moment of the particle, resulting in the anomalous magnetic moment of the particle. The recessive magnetic moment is only part of the anomalous magnetic moment of a particle.

For electrons, there is such a relationship: $\frac{R_e}{\lambda_e} = \frac{\alpha}{2\pi}$, R_e is the classical radius of electron, λ_e is the Compton wavelength of electron. It is also applicable to muon and tauon, and then:

$$\frac{R_Q}{\lambda_Q} = \frac{\alpha}{2\pi} \tag{1}$$

R_Q is the classical radius of charged leptons. λ_Q is the Compton wavelength of charged leptons. α is a fine structure constant. π is the pi.

If equation (1) is used to calculate the anomalous magnetic moment of charged leptons, we call it the **classical contribution** of the anomalous magnetic moment of charged leptons. It is produced by the mass of the charged lepton itself, not the mass of other particles.

Since equation (1) cannot accurately express the anomalous magnetic moment of charged leptons, we improve equation (1) to obtain the expression of the anomalous magnetic moment of charged leptons as follows:

$$a = \frac{R_Q + N_Q R_Q}{\lambda_Q} = \frac{R_Q}{\lambda_Q}(1 + N_Q) = \frac{\alpha}{2\pi}(1 + N_Q) \tag{2}$$

a is the anomalous magnetic moment of charged lepton, N_Q is the proportional coefficient of the mass of other particles participating in the anomalous magnetic moment of charged leptons.

The following is the specific formula for the anomalous magnetic moments of the three charged leptons that we wrote out according to equation (2):

1. Anomalous magnetic moment of the electron: a_e

$$a_e = \frac{\alpha}{2\pi}\left[1 - \frac{1}{4}\frac{m_e}{m_\mu} - \frac{m_e}{3m_p}\frac{m_p^4}{m_n^4}\frac{g_p + g_n}{g_p} + \left(\frac{m_e}{m_\tau}\frac{\pi\alpha}{2}\right)^2\right] \tag{3}$$

2. Anomalous magnetic moment of the muon: a_μ

$$a_\mu = \frac{\alpha}{2\pi}\left[1 + \frac{4}{5}\frac{m_e}{m_\mu} + \frac{m_e}{3m_p}\frac{m_p^4}{m_n^4}\frac{g_p + g_n}{g_p}\frac{1}{7\pi} + \frac{m_e}{m_\tau}\frac{2\alpha}{\pi}\right] \tag{4}$$

3. Anomalous magnetic moment of the tauon: a_τ

$$a_\tau = \frac{\alpha}{2\pi}\left[1 + \frac{g_p}{2}\frac{m_e}{m_\mu} + \frac{m_e}{3m_p}\frac{m_p^4}{m_n^4}\frac{g_p + g_n}{g_p}\frac{1}{\pi} + \frac{m_e}{m_\tau}\frac{\pi\alpha}{2}\right] \tag{5}$$

Where:

m_e is the mass of the electron.
m_p is the mass of the proton.
m_τ is the mass of the tauon.
m_μ is the mass of the muon.
m_n is the mass of neutron.
g_p is the spin g-factor of the proton.
g_n is the spin g-factor of the neutron.

In the above three formulas, the part of the same color indicates the same structure, which we call **the fixed magnetic moment structure** inside the charged lepton. As for the operator signs + and -, they can be understood as the direction of the magnetic moment.

Now let's discuss the calculation results of the above three formulas.

Calculation of electron anomalous magnetic moments

By calculating formula (3), we get the anomalous magnetic moment of the electron is: $a_e = 0.0011596521812831$.

The recommended value for 2018 CODATA is: $a_e = 0.00115965218128$.

Comparing the two with each other, it can be found that the calculation result of formula (3) is in good line.

If there is no $\left(\frac{m_e}{m_\tau}\frac{\pi\alpha}{2}\right)^2$ in formula (3), its result is: $a_e = 0.0011596521812705$.

Compared with the recommended value of 2018 CODATA, it is also in line with the good

Calculation of the anomalous magnetic moment of the muon

By calculating formula (4), we get the anomalous magnetic moment of the muon is: $a_\mu = 0.001165920921$.

The recommended value for 2018 CODATA is: $a_\mu = 0.0011659209(07)$.

Comparing the two with each other, it can be found that the calculation result of formula (4) is in good agreement.

Explanation of Anomalous Magnetic Moment Difference of Moon

If we make a change to formula (4), it looks like this:

$$a_\mu = \frac{\alpha}{2\pi}\left[1 + \frac{4}{5}\frac{m_e}{m_\mu} + \frac{m_e}{3m_p}\frac{m_p^4}{m_n^4}\frac{g_p + g_n}{g_p}\frac{1}{7\pi} + \frac{m_e}{m_\tau}\frac{\alpha}{2}\right] \tag{6}$$

The calculation result of formula (6) is: $a_\mu = 0.001165920588$.

The latest laboratory measurement is [1]: $a_\mu = 0.00116592061(41)$.

Comparing the two with each other, it can be found that the calculation result of formula (6) is in good agreement.

