

# Progress and Review of Applied Research on New Theory of Electronic Composition and Structure

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## Abstract

Quantum field theory regards particles as fields, and generally does not discuss the internal composition and structure of electrons. Exploring the internal composition and structure of electrons does not conflict with quantum field theory that does not discuss the internal composition and structure of electrons. Quantum mechanics is greatly embellished by a hypothesis of "the internal composition, structure and motion of electrons" — the important equations of quantum mechanics are no longer written intuitively, but can be derived from rigorous logic. It can give a reasonable and non-contradictory classical rotation model for electron spin and atomic structure. The most attractive thing is that the classical planetary model of atoms can also be successfully applied to the calculation of the dissociation energies and bond lengths of hydrogen molecules, lithium molecules, and sodium molecules. For atomic and molecular calculations a mixture of wave dynamics methods and classical methods in the context of planetary models can be used. There are hundreds of successful application cases. Which in turn shows that the two methods are equivalent or compatible. It can promote human beings to re-understand the characteristics of micro-systems.

**Key words:** Simplest circularly polarized photon, Internal structure of electron, Quantum mechanics, Electron spin operator, Applied research, Quantum mechanics.

## 1. Introduction

For a long time, it was believed that the internal structure of electrons was unknown. Some people say that electrons are resonant states of photons. Some people claim to have discovered in experiments that electrons are composed of caution, orbiton and spinon [1](this view does not appear to be widely accepted. The vast majority still believe that the internal structure and intrinsic form of motion of electrons are unknown). The application of these ideas in quantum mechanics and quantum chemistry is almost blank (at least in terms of application, they do not have any advantages compared with models of light-knot electronic structures). Existing quantum field theories do not discuss the internal structure and intrinsic motion of electrons in depth, but regard it as a field [2]. This situation allowed theories about the composition and structure of electrons to be born. Reference [3] established a theory of the internal motion, composition and structure of electrons — the electronic structure model of the light-knot, and established a new and complete quantum mechanics theoretical system based on it. This seems to be the perfection and development of quantum field theory. Excitingly, the reference [4,5] also provides a large number of successful applications of these new theories. The logic of the system of the new theory and its successful application show that we can use the Bohr planetary model and wave mechanics both independently and in combination (showing that the two methods are either equivalent or highly compatible). It is particularly convincing that we can not only overcome the shortcomings of the old quantum theory, but also extend the planetary model to successfully describe and calculate the bond lengths and dissociation energies of some molecules. The calculation methods for atoms, molecules, and electrons corresponding to the Bohr planetary model

are methods using classical rotation and classical electrodynamics.

Observing in the coordinate system of the centroid system of the photon, the electric field of the photon only extends to the two wings, and the light field is not a spherically symmetric central force field. However, the electric field of the electron is a spherically symmetric central force field. In addition, the electric field of a photon has no polarity, while the positive-anti-electron into which the photon decays has two different polarities (this polarity is exhibited by the negative charge of the electron and the positive charge of the anti-electron). The vacuum polarization it refers to is not photon polarization, and the vacuum polarization produces virtual electron pairs instead of real electron pairs. Its transition-like theory of how photons decay into electrons also doesn't specify how photons, which are bosons, become electrons, which are fermions. The photon is the resonance of the electron, which means that the photon and the electron are a resonance complex. A high degree of resonance recombination is a photon, and a low degree of resonance recombination is a positive-anti-electron couple. Resonant states are all hadrons, and electrons are leptons. It can be seen that such a resonance state and the way it changes are also very bizarre, and it is not a detailed explanation of the photon decay process. Given that quantum field theory does not describe the electron's internal structure and motion in detail, it should allow us to speculate on the electron's internal structure and motion.

In layman's terms, a light-knot electronic structure model is an assumption that photons can be rolled up to form electrons. The assumptions in the process of scientific exploration are all subjective speculations and choices made by human beings when they encounter difficulties in understanding nature. Once a hypothesis has a positive effect (a logical self-consistent theoretical system can be established or used to solve practical problems), the hypothesis becomes a research result and is a research progress. Since scientific hypotheses are all speculation and choice about the unknown, there must be a phenomenon or a regular—judging the content of new hypotheses with known knowledge, new hypotheses must be deviant or strange. There are countless examples of this. For example, the assumption of discontinuous change of energy, the assumption of heliocentric theory, etc. The assumption that photons can be rolled up does not escape this law. Therefore, the assumption that photons can be rolled up is also bizarre, judging by existing knowledge. The author hopes that readers will not immediately force the new hypothesis to be completely consistent with accepted knowledge, but instead focus on the usefulness of the new hypothesis (*i.e.*, focused review of the value of the new hypothesis for use).

Regarding the application of the light-knot electronic structure model, it is mainly divided into the following aspects. First, use it to establish a complete mathematical formal system of quantum mechanics (beautify the logic system of quantum mechanics). 2<sup>th</sup>, according to it, calculate several small molecules such as "electron radius, spin angular momentum, spin magnetic moment and hydrogen molecule. Determine the electron spin function, so as to derive the electron spin solution momentum operator, electron spin magnetic moment" operator, the angular momentum operator for the electron orbital motion of the hydrogen atom. 3<sup>th</sup>, we can use the Bohr planetary model [6] and wave mechanics to calculate the relevant data of electrons, atoms and molecules, and derive the basic equations of quantum mechanics. The application of the above three aspects determines that the electronic structure model of the light-knot is completely wrong and the evidence is insufficient. Even if all physicists agree that the light-knot electronic structure model is unimportant, the above applications could decide that quantum chemists need it.

The last section of this article lists ten favorable factors for modeling the electronic structure of light-knots. This undoubtedly makes the light-knot electronic structure model have a certain reference value. Due to the large number of application results presented in this article that are consistent with the facts, the probability of "results by chance" is very low. Therefore, unless probability theory fails, or quantum field theory (especially the Standard Model theory) is not at all flawed, we cannot deny the light-knot electronic structure model and the quantum-mechanical method of local realism based on it. We first introduce the electronic structure model of the

light-knot and the calculation methods and results using it, and then give corresponding comments in time (which can also be said narration interspersed with comments).

## **2. Calculate the electron radius and spin angular momentum according to the light-knot electronic structure model**

Most people think that they have a better understanding of electromagnetic waves or photons. actually not. An example is given below. <1> How long does the electromagnetic field in a photon or electromagnetic wave survive at each stationary point in space? That is, what is the lifetime of a nascent electromagnetic vector at a point in stationary space where the phase orbit of the wave in an electromagnetic wave or photon crosses? The atom emits photons continuously for  $10^{-8}$  seconds. The wave vector stays for infinitesimal time at each stationary space point. Neither of these two kinds of time is the residence time of the same electric vector path and or the magnetic vector path of the electromagnetic wave at the same space point, that is, neither is the lifetime of the photon or the electromagnetic field in the electromagnetic wave. The natural lifetime of a photon in a vacuum is very long, but the electric field in a photon has a very short residence time at the point in space where its phase line swipes (In the process of electromagnetic wave propagation, the electromagnetic field vector at the previous point is quickly replaced by the induced nascent electromagnetic field at the next point). The lifetime of a photon is the duration of repeated iterations of the electromagnetic field in the photon. <2> Can the simplest plane polarized light be decomposed into left-handed circularly polarized light and right-handed circularly polarized light? <3> Mathematically, two sine waves intersecting vertically can become a circle. If two photons of the same sine wave intersect vertically, can it also become a circle? <4> Can photons roll up (whether in flat or non-flat space) to form a wave ring whose center of mass does not translate? The answers to these questions cannot be found in textbooks. This shows that human understanding of photons or electromagnetic waves has not reached the end. People who do not have a thorough understanding of photons or electromagnetic waves should be inconvenient to deny others' speculation and exploration of the unknown properties of electromagnetic waves or photons. In the existing electromagnetic theory, when the electromagnetic wave propagates, neither the electric vector nor the magnetic vector is displaced. In the existing electromagnetic theory, in the process of electromagnetic wave propagation, neither the electric quantity nor the magnetic vector is displaced (but is reborn in the front, with the effect of displacement), and the wave vector is displaced.

Reference [3] has made bold speculations on the unknown properties of electromagnetic waves and photons (provided a speculative answer to the above question). Answer to question <1>: the lifetime of a photon or an electric vector in an electromagnetic wave is one cycle of an electromagnetic wave. Answer to question <2>: The simplest front polarized light can be decomposed into left-handed circularly polarized light and right-handed circularly polarized light. A composite plane-polarized light can be split into two circularly polarized light by a quarter crystal. Therefore, it is entirely possible that a beam of the simplest plane polarized light can be decomposed into two beams of the simplest circularly polarized light. Answer to question <4>: The simplest circularly polarized light can be rolled up to form an end-to-end wave ring. Chemists all know that at first people were distressed to can not find a suitable chemical structure for benzene. Later, Kekule dreamed of a snake biting its own tail to form a ring, thus proposing the benzene ring structure. The ring structure is a magical structure. Three kinds of unification or transformation of entities can be achieved by changing the linear state into a ring: The unification and transformation of the displacement of the center of mass and the static of the center of mass; the unification and transformation of the discrete and localized; the unification and transformation of the non-static field and the static field. Let's think of a photon as a multi-legged centipede. In this way, the combined result of the above three answers is a ring-shaped entity centipede connected end-to-end (its legs correspond to the lines of force of the photon's electric field, or the radii of the electric vector). Its movement change is characterized by the

continuous disappearance of the tail while the head continues to grow. The effect is that the head advances along the circle without displacement (in appearance, its body is doing peristaltic rotation). The body and legs of the ringed centipede are in a steady state (size and stretch direction constant). The three answers above are a hypothetical series. The three answers above are a hypothetical series. For convenience, we call the hypothesis series of the properties endowed by this natural section to photons as **hypothesis 1**. It can also be called the light-knot electronic structure model or the wave-spinor electronic structure model.

According to hypothesis 1, it can be known that the process of photon decay into positive and negative electron pairs is that the simplest plane polarized photon with energy reaching or exceeding the threshold frequency is decomposed into a left-handed circularly polarized photon and a right-handed circularly polarized photon, these two circularly polarized photons. They roll up again to form electrons and anti-electrons. Under the premise of explaining the change process of photons decaying into positive and negative electron pairs, the above three sub-hypotheses are not independent but interrelated. Once one of the sub-hypotheses is proposed, the contents of the other two sub-hypotheses cannot be chosen arbitrarily in order to achieve the purpose of the photon decay process (otherwise the purpose will not be achieved). Under the premise of explaining the change process of photons decaying into positive-anti-electron pairs, the above three sub-hypotheses are not independent but interrelated. Once one of the sub-hypotheses is proposed, the contents of the other two sub-hypotheses cannot be chosen arbitrarily for the purpose of explaining the photon decay process (otherwise it won't work). If you choose an affirmative answer to question <3>, it can provide a mathematical basis for the hypothesis that "photons can be rolled up". Because, as long as this kind of wave circle exists stably, photons must be able to form this kind of wave circle in other ways.

