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The Essence of Microscopic Particles and Quantum Theory

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Abstract

In the paper, we have given the quantum equation of the gravitational field intensity $E_g(\boldsymbol{r},t)$ and electric field intensity $E(\boldsymbol{r},t)$ for the material particles, since the gravitational field intensity $E_g(\boldsymbol{r},t)$ and electric field intensity $E(\boldsymbol{r},t)$ is in direct proportion to the distribution function $\psi(\boldsymbol{r},t)$ of particle spatial position (wave function), these quantum equations are natural converted into the Schrodinger equation. In addition, we have proposed the new model about the photon and matter particles. For all particles, they are not point particles, but they have a very small volume. The photon has a vibration electric field in its very small volume. The neutral material particle, such as neutron, it has a vibration gravitational field in its very small volume. For the charge material particles, such as electron and proton, they have both vibration gravitational field and vibration electric field in their very small volume. With the model, we can explain the diffraction and interference of single slit and multiple-slit for the single photon and material particles, the volatility of all particles come from the superposition of their respective vibration field. After the vibration field of particle superposition, it shows up as a particle property. On this basis, We have obtained some new results, and realized the unification of both wave and particle and field and matter.

Keywords

Photon, Material Particles, Electromagnetic Field, Gravitational Field, Schrodinger Equation

1. Introduction

In 1900, the derivation of the black-body spectrum due to Planck is taken as the birth of quantum theory [1]. After Einstein proposed the light quantum hypothesis and successfully explained the photoelectric effect, people accepted the theory that light has wave-particle duality. In 1922, D. E. Broglie argued that all particles, like photons, have wave-particle duality [2] [3]. Broglie further thinking matter wave theory, he thought the matter waves of wave mechanics and classical mechanics is similar to the relationship between wave optics and geometrical optics, the relationship between the analogy thought for later founded the schrodinger wave mechanics to lay the important foundation of schrodinger in material Broglie wave theory, on the basis of schrodinger quantum wave equation is given [4] [5] [6].

In the development of physics in the 20th century, Einstein and Bohr are the two greatest scientist. They both created the glory of modern physics, but they had their own unique and profound views on the basic problems of modern physics, which caused a long-term debate. Bohr think quantum own existence form, can be described by probability wave function, when the quantum system interact with the outside world, the wave function will collapse to a specific value can be observed, for quantum system, it is impossible to get something other than the probability, the laws of quantum mechanics is only spontaneously, must abandon the decisive principle of cause and effect. Bohr later put forward the famous correspondence principle and complementary principle, which further caused a great shock in the physics.

In 1935, Einstein, Podorsky and Rosen proposed the criterion of the completeness of physical theoretical system and the famous EPR paradox [7], which involves how to understand the reality of the micro world and demonstrates the incompleteness of the description of physical reality by quantum mechanics. In 1950s, Bohm proposed the quantum theory of hidden parameters inspired by EPR paradox [8]. In the 1960s, John Bell derived a quantitative Bell's inequality [9] [10], on the quantum correlation of distant particles from mathematics according to the quantum theory of hidden parameters. It was possible to design experiments to test the EPR paradox. Physicists completed experiment results are in violation of Bell's inequality and consistent with the predictions of quantum mechanics [11] [12] [13]. The above experiments only show that quantum theory is related at a distance and non-local, but do not determine whether quantum theory is deterministic or non-deterministic, that is to say, whether the causality of the microscopic world is established has not been determined, and the debate on the basis of quantum theory needs to go on. Einstein acknowledged that the internal system of quantum mechanics was self-consistent, but he insisted that quantum mechanics was not the final description of a complete microscopic system.

Although quantum mechanics has made many achievements in developing new technologies, many fundamental questions still exist and need to be studied. In order to understand the microscopic world, whether we need to introduce new concepts and ideas to explain why we should introduce the concept of probability into quantum mechanics, thereby unifying the ideas of determinism and probability theory.

In classical electrodynamics, charged particle is treated as point charge, which leads to infinite self-energy. Therefore, it is problematic to treat particles as points. From the point of view of quantum mechanics, the Compton wavelength is usually used to describe the distribution area of particle, and the concept of point particles should be abandoned.

According to De Broglie's idea of analogy, the relation between quantum mechanics and classical mechanics is similar to that between wave optics and geometric optics. In the paper, we have given the quantum equation of the gravitational field intensity $E_g(\boldsymbol{r},t)$ for matter particles, since the gravitational field intensity $E_g(\boldsymbol{r},t)$ relatives to the particle position distribution function $\psi(\boldsymbol{r},t)$, the quantum equation convert into the Schrodinger equation. In the paper, we have given the quantum equation of the gravitational field intensity $E_g(\boldsymbol{r},t)$ and electric field intensity $E(\boldsymbol{r},t)$ for the material particles, since the gravitational field intensity $E_g(\boldsymbol{r},t)$ and electric field intensity $E(\boldsymbol{r},t)$ is in direct proportion to the distribution function $\psi(\boldsymbol{r},t)$ of particle spatial position (wave function), these quantum equations are natural converted into the Schrodinger equation. In addition, we have proposed the new model about the photon and matter particles. For all particles, they are not point particles, but they have a very small volume. The photon has a vibration electric field in its very small volume. The neutral material particle, such as neutron, it has a vibration gravitational field in its very small volume. For the charge material particles, such as electron and proton, they have both vibration gravitational field and vibration electric field in their very small volume. With the model, we can explain the diffraction and interference of single slit and multiple-slit for the single photon and material particles, the volatility of all particles come from the superposition of their respective vibration field. After the vibration field of particle superposition, it shows up as a particle property. On this basis, we have obtained some new results, and realized the unification of both wave and particle and field and matter.

2. The Relationship between Quantum Equation of Photon and Maxwell's Equations

The Maxwell's equations are the macroscopic equation of electromagnetic field, which are description the change rule of electric and magnetic fields for a beam of light or a large number of photons. The single photon also has electric and magnetic fields, it satisfies the Maxwell's equations.

1) The Maxwell's equations in vacuum are

$$\nabla\times\boldsymbol{E}=-\frac{\partial\boldsymbol{B}}{\partial t}\tag{1}$$

$$\nabla\times\boldsymbol{B}=\mu_0\varepsilon_0\frac{\partial\boldsymbol{E}}{\partial t}\tag{2}$$

$$\nabla\cdot\boldsymbol{E}=0\tag{3}$$

$$\nabla \cdot \boldsymbol{B} = 0 \tag{4}$$

In the Ref. [14], we have given the quantum vector wave equation of photon, it is

$$i\hbar \frac{\partial}{\partial t}\boldsymbol{\psi} = c\hbar \nabla \times \boldsymbol{\psi} + V\boldsymbol{\psi}, \tag{5}$$

where the $\boldsymbol{\psi}$ is the vector wave function of photon, the V is the potential energy of photon in medium, it is

$$V = \hbar\omega(1-n), \tag{6}$$

where the n is the refractive index of photon in medium. when the photon is in the air or vacuum, the refractive index $n = 1$, the potential energy $V = 0$, *i.e.*, it is a free photon, the Equation (2) becomes

$$i\hbar \frac{\partial}{\partial t}\boldsymbol{\psi} = c\hbar \nabla \times \boldsymbol{\psi}. \tag{7}$$

