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CAN QUANTUM MECHANICS BE CLEARED FROM CONCEPTUAL DIFFICULTIES?

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Abstract

The major conceptual difficulties of quantum mechanics are analyzed. They are: the notion "particle-wave", the probabilistic interpretation of the Schrödinger wave ψ-function and hence the probability amplitude and its phase, long-range action, Heisenberg's uncertainty principle, etc. The probabilistic formalism is developed in the phase space, but not in the real one. Elimination of the difficulties are likely if we are able to develop quantum mechanics in the real space. Such a theory in fact can be constructed, however, it should proceed from deepest first principles starting from the notion of a 4D space-time, the notion of a massive particle in the space, the principles of the motion of a particle, etc. The theory should be characterized by short-range action that automatically means the introduction of a quantum mechanical force. It is shown that the said force makes it evident and, moreover, is able to appear on the macroscopic scale.

A simple experiment, which in fact proves the macroscopic manifestation of quantum mechanical force, is demonstrated at the conference. The demonstration might be included in the quantum curriculum.

1 INTRODUCTION

The question raised in the title indeed is very interesting as the searching for the answer could clarify the major fundamental physical notions and culminate in the discovery of a series of new links between them, which so far were still hidden from researchers including those who follow Louis de Broglie and David Bohm, pioneers of determinism.

Nowadays, however, researchers who are interested in the foundations of quantum mechanics try to center on a search not for determinism, but for a possible nonlocality of quantum theory. Bell [1] introduced some new aspects to the problem of completeness of quantum theory. He formulated a locality requirement introducing some additional variables, so called local hidden variables. Such a study initiated a long series of thought experiments, which then resulted in some actual experiments (however, the experiments involved photons as quantum entities, which, strictly speaking, are entities of quantum electrodynamics, but not quantum mechanics). In particular, we should mention here research by Stapp [2,3] who has carried out a detailed analysis of both theoretical and experimental results, which touch questions like these: Is quantum theory local or nonlocal? and Is nonlocality is real? Stapp has adduced many arguments for this or that point of views and specifically noted that quantum theory is still formulated as an indeterministic theory.

Indeterminism is a very important starting point of modern quantum theory. However, would are we based on the other assumption?..

2 WHITE GAPS IN QUANTUM CONCEPT

<u>**1.**</u> First of all let us take a good look at the term "conceptual difficulties". The term implies that the doctrine under consideration features strong discrepancies between characteristics, which it describes, and

methods, which the doctrine uses. In the case of quantum mechanics, the situation is dramatized by the fact that one more characteristic should be ascribed to a canonical particle, namely, the particle as such is transformed to a certain "particle-wave". And this is the first conceptual difficulty of quantum mechanics! Indeed, how can one understand the particle-wave? In 1924 de Broglie, when wrote his remarkable relationships

$$E = h\nu \qquad \text{and} \qquad \lambda = h/p, \tag{1}$$

assumed that some real wave is connected with the moving particle and that just this wave guided the particle. In expressions (1) parameters E and p (the energy and the momentum) belonged to the particle, but the frequency ν and the wavelength λ were characteristics of a wave that should accompany the particle at its motion in the real space. Especially as relationships (1) enable one to derive the Schrödinger equation [4].

Corollary 1. The de Broglie's transparent idea that a moving particle is accompanied by an actual wave did not receive any further development.

2. The Schrödinger equation written in 1925 was successfully applied to the calculation of energies of equilibrium states of an electron in the Coulomb potential of a proton, which practically coincided with the experimentally measured spectrum of the hydrogen atom. Such an excellent correspondence between the prediction of the theory and the experimental results gave immediate impetus to the construction of the probabilistic formalism of quantum mechanics. Born's and Heisenberg's abstract formalism replaced de Broglie's common sense. Thus, Born's probabilistic interpretation of the Schrödinger wave ψ-function rejected any conceivable physical content from the ψ. Nowadays a quantum system is described by the probability amplitude $|\psi|^2$ and its phase ϕ that includes information on the energy, momentum and coordinate of the particle and it is also implied that ϕ involves information on the wave characteristics of the particle, some frequency ν and wavelength λ.

