"THE OBSERVER FACTOR"

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ABSTRACT

In the analysis below, we will show that the idea of a "quantum computer" contradicts the principles of quantum mechanics and its practical implementation will be impossible. The analysis points out the phenomena of theoretical physics, the incorrect interpretations of which contributed to the birth of this erroneous idea. One of these errors is the phenomenon of "quantum entanglement", which is based on a misinterpretation of the "observer factor". This part analyzes the "observer factor" and the history of the appearance of this factor in the physical reasoning of quantum theory.

1: INTRODUCTION

Since the 90s of the last century, the development of digital technologies has been accompanied by a leap in information flows, which makes it difficult to separate reliable and unreliable information. This circumstance contributed to the creation of the myth of the "quantum computer". As the pioneers of this myth point out (see, e.g. [1]), the idea is based on the following three "quantum phenomena":

The first phenomenon is "quantum discreteness".

According to the "followers of the idea", discrete numerical values of the physical characteristics of the "quantum objects" of the microcosm can be used to create bits of digital information;

The second phenomenon is "quantum superposition".

According to the principle of "quantum superposition", when a quantum object is not observed, at any given time it is in many different physical states at the same time, and each of these states can potentially be used to create a classical bit. Based on this phenomenon, it would be possible to simultaneously create many (potentially infinite) classical digital bits from a single quantum object – when we are not observing it. The information bit created on the basis of this phenomenon was called the quantum bit, or "Q-bit".

The third phenomenon is "quantum correlation", i.e. "quantum entanglement".

Followers of the idea rely on a well-known misconception: two interacting objects, after the interaction between them ends and they become free, they still continue to be in a “unified quantum state”. This leads to the emergence of the following "physical phenomenon": information - about the quantum state of one object, which is formed during the act of "observation"[1] to this object, is instantly transferred to another object, the quantum state of which is instantly rearranged in such a way that the conservation laws - operating in the joint system of these objects before observation - are not violated during "observation". According to the "adherents of the idea", this "physical phenomenon" can be used as a basis for creating a mechanism for instantaneous "quantum computing".

We will consider the phenomena mentioned above from the point of view of the principles of quantum mechanics and point out in what ways they contradict these principles. The review will be presented in five parts: the second part discusses the phenomenon of "Quantum Discreteness"; the third part discusses "The Classical Origins of Quantum Superposition"; in the fourth part – "Quantum Superposition; and in the fifth, "Quantum entanglement".

Let us briefly indicate the list of statements considered in the first part:

1: Do objects in the microcosm have trajectories?

Answer - Yes, they have trajectories;

2: Does the act of "observation" change the physical state of the micro-object uncontrollably?

Answer - yes, it does!;

3: The laws operating in the microcosm before the act of "observation" are or are not determined in nature.

Answer - both classical and quantum mechanics are based on the assertion that, by their nature, both of these laws are deterministic;

4: Do quantitative relationships - that correspond to the laws of the microworld, change uncontrollably in acts of “observation”?

Answer - yes, they do! ;

5: According to the above statements, the results of “observation” of processes in the microcosm - carried out by an “observer” with macro dimensions, will necessarily be random in nature?

Answer - yes, they will definitely have a random character! ;

6: Processes in the microcosm can only be described by statistical methods, and the resulting “laws of large numbers” and corresponding mathematical principles can only be described within the framework of probability theory.

2: BRIEF BACKGROUND

The "observer factor" became a hot topic after the publication of an article by three authors in 1935 - Einstein, Podolsky and Rosen - "Can Quantum-Mechanical Description of Physical Reality Be Considered

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[1] By the term "observation" we will mean both ordinary human observation and the measurement of some physical characteristic of the object of observation.

Complete?" (see [2]) in 1935. This article is often cited as the primary source from which the phenomenon of "quantum entanglement" appeared in the discussions. However, it should be noted that this publication does not mention either this phenomenon or the corresponding term. The authors discussed the already formed idea that if in a fixed physical circumstance it is possible to specify the coordinate of a micro-object accurately, then in the same circumstance it is impossible to specify the momentum of the same object and vice versa. Based on the above, the founders of quantum mechanics, who were called representatives of the "Copenhagen School", made a simple conclusion: in quantum mechanics, reasoning about the trajectories of micro-objects like classical mechanics makes no sense. Some physicists went even further and put forward incorrect statements: when a micro-object has a fixed coordinate in a fixed quantum state, in the same state it has no momentum, and therefore does not have a trajectory. Based on this and other similar statements, the wrong conclusion was made - ***quantum objects do not have trajectories at all***. Einstein was against this idea of the reality of the microcosm and supported a completely logical opinion that:

All objects, including objects of microcosm, always have both momentum and a coordinate, and consequently - a trajectory.

