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Quantum register cannot be real.

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Abstract A quantum computer cannot be real since a quantum register must exist in the real three-dimensional space rather than in a multidimensional Hilbert space. Quantum states, according to Born's proposal, describe the knowledge of the observer about the probability of results of upcoming observations. The knowledge of the observer about N qubits is described with the help of N-dimensional Hilbert space. But any real device, including a quantum register, should exist in the real three-dimensional space. Spinors describe not only the probability to observe a spin projection, spin-up or spin-down, but also real spin states existing in the real three-dimensional space. The components of the spinor, like the components of a vector, undergo a linear transformation with a rotation of the coordinate system in the real isotropic three-dimensional space. But the quantum register cannot describe real states in the real three-dimensional space since the operators of finite rotations of the coordinate system cannot be applied to spin states of entangled particles. The entangled states can describe only the knowledge of the observer in agreement with the only correct definition of the EPR correlation as 'entanglement of our knowledge' given by Schrodinger in 1935. Therefore no quantum register can be real.

Keywords Quantum computation · Quantum register · Real three-dimensional space · Hilbert space · Operators of finite rotations of the coordinate system · Bloch sphere · Non-entangled spin states · Entangled spin states · Entanglement of our knowledge · Born's proposal · EPR correlation · Bell's inequalities

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1 Introduction

Alain Aspect, a well-known experimenter, whose team was the first to obtain reliable evidence for the violation of Bell's inequalities [1–3], stated in his Viewpoint: "*By closing two loopholes at once, three experimental tests of Bell's inequalities* [5–7] *remove the last doubts that we should renounce local realism. They also open the door to new quantum information technologies*" [4]. New quantum information technologies, in particular the idea of a quantum computer, are based on the most paradoxical principle of quantum mechanics, known as the Einstein - Podolsky - Rosen (EPR) correlation [8]. This principle is paradoxical already because A. Einstein, B. Podolsky, and N. Rosen were sure in its impossibility [8]. But according to the now dominant view, shared by Aspect [4], the violations of Bell's inequalities [1–3,5–7,9–12] prove the validity of quantum mechanics, give evidence of the observation of the EPR correlation and refute realism.

But John Bell, who proposed Bell's inequalities, had opposite opinion. He said in his talk "Speakable and unspeakable in quantum mechanics" at Naples-Amalfi meeting 1984 about experimental evidence of violation of Bell's inequalities obtained by Alain Aspect with coauthors [3]: "*For me then this is the real problem with quantum theory: the apparently essential conflict between any sharp formulation and fundamental relativity. That is to say, we have an apparent incompatibility, at the deepest level, between the two fundamental pillars of contemporary theory... and of our meeting*", see p. 172 in [13]. Bell, following to Einstein and other critics, argued that quantum mechanics is inadequate and should be replaced with other theory, for example a theory of 'hidden variables' [13]. Therefore Bell's works were ignored during a long time [14] (see also Fig.5-1 in the book [15]). John Stewart Bell has become the world-famous scientist when experimental evidences of violation of Bell's inequalities [16] were misinterpreted as the corroboration of the almost universal belief in quantum mechanics. The majority consider now Bell's inequalities as one of the most profound results of physics. The number of experimental tests of Bell's inequalities is incalculable now.

These tests, according to the majority, prove the reality of new quantum information technologies [4] and in particular the reality of a quantum computer. But how can a quantum computer be real if its idea is based on the quantum principle - that contradicts realism? It seems that most of the authors of publications about the quantum computer do not understand well enough what reality is. This misunderstanding manifests itself in particular in the fact that the principle of operation of a quantum computer is considered by these authors in Hilbert space, while any real device, such as a quantum register, must exist in the real three-dimensional space in order to be real. It will be mathematically proved in this work that the entangled spin states cannot exist in the real isotropic three-dimensional space. The entangled states can describe only the knowledge of the observer about the probability of a result of an upcoming observation.