According to hypothesis 1, the free electron is a wave ring (similar to a large closed string). Plane polarized light consists of two simplest circularly polarized lights whose electric vectors rotate in opposite directions. The simplest circularly polarized photon has half the energy of the corresponding plane polarized photon (the reason why the "simplest circularly polarized light" is emphasized is that there is also a combined circularly polarized light composed of two plane polarized lights with different phases):

$$E_c = E_e = h\nu/2. \quad (1)$$

Here,  $E_c$  is the energy of the most simple circularly polarized light,  $E_e$  is the energy of the electron, and  $\nu$  is the frequency of the most simple circularly polarized light (also the frequency of the plane polarized light before decomposition). The wavelength and frequency do not change when a photon decays. The value of the electron radius is the quotient of the wavelength corresponding to the threshold frequency of photon decay and  $2\pi$ .

$$r_e = \lambda/2\pi. \quad (2)$$

Equation (2) The relationship between  $\lambda$  and frequency is  $c = \nu\lambda$ . Substituting  $c = \nu\lambda$  and the valve frequency of photon decay into electron-anti-electron couple into Equation (2), we get  $1.929 \times 10^{-13}$  meters. The calculation result is half of the theoretical value  $r_e = 3.86 \times 10^{-13}$  meters published in the literature [7].

According to **hypothesis 1**, the intrinsic motion (spin) of free electrons is also the intrinsic movement of the circular propagation of the simplest circularly polarized photons inside the electrons. The angular momentum of the electron spin is equivalent to the angular momentum ( $L_e$ ) of the elementary photon in the uniform circular motion. As we all know, the momentum of the plane polarized photon is  $p = h/\lambda$ , then the linear momentum of the corresponding element photon is only half of it:

$$p_e = p/2 = h/2\lambda = mc. \quad (3)$$

Here,  $m$  is the mass of the electron,  $p_e$  is the momentum of the simplest circularly polarized light,  $mc$  is the linear momentum of the electron's intrinsic motion. According to **hypothesis 1** and the equivalent law of mass and energy,  $h\nu/2c^2 = m$ . In this equation,  $m$  is the rest mass of the electron. The electron spin angular momentum is

$$\vec{L}_e = \vec{r}_e \times \vec{p}_e. \quad (4)$$

The direction of the angular momentum of the elementary photons within the electron changes with time. Therefore, in general we only consider its scalar. Substituting equations (2) and (3) into the scalar form of Equation (4), we can get  $L_e = h/4\pi = (1/2)\hbar$  (many books use  $M_s$  to represent  $L_e$ ). The calculated results are in complete agreement with the experimental values (no error). This is the first time that the electron spin solution momentum has been calculated by using the intrinsic motion state of the electron and the classical mechanical method. This is also a component of the electron spin angular momentum (the Z-direction component). The Z direction does not change, the electron flips 180 degrees, and  $L_e$  is  $-(1/2)\hbar$ . The electron spin angular momentum was accurately calculated using a model of the electronic structure in which "waves travel along a small circle." This is very similar to the situation when Bohr used the planetary model to calculate the energy of the hydrogen atom. It is now recognized that spin is represented by spinor, and spinor exists in two-dimensional complex space, and the corresponding three-dimensional Euclidean space is a vector with zero length but direction, so we say that spin has no classical correspond. A suitable classical correspondence for electron spins has also not been found. Now, we can find the classical correspondence for electron spins. This classical correspondence has an interrelated duality: The first characteristic is the curling of light. Although it is also a rotation on a two-dimensional plane, it belongs to the rotation corresponding to classical electromagnetism; the second property is the classical correspondence of the fit, and is the rotation in a two-dimensional plane of a mass equivalent to the energy of a coiled electromagnetic wave, which is habitually regarded as a classical rotation. It can be seen that admitting that "the spinor produced by the rotation of the electron" is the spinor in the two-dimensional complex space cannot deny the rotation model of the photon rolling up.

Both  $p=mv$  and  $L_e=rp$  are classical motion formulas (or formulas compatible with classical motion and rotation). Using these two formulas to derive the physical quantities of electrons, atoms and molecules can also be said to use classical motion or rotation when deriving these physics. There are quite a few friends who think that it is enough to consider that the light field becomes the steady field of electrons, and there is no need to describe it so carefully (no need to explore the specific process of this change). However, exploring this specific process of change does not require denying quantum field theory. From equation (4) and its calculation results, we can see that it is beneficial to explore this specific process. The electromagnetic fields of specific photons attached end-to-end propagate along a circle to form relatively localized energy concentrators — fields in nature but with the properties of particles as a whole. It can be said that this is the essence of wave-particle duality. This electronic structure model combined with its successful application can make people re-understand the micro world and the relationship between the micro world and the macro world.

According to **hypothesis 1**, it can be predicted that the simplest circularly polarized photon with higher frequency has the characteristic of partial steady charge. For example: the simplest circularly polarized light is deflected in a magnetic field, and can produce electric field magnetic induction similar to electromagnetic induction, etc. It is worth noting that the verification of this prediction can prove the correctness of the electronic structure model of the light-knot, but the **hypothesis 1** cannot be denied if this prediction cannot be verified (the reason is that the properties of circularly polarized light are poorly understood).

### 3. Calculation of Electron Spin Magnetic Moment Using Classical Rotation and Classical Physics Methods

**Hypothesis 1** states that the internal motion of the electron is the rotational motion of the wave (propulsion along a circular phase trajectory). The author fits the rotational motion of the wave to the classical rotation through the de Broglie relation and the concept of de Broglie matter wave. In fact, this kind of work has already started when formula (4) is written. The following is almost everywhere with this idea of work. This fitting is also justified. Because the rotational motion of the wave is the rotational motion of the energy, and the theory of relativity holds that the energy is equivalent to the mass. Therefore, the rotational motion of the wave is equivalent to the rotational

motion of the mass. The orbital motion of a mass has previously been regarded as a classical rotation. In this way, the rotation inside the electron is both the rotation of the wave and the classical rotation of the mass matter. It is inevitable to be able to use both classical mechanics and wave mechanics. The advantages of this approach are also obvious. Because the rotation of the wave does not emit electromagnetic waves outward, the Huygens iteration of the wave must be quantized, and there is no need for quantization to occur as rigidly as Bohr did. As long as we can describe the quantization process, we can explain spectral lines. The motion of waves conforms to the wave equation, so for describing electrons, classical mechanics and wave dynamics are naturally compatible. We can apply classical rotation to quantum mechanics while overcoming the shortcomings of Bohr's planetary model (derive the fundamental equations of quantum mechanics and calculate some physical quantities of electrons, atoms and molecules).

According to **hypothesis 1**, the intrinsic motion of free electrons is the propagation of electromagnetic waves along a small circle. According to the mass-energy equivalence principle of relativity, the rotation of the photon in the free electron is equivalent to the classical rotation of a charged point particle or ring with a mass of  $h\nu/2c^2$  (The calculation of electron spin angular momentum in the previous section also uses this concept). Since the elementary photon inside the electron propagates along a small circle, its whole (or center of mass, or energy center) is at rest, and  $h\nu/2c^2$  becomes the rest mass. This is how mass-energy equivalence imparts rest mass to electrons. According to the relationship between electron spin angular momentum and self-magnetic moment, the electron spin-magnetic moment in the framework of the light-knot electronic structure model is

$$\mu_e = -\frac{e}{2mc} L_e = -\frac{e}{4mc} \hbar. \quad (5)$$

Considering equation (4) and substituting the corresponding constant into equation (5), the electron spin magnetic moment is calculated to be  $9.27400968 \times 10^{-24} \text{J/T}$ . This value is the theoretical value, which is slightly different from the experimental value of  $9.28476430 \times 10^{-24} \text{J/T}$  (about 1/10,000). The reason for this is worth exploring (perhaps the magnetic field of the elementary photon in the electron plays a role).

According to the calculation results of Eq. (4) and Eq. (5), it can be known that the ratio of the spin magnetic moment of a free electron to its spin angular momentum is

$$-\frac{e\hbar}{4mc} \bigg/ \frac{\hbar}{2} = -\frac{e}{2mc}. \quad (6)$$

#### 4. Deriving the Electron Intrinsic Momentum Operator and the Electron Spin Operator According to the Light-knot Electronic Structure Model

Whether it is plane polarized light or circularly polarized light, the wave equation is

$$\psi(x, t) = A e^{-i2\pi(\nu t - x/\lambda)}. \quad (7)$$

The difference is that for plane polarized light, where  $E=h\nu$ ,  $p=h/\lambda$ , and for the simplest circularly polarized light,  $E_e=h\nu/2$ ,  $p_e=h/2\lambda$ . After the plane polarized light is decomposed into circular light, the wavelength and frequency remain unchanged. Therefore, the wavelength and frequency are still in their original symbols  $\lambda$  and  $\nu$ . But their

momentum relation is:  $p_e=p/2$ . Equation (7) can also be written in the form of  $\Psi(x, t) = A e^{-(i/\hbar)(Et - xp)}$ . When the iterative process of the wave in Huygens' principle occurs, the meaning of A in the formula changes from the amplitude of the mother wave to the amplitude of the wavelet. According to the electronic structure model of the light-knot, although the simplest circularly polarized photon of the electron propagates along the circumference. But described in a curved space on a curved surface, its wave function is of course also the equation (7). Under the premise of **hypothesis 1**, the waves inside the free electrons are real monochromatic waves rather than probability

waves and wave packets. We first use the one-dimensional equation (7) in the curved space, and then extend it to the three-dimensional space after the one-dimensional linear momentum operator is obtained. When the same particle or wave has the same motion law in the flat space and the curved space, the linear momentum is calculated in the curved space and the straight space, and the result is exactly the same. Therefore, when calculating the linear momentum of a particle, it is not necessary to distinguish whether it is a curved space or a straight space. **Hypothesis 1** tells us that for the intrinsic fluctuations of free electrons, the wavelength  $\lambda=h/2p_e=\pi\hbar/p_e$  [See Equation (3)]. Considering the wavelength expression  $\lambda=h/2p_e=\pi\hbar/p_e$  of the intrinsic fluctuation of free electrons, to find the partial derivative of (7) with respect to  $x$ , we have

$$\frac{\partial}{\partial x}\psi(x,t) = \left[ i \frac{p_e}{2\hbar} \right] \psi(x,t). \quad (8)$$

Transform this formula into

$$\left[ -i2\hbar \frac{\partial}{\partial x} \right] \psi(x,t) = p_e \psi(x,t). \quad (9)$$

According to the definition of the operator,  $-\frac{i\hbar}{2} \frac{\partial}{\partial x}$  is the linear momentum operator ( $\hat{p}_e$ ) of the intrinsic motion of free electrons, namely

$$\hat{p}_e = -\frac{i\hbar}{2} \frac{\partial}{\partial x}. \quad (10)$$

Equation (10) is the momentum operator for the intrinsic motion of the elementary photon or free electron.

