"QUANTUM SUPERPOSITION"

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ABSTRACT

According to the principles of quantum mechanics, a quantum superposition is defined by the sum of the basis vectors of a probability space. Depending on the physical circumstances under which the corresponding events with random outputs occur, these sums can be realized by an infinite number of different combinations of the mixing coefficients of these vectors. Theoretical concepts of a "quantum computer" assume that when creating an information bit, each physical state corresponding to a specific superposition sum can be used as a separate detail of this information bit. Based on this phenomenon, in the case of a single quantum object, the creation of many and potentially infinite classical digital bits is assumed, and it is precisely this phenomenon that corresponds to the "Q-bit." Our goal is to determine, from the standpoint of the principles of quantum mechanics, whether an empirical realization of the "Q-bit" is possible. Below, we demonstrate that a physical realization of this idea will be impossible, since the arguments cited as the basis for such an implementation contradict the principles of quantum mechanics and are based on false interpretations of these principles.

1: INTRODUCTION

As we noted in Part III of the text (see [1]), the phenomenon of superposition of probability amplitudes is a characteristic feature of probability theory and arises in all types of mechanics on the same basis—as a characteristic corresponding to our expectations. In this part of the text, our goal will be to clarify: in a probabilistic description of microscopic processes, whether the phenomenon of superposition reveals fundamentally different details that have no analogues in macroscopic processes. As we will demonstrate below, no empirical fact can be found in the mechanics of microcosm processes that would indicate the existence of such details. Based on the above, we will also demonstrate that the creation of a "quantum transistor," i.e. - a "Q-bit," which could potentially replace an infinite number of classical transistors, will in fact be impossible.

2: – A BRIEF HISTORY OF THE ISSUE

The concept of "quantum superposition" arises from the fundamental principles of quantum mechanics. According to Bohr, the results of observations of microcosm processes—due to the "observer factor"—will always appear random to us (see [2]). Therefore, the description of these processes is possible only by statistical and probabilistic methods. The mathematical principles of quantum mechanics are based on Born's idea: the "Wave-Corpuscular" dualistic nature should be attributed objects of the microcosm not in the form of direct physical characteristics, but in the form of probabilistic ones. In addition to this, it followed from empirical observations that it is not the physical or probabilistic characteristics of various micro-objects that "interfere" with each other, but only the probabilistic alternatives of the individual objects themselves (for more information on why we use the symbol "" here, see [3]). The mathematical principle corresponding to this fact was reflected in the basic idea of M. Born, according to which the statistical regularities obtained by the phenomenological study of the results of multiple events should be attributed to each quantum object in the form of probability amplitudes. As noted in Part III of this text (see [1]): "The formation of a logical chain corresponding to new ideas was completed when M. Born gave an interpretation of the Schrödinger equation as a dynamic equation for probability amplitudes. As a result, the probabilistic space was extended not only to abstract hyper numbers—corresponding to matrix algebra—but also to an even more abstract space of complex numbers. Since probability and probability amplitude are abstract mathematical constructs, the attribution of wave properties to them did not require the existence of any really existing etheric medium. However, such an expansion of the probabilistic space can introduce such degrees of freedom into the corresponding mechanics, that it will require great vigilance in the physical interpretation of the corresponding mathematical relations (when such details are not given sufficient attention, the ground is created for the emergence of myths). But at the same time, it is necessary to say the following: the introduction of probability amplitudes for the description of physical states was one of the most important facts from both a physical and a mathematical point of view. The fact is that – **the introduction of state vectors as a mathematical principle of probability theory makes it possible to describe statistical reality more perfectly than would be possible without these vectors.**

Since Schrödinger's equation was linear, it made it possible to realize wave properties, on the basis of which the concepts of "superposition of probability amplitudes" and "interference of probabilistic alternatives" appeared in the concepts of quantum mechanics. And as it was noted in [3], with such an expansion of the probability space, neither other fundamental principles of this space, nor the physical interpretations arising from these principles should be violated. At the initial stage of the formation of quantum mechanical concepts, satisfying this condition was not an easy task, since the mathematical principles according to which the expansion of the probability space to the spaces of probability amplitudes took place were a completely new mathematical phenomenon that was not based on previous experience. The formation of the corresponding principles took place in parallel with the formation of quantum concepts. This created the basis for the illusion that this extension and the corresponding mathematical principles are unique characteristics of quantum processes. On this basis, in the middle of the 20th century, a well-known version of the definition of the phenomenon of "quantum superposition" was formed (see, for example, [4], [5]):

