New interpretation of the atomic spectra and other quantum phenomena: A mixed mechanism of classical LC circuits and quantum wave-particle duality

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(Dated: March 31, 2022)

We study the energy conversion laws of the macroscopic harmonic LC oscillator, the electromagnetic wave (photon) and the hydrogen atom. As our analysis indicates that the energies of these apparently different systems obey exactly the same energy conversion law. Based on our results and the wave-particle duality of electron, we find that the atom in fact is a natural microscopic LC oscillator. In the framework of classical electromagnetic field theory we analytically obtain, for the hydrogen atom, the quantized electron orbit radius \( r_n = a_0 n^2 \), and quantized energy \( E_n = -R_H \hbar c/n^2 \), \((n = 1, 2, 3, \ldots)\), where \( a_0 \) is the Bohr radius and \( R_H \) is the Rydberg constant. Without the adaptation of any other fundamental principles of quantum mechanics, we present a reasonable explanation of the polarization of photon, the Zeeman effect, Selection rules and Pauli exclusion principle. Particularly, it is found that a pairing Pauli electron can move closely and steadily in a DNA-like double helical electron orbit. Our results also reveal an essential connection between electron spin and the intrinsic helical movement of electron and indicate that the spin itself is the effect of quantum confinement. In addition, a possible physical mechanism of superconductivity and the deeper physical understandings of the electron mass, zero point energy (ZPE), and the hardness property of electron are also provided. Finally, we show analytically that the Dirac’s quantization of magnetic monopole is merely a special handed electron at absolute zero-temperature with the de Broglie wavelength \( \lambda_0 = 0 \). This is a new and surprising result, which strongly suggests that any efforts to seek for the magnetic monopole in real space will be entirely in vain. Furthermore, it appears that the electron’s spin and the magnetic monopole are actually two different concepts for one possible physical phenomenon.

PACS numbers: 31.10.+z, 32.30.-r, 31.90.+s

I. INTRODUCTION

No one doubt that twentieth century is the century of quantum theory [1-13]. After 100 years of development quantum physics is no longer just a field, it is the bedrock of all of modern physics. Although the modern quantum theory has provided a beautiful and consistent theory for describing the myriad baffling microphenomena which had previously defied explanation \( \mathbb{R} \), one should not neglect a curious fact that quantum mechanics never take into account the deep structures of atoms. In fact, at the heart of quantum mechanics lies only the Schrödinger equation \( \mathbb{R} \), which is the fundamental equation governing the electron. According to quantum theory, it is the electromagnetic interaction (by the exchange of photons) which hold electrons and nuclei together in the atoms. But, up to now, quantum theory never provides a practical scheme that electron and nuclei can absorb and emit photons.

In this paper, we investigate the energy relationship of electron in the hydrogen atom. Significantly, we find a process of perfect transformation of two forms of energy (kinetic and field energy) inside the atom and the conservation of energy in the system. By applying the principle of wave-particle duality and comparing to known results of the macroscopic harmonic LC oscillator and microscopic photon, we are assured that electron kinetic energy in fact is a kind of magnetic energy and the atom is a natural microscopic LC oscillator. Moreover, the mixed mechanism (classical LC circuits / quantum wave-particle duality) turns out to have remarkably rich and physical properties which can used to describe some important quantum principles and phenomena, for instance, polarization of photon, Zeeman effect, Selection rules, the electron’s mass and spin, zero point energy (ZPE), the Pauli exclusion principle and the Dirac’s magnetic monopole.

II. ENERGY TRANSFORMATION AND CONVERSION IN HYDROGEN ATOM

Classically, as shown in Fig. \( \mathbb{R} \) the hydrogen atom consists of one electron in orbit around one proton with the electron being held in place via the electric Coulomb force. Equation of motion is

\[
\frac{e^2}{4\pi\varepsilon_0 r^2} = m_e \frac{u^2}{r},
\]

where \( m_e \) is mass of electron. Eq. \( \mathbb{R} \) can be rewritten in the form of kinetic energy \( E_k \) and field energy \( E_f \) (stored in the capacitor of hydrogen atom) as follows:

\[
\frac{e^2}{2C_r} = \frac{1}{2} m_e u^2,
\]
where \( C_r = 4\pi\varepsilon_0 r \) is the capacitance of the hydrogen system. Thus the total energy of the hydrogen system is given by

\[
E_{\text{total}} = \frac{1}{2} m_e u^2 - \frac{e^2}{4\pi\varepsilon_0 r} = \frac{e^2}{2C_r}.
\]

(3)

It should be pointed out that Eqs. 2 and 3 are the foundation of our study. These two equations together indicate a process of perfect periodically transformation of two forms of energy (kinetic energy \( E_k = \frac{1}{2} m_e u^2 \) and field energy \( E_f = \frac{e^2}{2C_r} \)) inside the atom and the conservation of energy in the system

\[
E_{\text{total}} = E_f = E_k.
\]

(4)

Recall the macroscopic harmonic LC oscillator where two forms of energy, the maximum field energy \( E_f = Q_0^2/2C \) of the capacitor \( C \) (carrying a charge \( Q_0 \)) and the maximum magnetic energy \( E_m = LI_0^2/2 \) of the inductor \( L \), are mutually exactly interconvertible (\( E_{\text{total}} = E_f = E_m \)) with a exchange periodic \( T = 2\pi\sqrt{LC} \). And for a microscopic photon (electromagnetic wave), the maximum field energy \( E_f = \frac{1}{2}\varepsilon_0 E_0^2 \) and the maximum magnetic energy \( E_m = \frac{1}{2}\mu_0 H_0^2 \) also satisfy \( E_{\text{total}} = E_f = E_m \).