**Hypothesis 1** specifies that the electron's intrinsic motion (spin motion) is that of a minimally circularly polarized photon propagating along a small circle. And end to end (the circumference of this small circle is exactly the wavelength). Therefore, in a curved space, the wave function of the electron spin is still in the form of Equation (7). Considering  $p_e=mc$ , multiply both sides of (10) by  $r_e$  (the expression of  $r_e$  is  $r_e=\lambda/2\pi=h/4\pi p_e=\hbar/2mc$ ). Considering  $L_e=rp$ , and the operator definition, we have

$$\hat{L}_e = -i \frac{\hbar^2}{4mc} \frac{\partial}{\partial x}. \quad (11)$$

Here,  $m$  is the static mass of the electron, and its value is  $h\nu/2c^2$  (A plane polarized photon decays into an electron and an anti-electron. Hence the relationship). Equation (11) is the electron spin angular momentum operator. The above derivation process shows that: if **hypothesis 1** holds, the electron spin function is the Equation (7), and the electron spin operator is the Equation (11). Applying equation (11) to equation (7), the eigenvalues of electron spin solution momentum can be obtained.

After calculating the electron spin angular momentum using the classical structural model, the notion that "the electron spin has no classical correspondence" has actually been broken.

The operator of the spin magnetic moment of the electron can also be derived from the light-knot electronic structure model (phase orbital electron model). Multiply both sides of equation (9) by  $\mu_e/mc$ . Then use the formula (5) to eliminate one of the two  $\mu_e$  in the formula, and at the same time use  $mc$  to eliminate  $p_e$  on the right side of the equal sign to get, we can obtain

$$i \frac{e\hbar^2}{8m^2c} \frac{\partial}{\partial x} \psi(x,t) = \mu_e \psi(x,t). \quad (12)$$

According to the definition of operator, the operator of electron spin magnetic moment is

$$\hat{\mu}_e = i \frac{e\hbar^2}{8m^2c} \frac{\partial}{\partial x}. \quad (13)$$

The unit system is the CGS unit system (the same below). Equation (13) can also be derived using the well-known operator derivation method. According to the relationship between spin angular momentum and spin magnetic moment, we know  $\mu_e = -\frac{e}{2m} L_e$ . Considering  $L_e = r_e p_e$  and  $r_e = \hbar/2m$ , result in

$$\mu_e = -\frac{e\hbar}{4m^2c} p_e. \quad (14)$$

Using equation (10) to replace  $p_e$  in Equation (14) with an operator, equation (13) can be obtained.

## 5. Deriving the Schrödinger Equation Based on the Electronic Structure Model of the Light-knot

Both the Schrödinger equation and the Dirac equation correspond to a suitable energy summation formula. The correctness of the derived Schrödinger and Dirac equations can be checked on the basis of this feature.

The Huygens principle says that every point on the spherical wave surface is a sub-wave source of a secondary spherical wave, and the wave speed and frequency of the sub-wave are equal to the wave speed and frequency of the primary wave. For convenience, we call the change process of the wave described by Huygens principle as the Huygens splitting of the wave or the Huygens iteration process of the wave (the Huygens propagation of the wave). Another wave law is that in a potential field, the energy of the wave changes, but the form of the wave does not change. In the electric field of the nucleus (or atomic core), the wave equation of the electron is still the wave equation of plane polarized light or circularly polarized light.

However, according to Huygens' principle, in the hydrogen atom, the electrons outside the nucleus have been expanded into a wave train (one beat of the beat wave), and the sub-wave number in this wave train is 274 (this is **hypothesis 2**). **Hypothesis 2** contains "in the potential field, special electromagnetic waves can complete the Huygens iteration process". The essence of **hypothesis 2** is still Huygens' principle. Huygens' principle also tells us that a series of sub-waves and parent waves have the same wave speed, the same wavelength, the same frequency, and different amplitudes. This beat wave has always been referred to as a de Broglie wave. De Broglie waves are the bridge between the microscopic world and the macroscopic world. Since the use of de Broglie waves to deal with microscopic systems is successful, we fit the beat waves in the potential field to de Broglie waves. The relationship between its wavelength and momentum is  $p = h/\lambda = mv$ . Here  $v$  is the de Broglie wave velocity and  $p$  is the linear momentum of the overall motion of the electron outside the nucleus. Its total energy is the sum of the potential energy ( $V$ ), kinetic energy ( $T$ ) and the energy corresponding to the rest mass ( $m_0c^2$ ) of the electron outside the nucleus (We still use  $E$  to denote). After the beat length is also denoted by  $\lambda_d$ , the de Broglie relation is Equation (15) (for  $s$  electrons with circular orbits). It can be seen from the above discussion that the connotation and application of de Broglie wave are exactly the same as before, but the understanding of it is a little different. In this paper, the essence of the de Broglie wave is a standard wave, but it can be fitted to a matter wave.

$$\lambda = \frac{h}{p} = \frac{2\pi\hbar}{p} = 2\pi r. \quad (15)$$

Taking the first-order partial derivative of Equation (7) with respect to  $x$ , we get:

$$\frac{\partial}{\partial x} \psi(x, t) = i \frac{p}{\hbar} \psi(x, t). \quad (16)$$



Transform this equation to get  $p\psi(x,t) = -i\hbar \frac{\partial}{\partial x} \psi(x,t)$ . According to the definition of operator, we know:

$$\hat{p} = -i\hbar \frac{\partial}{\partial x}. \quad (17)$$

Equation (17) is the momentum operator for electrons in atoms and molecules. In the above process, "seek first-order derivative" is changed to "seek second-order partial derivative", result in:

$$\hat{p}^2 = -\hbar^2 \frac{\partial^2}{\partial x^2}. \quad (18)$$

In the electrodynamic equilibrium system, the Virial theorem holds, and the kinetic energy of a particle has a definite relationship with its mass. In the case of the hydrogen atom, this relationship is:

$$T = p^2/2m. \quad (19)$$

According to Equation (18), change  $p_d^2$  in Equation (19) into operator form, result in

$$\hat{T} = -\frac{\hbar^2}{2m} \frac{\partial^2}{\partial x^2}. \quad (20)$$

$T+V=H$  is the sum of the kinetic and potential energies of particles in an electrodynamic equilibrium system other than the energy equivalent to the static mass. Considering  $T+V=H$ , adding  $V$  to both sides of the above equation. Then according to the definition of the operator (the operator of  $V$  is  $V$  itself), we can get

$$\hat{H} = -\frac{\hbar^2}{2m} \frac{\partial^2}{\partial x^2} + V. \quad (21)$$

Equation (21) is the Hamilton operator of the electrodynamic equilibrium system obtained by taking the hydrogen atom as an example. It acts on the wave function to get the energy eigenvalue  $H$  (Hamiltonian).

$$\left[ -\frac{\hbar^2}{2m} \frac{\partial^2}{\partial x^2} + V \right] \psi = H\psi. \quad (22)$$

Equation (22) is the non-relativistic Schrödinger equation. where  $\psi$  is the wave equation for plane polarized light (where  $E=h\nu$ ,  $p=h/\lambda$ ). The time-dependent Schrodinger equation will be derived in Section 7. Equation (22) corresponds to the energy summation formula  $T+V=H$ .

The Schrödinger equation occupies a high place in the mathematical formal system of quantum mechanics. Previously, when deriving the Schrödinger equation, the rationale for using the wave function  $\psi(x,t)$  was that "the motion of microscopic particles is similar to equation (7)". Under the light-knot electronic structure model, the vague "similar" becomes a positive "yes". This obviously makes the derivation process of the Schrödinger equation farther from intuition and more logical.

## 6. Calculation of Hydrogen Atoms According to the Light-knot Electronic Structure Model

**Hypothesis 2** considers that the small ring of free electrons becomes a large ring through Huygens iteration process when it becomes the extranuclear electron of hydrogen atom. That is, the radius of the 1s electron is 274 times the radius of the free electron. In this way, the structure of a ground-state hydrogen atom is: the hydrogen nucleus is located above the center of a circle surrounded by 274 secondary wavelets, and the ground-state electron closed chord radius (also the Bohr radius, denoted as  $r_d$ ) is

$$a_0 = r_{1s} = 274\lambda/2\pi, \quad (23)$$

where  $\lambda$  is still the wavelength of the  $\gamma$ -quantum "corresponding to the energy exactly the threshold frequency at which the photon decays into an electron couple". It is half the electron Compton wavelength  $\lambda_c$  (*i.e.*,  $\lambda=\lambda_c/2$ ), and the value is  $\lambda=h/2mc=1.213\times 10^{-12}$  meters. The free electron radius is:  $r_e=1.213\times 10^{-12}\div 2\pi=1.929\times 10^{-13}$  meters. Therefore,  $r=274r_e=274\times 1.929\times 10^{-13}$  meters= $5.29\times 10^{-11}$  meters, and the calculated results are consistent with the Bohr radius values. The same result can be obtained by substituting the potential energy function  $V=-e^2/r$  into Eq. (42) extended to three-dimensional space. "Extending (22) to three-dimensional form" is a purely mathematical process. Its corresponding physical content is that the motion of the hydrogen atom and the outer electron is the motion of the four-dimensional manifold. The fitted classical rotation model is the same as the numerical value of the hydrogen atomic radius obtained by the four-dimensional manifold method. The fitted classical rotation model is the same as the numerical value of the hydrogen atomic radius obtained by the four-dimensional manifold method. This suggests that the two approaches are not mutually exclusive. Even if there is an irreconcilable contradiction between them, it is possible that the 4-manifold method of space is distorted. It is believed that the movement of the electron outside the nucleus is a four-dimensional manifold, which leads to the unknown movement of the electron (or very vague), and must use the ugly concept of an electron cloud. According to **hypothesis 2**, the electron outside the hydrogen nucleus is a wave ring. It also determine "the energy density has a maximum in a spherical shell of a certain radius".

