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CRITICAL REVIEW OF FUNDAMENTAL CONCEPTS IN PHYSICS Part 7 – "Quantum Entanglement"

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Abstract
One of the most important details of the myth about "quantum computers" is the phenomenon of "quantum computing" associated with the phenomenon of "quantum entanglement". In particular, if two "qubits" are brought into a "quantum entangled" state, then the transfer of information from one "qubit" to another becomes possible by the mechanism of "spooky action at a distance", that is - instantly. As a result of the creation of such a technology, the speed of calculations performed on "quantum computers" will be significantly higher compared to the speed of calculations on conventional computers. Below we will show that the creation of such technologies will be impossible for a simple reason - in physical reality, the phenomenon of "quantum entanglement" does not exist, and the introduction of this phenomenon into the discussion is based on the Schrödinger error. This error is also a clear manifestation of the opinion expressed by us in the previous sections, according to which incorrect interpretations of the mathematical principles of probability theory, due to the insufficient level of development of the ideas of this theory at the initial stage of the formation of ideas of quantum mechanics, led to the emergence of incorrect opinions regarding the interpretations of the principles of quantum mechanics.

Index Terms- *Quantum computer; Q-bit; quantum entanglement; spooky action at a distance; observer factor; Measuring spin.*

INTRODUCTION

In our proposed six-part text (see - Baghaturia et al, 2025a,b,c,d,e), several "quantum phenomena" were discussed that do not actually exist and are merely theoretical products based on incorrect interpretations of the physical and mathematical principles of quantum mechanics.

Below, in Part 7 of the full text, we will look at another such phenomenon, which is called "quantum entanglement" and which is closely related to the myth of the "quantum computer".

Speaking about the misinterpretations of the principles of quantum mechanics and probability theory, it is necessary to note the following: of course, they are partly based on subjective factors, but it would be a mistake to suppose that subjective factors can create serious problems for fundamental physics. Like processes in all large statistical populations, processes in large human societies, including science, are governed by the "laws of large numbers" and not by the subjective factors of individuals.

Starting from the 19th century, scientific communities - including the physical one, are turning into ever-growing large statistical sets. On one hand, this gives possibility to constantly obtain new results, but as a result of this, information flows grow so dramatically that instruments that existed before the next big jump, and with help of which reliable and unreliable information was separated before this, can no longer work successfully in the new reality - created by the jump, and separation of reliable and unreliable information from each other becomes impossible.

To this should be added significant factorization of physics into experimental and theoretical parts, which is caused by

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introduction of complex experimental and mathematical instruments into these specialties. As a result - it is difficult for a theorist to understand the essence of details of conducted experiments, and it is difficult for an experimentalist to understand the mathematical details of theoretical representations being created. In such circumstances the possibility of positive mutual criticism of these two specialties is significantly weakened and the instrument of "empirical criticism" cannot function effectively. Without this, development of natural sciences becomes quite difficult, and in some cases impossible. This is the same objective and fundamental problem as the considered "observer factor", which is not caused by subjective factors of the observer.

It is within the framework of such reasoning that we will analyze below - the non-existent phenomenon of “quantum entanglement”.

CHAPTER I: Brief History of the Phenomenon

The question of "quantum entanglement" first appeared in Schrödinger's 1935 publication (see (Schrödinger, 1935)), which became a continuation of the discussion begun earlier that year by Einstein-Podolsky-Rosen (see (Einstein et al, 1935)). These authors, when considering an imaginary experiment, based on incorrect arguments, made a number of false statements that were subsequently called the "EPR Paradox." In addition to false statements, they also made some correct ones. For example, the statement that quantum mechanics describes physical reality incompletely – true by definition, because quantum mechanics describes reality through a probabilistic description. And this automatically means that reality is not described completely. The mistake was their statements in connection with the uncertainty principle in quantum mechanics (see Part 2 - Baghaturia et al, 2025b). Soon after the EPR publication, N. Bohr published a response in which he pointed out the source of errors - incorrect use of the "observer factor" when discussing microworld processes (see (Bohr, 1935)). Bohr's quite understandable and logical arguments did not convince some physicists, including Schrödinger. He continued reasoning in connection with one detail discussed in (Einstein et al, 1935), and in these discussions introduced the phenomenon of "quantum entanglement." As we noted in Part 2 of our text, the publication (Einstein et al., 1935) is often cited as the primary source of this phenomenon. This is an erroneous representation, and it should be definitively stated that Schrödinger was the author of the myth about "quantum entanglement." For the subsequent fifteen years, these questions were not of great interest for discussions in scientific publications. However, as it turned out later, Bohr's arguments did not seem convincing to Einstein, who shared Schrödinger's views on the existence of the phenomenon of "quantum entanglement". And in one of his letters to M. Born, he called the mechanism that ensures this phenomenon "spooky action at a distance". The question became active again from the early 1950s when D. Bohm published his work (see (Bohm, 1952). Bohm attempted to bypass Bohr's arguments, for which he introduced spin characteristics with discrete numerical values into the discussions, which - allegedly, looked more stable relative to uncontrolled influences of the "observer factor" than the continuous physical characteristics discussed in “EPR Paradox”. However, if we carefully analyze Bohm's theoretically imaginary experiment, we can easily discover that Bohr's arguments are as effective in this case as they were in the case of the "EPR Paradox". This question will be examined in detail in the next subsection.