To demonstrate this, the authors [2] considered a thought experiment, on the basis of which they allegedly showed that the coordinate and momentum of a quantum object can be specified simultaneously. This contradicted Heisenberg's uncertainty principle and, accordingly, the principles of the “Copenhagen Views”. The arguments given in [2] were later called the "EPR-Paradox".

In a response publication by N. Bohr (see [3]), the source of the errors in these arguments was pointed out – the incorrect consideration of the role of the "Observer Factor" in describing the processes of the microcosm. Bohr's article did not convince all critics of the “Copenhagen School Views”, and in the same year **Schrödinger's** article was published (see [4]), in which the term **"quantum entanglement"** appeared for the first time. Schrödinger's reasoning was a continuation of the discussion initiated in the two publications mentioned above, and it made the following statement:

According to the principles of quantum mechanics, the interacting micro objects of a conservative system are in a joint quantum state, which is described by a single state vector. After the interaction is complete, when the objects become independent and free of each other, they continue to exist in a shared quantum state, reflected in the following fact: if a system consists of two quantum particles, then, according to the principles of quantum mechanics, when measuring the momentum of one particle, the measurement result will always be a random variable. In a specific measurement, a specific value of the random momentum variable is recorded, and a quantum state corresponding to this momentum is formed. Since the total momentum of a conservative system is a conserved quantity, information about the momentum of the first particle, formed in this measurement, must be instantly transmitted to the second object and instantly reflected in the formation of the physical state of the second object in such a way as to ensure the law of conservation of momentum for the conservative system. After the interaction is complete, when the objects become independent and free of each other, they continue to exist in a shared quantum state, reflected in the following fact: if a system consists of two quantum particles, then, according to the principles of quantum mechanics, when measuring the momentum of one particle, the measurement result will always be a random variable. In a specific measurement, a specific value of the random momentum variable is recorded, and a quantum state corresponding to this momentum is formed. Since the total momentum of a conservative system is a conserved quantity, information about the momentum of the first particle, formed in this measurement, must be instantly transmitted to the second object and instantly reflected in the formation of the physical state of the second object in such a way as to ensure the law of conservation of momentum for the conservative system. Consequently, after the interaction is over,

the quantum state of the system of these objects remains informative, i.e. "quantumly entangled" and the quantum state of the system cannot be reduced to a simple set of quantum states corresponding to the independent existence of the objects of this system. Accordingly, after the interaction is over, the state vector of the system is not reducible to a simple tensor product of the corresponding state vectors of independently existing objects.

This statement represents the essence of the phenomenon of "Quantum Entanglement" and we will touch on this issue in more detail in the fifth part of our research.

In this part, we will dwell only on the statements of the publication [2] concerning the observer factor.

Statement 1: All objects, including quantum objects, always have both a coordinate and a momentum, and, accordingly, a trajectory.

To demonstrate this idea, the authors [2] considered the following imaginary experiment: one quantum object - with a known momentum - decays into two objects. The process is completely conservative and the law of conservation of momentum operates in the act of decay. According to this law, the impulses of finite objects satisfy the correlation:

$$\vec{P}_0 = \vec{P}_1 + \vec{P}_2 \ ;$$

$\vec{P}_0$ is the momentum of the initial object; $\vec{P}_1$ and $\vec{P}_2$ are the impulses of the generated objects. Since, according to the principles of quantum mechanics, it is impossible to simultaneously measure and specify the coordinate and momentum of an object in one quantum state, the authors [2] came up with a simple technique that allows us to circumvent this limitation: we measure the coordinate of one object, and the momentum of the other, which is in no way limited by quantum mechanical principles. Using the law of conservation of momentum, you can specify the value of the momentum of the first object as well. That is, without the additional impact on the quantum state of the first object with the measured coordinate, which would cause the destruction of this state, it is possible to specify the momentum of the same object without destroying this state. As a result of these considerations, a second statement was made:

Statement 2: Heisenberg's uncertainty principle, according to which it is impossible to specify a coordinate and momentum simultaneously in a fixed quantum state, does not adequately reflect the physical reality of the microcosm.

Therefore:

Claim 3: A quantum-mechanical description of reality based on Heisenberg's uncertainty principle is incomplete.

It should be noted that the reasoning [2] was based on a quite reasonable initial assumption that quantum objects have trajectories, but erroneous arguments were used to prove this statement. Based on the erroneous arguments of EPR, Schrödinger also erroneously introduced the phenomenon of "**Quantum Entanglement**" into the discussion.

Since the 90s of the twentieth century, these erroneous considerations of Schrödinger have become more popular than Bohr's arguments. Therefore, we will try to bring more clarity to the essence of the "observer factor".