Within the framework of the light-knot electronic structure model, the non-relativistic orbital angular momentum ( $L_s$ ) of the 1s electrons outside the hydrogen nucleus can be calculated using two different methods. The first method is to fit the motion of the extranuclear electrons other than the intrinsic motion as de Broglie matter waves. Thereby making use of the classical rotation and de Broglie relation. The angular momentum of the orbital motion of the 1s electron outside the hydrogen nucleus is  $\hat{L}_s = \vec{r} \times \hat{p}$ . Substituting the Debro relation (15) and  $r=\lambda/2\pi$  into  $L_s=rp$ , we can obtain the absolute value of one of its components:

$$L_s=r[h/(2\pi r)]=\hbar. \quad (24)$$

It is exactly 2 times the spin angular momentum of a free electron. The second method uses the orbital spin operator on the wave function [see Equation (28) for operators. The spin function is still equation (7)].

Previously, it was believed that the wave function of the electrons in the s subshell of the hydrogen atom is spherically symmetric, and the angular quantum number  $L_s=0$ , so its orbital magnetic moment is zero. That is, there is no orbital spin motion. But in this paper,  $L_s$  is the electron orbital angular momentum in the atom). That is, there is no orbital rotational motion. The reason for the deflection of the hydrogen atomic rays in the non-uniform magnetic field detected by the Stern-Gerlach experiment is the magnetic moment of electron spin, not the magnetic moment of electron orbital motion. Under this interpretation, the orbital angular momentum  $L_s$  of the hydrogen should be  $(1/2)\hbar$  instead of  $\hbar$ . In theory, the Stern-Gerlach experimental data can judge whether the paper is correct or the previous understanding is correct. However, things are not that simple. The reason is that if the intrinsic angular momentum and spin magnetic moment of the orbiting electron are still there, then the spin magnetic moment of the proton should be coupled with the electron spin magnetic moment. The result measured by the Stern-Gerlach experiment is still more likely to be just the orbital magnetic moment of the electron. As mentioned above, this paper predicts that using neutral atoms with an odd number of protons to do the Stern-Gerlach experiment, the result obtained is that the magnetic moment is a Bohr magneton; while using neutral atoms with an even number of protons to do Stern-Gerlach experiments Experiments did not yield this result. This prediction also provides a new verification method for the electronic structure model of the light-knot.

Electrons orbit the nucleus to balance the centrifugal force and the attractive force between charges. This mechanical equilibrium is exactly the same when the ring-like entity of the electron and the point-like entity move around the nucleus. The equilibrium state equation in this equilibrium state is

$$\frac{Ze^2}{4\pi\epsilon_0 r^2} = \frac{mv^2}{r}, \quad (25)$$

The rotational velocity of the 1s electron around the hydrogen nucleus is  $v=Zac$  (it is the solution to the above equation). where  $a$  is the fine structure constant and  $Z$  is the number of nuclear charges. When deriving  $v=Zac$ , one variable  $r$  is eliminated by using the orbital motion angular momentum expression  $mvr=\hbar$ , so that the above mechanical equilibrium equation has a definite solution  $v=Zac$ . According to **hypothesis 2**, when the electron outside the nucleus of a hydrogen atom is at the  $n$  energy level, the orbital radius is  $r_n=n^2 r_{1s}$  [6], which can be

denoted as  $r_{ns}$ . Substitute the Bohr radius quantization formula  $r_n=n^2 r_{1s}$  and the angular momentum quantization formula  $L_{ns}=r_n m v_{ns}=nL_{1s}=n\hbar$  [6] into equation (25), re-solve this equation and compare it with the first solution  $v_{ns}=(Z/n)v_{1s}=(Z/n)ac$ . This velocity quantization formula apparently also originates from Bohr's quantization hypothesis in the context of the planetary model. The quantized formulation in the context of the classical model containing  $Z$  can show that the planetary model can be successfully used at least for the  $s$  electrons of atoms other than hydrogen atoms (The main determinant of what is referred to here as "successful" is the fit of the waveable curl motion to a classical rotation. We'll get to this fit shortly).

Equation (25) is the classical orbital motion formula of planetary motion, and the motion of Saturn's rings also conforms to this formula. Most of them use this formula and its derived formulas  $v=Zac$  and  $E_k=T=p^2/2m$ , both of which use the classical laws of motion and classical motion models. The mathematical formal system of quantum mechanics derived in this way must be compatible with the Bohr planetary model. The reader will soon see that the derivation of the Dirac equations can also take advantage of the classical mechanics of motion. Although the method of "derivation of Dirac equations from properties of spinor transformations under Lorentz groups" appears, this method cannot deny the classical derivation method (the method used by Dirac himself). The derivation and application of the Schrödinger equation also cannot bypass the classical momentum-energy relationship and the classical electrodynamic potential energy formula. This is the theoretical basis for the compatibility of Bohr's planetary model with wave mechanics. Scholars who are superstitious in quantum field theory reject classical motion, which can be said to be the result of emotion rather than strict logic.

The theoretical value of non-relativistic orbital magnetic moment of the 1s electron in the hydrogen atom is

$$\mu_s = -\frac{e}{2mc} L_s = -\frac{e}{2mc} \hbar = 2\mu_e. \quad (26)$$

These calculated results are consistent with the experimental facts. The orbital magnetic moment of an electron is exactly 2 times the spin magnetic moment of the electron in that orbital (relativistic effects exist for the orbital motion of electrons, but not for spin motions. So, taking into account relativistic effects, this multiple is slightly larger than 2). This result follows naturally from the light-knot electron model. It can be seen that the Landé factor  $g$  can also be derived by using the fitted classical rotation. Note to readers: Previously, both the Bohr magneton and the nuclear magneton were defined, whereas in this article it is calculated.

According to the equations (25) and (26), the ratio of the orbital magnetic moment of the 1s electron of the Bohr hydrogen atom to its spin angular momentum is  $-[e\hbar/(2mc)]/\hbar=-e/(2mc)$ . According to (11) and  $p=2p_e$ , it can be known that

$$\hat{L}_s = -i \frac{\hbar^2}{2mc} \frac{\partial}{\partial x}. \quad (27)$$

This is the angular momentum operator for orbital motion of extranuclear electrons. Before the establishment of the

electronic structure model of the light-knot, the orbital magnetic moment of the electron in the hydrogen atom was mistakenly regarded as the electron spin magnetic moment (the hydrogen atom was considered to be spherically symmetric, and the classical mechanical orbital of the electron did not exist).

According to (26) and (13), it can be known that,

$$\hat{\mu}_s = i \frac{e\hbar^2}{4m^2c} \frac{\partial}{\partial x}. \quad (28)$$

This is the magnetic moment operator for the orbital motion of the electrons outside the nucleus of the ground state hydrogen atom. The absolute value of the Z-direction component of the orbital magnetic moment of the 1s electron of a hydrogen atom is  $\mu_s = -(e/2m)rp$ . Considering  $r = \lambda/2\pi = (h/p)/(2\pi) = \hbar/2mc$ , we can get  $\mu_s = -(e/2m)(\hbar/2mc)p$ , namely  $\mu_s = -\frac{e\hbar}{4m^2c} p$ . Replacing p in this formula with the operator represented by formula (17), we can obtain formula (28).

The calculations in this section can be said to be a continuation or extension of Bohr's hydrogen atom model. The calculation results explain why Bohr's hydrogen atom model can get some correct results. Bohr's model of the planetary hydrogen atom had previously been thought to be a dead end. It now appears that Bohr's hydrogen atom model is highly compatible with existing quantum mechanics and even quantum field theory. The calculation results in Section 8 of this paper show that the application of Bohr's planetary model can also be extended to all atoms and even small molecules.

## 7. Deriving the Klein-Gordon Equation and the Dirac Equation According to the Electronic Structure Model of the Light-knot

The original results presented in this section show that even relativistic quantum mechanics can use the classical laws of motion in the context of Bohr's planetary model to get correct results.

Considering that "in the potential field, the energy of the wave changes, but the form of the wave does not change", the wave equation of the extra-nuclear electron is still equation (7). Its total energy is also  $E = h\nu$ ,  $\sqrt{m^2c^4 + p^2c^2}$ . Taking the first-order partial derivative of the wave equation (7) of the electron motion outside the nucleus with respect to t, result in

$$\frac{\partial}{\partial t} \psi = \frac{-iE}{\hbar} \psi. \quad (29)$$

According to the definition of the operator, we can get

$$\hat{E} = i\hbar \frac{\partial}{\partial t}. \quad (30)$$

This is the total energy operator of the particles.

The total energy  $E$  of the electrons outside the ground state hydrogen nucleus is: (the orbital kinetic energy of the electron  $T$ )+(potential energy  $V$ )+(the electron's intrinsic energy  $mc^2$ ):

$$T + V + m_0c^2 = E, \quad (31)$$

$T = mv^2/2 = \alpha cp/2$ ,  $V = -2T = -mv^2 = -\alpha cp$ ,  $T + V = -(1/2)\alpha cp$  以及 here m, is the mass of the electrons. The Virial theorem is a dynamic theorem for classical multi-particle equilibrium systems. Nor can relativistic effects destroy it. In Bohr's model of the hydrogen atom, it certainly holds. The virial theorem also holds for Saturn-like ring hydrogen atoms under **hypothesis 2**. Existing quantum mechanics also uses the virial theorem. Comparing the virial theorem  $2T + V = 0$ ,  $p = mv$  and  $v = \alpha c$  (where  $Z=1$ ) and equation (31) "derived from the equilibrium equation (25) of classical mechanics", we can get:  $T = mv^2/2 = \alpha cp/2$ ,  $V = -2T = -mv^2 = -\alpha cp$ ,  $T + V = -(1/2)\alpha cp$  and

$$T+V+m_0c^2 = -(1/2)\alpha cp+m_0c^2=E. \quad (32)$$

The relationship between the kinetic energy of a moving particle and the relativistic energy is  $mc^2-m_0c^2=T=(1/2)\alpha cp$ . Using this formula to eliminate  $m_0c^2$  in equation (32), we have

$$-\alpha cp+mc^2=E. \quad (33)$$

Equation (33) can express that the total energy of the moving particle minus the kinetic energy of the particle equals the internal energy of the particle. Replace  $p$  and  $E$  in equation (33) with applying the operators expressed by equations (17) and (30) to  $\psi(x,t)$ , respectively. Result in

$$-\alpha c\hat{p}\psi + mc^2\psi = i\hbar \frac{\partial}{\partial t}\psi. \quad (34)$$

Equation (34) is the Dirac equation. The meaning of the Dirac equation derived in this paper is that in the electrodynamic equilibrium system of hydrogen atom, the total energy of electrons in the system is equal to the sum of its relativistic total energy and its potential energy. If the description is the motion of negative energy particles, the signs of the terms in the formula should be changed. Only by changing the sign of the mass alone can you get the exact same form as the Dirac equation. However, negative mass is caused by people mistakenly treating antiparticles as particles of negative energy (or negative mass).  $\alpha$  in the equation (34) is a specific constant — the fine structure constant, and  $\alpha c$  is the fitted classical motion velocity of the electron outside the ground state hydrogen atom. However, before this article,  $\alpha$  is not a simple constant (if certain conditions are met,  $\alpha$  can take  $\pm 1$ ). The matrix form of  $\alpha$  is not derived from Dirac, but written to satisfy the covariance of the Dirac equation under the Lorentz transformation. From this point of view, we cannot judge the correctness of the Dirac equation derived in this paper based on the original Dirac equation. It can be seen that it is not easy to deny the meaning of  $\alpha$  given in this article. Only by solving a number of Dirac equations specifically, and seeing whether the results are consistent with the facts. Equation (34) must correspond to the energy summation equation (32), otherwise it is wrong.

