A New Description For Quantum Systems And Uncertain Complex Wave

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Abstract

This paper suggests a new axiomatic system to describe quantum systems. It can solve elegantly the measurement problem. The wave function collapse is understood by an axiom about possible states. And observable properties are driven by the Schrodinger equation without the axioms about operators in orthodox quantum mechanics. From the new description , a strange quantum reality is suggested.

I. Introduction

Quantum mechanics has 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 foundation of the quantum mechanics has been never stopped [1][2]. The most outstanding debate is how the wave function collapse happens [4][5]? What properties are observable in a particular experiment [6]? What is 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 operators 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 all time then we can understand the wave function collapse. So in this paper, I suggest a new description for quantum systems. Axiomatic system in this description is obtained by modifying axiomatic system of the orthodox quantum mechanics. The 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 possible states. This suggestion shows that discrete potential energy makes change of state uncertain and suddenly. The wave function collapse is a simple consequence of this process. From this new description, I suggest a strange quantum reality.

II. Theory and discussion

1. Description for quantum systems

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 in new description. The new axiomatic system includes two axioms from Harris's statement. They are the Born rule and the Schrodinger equation. The axiom about vector in Hilbert space is modified to become a 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:

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

Here, only one vector in the Hilbert space is not enough to describe a quantum system. The first axiom requires many vectors for description. These vectors are determined by 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 new description is*:*

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

Wave functions also satisfy two packs of conditions. The first includes initial condition and boundary conditions. The first pack is called tight condition. The second includes integrable square, single-valued and continuous conditions. This pack is called open condition. Wave function which satisfies the 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 4-dimensional space into domains D_i(i=1,2,..) as large as possible in which the potential energy is continuous. These domains are called continuous domains of system. The Schrodinger equation has one the largest symmetry group G_i in each domain D_i. It is called basic group of 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,..) are irreducible representations of G_i in U_i. In the space of open solutions, U_{in} are subspaces which are invariant with T_{in}. Spaces U_{in} are called irreducible spaces of G_i. The axiom about possible states is suggested by the following:

Possible states of system in a continuous domain D_i are vectors which belong to irreducible spacess of basic group.

The open solutions in U_{in} are called possible solutions, possible wave functions and possible state vectors. Basis of each space U_{in} are orthogonal, 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. So ψ_i isn't a possible state. So the axiom about 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. Degenerative degree of this energy level equals dimensional number of U_{in}. Note that D_i is a 4-dimensional domain. So the axiom about possible states is also used for time-dependent possible states.

If ψ^i is the tight solution in D_i , it can be expanded: $\psi^i = \sum_n c_{in}.\psi_{in}$. Set of ψ^i and ψ_{in} are called state of system in D_i. We symbolize the state $\{\psi^i|\psi_{in}\}$. The state of system is also described by vectors $\{\psi_{in}\}$ and coefficients $\{c_{in}\}$. So we can also symbolize the state $\{\psi_{in}|c_{in}\}$. The Born rule is stated:

I*n general, in a continuous domain, system doesn't belong to any particular possible state. Possibility of each possible state ψ_{in} is $|c_{in}|^2$.*

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

2. Observable properties

We can classify measurements into two types. The first, system acts directly on detector. Experiments Stern-Gerlach [10] and double slits [11] belong to this type. The second, system acts on a middle system then it acts on detector. Example, measurements of radiative spectrum of atom [12], radiative field is the middle system.

Function of possibility density of system can be got from the first type. We must combine measurement results and a suitable mathematical model to get other information about system. Quantitative quantum properties can be gotten only from the combination between experiment results and quantitative solutions of the Schrodinger equation. Example, we can find the energy levels of an atom by combining its experimental spectrum with perturbation solution of the Schrodinger equation. If the Schrodinger equation of system is difficult to analyze then we drive only a little information from experiment results. Example, we only get a little information from a visible radiative spectrum of solid material [13] because its Schrodinger equation is very difficult to analyze.

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 operators A which commute with the Hamiltonian. We can drive the value of the eigenvalues a_i of operators A because they appear in the quantitative solutions of the Schrodinger equation. So observable quantities in a particular experiment are indicated clearly by the Schrodinger equation without axioms of operators. They correspond to operators which their eigenvalues appear in the solutions of the Schrodinger equation. And we can define: *quantum properties of the system can be described by hermitic operators, possible values of each quantity are eigenvalues of correspondent 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 in domains D_i are differential eah other. Of course, possible states are different in domains D_i too. 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 measurement. The shifting between continuous domains of system makes the change of state. This process is suddenly and uncertain. It is like the wave function collapse [5].

Here, the apparatus isn't restricted in 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 system after measurement doesn't depend on observer's mind. It only depends on the Hamiltonian and the measurement potential energy.

Here, there are no registered properties. This is different from orthodox quantum mechanics. This difference may be cleared because the orthodox quantum mechanics can't indicate clearly observed operators in a particular experiment.

4. The quantum reality

From the description above, I suggest that quantum reality is a wave. However, this wave is differential from classical wave. The wave of quantum system is changed uncertain and suddenly. On the other hand, in general, this wave is a complex field. So It is called uncertain complex wave. It need not only one wave function but also a set of wave functions $\{\psi^i | \psi_{in}\}$ to describe completely. Because quantum system is a wave, it is nonlocal. So coordinates of quantum system are never observable. But in some cases, we can say about coorinates of system approximately.

In some researchs, classical picture is only a limit of quantum theory [15]. I believe that 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 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 suggests an axiomatic system to describe quantum systems. It is obtained by modifying the axiomatic system of the orthodox quantum mechanics. Then the Schrodinger equation without axioms about operators can indicate observable properties by itself. They are operators which their eigenvalues appear in solutions of the Schrodinger equation. While the wave function collapse is a simple consequence of discontinuous potential energys in 4-dimensional space. Quantum system doesn't belong to any particular possible state. A so strange quantum reality is suggested to an uncertain complex wave.

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