3: THE OBSERVER FACTOR IN CLASSICAL MECHANICS – "THE PRINCIPLE OF NEGLECTING THE INSIGNIFICANT"

The basis of the ideas of all mechanics is the **"Principle of Neglect of the Insignificant",** which, in turn, is closely related to the **ancient Greek essence of the term "Mechanics".**

The term "Mechanics" meant the invention of such "Physical Techniques" with the help of which separate "Large and Heavy" bodies could be studied separately, i.e. ignoring the insignificant influences of other bodies. As a result, it became possible to neglect numerous insignificant details, the quantitative accounting of which was associated with great practical difficulties.
The search for such "techniques" is still the basis both for the description of modern empirical facts and for obtaining most theoretical results.
It is not difficult to understand that in the case of "Large and Heavy" bodies, the corresponding "techniques" can be found insofar as the physical characteristics of these bodies have the property of great inertia. And therefore, well-chosen "Observation Techniques" make insignificant changes in the values of the measured characteristics.

The second principle of the formation of theoretical ideas of different mechanics is "**the principle of the one-to-one dependence of the properties of the whole and its parts".**

This principle is also based on ancient Greek ideas and consists of the following: the material whole consists of parts, the empirical proof of which is the possibility of dividing the whole into component parts. These parts are themselves material wholes, consisting of even smaller parts. According to this principle, the quantitative characteristics of the parts obtained as a result of each subsequent act of division will decrease. An extreme case is the spatial dimensions of the parts when they transition to points. Regarding this case, in ancient Greek philosophy, there was the following judgment:

Matter occupying a volume with zero dimensions has physical characteristics whose numerical values are zero. This, in turn, means that there is no matter in a volume with zero dimensions.

In addition:

It is impossible to create matter from nothing, i.e. from a point, and when dividing matter into small parts, it is impossible to make matter disappear at a point. **Therefore, there must be parts of matter of minimal size that cannot be separated, that is, they will be indivisible**.

In ancient Greek, these indivisible parts were called **"Atoms"**. According to the same philosophy, the diversity of atoms is finite. In reality, the observed diversity is much greater and may even be infinite. This diversity was due, in part, to the finite amount of diversity of the atoms themselves, and mainly to the infinite number of possible ways in which the whole could be constructed from spatially extended and diverse atoms. This reasoning was followed by a basic statement:

The properties of a whole are completely determined by the properties of its constituent atoms and by the specific rules for constructing this whole from the corresponding atoms. The opposite statement was also considered to be true: with full knowledge of the properties of the whole and the laws to which these integral bodies are subject, it will be possible to indicate both the properties of the constituent atoms and the laws to which these atoms are subject, as well as the rules according to which integral bodies are built with the help of these atoms.

The use of "Successful Methods of Observation" has always shown that the laws that govern "Large and Heavy" bodies are deterministic. Since, in the case of atoms, it was impossible to find such "Methods", on the basis of the stated Principle of the whole and parts, the statement was made:

Since the laws governing "large and heavy" telems are deterministic in nature, the laws that atoms obey must also be of the same nature.

In ancient Greek philosophy, representatives of the school of Democritus adhered to similar ideas. However, one of the representatives of this school, Epicurus, did not fully share all the statements and said: **since human behavior is often characterized as accidental, the existence of such a whole indicates that in the list of various atoms, there must also be those whose nature also obeys the laws of random events** (see [5]).

Newton's mechanical model of “Natural Philosophy”, in which the role of atoms was played by so-called "Material Points", was also based on ancient Greek ideas. A “Material Point” was a spatially continuously extended corpuscle, the linear sizes of which were so small in comparison with the sizes of the "Large and Heavy" bodies under study that they could be neglected. In this “Mechanical Technique", the mass of the corpuscle was attributed to one of its internal points. The transition from continuously extended corpuscles to point corpuscles was considered only a "Convenient Mathematical Device", with the help of which it was easy to introduce the appropriate mathematical principles necessary for the description of empirical reality. It should be noted that the tools of mathematical analysis created by us do not provide an opportunity to directly describe spatially continuously extended objects and are suitable only for the description of point objects. For example, a continuous line segment is parameterized by its two points (usually - boundary points). In the methods of mathematical analysis, we cannot simultaneously specify an infinite number of continuously located points of a segment. Therefore, the continuous distribution of points is replaced by a set of discretely located points.

