Article

Reasoning on Many-Worlds Interpretation of Quantum Theory

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ABSTRACT

Some difficulties that arise, when we try to imagine how a wave packet is reduced in the many-worlds interpretation of quantum theory, are discussed in the work. It is shown that suggested by now explanations how the "wave packet reduction" happens cannot claim upon the role of the final answer to this question, even though they are not formally contradictory.

Key Words: Many-worlds interpretation; quantum mechanics

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Introduction

Some difficulties that arise, when we try to imagine how a wave packet is reduced in the many-worlds interpretation of quantum theory, are discussed in the work. It is shown that suggested by now explanations how the "*wave packet reduction*" happens cannot claim upon the role of the final answer to this question, even though they are not formally contradictory.

Lots of people suppose that any interpretation that keeps constant the mathematical apparatus of a theory can bring no new information to it. A new interpretation can at best only explain the theory by any way and make it clearer. However it is difficult to agree with this statement. The interpretation can make something clear only, if it uses some concepts being connected with certain associations, whether they exist only at an intuitive level. Thus, the information connected with the similar associations, even not formulated logically, is brought inevitably to the existing theory to stimulate new questions and new statements in it.

Let us make an example to explain this idea. Let the theory describing all that is going on around is formulated as follows: any event happens only by the will of Demiurge (*Creator*). Thus, almost all the people simply believe with no logic definitions that Demiurge should be an all almighty and omniscient being with boundless intelligence. However one can come to an agreement even with any intellectual being in some cases. We have just come to the statement is meaningful to pray. It directly follows from the Demiurge associations. If we have replaced the Demiurge with another neutral term, for example, the multiverse that does not cause similar associations, the question on the benefit of a pray would be much more problematic.

Let us discuss now the many-worlds interpretation of quantum theory (Everett, 1957; DeWitt, 1973) in view of the above considered. It is actually a consequence of a very simple statement. If we take that everything in the world is described by quantum theory, the following relationships should be satisfied in all cases without exception:

$$\psi\left(\mathbf{r},t_f\right)\equiv\hat{U}\psi\left(\mathbf{r},t_i\right) \quad (1)$$

$$\psi\left(\mathbf{r},t_i\right)\equiv\hat{U}^{-1}\psi\left(\mathbf{r},t_f\right) \quad (2)$$

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where $\psi(\mathbf{r},t_i)$ is a wave function at the initial time moment t_i, $\psi(\mathbf{r},t_f)$ is a wave function at the final time moment t_f, and $\hat{U}$ is an evolution operator from t_i to t_f. However if the wave packet is reduced in the time interval between t_i and t_f, i.e. from the variety of possible states being described by $\psi(\mathbf{r},t_f)$ only one is left after the interaction with an observer, relationship (2) will not obviously fulfilled. (In this case even the reverse operator cannot be constructed in principle). Hence, on the assumption that the world is described by quantum theory, it must necessarily follow that "reduction" cannot exist. If we can observe only one state in an experiment, it is only because other states do not fall under our observation as they posses to any other "worlds".

However the many-worlds interpretation does not explain directly what these "other worlds" are. However it is supposed by default, that not everything, but some of these "worlds" resemble the usual classical world that we know. Thus, except for reasons such as "Such worlds should exist, as we live in one of them", any stricter argumentation is not presented for similar statements.

Let us try now to hunt down those difficulties which arise at attempts to imagine what the "worlds" could be. First of all, it should be noted that trying to describe the totality of similar "worlds", it is necessary to avoid statements basing on the concepts which have come directly from the quantum theory. Otherwise we can easily and insensibly get into a logic circle situation (*petitio principii*) when explanations are based on concepts which, in fact, are consequences of the similar explanations. (Among other statements we can come by this way to a formally faultless, but actually senseless statement such as "The fact that our world is described by quantum theory is impossible to understand without considering its structure on the basis of the many-worlds interpretation, understanding of which is impossible without using entities being introduced in consideration by quantum theory".)