We will briefly indicate the list of statements that will be considered in 7-th part of the text:

1. Does the reasoning about spin characteristics in Bohm's theoretical problem indicate the existence of Schrödinger's phenomenon of "quantum entanglement"? Answer - no, it does not!
2. In microworld processes - in case of the existence of Bohm's hidden variables, does the phenomenon of quantum randomness disappear? Answer - it does not disappear, since the phenomenon of quantum randomness is a characteristic of our possibilities for extracting information from acts of observation, not a characteristic of the micro world;
3. Is the phenomenon of quantum discreteness caused by the "observer factor" or is it a characteristic of the micro world? Answer - the phenomenon of quantum discreteness is a characteristic of the micro world and is not caused by the "observer factor";
4. Do Bell's inequalities correspond to any physical requirements regarding probabilities of event outcomes arising from reality? Answer - no, they do not correspond;
5. Do Schrödinger's "quantum entangled" physical states exist? Answer - no, they do not exist.

CHAPTER II: "Bohm's Puzzle-Riddle – An Example of Quantum Entanglement"

Before describing Bohm's “riddle”, let us briefly recall the imaginary experiment of the "EPR paradox." A quantum object with fixed momentum - e.g. zero, decays into two quantum objects, and during the decay the law of conservation of momentum acts:

$$\vec{P}^{(0)}(T|T \le t_0) = 0 = \vec{P}^{(1)}(t|t \ge t_0) + \vec{P}^{(2)}(t|t \ge t_0); \quad (1)$$

$\vec{P}^{(0)}(T|T \le t_0)$ - momentum of the initial object that decays at moment $T = t_0$; $\vec{P}^{(1)}(t|t \ge t_0)$ and $\vec{P}^{(2)}(t|t \ge t_0)$ - momenta of objects obtained as a result of decay. The EPR-authors' idea was as follows: in order to know simultaneously coordinate and momentum in one fixed state, we measure coordinate in the first object and momentum in the second. Using (1), we can indicate the momentum of the first object without changing the quantum state formed by measuring the coordinate of this object. As a result - in the indicated quantum state, we will simultaneously and precisely know both momentum and coordinate of the first object, which will contradict Heisenberg's uncertainty principle. Accordingly - quantum mechanics, based on the uncertainty principle, incompletely describes reality. Bohr criticized this statement and indicated that relation (1) refers to objects before the act of observation, and during measurement of the second object's momentum, a new physical state is formed for this object as well - corresponding to this momentum that we measure. The measured momentum value has no direct connection either with the momentum of the second object from (1) or with the corresponding conservation law. And if the act of measurement occurs at moment $t = t_1$, then (1) should be rewritten as follows: $\vec{P}^{(0)}(T|T \leq t_0)$ =

$$= \vec{P}^{0(1)}(t|t_0 \leq t < t_1) + \vec{P}^{0(2)}(t|t_0 \leq t < t_1) = 0; \quad (2)$$

where - the additional zero index denotes the fact that this momentum conservation law refers to momenta of objects that existed before the act of observation. In these notations, for the measured momentum of the second object we will have:

$$\vec{P}^{(2)}(t|t \geq t_1) = \vec{P}^{0(2)}(t|t \geq t_0) + \delta\vec{P}^{(2)}(t|t \geq t_1)\ ; \quad (3)$$

where $\delta\vec{P}^{(2)}(t|t \geq t_1)$ - momentum arising as a result of the observation act's impact on the second object, the magnitude of which is uncontrollable and remains unknown to the "observer," regardless of whether this observer is a human or a measuring device prepared by humans. Because of this, from the measured numerical value $\vec{P}^{(2)}(t_1)$ we cannot restore the magnitude of momentum $\vec{P}^{0(2)}(t|t \geq t_0)$ that existed before observation, and accordingly - we cannot restore the magnitude of momentum $\vec{P}^{0(1)}(t|t \geq t_0)$ either. $\vec{P}^{(2)}(t_1)$ itself - due to the uncontrollable momentum $\delta\vec{P}^{(2)}(t_1)$ entering it, must be considered as a random variable. Similarly - results of measurements of all quantum-mechanical characteristics must also be considered as random variables, which constitutes the essence of quantum mechanics (for more detail see Pfrt-2).

