Physics – Uspekhi **46** (12) 1307 – 1309 (2003)

LETTERS TO THE EDITORS

PACS numbers: **01.55. + b**, **01.70. + w**

In defence of quantum idealism

M A Popov

DOI: 10.1070/PU2003v046n12ABEH001642

Contents

Abstract. **Quantum physics is discussed in the context of the philosophy of idealism.**

1. Introduction

Certain characteristics of quantum particles cannot exist without the experimentalist. Correspondingly, experiment (but not simply 'measurement') is a natural state of the quantum world.

However, according to Einstein, such Quantum Solipsism (using the Einsteinian term [1]) is a "risky game, playing with reality – reality as something independent of what is experimentally established" [2].

In contradiction with his own idealism (see, for example, K Gödel's "Remark about the relationship between Relativity theory and Idealistic philosophy" [3] and contemporary studies on the pseudo-tensor problem in General Relativity [4]), Einstein (like Vladimir Lenin earlier [5]) suggested that physicists must believe certain characteristics of quantum particles can exist without the experimentalist, even if quantum experiments prove the opposite [6].

The Entanglement Paradox, formulated by Einstein, Podolsky, and Rosen in 1935 [7], was not, however, able to stop development of Quantum Idealism in physics. And today, when the Einstein – Podolsky – Rosen effect, in which strong correlations are observed between presently non-interacting particles, even if they are detected arbitrarily far away from each other, [8] is routine in the laboratory, we may at last regard Quantum Solipsism (but not Berkeleianism in general) as taking the experimental idealism of modern science seriously.

According to E Schrödinger (1961), "Scientific knowledge forms part of the idealistic background of human life" [9], and humans are exalted from an ignorant state to *True Humanity*.

Thus, although the imperfection of Quantum Idealism is the unwelcome and unpleasant property of modern experimental idealism in science, we may expect that the traditional dominance of trivial 'materialism' in quantum physics cannot, however, *always* be tolerated. In one way or another, the evolution of scientific knowledge is moving remarkably close to an *idealistic picture of nature*.

2. Kinds of objections to quantum idealism

Certain characteristics of quantum particles cannot exist without the experimentalist; thus, generally speaking, the experimental-like state of quantum matter is as fundamental and natural as the liquid, gas, solid, and plasma-like states of matter (in other words, EXPERIMENT is a so-called 'FIFTH' state, speaking historically).

However, it is difficult *not* to think of the experimental quantum result as referring to some pre-existing, 'locally realistic' or 'hidden' property of 'objective' reality, which must exist without the experimentalist.

Such cognitive difficulties are traditionally expressed by different kinds of objections, deduced usually from the common-sense attitudes of *Anti-Idealism*. In 1990, John Bell in his stimulating article "Against 'measurement'" [10] defined three main kinds of objections to quantum idealism in contemporary quantum mechanics.

2.1 Objection in the Landau – Lifshitz manner

This kind of objection is quite clear and well-defined. According to Bell, the Landau – Lifshitz objection (or 'LL-objection') emphasizes, following N Bohr, that quantum mechanics requires for its formulation 'classical notions', namely: a 'classical apparatus', 'classical measurement', 'the classical insignificance of the presence of an external observer' (inhumanity), and a small quantity of quasi-classical mathematics.

Hence, we can formulate the LL-objection in the following manner:

STEP 1. It is in principle impossible to formulate the basic concepts of quantum mechanics without using classical mechanics [11].

M A Popov The Royal Institute of Philosophy,
14 Gordon Square, WC1H OAG, London, United Kingdom
Tel. (44-0207) 326 21 49. Fax (44-0207) 383 40 61, (44-0798) 602 61 08
E-mail: j.garvey@royalinstitutephilosophy.org,
j.armstrong@langfordgreen.demon.co.uk

Received 21 May 2003
Uspekhi Fizicheskikh Nauk **173** (12) 1382 – 1384 (2003)
Translated by M A Popov; edited by M V Chekhova

STEP 2. The possibility of a quantum description of the motion of an electron also requires the presence of physical objects which obey classical mechanics to a sufficient degree of accuracy.

