Interpret Quantum Mechanics by uncertain complex waves

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Abstract

This paper suggests a quantum reality which is uncertain complex waves. These waves are described completely by a system axiom. This system axiom solves the measurement problem elegantly. From the uncertain complex waves, I revalue the classical picture.

I. Introduction

Quantum mechanics has a long history and it has been used to explain many experiment results. Quantum mechanics passed through countless testing experiment [1][2], even the most rigorous experiment [3]. However, the controversy of the foundation of quantum mechanics has been never stopped [1][2]. The most outstanding debate is how the wave function collapse happen does [4][5]? What properties are observable in a particular experiment [6]? What is a quantum reality [7]? Many works were done to answer these questions [8]. However, no approach is agreed widely because each has own difficulty [8].

If axioms about the operator in orthodox quantum mechanics are removed then the Schrodinger equation can indicate the observable properties. So in this paper, I suggest a modification of the orthodox quantum mechanics. Axioms about operators are removed. The observable properties are indicated to operators which their eigenvalues appear in solution of the Schrodinger equation.

On the other hand, if we know a general rule about possible states before and after measurement then we can understand the wave function collapse. So I propose an axiom about the possible states. This suggestion shows that discrete potential energy makes the change of state uncertain and suddenly. The wave function collapse is a simple consequence of this process.

From suggested modification, the quantum reality is regarded as uncertain complex wave. The quantum reality is counterintuitive but it can drive the classical picture by averaging of the uncertain complex wave. On other words, the classical reality isn't regarded as real reality.

II. Theory and discussion

1. The uncertain complex waves

We know that the world is composed of micro-particles. So I believe that it exits a quantum reality of micro-particles. N. Bohr considered the quantum reality is counterintuitively [9]. I suggest a viewpoint that the quantum reality is an uncertain complex wave. In this paper, I give a system axiom to describe completely these waves. The system axiom of the orthodox quantum mechanics is stated by E. G. Harris and it is showed in [10]. It is modified to become a new system axiom for uncertain complex waves. The new system axiom includes two axioms from Harris's statement. Axioms about operators are removed. The axiom about vector in Hilbert space is modified to become new form. I proposed an axiom about possible states. It can be used for observed system as well as any other case. The first axiom in the suggested system axiom is:

Quantum system is described by a set of vector which is in Hilbert space. They are called state vectors or wave functions of system. The vector ψ and $\lambda.\psi$ (λ is a complex number) describe the same state. In general, ψ is normalized to the unit.

In the Hilbert space, we can define operators. Example, operators coordinate: $\hat{x}$=x; $\hat{y} = y$; $\hat{z} = z$. Operators momentum: $p_x = -i.\hbar.\frac{d}{dx}$; $p_y = -i.\hbar.\frac{d}{dy}$; $p_z = -i.\hbar.\frac{d}{dz}$. Operator Hamilton of single particle system: $H = \frac{{p_x}^2+{p_y}^2+{p_z}^2}{2.m} + V(x,y,z,t)$. The quantity $V(x,y,z,t)$ is operator potential energy. It is a function of coordinate and time. m is mass of the particle. Relativity Hamiltonian has form: $H = \alpha_x.p_x + \alpha_y.p_y + \alpha_z.p_z + \beta.m.c^2$. Here $\alpha_x = \begin{pmatrix} 0 & \sigma_x \\ -\sigma_x & 0 \end{pmatrix}$, $\alpha_y = \begin{pmatrix} 0 & \sigma_y \\ -\sigma_y & 0 \end{pmatrix}$, $\alpha_z = \begin{pmatrix} 0 & \sigma_z \\ -\sigma_z & 0 \end{pmatrix}$, $\beta = \begin{pmatrix} I_2 & 0 \\ 0 & -I_2 \end{pmatrix}$; σ_x, σ_y, σ_z are Pauli matrices. I_2 is unit matrix $\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$. The second axiom in E. G. Harris's statement is*:*

Wave functions of system satisfy the Schrodinger equation: $i.\hbar.\frac{d}{dt}\psi = H\psi$

The wave functions also satisfy conditions which belong to two types. The first is initial condition and boundary conditions which are Dirichlet and Neumann conditions. The first is called tight conditions. The second type includes single-valued and continuous conditions. They are called open conditions. Wave function which satisfies tight conditions exists only. It is called tight solution, tight wave function or tight state vector. Wave functions which satisfy the open conditions are called open solutions, open wave functions or open state vectors.

If the potential energy is discontinuous then the Schrodinger equation must be investigated in many space domains. We divide space into the as large as possible domains D_i (i=1,2,..) in which the potential energy is continuous in each domain. These domains are called continuous domains of the system. The Schrodinger equation has one the largest symmetry group G_i in each domain D_i. It is called basic group of the system in D_i. Open solutions of the Schrodinger equation in D_i is a set U_i which is a linear space. T_{in} (i=1,2,..;n=1,2,..) is an irreducible representation of G_i in U_i. U_{in} is a subspace which is invariant with T_{in}. Space U_{in} is called irreducible space of G_i. The axiom about the possible states is suggested by following:

Possible states of system in a continuous domain D_i are vectors which belong to irreducible spaces U_{in} of the basic group G_i.

The basis of each space U_{in} are orthogonal, the basis of each space U_i are too. From the first axiom, we can consider these bases are orthonormal. ψ_{in} is a vector in U_{in}. ψ_i is a vector in space U_i, we have: $\psi_i = \sum_n c_{in}.\psi_{in}$. Vector ψ_i which is a solution of the Schrodinger equation, in general, doesn't belong an irreducible space of G_i. So ψ_i isn't a possible state. So the axiom about the possible states and the superposition principle aren't compatible.