Based on the above energy relationship for three totally different systems and the requirement of the electromagnetic interaction (by exchanging photon) between electron and nuclei, we assure that the kinetic energy of electron (Eq. 2) is a kind of magnetic energy and the hydrogen atom is a natural microscopic LC oscillator. In 2000, a multinational team of physicists had observed for the first time a process of internal conversion between bound atomic states when the binding energy of the converted electron becomes larger than the nuclear transition energy. This observation indicate that energy can pass resonantly between the nuclear and electronic parts of the atom by a resonant process similar to that which operates between an inductor and a capacitor in an LC circuit. These experimental results can be considered a conclusive evidence of reliability of our LC mechanism.

Here raise an important question: how can the electron function as an excellent microscopic inductor? We think the answer lies in the intrinsic wave-particle duality nature of electron. In our opinion, the wave-particle nature of electron is only a macroscopic behavior of the intrinsic helical motion of electron within its world.

III. CHIRALITY AND “INDUCTON” OF FREE ELECTRON

In 1923, Broglie suggested that all particles, not just photons, have both wave and particle properties. The momentum wavelength relationship for any material particles was given by

\[
\lambda = \frac{h}{p},
\]

(5)

where \( \lambda \) is called de Broglie wavelength, \( h \) is Planck’s constant \( \hbar \) and \( p \) the momentum of the particle. The subsequent experiments established the wave nature of the electron. Eq.4 implies that, for a particle moving at high speed, the momentum is large and the wavelength is small. In other words, the faster a particle moves, the shorter is its wavelength. Furthermore, it should be noted that any confinement of the studied particle will shorten the \( \lambda \) and help to enhance the so-called quantum confinement effects.

As shown in Fig. 2(a) and (b), based on Eq. 6 and the demanding that the electron would be a microscopic inductor, we propose that a free electron can move along a helical orbit (the helical pitch is de Broglie wavelength \( \lambda_e \)) of left-handed or right-handed. In this paper, the corresponding electrons are called “Left-hand” and “Right-hand” electron which are denoted by Chirality Indexes \( \lambda_e \) and \( S = 1 \) and \( S = -1 \), respectively. Hence, the electron can now be considered as a periodic-motion quantized inductive particle which is called “inducton” (see Fig. 2). Moreover, the particle-like kinetic energy of electron can be replaced with a dual magnetic energy carried by a “inducton”. Therefore, we have

\[
E_k = \frac{1}{2} m_e u^2 = \frac{1}{2} L_e I^2,
\]

(6)
where \( u \) is the axial velocity of the helical moving electron and \( L_e \) is the inductance of the quantized “inducton”. The above relation indicates that the mass of electron is associated with an amount of magnetic energy.

From Fig. 2, the electric current, for one de Broglie wavelength, is given by

\[
I = \frac{e u}{\lambda_c}.
\]

(7)

From Eq. 7, it is important to note that the electric current should be defined within an integral number of de Broglie wavelength. Hence, the electric current \( I = e u / 2 \pi r \) (where \( r \) is the electronic orbital radius in the hydrogen atom), which was widely used in the semiclassical Bohr model, may be physically invalid. Collecting Eq. 6 and 7 together, we have the inductance of single “inducton”

\[
L_e = \frac{m_e \lambda_e^2}{e^2}.
\]

(8)

Then the dual nature of electron can be uniquely determined by \( L_e \), the periodic \( T \) (or frequency \( f = 1 / T = u / \lambda_c \)), the initial phase \( \varphi_0 \) and the chirality (\( S = 1 \) or \( S = -1 \)).

IV. ATOMIC SPECTRA OF HYDROGEN ATOM

A. Quantized radius and energy

By the application of helical electron orbit to the hydrogen atom (Fig. 2), we can not only explain the stability of the atom but also give a theoretical interpretation of the atomic spectra.

Fig. 3 shows four possible kinds of stable helical electron orbits in hydrogen atom, and each subgraph corresponds to an electron of different motion manner within the atom. The electrons can be distinguished by the following two aspects. First consider the chirality of electron orbits, as shown in Fig. 3, the electrons of Fig. 3(a) and (c) are “Left-hand” labelled by \( S = 1 \), while electrons of Fig. 3(b) and (d) are “Right-hand” labelled by \( S = -1 \). Secondly consider the direction of electron orbital magnetic moment \( \mu_L \), Fig. 3(a) and (b) show that the \( \mu_L \) are in the \( Z \) direction (Up) while (c) and (d) in the \(-Z\) direction (Down), the corresponding electrons are labelled by \( J = 1 \) and \( J = -1 \), respectively, here \( J \) is called Magnetic Index. Hence, the electrons of different physical properties become distinguishable, they are Up “Left-hand” (ULH) electron \( (J = 1, S = 1) \), Up “Right-hand” (URH) electron \( (J = 1, S = -1) \), Down “Left-hand” (DLH) electron \( (J = -1, S = 1) \) and Down “Right-hand” (DRH) electron \( (J = -1, S = -1) \).

As shown in Fig. 3(a), the helical moving electron around the orbit mean radius \( r \) can now be regarded as a quantized “inducton” of \( \lambda_e \), thus the hydrogen atom is a natural microscopic \( LC \) oscillator. We consider that the physical properties of the hydrogen atom can be uniquely determined by these natural \( LC \) parameters. To prove that our theory is valid in explaining the structure of atomic spectra, we study the quantized orbit radius and the quantized energy of hydrogen atom and make a comparison between our results of \( LC \) mechanism and the known results of quantum theory. For the system of \( \lambda_e \), the \( LC \) parameters of the hydrogen atom is illustrated in Fig. 3. Then the \( LC \) resonant frequency is

\[
\nu_r = \frac{1}{2 \pi \sqrt{L_e C_r}} = \frac{e}{4 \pi \lambda_r \sqrt{\varepsilon_0 m_e r}}.
\]

(9)