Corollary 2. In the modern interpretation, the wave ψ-function is quite abstract. However, it is believed that at the measuring process the abstract wave function collapses to a measurable actual point particle.

3. At the same time, the existence of the actual wave properties in particles, i.e. the matter waves, received empirical confirmation in the diffraction experiments. Therefore, particles in fact possess wave properties and this automatically implies that the pure probabilistic interpretation of the ψ-function is not complete.

Recently Briner et al. [5] has published an experimental work entitled "Looking at Electronic Wave Functions on Metal Surfaces", in which they demonstrate the colored spherical and elliptical figures, which the authors called "the images of ψ wave functions of electrons". Virtually they gave the evidence that the electron is not a point-like object, though the high energy physics asserts that it is a point object with the size no larger than 10^{-17} cm. Thus they fixed an actual perturbation of the space around an electron in the metal! Thereby, the authors subconsciously rose against the probabilistic interpretation of the ψ wave accepted by the Copenhagen School concept and, moreover, they practically proved the fallaciousness of the statement of the concept.

Corollary 3. Experimental data point to the fact that the wave ψ-function is not abstract but a measurable matter.

4. Furthermore, the Schrödinger and Dirac formalisms say nothing about true trajectories of the quantum system studied that is a direct consequence of the probabilistic approach to the description of quantum phenomena. Of course, one could use Feynman diagrams for any entity, with their point-like particles and photons, all having some absolute position and momentum. However, we cannot get the true path. Instead we must draw infinitely many Feynman diagrams and then calculate the Feynman's path integrals, which make it possible to find out only the most verisimilar trajectory of the quantum system.

Once again, this is because of the fact that conventional quantum mechanics is developed in the phase space, but not in the real one. Indeed, can one clarify the duality of a "particle-wave" in the real space where only a particle and a wave can separately be determined? The same is noted by Ligare and Olivery [6]: "it is not always clear which aspects of classical wave behavior are related in a fully quantum-mechanical treatment, or where to draw the line between wave-like aspects and particle-like aspects and how to justify the division".

When we talk about the real space we imply a 3D space or a 4D space-time, in which one can assign exact position, velocity and momentum to an object at any time. A wave can also simply be given in a 3D space or 4D space-time, but in this case the space should possess clear defined condensed matter properties.

Corollary 4. If we wish to understand the "particle-wave", we must turn to the consideration of quantum mechanics in a space filled with a subquantum medium that was first pointed out by de Broglie (see e.g. Ref. [7]).

5. Next negative aspect is that the probabilistic formalism severe suffers from long-range action. By conventional quantum mechanics, particles can interact simultaneously even if they are spaced at any quantity of kilometers, Ehrenfest [8]. Long-range action of quantum mechanics was also emphasized by Pauli [9]; in particular, he noted that quantum mechanics bears up against a hypothetical basis that the speed of the interaction in the quantum mechanical range $c = \infty$ and that the gravitational interaction is negligible, the constant of gravitational interaction $G = 0$.

For instance, let us turn to the problem of hydrogen atom, a typical example of long-range action in quantum mechanics. The radial part of the Schrödinger equation written for a particle in a spherically symmetric electrostatic potential $V(r)$ has the form (see, e.g. Schiff [10])

$$-\frac{\hbar^2}{2m}\frac{\mathrm{d}^2\chi}{\mathrm{d}r^2} + [V(r) + \frac{l(l+1)\hbar^2}{2mr^2}]\chi = E\chi \tag{2}$$

where $\chi(r)$ is the radial wave function. The second term in the square brackets is stipulated by the potential energy associated with the moment of momentum of the particle. The potential energy

$$V(r) + \frac{l(l+1)\hbar^2}{2mr^2} \tag{3}$$

ensures the stability of the particle orbit. In the case of the hydrogen atom the potential $V(r) = e^2/(4\pi\epsilon_0 r)$ and the equation of related motion of an electron and proton has the form similar to Eq. (2).

However, it should be noted that the Schrödinger *quantum* equation (2) includes the potentials $V(r)$ written in pure *classical* terms, much as in the problem of Newton gravity! $V(r)$ is a usual classical presentation of the motionless charge and the electromagnetic field that surrounds it. The mass m that enters into *quantum* equation (2) is also a pure *classical* parameter. Hence even the most comprehensive quantum mechanical description of the quantum system studied is only a quasi-classical pattern.