In Newton's mechanical model of natural philosophy, all the characteristics of "Large and Heavy" bodies are effectively replaced by summaric characteristics and, like the case of corpuscles, are attributed to one isolated point of the body, called the center of mass of this body. If, in the processes involving these bodies, the magnitude of the change in the shape of the bodies is very small in comparison with the dimensions of the body under consideration, then these changes can also be neglected and rigid connections can be introduced between different points of the body in such a way that the totality of a finite number of material points takes the same geometrical spatial form as the single body under consideration. In the same method of "techniques", when calculating the summaric characteristic - effectively replacing the real characteristics of an extended body, one could find one - when the shape of the entire set of points remained unchanged, and the number of points became infinite. In this limiting case, using a countable discrete set of points, it was possible to model a continuous spatial distributed whole and write down the corresponding empirical regularities in the same language, which made it possible to effectively obtain quantitative relations corresponding to empirical reality. These amounts were later called integral. The possibility of finding such "techniques" and introducing them into the mathematical principles of natural philosophy became even more accessible after the variational problem of Euler and Lagrange made it possible to mathematically correctly introduce rigid connections, which was impossible at the level of Newton's equations. On the basis of this, it became possible to create a mathematical algorithm that would be compatible with the way of representing an indiscontinuous whole in the form of atoms or corpuscles. Unfortunately, the mathematical algorithm corresponding to the system of rigid couplings - based on the Lagrange multiplier method - was never implemented on examples of specific problems, which is probably due to the critical estimates that followed the interpretations of the Euler-Lagrange equation. In particular, in the variational problem, when obtaining the Euler-Lagrange equations, it is necessary to fix the coordinates of material points at two moments of time. The self-consistency of the method required that the equations obtained under such conditions be solved with the same boundary conditions. And this, contrary to the ideas of physics of that time, according to which the boundary conditions corresponded to the correct description of reality, when at the initial moment of time the coordinate and velocity are fixed. This critique was shared by both Lagrange and Euler, and the variation method by which the equations were obtained was presented as a mathematical speculation that should not be given a deep physical meaning. It is generally accepted that this problem was solved in Hamilton's formalism. But it is not difficult to see that in this formalism, too, when obtaining the corresponding equations, it is necessary to introduce the same two conditions per coordinate as in obtaining the Euler-Lagrange equation. However, in Hamilton's formalism, this detail was no longer paid attention to. In the physics of the 19th century, the problem of continuously extended, rigidly connected bodies was no longer relevant and remained a "black spot" of classical mechanics, which had a significant impact not only on the further formation of ideas of this mechanics, but also, possibly, on the formation of ideas of quantum mechanics. The material point of classical mechanics corresponded to the model mathematical idealization, and three-dimensional continuously extended bodies were considered real.

In quantum mechanics, point objects, the so-called "Fundamental Elementary Particles," are considered to exist in reality, and continuously distributed objects correspond to the abstraction of mathematical modeling. This opposition of ideas was also manifested in the description of the processes of the microcosm: point particles are ascribed not only non-zero physical characteristics, but also imitations of "Proper Rotation" - the so-called "Spin characteristic". When determining this characteristic, the condition is additionally included – the point particle rotates as if and not in reality.

Since the spin phenomenon is directly related to the topic of "Quantum Computing", this phenomenon will be discussed in more detail in the part – "Quantum Discreteness". Here we will return to the issues of the "EPR-Paradox" and consider the analogue of the thought experiment - indicated in [2], for macroscopic objects.

Imagine two identical "Large and Heavy" rigid balls placed in a rigid tube and an explosive is placed between the balls. For simplicity's sake, suppose that in the observer's frame of reference, the construct is stationary and has no interaction with the outside world—except for the observer. After the explosion of explosives, the balls will fly in opposite directions, and our goal is to describe the movement of these balls. As in the cases [2] and [3], we know that the total momentum of the balls is zero, but we do not know the coordinate and momentum of the individual objects. Let us proceed to the empirical indication of these quantities. To do this, you will need to fix the positions of the balls several times. Since the balls are large and heavy, we can easily find a suitable "technique" to achieve this goal, while using which we do not make large changes to the physical characteristics of the observed process. Let's assume that with the help of lighting, we recorded the location of one of the balls - $\{\vec{R}_1(t_1), \vec{R}_1(t_2), \vec{R}_1(t_3)\}$ at the moments of time $\{t_1, t_2, t_3\}$. It is clear that by illuminating a moving ball with light to fix the coordinates, we affect it, causing a change in its momentum. It is also clear that this change would not have occurred if the act of observation had not made corresponding changes into the coordinates of the center of mass of the ball. Therefore, the above radius vectors should be represented as follows:

$$\vec{R}_1(t) = \overset{0}{\vec{R}}_1(t) + \Delta\vec{r}_1(t); \tag{3.1}$$

$\Delta\vec{r}_1(t)$ denotes changes in the position of the center of mass of the ball caused by the act of observation carried out at time t; $\overset{0}{\vec{R}}_1(t)$ is the radius-vector of the center of mass of the ball that the ball would have in the absence of observation act; $\vec{R}_1(t)$ is the result of observing the center of mass of the ball. Since the balls are "big and heavy", we can thus select devices to determine the location of the ball so that the condition is met:

$$(|\Delta\vec{r}_1(t)|/|\vec{R}_1(t)|) \to 0; \;\; \Rightarrow \vec{R}_1(t) \approx \vec{R}_1^{0}(t); \tag{3.2}$$

