SIMULATED INTERPRETATION OF QUANTUM MECHANICS

Miroslav Súkeník & Jozef Šima

Slovak University of Technology, Radlinského 9, 812 37 Bratislava, Slovakia

Abstract: *The paper deals with simulated interpretation of quantum mechanics. This interpretation is based on possibilities of computer simulation of our Universe.*

1: INTRODUCTION

Quantum theory and theory of relativity are two fundamental theories elaborated in the 20th century. In spite of the stunning precision of many predictions of quantum mechanics, its interpretation remains still unclear. This ambiguity has not only serious physical but mainly philosophical consequences. The commonest interpretations include the Copenhagen probability interpretation [1], many-words interpretation [2], and de Broglie-Bohm interpretation (theory of pilot wave) [3]. The last mentioned theory takes place in a single space-time, is non - local, and is deterministic. Moreover, Born's ensemble and Watanabe's time-symmetric theory being an analogy of Wheeler – Feynman theory should be mentioned. The time-symmetric interpretation was later, in the 60s re-elaborated by Aharonov and it became in the 80s the starting point for so called transactional interpretation of quantum mechanics. More modern interpretations cover a spontaneous collapse of wave function (here, a new non-linear component, causing this collapse is added to Schrödinger equation), decoherence interpretation (wave function is reduced due to an interaction of a quantum-mechanical system with its surroundings) and relational interpretation [4] elaborated by C. Rovelli in 1996. This interpretation treats the state of a quantum system as being observer-dependent, i.e. the state is the relation between the observer and the system. Relational interpretation is able to solve the EPR paradox. Along with many others more or less known interpretations, an interesting feature represents the instrumental interpretation which is absolutely pragmatic by the fact that it waived any interpretation of quantum mechanics. Interpretation of quantum mechanics lies rather in the philosophical than mathematical-physical level. The core of the problem is of why quantum theory is not deterministic (even if in some interpretations it might be) and mainly, how and why wave function collapse happens and what is the role of the observer. Up-to-now offered interpretations and not satisfactory enough. There are about 20 variants of them and new ones emerge.Double-slit experiment led to a conclusion that just the act of observation (consciousness) was able to influence the reality in the form of causing the collapse of wave function and changing wave properties to classical (corpuscular). This is the issue which is an object of tentative explanation by individual interpretation of quantum mechanics. A disadvantage of the Copenhagen interpretation is its probabilistic nature, that of the many-words interpretation is an excessive (even luxury) creation of a new Universe always following an action in an original Universe. Transaction interpretation fights with an incomprehensible selective effect of advanced waves. Theory of wave function collapse introduces anti-Occam and superfluous non-linear member into Schrödinger equation, decoherent interpretation is not able to explain the initial state of the Universe, where due to a high density and pressure, decoherence in principle disposes of validity of quantum theory (due to an instant decoherence no quantum systems could exist). Rovelli's relational interpretation seems to be subjective, explanation of von Neuman and Wigner is interesting but unable to explain the mode of how the observer (consciousness) can cause wave function collapse just by the act of observation of a quantum system. Whether pilot waves or hidden variables are used, all such interpretations are inadequate, insufficient and improbable. In fact, just two interpretations relate to the point. Von Neuman – Wigner interpretation correctly informs both on the consciousness and wave function collapse. It means, the actual consciousness influences the reality. The only defect of beauty is that the mode how it can be done is not known. A second appreciable interpretation is the Everett many-words one. In it the consciousness does not influence the reality al all, and wave function does not collapse. The world undergoes just disintegration and in a corresponding Universe any of the possibilities may be realized. As a weak point of this interpretation, a horrible waste of Universes – the inflation of a term Universe itself should be pointed out.

