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Comment on ”INCOMPATIBILITY OF COPENHAGEN INTERPRETATION WITH QUANTUM MECHANICS FORMALISM” by Yuri A. Rylov [Concepts of Physics V. 5 No. 2 (2008) 323]

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Author of [1] questions foundations of quantum mechanics as follows: "... the action for the Schrödinger particle (the dynamic system described by the Schrödinger equation) turns into the action for the statistical ensemble of free classical particles, when the quantum constant $\hbar \to 0$. Such a transition is possible only in the case, when the wave function describes a statistical ensemble of quantum particles, but not a single particle," we omit labels in the citation.

One can make a transition from the quantum mechanics to the quasi classical mechanics by approaching $\hbar \to 0$ when the number of particles and the time of interaction are large enough. In this case one can ignore discreteness of the energy levels and consider quasi continuum energy spectrum. However in this way one cannot substitute the quantum wave (wave function) by the classical wave. Unlike the classical wave propagating with a finite speed the quantum wave spreads over the space with an infinite speed. It is instantaneous spread of the quantum wave over the space allows one to put the quantum wave into correspondence with a single particle. The standard textbooks on quantum mechanics consider a lot of experiments exhibiting the wave behaviour of a single particle including the Young's two-slit experiment. Also, the phenomenon of entanglement gives an example of the wave function defined instantaneously between two space-like separated states that was confirmed in Bell experiments, e.g. [2] and references therein.

Consider the problem by taking the photon as a Schrödinger massless particle [3]. We think of the photon as a particle with the momentum p at the time t. Introduce the wave function of photon with the wave vector $k = p/\hbar$. In the stationary state the momentum of photon is fixed. Then the uncertainty in momentum is $\Delta p = 0$, the uncertainty in the wave vector is $\Delta k = \Delta p/\hbar = 0$. From the Heisenberg uncertainty principle, $\Delta p \Delta r \geq \hbar/2$, it follows that the uncertainty in the space coordinate is $\Delta r = \infty$. This means that one cannot specify the space coordinate hence one can consider the wave function of the photon with the wave vector $k = p/\hbar$ as being in the whole space at the time t.

Consider the problem for the non-stationary state of photon [4] associated with the birth (annihilation) of a photon, with the uncertainty in momentum being $\Delta p = p$. The Heisenberg uncertainty principle yields the uncertainty in the space coordinate as $\Delta r = \hbar/2p =$

$1/2k$. This means that for the non-stationary state of photon, one can consider the wave within the radius $r \leq 1/2k$.

In recent experiments [5] the speed of propagation of the bound magnetic field in the near zone was determined, with the magnetic field generated in the emitting antenna by the alternate current induces an electromotive force in the receiving antenna. The magnetic field is supposed to be the sum of a bound field and radiation. The speed of propagation of the bound magnetic field is reported to be $v > 10c$ in the near zone $r < 1/2k$. In the far zone, $r >> 1/2k$, the speed of propagation of the bound magnetic field tends to zero with the radiation being responsible for propagation of the magnetic field with the speed c. When considering quantized bound magnetic field its wave function spreads instantaneously over the space. When measuring electromotive force induced by the bound magnetic field one deals with the non-stationary wave function defined within the radius $r \leq 1/2k$. This agrees with the results of the experiments.

So, experiments exhibit the wave behaviour of a single particle which can be accounted for with the wave function spreading instantaneously over the space. Also, transition from the quantum wave to the classical particle occurs in accordance with the projection postulate specifying the measurement procedure in quantum mechanics. The projection postulate governs the instantaneous collapse of the wave function, with detection of a single particle. It is worth noting that the projection postulate is inconsistent with the unitary evolution dictated by the Schrödinger equation. Therefore, one cannot understand quantum phenomena by analysing the Schrödinger equation itself with no use of the projection postulate.

In conclusion, the Schrödinger equation itself is not sufficient to describe quantum phenomena. One needs to add the definition of the wave function spreading instantaneously over the space as well as the projection postulate specifying the measurement procedure. Author of [1] do not regard experiments exhibiting the wave behaviour of a single particle and tries to dispense with the rules of quantum mechanics which account for these experiments.

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Reply to comment by D.L. Khokhlov on my paper "INCOMPATIBILITY OF THE COPENHAGEN INTERPRETATION WITH QUANTUM MECHANICS FORMALISM"

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The theoretical physics deals with dynamic systems and only with dynamic systems. These dynamic systems are continuous in quantum physics. In the classical physics the dynamic system may be discrete and it may be continuous. Describing a single classical particle, one uses discrete dynamic system, which has a finite number of the freedom degrees. Describing statistical ensemble of classical particles, one uses continuous dynamic system, which has infinite number of the freedom degrees. Dynamic equations for a single particle and dynamic equations for a statistical ensemble of such particles are similar. Describing a single classical particle, one has a system of six ordinary differential equations of the first order (6 degrees of freedom). Describing the statistical ensemble of these particle one has N such similar systems of ODE ($6N$ degrees of freedom), where N is the number of the particles in the statistical ensemble.

Investigation of only dynamic equations does not admit one to distinguish between the single classical system and the statistical ensemble, because the difference between them lies in the number of the freedom degrees, but not in the form of dynamic equations. Consideration of the action instead of dynamic equations admits one to describe both the dynamic equations and the number of the freedom degrees.

My paper is simply a mathematical theorem, concerning interrelations between different dynamic systems. It is rather strange, that the author of the comment tries to disprove the mathematical theorem by means of verbal reasonings and by references to experiments, which are interpreted, basing on the Copenhagen interpretation. The verbal considerations of the QM interpretation last since the time of the QM creation. They have not lead to any result, because they are based on the supposition that the QM interpretation does not depend on the QM technique. In reality, the quantum interpretation is conditioned completely by the properties of the dynamic systems, describing quantum particles [1].