STEP 3. In this connection the 'classical object' is usually called the 'apparatus' and its interaction with the electron is spoken of as 'measurement' [11, p. 3].

STEP 4. Thus, by 'measurement' in quantum mechanics we understand any process of interaction between classical and quantum objects, occurring apart from and independently of any observer [11, p. 3].

STEP 5. Hence, even if quantum measurement is related to the fact that the dynamical characteristics of the electron appear only as a result of the measurement itself, nevertheless, it is 'clear' that the measured quantity has in itself a definitive (pre-existing) value independent of the measurement [11, p. 3].

Following [10], let us consider mathematically a system consisting of two parts: the classical one (the apparatus) and the quantum one (an electron).

The states of the apparatus are described by quasi-classical wave function $F_n(z)$, where the subscript n corresponds to the 'reading' g_n of the apparatus and z denotes the set of its coordinates.

Let $F_0(z)$ be the wave function of the initial state of the apparatus. Correspondingly, $W(q)$ is the wave function of the electron. Then the initial wave function of the whole system is the product

$$W(q)F_0(z)\,.$$

Hence, after the measurement we obtain a sum $\sum A_n(q)F_n(z)$, where the $A_n(q)$ are the functions of q.

The 'classical' nature of the apparatus means that at any instant the quantity g (the 'reading' of the apparatus) has some definite pre-existing value.

"This enables us to say that the state of the system apparatus + electron after the measurement will in actual fact be described not by the entire sum, but by only the one term which corresponds to the 'reading' g_n of the apparatus" [11, p. 22], or $A_n(q)F_n(z)$.

Hence, Landau and Lifshitz established the following 'objective' theorem (for objective physics *without* the observer).

Theorem. $A_n(q)$ is proportional to the wave function of the electron after the measurement [11, p. 22]

2.2 Objection in the Kurt Gottfried manner

This is an ambitious, innovative, and somewhat puzzling decoherence-oriented form of the objection, developed by Kurt Gottfried in 1966 and refined in 1991 [12, 13].

As is well known, von Neumann in his "Mathematical Foundations of Quantum Mechanics" (1955) divided the world into three parts: 1, 2, 3, where 1 was the system actually observed; 2, the measuring instrument, and 3, the actual observer [14]. Hence, von Neumann showed "that the boundary can just as well be drawn between 1 and 2 + 3 as between 1 + 2 and 3" [14, p. 421].

In contrast with von Neumann, however, Gottfried supposed that the basic global structure of the whole world (or W) is:

$$\mathrm{W} = \mathrm{S} + \mathrm{R}\,,$$

where S is the quantum system and R is the rest of the world — from which measurements on S are made. Thus, in the 'objective' whole world, the existence of the physicist-observer is not needed.

"Physics, in contrast to difficult pursuits, is the study of reproducible phenomena. In the microscopic realm it is an empirical fact, learned without any help from theory, that only the behavior of ensembles is, in general, reproducible, whereas that of individual systems is not. At one time it was impossible to entertain the conjecture that there are hidden variables which, when discovered will remove the need for STATISTICS at a fundamental level, but the experiments inspired by the Bell inequality have shut that escape hatch as they rule out all but non-local hidden variable theories. Hence a STATISTICAL theory of the microcosmos is all that theoretical physics should seek" [13, p. 36].

2.3 Objection in the van Kampen manner

This is a 'perfectionist' kind of quantum idealism, which supposes that quantum mechanics is "a perfectly logical, coherent physical theory, which can be understood rationally" [15, p. 17] without any irrational feeling.

According to van Kampen, the irrational feeling is the main problem in quantum physics, because it "has led to those fanciful 'interpretations' involving hidden variables, the mind of the observer, many worlds, or modifications a la Ghirardi et al. They are unnecessary and unhelpful for understanding mechanics. John Bell, Roger Penrose and others writing for the general public do a disservice to science by clothing quantum mechanics in a MYSTICAL aura." [15, p. 17].