Recall the well-known relationship \( E = h \nu_r \), we have

\[
h \nu_r = \frac{e^2}{8 \pi \varepsilon_0 r}.
\]

(10)

Combining Eq. 9 and Eq. 10 gives

\[
\lambda_r = \frac{2 \hbar}{e} \sqrt{\frac{\varepsilon_0 r}{m_e}}.
\]

(11)

Then the stable electron orbits are determined by

\[
\frac{2 \pi r}{\lambda_r} = n, (n = 1, 2, 3 \cdots),
\]

(12)

where \( n \) is called Principal number. The integer \( n \) shows that the orbital allow integer number of “induction” of the de Broglie wavelength \( \lambda_r \). From Eq. 11 and Eq. 12 the quantized electron orbit mean radius is given by

\[
r_n = \frac{\varepsilon_0 \hbar^2}{\pi m_e e^2} n^2 = a_0 n^2,
\]

(13)
where $a_0$ is the Bohr radius. And the quantized energy is

$$E_n = -\frac{e^2}{8\pi\varepsilon_0 r_n} = -\frac{m_e e^4}{8\varepsilon_0^2 h^2 n^2} = -R_H \frac{hc}{n^2}, \quad (14)$$

where $R_H$ is the Rydberg constant. Surprisingly, the results of Eq. 14 are in excellent agreement with Bohr model [8]. Besides, taking Fig. 3 into account, we can conclude that the quantized energies of Eq. 14 are quadruple degenerate.

### B. Lamb shift and polarization of photon

Now, in the framework of helical electron orbit (see Fig. 3), the electron orbital magnetic moment $\mu_L$ is allowed naturally to be both positive ($J = 1$) and negative ($J = -1$), therefore, the double splitting experiment is a immediate result of our theory. It seems that the electron spin no long as an essential quantum number in our studies. In Section V, we will try to explain for the first time the connection between the electron spin and the intrinsic helical movement of electron.

Furthermore, take a look at Fig. 3(a), the other two “inductons” with different de Broglie wavelengths $\lambda_-$, and $\lambda_+$ are defined. Here we should stress that $\lambda_+ \in$ is invalid in a system of circular motion. To illustrate this ideas, let us examine the three situations ($\lambda_-, \lambda_-$ and $\lambda_+$) carefully. For the case of $\lambda_+$, both ends of the “inducton” doesn’t fall in the $XY$ plane and electron travelling through these two locations has a non-zero radial velocity, in case we think the quantized “inducton” defined by $\lambda_+$ is unstable also invalid in the system. But, for the other two cases of $\lambda_-$ and $\lambda_+$, both ends of these “inductons” fall in the $XY$ plane, at the same time the corresponding radial velocity of the travelling electrons is zero, in other words, these two “inductons” described by $\lambda_+$ and $\lambda_-$ are stable and can function as the “inductons” of the studied system. Hence for a given quantized electron orbit mean radius of Eq. 13, the microscopic atom can contribute two natural LC oscillators ($L_+C_+$ and $L_-C_-$ of Fig. 3(a)). In our opinion, it is these two oscillators of $\lambda_+$ and $\lambda_-$ that finally lead to the Lamb shift and the Bohr theory of hydrogen electron orbits ($\lambda_-$) are merely a approximate treatment of the corresponding helical electronic orbits.

The polarization of photon perhaps still is the greatest mystery in the microscopic world. When we reduce the light intensity to its smallest possible level, then we are dealing with one single photon – the quantized light. Now a great number of the quantized light test experiments have show that, in reality, the intrinsic polarization of photon is purely circular: either right or left circular polarization. Quantum mechanics predicts that the “polarization” is related to the electronic spin. Nevertheless, this mystical explanation is somewhere far beyond the reality of the physical world. We state that the polarization of quantized photon is referred to the intrinsic helical movement of electron in the atom (Fig. 3). Namely, the left-hand electron ($S = 1$) will emit only left circular polarized photon, while right-hand electron ($S = -1$) will emit right circular polarized photon.

### C. LC oscillator and quantum numbers

In quantum theory, four quantum numbers (the principal quantum number $n$, the angular momentum quantum number $l$, the magnetic quantum number $m$ and the spin quantum number $s$) form a complete set used to specify the full quantum state of any system in quantum mechanics. To verify that our LC mechanism is designed to completely replace the quantum mechanism, a similar perfect set of indexes (or quantum numbers) must be physically defined. Recall the above discussions, three indexes (the Chirality Index $S$, the Magnetic Index $J$ and the Principal Oscillator Number $n$) have been introduced. Our three indexes (or quantum numbers) are not a complete set – that is, they are insufficient to fully specify the quantum state of the atom.

Our goal here is to make the quantum numbers of the LC mechanism towards integrality. As shown in Fig. 3, we represent the hydrogen atom of different states in the form of LC oscillators. Fig. 3(a)–(d) are the results for $n = 1, 2, 3$ of the ULH or URH electron ($J = 1$ of Fig. 3), respectively. In each subgraph, the gray oscillator is the initial one and the solid line indicates an ideal radiationless moving oscillator. In this stable situation, we have $C_{nl} = C_{n0}$ and $L_{nl} = L_{n0}$ (where $l = 0, 1, 2, \cdots n - 1$) and the corresponding atom can be regarded as a $n - fold$ degenerate LC oscillator, thus the resonant frequency as defined in Eq. 9 is also $n - fold$ degenerate. When interfered by extraneous factor, the electron will lose a small amount of en-

**FIG. 4:** The electron travelling orbits represented by the LC oscillators.
Quantum indexes Resonant frequencies

TABLE I: A comparison of the quantum numbers, eigenenergies of the quantum mechanism and the quantum indexes, resonant frequencies of the LC mechanism.