If it is an  $ns$  electron outside the atomic core with an effective charge of  $Z^*$ , the Dirac equation for a ground-state hydrogen atom is

$$-\frac{Z^*\alpha c}{n}\hat{p}\psi + mc^2\psi = i\hbar \frac{\partial}{\partial t}\psi. \quad (35)$$

The original Dirac original equation corresponding to equation (34) is

$$\alpha c\hat{p}\psi + \beta mc^2\psi = i\hbar \frac{\partial}{\partial t}\psi. \quad (36)$$

In the formula,  $\beta=\pm 1$ .  $\alpha =\pm 1$ . When both  $\alpha$  and  $\beta$  are taken as  $-1$ , equation (36) becomes equation (37).

$$-c\hat{p}\psi - mc^2\psi = i\hbar \frac{\partial}{\partial t}\psi. \quad (37)$$

The energy signs on both sides of the equal sign of (37) are inconsistent, which is wrong. The reasons will be stated later. The problem of equation (37) is also the problem of equation (36). Since  $\psi$  in formula is formula (7), so,

formula (36) and formula (37) where  $i\hbar \frac{\partial}{\partial t}\psi$  is the internal energy of the particle. As we all know, the relativistic

total energy of a moving electron is  $\sqrt{m^2c^4 + p^2c^2}$ . The absolute value of both sides of the equality sign of

equations (36) and (37) cannot be greater than it. It is equal to  $\sqrt{(mc^2 + pc)^2 - 2pmc^3}$ , but less than  $(mc^2+pc)$ . If

both  $\alpha$  and  $\beta$  take  $+1$ , then the left side of equation (36) is greater than the right side (the equation does not hold).

Under the premise that both  $\alpha$  and  $\beta$  are taken as  $-1$ , even if the negative energy particle is described by equation (37), the equation does not hold. The system energy summation method corresponding to equation (36) is  $cp+mc^2=E$ . This is inconsistent with the correct energy expression (31), and is also incompatible with the Bohr hydrogen atomic model. The first term ( $\alpha c\hat{p}\psi$ ) on the left side of the original Dirac equation (36) is the result of being erroneously enlarged by a factor of 137 by Dirac. On the premise that  $\alpha=\pm 1$  is admitted, no matter whether the signs of  $\alpha$  and  $\beta$  are the same or opposite, Eq. (36) is wrong.

Compared with the original Dirac equation expressed by equation (36), the Dirac equation [equation (34)] derived in this paper has at least 3 advantages: First, the meaning of  $\alpha$  is clear; Second, the equation is more in line with the energy summation method; Third, the equation (34) is derived, whereas Dirac wrote his equations purely by intuition.

Taking the second-order partial derivative of equation (7) with respect to  $t$  and comparing it with equation (30), we can get

$$-\hbar^2 \frac{\partial^2}{\partial t^2} \psi = \hat{E}^2 \psi. \quad (38)$$

The total relativistic energy applicable to the overall motion of the particle is  $E = \sqrt{m^2 c^4 + p^2 c^2}$ . Square both sides of the equation, divide the terms by  $c^2$  and shift the terms to get

$$(E/c)^2 - p^2 = m^2 c^2. \quad (39)$$

Representing  $E^2$  and  $p^2$  in Eq. (39) by Eq. (38) and Eq. (18), respectively, Result in

$$-\frac{\hbar^2}{c^2} \frac{\partial^2}{\partial t^2} \psi + \hbar^2 \frac{\partial^2}{\partial x^2} \psi = m^2 c^2 \psi. \quad (40)$$

Equation (40) is Klein-Gordon's equation. Here  $\psi$  is the wave equation for plane polarized light. Equation (40) corresponds to the expression of the relative momentum squared  $(E/c)^2 = m^2 c^2 + p^2$ .

De Broglie waves (*i.e.*, beat waves in **hypothesis 2**), are also fitted matter waves. The frequency of this fitted wave is 1/274 of the frequency of the elementary photon.  $h\nu_d$  is the kinetic energy  $T$  of the composite wave (where  $\nu_d$  is the frequency of the fitted matter wave, that is, the frequency of the de Broglie wave). The fitted velocity (apparent velocity) of the fitted matter wave is  $v = \alpha c$ . This velocity was formerly known as the group velocity of de Broglie wave. The relationship between the energy and momentum of the fitted matter wave is also a classical mechanical relationship:  $T = pv/2 = \alpha cp/2$ . Since the classical motion is fitted, the calculation method used must include the classical mechanics method. In this case,  $h\nu = E$  in equation (7) is the kinetic energy of the particle  $E_k = T$ . Meanwhile, we have  $\frac{\partial}{\partial t} \psi = -i \frac{E}{\hbar} \frac{\partial}{\partial t} \psi$ ,  $i\hbar \frac{\partial}{\partial t} \psi = E \frac{\partial}{\partial t} \psi$ . Comparing equation (20) with equation (30), considering  $E_k = T$  and  $T + V = E$ , the time-dependent Schrodinger equation can be obtained.

$$-\frac{\hbar^2}{2m} \frac{\partial^2}{\partial x^2} \psi + V\psi = i\hbar \frac{\partial}{\partial t} \psi. \quad (41)$$

As mentioned above, the non-time-dependent Schrodinger equation, the time-dependent Schrödinger equation, the Dirac equation, and the Klein-Gordon equation, respectively, describe different forms of energy of the system. These energy forms are in turn: kinetic energy + potential energy of the system, kinetic energy, the total energy of the moving particles including the energy equivalent to the static mass, and the product of the energy and mass of the moving particle equivalent to the static mass. As long as we choose the wave equation of the particle to be

equation (7), and apply the corresponding operator to them, we can get the corresponding eigenvalues, and with equation (7) to the end It is irrelevant whether it is a circularly polarized photon or a plane polarized photon (or de Broglie wave).

Based on the light-knot electronic structure model, the basic equations of quantum mechanics are derived, and the mathematical formal system of quantum mechanics is established. It cannot be said that the calculation using the mathematical formal system of quantum mechanics is not the calculation using the electronic structure model of the light-knot. It can be said that, as long as the reason clearly uses the fundamental equations of quantum mechanics or quantum field theory derived from equations (7), it is certain that the light-knot particle structure model is used to derive these fundamental equations. The reason is that equation (7) are the wave equations for photons. This is different from the previous case where the fundamental equations of quantum mechanics were derived speculatively (for unknown reasons) using these two equations.

The above narration shows that when building a quantum mechanical logic system, the premise is reduced and the logic is enhanced. This is to beautify the mathematical formal system of quantum mechanics.

## 8. Calculate the Hydrogen Molecule from the Classical Structure

Quantum chemists need to know the potential energy function of the system to calculate molecules and atoms. However, since the motion state of electrons is unknown, the potential energy function of most atomic and molecular systems is unknown, and even if some are known, correct atomic and molecular data cannot be easily calculated from it. They had to subjectively probe the form of the potential energy function, that is, the system potential energy function used by quantum chemists is a tentative function. This makes quantum chemical methods semi-empirical. Taking off the hat of semi-empirical methods and easily calculating some molecular data must be a quantum chemist's dream.

Using pure mathematics to generalize equation (22) to the three-dimensional case, we can get

$$\left[ -\frac{\hbar^2}{2m} \nabla^2 + V \right] \psi = H\psi . \quad (42)$$

For hydrogen atoms, this "generalization" operation amounts to acknowledging that the motion of electrons outside the nucleus is not a simple motion in the classical sense. Substitute the potential energy function  $V = -Ze^2/r$  into the equation (42) to calculate, it can be obtained that the electron energy of the hydrogen atom has a maximum value in a spherical shell outside the nucleus. The spherical shell radius at this maximum is the radius of the hydrogen atom. The electron energy level of the hydrogen atom can still be reflected from the solution of the Schrödinger equation. Simply put, the electronic structure model for the light-knot does not exclude the existing quantum mechanical calculation methods (as long as the potential energy function can be given, both atoms and molecules can use hydrogen-like atoms to greatly simplify the calculation process). Just modify the concept of "probability density" to the concept of "energy density".

According to **hypotheses 1-2**, both free electrons and extra-nuclear electrons are ring-shaped waves, and the extra-nuclear electron ring is the phase trajectory of the extra-nuclear electron fluctuations, which is exactly the classical motion orbit of the extra-nuclear electrons. Within the framework of the light-knot electronic structure model, rotating the electron ring by 180 degrees with the diameter of electron ring as the axis produces electrons with opposite spin directions. Electron pairing is when electrons with opposite spins coincide completely. After the two free electrons are paired, their total energy decreases. This is because, on the scale of electron orbitals, non-free electron pairings do not obey Coulomb's law (It is known that Coulomb's law applies only to the central force field of a point charge source. However, models of the light-knot electronic structure suggest that electrons are not point charges). This is the **hypothesis 3** of this paper. **Hypothesis 1** and **hypothesis 2** determine that the electron pairing

in **hypothesis 3** is like two beams of light with the same frequency overlapping (The mechanism is similar to the combination of left-handed circularly polarized light and right-handed circularly polarized light to form plane polarized light. When the distance between two electrons with opposite spin directions is small to a certain extent, the interaction between them will seriously deviate from Coulomb's law). **Hypothesis 3** satisfies the conditions and functions of Cooper pairs in superconductivity theory. The laws and empirical formulas for electron pairing energies can be found by induction. **hypotheses 1-3** are the main content of the light-knot electronic structure model (It can be said that the **hypotheses 1-3** are equivalent descriptions to the light-knot electronic structure model).