1: Let a specific outcome of an event involving a given quantum object be achieved in two different ways, and without a macroscopic external influence it is impossible to determine precisely which way this outcome was achieved. Let these different ways correspond to specific alternatives in the space of probability amplitudes, which are also assigned specific state vectors. The probability of the realization of the aforementioned specific outcome of the event is defined as the square of the "superposition sum" of the state vectors of the corresponding alternatives. If no macroscopic external influence is exerted on the given quantum object to fix the way in which a specific outcome was achieved, then both the squares and the mixed products of these state vectors contribute to the formation of the numerical value of the probability. The contributions corresponding to the mixed products are called "interference contributions," and the corresponding mathematical phenomenon—the summation of state vectors as probability amplitudes of quantum alternatives—is called "quantum superposition." Only those numerical values of the results of theoretical calculations that are obtained taking into account the "interference contributions" are consistent with the experimental data;

2: "Quantum superposition" is a purely quantum phenomenon and has no analogue in classical mechanics.

From these ideas it followed that the superposition of probability amplitudes automatically leads to the emergence of "interference contributions" in probability expressions, which is an erroneous statement.
Over time, even more dubious details have been included in the understanding of the phenomenon of "quantum superposition", and to indicate the final formulation, we will use versions authored by various artificial intelligences:

GEMINI: Quantum superposition is a fundamental principle of quantum mechanics that states that a quantum system (e.g., an electron or a photon) can exist simultaneously in several mutually exclusive states as long as it is not observed. Simply put: in the classical world, an object can only be in one particular state at any given time. For example, a coin is either heads or tails. In the quantum world (during superposition): A particle can be both heads and tails (i.e., a combination of both) until we look at the object. As soon as we observe (i.e., measure), the superposition breaks down and the particle chooses one of the specific states (e.g., "heads"). This concept sounds illogical based on our everyday experience, but it is a reality of the quantum world and underpins many modern technologies, including quantum computers. The famous thought experiment – "Schrödinger's Cat" – was also created to explain this principle.

SCISPACE: Quantum superposition is a fundamental principle of quantum mechanics that allows a quantum system to exist in multiple states at the same time until it is measured. This principle is essential for understanding phenomena such as quantum entanglement and the behavior of particles at the quantum level. This contradicts classical physics, according to which objects exist in the same state at any given time. Quantum superposition arises from the principle of quantum mechanical superposition, according to which a quantum state can be expressed as a linear combination of several states. This principle is formulated mathematically and is necessary for quantum computers to work, allowing them to perform complex calculations more efficiently than classical computers. The notion of superposition challenges classical notions of measurement and reality, as it implies that exact states cannot be determined until an observation occurs. The impossibility of achieving precise coordinates in quantum measurements highlights the flaw in the classical interpretation of superposition, which implies the need to rethink its physical meaning. Although quantum superposition is a cornerstone of quantum mechanics, its implications can lead to paradoxes and difficulties in understanding reality, leading to ongoing debates about the nature of measurements and observations in quantum systems.

OPTICA AI: Quantum superposition is one of the basic principles of quantum mechanics, which implies that a quantum system can be in several different states at the same time until a measurement or observation occurs. This means that if we have two or more possible states, the system can be a linear combination of them, i.e. a superposition, and only when measured does it "choose" one particular state. Phenomena such as quantum entanglement and quantum coherence, and has many important applications in quantum information technology, including quantum computing and quantum cryptography. For example, as described in Liu, Zhang, Guo, et al., "Creation of superposition of arbitrary states encoded in two high-Q cavities", Opt. Express 27, 27168–27182 (2019). This paper highlights that superposition is a physical resource that is essential for quantum information processing and quantum computing, as it causes other interesting quantum phenomena such as entanglement and coherence.

In this part of the text, our task will be to show that the above definitions and ideas contradict the fundamental principles on which discussions of probabilities and probability amplitudes should be based.