| Quantum Mechanism | Quantum Mechanism |
|-------------------|-------------------|
| Quantum numbers   | Eigenenergies     | LC Mechanism |
| n, l, m, S         | $E_{nl}$, $n = 1, 2, 3 \cdots$ | $n$, $\nu_{nl} = 1, 2, 3 \cdots$ |
|                   | $E_{nl}(l, m)$, $l = 0, 1, 2 \cdots n - 1$ | $l$, $\nu_{nl}(l, m)$, $m = 0 \pm 1, \pm 1 \cdots l$ |
|                   | $E_{nl}(m, s)$, $s = \frac{1}{2}, 1 \pm \frac{1}{2}$ | $S$, $\nu_{nl}(m, s)$, $S = 1, -1$ |

energy by emitting fluorescence and departure gradually from the original circular motion and get closer to nuclei (shown by the dash lines of Fig. 4), consequently, we have $C_{n,n-1} < \cdots C_{n1} < C_{n0}$ and $L_{n,n-1} < \cdots L_{n1} < L_{n0}$ thus the original $n = \text{fold}$ degenerate LC oscillator will split into n non-degenerate oscillators $L_{nl}C_{nl}$, where $l = 0, 1, 2 \cdots n - 1$, which is called Metastable Oscillator Number. For the DLH or DRH electron $(J = -1)$, similarly we can also obtain $n$ non-degenerate LC oscillators. Let us combine these results $(J = 1$ and $J = -1$) thus for a given $n$ of Eq. (12) there are at most $2n - 1$ metastable LC oscillators which are labelled uniquely by $m = 0, 1, 2 \cdots l$, and $m = 0, -1, 2 \cdots -l$ for $J = 1$ and $J = -1$, respectively. As a result, we claim that the concept of the so-called magnetic quantum number of quantum theory actually is the number of metastable LC oscillators existing in the atom. Now we include all quantum numbers required by the LC mechanism. To show this, we summarize the above discussions and make a comparison between the quantum numbers of the quantum mechanism and the quantum indexes of the LC mechanism. As shown in Table. 1 the resonant frequencies (energies) of the electron in the atom are uniquely defined by $\nu_{nl}(m, s)$. Without the external interference, $\nu_{nl}(m, s)$ $(J = 1, -1$ and $S = 1, -1)$ will keep its quadruple degenerate characteristic.

D. Zeeman effect

When atomic spectral lines are split by the application of an external magnetic field, it is called the Zeeman effect [12]. The Zeeman effect in hydrogen atoms showed the expected equally-spaced triplet. Quantum theory explains this by the spin-orbit interaction. By Fig. 5 we can also interpret qualitatively this puzzling experimental result. As shown in Fig. 5 the initial helical electron (with the same quantum indexes $n$ and $l$) can be in a metastable state: either $A$ of $m - 1$ $(J = 1)$ or $A'$ of $-(m - 1)$ $(J = -1)$. Without the external magnetic field, the electrons are likely decay to the next metastable state $(m$ or $-m)$ by emitting fluorescence, then transfer to the lower electronic orbit $(n - 1)$. During the transition $(B \rightarrow C)$ or $(B' \rightarrow C')$, the electron will emit a photon of frequency $\nu_0$ or $\nu'_0$, where $\nu_0 = \nu'_0$. When applied an external magnetic field in $Z$ direction, the electron $(J = 1$ or $m > 0)$ will be pushed to a higher energy states $(A \rightarrow D)$ by the lorentz force (centrifugal force) then the transition of the electron $(D \rightarrow E)$ is accompanied by the emission of a photon of frequency $\nu > \nu_0$, while the electron $(J = -1$ or $m < 0$) will be pulled to the lower states $(A' \rightarrow D')$ and the emitting photon frequency (from $D' \rightarrow E'$) is $\nu' < \nu_0$, consequently, the original single line $(\nu_0)$ will be triplet $(\nu', \nu_0, \nu)$. The lines corresponding to Zeeman splitting also exhibit polarization effects. According to our LC mechanism, the basic physical reason of the polarization is the intrinsic helical movement of electron. Without magnetic field, the line $(\nu_0)$ is a mix of equal amounts of both right and left circular polarization photons, hence the line $(\nu_0)$ is a nature light. When a magnetic field is applied (as shown in Fig. 6), the side lines $(\nu', \nu_0, \nu)$ are circular polarization. This turns to be in good agreement with experimental observations. A more detailed study of the Zeeman effect will involve the selection rules which will be given in the following discussions.

E. Selection rules

In spectral phenomena, it becomes evident that transitions are not observed between all pairs of energy levels.
Some transitions are "forbidden" while others are "allowed" by a set of selection rules. There are three main selection rules for photon emission given by quantum theory. These are $\Delta m = 0, \pm 1$, $\Delta s = 0$ and $\Delta l = \pm 1$. What are the selection rules under the LC mechanism? Fig. 6 shows the simplest transition ($n = 1 \rightarrow n = 2$) in the hydrogen atom. For the electron of higher energy ($n = 2$), there are two stable LC oscillators (or one double degenerate oscillator) for every circle, for convenience the oscillators are described in another manner: $A \rightarrow B \rightarrow C$ and $C \rightarrow D \rightarrow A$ (see Fig. 6), respectively. As can be seen, the direct transition of electron from a stable orbit, for example $A \rightarrow B \rightarrow C'$ and $C \rightarrow D \rightarrow E'$ are “forbidden”. When emitting fluorescence, the electron will decay to a slightly lower orbit (shown by $A \rightarrow B' \rightarrow C''$) then the electron has a possibility of transition ($C'' \rightarrow D'' \rightarrow E$) to orbit of $n = 1$ and emits a photon, note that $\Delta J = 0$. While the following transition $C'' \rightarrow D'' \rightarrow E''$ ($\Delta J \neq 0$) is “forbidden”. We cannot have a transition from $J = 1$ to $J = -1$, and vice versa, since the transition involves a flip of the electron orbital magnetic moment which must involve a change of flip energy. Another transition (unshown in the figure) $S = 1$ to $S = -1$ (and $S = -1$ to $S = 1$) can’t happen because there is also a barrier energy which forbids the transition. Though we consider only the simplest transition in the hydrogen atom, the forbidden transitions described here are valid in other complex atom systems.