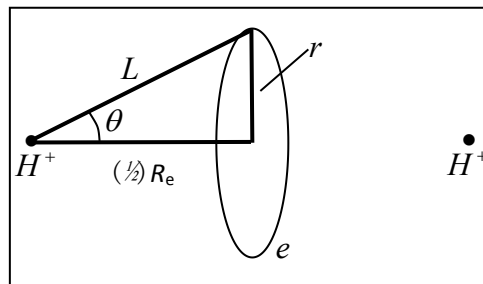
The three hypotheses in this paper are not independent, but related. They all revolve around the same core. The core is that the simplest circularly polarized photons are connected end to end and propagate along a circle, forming an elementary particle with localized energy and constant charge. Such electrons have three major characteristics: composition - the simplest circularly polarized photon; structure - wave rings connected end to end; important characteristics - in the potential field, a wave can be expanded into a beat wave according to Huygens' principle.

The main energy level of the  $1s^2$  electron of the helium atom is the same, and the ionization energy should be the same. The reason is "in the absence of the influence of the other electron, the ionization energy of these two electrons of  $1s^2$  must be the same". The difference in their ionization energies is the result of the interaction between the two electrons. The difference between the ionization energies of these two electrons is the pairing energy of the  $1s^2$  electron in the helium atom. According to the element ionization energy data, the regression equation of the relationship between the  $1s^2$  electron pairing energy and the effective nuclear charge number can be obtained by regression analysis [8].

$$\Delta I_{\text{paired electron}} = E_{e-e} = (-0.03100Z^{*2} - 16.619Z^* + 3.1613)/n^2. \quad (43)$$

The energy unit in the equation (43) is electron volt. The regression equations calculated using different amounts of ionization energy data and different software are slightly different (please conditional readers choose better statistical tools). It can be seen from equation (43) that when the effective number of charges is zero (in this case,  $n=1$ ), the energy released when free electrons are paired is  $3.1613 \text{ eV}$ . This is the pairing energy  $\Delta$  of free electrons. Equation (43) has two important effects: it makes the electron-phonon interaction hypothesis unnecessary; it provides an experimental method for measuring electron pairing energies. The electron pairing energy does not need to be calculated using the perturbation method. Two electrons completely coincident will not have infinite potential energy. This can eliminate the need for renormalization for some processes.

According to the **hypotheses 1-3** in this paper, the hydrogen molecular ion is an electrodynamic equilibrium system of an electron ball between two hydrogen nuclei.



**Figure 1.** Hydrogen molecule-ion  $H_2^+$ .

The ground state hydrogen molecule is a charge ring formed by the superposition of a pair of electrons between two hydrogen nuclei. This structure can reach the classical electrodynamic equilibrium. It can be calculated with helium-like atoms. The calculated results are that the dissociation energy and bond length are  $D_e = -4.2 \text{ eV}$ , respectively, and the bond length  $R_e \approx 0.71 \times 10^{-10} \text{ m}$ [9]. The relative experimental values are:  $D_e = -4.75 \text{ eV}$ ,



$R_e=0.74\times 10^{-10} m$ . The error is related to not taking into account the magnetic moment interactions between the nuclei. The calculation result of the hydrogen molecular ion in [3] is:  $D_e=-6.2eV$ ,  $R_e\approx 1.1\times 10^{-10} m$ . Corresponding experimental values are  $D_e=-2.8eV$ ,  $R_e\approx 1.06\times 10^{-10} m$ . For hydrogen molecular ions, the error in the calculation result of dissociation energy is large. The reason is that the hydrogen molecular ion has only one electron, and the interaction between its orbital magnetic moment and the nuclear magnetic moment is asymmetric, resulting in molecular asymmetry and a large error.

This is the first time that humans have used the classical structure to calculate the data about the hydrogen atom. Although the empirical formula is used to calculate the electron pairing energy in the calculation process, this empirical formula is a general formula and is summed up according to the experiment. This is much more objective than previous subjective methods that give empirical potential energy functions.

Using the same method, the lithium molecule  $Li_2$  can be calculated. Unlike hydrogen molecules, the bonding electrons of lithium molecules are at the energy level of  $n=2$ . The calculation result is: dissociation energy  $D_e=-1.19eV$ , Bond length  $R_e\approx 2.56\times 10^{-10} m$ [9]. The corresponding experimental values are  $D_e=-1.06eV$ ,  $R_e\approx 2.67\times 10^{-10} m$ . The error is also related to the nuclear magnetic interaction between the two nuclei. According to the basic idea of this paper, the hydrogen molecular ion has three magnetic dipoles: Two nuclear magnetic dipoles and one electronic magnetic dipole, and their interactions are asymmetric, resulting in molecular hydrogen ions that are not as symmetrical as hydrogen molecules. We can predict that with the same method to calculate the hydrogen molecular ion, the relative error is larger than that of the hydrogen molecule (This is indeed the case ) [10].

It can be seen intuitively from Figure 1 that the quantum chemical calculation method provided in this paper is a method of local realism.

## 9. Planetary Atomic Model Applied to Atoms Other Than Hydrogen and Atomic core [5]

The planetary model of the atom is a concept that continues. Under the framework of the light-knot electron model, it is more appropriate to change the planetary model to the Saturn model. In fact, the Saturn model of the atom is a model that is fitted and conforms to the laws of classical physics. The reason is that the Saturn-like rings in atoms are not solid rings, but wave rings, but on the whole, the mass equivalent to the energy of the ring wave is indeed distributed on the ring electrons (in this way, there are no stability problems and no quantization problems). Since the Saturn model of the atom is highly compatible with the wave mechanics model, we can similarly use the wave mechanics method and the classical electrodynamic method under the Saturn model to calculate the energy of the atom. In other words, we can add a planetary model calculation scheme for all atoms.

In this article, the following calculation methods can be mixed: The wave mechanics or matrix mechanics method, the classical electrodynamic method in the context of the Bohr planetary model, and the A method for dividing (fitting) atoms or small molecules into hydrogen-like atoms or hydrogen-like atomic core [After the hydrogen-like system is well fitted, the calculation results in the form of (44) can be used directly, and there is no need to re-solve the Schrödinger equation for hydrogen atoms]. One of the representation methods of the quantum mechanical calculation results of the energy eigenvalues of the hydrogen atom is

$$E_n = -Z^2 \times 1312.0/n^2. \quad (44)$$

Here,  $Z$  is the nuclear charge number. The relative effective nuclear charge released by the atomic real is represented by  $Z^*$ . Equation (44) is the result of substituting the potential energy function of the hydrogen atom  $-e^2/r$  into the Schrödinger equation, and the energy unit is  $\text{kJ/mol}$ . The relative effective nuclear charge of the atomic real can be calculated by substituting the known energy eigenvalues into equation (44). The fitting method for hydrogen-like atoms is as follows. Divide the two-electron potential energy function into two one-electron potential energy functions (the original one-electron ring obviously does not need to be divided), and then divide it by the potential energy function of the hydrogen atom ( $Z=1$ ). The resulting constant is the fitted nuclear charge

number for the hydrogen-like atom (denoted by  $z$  to distinguish it from the effective nuclear charge numbers  $Z$  and  $Z^*$ ). The  $ze^2/r$  obtained by substituting  $z$  for  $Z$  of the potential energy function of the hydrogen atom is the potential energy function of the hydrogen-like atom. The energy eigenvalue solution of the Schrödinger equation is  $E_n = -z^2 \times 1312.0/n^2$ . According to the planetary model and the dimensionality theorem, the calculation method of the Hamiltonian energy of the hydrogen atom is  $-Ze^2/2r$ . The classical electrodynamic calculation method in the context of the hydrogen-like planetary model is also exactly the same as that of the hydrogen atom.

Next, we use the planetary atomic model and classical electrodynamics and wave dynamics to calculate the size and energy eigenvalues of atoms and atomic core of lithium and beryllium, respectively. There are 3 electrons outside the lithium nucleus:  $1s^2 2s^1$ . According to assumptions 1-3, it can be known that these three electrons form two electron rings. Among them, the  $1s^2$  is a two-electron ring with electrons already paired, and the  $2s^1$  electron is a one-electron ring. Such lithium atoms are similar to the Saturn. However, the ring planes of the  $1s^2$  two-electron ring and the  $2s^1$  one-electron ring are not parallel. The radius of the  $1s^2$  two-electron ring is  $r_{1s} = 0.33333a_0 = 0.1763 \times 10^{-10}m$ . The radius of the  $2s^1$  one-electron ring is  $r_{2s} = 3.177a_0 = 1.681 \times 10^{-10}m$  [the radius  $r_{1s}$  and  $r_{2s}$  can be calculated according to the accepted Bohr radius expression — equation (44)]. The effective nuclear charge  $Z^*$  of the atomic core (which is also a lithium ion  $Li^+$ ) relative to the  $2s^1$  electron is not 1 but  $Z^* = 1.2594$ . It is calculated by substituting the first ionization energy of lithium  $E_n = -520.2$  kJ/mol and  $n=2$  into equation (44). For the Saturn model of the lithium atom and the classical electrodynamic calculation scheme, we first calculate the sum of the potential energy and kinetic energy of the three extra-nuclear

electrons (the sum is  $-\frac{3 \times 2e^2}{2r_{1s}} - \frac{1.2594e^2}{2r_{2s}}$ ), and then calculate the interaction potential energy between the

three electrons [the pairing energy of  $1s^2$  electron can be calculated by formula (43), its value is 4530.3 kJ/mol. The interaction potential energy between  $1s^2$  electron and  $2s^1$  electron has been reflected in the shielding effect or effective nuclear charge number], and finally, calculate the algebraic sum of energy ( $-23616.2 - 520.2 + 4530.3 = -19606.1$  kJ/mol  $= -203.3$  eV. If we want to reduce the error, we must make a relativistic correction). The corresponding experimental value is  $-19633.3$  kJ/mol or  $-203.3$  eV. In this article, the calculation using the Schrödinger equation is calculated in a hydrogen-like atom manner. The method is to establish the potential energy

function of the single electron relative to the nucleus:  $-\frac{3e^2}{r}$ ,  $-\frac{3e^2}{r}$  and  $-\frac{1.2594e^2}{r}$ , combine the constant parts

other than  $e^2/r$  into the reduced effective nuclear charge  $z$ , and then directly replace  $Z$  in the calculation result of the hydrogen atom into the reduction effective nuclear charge  $z$ . The calculated energy eigenvalues are  $-11808.0$  kJ/mol,  $-11808.0$  kJ/mol and  $-520.5$  kJ/mol, respectively. The algebraic sum of the energies of the parts is:  $-23616 - 520.5 + 4530.3 = -19606.2$  (kJ/mol)  $= -203.3$  eV. This value is the same as calculated by the Saturn model.