As we noted in Part-2, for "large and heavy" objects it is always possible to find such an act of measurement that the condition is fulfilled: $|\delta\vec{P}| \ll |\vec{P}|$. For this reason, in classical mechanics the quantitative difference between relations (1) and (2) is so insignificant that neglecting it is quite permissible. By inertia of thinking connected with classical mechanics concepts, Schrödinger also left without attention Bohr's argument - in the case of micro-objects, neglecting the magnitude$\delta\vec{P}$ - corresponding to the "Observer Factor", is impossible, and the quantitative difference between relations (1) and (2) takes on a fundamental character. And most importantly - it is precisely for this reason that results of observation of microworld objects always represent random variables. Failure to account for this detail led Schrödinger to an erroneous logical conclusion. Let us describe the logic of this conclusion: according to quantum mechanics representations, the result of measuring momentum of quantum objects represents a random variable, and as a result of its measurement, a corresponding quantum state of the object is formed. Therefore, when forming the momentum state of the second object, which corresponds to the measured momentum $\vec{P}^{(2)}(t_1)$, a corresponding state should also be formed for the first object, which will ensure fulfillment of the momentum conservation law even after the act of measurement. Accordingly, when two non-interacting objects are in one quantum state in which the momentum conservation law acts, measurement and fixation of momentum value in one object should cause instantaneous propagation of corresponding information and reflection on the quantum state of the second object. He called the corresponding physical state "quantum entangled," and the phenomenon ensuring fulfillment of conservation laws he called "quantum entanglement."

It is easy to understand that with correct accounting of the "observer factor," Schrödinger's statement becomes completely groundless, and in reality there is no need for "spooky action at a distance."

As already noted, Bohm attempted to circumvent Bohr's arguments and, instead of considering the measurement of continuous quantities of momentum, introduced the observation of discrete quantities of spin into the consideration. The essence of the advantage of considering this problem is connected with discrete numerical values of spin. Presumably, in Bohm's opinion, numerical values of the discrete spectrum of spin characteristics are not subject to change under uncontrolled influence caused by the "observer factor." Therefore, in this case, Bohr's arguments should also not be effective. For clear indication of the illusory nature of this advantage, let us briefly describe Bohm's proposed "example-riddle": a quantum object with zero spin at time moment t_0 decays into two objects with half-integer spin, and during the decay the spin conservation law acts:

$$\vec{S}^{(0)}(T|T \leq t_0) = \vec{S}^{0(1)}(t|t \geq t_0) + \vec{S}^{0(2)}(t|t \geq t_0) = 0; \quad (4)$$

$\vec{S}^{(0)}(T|T \leq t_0)$ - spin vector of the original object before the decay; $\vec{S}^{0(1)}(t|t \geq t_0)$ and $\vec{S}^{0(2)}(t|t \geq t_0)$- spin vectors of objects obtained as a result of decay. Before conducting an act of observation, we do not know in which direction the spin vectors of these objects are oriented. What we know is that they are directed mutually opposite. Since components of one object's spin are not simultaneously precisely measurable quantities, by analogy with the "dilemma" of momentum measurements - we measure one specific component of the spin of one object, and we measure another component of the spin of the second object. As a result of measurements, a quantum state corresponding to its measured component will be formed for the first object, and for the second object will be formed a quantum state, corresponding to its measured component. If we measure the Z-component of spin for the first object and get $S^{(1)}_{(z)}$ = 1/2, and measure the X-component for the second and get $S^{(2)}_{(x)}$ = 1/2, then using (4), we restore the numerical value of the X-component of the first object's spin, which contradicts Heisenberg's uncertainty principle for spins. From Bohm's point of view, this once again confirms the incompleteness of reality description by quantum mechanics principles, which was already noted by the authors of “EPR Paradox”. Bohm indicated a possible cause of this incompleteness: similar to the case of describing reality by thermodynamic methods, possibly - when describing the microworld by quantum-mechanical method, hidden variables also exist, in case of knowing which - there would be no need either for using probabilistic description method or for corresponding "quantum entanglement" and "spooky action at a distance," since everything would be explained and described by the classical picture of cause-and-effect relationships. Note that in the logic of indicating the essence of "quantum entanglement," details of hidden variables do not have essential significance, and therefore we will turn to them later. At this stage, we focus attention on details significant from the point of view of the question under investigation. According to quantum mechanics principles - in measurement acts, numerical value of spin vector components represent random variables. Despite this, we can still say the following: if both objects obtained in the decay process are passed through one common field created by Stern-Gerlach magnets, we can say in advance - if the trajectory of one of them deviates in one direction, the second will deviate in the opposite direction. This means that if for one of them a fact of trajectory deviation corresponding to $S^{(1)}_{(z)}$ = 1/2 will be observed, then for the second a fact corresponding $S^{(2)}_{(z)}$ = (-1/2) will be observed. Similarly - if for one an empirical fact corresponding to $S^{(1)}_{(z)}$ = (-1/2) will be observed, for the second a fact corresponding to $S^{(2)}_{(z)}$ = 1/2 will be observed. Since this spin case directly intersects with the “quantum computer” myth, our goal will be to find out whether this case leads to Schrödinger's “quantum entanglement” phenomenon. To answer this question it will be convenient to return to the classical case with coins considered in Part-4 (Baghaturia et al, 2025d), (Bell, 1964) of the text, which we will implement in the next subsection.