In the Ref. [15], we have given the quantum spinor wave equations of free and non-free photons (see Appendix A and B), they are:

$$i\hbar \frac{\partial}{\partial t}\psi(\boldsymbol{r},t) = -ic\hbar \boldsymbol{\alpha} \cdot \nabla \psi(\boldsymbol{r},t), \tag{8}$$

and

$$i\hbar \frac{\partial}{\partial t}\psi(\boldsymbol{r},t) = -ic\hbar \boldsymbol{\alpha} \cdot \nabla \psi(\boldsymbol{r},t) + V\psi(\boldsymbol{r},t). \tag{9}$$

The photon spinor wave function ψ and the matrices $\boldsymbol{\alpha}$ are:

$$\psi(\boldsymbol{r},t) = \begin{pmatrix} \psi_1(\boldsymbol{r},t) \\ \psi_2(\boldsymbol{r},t) \\ \psi_3(\boldsymbol{r},t) \end{pmatrix}, \tag{10}$$

and

$$\alpha_x = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & -i \\ 0 & i & 0 \end{pmatrix}, \alpha_y = \begin{pmatrix} 0 & 0 & i \\ 0 & 0 & 0 \\ -i & 0 & 0 \end{pmatrix}, \alpha_z = \begin{pmatrix} 0 & -i & 0 \\ i & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}, \tag{11}$$

Using the method of separation variable $\psi(\boldsymbol{r},t) = \psi(\boldsymbol{r}) f(t)$, the Equations (8) and (9) become

$$-ic\hbar \boldsymbol{\alpha} \cdot \nabla \psi(\boldsymbol{r}) = E\psi(\boldsymbol{r}), \tag{12}$$

and

$$\left[-ic\hbar \boldsymbol{\alpha} \cdot \nabla + V\right]\psi(\boldsymbol{r}) = E\psi(\boldsymbol{r}), \tag{13}$$

where E is the total energy of photon, Equations (9) and (13) are the spinor wave equations of time-dependent and time-independent of photon in medium, which can be used to study the quantum property of photon in medium.

Substituting Equations (10) and (11) into (9), we have

$$i\hbar\frac{\partial}{\partial t}\begin{pmatrix}\psi_1\\ \psi_2\\ \psi_3\end{pmatrix}=-i\hbar c\begin{pmatrix}0 & -i\frac{\partial}{\partial z} & i\frac{\partial}{\partial y}\\ i\frac{\partial}{\partial z} & 0 & -i\frac{\partial}{\partial x}\\ -i\frac{\partial}{\partial y} & i\frac{\partial}{\partial x} & 0\end{pmatrix}\begin{pmatrix}\psi_1\\ \psi_2\\ \psi_3\end{pmatrix}+\begin{pmatrix}V & 0 & 0\\ 0 & V & 0\\ 0 & 0 & V\end{pmatrix}\begin{pmatrix}\psi_1\\ \psi_2\\ \psi_3\end{pmatrix}$$
$$=\hbar c\begin{pmatrix}\frac{\partial\psi_3}{\partial y}-\frac{\partial\psi_2}{\partial z}\\ \frac{\partial\psi_1}{\partial z}-\frac{\partial\psi_3}{\partial x}\\ \frac{\partial\psi_2}{\partial x}-\frac{\partial\psi_1}{\partial y}\end{pmatrix}+\begin{pmatrix}V & 0 & 0\\ 0 & V & 0\\ 0 & 0 & V\end{pmatrix}\begin{pmatrix}\psi_1\\ \psi_2\\ \psi_3\end{pmatrix}. \tag{14}$$

With Equation (14), we obtain

$$\hbar c\left(\frac{\partial\psi_3}{\partial y}-\frac{\partial\psi_2}{\partial z}\right)=i\hbar\frac{\partial}{\partial t}\psi_1-V\psi_1, \tag{15}$$

$$\hbar c\left(\frac{\partial\psi_1}{\partial z}-\frac{\partial\psi_3}{\partial x}\right)=i\hbar\frac{\partial}{\partial t}\psi_2-V\psi_2, \tag{16}$$

and

$$\hbar c\left(\frac{\partial\psi_2}{\partial x}-\frac{\partial\psi_1}{\partial y}\right)=i\hbar\frac{\partial}{\partial t}\psi_3-V\psi_3. \tag{17}$$

If we set $\boldsymbol{\Psi}=\psi_1\boldsymbol{i}+\psi_2\boldsymbol{j}+\psi_3\boldsymbol{k}$, the Equations (15)-(17) can be written as

$$i\hbar\frac{\partial}{\partial t}\boldsymbol{\psi}=c\hbar\nabla\times\boldsymbol{\psi}+V\boldsymbol{\psi}. \tag{18}$$

We can find the quantum vector wave Equation (5) and the quantum spinor wave Equation (9) are equivalent.

In Equation (7), if we set

$$\boldsymbol{\psi}=\frac{1}{\sqrt{2}}\left(\sqrt{\varepsilon_0}\boldsymbol{E}+i\frac{1}{\sqrt{\mu_0}}\boldsymbol{B}\right), \tag{19}$$

substituting Equation (19) into (7), we obtain

$$i\hbar\sqrt{\varepsilon_0}\frac{\partial}{\partial t}\boldsymbol{E}-\hbar\frac{1}{\sqrt{\mu_0}}\frac{\partial}{\partial t}\boldsymbol{B}=c\hbar\sqrt{\varepsilon_0}\nabla\times\boldsymbol{E}+ic\hbar\frac{1}{\sqrt{\mu_0}}\nabla\times\boldsymbol{B}, \tag{20}$$

comparing the real and imaginary parts of the both sides of Equation (20), we get

$$\nabla\times\boldsymbol{E}=-\frac{\partial\boldsymbol{B}}{\partial t}, \tag{21}$$

$$\nabla\times\boldsymbol{B}=\mu_0\varepsilon_0\frac{\partial\boldsymbol{E}}{\partial t}, \tag{22}$$

if we let $\nabla\cdot\boldsymbol{\psi}=0$, there is

$$\nabla\cdot\boldsymbol{E}=0, \tag{23}$$

$$\nabla \cdot \boldsymbol{B} = 0. \tag{24}$$

By the following quantum wave equation of photon and gauge condition

$$i\hbar \frac{\partial}{\partial t}\boldsymbol{\psi} = c\hbar \nabla \times \boldsymbol{\psi}, \tag{25}$$

$$\boldsymbol{\psi} = \frac{1}{\sqrt{2}}\left(\sqrt{\varepsilon_0}\boldsymbol{E} + i\frac{1}{\sqrt{\mu_0}}\boldsymbol{B}\right), \tag{26}$$

$$\nabla \cdot \boldsymbol{\psi} = 0. \tag{27}$$

We can obtain the Maxwell's wave Equations (1)-(4) in vacuum.