Quantum theory describes the selection rules by a too complicated schemes which include spin-orbit coupling, wavefunction, transition probability and total angular momentum quantum number, etc. Here, we only wanted to point out that fundamental law of nature cannot be so complicated. The selection rules expressed in quantum terms $\Delta m = 0, \pm 1$ and $\Delta l = \pm 1$ are only some characteristic parameters of the dominated and simplest electronic transfer paths determined by the least-action principle.

![FIG. 6: A schematic interpretation of the Selection rules](image)

**V. SOME DISCUSSIONS**

To interpret atomic spectra completely and neatly, the Pauli exclusion principle should be considered. In the following, firstly to describe the Pauli exclusion principle in our theory, and secondly to provide a possible physical mechanism of superconductivity and a deeper physical understanding of the electron spin, electron mass, zero point energy (ZPE), the hardness property of electron and magnetic monopole.

### A. Pauli exclusion principle

Up to now, the Pauli exclusion principle is still puzzling to researchers. It states that no two electrons in a single atom can have the same set of quantum numbers. More significantly, Pauli’s Exclusion Principle is not enforced by any physical force understood by mainstream science. “When an electron enters an ion, somehow it knows the quantum numbers of the electrons which are there, and somehow it knows which atomic orbitals it may enter, and which not.” This is nothing short of incredible! It implies consciousness or connectedness between any and all elementary particles, and by a method totally unknown to the mainstream purveyors of quantum physics. Our viewpoint about this apparently esoteric principle is quite different, we think that the nature of the Pauli exclusion principle can be illustrated by classical electromagnetic field theory.

How do the Pauli electrons (pairing electrons) maintain stable orbits around protons? According to the classical theory, if one electron is closer to another electron, each electron will experience a repulsive electromagnetic force which implies that it is impossible for these electrons to form a stable Pauli electrons. But, the Pauli Exclusion Principle was shown experimentally to be a more valid concept. Hence, this fact force us to seek a attractive force between the Pauli electrons. As shown in Fig. 7(a), two electrons (with the same initial phase) of the same
chirality ($S = 1$ or $S = -1$) can move closely in a DNA-like double helical electron orbit. Note that the two helical moving electrons are equivalent to a pair of parallel electric currents, by the classical theory, these two currents (or electrons) are attracted each other and the corresponding electrons are called coherent electrons (or superconducting electrons). More recently, Morris et al. reported a astonishing observation of an infrared nebula having the morphology of an intertwined double helix about 100 parsecs [18]. To our way of thinking, nature seems indeed miraculous but really knowable. Some nature’s laws and phenomena (for example, the double helical structure) would be analogous at all scales, microscopic, macroscopic or astrophasic scale. To the best of our knowledge, it is for the first time that a possible double helical structure of microworld is suggested and reported here.

To illuminate the physical scheme of the Pauli Exclusion Principle more clearly in the classical theory, we try to simplify the picture of the pairing electrons in the handed electron mechanism. As shown in Fig. [2] b), two same-phase helical moving electrons are also equivalent to a pair of parallel travelling current ring. It is known that, for the two static electrons, there is only a strong repulsive Coulomb force ($F_c$) between them, while for the two moving electrons, the new interaction will be the magnetic force which can be attractive and repulsive depending on the kinematic relation of the moving electrons. For the special case of Fig. [7] the magnetic forces $F_m$ exerted on the electrons are attractive, and normally the two forces satisfy $F_c \gg F_m$. In order to form a stable Pauli pairing electron, the condition $F_c = F_m$ should be required. Therefore, the complicated question about the physical original and the stability of the Pauli electrons may turn out to be a very simple question: how to increase the magnetic force $F_m$ between the two helical moving electrons? It has been known that $F_m \propto I^2$, thus, to demonstrate the reliability of our theory, the way to increase the electric current $I$ should be physically provided. From Eq. [7] we know that the confinement of electrons will shorten the $\lambda_e$ and hence greatly increase the electric current $I$, which eventually increase the attractive interaction between the two same-phase helical moving electrons. As shown in Fig. [7] b), when the two electrons are a certain distance apart ($\xi$, is called the coherent length), it is likely that the repulsive force ($F_\text{r}$) would be equal to the attractive force ($F_m$). If more electrons are added in the same helical orbit, then these new injected electrons will subject a strong repulsive Coulomb force from the existed Pauli electrons. The repulsive Coulomb force can force these new added electrons to depart from the occupied Pauli orbit. From our point of view, this fundamental characteristic of the helical electrons is the physical nature of Pauli Exclusion Principle.

B. Superconductivity

Now, we would like to give a brief discussion about superconductivity. It is no doubt that the studies of the mechanism of superconductivity were, and still are, a challenging physical problem. As shown in Fig. [7] our mechanism provides a vivid and solid physical picture where two electrons can be in pairing. We assume, for any kinds of superconductors, that the $T_c$ has the form: $T_c \sim \lambda_e^{-\eta}$, where $\lambda_e$ is the electron’s de Broglie wavelength and $\eta (\geq 1)$ is an index number. The only difference among the superconductors is the $\lambda_e$ of the paired electrons. Any quantum confinement of electrons will reduce the $\lambda_e$ and help to form the paired electrons, thereby, increase the superconducting temperature $T_c$.