3: THE BASIS OF QUANTUM SUPERPOSITION

In order to clarify the details of the essence of the "Quantum Superposition", let us consider the arguments of two demonstration examples indicated in [5]. In the first example, particles A and B collide, which we can distinguish from each other in the same way as in the third part of the text we distinguished coins painted in different colors. The authors' goal is to describe the scattering of these particles in the center of mass system at angles π/2. To achieve this, particle detectors should be installed in the appropriate plane, at equal distances and in opposite directions of one selected axis. One of them will be designated with the number 1, the other with the number 2. Let $\Phi_{AB}(1;2)$ denote the amplitude of probability when particle **A** enters detector 1 and **B** enters detector 2. Similarly, let $\Phi_{AB}(2;1)$ be the probability amplitude when particle **A** hits detector 2 and particle **B** hits detector 1. It is assumed that the interaction that causes the scattering process is symmetrical with respect to the rotations in the specified plane. This means that when scattered at π/2 angles, these particles are scattered with equal probability in all possible directions of this plane, and if the particle capture angles of these detectors do not completely cover the entire scattering plane, some particles may not reach detectors 1 and 2. If the capture angles of both detectors are equal to each other, the relation: $p_{AB}= |\Phi_{AB}(1;2)|^2=|\Phi_{AB}(2;1)|^2$. That is, in the case of large statistics, approximately equal numbers of particles **A** and **B** will be recorded in two oppositely located detectors. The probability that particles **A** and **B** will be detected in both detectors is denoted as W(A; B). According to the authors of this publication, as well as generally accepted concepts, since we can distinguish between the corresponding physical states $\Phi_{AB}(1;2)$ and $\Phi_{AB}(2;1)$, these physical alternatives are mutually exclusive, and to calculate W(A; B), we must use the probability addition rule:

$$W(A;B) = |\Phi_{AB}(1;2)|^2 + |\Phi_{AB}(2;1)|^2 = 2\,p_{AB}\,; \tag{3.1}$$

When **A** and **B** are identical particles, it is impossible to distinguish between the corresponding physical states, and according to the same ideas, these states no longer represent mutually exclusive alternatives. Therefore, to compute W(A; A) First, you need to add the corresponding amplitudes and calculate the desired full probability with the square of this sum:

$$W(A;A) = |\Phi_{AA}(1;2) + \Phi_{AA}(2;1)|^2\,; \tag{3.2}$$

Because of the symmetry of the interaction in the scattering plane, the theoretical expressions of the probability amplitudes obtained by solving the Schrödinger equation satisfy the relation $\Phi_{AA}(1;2) = \Phi_{AA}(2;1)$, and the probability sought will be:

$$W(A;A) = |2\Phi_{AA}(1;2)|^2 = 4p_{AA}\,; \tag{3.3}$$

In the literature on quantum particle studies, it is stated that in experiments on the scattering of α-particles, it is the theoretical result (3.3) for identical particles that is empirically confirmed, and not (2). This statement is given in all textbooks on quantum mechanics, including [5].

Let us begin our critical analysis of the evidence presented in the above discussion with a simple remark for the case of different particles: The Schrödinger equation can be written in the case of different particles, and the state vectors $\Phi_{AB}(1;2)$ and $\Phi_{AB}(2;1)$ can be explicitly specified as solutions. Since these state vectors correspond to mutually exclusive alternatives, as the authors [5] also note, these vectors must be orthogonal to each other:

$$< \Phi_{AB}(1;2)|\Phi_{AB}(2;1) > = < \Phi_{AB}(2;1)|\Phi_{AB}(1;2) > = 0; \tag{3.4}$$

In this case, the result indicated in (3.1) will automatically be obtained from the corresponding superposition sum. Then, in the case of distinguishable particles, it is unclear - what prevents us from using the amplitude addition rule according to recipe (3.2) instead of (3.1). The answer to the question posed is easy to obtain: the fact is that the method by which we write and solve the Schrödinger equation easily turns out that $\Phi_{AB}(1;2) = \Phi_{AB}(2;1)$. In the case of adding the amplitudes we would get: W(A; B) = $4p_{AB}$, which would be a mistake not only according to the concepts of quantum mechanics, but also according to the principles of the theory of probability, which we indicated in the third part of the text on the example of macro-bodies - coins. Therefore, the generally accepted ideas offer a simple way out - in the case of distinguishable particles, simply - without additional arguments, it is necessary to add up probabilities, not amplitudes.

