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The Mathematical General Solution of the Free Particle Schrödinger Equation Predict Theoretically that the $\pm$ Charged Elementary Particles and Atomic Nuclei All Have a Double Helix Structure of Mass and Charges

It produces and carries the de Broglie wave of the same velocity. $2n^2$ electrons in the main shells of the multi-electron atom form n^2 pairs of right-handed and left-handed electrons. They have elliptical orbits but radiate no energy to collapse into the nucleus.

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Abstract

We will prove that the general solution of free particle Schrödinger equation in mathematics is a helical wave. Next, we note that a uniformly moving particle itself can have wave property, as long as its mass distributes periodically along the moving direction Z. There exists a necessary condition to satisfy the Schrödinger equation that the particle or particle system must possess a helical structure represented by a complex number like a spring, its modular squared is the mass density. We will prove further that (i) $\pm$ charged elementary particles and atomic nuclei fall into two categories: they possess a charge $-e$ or $+e$, but different directions of charge and mass helix, like the right-handed electron and left-handed electron, etc. (ii) The charges distribute double helically on the particle side boundary. It produces and carries a double helix external electric **E**-field. It moves with the particle forming a wave with the same velocity. (iii) This **E**–wave is just the de Broglie wave. Its function is the particle's state function in quantum mechanics. (iv) The $\pm$ charged particle and the **E**-wave it carries form a particle-wave hybrid structure. The **E**-wave exhibits all the possible states and probabilities; as for the particle itself it can take only one basis state randomly, such as at a stationary state in the atoms or molecules or a point on the interference pattern. (v) $2n^2$ electrons in the main shells of the multi-electrons atom form n^2 pairs of right-handed and left-handed electrons. Any paired electrons will be proved having the same elliptical orbit in the paper; they do not radiate EM-energy to collapse into the nucleus. (vi) The self interference of the hybrid structure can better explain the single particle double-slits interference.

Keywords: Double helices structure, right-handed particle, left-handed particle, **i**ntrinsic self-rotation, particle-wave hybrid structure

I. Introduction

First, we study the mathematical general solution of the free particle Schrödinger equation. The mathematical solution is a helical $\psi = \psi(x, y, z, t)$ -wave, like the electric vector $E = E(x, y, z, t)$ in the circular polarized light. Chapter III is a proof of that there is a necessary condition for the uniformly moving particle or particles system to satisfy the Schrödinger equation: the mass density in the particle or particle system must distribute helically along the moving direction Z. In chapter IV, because near hundred years practice have shown that the $\pm$ charged elementary particles and the nucleus of atoms satisfy the Schrödinger equation, so they should possess such internal structure that satisfies the necessary condition. In other words, the mass density of the $\pm$ charged elementary particles and the nucleus of atoms must distribute helically along the Z-axis. Then we derive and prove further that (i) $\pm$ charged elementary particles and atomic nuclei fall into two categories: they possess a charge $-e$ or $+e$, but different directions of charge and mass helix, like the right-handed electron and left-handed electron, etc. (ii) The charges distribute double helically on the particle side boundary. It produces and carries a double helix external electric **E**-field with the same velocity as the particle. (iii) This **E**-wave is just the de Broglie wave. Its function is particle's state (wave) function in quantum mechanics. (iv) The $\pm$ charged particle and the **E**-wave it carries form a particle-wave hybrid structure. The **E**-wave exhibits all possible states and probabilities for the particle to take; as for the particle itself it can take only one basis state randomly, such as at an eigen state in the atoms or molecules or a point on the interference pattern. (v) $2n^2$ electrons in the main shells of the multi-electrons atom form n^2 pairs of right-handed and left-handed electrons. Any paired such electrons will be proved having the same elliptical orbit. They do not radiate EM-energy to collapse into the nucleus. (vi) It is a discussion about the self interference of the hybrid structure in the single particle double-slits interference. Chapter VII is the conclusion.

II. The general solution of the free particles Schrödinger equation in mathematics

The following two types of one-dimensional Schrödinger equations, Eq. (1) and Eq. (2) are treated as no difference in quantum mechanics.

$$i\hbar\frac{\partial\psi}{\partial t}=-\frac{\hbar^2}{2m}\frac{\partial^2\psi}{\partial z^2} \qquad (=E\psi \text{ or } (E-V(r))\psi) \tag{1}$$

$$-i\hbar\frac{\partial\psi}{\partial t}=-\frac{\hbar^2}{2m}\frac{\partial^2\psi}{\partial z^2} \qquad (=E\psi \text{ or } (E-V(r))\psi) \tag{2}$$

Where $V(r)$ is potential energy. Now let us discuss the Schrödinger equations for the free particle, $V(r)=0$, E and p are constant. As a differential wave equation in mathematics, the Schrödinger equation must have a general solution of the type $f(z-Vt)+f(z+Vt)$. Take $\psi(x,y,z,t)=\psi_0(x,y)\psi(z-Vt)\overset{let}{=}\psi_0(x,y)\psi(\varsigma)$ as an example, then, we have

$$i\hbar\frac{\partial\psi(x,y,z,t)}{\partial t}=i\hbar\psi_0(x.y)\frac{\partial\psi(\zeta)}{\partial t}=i\hbar\psi_0(x,y)\frac{d\psi(\zeta)}{d\zeta}(-V) \qquad (\zeta=z-Vt) \tag{3}$$

$$-\frac{\hbar^2}{2m}\frac{\partial^2\psi(x,y,z,t)}{\partial z^2}=-\frac{\hbar^2}{2m}\psi_0(x.y)\frac{\partial^2\psi(\zeta)}{\partial\zeta^2}(\frac{\partial\zeta}{\partial z})^2=-\frac{\hbar^2}{2m}\psi_0(x,y)\frac{d^2\psi(\zeta)}{d\zeta^2} \qquad (\zeta=z-Vt) \tag{4}$$

