International Journal of Pure and Applied Physics.
ISSN 0973-1776 Volume 13, Number 4 (2017), pp. 349-361

http://www.ripublication.com

The Interpretation of Original Principles of Quantum Theory and Nature of Quantum

Ge Guangzhou

Harbin Institute of Technology
92 West Dazhi St, Nangang District, Harbin, Heilongjiang Province, China

Abstract

In this article the author mainly contributes to the interpretation of original principles of quantum theory, which include the wave particle duality, uncertainty principle, the probabilistic interpretation of wave function and the complementarity principle, and also explores the nature of quantum and thus proposes the principle of quantum relativity which could be deemed as the unification of quantum theory and relativity theory. Finally the author provides a verification of the viewpoints as proposed in this article by conducting the thought experiment called as the new photon case.

Key Words: Quantum, Virtuality, Reality, Quantum Relativity, New Photon Case

1. INTRODUCTION

The quantum theory and relativity theory, born in the early twentieth century, were originally put forward by Planck and Einstein respectively and have in time been regarded as the fundamental physics methods for the research of microscopic and cosmoscopic world. However, the interpretation of quantum has ever since been a central issue of development of quantum theory, for instance, Einstein had never believed in the probabilistic interpretation of quantum, and further the quantum theory has not yet been consistent or unified with the relativity theory, as has been a concern of more and more physicists and has become one of the fundamental issues of current

physics research. This article represents the thinking and further exploration to this issue by the author. At first the article would start with the introduction of original principles of quantum theory, and then the author would examine and reinterpret each of them following some theoretical preparation, and further the discussion would point to the nature of quantum.

2. **THE ORIGINAL PRINCIPLES OF QUANTUM THEORY**

The author would at first introduce some original principles of quantum theory according to some relevant literature, which should constitute the foundation of current quantum theory.

(1) The wave particle duality

The moving particle with the mass of m and the velocity of v would also have the property of wave with the wave length to be the ratio of Planck constant h to the particle's momentum mv, i.e., $\lambda = \frac{h}{mv}$, and this expression is referred to as the de Broglie formula.

(2) The uncertainty principle

The uncertainty principle was put forward by Heisenberg in 1927 which indicates that a particle's position and momentum cannot be determined at the same time and the uncertainties of the position and momentum should follow the inequation $\Delta x \Delta p \geq \frac{h}{4\pi}$, among them h is the Planck constant.

(3) The wave function and its probabilistic interpretation

In order to quantitatively describe the conditions of microscopic particle, the concept of wave function Ψ was introduced into the quantum mechanics, which is the function of space and time, i.e., $\Psi = \Psi(x, y, z, t)$. And M. Born interpreted the physical meaning of wave function as that $|\Psi|^2$ would represent the probability

density of the particle's occurrence at some certain point $P(x, y, z)$ outside the nucleus, or probability of the particle's occurrence per unit volume at this point. The wave function and the probability density have since then been deemed as the most fundamental concepts of quantum theory.

(4) Complementarity principle

Complimentarity principle was proposed by N. Bohr in 1928 as one of the most fundamental principles of quantum mechanics, that is, the atomic phenomena cannot be described with the completeness as required by the classical mechanics, i.e., some certain complementary elements which constitute the complete classical description would be in here mutually exclusive although they are needed for the description of different aspects of atomic phenomena.

According to Bohr, the complementarity principle would originate from the viewpoint of wave particle duality, that is, the wave and particle should be unified with each other at a higher level although they are mutually exclusive at the same particular moment. On one hand, the properties of wave and particle would not occur with the one same measurement, as indicates that they would not interfere with each other in the experiment or they are mutually exclusive while depicting the microscopic particle, on the other hand, both of them are needed while depicting the microscopic particle or interpreting the experiment, therefore, the wave and particle should be complementary to each other.

It should be noted that the uncertainty principle should express the wave particle duality mathematically and the complementarity principle should highly generalize the wave particle duality philosophically, and the uncertainty principle and the complementarity principle have been deemed as the two pillars of Copenhagen interpretation of quantum mechanics.