Let us begin with the elementary variant with lots of "worlds". It is easy imaginable and even visible, and that is especially important, it is necessary to use no concepts taken from quantum theory. Suppose that these "worlds" are located in different parts of a "space", and we mean not the common three- or four-dimensional space under such term, but something less certain, such as, something like a multidimensional space. Its particular structure is not important for us, but only one its feature is essential: no point of the space can simultaneously belong to two or more such "worlds". Another essential feature is that objects being located in different "worlds" do not interact with each other. (It is a direct consequence of the statement that the "worlds" cannot "see" each other).

Let us consider an observer in any i^{th} "world". Assume that the observer detects a position of some particle. No matter what time moment he/she is observing at, he/she can never see a particle in two or more positions at once, but only in one position. One of two statements could be made from here. Either the particle in this fixed "world" is also in the certain point of the space at every given time moment between observations (i.e. in different points in different "worlds"), or if it isn't so, the "wave packet reduction" happens inside this i^{th} "world" at the observation moment too. If to accept the second of these statements as true, we shall come to the logic contradiction. On the one hand, according to the condition accepted by us, the observer is in the certain i^{th} "world", but on the other hand, if the "wave packet reduction" happens in it, this certain "world" should itself consist of set of various "worlds". If the first of the above-mentioned statements is accepted as true, we shall come to the contradiction with quantum theory, at least with quantum theory in its standard understanding. Actually, according to the quantum theory to calculate a probability of presence of a particle in some point at the given time, each of the similar trajectories in different "worlds" should be assigned to the complex numbers named "probability amplitudes", then these numbers should be summed, and then the module of the obtained sum should be squared. Thus, this mathematical operation will cause the appearance of terms representing products of values that contain the information on the trajectories in the various worlds. In other words, the probability to realize a trajectory in the given i^{th} "world" in the quantum case will depend on that happens in other "worlds" not

interacting with this world. At the same time, if the first of the made above statements is taken as true, the probability of appearance of any trajectory (this probability can be determined as the relation of a number of "worlds" where such trajectory was realized to the total number of "worlds") will be a functional, depending only on the defining this trajectory function, and no other trajectories realized in other "worlds".

Thus, this rather primitive model of the multiverse, the one advantage of which is rather illustrative, does not suit for principle reasons. Let us try to discuss other possible models now.

In the beginning we try to find out, whether any changes could be made in the considered model, as a result of that the presented above statements on the inconsistency of the model will not be applicable to it more. In principle, such changes could be made. We can assume that the number of "worlds" is not constant, but varies in time after every the "wave packet reduction". The "worlds" in this model are similar to tree branches when lots of new branches grow from every branch, each of which generates, in turn, some new ones, etc. Here the statement that the "wave packet reduction" cannot happen inside the given i^{th} "world", since the reduction leads to the logic contradiction becomes false. Respectively this model should be correct from this side. However some new questions arise connected with the "wave packet reduction" first of all. In fact not every process is accompanied with this "reduction". For example, when particles collide in an accelerator, all the processes in the collision zone do not require using the concept of the "wave packet reduction" for the consideration. The "reduction" arises only at the final stage for detecting the scattered particles far from the collision zone. Thus, it appears unclear absolutely, why such processes with the "reduction" are marked out among others, that only they cause the multiverse reconstruction and change of the number of "worlds"?

Let us pass now to other such unclear questions. Short, but not infinitesimal time is required to detect a particle position. What happens with the multiverse for this time interval where the number of "worlds" should change? What should be the multiverse structure that an observer getting into one of the possible "worlds" in this time could not see the same observer, but getting into another "world"?

Another unclear question is connected with the relativistic invariance. Indeed, while we consider a non-relativistic situation where time is absolute, we can think that a number of "worlds" (a numbers of "branches", if the introduced above visual metaphor is used) is changed in the whole space at once. However, in the relativistic case the similar rearrangement can result in serious difficulties, even if the information cannot be transferred with a speed exceeding the light speed in vacuum (that, in turn, requires separate evidence!).