2: THE UNIVERSE AS A COMPUTER SIMULATION

Nowadays, even in scientific and sci-fi literature, we can still more frequently meet hypotheses indicated that our Universe could be a computer simulation [5]. Those responsible could be beings who are before us in science and technology. In case the simulation of our Universe would be elaborated by sufficient computing capacity, we would not be able to distinguish simulation and reality. In case the mankind is a single intelligent entity in such a virtual Universe, it would not be necessary to simulate perfectly the whole observable Universe. The higher distance from our Solar system, the lesser precise and perfect simulation is necessary. At the time being we are able to simulate reality, however, only in a small degree. In October 2012 a paper „Constraints on the Universe as a Numerical Simulation“ was published in arxiv.org. [6]. The authors claim that scientists are able today simulate our Universe based on quantum chromodynamics in the range of femtometers and such simulation are not distinguishable from the reality. At present even such a small simulation is conditioned by together working the several most efficient computers. It is expected that within a few years we will be simulate a space of the biological cell dimensions. A further development of computing technique will create conditions for simulation still larger and larger parts of the Universe. At the mentioned simulation a discrete three dimensional lattice was used on which a given space was modelled. It is possible that due to a validity of holographic principle, a three dimensional lattice might be substituted for a two dimensional lattice. Holographic principle states that all information contained in a space volume are located on a surface confining that volume. The justification of the principle was for the first time evidenced when dealing with black holes. Of course, the situation in simulation will improve introducing quantum computers.

To simulate the whole Universe in detail, 10^{123} bits of information are necessary to use (calculated as the area of observable Universe divided by the square of Planck length) [7, 8].

Picture 1: ***Computer simulation of a galaxy, with the dark matter colourised to make it visible. Image credit: Springel et al., Virgo Consortium, Max-Planck-Institute for astrophysics.***

3: A BRIEF PROPOSAL OF SIMULATED INTERPRETATION OF QUANTUM MECHANICS

In connection with simulated Universe it can be expected that if we find any failure in the programme, it will probably be in cosmological distances where a high precision of the simulation is not so necessary. Paradoxically, the same may be said on microworld. A substantial part of operational programme used to simulate our Universe can be spared if those parts of the Universe, which are not observed by a simulation observer, are not displayed or are displayed just approximately. It would explain the entire microphysics as a collapse of wave function.When we do not observe a quantum system (elementary particle) it can be located anywhere and in any quantum state (or superposition of states). Using our common senses we cannot detect a quantum system and it can thus be modelled only approximately, saving thus a huge amount of computing capacity. Only after a detailed identification of the quantum state using instruments, a collapse of wave function happens and the particle will appear in a concrete state and concrete place. The same may hold for the macroworld as well. All things which are not observed by a simulated conscious observer at a given time need not be mathematically simulated, i.e. they cannot exist. In quantum mechanics, "observation" means , quantum measurement "observer" is a measurement apparatus, and "observable" with what can be measured. Thus the quantum mechanical observer does not have to *necessarily* present or solve any problems over and above the issue of measurement in quantum mechanics. The quantum mechanical observer is also intimately tied to the issue of observer effect.

It might represent another interpretation of not just quantum mechanics but the whole physical reality. The terms such as matter, charge, spin, time, space, Universe would be thus reduced to the single term information. Such type of interpretation of quantum mechanics has not been taken into account up to now. Now, let us characterize this interpretation. This interpretation is non-determined with a real wave function. There is a unique history, wave function collapses and the role of the observer is decisive. There are no hidden variables, non-locality holds and the universal wave function exists. This interpretation is identical to von Neuman – Wigner interpretation formulated in

1932 [9]. We are able to explain it in the simulation model through efficient/economic? behaviour of a programmer. Why to simulate the whole quantum mechanics when nobody observes? This is a reason of why quantum mechanics is so uncertain, blurry and probabilistic. In case of using an accelerator and observing in detail, simulation begins to fully run and wave function collapses. This is the exact weak point of von Neuman – Wigner theory. They know on wave function collapse induced by observation, however they are not aware of why it is so, since in their time simulation was not considered. There are no hidden variables, non-locality is hold which was proved in case of entangled quantum systems (instant effect between the particles separated by a large distance) evidenced in the 80s of the previous century by Aspect's experiments). In our case the non-locality can be incorporated directly into a simulation programme.