The 'perfectionist' canon of quantum mechanics, hence, includes the following perfect definitions in van Kampen's later manner:

(1) quantum mechanics deals with phenomena observed and recorded by a macroscopic apparatus. In order to be sensitive to a microscopic event the apparatus is prepared in a metastable state. Correspondingly, the event triggers a transition into a stable state, and thereby leaves an indelible record [15];

(2) a 'macroscopic system' is a quantum system with so many degrees of freedom that individual energy eigenstates and eigenvalues lose their relevance [15];

(3) a 'measurement' involves an interaction between the object and the apparatus and is described by the Schrödinger equation for the combined system [15];

(4) it is essential to differentiate between the collapse of the wave function and the collapse of probability. Unfortunately, the use of a density matrix tends to confuse both collapses [15, p. 17];

(5) collapses occur independently of the observer, once he has chosen his experiment [15];

(6) the wave function is a mathematical tool for computing probabilities. Probabilities can be compared with observations only by repeating the experiment many times.

Conclusion: quantum mechanics can be understood without any kind of irrational feelings [15, p. 17].

3. Crucial experiment

In his basic work "The Foundations of Idealism" Prince Sergei Nikolayevich Trubetskoi (1862 – 1905) gave a systematic analysis of the fundamental findings of philosophical idealism in the terms of the beginning of the 20th century science.

In particular, he showed that the basic assumption of all genuine idealists from the Eleatic School to Hegel is contained in the *formula*:

"There can be no doubt that all our knowledge begins with experience. However, we do not know reality beyond our consciousness, for we know only reality that exists in our consciousness. Correspondingly, there is no reality beyond our consciousness. Hence, things cannot exist without the mind" (hence, as a consequence — there is no object of experience without the subject; such an object as a thing-in-itself, as an unthinkable and unspeakable absolutely independent object, cannot exist at all; what we cannot think cannot exist, etc.) [16, p. 597–613].

As is well known, in order to test this *formula*, Kant developed the idea of so-called 'psychological self-experiments' where the experimentalist tries to imagine any object beyond space and time [16]. Sergei Trubetskoi, following Kant, made an attempt to use a kind of 'thought experiment' in order to prove the *formula*. In particular, he suggested that we cannot imagine the existence of a non-organic universe without the observer.There can be no doubt that contemporary science can help us in the reconstruction of this initial history of the universe without a reasonable observer. However, these descriptions are the descriptions of some imaginary, but not genuine, observer living at the time of the genesis of the universe [16, p. 606].

In 1935, Einstein, Boris Podolsky, and Nathan Rosen for the first time in the world history of idealism translated ANTI-IDEALISM into the experimentally verifiable conclusions of a crucial experiment [7].

We may describe this 'EPR-experiment' in David Bohm's terms as a quantum experiment where a particle with no spin, while at rest, decays into two identical particles (labeled 1 and 2), each with spin 1/2. Since momentum is conserved , the particles fly out in opposite directions. And since spin is conserved, the two spins must add up to zero. Therefore, if the spin of particle 1 is measured to be 'up' along some specific direction, then the spin of particle 2 must be 'down' along some specific direction. This 'experimental nonsense' was used by Einstein–Podolsky–Rosen to prove the existence of 'local reality' as something independent of the consciousness of the observer.

In the mid-1960s, John Bell showed that it was indeed possible to realize the EPR-experiment, when the two particles are emitted with definite spin directions, which are locally fixed at the decay. These directions, according to Bell, however, might be unknown to the experimentalist. He then showed that if we measure the spin of particle 1 along one direction, and the spin of particle 2 along another direction, the results will be correlated. For instance, if we measure the spin of both particles along the same direction, particle 2 will always have the spin down when particle 1 has the spin up. Thus, they are correlated (or rather, anti-correlated). But if the spins are measured along different directions, the correlation will decrease [17].