2) The Maxwell's equations in medium are

$$\nabla \times \boldsymbol{E} = -\frac{\partial \boldsymbol{B}}{\partial t} \tag{28}$$

$$\nabla \times \boldsymbol{B} = \mu\varepsilon \frac{\partial \boldsymbol{E}}{\partial t} \tag{29}$$

$$\nabla \cdot \boldsymbol{E} = 0 \tag{30}$$

$$\nabla \cdot \boldsymbol{B} = 0. \tag{31}$$

With Equations (5) and (6), we can obtain the quantum wave equation of photon in medium, it is

$$\begin{aligned} i\hbar \frac{\partial}{\partial t}\boldsymbol{\psi}(\bar{r},t) &= c\hbar \nabla \times \boldsymbol{\psi}(\bar{r},t) + V\boldsymbol{\psi}(\bar{r},t) \\ &= c\hbar \nabla \times \boldsymbol{\psi}(\bar{r},t) + \hbar\omega(1-n)\boldsymbol{\psi}(\bar{r},t). \end{aligned} \tag{32}$$

By the separation of variables

$$\boldsymbol{\psi}(\bar{r},t) = \boldsymbol{\psi}(\bar{r}) f(t), \tag{33}$$

substituting Equation (33) into (32), we have

$$c\nabla \times \boldsymbol{\psi}(\bar{r}) = n\omega \boldsymbol{\psi}(\bar{r}) \tag{34}$$

if we let

$$\boldsymbol{\psi} = \frac{1}{\sqrt{2}}\left(\sqrt{\varepsilon}\boldsymbol{E} + i\frac{1}{\sqrt{\mu}}\boldsymbol{B}\right), \tag{35}$$

with Equations (34) and (35), we get

$$\nabla \times \boldsymbol{E} = i\omega\mu \boldsymbol{H}, \tag{36}$$

$$\nabla \times \boldsymbol{H} = -i\omega\varepsilon \boldsymbol{E}, \tag{37}$$

by the gauge condition $\nabla \cdot \boldsymbol{\psi} = 0$, we have

$$\nabla \times \boldsymbol{E} = 0, \tag{38}$$

$$\nabla \times \boldsymbol{B} = 0. \tag{39}$$

Equations (36)-(39) are the Maxwell's wave equations for the monochromatic light in the medium.

By the following quantum wave equation of photon and gauge condition

$$c\nabla \times \boldsymbol{\psi}(\bar{r}) = n\omega \boldsymbol{\psi}(\bar{r}) \tag{40}$$

$$\boldsymbol{\psi}=\frac{1}{\sqrt{2}}\left(\sqrt{\varepsilon}\boldsymbol{E}+i\frac{1}{\sqrt{\mu}}\boldsymbol{B}\right), \tag{41}$$

$$\nabla\cdot\boldsymbol{\psi}=0. \tag{42}$$

We can obtain the Maxwell's Equations (36)-(39) in medium.

The probability density $\rho_{\gamma}(\boldsymbol{r})$ of photon in space $\boldsymbol{r}$ is

$$\rho_{\gamma}(\boldsymbol{r})=|\boldsymbol{\psi}(\boldsymbol{r})|^{2}=\frac{1}{2}\left(\varepsilon\boldsymbol{E}^{2}+\frac{1}{\mu}\boldsymbol{B}^{2}\right)=\varepsilon\boldsymbol{E}^{2}=\rho_{EB}(\boldsymbol{r}). \tag{43}$$

From Equation (43), we find the probability density $\rho_{\gamma}(\boldsymbol{r})$ of photon is equal to the energy density $\rho_{EB}(\boldsymbol{r})$ of the electromagnetic field of photon, we can obtain the following results:

1) For a lot of photons, the electromagnetic field energy density $\rho_{EB}(\boldsymbol{r})$ is in direct proportion to the photon numbers $N(\boldsymbol{r})$ and the single photon probability density $\rho_{\gamma}(\boldsymbol{r})$, it is

$$\rho_{EB}(\boldsymbol{r})\propto N(\boldsymbol{r})\propto\rho_{\gamma}(\boldsymbol{r}). \tag{44}$$

2) For a single photon, it is not a point particle, instead, it has a very small distribution area Ω of electromagnetic fields, the whole distribution area represents a photon.

We define a concept of partial photon, which is described by the occupancy $P_{\gamma}(\boldsymbol{r})$, it is

$$P_{\gamma}(\boldsymbol{r})=\frac{\varepsilon\boldsymbol{E}^{2}(\boldsymbol{r})}{\int_{\Omega}\varepsilon\boldsymbol{E}^{2}(\boldsymbol{r})\mathrm{d}^{3}\boldsymbol{r}}. \tag{45}$$

At space $\boldsymbol{r}$, the bigger the occupancy $P_{\gamma}(\boldsymbol{r})$, the bigger the photon component, there is

$$\int_{\Omega}P_{\gamma}(\boldsymbol{r})\mathrm{d}^{3}\boldsymbol{r}=1. \tag{46}$$

Since the photon itself is a very small distribution area of electromagnetic fields, the each point in the region represents the partial photon, the photon is not positioned. The wave-particle duality of photon can be understood as: The entire electromagnetic field distribution area of photon represents a photon, which manifests as the particle nature of photon. The electromagnetic field energy density distribution of photon manifests as the wave nature of photon. With the Equation (43), the probability density $|\psi(\boldsymbol{r})|^{2}$ of photon is equal to its electromagnetic fields energy density, it is

$$\rho_{\gamma}(\boldsymbol{r})=|\psi(\boldsymbol{r})|^{2}=\rho_{EB}(\boldsymbol{r})=\varepsilon_{0}\boldsymbol{E}^{2}(\boldsymbol{r}), \tag{47}$$

with Equations (45)-(47), we have

$$\psi(\boldsymbol{r})=\sqrt{\varepsilon_{0}}E(\boldsymbol{r})\mathrm{e}^{i\theta}. \tag{48}$$

where the θ is a phase factor. Photon is not a point particle, it exists in the distribution area of electromagnetic field, where the energy density of electromagnetic field is large, it means that the photon appears to be of great weight. So, the every point of the electromagnetic field distribution region, all are a part of the photon, such as the points $\boldsymbol{r}_A$ and $\boldsymbol{r}_B$ in electromagnetic field distribution region, they can be represented as part of photon. The photon can be expressed as the superposition of the every point of the electromagnetic field distribution region, that is, the photon can appear at both point $\boldsymbol{r}_A$ and point $\boldsymbol{r}_B$. If there is $P_\gamma(\boldsymbol{r}_A) > P_\gamma(\boldsymbol{r}_B)$, the probability of photon at point $\boldsymbol{r}_A$ is larger than point $\boldsymbol{r}_B$. When a photon shows the electric field distribution at the area Ω, the photon behaves as a wave. When the area Ω of photon shrinks to approximately a point, for example, in the interference and diffraction experiments of photon, the bright spots on the screen, which manifests as the particle nature of photon.

3. The Gravitational Field of Particle

1) The non-relativistic gravitational theory

The gravitational potential for a continuous mass distribution is

$$\Phi(\boldsymbol{x}) = -\int \frac{G\rho(\boldsymbol{x}')}{|\boldsymbol{x}-\boldsymbol{x}'|}\mathrm{d}^3\boldsymbol{x}', \tag{49}$$

where $\rho(\boldsymbol{x}')$ is the mass density. The Equation (49) satisfies the Poisson equation

$$\nabla^2\Phi(\boldsymbol{x}) = 4\pi G\rho(\boldsymbol{x}), \tag{50}$$

the self gravitational energy is

$$\begin{aligned} w_g &= \frac{1}{2}\int \rho(\boldsymbol{x})\Phi(\boldsymbol{x})\mathrm{d}^3\boldsymbol{x} \\ &= -\frac{1}{2}\int G\frac{\rho(\boldsymbol{x})\rho(\boldsymbol{x}')}{|\boldsymbol{x}-\boldsymbol{x}'|}\mathrm{d}^3\mathrm{x}\mathrm{d}^3\boldsymbol{x}' \\ &= \int \frac{1}{8\pi G}(\nabla\Phi(\boldsymbol{x}))^2\mathrm{d}^3\boldsymbol{x} + \int \rho(\boldsymbol{x})\Phi(\boldsymbol{x})\mathrm{d}^3\boldsymbol{x}, \end{aligned} \tag{51}$$

where

$$\rho_g = \frac{(\nabla\Phi(\boldsymbol{x}))^2}{8\pi G}, \tag{52}$$

is the energy density of gravitational field, and $\rho(\boldsymbol{x})\Phi(\boldsymbol{x})$ is the energy density of gravitational field interacts with matter.