2 A particle of spin 1/2 and a quantum bit

The EPR correlation, violation of Bell inequalities, and quantum bits (qubits) are considered on the example of particles of spin 1/2 in most publications. The superposition of states of qubit is described [17] with the help of the relation

$$\psi = \cos\frac{\theta}{2}|\uparrow> + \exp i\phi \ \sin\frac{\theta}{2}|\downarrow> \qquad (1)$$

taken from the description of the superposition of states of spin 1/2 [18]

$$\psi_{z1} = |\uparrow_{z1}>= \exp -i\frac{\phi}{2} \ \cos\frac{\theta}{2}|\uparrow_{z0}> + \exp i\frac{\phi}{2} \ \sin\frac{\theta}{2}|\downarrow_{z0}> \qquad (2)$$

The difference in the multiplier $\exp -i\varphi/2$ between (1) and (2) can be ignored [17] since the probabilities to observe $|\uparrow>$ and $|\downarrow>$ are $|\cos\theta/2|^2 = |\exp(-i\phi/2)\cos\theta/2|^2$ and $|\exp(i\phi)\sin\theta/2|^2 = |\exp(i\phi/2)\sin\theta/2|^2$. The states of qubit (1) and of spin 1/2 (2) can be visually represented with the help of the Bloch sphere [17], Fig.1. But there is a fundamental difference between the description of the states of spin 1/2 and other qubits, for example superconducting qubits [19,20]. The directions in which the spin projection is measured z_0 and the direction z_1 in which the spin state is an eigenstate $\psi_{z1} = |\uparrow_{z1}>$ are indicated in the case of spin 1/2 (2) [18], whereas no real direction is indicated in the relation (1) [17].

Although the relations both (1) and (2) predict the probability to observe one of two possible results $|\uparrow>$ or $|\downarrow>$, quantum mechanics considers the spin state (2) as a real state existing in the real three-dimensional space [18]. The spin state (2) is real in the sense that the probability amplitude to observe a spin projection, spin-up $|\uparrow>$ or spin-down $|\downarrow>$, changes with the rotation of the coordinate system in the real three-dimensional space (2), similar to the components of a vector. A vector, for example a magnetic moment $\mathbf{m} = (m_x, m_y, m_z)$, can be also represented with the help the Bloch sphere, Fig.1. A coordinate system exists for each vector in which this vector is directed along z-axis. Similarly, a coordinate system exists in the real three-dimensional space in which the spin state is the eigenstate along z-axis [18]. The transformation of spinors under rotation of the coordinate axes differs from the transformations of vectors. The vector directed along z_1 has component $m_x = m\sin\theta \ \cos\phi$, $m_y = m\sin\theta \ \sin\phi$, $m_z = m\cos\theta$ in the coordinate system (x_0, y_0, z_0), Fig.1. The eigenstate $\psi_{z1} = |\uparrow_{z1}>$ along z_1 has the probability amplitudes $\exp(-i\phi/2)\cos\theta/2$ and $\exp(i\phi)\sin\theta/2$ along z_0 (2), Fig.1.

But the operators of finite rotations of the coordinate system are deduced on the base of our notion about the isotropic space for spinors [18], like for vectors. Therefore, spin states (2) exist in the real isotropic space according to quantum mechanics, like the vector of the magnetic moment according to classical physics. The operators of finite rotations are applied for spin of particles [18] but cannot be applied to other qubits, for example persistent-current qubit [21] or flux qubit [22]. The flux qubit consist of a flat superconducting loop interrupted by either one or three Josephson junctions

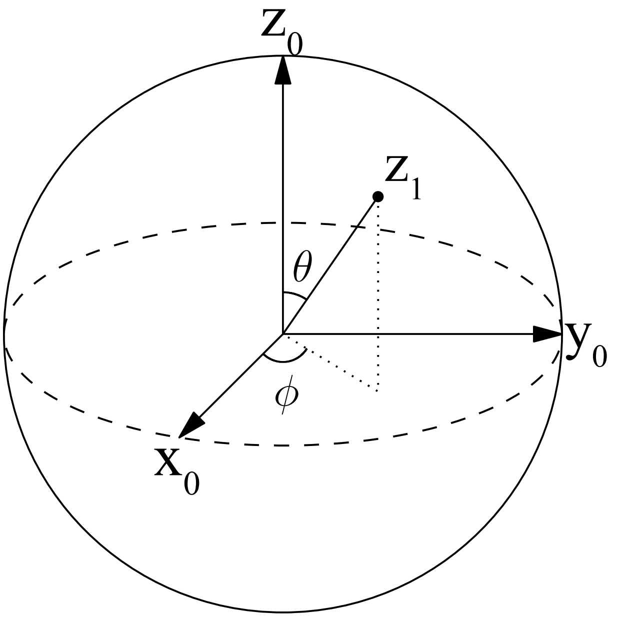

Fig. 1 The state of spin 1/2 and qubit can be described with the help of the three-dimensional Bloch sphere.