Corollary 5. If we remain devotees of orthodox quantum mechanics, the fundamentals will be kept in the shade of its statistical conformities.

6. Although there are Heisenberg's uncertainties for the coordinate and momentum and the energy and time of a particle,

$$\Delta x \Delta p \geq \hbar; \qquad \Delta E \Delta t \geq \hbar, \tag{4}$$

we are not able to write any similar relation for the particle mass, which should also be fuzzy in a undetermined volume, the same as the particle itself, as the probabilistic formalism prescribes.

De Broglie [11,12] studied this problem and came to the conclusion that the dynamics of particles had the characteristics of the dynamics of the particles with a variable proper mass. He was the first to indicate that the corpuscle dynamics was the basis for the wave mechanics. With the variational principle, he obtained and studied the equations of motion of a massive point reasoning from the typical Lagrangian

$$L = -M_0 c^2 \sqrt{1 - v^2/c^2} \tag{5}$$

in which the velocity v of the point and the velocity of light c were constant along a path. De Broglie's pioneer research allows one to suggest that a real wave, which indeed might accompany the moving particle, would complement the deficient value of the momentum and the energy of the particle. Then, say, we know the momentum and the energy, but have uncertainties in coordinate and time. If we assume the existence of an actual wave that travels in the space together with the particle, we can readily propose that the particle is entrained by the said wave and, therefore, position and time of the particle become in fact undetermined in a concrete point, i.e. become functions of the traveling wave.

Corollary 6. Heisenberg's uncertainty is a direct consequence of the probabilistic approach to quantum phenomena when only one of two subsystems is taken into account, namely, we treat the behavior only a particle, but totally ignore a wave, which accompany the particle.

7. All correct theories should be Lorentz invariant, i.e. they and Einstein's special relativity should agree (see, e.g. Ref. [13]). Nevertheless, the Schrödinger equation is not Lorentz invariant but it perfectly describes quantum phenomena and we trust wholly the results derived from the equation. How is it possible?

It seems that the disagreement between the strong theoretical conclusion and the experimental veracity is hidden in the statistical approach to the Schrödinger formalism. Indeed, relationships (1) allow the derivation of the Schrödinger equation as well [4], but what exactly do the relationships describe? In recent papers by the author [14,15] the inner sense of relationships (1) was studied in detail starting from an idea that the physical reality represented a space net that came into the interaction with a moving particle. This allowed the derivation of the Schrödinger equation from the deepest first principles that in fact removed a very unpleasant conflict that so far took place between nonrelativistic quantum mechanics and special relativity: Unlike the traditional presentation, the Schrödinger equation gained in paper [15] is Lorentz invariant owing to the invariant time entered in the equation.

Corollary 7. The Schrödinger equation is Lorentz invariant.

8. There is no correct determination of values E and ν in the expression $E = h\nu$ applied to a moving canonical particle. In one case $E = \frac{1}{2}m_0 v^2$ (see, e.g. Schiff [10], p. 33), and in the other one $E = m_0 c^2(1 - v^2/c^2)^{-1/2}$ (see, e.g. Schiff [10], p. 364). Which is true?

The problem has been studied by the author in paper [16], in which the motion of a relativistic particle has been treated based on a generalized lattice model of the real space. It has been shown that if the moving particle interacts with the space, the feedback governs the quantum system in question and the system undergoes the phase transition when its velocity v trends to c. In the case $v << c$, an associated real wave, which guides the particle, carries the particle's kinetic energy $E = \frac{1}{2}M_0 v^2$; in the case $v \to c$ the associated wave becomes closed inside of the range covered by the Compton wavelength $\lambda = h/mc$ of the particle and hence the kinetic energy of the particle is given by the total energy of the region, $E = m_0 c^2 (1 - v^2/c^2)^{-1/2}$.