Let $B=\frac{d\psi(\zeta)}{d\zeta}$ and substitute Eq. (3), (4) into Eq. (1), we have $-i\hbar VB=-\frac{\hbar^2}{2m}\frac{dB}{d\zeta}$ and

$$B=\frac{d\psi(\zeta)}{d\zeta}=B_0e^{i\frac{4\pi mV}{h}(z-Vt)} \qquad (\zeta=z-Vt) \tag{5}$$

Then

$$\psi(\zeta)=\eta_0 e^{i\frac{4\pi mV}{h}(z-Vt)} \qquad (\zeta=z-Vt) \tag{6}$$

It holds for all $\eta_0=r\le R$. Where R is the maximum radius of the free particle's cross section. For every η_0, it represents the uniform motion of a cylindrical surface helix of radius η_0. Owing to the linearity of the Schrödinger equations, the summation of the η_0, that is to replace η_0 with the variable r, Eq. (6) still be a solution of the Schrödinger equation. It represents a combination of the layer by layer coaxial and synchronized cylindrical surface waves. It forms a beam of solid cylindrically helical wave with radius R.

So, the general solution of the Schrodinger equation, Eq. (1) in mathematics is a right-handed ψ-wave:

$$\psi(x,y,z,t)=\psi_0(r)\psi(\varsigma)=\psi_0(r)e^{2\pi i(\frac{2mV}{h}z-\frac{2mV^2}{h}t)}=\psi_x+i\psi_y \qquad (r=\sqrt{x^2+y^2}) \tag{7}$$

The plane vector $\psi(x,y,z,t)$ on the X-Y plane rotates clockwise along the moving direction Z, like a beam of right circular polarized light. Where $\psi_0(r)$ is the amplitude of the plane vector $\psi(x,y,z,t)$ at the points r.

If we substitute Eq. (3), (4) into Eq. (2), we will have a left-handed ψ -wave"

$$\psi(x,y,z,t)=\psi_0(r)\psi(\varsigma)=\psi_0(r)e^{-2\pi i(\frac{2mV}{h}z-\frac{2mV^2}{h}t)}=\psi_x-i\psi_y \qquad (r=\sqrt{x^2+y^2}) \tag{8}$$

It rotates counter clockwise along the moving direction Z. Where $V=\lambda_V\nu_V$ is the phase velocity; $\frac{2mV^2}{h}=\nu_V$ is the frequency and $\frac{h}{2mV}=\lambda_V$ is the wave length. Because the Planck constant has the dimensions joule seconds (J·s),

so the quantity $2mV^2=\in$ must be the energy; besides, since it is proportional to V^2, so it must correspond to the kinetic energy of the non-relativistic object.

The domain of the amplitude $\psi_0(r=\sqrt{x^2+y^2})$ and the cross section of the wave Eq. (7), (8) are inside the maximum cross section πR^2 that is formed by the particle's largest radius R.

The components of Eq. (7) and (8) can be written as

$$\psi_x=\psi_0(r)\cos 2\pi i(\frac{2mV}{h}z-\frac{2mV^2}{h}t)$$

$$\psi_y=\psi_0(r)\sin 2\pi i(\frac{2mV}{h}z-\frac{2mV^2}{h}t) \tag{8*}$$

Then

$$\tan\theta=\frac{\psi_y}{\psi_x}=\tan 2\pi i(\frac{2mV}{h}z-\frac{2mV^2}{h}t) \tag{9}$$

Where θ is nothing to do with r, it means that the directions of the plane vector $\psi(x,y,z,t)$ at different points (x,y) on the same cross section are all the same, just like the electric field intensity **E** on the cross section of a cylindrical beam of the circular polarized light.[6], [7]

Internal forces of the particle are attractive forces; it keeps the particle as a whole; so the amplitude $\psi_0(r=\sqrt{x^2+y^2})$ varies monotonically with r.

In order to replace the phase velocity $V=\lambda_V\nu_V$ with the research object's velocity, we let the mass center (named particle) represent the research object. Then, the particle energy is $d\in=\vec{F}\bullet d\vec{r}=\frac{d\vec{p}}{dt}\bullet d\vec{r}=d\vec{p}\bullet\vec{U}=Udp$. $d\vec{r}$ Is the displacement of the particle (the mass center of the object) and $U=\frac{d\in}{dp}$ is the particle velocity. Since the kinetic energy of a non-relativistic particle is $\in_U=\frac{mU^2}{2}\overset{p_U=mU}{=}\frac{p_U^2}{2m}$, two expressions of the kinetic energy must be equal $2mV^2=\frac{1}{2}mU^2$, so $U=2V$. Then, the particle's wave length is $\lambda_U=\frac{h}{mU}=\frac{h}{2mV}=\lambda_V$ and the frequency is $\nu_U=\frac{\in_U}{h}=\frac{mU^2}{2h}=\frac{2mV^2}{h}=\nu_V$.