In the paper I have not considered corollaries of the statistical interpretation for quantum measurement. This circumstance is connected with the fact, that primarily the paper was submitted to PRL. It was rejected from PRL without any explanation and reviews, although the mathematical solution of the QM interpretation problem is suggested first time, and this problem is very important for the theory of quantum measurements.

The fact is that, in the quantum mechanics there are two kinds of measurements: (1) single measurement (S-measurement), which is produced under a single particle (dynamic system) and (2) massive measurement (M-measurement), which is produced under statistical ensemble of single particles. Properties of the two kinds of measurements are different, and one may not substitute them by one kind of the quantum measurement. In the Copenhagen interpretation one consider only one sort of quantum measurements. As a result one have many different paradoxes (Schrödinger cat, EPR-paradox, enigmatic definition of the wave function reduction and other paradoxes, generated by confusion with the quantum measurement, when two different measurement processes united into one process). The first (extended) version of the paper may be found in [2].

The proven theorem is important in the relation, that it opens the door for the model conception of quantum phenomena, which does not use quantum principles. The model conception of quantum phenomena is a relativistic classical statistical theory of stochastically moving particles [1]. This model theory relates to the conventional quantum mechanics in the same way, as the kinetic gas theory relates to the axiomatic thermodynamics. Statistical character of the theory of quantum phenomena is important in the theory of quantum computers. At the Copenhagen interpretation the quantum computer theory looks more optimistic, than it is in reality.

Now I consider remarks of the author of the comment concretely

Author of the comment:

One can make a transition from the quantum mechanics to the quasi classical mechanics by approaching $\hbar \to 0$*, when the number of particles and the time of interaction are large enough. In this case one can ignore discreteness of the energy levels and consider quasi continuum energy spectrum. However in this way one cannot substitute the quantum wave (wave function) by the classical wave. Unlike the classical wave propagating with a finite speed the quantum wave spreads over the space with an infinite speed. It is instantaneous spread of the quantum wave over the space allows one to put the quantum wave into correspondence with a single particle.*

My comment:

Why do I need to consider the quasi-classical approximation and other secondary effects, if I can consider dynamic (quantum and classical) systems directly? All arguments of the author of the comment are based on the Copenhagen interpretation, whose invalidity is discussed.

Author of the comment:

The standard textbooks on quantum mechanics consider a lot of experiments exhibiting the wave behavior of a single particle including the Young's two-slit experiment. Also, the phenomenon of entanglement gives an example of the wave function defined instantaneously between two space-like separated states that was confirmed in Bell experiments, e.g. and references therein. Further another quantum experiments are considered..

My comment:

Consideration of numerous experiments in the standard textbooks is based on the Copenhagen interpretation. One uses the conception of one kind of the quantum measurement instead of two different kinds of experiments (S-measurement and M-measurement). This standard consideration does not admit one to solve the main question, whether the Copenhagen interpretation is compatible with the quantum mechanics technique.

Author of the comment:

It is worth noting that the projection postulate is inconsistent with the unitary evolution dictated by the Schrödinger equation. Therefore, one cannot understand quantum phenomena by analyzing the Schrödinger equation itself with no use of the projection postulate.

My comments:

It is quite true, that the projection postulate is incompatible with the Schrödinger equation. In the Copenhagen interpretation the projection postulate is some external procedure with respect to the QM operator formalism. It cannot be understood in the framework of the axiomatic conception of quantum mechanics, where the wave function is simply a formal vector in the Hilbert space. In the statistical approach to the quantum mechanics the wave function is the way of the ideal fluid description. The projection postulate is explained freely in terms of two kinds of measurements [2].

The situation in quantum mechanics reminds the situation in the theory of thermal phenomena, where there are two conceptions: (1) axiomatic conception and (2) the model conception. The axiomatic conception (axiomatic thermodynamics) is based on some enigmatic fluid (thermogen), which describes motion of the heat. The meaning of the thermogen is explained in the model conception as the chaotic molecular motion.

In the theory of quantum phenomena there are also two conceptions: (1) axiomatic conception (quantum mechanics) and (2) the model conception. The axiomatic conception is based on the enigmatic axiomatic object (wave function). The meaning of the wave function is explained in the model conception, which is a statistical description of stochastically moving particles. The wave function is an effective method of this stochastic motion description.

In both cases (thermal and quantum phenomena) the axiomatic conception appears first, because it is simpler, than the statistical one. The statistical conception is more perfect and may describe such phenomena, which cannot be described in the framework of the axiomatic conception.

Author of comment:

In conclusion, the Schrödinger equation itself is not sufficient to describe quantum phenomena. One needs to add the definition of the wave function spreading instantaneously over the space as well as the projection postulate specifying the measurement procedure. Author of [3] do not regard experiments exhibiting the wave behavior of a single particle and tries to dispense with the rules of quantum mechanics which account for these experiments.

My comment:

It is true, that the Schrödinger equation itself is not sufficient to describe quantum phenomena. However, the action for the Schrödinger dynamic system is sufficient. Both the projection postulate and the rules for calculation of average values may be deduced from this action, provided the quantum description is considered as a statistical description of stochastically moving particles. Transition from the axiomatic description to the model description is difficult. It was difficult in the case of thermal phenomena, when the physical community ignores papers of Hibbs and Boltzman. The same situation takes place in the case of quantum phenomena

References

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