THE ROLE OF CONCEPTUAL FOUNDATIONS OF QUANTUM THEORY IN THE DIALOGUE BETWEEN SCIENCE AND RELIGION

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Abstract

Recent development in the understanding of conceptual foundations of quantum theory is discussed, giving a particular attention to the analysis of the so called Schroedinger's cat paradox. The solution of this problem in the frameworks of Everett-Wheeler many-worlds interpretation of quantum mechanics is considered as well as the philosophical and theological consequences following from this interpretation. The recommendations are given concerning the use of problems, related with the conceptual foundations of quantum theory, in the educational process when introducing students and senior class pupils into the problems of dialogue between science and religion.

KEY WORDS: science, religion, dialogue, foundations of quantum theory, many-worlds interpretation

1. Introduction

Now, more than ten years since the regaining of state independence, the education system of Latvia, besides the natural science based disciplines, comprises the courses which are related with the teaching of the basic principles of Christianity. Both directions are important for the development of pupil's and student's perception of the world which, in a more general sense, is related to the problem of the dialogue between science and religion. The questions of dialogue between science and religion have been discussed earlier in (Tambergs, 1999; Tambergs, 2000). In this article, we shall review a somewhat narrower facet of this problem – the role of the conceptual foundations of quantum theory.

Quantum theory describes processes of the microworld. It is accepted that the starting point of this theory is 1900 when a new physical constant has been proposed – the Planck constant. The one hundred year anniversary of its discovery has been commemorated also in the Latvian popular scientific literature (Rolovs, 2000). Somewhat later, in the 20-30th years of XX millennium, the quantum mechanics has been developed. Its validity and successes in the study of microworld phenomena are universally acknowledged. However, the discussions about the conceptual foundations of quantum theory are still going on, and in the last few years these discussions have been especially prominent (Менский, 2000). To a certain extent, it is due to the fact that the development of experimental techniques made it possible to carry out several fine experiments, for instance, the investigation of quantum superposition for individual atoms (Haroche, 1998) as well as the first quantum teleportation experiment (Bouwmeester et al., 1997). These experiments have been described in Latvian in a popular article (Klotiņš, 2000).

There are two main directions in the physicists views about the conceptual foundations of quantum mechanics (Менский, 2000) which differ by their basic assumptions.

According to the first direction, the presently adopted definition of quantum mechanics allows to answer all questions which physics presents, and there are no quantum paradoxes. The supporters of this direction believe that everything is all right with quantum theory, and one should just apply it for the solution of specific physical problems. There are even opinions that quantum mechanics needs no interpretation (Fuchs and Peres, 2000).

The representatives of the second direction are not satisfied with this "just physical" level of quantum theory. They ask questions which are usually left beyond physics, i.e., reach outside the purely physical methodological limits. These questions extend even to the domain of philosophy and theology, and they are related with the acknowledgement of the existence of quantum paradoxes (Менский, 2000).

The author of (Менский, 2000) comments that the supporters of the first direction, who believe that these second type questions are senseless within physics domain, are right from their point of view because, in order to work productively in physics, one must restrict oneself to the exactly formulated "purely physical" problems. On the other hand, one can understand also the wish of physicists, belonging to the second group, to reach outside the bounds of the purely physical methodology, proposing more general questions associated with quantum paradoxes. The unraveling of these paradoxes presents new and intriguing conceptions, and our task is to show their consequences in the sphere of relationships between physics (as well as the natural sciences in general) and theology. We shall consider one of the quantum paradoxes – the so called Schroedinger's cat paradox, the quantum mechanical many-worlds interpretation related with it, the role of human consciousness in this interpretation and the philosophically-theological consequences of all of this.

2. The Schroedinger's cat paradox

One of the founders of quantum mechanics, Austrian physicist E.Schroedinger, has proposed the following thought experiment having several components. The first component is some unstable radioactive element nucleus, which, according to quantum mechanics, is described as a superposition of two quantum states – the undecayed nucleus state "1" and the decayed nucleus state "2". This quantum superposition $C_1\Psi_1+C_2\Psi_2$ itself is a new quantum state, where Ψ_1 denotes the wave function of the undecayed nucleus state and Ψ_2 denotes the wave function of the decayed nucleus state. Coefficient C_1, characterizing the probability $|C_1|^2$ to observe the undecayed nucleus, decreases with the time since the beginning of the experiment, while coefficient C_2, characterizing the probability to observe the decayed nucleus $|C_2|^2$ – increases.