There are 4 electrons outside the nucleus of beryllium:  $1s^2 2s^2$ . Its Saturn model is very similar to that of lithium — the electron outside the nucleus is also a ring of two electrons. It's just that the two electron rings are already paired two-electron rings. The two two-electron rings are also not in the same plane. The radius of the  $1s^2$  double electron ring is  $r_{1s} = 0.2498a_0 = 0.1322 \times 10^{-10}m$ ; the radius of the  $2s^2$  electron ring is  $r_{2s} = 1.7278a_0 = 0.9143 \times 10^{-10}m$ . The effective nuclear charge felt by the  $2s^2$  electron is not 2 but  $Z^* = 2.3139$ . The calculation steps of the following Saturn model are as follows. Calculate the sum of the potential and kinetic energies of each of the 4 extranuclear

electrons (the sum is  $-\frac{4 \times 2e^2}{2r_{1s}} - \frac{2.3145 \times 2e^2}{2r_{2s}} = -42017.6$  kJ/mol  $-3514.1$  kJ/mol). Then calculate the interaction

potential energy between the electrons. The interaction energy between two  $1s$  electrons and the interaction energy

between two 2s electrons are calculated using equation (43). The values are 6751.9 kJ/mol and 857.6 kJ/mol, respectively. Between 1s<sup>2</sup> electrons and 2s<sup>2</sup> electrons The interaction potential energy of , is already reflected in the shielding effect or effective nuclear charge. Calculate the algebraic sum of energy [-42013.2-3514.2+6146.9+852.5= -38532.3 (kJ/mol)=- 399.5 eV]. The calculated results are in agreement with the experimental values. We then use the wave dynamics method to calculate (the same method as above). The

one-electron potential energy functions in the two electron rings of 1s<sup>2</sup> and 2s<sup>2</sup> are  $-\frac{4e^2}{r_{1s}}$  ,  $-\frac{4e^2}{r_{1s}}$  ,

$-\frac{2.3135e^2}{r_{2s}}$  and  $-\frac{2.3145e^2}{r_{2s}}$  , respectively. That is, consider them as two hydrogen-like atoms with  $z_{1s}=4$  and two

hydrogen-like atoms with  $z_{2s}=2.3145$ . The calculated energy eigenvalues are -20992.0 kJ/mol, -20992.0 kJ/mol, -1756.2 kJ/mol, -1756.2 kJ/mol, respectively. The algebraic sum of the energies of the parts is: -20992.0×2-1756.2×2+6146.9+852.5= -38497 (kJ/mol)=- 399.2 eV. The relativistic correction values of the electrons of the two energy levels are 14.6 kJ/mol and 1 kJ/mol, respectively. The total correction value is 32 kJ/mol= 0.32 eV. After correction: -399.2eV-0.32eV=- 399.5eV. This value is the same as calculated by the Saturn model. The corresponding experiment is -38512 kJ/mol = -399.3 eV.

The electron ring radius in the above calculation is obtained from the relationship between the ionization energy (experimental or calculated value) and the electron ring radius. They can also be obtained from the Bohr radius expression. Both the orbital radii of the extranuclear electrons (and also the radii of the extranuclear electron rings) are calculated based on the planetary model and the Saturn model (including classical electrodynamics and classical rotation of electrons). The Bohr radius is expressed as

$$r_n = \frac{4\pi\epsilon_0\hbar^2}{\mu e^2} \frac{n^2}{Z^*} = a_0 \times \frac{m_e}{\mu} \frac{n^2}{Z^*}. \quad (45)$$

Here,  $m_e$  is the mass of the electron and  $\mu$  is the reduced mass between the electron and the entity with which it interacts  $\mu=(Mm_e)/(M+m_e)$ . The capital M in this expression is generally the mass of the nucleus or atomic core. Substituting the corresponding effective nuclear charge number into equation (45), and changing the electron mass into the approximate mass, the obtained electron ring radius is exactly the orbital radius of the extranuclear electron used above. For Group IA and Group IIA elements, this calculation can be seen as a measure of atomic size. For other elements, the size of the atomic real with the outermost s electrons can also be calculated in the same way (i.e., according to Equation 44). Let's roughly verify the radius of the 2s electron ring of the beryllium atom (the orbital radius of the 2s electron):  $(2^2/2.3135)a_0=1.729a_0$ .

Some might say that atomic energy calculations using experimental values of ionization energy are of no value. However, it certainly makes sense to use the ionization energy of one electron to calculate the energy eigenvalues of more than one electron. In addition, using ionization energy data, it would be of great interest to find classical rotations of electrons, atoms and molecules that overcome the weaknesses of the Bohr model. The energy eigenvalues of the s electrons of any atom and the orbital radius of the extranuclear electrons are calculated by the method introduced in this paper, and the results are consistent with the facts. Such calculation methods are valuable. As I said in Section 8, taking off the hat of semi-empirical methods and easily computing some molecular data must be something quantum chemists can only dream of. This is sure to delight scientists who really care about quantum chemistry computing. Quantum chemists would be even more excited if they could use Bohr's planetary model to succinctly calculate the data of many atoms and molecules.

Although Eq. (43) is generalized using the experimental value of ionization energy, it is also valuable for

different atoms to use it to calculate the electron pairing energy. The energy eigenvalues of beryllium atoms require four ionization energies experimental data, and we now calculate them using only one ionization energy data. This is undoubtedly an improvement. What's more, the calculation method and calculation result also have the function of verifying the classical model and classical method? At least this paper calculates the energy eigenvalues of the helium atom is very simple. In the context of this article, there are three different ways to count helium atoms. <1> Establishment of the potential energy function of the  $1s^2$  double electron in the helium atom:  $-2 \times 2e^2/r$ . This potential energy function is decomposed into the potential energy functions of two hydrogen-like atoms with a reduced effective nuclear charge  $z=2$  according to the method introduced at the beginning of this section:  $-ze^2/r$  and  $-ze^2/r$ . Substitute them into the Schrödinger equation respectively. We can also directly use the existing solution of the Schrodinger equation for hydrogen atoms:  $E=-13.606 \text{ eV}$  (or  $-1312.0 \text{ kJ/mol}$ ) (add a multiplier factor  $z^2$  in front of it). The result without considering the interaction energy between electrons is  $-z^2 \times 1312.0 = -z^2 \times 1312.0 = -8 \times 1312.0 = -10496.0 \text{ (kJ/mol)}$ . Using the equation (43), the  $1s^2$  electron pairing energy can be calculated as  $30.201 \text{ eV} = 2912.6 \text{ kJ/mol}$ . The energy eigenvalue of the ground state helium atom is  $-10496.0 + 2912.6 = -7583.4 \text{ (kJ/mol)} = -78.60 \text{ eV}$  (Experimental value  $-79.0 \text{ eV}$ ). <2> The orbital radius of the extranuclear electron calculated according to the equation (44) is approximately equal to  $(1/2)a_0$ . The energy of the ground state helium atom is  $-2 \times 2e^2/a_0 + 2912.6 = -10496.0 + 2912.6 = -7583.4 \text{ (kJ/mol)} = -78.60 \text{ eV}$ . <3> The second ionization energy of helium atom is  $5250.5 \text{ kJ/mol}$ . Assuming the radius of the electron ring of the ground state helium atom (also the radius of the electron orbital at the nucleus)  $r$ , we have this relationship  $-5250.5 = -2e^2/2r$ . Solving this equation, result in  $r=0.4976a_0$ . The energy eigenvalue of the ground state helium atom is  $-2 \times 2e^2/(0.4976a_0) + 2912.6 = -7634.0 \text{ (kJ/mol)} = -79.1 \text{ eV}$ .

The above calculations show that it is possible to find the classical orbital motions of the required extranuclear electrons without stability difficulties (**hypotheses 1-3** overcome the stability difficulties of planetary atomic models and naturally allow for quantization of energy). The calculation method of the effective nuclear charge number in the energy eigenvalue expression is a power (and has no principal quantum number  $n$ ) is the classical electrodynamic calculation method using the planetary model (more precisely, the Saturn model). This paper shows that the wave dynamics calculation method and the planetary model calculation method can be mixed. This at least shows that the two approaches are equivalent (or highly compatible) for s electrons.

It is well known that both wave mechanics and matrix mechanics can deal with problems in microscopic systems. No one has ever said that one of matrix mechanics and wave mechanics is false, and its calculation results are coincidental with facts. The results presented in this paper show that that problems in microscopic systems can be dealt with using both "classical motion and classical electrodynamics of electrons" and using wave mechanics. What reason do we have to say that all the processing results of the classical concept of motion and classical electrodynamics on microscopic systems are accidental coincidences? Why aren't these two treatments equivalent or highly compatible? The atomic s electrons of all elements can be calculated correctly using the method presented in this paper. There are more than 100 elements in nature, and the correct calculation results in hundreds. If the results of these calculations are coincidental, the probability of coincidence is much greater than the theoretical probability. In addition, using classical rotation and classical electrodynamics to deal with microscopic systems can not only find a reasonable classical model, but also have many advantages. We then randomly select an atom of an element to calculate in order to verify the above conclusion. The 27th element cobalt Co was selected. The ionization energy of its last electron is  $-966023 \text{ kJ/mol}$ . The orbital radius of 1s electron is  $(1/27) a_0$  expressed by equation (45). The planetary model calculation of the electrical energy of this electron is  $-27e^2/2(1/27)a_0 = 956448 \text{ kJ/mol}$ . The required relativistic correction value should not exceed 1.03%, which is reasonable.

No matter what the structural model is, as long as it calculates many results that conform to the experimental facts, it cannot be said that the model has no experimental evidence. The electron ring mentioned in this paper is a

wave ring, so there is no problem of atomic instability and quantum force in Bohr's model.

It is well known that quantum chemical methods are semi-empirical methods. Previously, to calculate simple helium atoms using quantum chemical methods, very complex processes had to be used, the potential energy function needs to be tested empirically, and the mutual energy between the electrons can not be accurately calculated. This is also the weakness of quantum field theory and quantum mechanics. A method that no longer needs to tentatively establish the potential energy function from experience is undoubtedly an improvement. Using perturbation or variational or asymptotic methods (step-by-step approximation) to calculate helium atoms can be up to 10 pages long. The calculation process is greatly simplified, which is also exciting.