Let's move on to the case of identical particles. To experimentally verify the corresponding theoretical result, it is necessary to explicitly specify the state vectors $\Phi_{\alpha\alpha}(1;2)$ and $\Phi_{\alpha\alpha}(2;1)$, which requires solving the corresponding Schrödinger equation. In order for the obtained solutions to be assigned the status of probability amplitudes, it is necessary to use the principle of completeness of probabilities. As noted in Part III of the text (on the example of the consideration of macro-objects), by introducing equalities of the type - $\Phi_{AA}(1;2)= \Phi_{AA}(2;1)$, a certain detail, the presence of which is necessary for the correct fulfillment of the completeness condition, is destroyed. According to the basic principles of constructing probabilistic spaces, the state vectors $\Phi_{AA}(1;2)$ and $\Phi_{AA}(2;1)$ - like the vectors $\Phi_{AB}(1;2)$ and $\Phi_{AB}(2;1)$, must be orthogonal to each other and these vectors cannot be equal in any way. Neither the authors [5], nor other authors, discuss this detail, and all emphasize that the distinction of identical macro-bodies is in principle possible. At the same time, the distinction between identical micro-objects is fundamentally impossible. On the basis of the above, it is believed that the probabilistic space of the microcosm is fundamentally different from the probabilistic space of the macrocosm. Therefore, in the argument, the emphasis is shifted to the statement that the results of empirical observation correspond only to those probabilities whose superposition sums are constructed using the condition $\Phi_{AA}(1;2) = \Phi_{AA}(2;1)$. In this case, the fundamental question arises - which theoretical expression is compared with the results of empirical observations. In textbooks on quantum mechanics, these theoretical expressions are indicated (see, e.g., [6]), but no one analyzes the mathematic method of their receiving. Meanwhile, this mathematical method does not have a high standard of self-consistency and raises questions. We will devote a separate publication to this issue and there we will indicate in detail what specific incorrect mathematical calculations are used in the so-called "Moth's calculations" (see [6]). Here we will only indicate the final conclusion:

A critical revision of the method of deriving the so-called "Mott formula" shows that not only the methods of mathematical approximations were used incorrectly, but also the very formulation of the scattering problem by the method of solving the stationary Schrödinger equation is incorrect, since it does not have such a possibility by definition. Consequently, the comparison of experimental results of α particle scattering with theoretical ones requires more correct mathematical calculations and a correct formulation of the problem. Therefore, the relation given in (3.3) cannot be considered empirically proven either.

The example of α-particle scattering does not clearly illustrate the basic principle of quantum mechanics:

It is not the characteristics of different particles that interfere, but the probabilistic alternatives of one particle.

This principle is more clearly reflected in the second example [5], which is related to experiments in the passage of a flow of identical particles into a system of slits. The authors consider a theoretically imaginary experiment, since, in their opinion, in order to obtain an "interference" pattern when particles pass through two slits, it is necessary to construct slits of very small sizes and so close that from a technical point of view, the implementation of such an experiment will be a rather difficult task. Thus, all statements and conclusions were based only on theoretically imaginary "empirical facts". Here are the main statements on which the authors' logic was based:

Empirical statements corresponding to the thought experiment

E_0: Individual electrons passing through the holes leave spatially localized traces on the screen, which is consistent with their corpuscular nature;

E_1: When the flow of electrons passes through one micro-hole, the set of traces formed on the screen behind the hole will have the form of a Gaussian distribution, which is also consistent with their corpuscular nature;

E_2: when the same flow passes through two micro-holes located very close to each other, and it is not recorded through which hole a particular object has passed, the set of traces formed on the screen will have the spatial form of discretely located spots corresponding to the interference pattern, which is consistent with the manifestation of the wave nature of these objects;

E_3: If we use some device to determine which slit a particular object passes through, the set of traces formed on the screen will have a distribution that corresponds to the sum of two Gaussian distributions obtained for passage through individual holes. This, again, corresponds to the corpuscular nature of electrons;

These "empirical facts" were accompanied by corresponding theoretical statements:

T_1: In an ideal experiment, when a random event occurs without external intervention, the probability of the outcome of such an event is determined by the square of the complex number φ, which corresponds to the amplitude of this probability: $P = |\varphi|^2$;

T_2: When the same outcome of an event can be achieved by two different, mutually exclusive ways of realizing this event, which correspond to amplitudes of probability - φ_1 and φ_2, the corresponding complete probability of this outcome is determined by the ratio: $P = |\varphi_1 + \varphi_2|^2$;

T_3: When an electron passes through two holes, and we do not observe which particular hole the electron has passed through, the probability of the electron hitting a certain point on the screen is determined by the relation: $P = |\varphi_1|^2 + |\varphi_2|^2 + \varphi_1{}^*\varphi_2 + \varphi_2{}^*\varphi_1$ and in this case, the alternatives corresponding φ_1 to and φ_2 - interfere;