3. THE NEW INTERPRETATION OF QUANTUM

(1) The theoretical preparation

A. **The hypothesis of new quantum**

According to Feynman's Path Integral Principle, although a particle may pass through countless possible paths from its start point to its finish point, among them just one

path should really occur. Thus it could be deduced that the particle or quantum could be assumed as the combination of real path and virtual path, and in here the real path is the one path that should really occur and the virtual path is the countless possible paths. And as such the quantum could be regarded as the unification of real path and virtual path instead of the duality of wave-particle, and the quantum so interpreted could be referred to as the New Quantum or the New Quantum Hypothesis, and likewise a photon so interpreted could be referred to as the New Photon.

According to the new quantum hypothesis, in order to further depict the nature and motion of the new quantum the relationship between the real path and virtual paths of the new quantum needs to be formulated. The author then finds the Hamilton Principle should be able to formulate this very relationship, which represents the law of determining the real path out of the possible countless virtual paths.

According to the literature of analytical mechanics, Hamilton Principle is the variation principle which is applicable to dynamic holonomic system, that is, in the space $(q_1, q_2, \dots, \mathrm{q_N}; \mathrm{t})$ of (N+1) dimensions, the time integral of kinetic potential $\mathrm{L(q, \dot{q}, t)}$ of the line linking any two points will get the stationary value in its real movement path.

Suppose

$$\mathrm{S} = \int_{\mathrm{t_1}}^{\mathrm{t_2}} \mathrm{L}\,(\mathrm{q}, \dot{\mathrm{q}}, \mathrm{t})\mathrm{dt} \qquad (1)$$

S is referred to as the Hamilton action quantity, then

$$\delta \mathrm{S} = 0 \qquad (2)$$

And then its variation form is

$$\delta \mathrm{S} = \delta \int_{\mathrm{t_1}}^{\mathrm{t_2}} \mathrm{L}\,(\mathrm{q}, \dot{\mathrm{q}}, \mathrm{t})\mathrm{dt} = \int_{\mathrm{t_1}}^{\mathrm{t_2}} \left(\frac{\mathrm{dL}}{\mathrm{dq}}\delta \mathrm{q} + \frac{\mathrm{dL}}{\mathrm{d\dot{q}}}\delta \dot{\mathrm{q}} + \frac{\mathrm{dL}}{\mathrm{dt}}\delta \mathrm{t}\right)\mathrm{dt} = 0 \qquad (3)$$

And so the dynamic problem of mechanical system should come down to be a variation principle, that is, as far as the holonomic system is concerned, among all the possible movements of the system, which is conditioned by the same start and finish time, the same start and finish locations and the same constraints, the movement that enables Hamilton action quantity S to be the stationary value should be the one that really occurs in the system, and this is referred to as Hamilton Principle. Thus

Hamilton Principle should depict the system's action quantity with the integral equation and use the variation method to calculate the motion equation of overall system.

And thus the Hamilton Principle should represent the law of locating the real movement from all the possible movements of the system, or the law which determines the real path out of virtual paths. Therefore, Hamilton Principle could be employed to formulate the relationship between the real path and virtual paths of the new quantum, and as such the system's action quantity should be able to be represented by the Hamilton action quantity.

Further the real path and virtual path of the new quantum could be formulated respectively as follows.

According to the literature of analytical mechanics, as far as the holonomic system of N degree of freedom is concerned, if a system's motion is depicted by N generalized coordinates of $q_1, q_2, \dots, q_N$, the system's motion could be equivalent to a point's motion in this space of N dimensions, and this space could be referred to as configuration space or coordinates space and this abstract point could be referred to as the configuration point. Thus the motion of configuration point in the configuration space should represent the whole system's motion, and the configuration point's path in the configuration space could be referred to as location path which is the system's motion path. And thus the motion position of every moment of the system should correspond to one point of this assumed motion path. Suppose under the active force and in the period from t_1 to t_2 the system moves from the location of $A(q_{j1}, t)$ to the location of $B(q_{j2}, t)$, the configuration point's motion path in the augmented configuration space of $(N + 1)$ dimensions is to be the real motion path or real path. There's but one real path and its motion equation is

$$q_j = q_j(t), j = 1,2, \dots, N \qquad (4)$$

While under the conditions of same start/finish time and same start/finish locations, any one possible motion of the particles system close to the real motion as permitted by the constraints could be referred to as the possible path or virtual path. The virtual path is countless and its motion equation is

$$\tilde{q}_j = q_j(t) + \varepsilon_j \eta_j(t), j = 1,2, \dots, N \qquad (5)$$

ε_j is the arbitrary micro amount, $\eta_j(t)$ is the arbitrary function of t, and $\eta_j^{(t)}\Big|_{t=t_1,t=t_2} = 0.$

Thus the real path and virtual path of the new quantum could be formulated by the equations (4) and (5) respectively.