CHAPTER III: Classical Analogy of "Entanglement"

As already repeatedly noted in previous parts of the text, according to Bohr's principle - for an observer having macroscopic sizes, observation of microworld objects by "soft methods" is fundamentally impossible. Therefore, indicating classical analogs for quantum processes is quite difficult. However, when reasoning about this question, it should also be taken into account that one of the principles of constructing quantum concepts is the so-called "correspondence principle." According to this principle, since macroworld objects are built through microworld objects, from quantum mechanics laws - by applying a certain limiting procedure, classical mechanics laws should be obtained. And between these two laws there should exist the same reverse connections that exist between micro and macroworlds.

However, it is also clear that due to the "observer factor" we will never be able to carry out direct empirical verification of the adequacy of classical analog to quantum. Despite this, indicating certain indirect hints should be possible, since information about microworld processes we still obtain only from macroscopically observable processes. This is all the more understandable when it comes to correct application of mathematical principles of probability theory. The phenomenon of "quantum entanglement" is also connected with principles of probability theory, and therefore adaptation of mathematical principles connected with this phenomenon - to examples of classical objects, should not be too difficult. For this purpose, let us consider events of jointly tossing two coins. Since results of events have random nature, superposition state vectors corresponding to our expectations can also be introduced for them. In "game mode," state vectors corresponding to coin tossing events, we write as follows (see Part-4 -- Baghaturia et al, 2025d):

$$\psi^{(1)}=(1/\sqrt{2})\sum_{n=1}^{2}\psi^{(1)}_{[n]};$$

$$\psi^{(1)}_{[1]} = (1/\sqrt{2})\begin{pmatrix}1\\0\end{pmatrix}^{(1)}; \qquad \psi^{(1)}_{[2]} = (1/\sqrt{2})\begin{pmatrix}0\\1\end{pmatrix}^{(1)};$$

$$\psi^{(2)} = (1/\sqrt{2})\sum_{n=1}^{2}\psi^{(2)}_{[n]};$$

$$\psi^{(2)}_{[1]} = (1/\sqrt{2})\begin{pmatrix}1\\0\end{pmatrix}^{(2)}; \qquad \psi^{(2)}_{[1]} = (1/\sqrt{2})\begin{pmatrix}0\\1\end{pmatrix}^{(2)}; \qquad (5)$$

where $\psi^{(1)}_{[n]}$ - state vectors of the first coin, and $\psi^{(2)}_{[n]}$ - state vectors of the second coin. The state vector of the two-coin system will have the form:

$$\psi^{(1)(2)} = \psi^{(1)} \otimes \psi^{(2)} = \psi^{(1)(2)}_{[1][1]} + \psi^{(1)(2)}_{[1][2]} + \psi^{(1)(2)}_{[2][1]} + \psi^{(1)(2)}_{[2][2]};$$

$$\psi^{(i)\ (j)}_{[m][n]} = \psi^{(i)}_{[m]} \otimes \psi^{(j)}_{[n]}; \qquad (6)$$

The completeness condition for mutually exclusive probabilities will have the form:

$$< \overline{\Psi}^{(1)(2)}|\Psi^{(1)(2)} > = |\Psi^{(1)(2)}_{[1][1]}|^2 + |\Psi^{(1)(2)}_{[1][2]}|^2 + |\Psi^{(1)(2)}_{[2][1]}|^2 + $$
$$+ |\Psi^{(1)(2)}_{[2][2]}|^2 = 1/4 + 1/4 + 1/4 + 1/4 = 1; \qquad (7)$$