This condition corresponds to the fact that the act of observation slightly changes the position of the observed object. As a result of the action of observation, the direction of movement can be changed, i.e. the momentum of the ball will change. Therefore, it is necessary to check whether the vectors $[\vec{R}_1(t_1) - \vec{R}_1(t_2)]$ and $[\vec{R}_1(t_2) - \vec{R}_1(t_3)]$ are parallel. If, within the precision we are using, these vectors are parallel:

$$[\vec{R}_1(t_1) - \vec{R}_1(t_2)] \,||\, [\vec{R}_1(t_2) - \vec{R}_1(t_3)] \; ; \tag{3.3}$$

this will be evidence that the velocity and momentum of a freely moving ball do not change the acts of observation. On the basis of these data, if we calculate the momentum of the first object $\vec{P}_1$, then - based on the law of conservation of momentum, we automatically know the momentum of the second object $\vec{P}_2 = -\vec{P}_1$. This ratio can be easily verified empirically if similar observations are made on the second ball. Our knowledge of the existence of the law of conservation of momentum follows from the results of such observations. Using the "**principle of neglecting the insignificant**", this law is also ascribed to the free-moving balls themselves—without our observations. Moreover, we say that condition (3.3) is realized only insofar as an analogous property is present for quantities of type - $\vec{R}_1^{0}(t)$. That is, (3.3) is due to this fact, and not vice versa.

That is, **all laws, including the law of conservation of momentum, are characteristics of things without observations.**

Observations are a set of actions through which we try to record the existence of these patterns for us. For this purpose, we come up with various "Cunning Observation Techniques". When observing an object of the microcosm, it becomes impossible to find such "Cunning Techniques" so that relations of type (2.2) are met. In this regard, in the results of observation, knowledge of values of type $\Delta\vec{r}_1(t)$ - corresponding to the "Observer Factor" - becomes essential. The situation becomes similar to Kant's description of reality, according to which –

There is a "Thing-in-itself" and there is a "Thing for us". The "thing-in-itself" corresponds to reality without our observations, and the "Thing for us" corresponds to the results of our observations of the "Thing-in-itself". Things in themselves, i.e. the "Thing-in-itself", are governed by physical laws, the indication of which is the main task of physics.

When things are "Big and Heavy," the results of our observations—i.e., "The Thing for Us"—coincide with the "Thing-in-Itself" with great accuracy. At the same time, within the limits of the accuracy of our observations, we find that the laws governing "Large and Heavy Bodies" are deterministic. For this reason, the same nature is ascribed to quantities of type $\Delta\vec{r}_1(t)$, but in essence these quantities differ significantly from quantities of type $\vec{R}_1^{0}(t)$ and $\vec{R}_1(t)$. The fact is that the more successful the "technique" is selected for the accurate measurement of quantities of type $\vec{R}_1^{0}(t)$, the more the numerical values of quantities of type $\Delta\vec{r}_1(t)$ will decrease. At some stage of reduction, the physical characteristics of quantities of type $\Delta\vec{r}_1(t)$ will become uncontrollable for us, since due to the macroscopic dimensions of the observation devices we use, observation acts are naturally accompanied by limited measurement accuracy. The values of $\Delta\vec{r}_1(t)$ - corresponding to the best "techniques" - will become completely uncontrollable for us. In the methods of mechanical observation, uncontrolled quantities are called random quantities. And, if it were not for condition (2.2), then the values of the type - $\vec{R}_1(t)$, corresponding to "Things for us", would also be random

Some events involving macrobodies are still called random. The most well-known examples are coin and dice tosses. If we toss a dice, or a coin in the Earth's gravitational field and observe the result of a fall on a horizontal surface, then, after stopping, we will find one of the faces on the upper side of these objects. If these grains are somehow marked, and repeat the toss action, then the same face or another one may appear on the top side. Because of this, we say:

If with repeated actions, the results may be different, then the results of such actions are called random.