B. The general equivalence principle

According to the new quantum hypothesis, the new photon so produced would substitute for the original photon and act as the action quantity of the physical space system outside the nucleus in the atom. Considering the original photon exists as the action quantity of electromagnetic force and it should now be replaced by the new photon, the new photon should then impact the nature and interpretation of electromagnetic force. From this perspective the electromagnetic force could be reinterpreted.

If the system's action quantity transforms to the new photon from the original photon, the electromagnetic force as represented by the original photon should be replaced by the force that applies to the new photon, or exactly the electromagnetic force is supposed to be replaced by the force that applies to the physical space as represented by the new photon. Considering the motion of new photon could be formulated by the Hamilton Principle and further the Hamilton Principle be the necessary and sufficient condition of Lagrange equation of the holonomic system, this Lagrange equation should be able to formulate the force that applies to the physical space as represented by the new photon, and thus by replacing the electromagnetic force with the force which is represented by Lagrange equation of the holonomic system, the electromagnetic force should be so reinterpreted. Therefore the author would hereby introduce Lagrange equation of the holonomic system, which is Euler-Lagrange Equation.

According to the literature of analytical mechanics, Euler–Lagrange Equation could be formulated as follows:

$$\frac{\partial \mathrm{L}}{\partial \mathrm{q}} - \frac{\mathrm{d}}{\mathrm{dt}}\frac{\partial \mathrm{L}}{\partial \dot{\mathrm{q}}} = 0 \qquad (6)$$

Among them, Lagrangian $\mathrm{L}(\mathrm{q}, \dot{\mathrm{q}}, \mathrm{t})$ is the function of time, coordinate and velocity, the generalized coordinate $\mathrm{q} = (\mathrm{q}_1, \mathrm{q}_2, \dots, \mathrm{q}_\mathrm{N})$ is the function of time, and the generalized velocity $\dot{\mathrm{q}} = (\dot{\mathrm{q}}_1, \dot{\mathrm{q}}_2, \dots, \dot{\mathrm{q}}_\mathrm{N})$ is also the function of time.

The zero on the right side of the equation indicates that the system's generalized force is to be zero, which means that the system would not be affected by any forces but be kept in a balanced and stabilized condition, which just coincides with the New Photon Case as aforementioned. And thus the very condition of the system's generalized force being zero indicates that the electromagnetic space system outside the nucleus in an atom as represented by the original photon should have become the new physical space which is constituted by the energy distribution as represented by the new photon.

Based on the reinterpretation of the electromagnetic force outside the nucleus, the electromagnetic space outside the nucleus as represented by the original photon should be equivalent to the new physical space which is constituted by the energy distribution as represented by the new photon, or it could be further assumed/deduced that the physical phenomena that occur in the inertial reference system under the action of the electromagnetic force should be identical with that of the non inertial reference system which is constituted by the physical space as represented by the new photon, and this assumption could be referred to as the Relativity of Electromagnetic Field. Thus the space of electromagnetic field should not be abstract but be dominated by the energy distribution of the physical space as represented by the new photon that is formulated by the Hamilton Principle.

Based on the Relativity of Electromagnetic Field, the action particle of electromagnetic field (i.e. photon) could be replaced by an appropriate physical space which is to be constituted by the energy distribution represented by the new photon, and the energy distribution as represented by the new photon is actually the integral of energy to time as determined by Hamilton principle could be then referred to as the energy-time metric.

In brief, the action particle of electromagnetic field (i.e. photon) could be replaced by an appropriate energy-time metric, or they are equivalent to each other. Considering the universality of Hamilton principle, which is actually the least action principle used

for depicting an object's motion law, this equivalence which originates from the electromagnetic field could be further generalized to apply to other fields such as the gravitational field, strong field or weak field, that is, now that every field has a corresponding action particle, it could be assumed that the action particle of every field, just as the photon could be replaced by the appropriate energy-time metric, could be replaced by its corresponding energy-time metric which is determined by the Hamilton principle, that is, the action particle of a field is equivalent to the corresponding energy-time metric or the physical space as determined by the appropriate energy-time metric, this equivalence could be referred to as the general equivalence principle.