Corollary 8. Allowance for the interaction of the quantum system under consideration with the real space clarifies difficult questions of quantum mechanics and, in particular, gives the unambiguous answer to the question [16]: What is nature of the phase transition, which occurs in the quantum system, that turns us from the description of the system based on the Schrödinger equation to that resting on the Dirac one?

9. What is spin? It is one more mystery of the microworld. In quantum mechanics spin is perceived to be a certain inner property of canonical particles. Quantum field theories define spin as an "inseparable and invariable property of a particle" (see e.g. Ref. [13], p. 17). That is all.

As a rule the notion of spin of a particle is associated with an intrinsic particle motion. Several tens of works have been devoted to the spin problem. Major of them is reviewed in recent author's papers [16,17]. Main ideas of the works quoted in Refs. [16,17] are reduced to a moving particle that is surrounded by a wave, or a small massless particle, or an ensemble of small massless particles, which engage in a circular motion.

Of course, it seems quite reasonable to assume that spin in fact reflects some kind of proper rotation of the particle. However, canonical particles possess also electrodynamic properties and the operation "rotor" is the principal characteristic of the particle electromagnetic field. Therefore, the accord between quantum electrodynamics and quantum mechanics of a particle requires the abandonment of the idea of rotation with respect to the notion of the particle spin. This means that we should associate the rotational electromagnetic field generated by a canonical particle with the particle's proper rotation of some sort.

Particle physics also cannot offer any reasonable answer to the question on the problem of spin, as this branch of physics does not deal with spatial images of particles which, nevertheless, are the main subject of its study. If quantum mechanics considers particles by means of their abstract ψ functions, particle physics treats the subject basing on all the more abstract notion of fundamental symmetry.

In the author concept [14-17] particles are determined just as spatial images in the real space, which in fact makes it possible to investigate the notion of spin in detail. In this case along with an oscillating rectilinear motion, the particle undergoes also some kind of an inner pulsation, like a drop. The two possible orientations of pulsations either along the particle velocity vector or diametrically opposite to it are associated with the particle spin.

Corollary 9. The notion of the particle spin can be determined only in the framework of quantum mechanics constructed in the real space. Two possible own pulsations of the particle in the real space are exhibited by two so-called spin-1/2 projections in the phase space. An integer-valued spin is the property of a composite quantum system.

10. Dirac [18] considering links between general relativity and quantum mechanics noted that although the relativity posed the objections to an aether, quantum mechanics practically removed them. This automatically means that a vacuum, which is hazy something or nothing in all modern quantum theories (quantum mechanics, quantum electrodynamics, chromodynamics, etc.), should be replaced by a concrete subquantum substance. High energy physics working on sub microscopic scales proposes some Higgs condensate, which would be initial at the creation of the physical world. Nonetheless, the Higgs condensate of models of grand unification of interactions is not constructed in a real 4D space-time and moreover, it does not give any idea in what way it can manifest itself in quantum mechanics. We emphasize that it is quantum mechanics that is the most reliable basis for all the other quantum theories. Because of that any new quantum concept should produce orthodox quantum mechanics as a limiting case of the theory constructed. However, either quantum chromodynamics, or some other contemporary theory (such as string theory) is not able to mutate in the orthodox quantum mechanical formalism. Quantum field theories and their derivatives suffer from undetermined field variables φ, φ^4 and so on. Group methods also isolate themselves from both the constitution of the space and the direct measurement.

General relativity does not deal with any substance, its major subject is the geometry. However, we should not forget that the relativity separates the mass from the geometry, i.e. matter from space. Nonetheless, if we assume that matter appears from the space, which in turn is a substance, we immediately arrive at the conclusion that the matter should interact with such a space: the space itself becomes material.

Corollary 10. A quantum theory constructed with regard to the connection of a quantum system with the real space in which the system is found will arrive us at very new horizons in both the subatomic area (the strong and electroweak interaction would be revised) and macroscopic one (the theory of gravity would be developed starting from quantum mechanics as well).

3 GO AHEAD!.. TO THE KNOWLEDGE BASE OF THE ANCIENTS

As of now, quantum entanglement, the property that allows two particles to behave as one, no matter how far apart they are, has been much investigated. Experimentally, if we measure the state of one particle, we instantly determine the state of the other. Researchers probe the possibility to teleport not just quantum states of photons, but also of more massive particles. And it is anticipated that the phenomenon could one day allow us to teleport objects by transferring their properties instantly from one place to another.