## **10. Favorable Factors and Controversies of Electronic Structure Models of Light-knot**

The contents introduced in Sections 2-9 of this paper are all beneficial to the model of the electronic structure of the light-knot. Because these contents are based on the light-knot electronic structure model, these are the successful application of the light-knot electronic structure model. In addition, there are many application examples, and accidental factors can be excluded. Quantum chemists would be ecstatic to have achieved this without quantum field theory and the Standard Model theory. However, the reality is that this situation did not arise after the birth of quantum field theory and model theory (instead, it was many years after the advent of the theory of light-knot electron composition and structure, which was still not widely accepted). Be aware that quantum field theory does not address the composition and structure of electrons (quantum field theory and standard model theory only describe a source of electrons and the properties of the field). There is injustice and incomprehension here. The reason is that while quantum field theory and Standard Model theory have advantages, they are not without weaknesses and inapplicability (it also has unexplored areas). It is not a dominant theory and should not restrict other theories from exploring areas it has not explored. The "injustice and incomprehension" mentioned above has become a disadvantage of the electronic structure model of the light-knot. A more detailed description is as follows.

The foundation of Standard Model theory is quantum field theory. The downside of the light-knot electronic structure models is that they conflict with the Standard Model theory in terms of the origin and structure of elementary particles. Therefore, some people think that the electronic structure model of the light-knot is also inconsistent with the quantum field theory. The theory developed on the basis of quantum field theory cannot be the only standard model theory, and it is also possible to develop to the left as shown in **Figure 2**. This development direction includes the light-knot electronic structure model, so that quantum field theory can be integrated with the the light-knot electronic structure model. The light-knot electronic structure model is clearly a next-level theory of the composition and structure of electrons. Since quantum field theory has not discussed the internal composition and structure of electrons, it cannot restrict its branch theories or other theories to discuss the composition and structure of elementary particles, let alone use quantum field theory as a standard to judge the correctness of new theories. This paper also clarifies that the establishment of the mathematical formal system of general quantum field theory and quantum mechanics can start from the electronic structure model of the light-knot (with the particle structure model of the light-knot as the source). We must know that before this article, the establishment of the mathematical formal system of quantum field theory and quantum mechanics has never found such a unified logical starting point.

The light-knot electronic structure model is not always at a disadvantage, and in some ways it is more successful than quantum field theory. These successes (advantages) are: quantum field theory does nothing to solve the problem of semi-empirical methods in quantum-mechanical chemical calculations, and light-knot electronic structure models can take off the hat of semi-empirical methods in quantum chemistry; the light-knot electronic structure model can be proved to be equivalent and compatible with the wave dynamics method derived from the planetary atomic model method (classical electrodynamic method), which cannot be done by quantum field theory;

light-knot electronic structure models can beautify the theoretical system of quantum mechanics and can greatly simplify quantum chemical calculations (quantum field theory does not have this function). Some calculations of quantum field theory are accurate to more than ten significant figures. If the free electron spin angular momentum is calculated using the light-knot electronic structure model, the calculation result can also be realized without error.

Quantum field theory and Standard Model theory only really provide a principle for exploring the next level composition and structure of elementary particles. Therefore, electrons remain one of the most fundamental particles in quantum field theory and Standard Model theory. Since this principle has not been successful for electrons, it cannot be used as a criterion to comment on the new electron's internal composition, structure and motion state model.

A realistic pattern of the development of theoretical physics is that mathematics, quantum field theory and standard model theory lead the development of the theory of the structure of matter. The work pattern presented in this paper is the opposite: the theory of the structure of matter influences the refinement and development of the theory of quantum mechanics. Quantum mechanics was established when humans realized that atoms are composed of nuclei and electrons. In the days that followed, the theory of physical structure went down two or three levels without any help to quantum mechanics. We have no reason to think that the theoretical research landscape chosen in this paper is inferior to the popular theoretical research landscape in any branch at any time. The effect of the theoretical research pattern of physics introduced in this paper may be the value of this paper. Another manifestation of the value of this paper is to prove that Bohr's planetary model is equivalent or highly compatible with quantum mechanics, both theoretically and with applied cases (calculation methods can be mixed in the two contexts). The author's completed the 11 scientific events listed below that "occur for the first time in human society." That said, the following ten are the first breakthroughs in the history of science and technology to fill the gaps in the world. The following 11 scientific events are based on revealing the internal composition, structure and motion of electrons.

(1) A complete model of the photojunction electronic structure is created (a new scheme for the internal composition, structure and motion of electrons is proposed, and hundreds of application cases are provided).

(2) The electron radius  $r$  is calculated using classical structure, classical rotation and classical electromagnetism:  
 $r=\lambda/2\pi$ .

(3) The electron spin angular momentum and the electron spin magnetic moment  $\mu_e$ , as well as the electron spin angular momentum operator and the electron spin magnetic moment operator are calculated by classical structure and classical mechanical methods.

(4) The electron orbital angular momentum  $L_s$  of the hydrogen atom was calculated using classical structure, classical rotation and classical mechanics methods. Note: It was previously believed that electrons in atoms do not have orbital motion.

(5) The electron orbital magnetic moment and its operator of hydrogen atom were calculated by classical structure and classical mechanics method (Note: It was previously thought that electrons in hydrogen atoms have no orbital motion).

(6) An experimental measure of electron pairing energy—the difference between the ionization energies of two electrons that have been paired—was obtained using classical structure and classical mechanics.

(8) The bond length and dissociation energy of hydrogen molecule and hydrogen molecule ion are calculated by classical structure and classical mechanics method.

(9) Use the internal composition, structure and intrinsic motion form of the electron, as well as the laws of classical mechanics (for example: classical momentum-velocity relationship  $p=mv$ , classical kinetic energy-momentum relationship  $E_k=p^2/2m$ , planetary motion equation under electrodynamics, angular momentum expression  $\hat{L} = \vec{r} \times \vec{p}$  and the potential energy expression of the planetary equilibrium system  $V=f(r, Z, e)$ , etc.) to

establish a quantum mathematical formal system of mechanics. This lays a theoretical foundation for the compatibility or even equivalence of quantum mechanical methods with classical mechanical methods in the context of Bohr's planetary model.

(10) The specific form of the electron spin function, the angular momentum operator of the electron orbital motion, the magnetic moment operator of the electron orbital motion, and the specific meaning of the  $\alpha$  in Dirac equation are given by using the internal composition, structure and intrinsic motion state of the electron. The  $\alpha$  is fine structure constant.

(11) The theoretical basis for the compatibility of the planetary model or the Saturn model method with the quantum mechanical method and a large number of cases where the two methods are mixed are established.

The above main achievements can be displayed intuitively in the form of a list.

Table 1. The main results of using the planetary model or using the classical and quantum mechanical methods in the context of the planetary model to deal with microscopic systems (I)

Classification	Angular Momentum		Magnetic moment	
	Value or expression	Operator	Value or expression	Operator
Electron spin	$\vec{L}_e = \vec{r}_e \times \vec{p}_e$ $= (1/2)\hbar$	$\hat{L}_e = -i \frac{\hbar^2}{4mc} \frac{\partial}{\partial x}$	$\mu_e = -\frac{e}{2m} L_e = -\frac{e\hbar}{4m}$ $\mu_e = -\frac{e\hbar}{4m^2 c} p_e$	$\hat{\mu}_e = i \frac{e\hbar^2}{8m^2 c} \frac{\partial}{\partial x}$
Orbital motion of 1s electron in hydrogen atom	$L_s = r(h/2\pi r)$ $= \hbar$	$\hat{L}_s = -i \frac{\hbar^2}{2mc} \frac{\partial}{\partial x}$	$\mu_s = -\frac{e}{2m} L_s = -\frac{e\hbar}{2m}$ $\mu_s = -\frac{e\hbar}{4m^2 c} p$	$\hat{\mu}_s = i \frac{e\hbar^2}{4m^2 c} \frac{\partial}{\partial x}$

Table 2. The main results of using the planetary model or using the classical and quantum mechanical methods in the context of the planetary model to deal with microscopic systems (II)

Classification	Contents	Remark
Electron radius	$r_e = \lambda/2\pi = \hbar/mc = 1.929 \times 10^{-13} m$	It is exactly the quotient of the Compton wavelength of the electron and $2\pi$
The orbital radius of the ns electrons of the hydrogen atom	$r_{ns} = n^2 r_{1s}$	Quantization Conditions for Orbital Radius of Hydrogen Atom s Electrons
Dissociation energy and bond length of ground-state hydrogen molecular ions	$D_e = -6.2 eV, R_e \approx 1.1 \times 10^{-10} m$	The calculated results of molecules with with electron-nuclear magnetic coupling symmetry are all close to the experimental values. The calculated result of $R_e$ of hydrogen molecular ion is close to the experimental value, but $D_e$ is quite different from the experimental value. This predicts that the magnetic moment interactions of electrons and nuclei are asymmetric, resulting in asymmetric molecular structures. These results just show that the application of Bohr's planetary model can be extended to molecules and other molecules.
Dissociation energy and bond length of ground-state hydrogen molecule	$D_e = -4.2 eV, R_e \approx 0.71 \times 10^{-10} m$	
Dissociation energies and bond lengths of ground-state lithium molecules	$D_e = -1.19 eV, R_e \approx 2.56 \times 10^{-10} m$	
Total ionization energy of helium atom	79.1eV	
Orbital Velocity Quantization Formula	$v_{ns} = (Z/n)v_{1s} = (Z/n)ac$	It works for s electrons of all atoms

The electron pairing energy of $ns^2$ dual electrons	$(-0.03100Z^{*2} - 16.619Z^* + 3.1613)/n^2$	An empirical formula obtained by fitting a regression curve based on a number of ionization energy data.
Pairing energies of paired free electrons (Dissociation energy of free electron pair)	$\Delta \approx 3.1613 eV$	Consistent with the case of Cooper pairs in superconductivity theory

The completion of the work listed above is an event that has occurred and is a fact. It cannot be said that those events did not happen, at best they are considered unimportant from an emotional standpoint. We should avoid emotional factors in evaluating the value of scientific research.

Theoretical beauty has the following categories: real beauty, concise beauty, rigorous and smooth beauty (rigorous beauty), symmetrical beauty, and practical beauty. There is no complex beauty in them. Therefore, the notion that the more complex and more reliable is currently considered is not necessarily correct, nor can it be used as a criterion for judging the correctness and reliability of a theory. To judge the reliability and value of a theory, the key is to look at its practicality rather than its complexity.

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