2) The relativistic gravitational theory

In the presence of gravitational field, the dynamic problem of particle can be equivalently transformed into the geometric problem of Riemann space. That is, the motion profile of particle in the gravitational field is the geodesic line of Riemann space. Einstein not only geometrized the particle dynamics in the gravitational field, but also geometrized the gravitational field itself. That is, the metric field $g_{\mu\nu}$ of Riemann space represents the gravitational field. In this way, it is always controversial. The gravitational field, like electromagnetic field, is an objective material field, the geometrization of gravitational field is only an equivalent theory. The relationship between curved space-time metric $g_{\mu\nu}$, flat space-time metric $\eta_{\mu\nu}$ and gravitational field $h_{\mu\nu}$ is as follows

$$g_{\mu\nu} = \eta_{\mu\nu} + kh_{\mu\nu}. \tag{53}$$

From Equation (53), we can find if there is the gravitational field $h_{\mu\nu}$ then there is the curved space-time metric $g_{\mu\nu}$, if there is no the gravitational field, the space-time is flat, and the metric is $\eta_{\mu\nu}$. Therefore, it is the gravitational field causes the space-time bending, and cannot be considered gravitational field as the curved space-time, the gravitational field and curved space-time are causal relation. It is only an equivalent theoretical method to study gravitational field with the curved space-time.

The electromagnetic field is from electromagnetic current

$$J^{\mu} = (c\rho, \boldsymbol{J}), \tag{54}$$

where ρ is the electric density, $\boldsymbol{J}$ is the electric current density, the electromagnetic field vector $A^{\mu} = (\varphi, \boldsymbol{A})$ satisfy an equation

$$\Box A^{\mu} = -\mu_0 J^{\mu}, \tag{55}$$

and Lorentz condition

$$\partial_{\mu} A^{\mu} = 0. \tag{56}$$

The source of gravitational field is energy-momentum tensor $T^{\mu\nu}$, and the gravitational field tensor $h^{\mu\nu}$ equation is [16]

$$\Box\left(h^{\mu\nu} - \frac{1}{2}\eta^{\mu\nu} h\right) = -kT^{\mu\nu}, \tag{57}$$

and gauge condition is

$$\partial_{\mu}\left(h^{\mu\nu} - \frac{1}{2}\eta^{\mu\nu} h\right) = 0, \tag{58}$$

where k is a constant, $h = h_{\mu}^{\mu}$ is the trace of $h^{\mu\nu}$, and $\eta^{\mu\nu}$ is the metric of flat space-time.

Definition a new gravitational field

$$\phi^{\mu\nu} = h^{\mu\nu} - \frac{1}{2}\eta^{\mu\nu} h, \tag{59}$$

the Equations (57) and (58) can be written as

$$\Box\phi^{\mu\nu} = -kT^{\mu\nu}, \tag{60}$$

$$\partial_{\mu}\phi^{\mu\nu} = 0, \tag{61}$$

the energy-momentum tensor of field $\phi^{\mu\nu}$ is

$$t^{\mu\nu} = \frac{1}{4}\left[2\phi^{\alpha\beta,\mu}\phi_{\alpha\beta}^{,\nu} - \phi^{,\mu}\phi^{,\nu} - \eta^{\mu\nu}\left(\phi^{\alpha\beta,\sigma}\phi_{\alpha\beta}^{,\sigma} - \frac{1}{2}\phi_{,\sigma}\phi^{,\sigma}\right)\right], \tag{62}$$

where t^{00} is the energy density.

The Newton gravitational theory is the non-relativistic limit of relativistic gravitational theory, there are

$$\Phi = \frac{1}{2}kh_{00}, \tag{63}$$

$$\nabla^2 h_{00} = \frac{1}{2} k\rho, \tag{64}$$

with Equations (51) and (52), we can obtain the equation of the Newton gravitational field

$$\nabla^2 \Phi = 4\pi G\rho, \tag{65}$$

where $k = 4\sqrt{\pi G}$, and ρ is mass density. In the Newtonian approximation, the gravitational field energy density is

$$\rho_g = t^{00} = \frac{(\nabla\Phi)^2}{8\pi G}, \tag{66}$$

defining the strength of the gravitational field $\boldsymbol{E}_g$ as

$$\boldsymbol{E}_g = -\nabla\Phi, \tag{67}$$

the gravitational field energy density ρ_g becomes

$$\rho_g = \frac{\boldsymbol{E}_g^2}{8\pi G}, \tag{68}$$

the energy density of electromagnetic field is

$$\rho_{(EB)} = \varepsilon_0 \boldsymbol{E}^2. \tag{69}$$

From Equations (68) and (69), we find the gravitational field energy density is in direct proportion to the square of the gravitational field strength $\boldsymbol{E}_g$, and the electromagnetic field energy density is in direct proportion to the square of the electric field strength $\boldsymbol{E}$.

All material particles ($m_0 \neq 0$), such as electron, proton and neutron cannot be regarded as point particles, they have a tiny energy distribution area of electric field and gravitational field. For the electron and proton, because they have both charge and mass, they have both electric field distribution and gravitational field distribution. For the neutron, because it has only mass and has not charge, the neutron has only the gravitational field distribution.

We define a concept of partial neutron, which is described by the occupancy $P_g(\boldsymbol{r})$, it is

$$P_g(\boldsymbol{r}) = \frac{t^{00}}{\int_V t^{00} \mathrm{d}^3\boldsymbol{r}} = \frac{\boldsymbol{E}_g^2(\boldsymbol{r})}{\int_V \boldsymbol{E}_g^2(\boldsymbol{r}) \mathrm{d}^3\boldsymbol{r}}. \tag{70}$$

At space $\boldsymbol{r}$, the bigger the occupancy $P_g(\boldsymbol{r})$, the bigger the neutron component, *i.e.*, the bigger the probability of neutron in space $\boldsymbol{r}$. At the whole gravitational field distribution area V of the neutron, there is

$$\int_V P_g(\boldsymbol{r}) \mathrm{d}^3\boldsymbol{r} = 1. \tag{71}$$

where the volume $V \to \infty$, but the gravitational field of neutron can be divided into two areas, one area is the spherical area that the radius is about 50λ (when the slit width is about 100λ, the diffraction effect is not obvious), which is called interior zone, the gravitational field energy of neutron is largely concentrated in this area, the other one is the outer region. Where $\lambda = \frac{h}{p}$ is the de

Broglie wavelength. For the high energy neutron, its interior zone become small, it is particle-like. For the low energy neutron, its interior zone become large, it is wave-like.

4. The Quantum Wave Equation

In 1923, DE Broglie had extended the wave-particle duality of photon to material particles [2], like electrons, protons and so on. Later, he had perfected the theory of matter waves [3], and by analogy Fermat and Morperto principle, he believed the relation between the new wave theory and classical mechanics is similar to the relationship between wave optics and geometric optics, this analogy inspired Schrodinger when he founded wave mechanics. In the following, we should give the quantum wave equation of particle with the analogy method.