Eq. (7) and (8) can be rewritten as

$$\psi(x,y,z,t)=\psi_x+i\psi_y=\psi_0(r)e^{2\pi i(\frac{z}{\lambda_U}-\nu_U t)} \qquad (\lambda_U=\frac{h}{mU}=\frac{h}{p_U}\,,\ \nu_U=\frac{mU^2}{2h}=\frac{\in_U}{h}) \tag{10}$$

And

$$\psi(x,y,z,t)=\psi_x-i\psi_y=\psi_0(r)e^{-2\pi i(\frac{z}{\lambda_U}-\nu_U t)} \qquad (\lambda_U=\frac{h}{mU}=\frac{h}{p_U}\,,\ \nu_U=\frac{mU^2}{2h}=\frac{\in_U}{h}) \tag{11}$$

The plane vector $\psi(x,y,z,t)$, ψ_x and ψ_y vary helically along the moving direction Z, right handed or left handed.

Eq. (10) and (11) are the general solutions of the free particle Schrödinger equation in mathematics. They are two complex number, the right-handed and left-handed helical ψ -wave respectively. It means that in order to satisfy the Schrödinger equation, the uniformly moving particle or particle system must form a helical wave, Eq. (10) or (11). Then, a problem arises: can a particle itself form such a helical wave when it moves uniformly along the Z-axis?

As well known, a sine curve $x=a\sin z$ moving at a uniform speed $z=z-Vt$ will form a sine wave $x=a\sin(z-Vt)$. A spring like object $a(\cos z+i\sin z)=ae^{iz}$ in the uniform motion will form a right handed cylindrical surface wave $\vec{r}=ae^{i(z-Vt)}$ with radius a . It is easy to see that if $a=a(r)$, and then, $\vec{r}=a(r)e^{i(z-Vt)}$ is a layer by layer cylindrical surface wave with different radius r , the conclusion also holds. Then we arrive at an important conclusion that the periodic distribution of mass (density) $\sum a_k(\cos kz+i\sin kz)=\sum a_k e^{ikz}$ ($a_k=a_k(r)$) along the moving direction Z, plus uniform motion $z=z-Vt$ can form a wave directly. In other words, **the particle itself can have both particle property and wave property at the same time, as long as its mass (density) distributes periodically along the moving direction** Z. So, the possibility of a particle itself to satisfy the Schrödinger equation is existed.

III. The necessary condition for the particle or particle system to satisfy the Schrödinger Equation

What kind of internal structure of the particle or particle system, its uniform motion can form the wave, Eq. (10) or (11) to satisfy the Schrödinger equation?

Let the unknown function $\psi=\psi(x,y,z)$ represent the internal structure needed by a particle or a system, its uniform motion $z=z-Ut$ can form the wave Eq. (10) or Eq. (11) to satisfy the Schrödinger equation. The z on the left side of the equation $z=z-Ut$ is a function of t , it represents the uniform motion; the z on the right side is a parameter representing the point z inside the particle. Substitute $z=z-Ut$ into the unknown function $\psi=\psi(x,y,z)$, it must satisfy the necessary condition, Eq. (10) or (11), that is

$$\psi=\psi(x,y,z-Ut)\overset{must}{=}\psi_0(r)e^{\pm 2\pi i(\frac{z}{\lambda_U}-\nu_U t)} \tag{12}$$

Let $t=0$, it gives the necessary internal structure for the particle or particle system to satisfy the Schrödinger equation as follow

$$\psi=\psi(x,y,z)\overset{must}{=}\psi_0(r)e^{\pm 2\pi i(\frac{z}{\lambda_U})}=\psi_x \pm i\psi_y \tag{13}$$

This is a helices structure represented by a complex number, an unobservable quantity. Where constant λ_U is the pitch of this helical structure. The modular squared of the $\psi=\psi(x,y,z)$ must be an observable physical quantity. For the mechanical motion of a particle, except the space time factors, the only fundamental characteristic of the particle is its mass. So, the modulus squared $\psi^*\psi(x,y,z)=\psi_0^2(\mathrm{r})$ must be the distribution function of the particle's mass density along r.

On the other hand, since the function $\psi=\psi(x,y,z)=\psi_x+i\psi_y$ is a plane vector on the X-Y plane at the point z, owing to the relation with the mass density we may call it as the inertia vector or mass amplitude.

So, the **necessary condition** for the particle to satisfy the Schrödinger equation is that the particle must possess the right helices or left helices structure of mass (density) as shown in the Eq. (13).

In order to make the terminology clear in the following, let us call the particle with the structure $\psi(x,y,z)=\psi_x+i\psi_y=\psi_0(r)e^{+2\pi i\frac{z}{\lambda_U}}$ as right-handed particle; the plane vector $\psi=\psi(x,y,z)$ is turning clockwise along the Z-direction. If the particle has the structure $\psi(x,y,z)=\psi_x-i\psi_y=\psi_0(r)e^{-2\pi i\frac{z}{\lambda_U}}$, it will be called as left-handed particle. Its plane vector $\psi=\psi(x,y,z)$ is turning counter clockwise along the Z-direction.