When introducing this definition, an important detail is used - **repetitive actions**, which corresponds to the "**principle of neglecting the unimportant**". According to this principle, we consider each toss of the mentioned objects as identical actions. From a physical point of view, it is quite clear that these actions are not identical and therefore exactly repeatable. But, for some subjective reasons, we ignore the difference and call the corresponding physical circumstance **- "Game Mode".** It should be noted that in order to obtain deterministically fixed results, it is not necessary to repeat the tossing actions exactly. It is simply necessary to select such "techniques" of tossing with the help of which we will obtain deterministic results. Since these objects are "Big and Heavy", it is possible in principle, but it is not so easy to implement. Despite the complexity, the macroscopic sizes of these objects still allow, by the method of "Trial and Error", to find such regions for the values of the transmitted impulses, the transmission of which by appropriate methods will lead to the same results for such repeated actions. The physical circumstances of the corresponding actions presuppose such a movement of these objects that "very powerful and large actions" do not occur. The fact is that it is extremely difficult to control the physical characteristics of "very powerful and large actions" - relative to the scale of the dice and the coin. Therefore, during such actions, the corresponding results acquire a random character. To avoid this, it is necessary to choose such methods of tossing that the results are predetermined, and at the same time - the macroscopic repetition of the tossing acts is insured, even if it is not very correct the use of the "Principle of neglect of the insignificant". It should be noted that the criteria for assessing the magnitude of actions are uniquely related to the size of the objects that are tossed. Therefore, the actions implemented can become large both as a result of the transmission of large impulses and in the case of a decrease in the size of these objects. In both cases, because of our limited control over the "techniques" of tossing, the results of these events in both cases will be random. A "Game Mode" corresponds to a physical situation where the size of the action is small, but the results are still random. This mode implies a physical circumstance in which the "ensemble of repetitive events" includes the widest possible range of possible "mechanical techniques" of tossing corresponding to the various deterministic outcomes mentioned above. In such an ensemble of "repetitive events", all possible outcomes become equally expected. We will touch on the mathematical principles of this issue in the part "Quantum Superposition" when we discuss the principles of probability theory when describing the statistical data of the event of the toss of these objects. And at this stage, we will conclude the discussion with the following important remark: **as the linear sizes of "playing objects" decrease, the range of permissible "techniques" for obtaining deterministic results is also reduced**. From some threshold values of sizes and below, we will have only such "techniques" at our disposal, the corresponding events of which will be only random outcomes. In accordance with the ideas according to which the need for a probabilistic description in quantum mechanics arises precisely because the scale of the microcosm is much smaller than the deterministically controlled scales on the part of the "large observer", and inventing "cunning techniques" to overcome this factor becomes impossible for such an "observer" in principle.

4: "EPR Paradox" and the "Observer Factor" in Quantum Mechanics

The discussion of the "EPR Paradox" is based on one of the statements mentioned above in **1-** subsection: **the act of observation violates the conservation laws that were in effect before the act of observation.** As we mentioned in the second subsection, when one object conservatively decays into two objects, the objects involved in this process with the status "Thing-in-itself," are subject to conservation laws - including the law of conservation of momentum. This law can be written as a chronological relation:

$$\vec{P}^{0}_{0}(T|T\leq t_0) = \vec{P}^{0}_{1}(t|t\geq t_0) + \vec{P}^{0}_{2}(t|t\geq t_0)\ ; \qquad (4.1)$$

$\vec{P}^{0}_{0}(T|T\leq t_0)$ - Impulse of the original object before decay; $\vec{P}^{0}_{1}(t|t\geq t_0)$ and $\vec{P}^{0}_{2}(t|t\geq t_0)$ - Impulses of objects that have arisen as a result of decay; t_0 – the moment of disintegration of the original object. At the moment t = $t_1 \geq t_0$ - by the act of observation, we fix the impulse of the first object. This characteristic corresponds to the "Object For Us" and is given by the relation:

$$\vec{P}_1(t_1) = \vec{P}^{0}_{1}(t_1) + \Delta\vec{p}_1(t_1)\ ; \qquad (4.2)$$

$\Delta\vec{p}_1(t_1)$ - The value corresponding to the result of an uncontrolled impact introduced by the act of observation into the impulse of the observed object. Because we cannot control the acts of observation at the microscopic level, this magnitude is random to us. It is clear that when the fraction of $\Delta\vec{p}_1(t_1)$ in (4.2) is not small, the momentum $\vec{P}_1(t_1)$ also becomes a random variable. As noted by N. Bohr (see [3]):

The phenomenon when $\vec{P}_1(t_1)$ turns into a random variable due to the random nature of $\Delta\vec{p}_1(t_1)$ is called the "**Observer Factor**" in quantum mechanics.

And therefore:

Quantum mechanics is based on a method of describing empirical reality using statistical methods. Unlike the dynamic-chronological description of classical mechanics, this method does not presuppose a chronological description of the events being studied and their outcomes. As an alternative to chronological description, so-called "expectation functions," also known as "probability functions," are introduced. Consequently, the mathematical principles of quantum mechanics are realized precisely in the space of probabilities.