1) The time-independent wave equation of particle

The particle nature of photon is described by the Fermat principle, it is

$$\delta\int n\mathrm{d}s = 0, \tag{72}$$

the motion of material particles is described by Morperto principle, it is

$$\delta\int\sqrt{2m(E-V)}\,\mathrm{d}s = 0, \tag{73}$$

the time-independent photon wave equation is

$$\nabla^2\boldsymbol{E} + \frac{\omega^2 n^2}{c^2}\boldsymbol{E} = 0, \tag{74}$$

where $\boldsymbol{E}$ is electric field intensity of photon, ω is photon frequency, n is refractive index of medium and c is velocity of light.

Comparing Equations (72) and (73), we find

$$n \propto \sqrt{2m(E-V)}. \tag{75}$$

With Equations (74) and (75), the material particle wave equation can be written as

$$\nabla^2\boldsymbol{E}_g + A\cdot 2m(E-V)\boldsymbol{E}_g = 0, \tag{76}$$

the Equation (74) is about the equation of photon electric field, the analogy Equation (76) should be the field equation of material particles. For a neutral particle, the $\boldsymbol{E}_g$ is the gravitational field intensity of the neutral particle. For a charge particle, the field should be considered the electric field of the charge particle, except its gravitational field.

For the free particle, the potential energy $V = 0$, the Equation (76) has a plane wave solution, it is

$$\boldsymbol{E}_g(\boldsymbol{r}) = \boldsymbol{E}_{g0}\mathrm{e}^{i(\boldsymbol{k}\cdot\boldsymbol{r}-\omega t)}, \tag{77}$$

with Equations (76) and (77), there is there is

$$-k^2 + A\cdot 2mE = 0, \tag{78}$$

where $E = \frac{p^2}{2m}$, and the De Broglie's formula

$$k = \frac{p}{\hbar}, \tag{79}$$

with Equations (78) and (79), we get

$$A = \frac{1}{\hbar^2}, \tag{80}$$

substituting Equation (80) into (76), we obtain

$$\left[-\frac{\hbar^2}{2m}\nabla^2 + V(r)\right]\boldsymbol{E}_g(\boldsymbol{r}) = E\boldsymbol{E}_g(\boldsymbol{r}), \tag{81}$$

the scalar form of Equation (81) is

$$\left[-\frac{\hbar^2}{2m}\nabla^2 + V(r)\right]E_g(\boldsymbol{r}) = EE_g(\boldsymbol{r}). \tag{82}$$

The Equations (81) and (82) are the time-independent quantum gravitational field equations of particle. For the charge particle, such as electron and proton and so on, in addition to the gravitational field, there is electric field distribution $\boldsymbol{E}(\boldsymbol{r})$, which satisfies Equations (81) and (82), they are

$$\left[-\frac{\hbar^2}{2m}\nabla^2 + V(r)\right]\boldsymbol{E}(\boldsymbol{r}) = E\boldsymbol{E}(\boldsymbol{r}), \tag{83}$$

the scalar form of Equation (83) is

$$\left[-\frac{\hbar^2}{2m}\nabla^2 + V(r)\right]E(\boldsymbol{r}) = EE(\boldsymbol{r}). \tag{84}$$

We know the probability density $\rho_\gamma(\boldsymbol{r})\left(|\psi(\boldsymbol{r})|^2\right)$ of photon is equal to its electromagnetic fields energy density (Equation (47)), the probability density $\rho(\boldsymbol{r})$ of neutral particle in space $\boldsymbol{r}$ is proportional to the gravitational field energy density $\rho_g\left(t^{00}(\boldsymbol{r})\right)$. In Equation (66), the energy density ρ_g of gravitational field is in direct proportion to $\boldsymbol{E}_g^2$. We can define spatial probability amplitude distribution function $\psi(\boldsymbol{r})$ of particle, it satisfies

$$\rho(\boldsymbol{r}) = |\psi(\boldsymbol{r})|^2 \propto \rho_g = \frac{E_g^2(\boldsymbol{r})}{8\pi G}\mathrm{e}^{i\theta}, \tag{85}$$

then we have

$$\psi(\boldsymbol{r}) \propto \frac{E_g(\boldsymbol{r})}{\sqrt{8\pi G}}\mathrm{e}^{i\theta}, \tag{86}$$

where the θ is a phase factor, the $E_g(\boldsymbol{r})$ is the gravitational field intensity of particle. The Equation (82) becomes

$$\left[-\frac{\hbar^2}{2m}\nabla^2 + V(r)\right]\psi(\boldsymbol{r}) = E\psi(\boldsymbol{r}). \tag{87}$$

The position distribution function $\psi(\boldsymbol{r})$ is the wave function of quantum mechanics, the Equation (87) is the time-independent Schrodinger equation, which is from the gravitational field Equation (82).

For a electron, it has both the gravitational field distribution $E_g(\boldsymbol{r})$ and electric field distribution $\psi(\boldsymbol{r})$, because electron has very little mass, its gravitational field can be neglected, and its electric field is the primary. The electric field energy density of electron is

$$\rho(\boldsymbol{r}) = \varepsilon_0 E^2(\boldsymbol{r}), \tag{88}$$

similarly, we can define spatial probability amplitude distribution function $\psi(\boldsymbol{r})$ of electron, it satisfies

$$\rho(\boldsymbol{r}) = |\psi(\boldsymbol{r})|^2 \propto \rho(\boldsymbol{r}) = \varepsilon_0 E^2(\boldsymbol{r}), \tag{89}$$

there is

$$\psi(\boldsymbol{r}) \propto \sqrt{\varepsilon_0} E(\boldsymbol{r}), \tag{90}$$

with the Equation (90), the electric field Equation (84) of electron becomes the Schrodinger Equation (87).

2) The time-dependent field equation of particle

The time-dependent photon wave equation is

$$\nabla^2 \boldsymbol{E} - \frac{n^2}{c^2}\frac{\partial^2}{\partial t^2}\boldsymbol{E} = 0, \tag{91}$$

substituting Equation (75) into (91), we can obtain the time-dependent gravitational field equation of particle, it is

$$\nabla^2 \boldsymbol{E}_g - B \cdot 2m(E - V)\frac{\partial^2}{\partial t^2}\boldsymbol{E}_g = 0. \tag{92}$$

For the free particle, the potential energy $V = 0$, the Equation (88) has a plane wave solution, it is

$$\boldsymbol{E}_g = \boldsymbol{E}_{g0} \mathrm{e}^{i(\boldsymbol{p}\cdot\boldsymbol{r} - Et)/\hbar}, \tag{93}$$

with Equations (92) and (93), there is

$$B = \frac{1}{E^2}, \tag{94}$$

the Equation (92) becomes

$$\nabla^2 \boldsymbol{E}_g - \frac{1}{E^2} \cdot 2m(E - V)\frac{\partial^2}{\partial t^2}\boldsymbol{E}_g = 0. \tag{95}$$

By separation of variable

$$\boldsymbol{E}_g(\boldsymbol{r}, t) = \boldsymbol{E}_g(\boldsymbol{r}) f(t), \tag{96}$$

substituting Equation (96) into (95), there are

$$\nabla^2 \boldsymbol{E}_g(\boldsymbol{r}) - D \cdot 2m(E - V)\boldsymbol{E}_g(\boldsymbol{r}) = 0, \tag{97}$$

$$f''(t) - D \cdot E^2 f(t) = 0. \tag{98}$$

comparing Equation (81) with (97), we have

$$D = -\frac{1}{\hbar^2}, \tag{99}$$

$$f(t) = e^{-\frac{i}{\hbar}Et}, \tag{100}$$

and

$$\boldsymbol{E}_g(\boldsymbol{r},t) = \boldsymbol{E}_g(\boldsymbol{r}) e^{-\frac{i}{\hbar}Et}, \tag{101}$$

taking the derivative of both sides of the Equation (101), we get

$$i\hbar \frac{\partial}{\partial t} \boldsymbol{E}_g(\boldsymbol{r},t) = \left[-\frac{\hbar^2}{2m}\nabla^2 + V(r)\right] \boldsymbol{E}_g(\boldsymbol{r},t), \tag{102}$$

the scalar form of Equation (102) is

$$i\hbar \frac{\partial}{\partial t} E_g(\boldsymbol{r},t) = \left[-\frac{\hbar^2}{2m}\nabla^2 + V(r)\right] E_g(\boldsymbol{r},t). \tag{103}$$

The Equations (102) and (103) are the time-dependent quantum gravitational field equations of a particle, and the $E_g(\boldsymbol{r},t)$ is the gravitational field intensity distributions of the particle.