And, at last, an absolutely strange question whether will processes are in general invariant relative to the time shift and time reversal in such a system with a variable and increasing in time number of "worlds"?

Certainly, in principle, since the model does not contain direct contradictions, some answers all these questions (though not many would recognize them as answers) can be provided. The matter is that these answers appear rather formal. They look like not as the explanations based on understanding of the specific structure of the similar multiverse and its functioning, but more likely as a set of postulates such as "It have been so, because we have accepted as a condition or an axiom that should be exactly". Unfortunately, this model (and others similar to it) does not possess that Einstein considered as the most important attribute of a correct fundamental theory – internal perfection. Therefore we shall not discuss it further, but we shall try to consider below other more interesting models as seems to us.

The main feature of the "wave packet reduction" is that its realization needs a presence of a living creature as an observer, even may be a living creature with consciousness and thinking. It is entirely possible that such living creature can be only a human. Therefore it was completely logical, as it was offered by M. B. Mensky (2007), to connect the "reduction" with taking the "quantum world" by the human. Exactly: if to consider the human is created by the way that he/she cannot take itself (and respectively the "world" that he/she can "see") in the intermediate state, it is completely clear that

belonging any object to any "world" is extracted by the human's consciousness. That is we pass in fact to subjective idealism positions: the "world" perceived by us is a kind of "sleep" of the human's consciousness.

Certainly, lots of questions arise here, and some of them are simply taken from criticism of subjective idealism. We will consider only one of them, probably not the most interesting and incomprehensible.

We know (if it is actually even not so, it at least seems to us) that the individual human's consciousness is rather closely coupled with this human. The human in total simply represents a rather complex structure constructed from such elements as carbon, hydrogen, oxygen, nitrogen, sulfur, and lots of others that are in much smaller amounts. A human has no especial fundamental distinctions from others even more complex structures in the universe. Certainly, if we study "sleeps" of this structure, that is, how the structure conceive a reality around it, that it can "see", and that it cannot "see", so its features play the main role. As for some "simple" influences being able to destroy this structure, all its complexity and complexity of its perception mechanisms play no role. In relation to these influences the human-observer, apparently, is marked out by absolutely nothing in comparison with all other objects which are not causing the "reduction". Respectively, it is not clear, why the similar influences even if they proceed from other "worlds" being "invisible" for consciousness of this observer do not act on it? In fact, the destruction is destruction with no dependence on whether it is fixed by consciousness or not.

Certainly, it is possible to answer like this both this question, and lots of similar ones. Thinking in the considered above way, he/she comes to a logic contradiction. On the one hand, he/she recognizes that the reality being seen by the observer is like his/her "sleep" (where everything and the destroying influence among others is a "sleep" for him/her), and with another hand, he/she thinks all surrounding the observer as an objective reality, even the "quantum reality".

Given that the reality is not objective and it is only "the sleep of reason", the initial question becomes senseless – why we "see" not the whole reality, but only its part? It is difficult to consider the answer to a question that destroys the question in general.

A partial answer to the discussed question could be in the hypothesis that has been brought forward in (Mensky, 2007; 2011; 2012) that a human has a kind of "postcorrection" ability, *i.e.*, the ability to correct his/her behavior in present time depending on that should be happened with him/her in the future. Apparently, it allows him/her to avoid the future destruction in some cases as against nonliving objects. Though neither specific mechanism of the postcorrection, no proofs of its existence being met the standard scientific criteria are presented in (Mensky, 2007; 2011), this hypothesis nevertheless deserves the closest attention.

Coming back to the beginning of the article, we can say that no actually consistent explanation of the reasons why various quantum "worlds" do not "see" each other and do not interact among themselves is brought forward for the present time.

Most likely, it is a consequence of that those concepts and entities on which we base trying to find such explanation are inadequate to the available reality.

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