The relations indicated above correspond to coins that are not connected to each other in any way. To introduce connection, we assign the number (-1/2) to coins on one side, and (1/2) on the other side. We correspond the coin state when after tossing - in the stopped position, the number 1/2 is visible from above, with $\Psi^{(i)}_{[1]}$, and when (-1/2) is visible - we correspond with $\Psi^{(i)}_{[2]}$. We place these two coins close to each other in such a way that the number 1/2 was visible on the upper side of both. In this state we fasten the coins with some rigid connecting construction so that the connecting detail does not cover the numbers written on the coins. If we carry out events of tossing such a rigidly connected system, it is easy to understand that in "game mode" the superposition state vector corresponding to full expectations will have the form:

$$|\psi^{(1,2)}_{\{1\}}\rangle = [|\psi^{(1,2)}_{[1,1]}\rangle + |\psi^{(1,2)}_{[2,2]}\rangle]/\sqrt{2}; \qquad (8)$$

and the corresponding completeness condition:

$$\langle\psi^{(1,2)}_{\{1\}}|\psi^{(1,2)}_{\{1\}}\rangle = 1/2 + 1/2 = 1; \qquad (9)$$

Similarly we could implement rigid connection when the number 1/2 is visible on one coin and the number (-1/2) on the other. In this case instead of (8) and (9) we would have:

$$|\ |\psi^{(1,2)}_{\{2\}}\rangle = [|\psi^{(1,2)}_{[1,2]}\rangle + |\psi^{(1,2)}_{[2,1]}\rangle]/\sqrt{2};$$

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$\langle\psi^{(1,2)}_{\{2\}}|\psi^{(1,2)}_{\{2\}}\rangle$ = 1/2 + 1/2 = 1; (10)

Since these coins are no longer free, superposition state vectors of these cases are also not represented as tensor products of corresponding superposition state vectors of free coins indicated in (6). It might seem that state vectors - $|\psi^{(1,2)}_{\{1\}}\rangle$ and $|\psi^{(1,2)}_{\{2\}}\rangle$, correspond to mathematical implementation of "quantum entanglement." In connection with this, the first thing to note is that the phenomenon of "quantum entanglement" is defined for free objects, not for interacting and especially not for rigidly connected objects. Accordingly, the indicated mathematical parametrizations - only by the fact that they represent shortened superposition sums, are not facts indicating "quantum entanglement" of coins. For greater clarity we note that when state $|\psi^{(1,2)}_{[1,1]}\rangle$ is realized, random events are given only by that result which corresponds to the pair (1/2; 1/2) - visible from above on both coins. Similarly occurs realization of state $|\psi^{(1,2)}_{[2,2]}\rangle$ in case of pair (-1/2; -1/2). The physical state of a separate pair is formed not as a result of the fact that the result of observation of one coin induces corresponding state of the second coin, but the state of both coins is formed simultaneously as a result of existence of rigid connection, which has no direct relation to the probabilistic character of the results indicated above. That is, the act of observation carried out on one coin is not the cause of formation of the second coin's state. Therefore, this case does not correspond to the phenomenon of Schrödinger's "quantum entanglement."

Based on the considered example, let us return to Bohm's "riddle."

CHAPTER IV: Probabilistic Solution of "Bohm's Quantum Entanglement Puzzle"