By the Equation (86), there is

$$\psi(\boldsymbol{r},t) \propto E_g(\boldsymbol{r},t), \tag{104}$$

then the Equation (103) becomes

$$i\hbar \frac{\partial}{\partial t} \psi(\boldsymbol{r},t) = \left[-\frac{\hbar^2}{2m}\nabla^2 + V(r)\right] \psi(\boldsymbol{r},t). \tag{105}$$

The Equation (105) is the time-dependent Schrodinger quantum wave equation, which is turned gravitational field equation into the Schrodinger equation.

For a charge particle, its electric field $\boldsymbol{E}(\boldsymbol{r})$ and gravitational field $\boldsymbol{E}_g(\boldsymbol{r})$ satisfy the same Equation (92). Repeating the same derivation as above, we can obtain the time-dependent quantum electric field equation of the charge particle, it is

$$i\hbar \frac{\partial}{\partial t} E(\boldsymbol{r},t) = \left[-\frac{\hbar^2}{2m}\nabla^2 + V(r)\right] E(\boldsymbol{r},t). \tag{106}$$

With Equations (90) and (106), we can obtain the time-dependent Schrodinger quantum wave Equation (105), which is turned electric field Equation (106) into the Schrodinger Equation (105).

In the above, we can find the Schrodinger equation comes from the gravitational field equation or electric field equation of particle by the relation of Equations (90) and (104). The gravitational field intensity $\boldsymbol{E}_g(\boldsymbol{r},t)$ and electric field intensity $\boldsymbol{E}(\boldsymbol{r},t)$ are the hidden variable of quantum theory, they are the objective and measurable physical quantity. In quantum theory, why we introduce the probability? It is because microscopic particle is not point particle, it have the gravitational field or electric field distribution. In space $\boldsymbol{r}$, the energy density of the gravitational field or electric field determine the probability of particle in space $\boldsymbol{r}$. We study the quantum properties of hydrogen atom with the Schrodinger equation, we can give its energy level and wave function. For an electron, it has both charge and mass, but the mass is very small, we can only consider the electric field of the electron, and neglect its gravitational field. The wave function of electron $\psi(\boldsymbol{r},t)$ is in direct proportion to its electric field distribution in the interior zone of electron (about 100λ). The so-called volatility of electron in hydrogen atom is from the electric field distribution of electron in hydrogen atom.

5. The Interference and Diffraction of Single Photon and Electron

In the interference and diffraction experiment, when a beam of light pass the single and double slit, it should form the interference and diffraction stripe immediately. Only one photon passes through the single or double slit at a time, only one highlight is displayed on the display. Making a long time observation, the interference and diffraction stripe can be obtained on the display. The previous experiment can be explained by the electromagnetic theory and Huygens-Fresnel principle, *i.e.*, the electromagnetic wave total amplitude on the display point p is obtained by infinitesimal of slit emit secondary waves superposition at this point, this theory explains the experimental results well. The previous experiment result is from the continuous electromagnetic wave superposition. Obviously, the latter experiment is from the interference and diffraction of a single photon itself. How can a single photon form its own interference? In order to solve this problem, we propose a single photon model. A single photon has volume V, and has the vibration electric field and magnetic field in the volume V. they are

$$E = E_0 \cos \omega t, \tag{107}$$

and

$$B = B_0 \cos \omega t. \tag{108}$$

The single photon model is reasonable, we know a beam of light is made of a lot of photons, and the beam of light corresponds to a plane electromagnetic wave, naturally, the single photon has the vibration electric field and magnetic field in its volume V. When the free photon moves to $\boldsymbol{r}$, its electric field and magnetic field intensity become

$$E = E_0 \cos \omega\left(t + \frac{r}{c}\right), \quad B = B_0 \cos \omega\left(t + \frac{r}{c}\right), \tag{109}$$

where $r = |\boldsymbol{r}|$. **Figure 1** is diffraction pattern of single photon passing through a single slit. The width of single slit is b. In the diffraction angle $\theta = 0$ direction, the total amplitude of electric field intensity on the single slit is E_0, then the amplitude of electric field intensity on narrow slit of width $\mathrm{d}x$ is $\frac{E_0 \mathrm{d}x}{b}$, and its vibration electric field intensity is

$$\mathrm{d}E = \frac{E_0 \mathrm{d}x}{b} \cos \omega t. \tag{110}$$

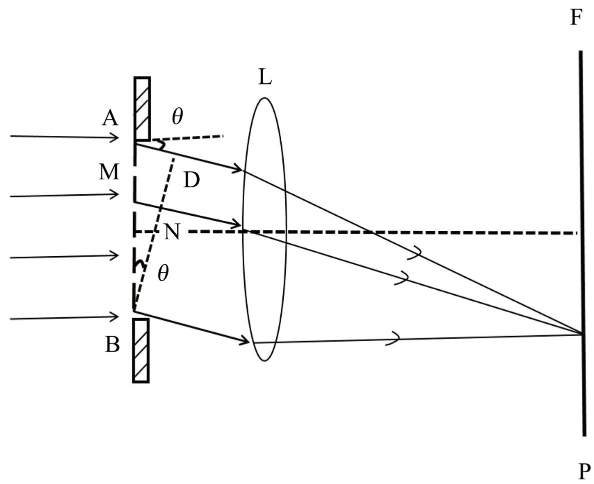

Figure 1. The single slit diffraction figure of single particle.

In the following, we shall give the single photon vibration electric field intensity, which passes through the single slit and travels in *MN* direction, and the diffraction angle $\theta \neq 0$. The electric field intensity vibration phase of the incident photon on the slit *AB* are all the same, when the photon spread to point *p* along the direction of θ angle, because of the interaction between photon and slit, the volume of photon should be deformed, the electric field intensity vibration phase of the deformed photon are different at every point of volume V_γ.