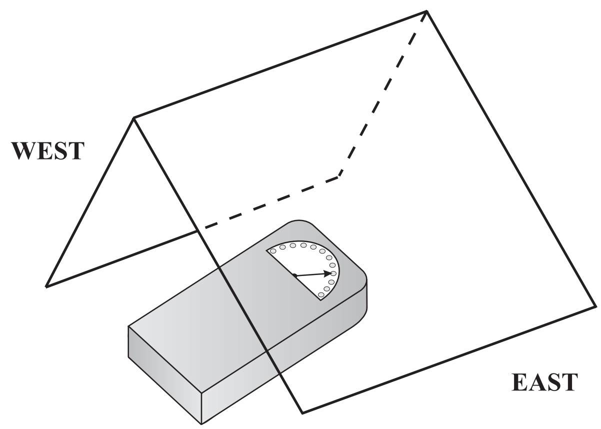

Figure 1:

From the view point of conceptual difficulties of quantum theory, the entanglement represents some synthesis of nonlocality and long-range action mentioned above. These two difficulties as well as all the other ones are associated with area of the existence of quantum mechanics, i.e. the phase space, in which orthodox quantum mechanics is constructed. However, all the problems are remedied by passing on to quantum mechanics derived on the more fundamental basis, namely, the real space.

Such a theory, submicroscopic quantum mechanics, indeed has recently been developed by the author (see self review [17]). It is argued that a moving particle is surrounded by a cloud of elementary excitations called "inertons", which appear due to friction of particle-on-superparticles (where superparticles are building blocks of the real space, see also Refs. [19]). The particle along with its inerton cloud moves as a typical real wave. Inertons which accompany the particle represent a substructure of its matter waves and, because of that, they are carriers of the particle inert properties.

Thus, just inertons teleport quantum states of one particles to the other ones. The mass of inertons can easily be estimated [20]. Besides, the inerton and the photon are not fundamentally different: It is an inerton that is a undercoat for the photon [21]. We know that photons are carriers of the electromagnetic interaction (or electromagnetic force) between both quantum entities and macroscopic objects. Therefore, it immediately follows that inertons are carriers of both the quantum mechanical interaction (or quantum mechanical force), which act between quantum entities, and macroscopic objects. In the last case inertons manifest themselves as carriers of the inertia force, which is the major mechanical force (besides, inertons are also carriers of the gravitational interaction [20,22]).

Can inertons, as carriers of quantum mechanical force, be measured on the macroscopic scale? Yes, they certainly can. Recent research has shown [23] that Egypt pyramids were functioning as peculiar plants, which projected (or teleported?) the Earth by transferring its properties to the pyramid. In other words, especially the Great Pyramid of Giza was constructed (by modern estimates several tens of thousand years ago [24]) as a transducer that converted the Earth inerton field into a microwave electromagnetic radiation [25]. In fact, the ancients possessed the detailed knowledge on the construction of the universe. Quite recently Roy [26] has found the clue to decoding of the Vedic manuscripts and nowadays we could ascribe another title to *The Ṛgveda*, namely: *Ultramodern handbook on the constitution of space, particle physics and cosmology* (see also Ref. [25]). Note that the theory of space, which is developing in Ref. [19], exactly corresponds to the pattern stated in *The Ṛgveda*.

Let an object that consists of two faces bonded together in the top and distant one from another at the bottom be oriented to the East and the West. This is a resonator of the Earth's inerton waves (due to the proper rotation of the Earth and hence its interaction with the space) [27]. The Figure presents the stunning demonstration experiment: in the resonator the device measures the inerton radiation of the Earth. The antenna of the device is turned at a concrete frequency ν_0, which is generated by the electronic circuit of the device. In the presence of inerton radiation, frequency ν_0 changes. In the resonator described (Figure) the value of ν_0 increased over than 100 times. If we turn the resonator on 90° so that its faces become oriented to the North and South, the device does not record any radiation; along the North-South line the Earth does not revolve and therefore in this direction no stable inerton flows are available.

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