In our opinion, it is the electronic helical motion which causes the pairing of electrons and leads to superconductivity. The BCS theory [26] of electron-phonon interaction is likely only to be a artificial mechanism of superconductivity and the true mechanism may still be the simplest electromagnetic interaction between the pairing electrons. For any stable atoms of nature, the closed-shell electrons are naturally in pairing and the corresponding atoms are the natural one-dimensional superconductors. For traditional superconductors, pairing electrons can move in 3D space and they are more freedom with a longer de Broglie wavelength $\lambda_e$, then, the corresponding $T_c$ are lower. For the high-temperature superconductors, the paired electrons are confined in a 2D plane orbit, this confinement will greatly decrease $\lambda_e$ of the electrons, consequently, increase the $T_c$.

Is it possible to increase the superconducting transformation temperature? With our mechanism of superconductivity, the question turn out to be: how to better confine the movement of paired electrons in the materials? High pressure had been proved as a useful way of increasing the $T_c$ [13, 21, 22, 23], but it is not the final solution. Maybe some artificial structures with fractional-dimension paired electrons orbits are good choices [23, 24, 25].

C. Mass of electron

In physics, the mass of the electron is associated with the maximum and most complicated physical phenomena. Though we are much better prepared today with copious amounts of definitions of the electron mass, for example, the inertia and gravitational mass in Newtonian mechanics, relativistic mass in Einstein theory, effective mass in semiconductor physics, electromagnetic mass in electromagnetic theory and heavy fermion in condensed matter physics. We think that a deeper physical understanding of this concept (mass) is still not available in known physics. It seems difficult to understand what is the mass of the electron and why the value of the electron mass is not the intrinsic physical quantity.

In 1905, Einstein presented his famous formula, $E =$
TABLE II: The relationship between the quantum confinement effect and the mass of electron.

| The less confinement systems | The more confinement systems |
|----------------------------|----------------------------|
| Systems                    | Electron mass              | Systems                    | Electron mass |
| 3D electronic orbit        | $m_e \downarrow$           | 2D electronic orbit        | $m_e \uparrow$ |
| 2D electronic orbit        | $m_e \downarrow$           | 1D electronic orbit        | $m_e \uparrow$ |
| outer-shell electron       | $m_e \downarrow$           | inner-shell electron       | $m_e \uparrow$ |
| wide-band electron         | $m_e \downarrow$           | narrow-band electron       | $m_e \uparrow$ |
| extended electronic state  | $m_e \downarrow$           | localized electronic state | $m_e \uparrow$ |
| increasing temperature     | $m_e \downarrow$           | decreasing temperature     | $m_e \uparrow$ |
| decreasing pressure        | $m_e \downarrow$           | increasing pressure        | $m_e \uparrow$ |
| low-speed helical movement | $m_e \downarrow$           | high-speed helical movement| $m_e \uparrow$ |
| isotope containing more neutron | $m_e \downarrow$   | isotope containing less neutron | $m_e \uparrow$ |

$mc^2$, known as the energy-mass relation. In this paper, we have found another energy-mass relation for the special particle of electron. Let us recall Eq. 4 what it says is that the mass of electron is associated with an amount of magnetic energy. The most important conclusion related to our energy-mass relation is, that a stronger quantum confinement of electron (reducing the wavelength $\lambda_e$) will directly result in the increment of the mass of the electron. Here we assume all known concepts of electron mass would have the same physical reason. In order to have a deeper understanding of the electron mass, we construct a table and make a comparison between the electron mass of the less confinement systems and that of the more confinement ones.

From Table. II, one can see that all relationships presented are in agreement with the known theoretical and experimental results. Therefore, the so-called quantum confinement effect is a procedure that leads to the increment of the mass of electron, and an enhancement of the electron to choose a more stable state. Our results indicate that the stability of the electron can be measured by the mass of the electron. The more confinement applied to a electron, the “heavier” and more stable it seems to be. To enhance comprehension of the correlation between electron mass and its stability, it can be useful to consider some specific examples. Special relativity says that a rapidly moving object will have a heavier mass than the same object at a relatively lower speed (or at rest). Our idea of this phenomenon is that the moving object has a tendency to be more stable (because of the heavier mass). In fact, it is a common knowledge that, like a bullet, high-speed helical movement can greatly increase the stability of the bullet, and hence increase the mass of the bullet. Next, let’s consider the isotopic effect (the dependence of $T_c$ on the square root of isotopic mass), which was interpreted as experimental evidence of the BCS theory of electron-phonon mediated. Physically, if the atomic nucleus has more neutrons, in one hand the nucleus will become less stable and in another hand it will weaken the interaction between nucleus and electron. These will directly cause the instability of electrons, consequently, decreasing both the mass of the pairing electrons and the superconductivity temperature $T_c$.

In the above discussion, we have concluded that the mass of electron is the effect of quantum confinement: a stronger quantum confinement of electron will lead to the increment of the electron’s mass, which is in good agreement with the experimental results. In the next subsection, we will show that the spin is no long as an intrinsic characteristic of electron and the spin itself is also a quantum confinement induced effect.

D. Spin, zero point energy, hardness property of electron and a comparison of different electrons

As well known, the rules for spin came from playing with experimental data. So far the rules worked but remained mysterious. This mystery has inspired vast theoretical and experimental activity to analyze and understand the spin structure of the electron. But, in the past several decades scientists have achieved little success in this challenging problem. Historically, Uhlenbeck and Goudsmit (and separately Kronig) initially proposed a physical picture for the electron as a spinning charge sphere of radius equal to the so-called classical electron radius. According to this model, the resulting speed of the surface of the electron would be greater than the velocity of light. Up to today, it seems the classical image of a body rotating about an axis is totally inadequate to describe the peculiar geometrical properties of intrinsic spin. In our opinion, it is still significative to ask: Where is the electron spin coming from? Do we really have to accept that the spin is an intrinsic property of the electron with no classical explanation for it whatsoever?