Let $BM = x$, then $MN = x\sin\theta$, the vibration electric field intensity of photon at point *N* is

$$\mathrm{d}E = \frac{E_0 \mathrm{d}x}{b}\cos\left(\omega t + kx\sin\theta\right), \tag{111}$$

the complex form of Equation (111) is

$$\mathrm{d}E = \frac{E_0 \mathrm{d}x}{b}\mathrm{e}^{i(\omega t + kx\sin\theta)}, \tag{112}$$

where wave vector $k = \frac{2\pi}{\lambda}$, when the photon pass through *BD*, the volume deformation of photon is over. The optical path Δ of the every point on the plane *BD* to the point *p* are all the same, then the vibration electric field intensity of photon from point *M* to point *p* is

$$\mathrm{d}E = \frac{E_0 \mathrm{d}x}{b}\cos\left(\omega t + k\left(x\sin\theta + \Delta\right)\right), \tag{113}$$

the complex form is

$$\mathrm{d}E = \frac{E_0 \mathrm{d}x}{b}\mathrm{e}^{ikx\sin\theta}\cdot\mathrm{e}^{ik\Delta}\cdot\mathrm{e}^{i\omega t}. \tag{114}$$

When the photon passes through the lens *L* and arrives at the point *p* on the screen *F*, which is situate in the focal plane of the lens *L*, the vibration electric field of photon should be superimposed, it is the integration of Equation (114) from $x = 0$ to $x = b$

$$E = \int \mathrm{d}E = \frac{E_0 \mathrm{d}x}{b} \mathrm{e}^{ik\Delta} \cdot \mathrm{e}^{i\omega t} \int_0^b \mathrm{e}^{ikx\sin\theta} \mathrm{d}x = E_0 \frac{\sin\left(\frac{\pi b \sin\theta}{\lambda}\right)}{\frac{\pi b \sin\theta}{\lambda}} \cdot \mathrm{e}^{ik\Delta} \cdot \mathrm{e}^{i\left(\frac{\pi b \sin\theta}{\lambda} + \omega t\right)}, \tag{115}$$

the intensity of single photon at point p is in direct proportion to the norm of the total vibration electric field E, it is

$$I \propto \left| E_0 \frac{\sin\left(\frac{\pi b \sin\theta}{\lambda}\right)}{\frac{\pi b \sin\theta}{\lambda}} \right|^2. \tag{116}$$

We can find the diffraction intensity of single photon and a beam of light are the same, but the physics significance is different. For the beam of light, the Equation (116) gives out the diffraction intensity distribution of difference point on-screen at the same time. For the single photon, the Equation (116) can only gives the diffraction intensity at a certain point and at a certain time, over a long period of time, it can obtain the same diffraction intensity distribution as a beam of light. At point p, if the superposition electric field of photon is enhanced, the photon volume reduces, the electric field energy density of photon increases, it appears as a point-like particle, and show a bright spot at this point. From a quantum mechanical point of view, when a bright spot appears at point p, the probability of photon is more larger at this point, since the probability of photon is in direct proportion to its electric field energy density. So, we can see single localized clicks at point p. At point p, if the superposition electric field of photon decreases or disappears, it shall show a dark spot at this point, and the photon becomes dark photon (the photon with no electric or magnetic fields).

Figure 2 is the two-slit interference of single photon, the single photon with volume V_γ passes through two-slit at the same time. At every slit, the vibration electric field of photon should be superimposed, and then the electric field of two-slit should be superimposed again. Combining with the single slit diffraction, when the single photon passes through the two-slit, at point p on the screen F (situated in the focal plane of the lens L), the global vibration electric field is

$$E = \frac{E_0}{b} \mathrm{e}^{i\omega t} \left[\int_0^b \mathrm{e}^{i\frac{2\pi}{\lambda} x \sin\theta} \mathrm{d}x + \int_d^{d+b} \mathrm{e}^{i\frac{2\pi}{\lambda} x \sin\theta} \mathrm{d}x \right] = E_0 \frac{\sin\left(\frac{\pi b \sin\theta}{\lambda}\right)}{\frac{\pi b \sin\theta}{\lambda}} \cdot \frac{\sin 2\left(\frac{\pi d \sin\theta}{\lambda}\right)}{\sin\left(\frac{\pi d \sin\theta}{\lambda}\right)} \cdot \mathrm{e}^{i\left(\frac{\pi(b+d)}{\lambda} \sin\theta + \omega t\right)}, \tag{117}$$

the two-slit interference intensity of single photon at point p is in direct proportion to the norm of the total vibration electric field E, it is

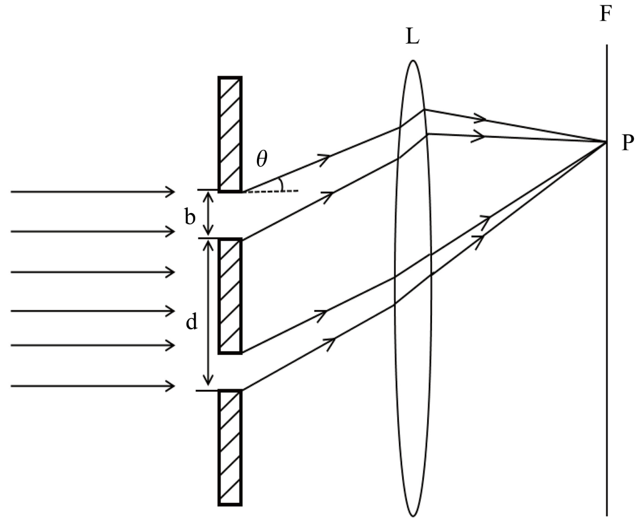

Figure 2. The two-slit interference figure of single particle.

$$I \propto \left| E_0 \frac{\sin\left(\frac{\pi b \sin\theta}{\lambda}\right)}{\frac{\pi b \sin\theta}{\lambda}} \cdot \frac{\sin 2\left(\frac{\pi d \sin\theta}{\lambda}\right)}{\sin\left(\frac{\pi d \sin\theta}{\lambda}\right)} \right|^2 . \tag{118}$$

We can find the interference intensity of two-slit for single photon and a beam of light are the same, but the physics significance is different. For the beam of light, the Equation (118) gives out the interference intensity distribution of difference point on screen at the same time. For the single photon, the Equation (118) can only gives the interference intensity at a certain point and at a certain time. On the screen F, Only one bright spot can be displayed at a time, we can see single localized clicks at point p. Over a long period of time, it can obtain the same interference fringe distribution as a beam of light.

For the material particles, like electrons, protons, neutrons, and so on, the single material particle can form the interference and diffraction over a long period of time. In order to solve this phenomena, we propose the material particles model, the single material particle has volume V, and has the vibration physical quantity of periodic alteration. For the charge particles, such as electron and proton, there are both the vibration gravitational field and electric field in the volume V, they are

$$\boldsymbol{G} = \boldsymbol{G}_0 \cos\omega t, \tag{119}$$

$$\boldsymbol{E} = \boldsymbol{E}_0 \cos\omega t. \tag{120}$$

For the neutral particle, such as neutron, there is only the vibration gravitational field. Because electron has very little mass, its gravitational field can be neglected, and the electric field is the primary. The proton has larger mass, its gravitational field cannot be neglected. It is similar to the interference and diffraction of single photon, when the single electron passes through the single slit or two-slit, the diffraction and interference intensity intensity are

$$I \propto \left| \boldsymbol{E}_0 \frac{\sin\left(\frac{\pi b \sin\theta}{\lambda}\right)}{\frac{\pi b \sin\theta}{\lambda}} \right|^2, \tag{121}$$

and

$$I \propto \left| \boldsymbol{E}_0 \frac{\sin\left(\frac{\pi b \sin\theta}{\lambda}\right)}{\frac{\pi b \sin\theta}{\lambda}} \cdot \frac{\sin 2\left(\frac{\pi d \sin\theta}{\lambda}\right)}{\sin\left(\frac{\pi d \sin\theta}{\lambda}\right)} \right|^2. \tag{122}$$

the Equations (121) and (122) can only give the diffraction and interference intensity of single electron at a certain point p and at a certain time. On the screen, Only one bright spot can be displayed at a time, we can see single localized clicks at point p. Over a long period of time, it can obtain the same diffraction and interference fringe distribution as a beam of electron.

