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Solving the Problem of Source of Electron Spin Magnetic Moment

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Author's contribution

The sole author designed, analyzed, interpreted and prepared the manuscript.

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ABSTRACT

The concept of electron spin has a broad application prospect. However, after a century of efforts, the essence and specific form of electron spin have not been revealed. The reason is probably that it is constrained by the concept of point particle material structure. In order to solve the problem, one way to initiate the quantum mechanics revolution on the concept of material structure is to establish the concept of wave element material structure. Assuming that the composition of electrons is waves, the inherent motion of electrons (the spin of free electrons) is "the rotation of mass equivalent to the energy of waves". This rotation is not the rotation of a sphere, but similar to the rotation of a ring-shaped substance along a ring. This assumption breaks the concept of point particle structure. According to it, the angular kinetic energy and spin magnetic moment of electrons can be accurately calculated by classical force electrodynamics method. Other applications are also very successful, which has led to the revolution of quantum mechanics and material structure theory. The electron spin magnetic moment and electron spin angular momentum both originate from the motion of the waves that make up the electrons along the phase trajectory, providing a highly unified explanation for the fact that "discrete waves make up localized electrons and electrons have spin magnetic moments".

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Keywords: Revolution in material structure concept; electron spin magnetic moment; point particle; wave element material structure theory; electron spin operator; electron spin angular momentum eigenfunction.

1. INTRODUCTION

The spin magnetic moment of electrons is determined by their composition, structure, and intrinsic mode of motion. The ideas in the theory of the next level structure of electrons are representative of the ideas in the basic particle structure theory. It is the key to unraveling the mysteries of basic particle composition and structure, as well as the origin of the universe. It can be said that the significance of establishing and improving spin theory far exceeds the discovery of universal gravitation and Coulomb's theorem.

How is spin magnetic moment generated? The existing quantum mechanics cannot provide satisfactory answers, and only forcibly and subjectively stipulate that spin is an inherent physical property of particles [1-3]. In other words, it is believed that it, like the mass and charge properties of particles, is innate [*i.e.*, has intrinsic properties], and is phenomenally classified into various spin forms through the laws of quantum mechanics. The satisfactory explanation of the reason for the formation of the magnetic moment of electron spin cannot be found through long-term efforts is a serious injury in the theory of quantum mechanics! From the perspective of theoretical inheritance, this serious injury in quantum mechanics theory is a dense dark cloud in the sky of physics. While enjoying the light and warmth brought by spin magnetic moments to modern physics, we should also see the efforts and failures, joys and frustrations of modern physicists.

For electron spin, under the structural model of point particles or spherical particles, existing quantum mechanics cannot write "electron spin angular momentum $\vec{L}$ as $\vec{r} \times \vec{p}$. This is a headache inducing question about electron spin [4]. As mentioned above, the current theory and application of electron spin can be said to be phenomenological.

The conclusion that "electron spin cannot be specifically described" was made after their attempts failed within the framework of point particle structure model and sphere structure model. It is necessary to attempt a new spin approach within the framework of non-point (and\or non-sphere) electronic structure models. Spin angular momentum has eigenvalues corresponding to classical motion. If there is no corresponding classical motion, then even the laws of classical mechanics are negated. It seems too hasty to negate the failure of classical mechanical laws without attempting the "new ideas" mentioned above, at least not the preferred explanation. The author of this article attempts this new approach. It is proposed that "discrete waves knotting or propagating along a small closed path can form localized particles", and "the motion of waves propagating along a circle is the spin motion of particles". According to the principle that "energy and mass are equivalent, and the energy of a wave rotating along a circle is equal to the mass rotation of the particle composed of this wave," the conclusion drawn is that "spin angular momentum has a classical correspondence and can be written as a function of r and *p* like classical angular momentum". It can explain the experimental phenomena related to electron spin and photon decay into electron pairs. This is the dividend provided by the electronic structure theory of wave elements for us.

In short, electron spin is a prediction made based on the experimental phenomenon of photon decay into electron pairs, which requires more basic facts, principles, and theories to explain.