Let us call the geometrical plane perpendicular to the particle moving direction Z as the observation plane, "O-plane". Quantity ν_U represents the rotation frequency on the O-plane it is made by the uniform motion $z=z_0-Ut$ of the helical structure $\psi(x,y,z)=\psi_0(r)e^{\pm 2\pi i\frac{z}{\lambda_U}}$. Observers will find very much concentric circular locus with different radius r on the O-plane. Every locus is made by the successive mass elements dm_j $(j=1,2,...)$ from its own equal mass density helix. **This is a special kind of rotation differed from the self rotation**. Its angular frequency $\nu_U=\frac{1}{T_U}=\frac{U}{\lambda_U}$ $(0\le U\prec c)$ increases as the velocity U increases.

On the other hand, the uniform motion $z=z_0-Ut$ does make the inertia vector, Eq. (13) become the ψ-waves Eq. (10) and Eq. (11). So, Eq.(13) is really the necessary and sufficient condition for the internal structure of the particle or particle system to satisfy the Schrödinger equation.

λ_U Is the common pitch of the particle's helical structure $\psi(x,y,z)$; it is also the wave length in the Eq. (10), (11). So $T_U=\frac{1}{\nu_U}=\frac{\lambda_U}{U}$ is the time for the particle to move a pitch, a wave length. It is also the time period for the plane vector $\psi(x,y,z)$ and the mass elements dm from themselves equal density helices to rotate a circle on the O-planes. Its angular velocity vector $\vec{\omega}_U \ (= 2\pi \vec{\nu}_U)$ is perpendicular to the O-plane, in the same direction as $\vec{U}$ or -$\vec{U}$, depends on whether it is a right helix particle (right-handed particle) or it is a left helix particle (left-handed particle). For such rotations, no superluminal problem will happen, because the rotation is made by all dm that one after one "rotates" on the O-plane, not the same dm.

According to the paper Schrödinger published in 1926,[1] he computed the hydrogen spectral series by treating a hydrogen atom's electron as a $\Psi(x,y,z,t)$ -wave moving in a potential well $V(x,y,z)$ created by the proton. The computation accurately reproduced the energy levels of the Bohr model. The Schrödinger equation details the behavior of $\Psi(x,y,z,t)$ but says nothing of its nature.

What is the nature of this $\Psi(x,y,z,t)$ -wave? Max Born successfully interpreted $\Psi(x,y,z,t)$ in an abstract configuration space as the probability amplitude its modulus squared $\Psi * \Psi(x,y,z,t)$ is equal to the probability density. This interpretation has achieved a great success.

But, because the general solutions of the Schrödinger equation, the ψ -wave Eq. (10) and (11), are the waves naturally formed by the uniform motion of the particle with internal structures (13) (this structure is necessary for the particle to satisfy the Schrödinger equation). So we try to take the waves, Eq. (10), (11) to be the nature of the Schrödinger's $\Psi(x,y,z,t)$ -wave: $\Psi(x,y,z,t) \overset{let}{=} \psi(x,y,z,t) = \psi_0(r) e^{2\pi i(\frac{z}{\lambda_U} - \nu_U t)}$ Or $\overset{let}{=} \psi_0(r) e^{-2\pi i(\frac{z}{\lambda_U} - \nu_U t)}$ to see what will happen? Is it consistent with Max Born? Is there any additional harvest? Fortunately, as we expected, the answer is positive. The result proves the correctness of Max Born and gives us many interesting and important additional harvests.

IV. ± Charged elementary particles and nuclei of atoms should possess a double helix internal structure and the following interesting and important properties

(A) Nearly a hundred years of practice have shown that ± charged elementary particles and atomic nuclei satisfy the Schrödinger equation, so they should satisfy the necessary condition required by the Schrödinger equation. In other words, anyone of these ± charged particles should have a right handed structure $\psi(x,y,z) = \psi_0(r) e^{2\pi i \frac{mU}{h} z}$ of mass density like a right multi-head screw or a left handed structure $\psi(x,y,z) = \psi_0(r) e^{-2\pi i \frac{mU}{h} z}$ of mass density like a left multi-head screw.

(B) Because all these $\pm$ charged particles possess intrinsic constant spin, e.g. $\hbar/2$ and the frequency ν_U of the non-relativistic particle varies with the velocity $\nu_U = \frac{1}{T_U} = \frac{U}{\lambda_U} \prec \nu_c$ ($0 \le U \prec c$); there must exist a constant and maximum frequency ν that the constant intrinsic spin corresponds to; it always satisfies $\nu_U \le \nu$.

What is the extra frequency? Obviously, the only possibility is the frequency of self axial rotation, the intrinsic self-rotation frequency ν_{self} :

$$\nu_{self} = \nu - \nu_U \tag{14}$$

Total angular velocity vector $\vec{\omega}\,(= 2\pi\,\vec{\nu})$ and self-rotation angular velocity vector $\vec{\omega}_{self}\ (= 2\pi\,\vec{\nu}_{self})$ are all perpendicular to the O- plane, in the same direction as $\vec{U}$ or -$\vec{U}$ depend on whether it is a right-handed particle or a left-handed particle.

The quantity $h\nu \overset{let}{=} \in$ has energy dimension. It is a constant. Compare to the expression of the kinetic energy of the non-relativistic particle $\in_U = \frac{mU^2}{2} = h\nu_U$ $(0 \le U \prec c)$ in Eq. (10), (11), the quantity

$$\in = h\nu \qquad (U \le c) \tag{15}$$

must be the maximum energy, the total energy of the particle with intrinsic spin under any velocity $U \le c$.