According to the general equivalence principle, the concept of force is no longer absolute, or all the forces could be replaced by the physical spaces as determined by the energy-time metrics which are corresponding to their action particles respectively.

According to the above, the general equivalence principle so produced should be universal and it should apply to all the reference systems, and thus it should have expanded the existing equivalence principle of general relativity, which could just apply to the local inertial system rather than the non local inertial system.

(2) The new interpretation of original principles of quantum theory

Based on the new quantum hypothesis as described above in the theoretical preparation A, the author would interpret the original principles of quantum theory as follows.

A. The new interpretation of wave particle duality

According to the new quantum hypothesis, the unification of virtual path and real path of the new quantum should be able to substitute for the wave particle duality of the existing quantum, as could be deemed as the new interpretation of wave particle duality.

B. The new interpretation of uncertainty principle

According to the new quantum hypothesis, the wave particle duality could be replaced wby the unification of virtual path and real path, and thus the Hamilton principle

which depicts the unification of virtual path and real path should be able to substitute for the uncertainty principle which depicts the wave particle duality, or simply put, the uncertainty principle could be so replaced by the Hamilton principle. Now that what the Hamilton principle depicts is actually the one real path out of the countless possible path, the movement of microscopic particle so determined should be of certainty.

C. The new interpretation of wave function and its probabilistic interpretation

According to the new quantum hypothesis, the hypothesis of new quantum should be able to substitute for the wave function to depict the microscopic particle, and further the deterministic movement of new quantum as determined by the Hamilton principle should be able to substitute for the probabilistic interpretation of wave function.

D. The new interpretation of complementarity principle

According to the complementarity principle, the atomic phenomena cannot be depicted with completeness as required by the classical mechanics. However, according to the new quantum hypothesis, the combination or unification of virtual path and real path should be able to completely depict the movement of microscopic particle, and the author would conduct further interpretation regarding this as follows.

The author would at first propose the concept of Unity of Virtuality and Reality, that is, it could be assumed that the virtual path should represent the “virtuality” and the real path should represent the “reality”, and the “unity of virtuality and reality” could just be considered as the high level generalization of the relationship between the virtuality and reality or exactly the philosophical interpretation of the relationship between the virtual path and real path. And it should be noted that in here the virtuality and reality are not mutually exclusive but they constitute an inseparable unity, that is, there should be no reality if without virtuality and the virtuality is actually the foundation of reality and the reality should originate from the virtuality, or in other words, all the objects in the world are born from the reality whereas the reality is born from the virtuality, and all the objects in the world are just created out of the unity of virtuality and reality. As far as the physics is concerned, the virtuality is embodied by the virtual path, which could be referred to the virtual path’s motion equation (5), and the reality is represented by the real path, which could be referred to the real path’s motion equation (4), and the relationship between them could be

formulated by the Hamilton principle, which could be referred to the equation of Hamilton principle (3).

Therefore, although the wave and particle are mutually exclusive as described by the complementarity principle, the virtual path and real path are not mutually exclusive as indicated by the unity of virtuality and reality, or exactly, the real path is resulted from the virtual path and thus they are unified with each other. Thus it should be noted that what the unification of virtual path and real path may indicate should be deeper than what the complementarity of wave and particle depicts, and thus with the replacement of wave particle complementarity by the unification of virtual path and real path, the unity of virtuality and reality should ultimately substitute for the complementarity principle.

The author believes the aforementioned should constitute the new interpretation of complementarity principle.

(3) The interpretation of the nature of quantum

According to the general equivalence principle as described above in the theoretical preparation B, a quantum such as a photon could be replaced by an appropriate physical space, and thus it could be assumed that the physical laws that respectively apply to the quantum and the physical space should be in nature identical with each other although they may have different formats, or simply put, the quantum could be identical with the physical space in nature.

On the other hand, according to Einstein's general theory of relativity, the gravitational force could also be replaced by the appropriate physical space, that is, although the physical laws which respectively apply to the gravitational force and its corresponding appropriate physical space may have different formats, they are in nature identical with each other.

According to above, either the quantum or the gravitational force could be identical with the appropriate physical space, and thus the author would propose the following postulate.

Although the physical laws may have the different formats, as is true with those respectively applied to the quantum, gravitational force and physical space, they should be identical with each other in nature, as would not be restricted by any reference systems or any conditions.