As a rule, the cause of quantum-mechanical paradoxes and myths is the incorrect interpretation of the principles of the probabilistic description method and the incorrect use of its elements. One such case corresponds to the "EPR Paradox," which will be demonstrated below. For this purpose, we note that, since we do not know the exact value of $\Delta\vec{p}_1(t_1)$, we cannot reconstruct the exact value of $\vec{P}_1(t_1)$ from (4.2). Consequently, by fixing $\vec{P}_1(t_1)$ only empirically, we cannot reconstruct the magnitude of the momentum of the second object in the "existing-in-itself" state, since its momentum—according to the law of conservation of momentum, was directly related only to the momentum of the first object in the "existing-in-itself" state. Furthermore, we note that if we repeat the measurement of the momentum of the freely moving first object at time $t_2 > t_1$, we obtain a value - $\vec{P}_1(t_2)$, which, in general, will not coincide with $\vec{P}_1(t_1)$. In actuality, it is this fact that determines the basis for the random nature of measurement results in the micro-world. Due to the aforementioned phenomenon, the existence of the law of conservation of momentum—even in the case of free motion, cannot be clearly established empirically, since each act of observation will uncontrollably and significantly change the momentum of a given freely moving object:

$$\vec{P}_1(t_{i+1}) = \vec{P}_1(t_i) + \Delta\vec{p}_1(t_{i+1}) \neq \vec{P}_1(t_i) \ ; \qquad (4.3)$$

Taking into account the above reasoning, we can conclude that the statement which lies at the basis of the "EPR Paradox":

The act of observation *does not violate the laws of conservation in force before the act of observation.*

- Not true.

Let us proceed to the analysis of the second statement and find out whether the Heisenberg uncertainty principle indicates that - ***quantum objects do not have a coordinate and momentum at the same time***. According to the principles of quantum mechanics, the numerical values of the coordinate and momentum of a quantum object correspond to the eigenvalues of the corresponding operators, and these operators are related to each other by a condition of non-chronological connection:

$$[\widehat{Q}_i, \widehat{P}_j] = \mathrm{i}\mathrm{h}\delta_{ij} \ ; \qquad (4.4)$$

$\widehat{Q}_i$ and $\widehat{P}_j$ are the spatial components of the coordinate and momentum operators of a point-like quantum object. Note that in condition (4.4), operators $\widehat{Q}_i$ and $\widehat{P}_j$ do not depend on time, which is one of the main characteristics of the quantities described by statistical methods (this issue will be considered in more detail in the following parts). Independence from time is also present in the Heisenberg uncertainty relation, obtained from (4.4):

$$\Delta Q_i \, \Delta P_j \geq (\mathrm{h}/2)\, \delta_{ij}; \qquad (4.5)$$

Often, the statistical essence of (4.5) is distorted, and the quantities ΔQ_i, ΔP_j are interpreted as the accuracy of a single measurement. Therefore, they are mistakenly called "measurement errors" of coordinates and momenta in the same measurement.

This error is logically followed by another false statement: when in a single act of measurement the coordinate of a quantum object is precisely fixed, as a result of such measurement accuracy, the "measurement error" becomes zero - $\Delta Q_i = 0$. According to (4.5), in this state - $\Delta P_i = \infty$, which allegedly indicates that - in the mentioned state, the given quantum object does not have momentum as a physical characteristic; And vice versa - if in a given state the momentum is precisely fixed and $\Delta P_j = 0$, for the same reason - the coordinate, as a physical characteristic, does not exist.

The mentioned type of interpretation was subjected to quite fair criticism both from N. Bohr and from other authors. In particular, in 1951, D.I. Blokhintsev published an article in which he quite rightly noted that the quantities ΔQ_i and ΔP_j indicated in (4.5) do not represent numerical values obtained in a single act of measurement, and therefore, on their basis, one cannot judge the simultaneous existence or absence of coordinates and momentum in a quantum object (see [6]). And as it was pointed out, the mentioned values are characteristics of a statistical "ensemble". Namely, ΔQ_i and ΔP_j are defined as the roots of the squared deviations from the statistical mean values of the corresponding quantities. These mean values, in turn, are constructed from sets of statistical data obtained through observations of numerous identical objects under identical macroscopic physical conditions (see [7]). It should be noted here that these quite correct comments were followed by a very interesting, but from the point of view of the probabilistic method of describing statistical data, not quite correct remark by the same author:

"When an object's physical properties are in the quantum realm, we cannot repeat an experiment on that object, since each observation significantly alters its state. Therefore, to conduct repeated experiments, it is impossible to repeatedly use the same object. Instead, it is necessary to place a set of non-interacting identical particles under identical—from a macroscopic perspective—physical conditions and conduct joint observations of this set."