T_4: When an electron passes through two holes and through the act of observation we register which particular hole the electron passed through, the overall probability of the electron hitting a certain point on the screen is determined by the ratio: $P = |\varphi_1|^2 + |\varphi_2|^2$ and in this case - the alternatives corresponding to φ_1 and φ_2 - do not interfere;

Indeed, any specific result from a set of statistical results can be realized by moving along different, mutually exclusive trajectories. However, a statistical-probabilistic description of the results of such events does not imply an indication of the trajectories along which a specific result is realized. On the other hand, it is obvious that even if we try to construct a probability space based on the principle of specifying all possible trajectories, even in this case it will be impossible to specify the physical mechanism for the formation of interference terms in the square of superposition sums. The point is that the detail used in T_2 regarding the mutual exclusion of alternatives contradicted the possibility of interference terms appearing in the squares of superposition sums, since the state vectors corresponding to such alternatives would have to be mutually orthogonal. In this case, the transition from T_2 to T_3 would have been impossible.

To overcome this contradiction, the authors of [5] – instead of the alternatives corresponding to mutually exclusive physical trajectories introduced in [4] – introduced another version of defining the alternatives

φ_1 and φ_2. This version is associated with motion along virtual trajectories, which do not require the introduction of the physical condition of mutual exclusion that automatically arises when moving along real trajectories. In this case, questions that might arise when moving along real trajectories are eliminated – what ensures the movement of a free electron along curved trajectories, after which it ends up at the same point on the screen. In the case of motion along virtual trajectories, such questions become meaningless, since the empirical laws of physics should not be satisfied on these trajectories.

In this case, the transition from T_2 to T_3 also becomes consistent. Despite this "success", in this case there is a need to introduce a condition corresponding to a non-physical requirement. In particular, the T_4 says: "When we observe the passage of an electron through holes, the electron always passes through only one hole, and therefore the trajectories corresponding to the real motion of the electron through two holes are also correspond to mutually exclusive alternatives. And when we do not observe the passage of an electron through the holes, the motion corresponds to virtual trajectories, and when passing through two holes, interference terms appear in the corresponding probabilities. Only the first part of this condition corresponds to physical reality: "**when we observe a particle, a quantum object behaves like a real corpuscle**". The second part is based on a mystical statement: "***when we do not observe, a quantum object behaves like a virtually existing corpuscle***", the probabilistic alternatives of passing through two holes cease to be mutually exclusive. The fact that the second part is truly mystical is supported by a simple question:

When we don't observe, how do we know how a quantum object behaves?

And even more, on what basis do we assert that alternatives to exit through two holes cease to be mutually exclusive? In this regard, it is appropriate to cite the main statement from [4], on which the corresponding quantum-mechanical representations of wave-particle dualism are based:

M. statement: "One might still like to ask: "How does it work? What is the machinery behind those laws? " No one has found any machinery behind those laws. No one can "explain" any more than we have just "explained." No one will give you any deeper representation of the situation. We have no ideas about a more basic mechanism from which these results can be deduced".

Despite the skepticism expressed in the **statement-M**, relying on empirical data obtained over the past few decades, it is not difficult to show that the "empirical statements" E_1 and E_3 contradict the actual empirical facts and, therefore, there is no need to introduce the corresponding dubious **T**-statements. What actually follows from the forms of multiple traces corresponding to the passage of quantum particle flows in the slits is discussed in detail in the publication [3]. In this work, we have shown that the statement E_1 contradicts the observed reality, and in the case of one slit the same diffraction pattern arises as in the case of two slits. We have also pointed out that these diffraction patterns and the mechanisms of their formation have nothing to do with the superposition of real waves, and that the term "interference" is not only erroneously attributed to the Huygens-Fresnel mechanism, but its original definition - introduced by Young, has been distorted by this. In conclusion, it was noted that there are no empirical grounds and theoretical arguments on the basis of which it would be possible to attribute wave characteristics to objects of the microcosm. This means that there is no need to attribute wave characteristics to the elements of the probabilistic space of quantum objects.

This mystical phenomenon—"the disappearance and reappearance of wave and corpuscular nature in quantum objects under various physical conditions"—is often presented as a special case of the so-called "wave function collapse." And the phenomenon of "collapse" is also defined as a specific feature of the quantum nature of the micro-world. In reality, as we demonstrated in Part III of our text, the phenomenon of "state vector collapse" corresponds to a general and fundamental principle of probability theory, which applies wherever we use this theory to describe the statistical data of multiple events.