It’s important to note that electrons have been physically divided into two classes: the classical electrons (spin-independent), and the quantum electrons (spin-dependent). Let’s first recall the classical free electron model (Fermi gases), which was good for explaining the Fermi energy, Fermi surface, thermal property, specific heat, Hall effect and electrical conduction of metals. For the quantum mechanical cases, a large variety of spin-dependent transport effects appears in different regimes of condensed matter physics: the Josephson junction [27], giant magnetoresistance [28], fractional Hall effect [29] and spin Hall effect [30], etc. With the consummation of sciences nowadays, it is not difficult to find that the so-
called spin-dependent phenomena can only be observed at very small scales (atomic scales) and under some extreme conditions, such as ultra-low temperatures, ultra-high pressures, ultra-high density, extremely magnetic fields. It is quite strange that the spin-dependent behaviors are usually not seen at larger scales. These evidently condition-dependent spin-related physical properties inspire us to raise the following question: Is the artificial concept of electron spin indeed “intrinsic”? According to our theory it is without any doubt that “intrinsic spin” means the properties of electron spin are condition-independent. Of course, an electric charge is an intrinsic property of electrons, but spin should be excluded. The electron spin, once thought to be intrinsic, now has an extrinsic nature. We think it is about time for us to re-examine the concept of electron spin defined by quantum theory. Evidently, the quantum number (spin) \( s \) can be either positive (spin-up) or negative (spin-down) depending on the chirality of the electron used to define it. In addition, we may note from the diagram of Fig. (a) that each ring contains a certain amount electromagnetic energy \( E_{\text{e}} \), which is likely the Zero Point vibrational Energy (ZPE) presented in quantum mechanics. The ZPE resulted from principles of quantum mechanics is so enormous that many physicists have questioned: Is the zero point energy real? Supposing that the concept of ZPE is physically genuine, what we are mostly interested in whether or not our mechanism can provide a constructive interpretation of the ZPE.

According to our theory, when a substance is cooled to absolute zero, inside the substance the electron’s de Broglie wavelength satisfies \( \lambda_e = 0 \). Since the inductance \( \lambda_e \) of the current ring of Fig. (a) always remains to be a finite quantity, then with the Eq. \( \lambda_e \) we have \( m_e \propto \lambda_e^{-2} \), consequently the mass of electron \( m_e \to \infty \) (as \( \lambda_e \to 0 \)). This suggests, according to Einstein’s mass-energy relation, that an absolute zero electron (or ring) contains an enormous amount of untapped electromagnetic energy (infinite) known as zero point energy or ZPE. Though our interpretation of ZPE seems consistent with that of quantum theory, but the conclusion of infinite electron’s mass implies that it is impossible to have an absolutely ZPE condition.

In physics, there are few theories which claim to have universal significance on all scales. It has been proved that the quantum mechanics is valid for describing the bizarre rules of electron and light only at atomic scales. Therefore, it becomes the first necessary to define a criterion by which we might distinguish between classical systems and quantum systems. After serious consideration, we think that the comparing the de Broglie wavelength to the size of the object is a appropriate candidate of the criterion. Figure (b) shows a traditional quantum system where the electron’s de Broglie wavelength (\( \lambda_e \)) has the atomic scale (\( d \)). We may note from the diagram that the quantized “inducton” can be uniquely presented by a quasi-spin quantum number \( s' \), which averagely can also be either positive (spin-up) or negative (spin-down) according to the chirality of the electron. If we increase the ratio between \( \lambda_e \) and \( d \), then both wavelengths and spin characteristic of electron will gradually become fuzzy. When \( \lambda_e \gg d \), the studied system will be a real classical system and the state of corresponding electron is much easy to be disturbed by the extraneous factors. As a result, it is impossible to define both the magnetic moment and the spin of the electron, and that is shown in Fig. (c).

Furthermore, we may note a particular case from the diagram of Figure with the radius of the helical orbit \( r_c = 0 \). For this case, the so-called intrinsic electron’s spin (strictly up and down) can be defined for all three situations of the figure unless \( \lambda_c \to \infty \). This implies that the quantum mechanism is nothing more than a limit (\( r_c \to 0 \)) of the \( LC \) mechanism. A comparison of different electrons from the \( LC \) mechanism’s point of view is given.
by: (i) Traditional classical electron: \( r_e = 0 \), and \( \lambda_e \to \infty \); (ii) Quantum mechanism electron: \( r_e = 0 \), and \( \lambda_e \) has a finite value; and (iii) \( LC \) mechanism electron: both \( r_e \) and \( \lambda_e \) are finite.

Obviously the electron, described by quantum mechanism (ii), seems physically inconsistent. As can be seen, on the one hand \( r_e = 0 \) indicates the vanishing of electron’s wave property, on the other hand the finite \( \lambda_e \) implies the existing electron’s wave property. Quantum mechanism overcame this difficulty by factiously introducing some uncertain and mysterious explanation of the microscopic particles.

Our results above reveal an essential connection between electron spin and the intrinsic helical movement of electron and indicate that the spin itself is the effect of quantum confinement, as well as provide new insights into quantum theory. Furthermore, with these discussions it can be fairly easy to interpret the hardness property of electron. Based on the well-known x-ray techniques, the soft (low-energy or long wavelength) and hard x-rays (high-energy or short wavelength) are defined. A similar situation exists for the hardness property of electron. Electrons are either hard or soft (only possibilities) depending upon the de Broglie wavelength of the electrons. A harder electron has a shorter wavelength (or a heavier mass), which implies that it contains more energy. Hence, the harder electron can be regarded as a high-energy electron. Likewise, the softer electron (longer wavelength or lighter mass) is a low-energy electron. This leads immediately to a very important conclusion of hardness property of electron: the quantum electron is harder and heavier than the classical electron. Because of the high stability of the harder electron, obviously, the harder electron will have both longer lifetime and longer coherent length. Otherwise, it has been proved much more difficult to remove the inner electron than the outer electron, our interpretation to this natural fact is: because the inner electron is harder and at the same time heavier than the outer electron of the same atom, therefore, the inner electron is harder to be removed.