The next component of that experiment is a device, registering the decay of the radioactive nucleus (for instance a Geiger counter), with an amplifier connected to the third component – a hammer, which breaks the ampula with a poison when the device registers a decay of the nucleus. A live cat is placed near this ampula, and the whole experimental set-up, starting with the radioactive nucleus and finishing with the cat, is placed in a closed container.

So, if the period of time since the beginning of this experiment is small, comparing with the half-life period of the radioactive nucleus, the probability to find a live cat, when observer opens the container, is great, while after the time, which many-times exceeds this nuclear half-life period, an observer with a greater probability would find a dead cat within. So, the superposition of two quantum states (undecayed and decayed nucleus), via a quantum measurement procedure (a Geiger counter with an amplifier, a hammer and an ampula with poison), is "amplified" and turned into the superposition of two macroscopical states – the superposition of live and dead cat. However, no observer has ever seen the simultaneously live and dead cat, as it would follow from quantum mechanics. Therefore, while the container is unopened, the logics of quantum mechanics makes us assume that the system "radioactive nucleus + cat" is a superposition of two states – "undecayed nucleus + live cat" and "decayed nucleus + dead cat". The essence of the paradox is such that the description of the whole situation depends on the fact whether we have opened a container to look what is within or not. One can also ask – why the superposition of quantum states, existing and experimentally observed for microscopical objects (atoms, atomic nuclei, particles), does not exist and is not observed when the number of microscopical particles is great – in the case of macroscopical objects (Schroedinger's cat)?

We shall not consider in detail the whole scope of questions and problems related with the investigation and analysis of superpositions of quantum states – let us note just a few moments:

1) It is assumed that the disappearance of quantum mechanical state superpositions and the system's transit to the macroscopical state is related with the so called decoherence process – the interaction of the considered quantum system with the environment. If one reduces this interaction to the minimum it would be possible to retain the superposition states of separate microscopical objects (photons, atoms) for a longer time.

2) Nowadays, especial attention is given to the direct study of quantum superpositions in systems with large number of particles, trying to enlarge these systems to macroscopical sizes. Very interesting results have been obtained in this direction recently. The paper (Friedman et al., 2000), published in summer of 2000, describes the creation of quantum superposition states in a really macroscopical size system using a superconducting quantum interference device. The physicists themselves are saying that the "Schroedinger's cat now becomes fat".

3) The results outlined above make one believe that there is no strict barrier between microscopic and macroscopic worlds, and, in "favorable conditions" (when decoherence is removed), the sphere, in which the laws of microscopical world rule, can be extended to the dimensions of macroscopical systems. So, in some sense, both worlds can coexist.

3. Quantum mechanical many-worlds interpretation

The decoherence conception can explain how within quantum mechanics one can obtain different alternative measurement results and observations, each with its own probability, like in the just considered Schroedinger's cat problem. However, reaching beyond the methodological boundaries of pure physics, one can suggest (Менский, 2000) to develop a theory, which would explain also the way how the definite choice between different superposition state components is made, for instance, the choice between "undecayed nucleus + live cat" and "decayed nucleus + dead cat" variants.

Such approach is proposed in the so called quantum mechanical many-worlds or Everett-Wheeler interpretation (Everett, 1957; Wheeler, 1957), known already since 1957. With regards to the growing interest about the conceptual questions of quantum mechanics, observed in last years, the Everett-Wheeler interpretation has attracted especial attention (Менский, 2000; Klotiņš, 2000).

The basic principle of the many-worlds interpretation is the idea of the unity of subject and object, when an observer (subject) and his measuring instrument together with the measured physical process (object) form a combined closed world – Universe. A decoherence problem is removed within this interpretation since there is no more division into the quantum microscopical world and the macroscopical environment. Each Everett-Wheeler world is associated with the one specific component of the quantum superposition state, and the number of these worlds depends on the number of different alternative measurement results which are allowed by this superposition. Therefore, according to the many-worlds interpretation, the observer and object are split, so that in each Everett-Wheeler world an observer obtains his own result, corresponding to the one specific component of the considered quantum superposition. The results, obtained in different Everett-Wheeler worlds, would be different, though there could be no preference with regards to reality. In the case of Schroedinger's cat, when the radioactive nucleus decays, at first, the cat is „split" (into the live cat and the dead cat) and, finally, when the container is opened, the observer is split in its turn – into the observer who sees a live cat and the observed who sees a dead cat. However, our everyday observer experience shows that only the one of many Everett-Wheeler worlds is realized, and there remains an open question: Who determines which of these worlds is realized and how this choice is made? Then, according to the cited work (Менский, 2000), one should make a conclusion which is very difficult for physicists:

"The theory, which would describe not just the set of alternative measurement results together with their probability distribution, but also a process which selects a [specific] result, should as a rule include the [observers] consciousness as well."