Since Bell's discovery, a number of experimental tests have been performed successfully [by J Clauser and S Freedman (1972), A Aspect, J Dalibard, and G Roger (1982), and G Weihs, Ch Simon, T Jennewein, H Weinfurter, and A Zeilinger (1998)] [18].

The results of EPR-experiments have a fundamental philosophical meaning, namely:

(1) EPR-experiments proved that it is impossible to find such 'local reality' in quantum physics (in the Einsteinian sense) that could be independent of the consciousness of the physicist-observer.

(2) Thus, quantum idealism as a form of philosophical idealism became a branch of experimental science for the first time in the history of idealism.

(3) This means that for the first time in its very long history, idealistic philosophy in the 21st century has exact, experimental arguments that cannot be rejected by ignorant governments, popular realists, or anti-philosophers without new and more precise experiments, in general!

Acknowledgements
I have adapted and developed this article from my paper "Space sciences and idealism", presented at the World Space Congress, 2002 (IAF-COSPAR, Houston, Texas, 10–19 October). I am grateful to all participants at our Special Session 1-0023-02 for useful comments.

References

1. Einstein A, in *Louis de Broglie*: *Physicien et penseur* (Paris: Michel, 1953)
2. "Letter by A. Einstein to E. Schrödinger dated 22 December, 1950", in Pais A "*Subtle is the Lord....*": *the Science and the Life of Albert Einstein* (Oxford: Oxford Univ. Press, 1982) p. 143
3. Gödel K "Remark about the relationship between relativity theory and idealistic philosophy", in *Albert Einstein, Philosopher-Scientist* (The Library of Living Philosophers, Vol. 7, Ed. P A Schilpp) (Evanston, Ill.: Library of Living Philosophers, 1949) p. 555
4. Logunov A A, Loskutov Yu M, Mestvirishvili M A *Usp. Fiz. Nauk* **155** 369 (1988) [*Sov. Phys. Usp.* **31** 581 (1988)]
5. Lenin V I *Materializm i Empiriokrititsizm*; *Kriticheskie Zametki ob Odnoĭ Reaktsionnoĭ Filosofii* (Materialism and Empirio-Criticism; Critical Comments on a Reactionary Philosophy) (Moscow: Gospolitizdat, 1946) [Translated into English (Moscow: Progress Publ., 1967)]
6. "Letter by A. Einstein to M. Besso, 24 July 1949", see Ref. [2] p. 463
7. Einstein A, Podolsky B, Rosen N *Phys. Rev.* **47** 777 (1935)
8. Pan J-W et al. *Nature* **421** 721 (2003)
9. Schrödinger E *Science and Humanism*; *Physics in Our Time* (Cambridge: Univ. Press, 1951) p. 9
10. Bell J *Phys. World* **3** (8) 33 (1990)
11. Landau L D, Lifshitz E M *Kvantovaya Mekhanika*: *Nerelyativistskaya Teoriya* (Quantum Mechanics: Non-Relativistic Theory) (Moscow: Nauka, 1974) [Translated into English (Oxford: Pergamon Press, 1977)]
12. Gottfried K *Quantum Mechanics* (New York: W.A. Benjamin, 1966)
13. Gottfried K *Phys. World* **4** (10) 34 (1991)
14. von Neumann J *Mathematical Foundations of Quantum Mechanics* (Princeton, NJ: Princeton Univ. Press, 1955)
15. van Kampen N G *Phys. World* **4** (12) 16 (1991)
16. Trubetskoĭ S N "Osnovaniya idealizma" ("Foundations of the idealism"), in *Sochineniya* (Works) (Ed. P P Gaĭdenko) (Moscow: Mysl', 1994)
17. Greenberger D, Zeilinger A *Phys. World* **8** (9) 33 (1995)
18. Weihs G et al. *Phys. Rev. Lett.* **81** 5039 (1998); quant-ph/9810080(v1)