Based on the above, it can be argued that both phenomena - "quantum collapse" and "quantum superposition" - correspond to the usual characteristics of probabilistic space and there are no "quantum phenomena" of a different nature.

Let us summarize the above as follows: in quantum mechanics, one must follow Bohr's principle: when describing the physical reality of the microcosm, in reasoning, one must use only empirically observable facts and introduce only those theoretical concepts that directly follow from these facts. E.g., from the empirically observed fact of the equality of probabilities $|\Phi_{\mathrm{AB}}(1;2)|^2 = |\Phi_{\mathrm{AB}}(2;1)|^2$ it does not follow that the relation $\Phi_{\mathrm{AB}}(1;2) = \Phi_{\mathrm{AB}}(2;1)$. And from the point of view of the basics of probability theory, this ratio is simply wrong! It is not very difficult to prove this. To do this, it is quite sufficient to correctly specify the state vectors $\Phi_{\mathrm{AB}}(1;2)$ and $\Phi_{\mathrm{AB}}(2;1)$. In particular, it should be taken into account that when particle **A** hits the first detector, it means that the same particle did not hit the second one, and these two events represent mutually exclusive physical realities. Similarly, in the case of the **B**-particle. This empirical circumstance means that in the construction - $\Phi_{\mathrm{AB}}(2;1)$, the state vector of particle **A** must be orthogonal to a similar vector in the construction - $\Phi_{\mathrm{AB}}(1;2)$. The state vectors of the **B-**particle should be arranged in a similar way. Since we are considering only two alternatives, we can represent this circumstance in two-component columns, just as we did in the case of coins (see Part III of the text):

$$\Phi_{\mathrm{AB}}(1;2) = \Psi_A(1) \otimes \Psi_B(2) = \begin{pmatrix} \Psi_A \\ 0 \end{pmatrix} \otimes \begin{pmatrix} 0 \\ \Psi_B \end{pmatrix};$$

$$\Phi_{\mathrm{AB}}(2;1) = \Psi_A(2) \otimes \Psi_B(1) = \begin{pmatrix} 0 \\ \Psi_A \end{pmatrix} \otimes \begin{pmatrix} \Psi_B \\ 0 \end{pmatrix}; \qquad (3.6)$$

Ψ_A and Ψ_B are ordinary numerical functions. We could write down any other combination of columns that would take into account the orthogonality condition (3.4) resulting from the physical requirements of empirical circumstances. Relations (3.6) unambiguously indicate that - $\Phi_{\mathrm{AB}}(1;2) \neq \Phi_{\mathrm{AB}}(2;1)$. Based on errors associated with such technical details, a myth has developed that:

"Quantum superposition is a purely quantum phenomenon that has no analogue in classical mechanics."

This statement is true only within the framework of the mysticism according to which, *when we do not observe the electron, it passes through two slits according to the "wave principles".* This statement is mystical, since it contradicts the results of empirical observations. Indeed, a wave formed on the surface of water—due to its spatial extension—does indeed pass through two slits, and this is an empirically observable fact. However, it is equally observable that micro-objects pass through only one slit. The most important statement of probability theory is the following:

According to the fundamental principles of the theory, probability characteristics should be introduced only based on statistical data obtained from empirical observations, and such probability characteristics should not contradict other empirically observable facts.

It is not difficult to guess that the probability characteristics corresponding to the alternatives of virtual trajectories in principle cannot correspond to empirical observations and, on the basis of the above, are obviously deprived of the possibility of being used in probabilistic theories).

All of the above clearly indicates that both the electron and the photon pass through only one hole, regardless of whether we observe the facts of the passage or not. Therefore, in order to explain the mechanism of the formation of diffraction patterns that appear on the screen in all experiments – with one slit, with two slits, and with three or more – there is no need to introduce wave properties for probability amplitudes through virtual trajectories. Therefore, no “interference” terms should arise in probabilistic superposition sums (see [3] for details).