For the single neutron passes through the single slit or two-slit, the diffraction and interference intensity intensity are

$$I \propto \left| \boldsymbol{G}_0 \frac{\sin\left(\frac{\pi b \sin\theta}{\lambda}\right)}{\frac{\pi b \sin\theta}{\lambda}} \right|^2, \tag{123}$$

and

$$I \propto \left| \boldsymbol{G}_0 \frac{\sin\left(\frac{\pi b \sin\theta}{\lambda}\right)}{\frac{\pi b \sin\theta}{\lambda}} \cdot \frac{\sin 2\left(\frac{\pi d \sin\theta}{\lambda}\right)}{\sin\left(\frac{\pi d \sin\theta}{\lambda}\right)} \right|^2. \tag{124}$$

For the single proton passes through the single slit or two-slit, the diffraction and interference intensity intensity are

$$I \propto \left| \boldsymbol{E}_0 \frac{\sin\left(\frac{\pi b \sin\theta}{\lambda}\right)}{\frac{\pi b \sin\theta}{\lambda}} \right|^2 + \left| \boldsymbol{G}_0 \frac{\sin\left(\frac{\pi b \sin\theta}{\lambda}\right)}{\frac{\pi b \sin\theta}{\lambda}} \right|^2, \tag{125}$$

and

$$I \propto \left| \boldsymbol{E}_0 \frac{\sin\left(\frac{\pi b \sin\theta}{\lambda}\right)}{\frac{\pi b \sin\theta}{\lambda}} \cdot \frac{\sin 2\left(\frac{\pi d \sin\theta}{\lambda}\right)}{\sin\left(\frac{\pi d \sin\theta}{\lambda}\right)} \right|^2 + \left| \boldsymbol{G}_0 \frac{\sin\left(\frac{\pi b \sin\theta}{\lambda}\right)}{\frac{\pi b \sin\theta}{\lambda}} \cdot \frac{\sin 2\left(\frac{\pi d \sin\theta}{\lambda}\right)}{\sin\left(\frac{\pi d \sin\theta}{\lambda}\right)} \right|^2. \tag{126}$$

where $\lambda = \frac{h}{p}$ is the de Broglie wavelength of material particle. With the Equations (121)-(126), we can obtain the diffraction and interference intensity distribution of single slit and two-slit for the electron, proton, neutron, atomic molecule and so on. The diffraction of X ray, electron and neutron in crystal are from self field interference, which are the same as the slit diffraction. Through the above analysis and research, we obtain the following results: 1) For a free photon, it is not a point particle, it exists in a very small volume, and the photon has a vibration electric field in the very small volume the Equation (106). 2) When a photon passes through the slits, its own electric field are superimposed on each other, if the own vibration electric field superposition enhance, a bright spot shall appear on the screen, the bright spot manifested as the particle nature of photon. 3) The vibration electric fields of photon have the superposition, it manifested as the wave nature of photon. 4) For a free neutral material particle ($m_0 \neq 0$), such as neutron, it has a vibration gravitational field in the very small volume (the Equation (118)). 5) When a neutron passes through the slits, its own vibration gravitational field are superimposed on each other, if the own gravitational field superposition enhance, a bright spot shall appear on the screen, the bright spot manifested as the particle nature of neutron. 6) The vibration gravitational field of neutron have the superposition, it manifested as the wave nature of neutron. 7) For a free charge material particles, such as electron and proton, they have both vibration gravitational field and vibration electric field in the very small volume (the Equations (118) and (119)). 8) When a proton passes through the slits, its own gravitational gravitational field and electric field are superimposed on each other respectively, if the own gravitational field and electric field superposition enhance, a bright spot shall appear on the screen. The bright spot manifested as the particle nature of proton. 9) The vibration gravitational field and electric field of proton have the superposition, it manifested as the wave nature of proton. 10) For a free electron, because it has a very small mass, its vibration electric field is primary, and vibration gravitational field can be neglected. The electric field of free electron is the vibration electric field, its wave property or the particle property is determined by the external measurement condition. 11) For a non-free electron, such as the electron in hydrogen atom, it is described by the wave function $\boldsymbol{\psi}(\boldsymbol{r},t)$, the electron has only the volatility in hydrogen atom, and the electron volatility is from the electric field distribution of electron. 12) In quantum theory, we have introduced the probability concept, the reason is microscopic particle is not point particle, it have the gravitational field or electric field distribution, their energy density distribution of the gravitational field or electric field determines the probability of particle in space. 13) In hydrogen atom, the electric wave function $\boldsymbol{\psi}(\boldsymbol{r},t)$ is in direct proportion to its electric field distribution, *i.e.*, $E(\boldsymbol{r},t) \propto \psi(\boldsymbol{r},t)$, the probability of electron in space is in direct proportion to the occupancy, *i.e.*, $|\psi(\boldsymbol{r},t)|^2 \propto P(\boldsymbol{r}) \propto |\boldsymbol{E}(\boldsymbol{r},t)|^2$. 14) The electric field distribution of electron determines its probability distribution. Similarly, the gravitational field distribution of neutron determines the probability distribution of neutron in space. The material fields of gravitational field and electric field are the hidden fields in quantum theory, they satisfy the Equations (103) and (106), the hidden fields decide the wave function or probability distribution of particle in space. 15) For all microscopic particles, when they confined to very small areas, the internal vibration fields take dominant role, which manifested as the wave property. When the microscopic particles are in a larger area, their external field take dominant role, which manifested as the particle property, such as an electron moves in an electromagnetic field. 16) For all microscopic particles, they all come from the field distribution, the particle mass is from itself gravitational field distribution, and the particle charge is from itself electric field distribution, which can unify both the volatility and particle nature and field and particle. 17) For a macroscopic object, its gravitational field distribution is mainly concentrated on the areas of the object volume, which is called internal gravitational field areas, and the surrounding gravitational field is called external gravitational field areas. The total energy of internal gravitational field is far outweigh the external gravitational field, when the external gravitational field distribution are changed, it has a little influence on its motion state, but if we apply external force to a macroscopic object, the internal gravitational field distribution shall change, the motion state of the macroscopic object should be changed, and it follows the Newton's law.

6. Conclusion

In the paper, we have given the quantum equation of the gravitational field intensity $E_g(\boldsymbol{r},t)$ and electric field intensity $E(\boldsymbol{r},t)$ for the material particles, since the gravitational field intensity $E_g(\boldsymbol{r},t)$ and electric field intensity $E(\boldsymbol{r},t)$ is in direct proportion to the distribution function $\psi(\boldsymbol{r},t)$ of particle spatial position (wave function), these quantum equations are natural converted into the Schrodinger equation. In addition, we have proposed the new model about the photon and matter particles. For all particles, they are not point particles, but they have a very small volume. The photon has a vibration electric field in its very small volume. The neutral material particle, such as neutron, it has a vibration gravitational field in its very small volume. For the charge material particles, such as electron and proton, they have both vibration gravitational field and vibration electric field in their very small volume. With the model, we can explain the diffraction and interference of single slit and multiple-slit for the single photon and material particles, the volatility of all particles come from the superposition of their respective vibration field. After the vibration field of particle superposition, it shows up as a particle property. On this basis, we have obtained some new results, and realized the unification of both wave and particle and field and matter.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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