Interpret Quantum Mechanics by uncertain complex waves

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Abstract

This paper suggests to describe quantum system by uncertain complex waves. These waves satisfy an axiomatic system. This axiomatic system solves the measurement problem elegantly. It understand wave function collapse from an axiom about possible states. And observable properties are drive by Schrodinger equation without axioms about operators.

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 [4][5]? What properties are observable in a particular experiment [6]? Many works were done to answer these questions [7]. However, no approach is agreed widely because each has own difficulty [7].

If axioms about the operator in orthodox quantum mechanics are removed then the Schrodinger equation can indicate the observable properties by itself. 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 in this paper, I suggest a new description of quantum system by uncertain complex waves. The axiomatic system for these waves is obtained by modifying the axiomatic system of the orthodox quantum mechanics. Axioms about operators are removed. The observable properties are indicated to operators which their eigenvalues appear in solutions of the Schrodinger equation. And 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.

II. Theory and discussion

1. Description of the quantum reality

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 [8]. The axiomatic system of the orthodox quantum mechanics is stated by E. G. Harris and it is showed in [9]. It is modified to become a new axiomatic system of new description. The new axiomatic system includes two axioms from Harris's statement. They are the Born rule and the Schrodinger equation. Axioms about operators of the orthodox quantum mechanics are removed. The axiom about vector in Hilbert space is modified to become new form. And 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 axiomatic system is:

Quantum system is described by a set of vectors 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.

Here, Only one vector in Hilbert space is not enough to describe quantum system. The first axiom requires many vectors for description. These vectors are determined the Schrodinger equation and its boundary conditions. Now, in the Hilbert space, we can define operators. Example, coordinates operators: $\hat{x}$=x; $\hat{y} = y$; $\hat{z} = z$. Momentum operators: $p_x = -i.\hbar.\frac{d}{dx}$; $p_y = -i.\hbar.\frac{d}{dy}$; $p_z = -i.\hbar.\frac{d}{dz}$. Hamiltonian operator for 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 potential energy operator. It is a function of coordinates and time. m is mass of the particle. Relativity Hamiltonian operator for single particle 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 two packs of conditions. The first are initial condition and boundary conditions which are Dirichlet and Neumann conditions. The first pack is called tight condition. The second pack includes integrable square, single-valued and continuous conditions. They pack is called open condition. Wave function which satisfies tight condition exists only. It is called tight solution, tight wave function or tight state vector. Wave functions which satisfy the open condition are called open solutions, open wave functions or open state vectors.

If the potential energy operator 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. In the space of open solutions, 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.

Now, the open solutions can be called possible solutions, possible wave functions and possible state vectors. 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 an open solution of the Schrodinger equation, in general, doesn't belong to any 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, in a continuous domain, system doesn't belong any particular possible state. The possibility of each possible state ψ_{in} is $|c_{in}|^2$.*

Here, I suggest that the uncertainty is natural property of quantum system. And it doesn't depend on restriction of human and apparatus.

The set of tight solution ψ and possible solutions ψ_{in} are called state of system. We symbolize the state $\{\psi|\psi_{in}\}$. The state of system is also described by vectors $\{\psi_{in}\}$ and coefficients $\{c_{in}\}$. So we can also symbolize the state $\{\psi_{in}|c_{in}\}$. Observable properties.

2. Observable properties

We can divide the measurement into two types. The first, the system acts directly on detector. Experiments Stern-Gerlach [10] and double slits [11] belong to this type. The second, the system acts on a middle system then it acts on the detector. Example the measurement of the radiative spectrum of the atom [12], 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 results and a suitable mathematical model to get other information about the system. We must combine the measurement results and solutions of the Schrodinger equation to get quantum properties of the system. Example, we can find the energy level's structure of an atom by combining the its experimental spectrum and perturbation solution of the Schrodinger equation. If the Schrodinger equation of the system is difficult to analyze then we can only drive a little information from the experiment results. Example, we only drive a little information from the visible radiative spectrum of solid materials [13] 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 atom's number of possible states 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 Hamiltonia. 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 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. And we can define: *quantitative quantum properties of the system can be described by operators, possible values of each quantity are eigenvalues of the operator*. These operators need to be hermitic because their possible values are real.

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. The shifting between continuous domains of system makes the change of state. This process is suddenly and uncertain. And it is like the wave function collapse [5]. Because of these properties, the possible states are called **uncertain complex waves**. And the quantum system can be described by uncertain complex wave and their possibility.

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 the 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.

III. Conclusion

Paper describes the quantum system by uncertain complex waves. An axiomatic system is suggested for these waves completely. They are obtained by modifying the axiomatic system of the orthodox quantum mechanics. Then the Schrodinger equation without axioms about operators can indicate the observable properties by itself. While we can understand the wave function collapse by using an axiom about possible states.

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