To solve Bohm's "puzzle" let us recall from Part 3 (Baghaturia et al, 2025c), (Bell, 1964) of the text - what measuring spin means. When we fix the Z-component of spin in an object with half-integer spin, this does not mean that we measure something whose quantitative numerical size equals (1/2). "Measuring spin" of an object implies passing this object through an inhomogeneous magnetic field. When passing a stream of such objects through this field, division of the stream into two is observed - and this is perceived as indirect empirical evidence that objects of the stream should be assigned spin equal to 1/2. And this is only because, similar to orbital momentum, we assume that the spectrum of eigenvalues in the case of spin is also calculated in steps equal to unity. Similar to orbital momentum, we consider that this characteristic is inherent to objects even before entering the field, and therefore we assign it to objects in free state. After this we say - whatever initial direction the object's spin vector had before entering the inhomogeneous magnetic field, after entering the field, the spin vector will take such spatial position that its one component - conditionally, the Z-component can occupy only two possible states - either in the direction of the field lines with the value of the Z-component (1/2), or in the opposite direction with the value of the Z-component (-1/2). It turns out as if the act of spin fixation implies spatial, that is mechanical rotation of the spin vector (see Part 3 – Baghaturia et al, 2025c). Obviously, such spin, besides discrete quantitative characteristic, also corresponds to continuous characteristic - direction, due to which the spin vector was introduced. When reasoning about this characteristic of micro-objects, one should again use characteristics introduced in Part 2 (see – Baghaturia et al, 2025b) of the text - the spin vector before observation corresponds to "object for itself," and the result of observation of the spin vector corresponds to - "object for us." The spin conservation law, which we mathematically wrote in form (4), acts only for objects existing before the act of observation. Similar to momenta from the "EPR paradox," before the act of observation - spin vectors of objects born as a result of decay are located along one line and mutually oppositely directed. What spatial orientation this line itself has - we can never determine empirically in principle, since the result of empirical observation for fixing the direction of the spin vector depends only on what physical characteristics the magnetic field has in which we must pass these objects. As a result of this we determine not what direction the spin vector had before entering the magnetic field, but only - what positions the Z-components of these vectors will occupy as a result of entering the magnetic field. One can consider the case when these particles are born directly in the internal region of Stern-Gerlach magnets. When moving in the magnetic field their trajectories deviate either in the direction of the Z-axis or in the opposite direction. As we noted in Part-3 -- according to our concepts about spin, the trajectory of that object whose spin vector makes an acute angle with the positive direction of the Z-axis - deviates in the opposite direction of this direction, and the trajectory of the second object will deviate in the positive direction of the same axis. This means that for first object a state corresponding to $S^{(1)}_z$ = (1/2) is realized, and for the second object - corresponding to $S^{(2)}_z$ = (-1/2). To the indicated physical state - in probability space, a state vector should be assigned:

$$|\psi_1\rangle^{(1)(2)}_{(z)(z)}\rangle = |1/2\rangle^{(1)}_{(z)}\rangle \otimes |-1/2\rangle^{(2)}_{(z)}\rangle ; \quad (11)$$

Similar to rigidly connected coins, this "entanglement" is ensured not by the phenomenon of randomness corresponding to the act of observation, but by spatial orientation of spins existing before the act of observation. To understand the essence of this statement, let us find out what the phenomenon of randomness consists of in the interaction of the spin magnetic moment with a non-uniform magnetic field. To do this, we repeat macroscopically identically the decay of the initial object with zero spin and see what happens. Obviously, when passing through a non-uniform magnetic field, we will again see two trajectories deviating in mutually opposite directions. But these trajectories can correspond to objects corresponding to both the state specified in (11), and another case, which must correspond to a state vector of the form:

$$|\psi_2\rangle^{(1)(2)}_{(z)(z)} = |-1/2\rangle^{(1)}_{(z)}\rangle \otimes |1/2\rangle^{(2)}_{(z)}\rangle ; \quad (12)$$

Since we cannot indicate the direction of Z-components of spins of these objects before entering the external field, obviously, physical states corresponding to (11) and (12) should be considered as mutually exclusive alternatives of a random event. As we noted in Part 4 − from the point of view of probability theory principles, it does not matter whether we can distinguish these objects from each other or not. Corresponding probability amplitudes, that is − state vectors, should be mutually orthogonal, as implied in (11) and (12). That is, similar to rigidly connected coins - paired combinations represented by $|\psi_1\rangle^{(1)(2)}_{(z)(z)}$ and $|\psi_2\rangle^{(1)(2)}_{(z)(z)}$, represent mutually exclusive alternatives. In this respect, it may seem, that the physical circumstance indicated is analogous to the case of rigidly bound coins, but in reality, this is not so. Demonstration of this is easily possible if we conduct the act of birth of these objects outside the Stern-Gerlach setup and later place one of the objects in the magnetic field of the indicated setup. As a result we will see that the trajectory of this object deviates either along the field force lines or oppositely. Say, it deviated along the field, which means that when passing through the field, the third component of this object's spin acquired orientation corresponding to S_z = (-1/2), that is, was in state corresponding to $|-1/2\rangle^{(1)}_{(z)}$. As we noted above, using this information we cannot restore any component of the spin vector $\vec{S}^{0(1)}(t|t \geq t_0)$ of this object, since due to the "observer factor" the relation acts:

$$\vec{S}^{(1)}(t_1) = \hat{O}(\vec{B})\,\vec{S}^{0(1)}(t_1); \qquad (13)$$

where $\hat{O}(\vec{B})$ corresponds to the "rotation operator" of the spin vector by magnetic field. In this "operator" - the impact of magnetic field on $\vec{S}^{0(1)}(t_1)$, enters as uncontrolled perturbation $\hat{\delta}(\vec{B})$:

$$\hat{O} = 1 + \hat{\delta}(\vec{B}) ; \qquad (14)$$

the meaning of which is very simple - since we cannot observe either the spin vector or possible mechanical rotation of the object's spin vector, the operator $\hat{\delta}(\vec{B})$ corresponding to this act also corresponds to an operation uncontrolled for us. Similar to the momentum example considered in Part 2 of the text, in this case too - by fixing $S_z^{(1)}(t_1)$= (-1/2), we will not be able to restore the direction of vector $\vec{S}^{0(1)}(t_1)$. The act of decay process determines relation (4) only for spin vectors $\vec{S}^{0(1)}(t|t \geq t_0)$ and $\vec{S}^{0(2)}(t|t \geq t_0)$, which is violated at moment t_1 as a result of action of relation (13). The spin component of the first object - $S_z^{(1)}(t_1)$, will be established along the force lines of the magnetic field gradient, but how the remaining two components will change will be uncontrolled and therefore incomprehensible for us. The only thing we can say about these components is that if $S_z^{(1)}(t_1)$ = (-1/2), then the sum of squares of corresponding X and Y components will be - [(1/2)(1/2+1) – 1/4] = 1/2, but what the magnitudes of the components themselves will be - we cannot know. If at the moment t_2 we measure the component $S_x^{(2)}(t_2)$ of the spin vector of the second object, then as a result of the action of the corresponding magnetic field the direction of the vector $\vec{S}^{0(2)}(t|t \geq t_0)$ will change in a way that is uncontrollable for us, as a result of which the corresponding component $S_z^{(2)}(t_2)$ is formed. Therefore, from knowledge of the value $S_z^{(2)}(t_2)$ we will not be able to restore either $S_z^{0(2)}(t_0)$ - which existed before the measurement, or $S_z^{0(1)}(t_0)$ and even more so - $S_z^{(1)}(t_1)$.

Based on everything said, one can conclude: as in the case of the "EPR paradox," in the case of spins also no logical argument is observed on the basis of which we could reason about existence of the phenomenon of "quantum entanglement" and necessity of existence of "spooky instantaneous action at a distance" for fulfillment of the conservation law of total spin characteristics. Based on the considered examples one can unambiguously say:

No empirical fact and mathematical principles connected with them require necessity of existence of Schrödinger's phenomenon of "quantum entanglement," which implies necessity of instantaneous information propagation. Due to non-existence of this phenomenon, and for quantum computers it will also be impossible to create a mechanism of "instantaneous calculations" based on this phenomenon.

CHAPTER V: Bohm's Hidden Variables and Bell's Riddle

As mentioned above, Bohm pointed to possible existence of hidden variables as a possible cause of incompleteness of quantum-mechanical description. As an analogy of such possibility he pointed to thermodynamic description of some physical realities. The essence of the analogy was as follows: in the method of thermodynamic description we say - movement of individual molecules of the described medium is governed by deterministic laws, and corresponding description of movement of a large number of molecules of this medium is also possible in principle. But this problem is difficult to realize only because corresponding mathematical algorithms are simply not developed. Therefore, with the goal of simplifying description, we prefer to introduce and use corresponding mechanical "techniques" of statistical methods. In these mechanical "tricks," coordinates and momenta of individual molecules act as some hidden variables, ignorance of which makes the statistical method of reality description incomplete.

According to Bohm's assumption, quantum-mechanical description may also be incomplete due to the fact that in the case of the microworld there exist similar "hidden characteristics" and connected "hidden variables" that we cannot observe and account for due to their small sizes. This creates information deficit, due to which we have to transition to random variables and which leads us to incompleteness in quantum-mechanical description.

This statement should be partially agreed with, since the statistical description method indeed implies the fact of existence of information deficit. However, in the case of quantum mechanics this deficit is caused not by possible existence of unknown hidden variables, but is caused by objective reason caused by significant differences in scales between observer and observed, which generates the phenomenon that Bohr called - "observer factor."

On the other hand, as we noted in Part 2 (Baghaturia et al, 2025b) of the text, the fact that in a fixed quantum state of a micro-object we cannot precisely simultaneously indicate numerical values of coordinate and momentum does not mean that these micro-objects do not simultaneously possess these characteristics. The fact of ignorance arising from impossibility of indicating these quantities should indeed cause random results of events and consequently - attraction of statistical description methods.

However, Bohm did not specify what types of physical quantities should be implied by "hidden variables" - coordinates and momenta, or something else.

Here we also note - ignorance and impossibility of precise and simultaneous fixing of momentum and coordinate cannot be the cause of emergence of the phenomenon of discreteness of atomic energy levels. Therefore, even without information deficit we could assume that there may indeed exist some characteristics - both static and dynamic, the existence of which we do not notice at the micro level, and - possibly, therefore we cannot correctly explain facts observed at the macro level.