(C) Because these $\pm$ charged particles possess both intrinsic constant spin and helices structure $\psi(x,y,z) = \psi_0(r)e^{2\pi i \frac{mU}{h} z}$ or $\psi(x,y,z) = \psi_0(r)e^{-2\pi i \frac{mU}{h} z}$, so replace the Eq. (10), (11), the equation of motion of the $\pm$ charged elementary particles and the nucleus of atom is

$$\psi(x,y,z,t) = \psi_x + i\psi_y = \psi_0(r)e^{2\pi i(\frac{z}{\lambda_U} - \nu t)} \qquad (\in = h\nu\,,\ p_U = mU = \frac{h}{\lambda_U}\,,\ U \le c) \tag{16}$$

Or

$$\psi(x,y,z,t) = \psi_x - i\psi_y = \psi_0(r)e^{-2\pi i(\frac{z}{\lambda_U} - \nu t)} \qquad (\in = h\nu\,,\ p_U = mU = \frac{h}{\lambda_U}\,,\ U \le c) \tag{17}$$

It is easy to verify that they satisfy the Klein-Gordon equation.

Long time ago, someone have ever thought that the elementary particle's spin is totally dependent on the self-rotation. But, it leaded to the superluminal difficulty as Pauling had ever pointed out. Using pure self-rotation to explain these particles spin is not available. So, if a particle possesses intrinsic spin, it must possess both the helical structure of inertia vector, Eq. (13) and the intrinsic self-rotation simultaneously.

The special kind rotation made by one after one dm from their own equal density helices "rotate" on the O-planes plus the intrinsic self-rotation is really the physical mechanism of the particle's intrinsic spin.

These two "intrinsic" are different, intrinsic spin is for the particle being treated as point particle or a particle of no internal structure. As to the intrinsic self-rotation, it is for the particle with helical structure. The intrinsic self-rotation is a true rotation; it does exist, except $U \to c$, $v_{elf} \to 0$ to become a "photon". While the particle is static, then $U = 0$, $v_{elf} = v$. It means that the magnetic moment of a static particle is totally depended on the particle's self rotation $v_{elf} = v$. The inequality $r \overset{must}{\prec} \frac{c}{2\pi v}$ is a limitation condition to the radius of the $\pm$ charged elementary particles and the nucleus of atoms.

Because a particle with intrinsic spin certainly possess the helical structure at the same time, So **the particle with intrinsic spin is actually the necessary and sufficient conditions for the particle to have the wave function Eq.(16) or Eq.(17) and satisfy the Schrödinger equation in the whole speed region $U \le 0$.**

(D) For the $\pm$ charged elementary particles and $\pm$ atomic nucleus (the "$-$" here means the antiparticles), any of them possesses a charge $-e$ or $+e$, but two directions of mass density and charge structures, so all of them fall into two categories: they possess the same sign of charge $-e$ or $+e$, but different directions of mass density and charge helices, like right-handed electron and left-handed electron; right-handed positron and left-handed positron, etc. The right-handed and left-handed charged particles have different orientations of the magnetic flux density **B.**

(E) Owing to the vector **B** having different orientations, two categories of these particles are distinguishable. They satisfy F-D statistics. As for the photons, according to the papers [2]… [7] the far field **of E** and **B** from a pair of $\pm e$ in the photon will offset each other, they are indistinguishable and obey B-E statistic.

(F) Also owing to the **B** effect, we can imagine that for the charged particles of the same kind, a pair of left-handed and right-handed particles can become "entanglement", if they are happen to locate closely parallel to each other and become a "**B** neutral pair". Because the spin direction is decided by the direction of the particle helices structure in this paper, so such "entanglement" is like a pair of gloves; left-handed part is always left-handed; right-handed part is always right–handed no matter how far they depart.

In order to check this conclusion, we think if we can split an "entanglement" pair of left-handed and right- handed charged particles and place at two places A_1 and A_2 respectively; then we always observe the same place A_1 or A_2 to see if the **B** orientation of the particles will always remain the same or random to judge whether the spin direction $\pm$ depends on the particle structure or on its quantum states.

(G) We can imagine when the temperature inside the metal wire gets lower and lower until the kinetic energy of the electrons cannot overcome the magnetic interaction between the electrons of the same category; these electrons of the same category will one by one string together along the electric circuit and become an independent electric current at last. Then, no collision will happen between these electrons and the nuclei, the current will be almost of no resistance $R \cong 0$.

We can imagine further that under the same temperature condition, the electrons of different category can also become an independent electric current of no resistance

$R \cong 0$ as long as all the electrons in the same electric current have the same magnetic **B** orientation.