There is, however, one probable possibility in addition, i.e. parallel simulation of more Universes, something as a virtual Multiverse. If it is a case, the interpretation would be fully deterministic, with an actual wave function, without a unique history and hidden variables. The wave function would undergo a collapse and the role of an observer would be again decisive. Non-locability and the existence of universal wave function would still hold. This kind of interpretation of quantum mechanics would be unique. It is so since in case of simulated many Universes it would be possible, following the wave function collapse, to determine a particular state or a position of particle and all states and positions would be realised in all existing universes. Then, even the history would not be unique since the current state could be accessible by various ways in different Universes. Our approach differs from that of Everett in the role of consciousness and wave function collapse. In the Everett approach the wave function does not collapse since at any action a new Universe is created so as in the result all possibilities of how to the action can terminate were included. This is why the role of the observer is meaningless. The Everett interpretation is extremely demanding since at any moment new and new Universes must be created. Contrary, applying simulated interpretation nothing must be created. It is enough to react by a reasonable simulation to the observer.

4: CONCLUSIONS

The presented hypothesis on computer simulation of our Universe has not been either proved or refuted. It might happen that during the time malfunctions in simulated programme will be identified and manifested through a determinism or causality violation, both in macrocosmos and microcosmos. The smaller dimensions will be observed in quantum theory or the larger in the

Universe, the higher the chance to unveil some malfunctions. Perhaps, such excesses are observed even at present in the form of dark matter and dark energy in macrocosmos. The essence of interpretation of quantum mechanics lies in explanation of why and how decoherence of the quantum system occurs leading to subsequent wave function collapse, and what is the role of consciousness in this process. Stemming from simulated interpretation it is a consequence of economic/efficient behaviour of the programmer aimed at optimizing the capacity of its operational and computing system. In other words, ***the reality is influenced by the consciousness since the reality is simulated and the programmer saves and optimizes its sources.*** If there is a single simulated Universe, von Neuman – Wigner interpretation is correct and we provided ammunition to it (explanation of how it is possible), our interpretation is, therefore, more complete. If there are many Universes simulated (an analogy of Everett'approach), our interpretation will differ from it in the fundamental issue, i.e. influence of consciousness on the reality and in wave function collapse. According to our approach, there is no necessity to lavish Universes. Our interpretation is in this meaning much simpler and thus probable (Occam razor principle).

REFERENCE

[1] Bohr, N. (1934/1987), *Atomic Theory and the Description of Nature*, reprinted as *The Philosophical Writings of Niels Bohr, Vol. I*, Woodbridge: Ox Bow Press.

[2] Everett, N. 1973, in The Many-Worlds Interpretation of Quantum Mechanics, ed. DeWitt, B. S. & Graham, N. (Princeton: Princeton Univ. Press)

[3] Bohm, David (1952). "A Suggested Interpretation of the Quantum Theory in Terms of 'Hidden Variables' I". *Physical Review*. 85 (2): 166–179.

[4] Rovelli, C., 1996, “Relational quantum mechanics”, *International Journal of Theoretical Physics*, 35: 1637–1678.

[5] Bostrom, N., „Are you Living in a Computer simulation „ *Published in Philosophical Quarterly (2003), Vol. 53, No. 211, pp. 243-255.*

[6] Silas R. Beane, Zohreh Davoudi, Martin J. Savage „Constraints on the Universe as a Numerical Simulation“ arXiv:1210.1847[hep-ph]

7] Sukenik, M.,Sima.J „.Nondecelerative cosmology“Scholars Press 2015 ISBN13: 9783639766509

[8] Sima.J, Sukenik.M.,“ New approaches to cosmology“ LAP 2017 ISBN-13: 978-3659793776

[9] von Neumann, John. (1932/1955). *Mathematical Foundations of Quantum Mechanics*. Princeton: Princeton University Press. Translated by Robert T. Beyer