This provides a solution to the long-standing problem of how electron spin works. The references at the end of the article provide many successful computational examples that can connect classical physics and quantum mechanics concepts. This is the basis for the application of electronic wave structure models.

2. THE BASIC ASSUMPTIONS AND PREDICTION FOR BREAKTHROUGH THE CONSTRAINTS OF POINT-PARTICLE CONCEPT AND SPHERICAL PARTICLE CONCEPT

The "point" in the concept of point particles is not an infinitesimal point, but a point with a finite volume. The point particles mentioned in this article are all particles in this sense.

The wave function assumption in the basic postulates of quantum mechanics is that the state of a microphysical system is fully described by a wave function [5]. In quantum mechanics, the most commonly used wave function is

$$\psi = Ae^{-\frac{i}{\hbar}(Et-px)}. \quad (1)$$

The closest connection between this equation and physics is that it can represent the plane wave solution of the electromagnetic wave equation. Equation (1) can be used in the Schrödinger equation for all particles and microsystems, implying that "electromagnetic waves may be a more fundamental component than elementary particles". Based on this suggestion and the fact that high-energy photons can decay into electron pairs, we assume that the spin of an electron is the motion of the fundamental circularly polarized photons that make up the electron, propagating along a circle with an intrinsic longitude of r (circumference=wavelength, $\lambda=2\pi r$). Basic circularly polarized photons are decomposed from basic plane polarized photons [the decomposition process is opposite to the process of 'two beams of basic circularly polarized light combined into one beam of basic plane polarized light']. The energy and momentum of this type of photon are half of that of a fundamental plane polarized photon ($p=h/2\lambda=mc$), and the wave speed, wavelength, and frequency remain unchanged ($c=\lambda v$), exactly the same as the plane polarized photon before decomposition [for fundamental circularly polarized photons, $\lambda=h/(2mc)$, $v=c/\lambda$, electron mass $m=E/c^2=hv/(2c^2)$]. This structure has the characteristic of "uniform distribution of electron charges on that phase trajectory circle". The form of the wave function of this wave is exactly the same as equation. The values of E and p in the equation are only half less than the corresponding plane polarized photons. A fundamental circularly polarized photon constitutes an electron. The electric field of electrons originates from that phase trajectory circle. In this way, in terms of effect, the charge of electrons is evenly distributed on that phase trajectory circle. For convenience, we will refer to the above assumption as Basic Hypothesis 1 (hypothesis 1 for short).

Assumption 1 specifies the composition, structure, and internal motion mode of free electrons (composition: a fundamental circularly polarized photon; structure: a phase trajectory circle composed of a fundamental circularly polarized photon; internal motion mode: a fundamental circularly polarized photon propagates at the speed of light along a small circumference). For convenience, we will refer to that circle as an electron ring.

As long as "Hypothesis 1" can solve some previously unsolvable problems, it has significance and its underlying reasons can be further explored in the future, and the underlying reasons can be further explored in the future. Before that, we can make some predictions based on hypothesis 1. If these languages can be validated, it adds strong support.

From assumption 1, it can be seen that each free electron is a magnetic dipole that can flip (also known as electron ring flipping) when passing through an uneven magnetic or electric field space. We predict that during a measurement process, the direction of an electron's spin magnetic moment can be continuously changed. If this prediction is verified by the relay style Stern-Gallach experiment [6,7] (multi-stage relay Stern-Gallach experiment), its expression is that one of the two atomic beams separated from the first stage Stern Gallach experiment can be collimated and then passed through the Stern-Gallach experimental device again, and this new atomic beam can be further divided into two beams. In the Stern Gallach experiment, the magnets were increased to two pieces and connected in series. The second block is rotated 90-180 degrees relative to the first block. A beam of incident atoms can be separated into four beams. If this prediction is confirmed, according to basic hypothesis 1, the experimental phenomenon can be explained as follows - the electron ring can continuously flip in a non-uniform magnetic field and change the direction of the electron's spin angular momentum and spin magnetic moment. This experimental result can also prove that the statement "once the intrinsic state of the particle is measured, continuing to measure will not change the intrinsic state of the particle again" [8] is incorrect. This is very detrimental to the existing quantum mechanical measurement observation and state superposition principles. If the atomic beam in the Stern Gallach experiment is changed to an electron beam, the proof will be more direct.