The above-mentioned phrase corresponded to the emphasis on the significance of the uncontrolled influence caused by the "Observer Factor". But, as a result of not quite correct indication of the essence of this phenomenon, this statement can also become a source of erroneous interpretations. Under this phrase of D.I. Blokhintsev, we should understand only that we cannot organize microscopically repeated physical circumstances, which is the main characteristic of the "observer factor". However, this does not preclude the repeated performance of macroscopically repeating experiments on a single particle, since it has been said that we can place multiple objects of an ensemble in the same macroscopic physical state and observe them many times. Similarly, we can repeatedly place a single particle in macroscopically repeating conditions and perform multiple observations on it. But, at the same time, a fundamental question arises, because of which this phrase of D.I. Blokhintsev becomes interesting – can we detect a single particle and place it in some physical conditions? This question arises naturally, since we can only make "observations" to detect a single particle using macroscopic instruments. To detect the trace of a single particle, the trace must also be macroscopic. But if the trace has macroscopic characteristics, then we cannot unequivocally say that these characteristics are formed by only one particle of interest to us. The fact is that the observation instrument itself consists of quantum particles, which can also take a significant part in the formation of the trace characteristics. In such a situation, we can make a mistake - attributing the fact of the appearance of this trace to the particle of interest to us. Therefore, when we reason for a "statistical ensemble" in quantum mechanics, we implicitly use one of the main characteristics of the statistical method of description, which is used in the case of "Large and Heavy" bodies:

In "game mode," i.e., "under certain macroscopically repetitive circumstances", the set of statistics obtained by tossing one dice (coin) N times, and the set of statistics obtained by tossing N identical dice (coins) at the same time, are carriers of exactly the same statistical status when describing the results of these events by the statistical method. Moreover, the greater the N, the greater the intersection of these sets. Within the limit of N →∞, these sets become identical.

This statement is generalized to all types of random events, including the results of observation of micro-objects, and is a general principle of statistics:

A statistical data set obtained by observing an ensemble of N non-interacting identical quantum particles under macroscopically identical physical conditions has exactly the same statistical status as a data set obtained by observing N times one of these particles, macroscopically repeated under the same physical conditions. Within the limit of N →∞, both these two sets and the statistical regularities - obtained as a result of their phenomenological studies, will be identical to each other. These results and regularities, as probabilistic characteristics, should be attributed both to the ensemble of these particles and to individual particles.

Accordingly, one and the same statistical ensemble can be obtained both by means of an event in which many identical objects participate simultaneously, and from many repeated events occurring with one object of this set. At the same time, all these events must be carried out in the same macroscopic conditions.

In this way, Blokhintsev's second statement corresponds to the description of the processes of the microcosm by a more fundamental standard than is implied by the "Mechanical Methods" of quantum mechanics. According to these principles, the impact of a well-chosen act of observation introduces only uncontrolled quantitative changes in the characteristics of the observed processes of the micro world, and the phenomenon of the process itself remains completely the same as it would have been without the act of observation. This statement has the status of a "mechanical assumption device", but without its introduction as a reasonable approximation, it would be impossible to attribute to individual quantum objects the characteristics that would be obtained by observing statistical ensembles - constructed by a set of identical objects. At the same time, in "mechanical methods of observation" it is necessary to use only those that will ensure the application of this assumption.

We will conclude our discussion on this issue with an important remark:

In the list of quantum-mechanical principles, the key is not the phenomenon of quantumness, i.e. - discreteness, but the statistical nature of the method of describing reality through which these principles are introduced.

And most importantly, we choose this method not for subjective reasons, as is done when describing the results of tossing a dice or a coin, but because of our limited ability to control processes in the micro world with the accuracy that would be necessary for a deterministic description of these processes. In this regard, the following should be clearly stated:

The probabilistic nature of the principles of quantum mechanics is not a direct characteristic of the micro world itself—as is often mistakenly claimed—but is a result of our limited ability to accurately describe this micro world. Due to the increasing role of the "observer factor," caused by the imbalance in the scales of the "observer" and the "observed," "things-in-themselves" of the micro world objectively give rise to "things for us," whose physical characteristics manifest as random variables.

On the basis of the considerations given here, regarding the last statement [2], the following remark can be made:

of course, quantum mechanics as knowledge based on the statistical-probabilistic method of describing the empirical "reality for us" is imperfect in comparison with classical determinism; But, on the other hand, Bohr's assertion that in the "market of our possibilities" there are no possibilities for a more complete description of reality than on the basis of the statistical-probabilistic method is also absolutely correct and understandable.

In accordance with this statement, we note one well-known opinion: physics is built by postulates, i.e., principles corresponding to the empirical "Phenomena of Epicurus", and mathematics by axioms, i.e., principles corresponding to the phenomena of mental imagination, i.e., "Phenomena of Plato". This circumstance is the main distinguishing feature of these two knowledge. For physics, mathematics is a "tool" and should not be confused with "neither the goal of labor nor the results of labor." Together, they create more complete knowledge than they could do separately.

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