The best example of this is light, for which we have supposedly established that it represents a stream of corpuscular photons, not a continuously distributed wave construction in space. But despite this, when describing some physical realities, we still often use wave representation as if these waves really existed. As a result of this, when quantum-mechanically describing the microworld, we have to make false statements (see - Baghaturia et al, 2025a).

It is also possible that we make an error when we assert pointedness of fundamental particles, and we need to more carefully consider the ancient Greek statement: in a point - with zero volume, there is zero quantity of matter, which should be a sign that existence of matter does not correspond to zero volume. The phenomenon of existence of matter in zero volume we can never observe directly and only by indirect signs can we reason about existence of matter in such forms.

However, along with all this, it is also necessary to note that whatever types of quantities we might imply behind Bohm's hidden variables, their existence or non-existence cannot cause necessity of introducing the phenomenon of "quantum entanglement" into quantum-mechanical descriptions. Such necessity simply does not exist, and the question is reduced only to correct accounting of the "observer factor" and correct application of probability theory principles.

It should be noted that our statement contradicts the "general line" of physics representations formed in recent decades, according to which the existence of "quantum entangled" photons is considered an empirically proven fact and "which creates a large arena of innovation in informatics" (see e.g. (10, 2022).

The formation of such representation was facilitated by J. Bell's publication published in 1964 (see Bell JS. 1964). In this work the author introduced mathematical inequalities which - allegedly, in case of existence of hidden variables should be imposed as physical restrictions on random variables and their corresponding probabilities.

However, the mathematical relations that Bell introduced in his reasoning are so far from correct interpretations of elements of probability space that not only the status of conclusions made by him becomes unclear, but also interpretations of the essence of individual mathematical expressions.

Unfortunately, among theoretical physicists no one paid attention to these details, and as a result - these relations passed into experimental physics as theoretically argued.

Despite such an assessment of Bell's statements, it is quite clear that even without our assessment, it would be impossible to prove the existence of "quantum entangled" photons by fulfilling or violating any inequalities, since the phenomenon of "quantum entanglement" itself is a theoretical product, erroneously introduced into theoretical considerations.

The solution to this experimental riddle is also not complex, and the matter is as follows: the main statement of Bell's indicated work is the conclusion: if his introduced inequalities are fulfilled, then hidden variables exist, and both quantum-mechanical randomness and Schrödinger's phenomenon of "quantum entanglement" do not represent characteristics of reality, and microworld reality is strictly deterministic. Quantum randomness arises only from ignorance of information about these hidden variables.

And on the other hand - if these inequalities are violated, this means that no hidden variables exist, and quantum randomness represents direct characteristics of the microworld. Accordingly, if we empirically discover the fact of violation of these inequalities, this will be empirical proof that all principles of quantum mechanics are empirically founded. And since from these principles follows existence of the phenomenon of "quantum entanglement," consequently, with help of experimental verification of these inequalities, proof of existence of the indicated phenomenon also becomes possible.

The fallacy of this chain of logic is that empirical proof of the principles of quantum mechanics does not at all imply proof of the existence of the phenomenon of “quantum entanglement”.

Therefore, it should be clearly stated that: the “general line” in fundamental concepts of physics that has emerged in recent decades requires critical rethinking and that a “large field of innovation” based on the phenomenon of “quantum entanglement” is not emerging in computer science.

CONCLUSION

From the issues discussed in parts (1-7) of the full text, one can draw an unambiguous conclusion: the transformation of the erroneous idea of a "quantum computer" into a myth is indeed caused by an incorrect interpretation of the principles of quantum mechanics and probability theory. As we noted in the introduction to this part of the full text, a similar problem was observed in the 19th century, and it can be said with confidence that we are dealing with the same phenomena that are observed in physical processes and are subject to laws corresponding to the "law of large numbers".

In conditions of globalization, when communication also greatly increases and information technologies develop significantly, significant growth of information flows automatically causes appearance of significant problems. For effective solution of such problems, it will periodically be necessary to include the instrument of "empirical criticism." That is, on one hand, from positions of theoretical physics - critically reconsider phenomenological assessments of empirical data and conclusions made based on these assessments; on the other hand, using empirical data, critically analyze mathematical principles introduced into theoretical physics for describing these data.

As the past two-hundred-year experience shows, it is desirable that this occur every 50 years, since - it is precisely in such terms that myths are born, which develop and begin to create problems.

Our 7-part series of publications should be taken in the spirit of the above strategy.

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