3. DERIVATION OF SPECIFIC ELECTRON SPIN ANGULAR MOMENTUM OPERATORS AND SPIN MAGNETIC MOMENT OPERATORS

According to basic assumption 1 and classical electromagnetic theory, the magnitude of the angular momentum of the internal motion of electrons is $L=rp=rh/(2\lambda)$. Considering $\lambda=2\pi r$, we have

$$L=r\cdot p=\hbar/2. \quad (2)$$

This is a result calculated based on hypothesis 1 and classical electromagnetic theory, which is consistent with the facts. It is the first time that humans have calculated the magnitude of electron spin angular momentum based on the internal structure of electrons and classical electromagnetic theory. The direction of electron spin angular momentum is determined by the vector product of $\vec{r}$ and $\vec{p}$ in equation (2): $\frac{\vec{r}\times\vec{p}}{r\cdot p}$. In this way, the electron spin angular momentum is

$$\vec{L}=\left(\frac{\vec{r}\times\vec{p}}{r\cdot p}\right)\frac{\hbar}{2}. \quad (3)$$

If we define the plane of the electron ring as horizontal and the electron spin angular momentum of circularly polarized photons propagating counterclockwise on the ring is positive, then the sign of $\vec{L}$ is positive (spin up):

$$\vec{L}=+\frac{\hbar}{2}. \quad (4)$$

Flip the electronic ring 180 °, then the sign of $\vec{L}$ is negative $\vec{L}=-\frac{\hbar}{2}$. This equation is not the human component of angular momentum in the Z-direction, where ± is considered defined. The spin up and spin down transitions of a dot only require flipping the electron ring.

Assumption 1 indicates that Eq. (1) is the eigenfunction of electron spin. Compared with the Hamiltonian operator, the electron spin angular momentum operator can be written in the following form: L= [$f(m, c)$][$\frac{\partial}{\partial x}\psi$] =[$f(m, c)$] [$\frac{ip}{\hbar}$]. Comparing it with Eq. (2) and considering $p=mc$, result in $f(m, c)=\frac{\hbar}{2}\frac{\hbar}{ip}=-i\frac{\hbar^2}{2mc}$. Therefore

$$\hat{L}=-i\frac{\hbar^2}{2mc}\frac{\partial}{\partial x}. \quad (5)$$

Equation (5) is the electron spin angular momentum operator. The specific eigenfunction of electron spin angular momentum is Eq. (1). According to hypothesis 1 and the operator assumption of quantum mechanics postulates, Eq. (5) can also be obtained. Substituting $r=\lambda/2\pi=\hbar/2mc$ into Eq. (2), it can be obtained that:

$$L=r\times p=\frac{\hbar}{2mc}p. \quad (6)$$

According to the operator assumption of the quantum mechanics assumption, replacing the left p in Eq. (6) with the momentum operator $\hat{p}=-i\hbar\frac{\partial}{\partial x}$ can obtain the operator for L [*i.e.*, Eq. (6) can be changed to Eq. (5)]. Verification: Applying equation (5) to equation (1) yields an electron spin angular momentum of (1/2)$\hbar$.

The relationship between the spin angular momentum and spin magnetic moment of an electron moving along a circumference, derived from classical electrodynamics, is [9,10,11]:

$$\vec{\mu}_s=-\frac{e}{2mc}\vec{L}. \quad (7)$$

Replace $\vec{L}$ in Eq. (7) with the angular momentum operator represented by Eq. (5) to obtain the electron spin magnetic moment operator.

$$\hat{\mu}_s=-i\frac{e\hbar^2}{4m^2c^2}\frac{\partial}{\partial x}. \quad (8)$$

Verification: Eq. (8) acts on Eq. (1), result in $\mu_s=\frac{e\hbar}{4mc}$.