[20]. The persistent current I_p circulating in the loop with an area of S clockwise or anticlockwise creates a macroscopic magnetic moment $M_m = +I_pS$ or $M_m = -I_pS$ [20].

The assumed superposition of the flux qubit states with opposite directions of the magnetic moment $M_m = +I_pS$ or $M_m = -I_pS$ [20] can be described with the expression (1) for qubits since $|\cos\theta/2|^2 + |\exp(i\phi/2)\sin\theta/2|^2 \equiv 1$ and since the angles θ and ϕ are the angles in the Hilbert space rather than in the real three-dimensional space. The Bloch sphere, Fig.1, cannot represents the states of the flux qubit in the real three-dimensional space since if, for example, $\theta = \pi/2$ and $\phi = 0$ then the expression (1) would predict that the projection $M_m = +I_pS$ and $M_m = -I_pS$ will be observed with the equal probability $|\cos\pi/4|^2 = |\sin\pi/4|^2 = 1/2$ along z_0 and that the projection $M_m = +I_pS$ along $z_1 = x_0$ will be observed with the probability $|\cos 0|^2 = 1$. But it is well known that the projection of the magnetic moment $\mathbf{M_m} = I_p\mathbf{S}$ of the flat loop with the current I_p equals zero in any direction lying in the plane of the loop. Therefore the expression (1) can describe only the knowledge of the observer about the probability of one of two possible results $|\uparrow>$ or $|\downarrow>$ of an upcoming observation of the flux qubit and other qubits, but, unlike (2), not a real state existing in the real three-dimensional space.

3 The operators of finite rotations cannot be applied to entangled spin states

The operators of finite rotations can be applied for any number of particles with spin [18] but only if the states of these particles are not entangled. Each non-entangled particle has a direction in which its spin state is the eigenstate. For example, the eigenstates of the non-entangled particles A and B

$$\psi_A = \cos\frac{\theta_A}{2} \mid \uparrow_{z0}> + \sin\frac{\theta_A}{2} \mid \downarrow_{z0}> \qquad (3a)$$

$$\psi_B = \cos\frac{\theta_B}{2} \mid \uparrow_{z0}> + \sin\frac{\theta_B}{2} \mid \downarrow_{z0}> \qquad (3b)$$

lie in the plane $x_0 - z_0$ at the angles θ_A and θ_B to the z_0-axis, Fig.1, according to the operator of rotation about the y_0-axis [18]. But the particles A and B of the EPR pair

$$\psi_{EPR} = \frac{1}{\sqrt{2}}(\mid \uparrow_A \downarrow_B> + \mid \downarrow_A \uparrow_B>) \qquad (4)$$

have no direction in which their spin states are the eigenstates. Moreover we must conclude that the probability amplitudes in (4) can not be different from $1/\sqrt{2}$ since we do not know the spin projection of which particle A or B will be measured first. The probability of the result (↑ or ↓) of the first measurement of one of the particles does not depend on the direction, for example z_0 or z_1, along which the projection is measured. Therefore the expression (4) can not change because of the rotation of the coordinate axes. Thus, we cannot even think that the spin states of the particles A and B of the EPR pair (4) exist in the real isotropic space before the first observation.

4 Spin states of the both particles of the EPR pair appear in the real space after measurement of one of them.

The expression (4) for the EPR pair describes only the knowledge of the observer that the first observation of the projection in any direction of any particle will give spin up ↑ with the probability 1/2 and spin down ↓ with the same probability. Quantum mechanics postulates that this first observation creates the spin states existing in the real isotropic space of the both particles A and B, for example the eigenstates

$$\psi_{A,z1}\psi_{B,z1} = \mid \uparrow_{A,z1}> \mid \downarrow_{B,z1}> \qquad (5)$$

along z_1 after the observation of spin up $\mid \uparrow_{A,z1}>$ along the direction z_1 of the particle A. The observer can create different spin states of the both particles measuring the projection in different directions. Moreover two observers, Alice and Bob, can create different states of the same particles at the same time. Alice will create the state

$$\psi_{A,z1} = \mid \uparrow_{z1,A}> = \exp i\frac{\phi}{2}\ \cos\frac{\theta}{2} \mid \uparrow_{z0}> + \exp -i\frac{\phi}{2}\ \sin\frac{\theta}{2} \mid \downarrow_{z0}> \qquad (6a)$$