(H) For these $\pm$ charged particles, they have the helices structure of inertia vectors $\psi(x,y,z)=\psi_0(r)e^{2\pi i\frac{mU}{h}z}$ or $\psi(x,y,z)=\psi_0(r)e^{-2\pi i\frac{mU}{h}z}$ and charge $-e$ (or $+e$) simultaneously. Repulsion between the same sign of charge will split the charge element de ($\sum de = e$) into $2\times\frac{de}{2}$ and located at two ends of the diameter on all the cross sections. Owing to the similarity among the cross sections, charge $-e$ (and $+e$) will become a pair of charged double helices on the particle's side boundary. It will make the particle's internal material polarized to become a double helices structure. In the meantime, the charge $-e$ (and $+e$) will produce a double helices external **E**-field. This **E**-field becomes a circular polarized **E**-wave when the particle moves with $z = z_0 - Ut$ along the z-axis. The **E**-wave and the double helix distribution of the charge $-e$ (or $+e$) in the moving particle have the same velocity, the same wavelength, and the same frequency, so the equation of motion of the charged particles, Eq. (16), (17) and the function of **E**-wave are of the same form except the amplitude. In order to avoid confuse, we use

$$E(x,y,z,t) = E_x + iE_y = E_0(r)e^{2\pi i(\frac{z}{\lambda_U}-\nu t)} \qquad (\in = h\nu,\ p_U = mU = \frac{h}{\lambda_U},\ U \prec c) \tag{18}$$

And

$$E(x,y,z,t) = E_x - iE_y = E_0(r)e^{-2\pi i(\frac{z}{\lambda_U}-\nu t)} \qquad (\in = h\nu,\ p_U = mU = \frac{h}{\lambda_U},\ U \prec c) \tag{19}$$

To express the function of right circular polarized **E**-wave and left circular polarized **E**-wave respectively.

According to the Eq. (18),(19), $\in, p_U$ of the moving particle and ν, λ_U of the **E**-wave the particle produces and carries naturally satisfy the de Broglie relation $\in = h\nu$, $p_U = mU = \frac{h}{\lambda_U}$. So the **E**-wave as a real wave, it satisfies the de Broglie relation. **The charged particle itself and the E-wave it produces and carries form a particle-wave hybrid structure**. The **E** -wave is covering the particle; they move with the same phase until meeting the obstacle.

V. Self-interference of the $\pm$ charged subatomic and atomic particles in the single particle double-slits experiments [8]…[11]

For the single particle double slit interference, because the $\pm$ charged particle itself as a point particle floats on the front surface of the **E**-wave and moves together; it cannot split into two parts to pass two slits. Only the particle itself along with its E-wave beam and another E-wave beam passing through the second slit (i.e. split from the same original E-wave) can form the distribution of phase differences, which is also the probability distribution pattern on the screen behind the slits. As for the particle itself, owing to the momentum $\pm\Delta p_s$ of the Heisenberg uncertainty principle $\Delta x\Delta p_x \geq \frac{\hbar}{2}$ at the slit Δx, it will be deflected in general and locates randomly (with probability) at a point on the screen. For the all particles, they one by one pass through the slit Δx will be deflected symmetrically and distribute symmetrically on the screen; plus the interference effect, they will form the interference pattern on the screen at last. The single particle double slit interference of $\pm$ charged atomic and subatomic particles are all based on the self-interference of the particle-wave hybrid structure of the particle.[8], [9]

Now we can say that the E-wave is the probability wave, de Broglie wave, in quantum mechanics. In other words, **the de Broglie wave in quantum mechanics is really a helically distributed electric field produced and carried by the $\pm$ charged subatomic and atomic particles themselves and moves at the same speed. Therefore, the functions of E-wave, Eq. (18),(19) is really the wave (state) function of the charged particles in quantum mechanics.** It is easy to believe that with the aid of the particle-wave hybrid structure, such state function can completely specify the states of these $\pm$ charged particles; need not to presuppose that the state of the particle is completely specified by a wave function that satisfies the Schrödinger equation and need not depend on the idea of wave function collapse.

By the way, in the single particle double slit experiment, due to wave-particle structure, if the particle is detected (being absorbed) by a detector, or if one of the **E** –wave beams is disturbed to disable by certain effects, only another beam of **E** –wave with its particle can reach the screen, then the total particles that one by one pass through the same slit Δx will be deflected symmetrically. As long as the experiment time is long enough, it will not only form a symmetrical pattern on the screen, but also a single-slit diffraction pattern. We believe that this assertion will be proved in the experiments.

Generally speaking, owing to the particle-wave hybrid structure, the superposition principle of the Schrodinger equation for the **E** -wave will exhibit all the possible states and the probabilities for the particle to take. As for the particle itself, since it cannot split into two parts or with two different energies to move with two velocities at the same time, it can take only one basis state any time t; such as at an Eigen state in the atom or molecule or at a point on the interference pattern.

The superposition principle of the Schrödinger equation for the particle itself is just to bring in the integral constants and general solution. Depending on the given conditions, like the normalized condition and boundary condition..., etc. the state of the electron in the atom or molecule can be decided definitely by the quantum number n, l, m_l, m_s. So, the electrons themselves in the atom or molecule have the definite Eigen states and **then, as a particle, the electron's stable moving history must be a stable orbit.**

Then, a problem arises: if the electron has a definite orbit in the atom or molecule Eigen state, due to EM radiation whether the electron would rapidly spiral inwards, collapsing into the nucleus? We will discuss this problem in the following chapter.

All in all, for the particle-wave hybrid structure, it shows particle like character and wave like character at the same time, not exhibits different character for different phenomena.