4. The philosophical and theological consequences of the many-worlds interpretation

One can see that the above-described quantum mechanical many-worlds interpretation, involving the notions about the subject-object unity and the inclusion of observer's consciousness into the theory, goes far beyond the methodological limits accepted in physics. It infringes the sphere of philosophical and theological problems and should be associated with the second line of views about the conceptual foundations of quantum theory mentioned in the introduction. Before we review these philosophical and theological problems in more detail, let us note that Everett-Wheeler interpretation does not provision an interaction between different worlds, and so there is no possibility to check the reality of that „many-worlds splitting". Therefore, further discussions about problems associated with the quantum mechanical many-worlds interpretation are of a purely speculative nature as yet.

As it has been noted in work (Менский, 2000), the idea, about the necessity to include in the theory an observer and even his consciousness, has been proposed by several prominent physicists – E.Schroedinger, W.Pauli, E.Wigner, starting from the creation of quantum mechanics. E.Wigner expressed even more extreme view, that it is not enough just to include the consciousness into the measurement theory but that the consciousness can affect reality. In order to solve two yet unsolved problems: 1) how the choice of one specific alternative occurs in the quantum measurement process and 2) how the observer's consciousness operates, the author of work (Менский, 2000) proposed a hypothesis that the function of consciousness is to choose one of several alternative results of quantum mechanical measurement process. In the case of many-worlds interpretation, this hypothesis means that the function or task of the consciousness is to choose one specific world (Universe) from the set of alternative Everett-Wheeler worlds. According to (Менский, 2000), only when this choice is made, some specific reality, which can be described by classical physics laws, comes into being, and, until this choice, there is only a quantum world with the characteristic set of different alternatives. In other words, only the choice of alternative determines what happens in reality (Менский, 2000).

Considering E.Wigner's idea about the possible impact of consciousness on the reality in the frameworks of many-worlds interpretation, the author of work (Менский, 2000) acknowledges the possibility that there can be the so called „active" consciousness of „miracle-maker" men, having special powers to choose some specific Everett-Wheeler world intentionally. For such „miracle-makers" with „active" consciousness, it would be possible to repeat many times the low-probability actions – to make miracles. The author (Менский, 2000) concludes that the breaking of natural laws could be possible in the individual experience of some „active" consciousness men. However, that experience wouldn't be confirmed by the ordinary consciousness people.

With regards to the fact that this work (Менский, 2000) was published in the most authoritative and serious physics journal of the Russian Academy of Sciences, we believe that the ideas proposed in it could be an essential stimulus for the dialogue between science and religion. So, let us point out the following:

1) The ideas about the unity of subject and object, about human consciousness as a reality choosing factor – in fact a measuring instrument, and about paying an attention to the hidden („miracle-maker") part of human consciousness are in agreement with the new paradigm (Tambergs, 2000) concerning the problem of man in modern science, proposed by V.Nalimov (Налимов и Дрогалина, 1995). It is well-known that the idea about subject-object unity has strong roots in the Eastern philosophical and religious tradition as well (Капра, 1994).
2) The Christian theological tradition points out a great importance of men's free will (Klīve, 1988), his choice to follow Gods' call or to submit himself to the power of Satan and evil forces, which could correspond to our conscious choice between different Everett-Wheeler worlds.
3) The acknowledgement, from the side of serious scientists (Менский, 2000), of the existence of "miracle makers" and the possibility to make miracles is directly related to religious views since a belief in miracles is an essential part of religion (Фейнберг, 1992; Tambergs, 2000).
4) In the frameworks of anthropic principle, the quantum cosmological models, describing „quantum states of the Universe" each associated with its own Everett-Wheeler world, have been developed (Barrow and Tipler, 1986). Some aspects of these ideas are analogous to the Eastern philosophically-religious and mythological concepts about great cosmological cycles, rebirth and reincarnation (Капра, 1994; Klīve, 1988).

The above outlined moments cover only some questions of the dialogue between science and religion which requires a serious analysis and appraisal in future.