4. CONCLUSION AND SIGNIFICANCE

By establishing a new model, the unsatisfactory explanation of electron spin phenomenon by existing theories has been solved. It is predicted that the direction of the "electron spin magnetic moment" can be continuously changed. For the eigenvalues of electron spin angular momentum and spin magnetic moment, they can be calculated either by establishing specific spin operators and their eigenfunctions (the spin operators act on their eigenfunctions), or directly based on the established new model and classical electromagnetic theory. The significance of these works is as follows.

4.1 The Great Revolution in the Conceptual Conception of Material Structure

Scholars in the fields of physics and chemistry are familiar with concepts and data such as atomic radius, electron radius, and proton radius. This is a deeply ingrained manifestation, which matter structure concept of point-particle has deeply penetrated people's hearts. The wave element electronic structure model introduced in hypothesis 1 breaks through the concept of point particle material structure. This indicates that physics is still in the era of point particle concepts. The Great Revolution of Scientific Thought and Concept can promote the arrival of a new era of science.

4.2 Expected to Dispel the Dark Cloud of Electron Spin Magnetic Moment

This article can provide a satisfactory answer to the question of how electron spin magnetic moment is generated. Excluding the spin of microscopic particles artificially defined according to the rules of quantum mechanics.

4.3 Narrowing the Macro Micro Gap

The existing quantum mechanics have created an insurmountable gap between macro and micro levels. As stated in the title of this article, the microscopic electron spin magnetic moment and electron spin angular momentum were described using classical theoretical methods. At least narrowing this gap (or building a bridge over it).

4.4 Beneficial for the Regression of Local Realism and Determinism

Assumption 1 illustrates that electron spin is determined by the intrinsic motion of electrons. The composition, structure, and intrinsic motion of electrons are all clear and tangible. As long as electrons are not subjected to external forces, the spin angular momentum and spin magnetic moment determined by their intrinsic motion are determined and invariant. According to hypothesis 1, it can be inferred that, at the same time, an electron can only exhibit one spin state and cannot exhibit two different spin states simultaneously. In reality, it is objective for an electron to have only one spin state at the same time, and it cannot be superimposed with a spin state that does not exist in reality. Assumption 1 also tells us that the spin of an electron is not formed during measurement, but is inherent in a complete and mature electron. These results can pose a threat to the existing interpretation system of quantum mechanics, especially the measurement view (because the existing interpretation system of quantum mechanics is based on non-realism and non-determinism).

4.5 Can Trigger a Physics Revolution

Clarifying whether the spin magnetic moment of a particle should be described as a point spin or a body spin can not only trigger a physics revolution, but also a mathematical revolution. The emergence of Lie group algebra is precisely this result.

This article demonstrates that classical mechanics and wave dynamics can be compatible. That is to say, we can use both wave dynamics (quantum mechanics) and classical mechanics to describe the same object, regardless of whether it is a macroscopic or microscopic system. Simply put, this article is the theoretical basis for establishing the Schrödinger equation for the Earth's revolution. For example, we can use both classical mechanics and quantum mechanics (including wave mechanics and matrix mechanics) to describe the hydrogen atom, and we can also use both classical mechanics and wave dynamics to describe macroscopic objects such as the Earth. We provided the Schrödinger equation for the Earth in the third section of reference [9]. We will also provide a more detailed introduction to the Schrödinger equation that can describe the Earth's revolution in the article " Research Progress on the Schrödinger Equation of Earth's Revolution and Its Applications"for example, the Schrödinger equation for time-dependent macroscopic objects : $-i\frac{\hbar}{2}\frac{\partial}{\partial t}\psi = -\frac{\hbar^2}{2m}\frac{\partial^2}{\partial x^2}\psi - \frac{GMm}{R}\psi = E\psi$).

References [11-16] provide a detailed discussion on the formation, development, and application of the electronic structure model introduced in this article. A large number of computational examples are found in references [12] and [16]. References [14] and [15] systematically summarize and generalize the sources and significance of wave element electronic structure models. This article is only written to highlight the role of wave element electronic structure models in solving the problem of the source of electron spin magnetic moments.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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COMPETING INTERESTS

Author has declared that no competing interests exist.

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