VI. The proof of that the electrons in the main shells of the multi electron atoms have definite elliptical orbits. They do not radiate EM energy to collapse into the nucleus

For the electron in the hydrogen isotope atom or hydrogen-like ion, its Eigen values of the energy E are given by the formula

$$E_n = -\frac{\mu Z e^4}{8\varepsilon_0 h^2}(\frac{1}{n^2}) \qquad (n = 1,2,...) \tag{20}$$

For each value of n, there are n different possible values of the azimuth quantum number l, namely $0,1,2,...,n-1$. Each values of l represents a different kind of stationary state.

As for the spin quantum number $m_s = \pm 1/2$, because in this paper, the spin of the particle is made by the uniform motion of the particle's helical structure and the intrinsic self-rotation, so, the two spin quantum numbers $m_s = \pm 1/2$ should correspond to the two spins of the right-handed electron and left-handed electron respectively.

As well known, in the main shells (stationary states) of a multi-electron atoms there are at most $2n^2$ electrons. Due to $m_s = \pm 1/2$, so they have n^2 $m_s = 1/2$ (right-hand) electrons and n^2 $m_s = -1/2$ (left-hand) electrons. In other words, they form n^2 pairs of right handed electron and left handed electron. These two kinds of electrons $m_s = \pm 1/2$ have different magnetic pole orientations as mentioned above.

Since the electron in a stationary state has definite energy, as a particle it must have a definite orbit. Because it moves in the centripetal force field, its energy is negative, so its orbit is an ellipse in general.

Owing to spherical symmetry of the field in which the electron moves and because the electron's total angular velocity vector $\vec{\omega}(= 2\pi \vec{\nu})$ and then the angular momentum vector are all perpendicular to the O-plane, it makes no contribution to the orbital angular momentum L; only the orbital motions can make it. So the orbital motion of the $m_s = 1/2$ electron and $m_s = -1/2$ electron is regardless of the electron's self rotation direction.

For the two electrons in the quantum state $n, l = 0, m_l = 0, m_s = \pm 1/2$, their resultant orbital angular momentum is zero **at any time**. So the precondition is that they must have the same elliptical orbit. For these two $m_s = 1/2$ and $m_s = -1/2$ electrons, they move oppositely in the same elliptical orbit, there must have a meeting point. Take this point as $t=0$, the equations of motion of the two electrons can be written as

$$x_1 = a\sin\omega t$$
$$y_1 = b\cos\omega t \tag{21}$$

And

$$x_2 = a\sin(-\omega t)$$
$$y_2 = b\cos(-\omega t) \tag{22}$$

At $t=0$, they start from the same point $(0,b)$ and move toward opposite directions.

The semi-major axis a of different n has different value. The minimum of a happens at $n=1$. Because

$$(\frac{x_i}{a})^2 + (\frac{y_i}{b})^2 = 1 \qquad (i=1,2) \tag{23}$$

So their orbits are all elliptical. On the other hand, Eq. (21) and (22) give us:

$$x_1 + x_2 = a\sin\omega t + a\sin(-\omega t) = 0$$
$$\int_0^T (y_1+y_2)\,dt = \frac{1}{T}\int_0^T [b\cos\omega t + b\cos(-\omega t)]\,dt = 0 \tag{24}$$

In Eq. (24) the formula $x_1 + x_2 = 0$ means that the resultant vibration equal to zero. When an electron in this pair radiates certain amount of EM energy radiated by the x-direction vibration, it will absorb the same amount of EM energy from another electron at the same time; no EM energy will lose. As to the second formula, it means that the minor axis of the ellipse or the flatness of the ellipse happen periodic oscillation (average oscillation equal to zero). It doesn't matter to the energy loss or gain. In a word, the electron in the Eigen state radiates no net energy. It does not collapse into the nucleus.

Next, let's discuss the electrons in the stationary state $n, l=1, m_l=1, m_s=\pm 1/2$. The resultant orbital angular momentum (correspondent to $l=1,\ m_l=1$) must be the sum of the two electrons' orbital angular momentum. They move in the same direction; one is made by the $m_s=1/2$ electron, another one is made by the $m_s=-1/2$ electron. Since it require $n, l=1, m_l=1$ at any time, so the only possibility is that they must also have the same elliptical orbit.

If two electrons of the same category move along an elliptical orbit, the magnetic attraction from both sides of the electron will make them unstable and get together; but the magnetic attraction between the two electrons of the same category cannot overcome the electron kinetic energy at room temperature, so the state of aggregation is unstable (This is the similar conclusion as the Pauli Exclusion Principle).

Only two electrons of different categories in the elliptical orbit, the magnetic repulsions from two sides will make any pair of $m_s=\pm 1/2$ electrons into stable equilibrium and distribute at the two symmetrical points on the orbit. Let $x_1 = a\cos\alpha$, $y_1 = b\sin\alpha$ and $x_2 = a\cos(\alpha+\pi)$, $y_2 = b\sin(\alpha+\pi)$ represent their initial positions at the orbit. Then their equations of motions are

$$x_1 = a\cos(\pm\omega t + \alpha)$$
$$y_1 = b\sin(\pm\omega t + \alpha) \quad (25)$$

And

$$x_2 = a\cos(\pm\omega t + \alpha + \pi)$$
$$y_2 = b\sin(\pm\omega t + \alpha + \pi) \quad (26)$$

Since $(\frac{x_i}{a})^2 + (\frac{y_i}{b})^2 = 1 \quad (i = 1,2)$, their orbits are also elliptical. On the other hand, because $\sin(\alpha+\pi) = -\sin\alpha$ and $\cos(\alpha+\pi) = -\cos\alpha$, the resultant vibration of the $m_s = 1/2$ and $m_s = -1/2$ electrons is

$$x_1 + x_2 = a\cos(\pm\omega t + \alpha) + a\cos(\pm\omega t + \alpha + \pi) = 0$$
$$y_1 + y_2 = b\sin(\pm\omega t + \alpha) + b\sin(\pm\omega t + \alpha + \pi) = 0 \quad (27)$$

So, we have the same conclusion as the Eq. (24). The resultant vibration of the electrons pair is zero. It also causes that when one electron in the pair radiates a certain amount of EM energy, it will absorb the same amount of energy from the other electron in the same time. The electron in this layer does not radiate net EM energy to collapse into the nucleus.