5. Conclusion

In this work we have considered some ideas and problems, related with the recent developments in the understanding of foundations of quantum theory, their impact on the possible change of our conception of the outer world and ourselves in the XXI century, as well as the role of these questions in the dialogue between science and religion. Author's experience, since 1991 reading a lecture course about biblical and scientific conceptions of the world at the Faculty of Theology of the University of Latvia, has shown that in most cases student's views about the relationships between religion and science are „black and white", strictly maintaining either fundamentally-biblical (creationistic) or naturalistically-scientific points of view. It is possible that such opposition exists in other educational institutions as well. Therefore, the task of lecturers and teachers would be to lessen the tension between both lines of thought, pointing out the great potential possibilities which the dialogue of science and religion offers. The facts, outlined in this work, could be the basis on which students and senior class pupils could be introduced in the popular form into the problems of dialogue between science and religion.

References

Barrow J.D. and Tipler F.J. The Anthropic Cosmological Principle. Oxford: Clarendon Press, 1986.
Bouwmeester D., Pan J.-W., Mattle K., Eibl M., Weinfurter H. and Zeiliger A. Experimental quantum teleportation. "Nature", vol.390, No.6660 (11 December 1997), p.575-579; Sudbery T. The fastest way from A to B, *ibid.* p.551-552.
Everett H., III. "Relative State" Formulation of Quantum Mechanics. Rev.Mod.Phys., vol.29, No.3 (July 1957), p.454-462; Wheeler J.A. Assessment of Everett's "Relative State" Formulation of Quantum Theory. *ibid.* p.463-465.
Фейнберг Е.Л. Две культуры. Интуиция и логика в искусстве и науке. Москва. «Наука» 1992.

Friedman J.R, Patel V., Chen W., Tolpygo S.K. and Lukens J.E. Quantum superposition of distinct macroscopic states. “Nature”, vol.406, No.6791 (6 July 2000), p.43-46; Blatter G. Schroedinger’s cat is now fat, *ibid*. p.25-26.
Fuchs C.A. and Peres A. Qauntum Theory Needs No “Interpretation”. “Physics Today”, vol.53, No.3 (March 2000) p.70-71.
Haroche S. Entanglement, decoherence and the quantum/classical boundary. “Physics Today”, vol.51, No.7 (July 1998) p.36-42.
Капра Ф. Дао физики. Исследование параллелей между современной физикой и мистицизмом Востока. Санкт-Петербург. «ОРИС», 1994.
Klīve V. Pa kuru ceļu? Pārdomas par iespējamām atbildēm uz mūsu dzīves lielajiem jautājumiem. (Lincoln, Nebraska: LELBA apgāds) 1988.
Klotiņš Ē. Patiesība ir stiprāka par mums. Žurnāls “Terra”, Nr.4 (decembris 2000), lpp.6-11.
Менский М.Б. Квантовая механика: новые эксперименты, новые приложения и новые формулировки старых вопросов. «Успехи физических наук», т.170, №6 (июнь 2000) стр.631-648.
Налимов В.В. и Дрогалина Ж.А.. Реальность нереального. Вероятностная модель бессознательного. Москва. Издательство «Мир идей», АО АКРОН, 1995.
Rolovs B. Kvantu fizikai 100 gadu. Žurnāls “Terra”, Nr.4 (decembris 2000), lpp.12-13.
Tambergs J. Dabaszinātniskās pasaules ainas interpretācija bibliskā skatījumā. “Dabaszinātnes un skolotāju izglītība”, Rakstu krājums, 1.daļa. Rīgas Pedagoģijas un izglītības vadības augstskola, Daugavpils Pedagoģiskā universitāte. Starptautiskā zinātniskā konference, Rīga, 1999.g. 4-5.februāris. (Rīga: “Vārti”,1999) lpp.53-62.
Tambergs J. Zinātnes un reliģijas dialoga problēma 21.gadsimtā. “Ceļš”, LU Teoloģijas fakultātes teoloģisks un kultūrvēsturisks izdevums. Nr.52 (2000), lpp.209-229.

Резюме

В статье обсуждаются актуальные вопросы понимания концептуальных основ квантовой теории. Особое внимание уделено так называемому парадоксу шредингерова кота. Рассмотрено решение данной проблемы в квантовой механике на основе интерпретации множественных вселенных Эверетта-Уилера, а также философские и теологические следствия данной интерпретации. Даются рекомендации по использованию в процессе обучения проблем, связанных с концептуальными основами квантовой механики, знакомя студентов и учащихся старших классов с вопросами диалога науки и религии.