If we consider the essence of the "Q-bit" from the same point of view, we will see that the corresponding physical state of the "Q-bit" will not be able to store more information than it is done with the help of classical transistors. Indeed, the mathematical parameterization of the Q-bit is done by the same mathematical tool that parameterizes the results of a coin toss (see Part III):

$$\Psi(\theta) = [\cos\theta\, \Psi_z(1/2) \pm \sin\theta\, \Psi_z(-1/2)] = [\cos\theta \begin{pmatrix}1\\0\end{pmatrix} \pm \sin\theta \begin{pmatrix}0\\1\end{pmatrix}]; \qquad (3.7)$$

In the state vector written in this form, we say that $\cos^2\theta$ and $\sin^2\theta$ represent the probabilities of the realization of the corresponding physical states - $\Psi_z(1/2)$ and $\Psi_z(-1/2)$. As we noted in Part-III, the particular numerical value of $\theta = \theta_1$ corresponds to the particular physical circumstance in which the particular values of the probabilities - $\cos^2\theta_1$ and $\sin^2\theta_1$. In order to move from the numerical value of $\theta = \theta_1$ to the numerical value of $\theta = \theta_2$, the physical circumstance of the occurrence of repeating events - corresponding θ_1, must be replaced by the physical circumstance of the occurrence of repeating events - corresponding θ_2. Obviously, the physical circumstances corresponding to θ_1 and θ_2 will be mutually exclusive, and the state vectors corresponding to these two cases must be orthogonal to each other. Since the mathematical form of the realization of relation (2.7) is not the carrier of this property, the corresponding mathematical problem must be formulated as follows: to construct a vector space whose vectors will satisfy the orthogonality condition:

$$< \overline{\Psi}(\theta_i)|\Psi(\theta_j) > = \delta_{ij} \; ; \qquad (3.8)$$

In summary, with regard to "Q-bits" we can say:

"Quantum transistors" constructed using "Q-bits" and based on the phenomenon of "quantum superposition" will also obey the principle of mutual exclusion: if a "Q-bit transistor" corresponding to a specific θ_i- angle is realized, no other "transistor" can be realized in the same physical circumstance. As soon as a "transistor" corresponding to a angle θ_j is realized, the previously existing "transistor" disappears, and the newly created "transistor" will be indistinguishable from the one that disappeared, and these two mutually exclusive circumstances are not remembered or constitute a list of different "transistors." Thus, with the help of a "Q-bit," the simultaneous physical realization of several, much less an infinite number of "classical transistors" will be impossible. The "Q-bit Quantum Transistor of Infinite Volume" combines only those possible probabilistic outcomes that correspond to our expectations, conditioned by those infinitely possible types of changes in physical circumstances under which macroscopic repeating events are produced.

To demonstrate the analogy between quantum and classical "transistors", let's give an example of a circuit breaker. Suppose we have a macroscopic switch, which is designed in such a way that to turn it on, you need to press the switch button. Switching on occurs according to the following principle: when we press the switch button, the activation is realized with a probability of 1/2 and with a probability of 1/2 the activation is not implemented. Obviously, we can compare the state vectors of probability amplitudes to such a "transistor" according to the same mathematical principles as we compared it to a coin and a "Q-bit". Like such a switch, we can also make such a switch, in which, after pressing the button with a finger, the implementation of switching on will take place three times more often than not turning on. Such a "transistor" also corresponds to state vectors, the coefficients of which will be corresponding. Likewise, we can make many different classical transistors that operate on the principle of random events, and we can make all of these transistors by physically altering the design of one original "transistor" in such a way as to conform to the mathematical principle specified in (2.7). However, it is quite obvious that if we have a "transistor" with superposition sum coefficients cos θ = sin θ = $1/\sqrt{2}$, this "transistor" is not at the same time a "transistor" to which the coefficients cos θ = $\sqrt{3}/2$ and sin θ = 1/2 correspond. In the same way, an electron acts if we want to "mount" a "Q-bit" on it - in some physical circumstance that we create, it acts as a "transistor" with the coefficients cos θ = sin θ = $1/\sqrt{2}$, and if we create another physical circumstance - it acts as a "transistor" with the coefficients cos θ = $\sqrt{3}/2$ and sin θ = 1/2. It is easy to understand that these circumstances are macroscopic and therefore we will be able to both arrange and control them.

Clearly, if we use a "Q-bit" to multiply information, we'll replace a properly functioning classical transistor with a single "broken transistor," which we'll call a "quantum transistor." A properly functioning transistor corresponds to the case where turning it on deterministically causes the desired result, and turning it off also deterministically causes the desired result. We'll address these issues in more detail in Part V, which deals with the phenomenon of "quantum entanglement."

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