Because the difference between the two $n, l = 1, m_l = 1, m_s = \pm 1/2$ and $n, l = 1, m_l = -1, m_s = \pm 1/2$ quantum states is that they move in opposite directions on the same stable orbit, so they have the same conclusion as mentioned above: the electron in this layer radiates no EM energy. It does not collapse into the nucleus.

It is evident that for the case of $l = 2,3,...$, the conclusions will be also the same. The electron does not radiate net EM energy to collapse into the nucleus. This is because that $l = 2,3,...$, $m_l = \pm 2, \pm 3,...$ represent that there are two or three or … pairs of different categories electrons symmetrically distribute on the ellipses and the above assertion is available for each pair of them.

By the way, because the double helix distribution of charge $-e$ and $+e$, the attractive force between the nucleus and electron is no longer so precisely as $\vec{f} = \frac{1}{4\pi\varepsilon_0}\frac{Ze^2}{r^3}\vec{r}$, so the equation $\vec{r}\times\vec{f} = \vec{r}\times(\frac{1}{4\pi\varepsilon_0}\frac{Ze^2}{r^3}\vec{r}) = 0$, $\vec{r}\times\vec{f} = \vec{r}\times\frac{d}{dt}(m\vec{V}) = \frac{d}{dt}(\vec{r}\times m\vec{V}) = 0$ and then $(\vec{r}\times m\vec{V}) = constant$ are no longer extremely precise. $\vec{r}$ And $m\vec{V}$, then their projections on the same axis cannot be extremely precisely determined at the same time. In other words, the elliptical orbit and the relation between Δx and ΔmV_x; Δy and ΔmV_y are not as precise as shown in the equation (22) and its inference. It makes no harm to the Heisenberg Uncertainty Principle.

VII. Conclusion

The first conclusion is that the object or system itself can have wave property (become a wave in uniform motion) at the same time, as long as it possesses a periodic distribution of mass (density) along the moving direction. Next, the study of the general solution of the free particle Schrödinger equation in mathematics shows that there is a necessary condition for the object or system to satisfy the Schrödinger equation: They should possess a helices structure $\psi = \psi_0(x,y)e^{\pm 2\pi i(\frac{z}{\lambda_U})}$, its modular squared $\psi^*\psi(x,y,z,t) = \psi_0^*\psi_0(x,y)$ represents the interior distribution of mass density in the particle. Since near hundred years practices have shown that all the $\pm$ charged elementary particles and the nuclei of atoms satisfy the Schrödinger equation, so (i) they should possess one of the internal structure $\psi = \psi_0(x,y)e^{\pm 2\pi i(\frac{z}{\lambda_U})}$. And the further results are: (ii) All the mentioned $\pm$ charged particles fall into two categories, they have the same sign of charge $-e$ or $+e$, but different directions of mass density and charges helices, like left-handed electron and right-handed electron, left-handed positron and right-handed positron etc. (iii) The charge $-e$ (or $+e$) distributes double helically along the particle side boundary. The electric polarization makes the particle's internal structure become double helices; and produces and carries a circularly polarized external electric field E with the same velocity as the particle or system. (iv) This E-wave has been proved is just the de Broglie wave. (v) The E-wave's function is particle's state function in quantum mechanics. (vi) The $\pm$ charged particle itself and the de Broglie **E**-wave it produces and carries form a particle-wave hybrid structure. The charged particle as a point particle floats on the front surface of the **E** -wave and moves together with the same phase. The **E** -wave exhibits all the possible states and probabilities for the particle to take; as for the particle itself it can take only one basis state randomly, such as at an eigen state in the atom or molecule or at a point on the interference pattern. (vii) The self-interference of the hybrid structure can better explain the single particle double-slit interference. For the particle-wave hybrid structure, it shows particle like character and wave like character at the same time, not exhibits different character for different phenomena. (viii) Depending on the given conditions, the quantum state of the electron in the atom or molecule can be decided definitely by the quantum numbers; it has definite energy; (ix) For the electron in the atom or molecule, as a particle its moving history, the orbit idea corresponding to a set of definite quantum numbers must be available; It has been proved that the orbital motion of electrons in the main shells in multi-electron atoms does not radiate EM energy to collapse into the nucleus. (x) The spin of the particle has its mechanism it is formed by the uniform motion of the helices structure of mass density plus intrinsic self rotation. (xi) In fact, the intrinsic spin is actually the necessary and sufficient conditions for the particle to satisfy the Schrödinger equation in the whole speed region $U \prec c$.

It is obvious that this paper is a complement to the quantum physics, not the opposite.

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