of her particle A and the state

$$\psi_{B,z1} = |\downarrow_{z1,B}> = \exp i\frac{\phi}{2}\ \sin\frac{\theta}{2}|\uparrow_{z0}> + \exp -i\frac{\phi}{2}\ \cos\frac{\theta}{2}|\downarrow_{z0}> \qquad (6b)$$

of the other particle B of the EPR pair (4) when she will direct her analyzer along z_1-axis and will see that her particle A has deflected up. The other observer Bob can create other spin states of the same particles orienting his analyzer along other axis, for example the z_0-axis on Fig.1. He will create the state

$$\psi_{A,z0} = |\downarrow_{z0,A}> = -\exp -i\frac{\phi}{2}\ \sin\frac{\theta}{2}|\uparrow_{z1}> + \exp i\frac{\phi}{2}\ \cos\frac{\theta}{2}|\downarrow_{z1}> \qquad (7a)$$

of Alices particle and the state

$$\psi_{B,z0} = |\uparrow_{z0,B}> = \exp -i\frac{\phi}{2}\ \cos\frac{\theta}{2}|\uparrow_{z1}> - \exp i\frac{\phi}{2}\ \sin\frac{\theta}{2}|\downarrow_{z1}> \qquad (7b)$$

of his particle when he will see that his particle B has deflected up along z_0. The operator of rotation about the z-axis and the y-axis is used in (6) and (7) [18] in order to demonstrate that the eigenstate along z_1 is the superposition of states along z_0 and vice versa.

Thus, two observers, Alice and Bob, can create different states of the same particles orienting their analyzers along different axis z_0 and z_1 in the real three-dimensional space. This prediction of quantum mechanics is obvious logical absurd. But the EPR correlation, on which the idea of quantum computer is based, cannot be observed and quantum mechanics cannot predict violation of Bell's inequalities without this absurd. The logical inference of the absurdity of the EPR correlation is trivial:

1) according to the postulate about the EPR correlation, any observer can create eigenstates of both particles of the EPR pair, measuring different dynamical variables of one of the particles, regardless of the distance between the particles;

2) two observers can measure different dynamical variables of particles of the EPR pair;

3) thus, two observers will have created different eigenstates of the same particles (for example different spin states (6) and (7)), measuring different dynamical variables.

Logically, there are only two ways to avoid this absurdity deduced from quantum mechanics: 1) to argue that there is only one observer, or 2) to deny the existence of free will of observers. The first way testifies that Einstein was right when he argued that "*we cannot escape solipsism*" if we reject realism [23]. The second way was proposed by Gerard 't Hooft in his talk presented at the General meeting of the Russian Academy of Sciences [24].

5 Born's proposal.

This absurd could become possible because of the desire of the creators of quantum mechanics to describe paradoxical quantum phenomena at any cost, even at the cost of contradiction with realism. The absurdity is a logical consequence of Born's proposal 1926 to consider the Schrodinger wave function as a description of the amplitude of the observation probability. Einstein as far back as 1927 during the discussion at the Fifth Solvay Conference [25], much earlier than Bell [13], rightly noted that Born's proposal "*leads to a contradiction with the postulate of relativity*".

But most physicists ignored this important point. Richard Feynman in the Section "The Schrodinger Equation in a Classical Context: A Seminar on Superconductivity" of his Lectures on Physics [26] stated that Schrodinger *"imagined incorrectly that* $|\Psi|^2$ *was the electric charge density of the electron.* $\cdots$ *It was Born who correctly (as far as we know) interpreted the* Ψ *of the Schrodinger equation in terms of a probability amplitude"*. But Feynman did not put the question: "Why does he think that Schrodinger imagined incorrectly and Born interpreted correctly?" The answer is connected with the problem of wave-particle duality. In order to describe the transformation of a wave - a non-localized object into a particle - a localized object we must postulate an instant and non-local change during observation. We cannot think that a real density can change due to the observation whereas we know from our everyday experience that a probability of observation changes at first observation.

Thus, Feynman and most physicists were convinced that Born's proposal was correct because it created the illusion of describing the wave-particle duality and other paradoxical quantum phenomena. But they did not take into account that the probability of observation changes in the mind of the observer first of all. Schrodinger understood that his wave function describes the state of the mind of the observer if we agree with Born's proposal. Therefore he defined the EPR correlation as 'entanglement of our knowledge' [27]: "*Maximal knowledge of a total system does not necessarily include total knowledge of all its parts, not even when these are fully separated from each other and at the moment are not influencing each other at all*" [28]. The entanglement of our knowledge may be both 'classical' and 'quantum'.