According to this postulate, the physical laws would not be restricted by their formats, that is, the physical law that is expressed by the movement of an action quantum should be in nature the same as the physical law that is expressed by the movement of its corresponding physical space system, or simply put, the quantum should be identical with the physical space in nature. Therefore, this postulate will not only be the further interpretation of quantum but also be the further expansion of the general theory of relativity and its gravitational theory, and thus this postulate could be referred to as the **Principle of Quantum Relativity**. According to the principle of quantum relativity, the quantum should not be absolute but relative, or exactly the quantum could be replaced by the energy time metric or the appropriate physical space. Thus it could be assumed that the principle of quantum relativity should reveal the nature of quantum just as the theory of general relativity reveals the nature of gravitational force. Furthermore, the principle of quantum relativity should have completely broken the dependence of physical law on reference system, and even it has broken the so called "format" restriction, or in other words, the physical laws are no longer "format invariant" as stipulated in the theory of special or general relativity, but they could ultimately be not restricted by the formats, or exactly the physical laws should be identical in nature although they may have different formats.

Now that the principle of quantum relativity further interprets the nature of quantum and the relativity theory as well, this principle could so be deemed as the unification of quantum theory and relativity theory.

（4）Experimental verification

The author would now propose a thought experiment called as the "new photon case" through the discussion regarding the radiation of the original photon outside the nucleus, which would provide the verification of the aforementioned viewpoints of virtuality and reality and the nature of quantum.

The author would then apply the new quantum hypothesis to the interpretation of radiation of the original photon acting outside the nucleus.

According to the new quantum hypothesis, which calls for the new photon to replace the original photon, among all the possible movements of the space system outside the nucleus with the action quantity to be the new photon instead of the original photon which is originally regarded as the release by the electron transition or quantum jumps between different energy levels in an atom, only the movement which would enable

Hamilton action quantity S to be the stationary value should really occur as the real path, and thus the real path so defined could be deemed to be a balanced and stable condition of the space system outside the nucleus, which could then be referred to as the New Photon Case. Now that this balance exists between the new photon's real path and virtual paths, this Case could be referred to as the Principle of Virtual-Real Balance and the motion of the new photon in here could then be simply referred to as the Virtual-Real Motion. Thus it should be the new photon's Virtual-Real Motion that keeps the balance and stability of the space system outside the nucleus, and it is to keep the Hamilton action quantity to be the stationary value i.e. $\delta S = 0$ that produce the real motion of the system and constitute the physical space system outside the nucleus or exactly the different energy levels outside the nucleus in the atom in which the electrons should exist. Just as Schrodinger indicated that **there should be no quantum jumps between different energy levels in an atom, but only smooth and continuous transitions from one standing wave into another with the emission of radiation being the product of some exotic resonance phenomenon,** which is in here referred to as the **New Photon Case**.

In brief, it's the very motion which enables the Hamilton action quantity to be the stationary value that constitute the Virtual-Real Balance of the space system outside the nucleus, which in turn corresponds to the energy level distribution or the physical space itself outside the nucleus in the atom, that is, the new photon should only choose the one out of all its possible paths as the real path that would keep the system's Virtual-Real Balance, which in some previous circumstances was assumed as the radiation of the original photon or the quantum jumps between the different energy levels in the atom which should not actually exist. So the radiation of the original photon should just represent the phenomenon with the real action mechanism to be the Virtual-Real Balance that exists in the space system outside the nucleus which is the New Photon Case.

Based on the discussion as above, the new photon case should reinterpret the phenomena of the radiation of original photon and thus reveal the motion law of particles outside the nucleus, which could be explained as follows:

There should be no quantum jumps in the space system outside the nucleus, but the very virtual-real balance with the system's Hamilton action quantity S being the stationary value, which should constitute the space system outside the nucleus and the energy levels where the electrons exist. Or alternatively, according to the principle of quantum relativity, the movement of an electron outside the nucleus in the

electromagnetic field with the action quantum to be the existing photon could be replaced by its movement in the appropriate physical space as represented by the new photon, which should substitute for the electromagnetic field as represented by the original photon.

In summary, the thought experiment of new photon case should not only provide the supports to the viewpoints of virtuality and reality but also reveal the nature of quantum.

4. CONCLUSION

Based on the new interpretation of original principles of quantum theory and the discussion on the nature of quantum, the author believes that the quantum should not be absolute but relative, and in essence it could be replaced by the appropriate physical space, and further it is the unity of virtuality and reality in itself.

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