E. Magnetic monopole

Now we will discuss the magnetic monopole. In 1931 Dirac \[31\] introduced a magnetic monopole into the quantum mechanics and found a quantization relation between an electric charge \( e \) and magnetic charge \( g \), \( eg = \frac{n}{2\pi} \hbar c \), where \( \hbar \) is the Plank’s constant divided by \( 2\pi \) and \( n \) is an integer. Since then, numerous attempts of experimental search for these magnetic monopoles at accelerators and in cosmic rays have been done. Though, recently a multinational research group claimed that the magnetic monopole can appear in the crystal momentum space \[32\]. There has not yet been any firm evidence for its existence in real space. Theoretically, ’t Hooft \[33\] pointed out that a unified gauge theory in which electromagnetism is embedded in a semisimple gauge group would predict the existence of the magnetic monopole as a soliton with spontaneous symmetry breaking, Wu and Yang first described magnetic monopoles in terms of a principal of fiber bundle \[34\]. Seiberg and Witten developed the famous magnetic monopole equations \[35\].

Here we are mostly concerned about the reason: Why have no magnetic monopoles been detected after it had been hypothesized for 75 years? There is a well-known reason: the magnetic monopoles are extremely heavy (\( \sim 10^{16}\)GeV) and well beyond the capabilities of any reasonable particle accelerator to create. We don’t think the mass of magnetic monopoles can be a reasonable reason, personally, we are more inclined to think magnetic monopoles aren’t naturally real. We have an immature idea: Is the concept of magnetic monopole only a well-known particle of different state? In fact, Seiberg-Witten proved that there has an equivalent dual description through which electron and magnetic monopole are interconvertible. In the following discussion, it is shown that the magnetic monopole is, in fact, a handed electron at absolute zero-temperature and related to the “spin” of electron.

The huge mass of magnetic monopoles means that they are going to be pretty slow (or more localized). Let us turn our attention to Fig. 8a of tremendous electron’s mass, when \( r_e \to 0 \), the electron’s circular orbit will gradually disappear thus the handed electron will degenerate into a structureless point charge of quantum theory. Eventually, the so-called “spin-up” and “spin-down” heavy electrons will turn out to be the magic Dirac’s magnetic monopoles with north (“N”) and south (“S”) magnetic poles, respectively. Note the case of \( r_e = 0 \) is unallowed in our theory, hence, the concept of magnetic monopoles is physically unreal. Now, I am confident that any attempts for searching magnetic monopoles will be proved completely valueless and furitless. Suppose \( r_e = 0 \) (quantum mechanism approximation), based on the above discussions, it is clearly shown that the electron spin and magnetic monopole of quantum mechanism are just two different expressions for one and closely related thing of the mixed mechanism.

VI. CONCLUDING REMARKS

In conclusion, we have found a process of perfect transformation of two forms of energy (kinetic and field energy) inside the hydrogen atom and the conservation of energy in the system. Then, we have shown that the helical moving electron can be regarded as an inductive particle (“inducton”) while atom as a microscopic \( LC \) oscillator then the indeterministic quantum phenomena can be well explained by the deterministic classical theory. In particular, we have show that a pairing Pauli electron can move closely and steadily in a DNA-like double helical electron orbit. Moreover, we have pointed out that the mass of electron, the ZPE and what has
been called the intrinsic “electron spin” are all really the quantum confinement effects of the intrinsic chirality of the electron of helical motion. For superconductivity, we should be able to confine electron pairs to the low dimensional systems and produce a higher temperature superconductor. Finally, we show analytically that the magnetic monopole is, in fact, a special handed electron ($r_e = 0$) at absolute zero-temperature with a de Broglie wavelength $\lambda_e = 0$. This result indicates that any attempts to search for magnetic monopole in real space will be proved to be in vain. In addition, we have pointed out that the quantum mechanism’s concepts of electron’s spin and magnetic monopole are just two different expressions for one possible physical phenomenon.

We have shown that the quantum mechanism is nothing but an approximate theory (with the radius of the helical orbit $r_e \to 0$) of the LC/wave-particle duality mixed mechanism. Our mixed mechanics force us to rethink the nature and the nature of physical world. We believe all elementary particles, similar to photon and electron, are only some different types of energy representation. Though, the standard quantum mechanics nature is intrinsically probabilistic, permitting only predictions about probabilities of the occurrence of an event. Nevertheless, one century after its birth, it still presents many unclarified issues at its very foundations. Starting from an Einstein’s work \cite{30}, many attempts have been devoted to build a deterministic theory reproducing all the results of quantum mechanics. The latter include the de Broglie-Bohm’s hidden variable theory, the most successful attempt in this sense \cite{31}. Recently, a first experimental test of de Broglie-Bohm theory against standard quantum mechanics was reported \cite{38}. In our study, it has been shown definitely that the electron follows a perfectly defined trajectory in its motion, which confirms the de Broglie-Bohm’s prediction. Also in our work, it is found that the known wave-particle duality can be best manifested by showing that the wave motion associated with an electron is just the phenomenon of its complex helical motion in real space. Therefore, the wave-particle duality should lie at the heart of the quantum universe.

We are now more and more convinced that the universe was built in the simplest manner and all things in it are unique and definitive. As Albel Einstein one said, “God does not play dice with the universe”. Of course, a more clear understanding of microscopic world is still of the greatest challenge.

Acknowledgement: The author would like to thank Ron Bourgoin for valuable discussions. This work was supported by the grants from National Nature Science Foundation of China (90201039, 10274029).

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