We may propose many examples of the entanglement of our knowledge about a classical system parts of which are fully separated from each other and at the moment are not influencing each other at all. For example, two observers Alice and Bob know that two balls, red and blue, are in a closed box. Bob takes one ball without looking, and drives away with it at an arbitrarily long distance. Alice, before she look at the remaining ball, knows that Bob will see the blue ball with a probability of 0.5 and with the same probability of the red ball. Her knowledge can be described using the expression for the EPR pair (4) in which the up arrow $\uparrow$ represents the red ball and the down arrow $\downarrow$ represents the blue ball.

The knowledge of Alice about the EPR pair and about two balls can be described with the help of the same expression (4) since two results of observation are possible in the both cases: $\uparrow$ - spin up and red ball or $\downarrow$ - spin down and blue ball. But there is a fundamental difference between the 'classical' and 'quantum' entanglement of our knowledge. We can think that the color of the balls existed before observation and only the knowledge of Alice will change after her observation of her ball. New knowledge of Alice about the probability of the result of the second observation will be describes with the expression (5), but without the index z_1, if she will see the red ball at the first observation. The expression (5) means that Alice will see the red ball with the probability of 1 during the second observation, since $\psi_A = \mid \uparrow_A>$ and Bob will see a blue ball with the same reliability, since $\psi_B = \mid \downarrow_B>$.

But we cannot think that the spin states $\mid \uparrow_{A,z1}>$ and $\mid \downarrow_{B,z1}>$ in (5) were really existing before the first observation since the spin states of the entangled particles (4) cannot exist in the real three-dimensional space and because of the possibility to measure spin projections in different directions. We can label red the observation spin up $\uparrow_{z1}$ and blue - spin down $\downarrow_{z1}$ when the spin projection is measured along z_1, Fig.1. But we have to use other colors when the spin projection is measured along other direction. For example, we can use green for $\uparrow_{z0}$ and yellow for $\downarrow_{z0}$ when the spin projection is measured along z_0, Fig.1 Thus, quantum mechanics states the following: there are two balls in the box that do not have color until the first observation of one of them. This essence of the contradiction between quantum mechanics and realism can be expressed by the Einstein dictum: the moon is not there if no one look at it. This essence means: only the knowledge of the observer changes because of observation according to realism whereas according to quantum mechanics the state of quantum system must also change under influence of the mind of the observer.

6 The Dirac jump.

Schrodinger tried to draw the attention of physicists to this contradiction of quantum mechanics with realism in 1952, when he noted that "*the simple statement, that each observation depends both from the object and the subject which 'are entangled' by extremely complex manner is a statement which is hardly possible to consider new, it is old almost also, as the science*" [29]. But according to quantum mechanics "*the causal interconnection between the subject and object is considered reciprocal. It is stated, that the unremovable and uncontrollable influence of the subject on the object takes place*" [29]. The 'quantum' entanglement of our knowledge differs from the 'classical' one precisely by this influence of the subject (the mind of the observer) on the object (the state of the quantum system).

Einstein pointed out as far back as 1927 [25] that Born's proposal implies such an influence. Quantum mechanics could predict the possibility of observing one particle in several places at once, i.e. the absurdity, if a jump of the quantum state would not postulated at the first observation: the probability of observation $|\Psi(r)|^2$ can be non-zero in a wide area of space before the first observation and the probability to observe the particle at the second observation should be non-zero $|\Psi(r)|^2 \neq 0$ only in the place where the particle was observed at the first observation. Otherwise, quantum mechanics could predict the observation of the same particle in different places at the first and subsequent observations. The jump in the quantum state must be instantaneous and non-local, since the first and second observations can be made after an arbitrarily small period of time.

The necessary jump was first postulated by Dirac in 1930 [30]. Assuming that "*after the first measurement has been made, there is no indeterminacy in the result of the second*" Dirac postulated: "*In this way we see that a measurement always causes the system to jump into an eigenstate of the dynamical variable that is being measured*" [30]. The Dirac assumption is obvious from our everyday experience: there is no indeterminacy in the result of the second observation since our knowledge was changed after the first observation. Thus, Dirac postulated a change in the quantum state under influence of the change of the observer knowledge. Dirac jump is better known as wave function collapse or reduction of quantum state, in terms introduced by von Neumann in the book of 1932 [31].