With stationary systems, each space U_{in} corresponds to a stationary energy level. Vectors in U_{in} correspond to the same energy level. The degenerative degree of this energy level equals the number of dimensions of U_{in}. Of course, with a stationary system, combinations of two possible states which aren't the same energy level are not a possible state. Note D_i is a 4-dimensions domain. So the axiom about possible states is also used for time-dependent possible states.

If ψ is the tight solution, it can be expanded: $\psi = \sum_n c_{in}.\psi_{in}$. The Born rule is stated:

I*n general, we can't know exactly possible state of the system in each continuous domain D_i. The possibility of each possible state ψ_{in} is $|c_{in}|^2$.*

2. Observable properties

We can divide the measurement into two types. The first, the system act directly on detector. Experiments Stern-Gerlach [11] and double slits [12] belong to this type. The second, the system act on a middle system then it acts on the detector. Example the measurement of the radiative spectrum of the atom [13], the radiative field is the middle system.

The distribution function of possibility density of the system can be got from the first type. We must combine the measurement result and a suitable mathematical model to get any other information about the system. We have to combine the measurement result and solution of the Schrodinger equation to get quantum properties of the system. Example, we can find the structure of energy levels of the atom by combining the perturbation solution of the Schrodinger equation with the experimental spectrum of the atom. If the Schrodinger equation of the system is difficult to analyze then we can dive a little information from the experiment result. Example, we drive only a little information from the visible radiative spectrum of solid materials [14] because its Schrodinger equation is very difficult to analyzing.

Qualitative quantum properties can be gotten from the qualitative solutions of the Schrodinger equation. Example, it may be driven to the number of possible states of an atom from qualitative solutions of the Schrodinger equation.

Quantitative quantum properties can be gotten only from the combination between experiment result and quantitative solutions of the Schrodinger equation. The quantitative properties are divided into two types. The first are constants as mass and charge of micro-particle. The second, in a stationary system, are eigenvalues of the operator A which commutes with H. We can drive the value of the eigenvalues a_i of operator A because they appear in the quantitative solutions of the Schrodinger equation. So we can define: *quantitative quantum properties of the system can be described by operators, possible values of each quantity equal eigenvalues of the operator*. These operators need to be hermitic because their possible values are real.

Observable quantities in a particular experiment are indicated clearly by only Schrodinger equation without axioms of operators. They correspond to operators which their eigenvalues appear in the quantitative solutions of the Schrodinger equation.

3. The wave function collapse

If the potential energy is discontinuous then space is divided into many continuous domains D_i. Symmetry groups of the Schrodinger equation and possible states are different in each domain D_i. So the state of the system changes when it shifts to the next continuous domain. An observed system is acted by apparatus. We describe this effect by a measurement potential energy V_{meas}. It is made by the apparatus and like every other interaction. The total potential energy of system is $V_{total} = V + V_{meas}$. The total potential energy of system usually is discontinuous because of the measurement potential energy. So space is usually divided into continuous domains because of the measurement potential energy. The shifting between these domains makes the change of state. This process is suddenly and uncertain. And it is like the wave function collapse [5].

Here, we don't require to apparatus is classical. Here, the apparatus isn't restricted in the frame of classical law to understand the wave function collapse [14]. It isn't only the measurement potential energy, the state of the system but also may change suddenly because of any other interaction. The state of the system after measurement doesn't depend on the observer's mind. It only depends on Hamiltonian and the measurement potential energy. Here, there are no registered properties. This is difference from orthodox quantum mechanics. This difference may be cleared because the orthodox quantum mechanics can't indicate clearly observed operator in a particular experiment.

1. Reality and the classical picture

From the Born rule, it is easy to find the average value of the operator $\langle A\rangle = \langle\psi|A\psi\rangle = \int \psi^* A\psi . dx_\mu$. Here, the integration is executed in 4-dimensional space.

We define average in 3-dimensions space $\langle A\rangle_t = \int \psi^* A\psi . dV$. From the Schrodinger equation we have the Heisenberg equation for the 3-dimension average:

$$i.\hbar.\frac{d}{dt}\langle A\rangle_t = \frac{\partial\langle A\rangle_t}{\partial t} + \langle[H, A]\rangle_t$$

The Heisenberg equation for coordinate average is:

$$\frac{d}{dt}\langle x\rangle_t = \frac{\langle p_x\rangle_t}{m}$$

The Heisenberg equation for momentum average is:

$$\frac{d}{dt}\langle p_x\rangle_t = -\frac{\partial\langle V\rangle_t}{\partial x}$$

Two equations above are the motion equations in classical mechanics. It shows clearly viewpoint that the classical properties are averages of the quantum properties. And the laws of the macro-world are obtained by averaging of the quantum laws. It is suitable if the classical picture is only considered averaging of the uncertain complex waves. The classical picture is only a reflection image of quantum reality on human senses. In general, each sensing structure gets a correspondent reflection image of reality. However, the uncertain complex wave is the unique origin of all image. The uncertain complex waves are strange things because of restriction of human sensing. But no reason prevents these waves to become a real reality.

III. Conclusion

Paper describes the quantum reality as uncertain complex waves. Although these waves are counterintuitive but they can offer the classical picture by averaging. A system axiom is suggested to describe these waves completely. They are obtained by modifying the system axiom of the orthodox quantum mechanics. Then the Schrodinger equation without axioms about operators can indicate the observable properties. while we can understand the wave function collapse by using an axiom about possible states.

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