If we change the operation symbol before $\frac{m_e}{m_\tau}\frac{\alpha}{2}$ in formula (6), "+ into "-", then the calculation result of formula (6) is: $a_\mu = 0.001165918504$.

The theoretical value of the muon anomalous magnetic moment is [2]: $a_\mu = 0.00116591810(43)$.

Comparing the two with each other, it can be found that the calculation result of formula (6) at this time is in good line.

Now we can see that after this simple operation, the difference between the Laboratory measurement and the theoretical value of the anomalous magnetic moment of the muon can be well explained.

Calculation of the anomalous magnetic moment of the tauon

By calculating formula (5), we get the anomalous magnetic moment of the tauon is: $a_\tau = 0.001177213343$.

The theoretical value of the anomalous magnetic moment of the tauon is [3]: $a_\tau = 0.00117721$.

Switching of the recessive magnetic moment mode

Generally, when the charged lepton decays, its recessive magnetic moment mode will be switched. At this time, the recessive magnetic moment inside the charged lepton does not disappear, it will only switch from one mode to another. Only in the switching, part of the dimensionless proportional coefficient will change, and at the same time, the direction of some magnetic moments will also change.

In the formulas (3), (4) and (5), if we remove the parts of them of the same color, then there are:

$$\delta_e = -\frac{1}{4} - 1 + \left(\frac{\pi}{2}\right)^2$$

$$\delta_\mu = +\frac{4}{5} + \frac{1}{7\pi} + \frac{2}{\pi}$$

$$\delta_\tau = +\frac{g_p}{2} + \frac{1}{\pi} + \frac{\pi}{2} \qquad (7)$$

δ_e, δ_μ, δ_τ, we can call them the **magnetic moment code** of the anomalous magnet
ic moment of electron, muon, and tauon. By entering different magnetic moment codes, the recessive magnetic moment of a charged lepton can be switched from one mode to another. In the magnetic moment cipher above, the most easily changed number is π / 2, which affects the accuracy of the particle's magnetic moment. We can replace it with other numbers depending on the situation, such as in formula (6), we replace $2/\pi$ with $1/2$ according to the situation.

In the formulas (3), (4) and (5), if the part of the same color contains a m_μ term, we call that term in which it is located the magnetic moment contribution of the muon. For example, in the anomalous magnetic moment formula (3) of electron, the term of m_μ is $-\frac{1}{4}\frac{m_e}{m_\mu}$, which is called the magnetic moment contribution of the muon in the anomalous magnetic moment of electron. As for the magnetic moment contribution of proton and tauon is also the same. For $-\frac{1}{4}\frac{m_e}{m_\mu}$, we can understand it as the mass ratio of m_μ and $m_e/4$. For “-” , we can understand that the direction of the magnetic moment contributed by it is the same as the direction of the magnetic moment of the electron.

Composition of the anomalous magnetic moment of a charged lepton

We observe the equations (3), (4) and (5), we can find that the anomalous magnetic moment of a charged lepton is composed of four major parts, namely: the classical contribution of the charged lepton, the magnetic moment contribution of the muon, the magnetic moment contribution of the proton, and the magnetic moment contribution of the tauon. The contribution of these four magnetic moments determines the anomalous magnetic moments of charged leptons.

Since there is a fixed magnetic moment structure inside the lepton, the anomalous magnetic moment of the charged lepton can also be composed of a fixed magnetic moment structure and a magnetic moment code.

A uniform formula for the anomalous magnetic moment of a charged lepton

$$a = \frac{\alpha}{2\pi}\left[1 \pm A\frac{m_e}{m_\mu} \pm \frac{m_e}{3m_p}\frac{m_p^4}{m_n^4}\frac{g_p + g_n}{g_p}B \pm \frac{m_e}{m_\tau}\alpha C\right] \tag{8}$$

A, B, C, are dimensionless proportional coefficients. $\delta = \pm \mathrm{A} \pm \mathrm{B} \pm \mathrm{C}$. δ is the magnetic moment code of the anomalous magnetic moment of the charged lepton.

The presence of a recessive magnetic moment complicates the internal structure of the charged lepton, but it also shows that no charged lepton exists in isolation, and that there is a connection between their interiors and other particles. Recessive magnetic moments can explain why charged leptons change their anomalous magnetic moments during decay, and how they change. The recessive magnetic moment can also explain why a particle has many decay patterns when it decays, and why they can become a variety of other particles. However, this paper also has many problems to be solved. For example, why are there magnetic moments of other particles inside the charged leptons? how did the fixed magnetic moment structure come about? What is the basis of magnetic moment coding, etc. But we believe that this paper presents an enlightening point of view, enough to guide people to think in this regard.

Finally, from the above formula, we can find that the anomalous magnetic moment of a charged lepton is actually a mass effect produced by the mass interaction of many kinds of particles.

References

[1] arXiv: 2104.03281v1 [hep-ex].

[2] The anomalous magnetic moment of the muon in the Standard Model, T. Aoyama, et. al. Phys.Rept. 887 (2020) 1-166.

[3] arXiv: hep-ph/0702026v1.