Heisenberg was justifying the postulate about the jump by a discontinuous change in our knowledge: "*Since through the observation our knowledge of the system has changed discontinuously, its mathematical representation also has undergone the discontinuous change and we speak of a quantum jump*" [32]. But Dirac postulated the jump of the quantum system into an eigenstate rather than the jump of our knowledge. Quantum mechanics could predict the obvious absurd without the Dirac jump or the wave function collapse. Dirac [30] and von Neumann [31] spared quantum mechanics from one logical absurd, providing the prediction of the same result for the first and subsequent observations of the same dynamical variable. But they postulated the other absurd considered above: two observers can create the different spin states of the same particles, see (6) and (7).

7 Quantum register can describe only the knowledge of the observer.

The authors of the book [17] are sure that the Stern-Gerlach experiment [33] gives evidence of the real existence of qubits in Nature. This naive opinion of the authors of the well-known book about quantum computing indicates the lack of knowledge of what quantum mechanics can and what cannot describe. Einstein and Ehrenfest [34] drew attention to the paradox of the Stern-Gerlach effect just after its discovery in 1922 [33]. The essence of this paradox was explained in detail by Bell in the article [35].

Bell drew reader's attention that it is impossible to imagine how the projection of the magnetic moment can have only discrete values in any direction [35]. The magnetic moment is a vector in the three-dimensional space $\mathbf{m} = (m_x, m_y, m_z)$. The projection of any vector $\mathbf{m}$, for example on the z-axis $m_z = m\cos\theta$, depends on the angle θ between the direction of that vector and the z-axis. The angle θ depends on the direction of both the vector $\mathbf{m}$ and the z-axis. We should expect that the projection will be equal $m_z = m\cos\theta$ along z_0 if the projection along z_1 equal the magnitude of the vector $m_{z1} = m$ and the angle between z_1 and z_0 equals θ, Fig.1. But all measurements, starting with the Stern and Gerlach experiment [33], give only two magnitudes of the projections of the magnetic moment of particles with the spin 1/2 on any direction: $m_z = +m$ which implies $\theta = 0$ and $m_z = -m$ which implies $\theta = \pi$.

Bell wrote: "*Phenomena of this kind made physicists despair of finding any consistent space-time picture of what goes on the atomic and subatomic scale*" [35]. The creators of quantum mechanics refused to recognize our inability to understand the cause of the Stern-Gerlach effect and created the illusion of solving the problem limiting themselves to the description of the probability of observing spin up ↑ and spin down ↓. To justify the using Born's proposal and the refusal of realism, some of the creators of quantum mechanics, as Bell wrote, "*asserted that atomic and subatomic particles do not have any definite properties in advance of observation. There is nothing, that is to say, in the particles approaching the magnet, to distinguish those subsequently deflected up from those subsequently deflected down. Indeed even the particles are not really there*" [35].

The creators did not take into account an elementary logic: if properties are absent before observation and appear after observation then the mind of the observer creates these properties. Bell understood this logic. Therefore he was proposing to replace quantum mechanics with the theory of 'hidden variables' for the description of the Stern-Gerlach effect, see the relation (2) in [35]. Bell was right in spite of all experimental evidence of violations of Bells inequality since the refusal of realism results to the logical absurd, for example the one demonstrated above.

The illusion of the authors [17] and other numerous publications that the Stern-Gerlach experiment [33] gives evidence of the real existence of qubits in Nature became possible because of two cause: 1) Most scientists are naive realists who are sure that any scientific theory describes a reality even if the theory describes only results of observation; 2) The creators of quantum mechanics were also naive realists even though they rejected realism. Therefore they considered the spin states (3), which predict the probability to observe spin-up or spin-down, as real states existing in the real three-dimensional space [18]: θ_A and θ_B in (3) are the angles between the z_0 - axis and the directions in which the spin states of the particles A and B are the eigenstates.

But the particles have the eigenstates only if their states are not entangled. Therefore a quantum register can be real in the real three-dimensional space only if its qubits - particles with spin 1/2 are not entangled. But a quantum computer has no advantage in the absence of the entanglement. Its advantage [17] is the exponential increase in the number $g_N = 2^N - 1$ of independent probability amplitudes γ_i with the number N of qubits in the quantum register

$$\psi_{qr} = \gamma_1 | \uparrow\uparrow\uparrow \cdots \uparrow > + \gamma_2 | \uparrow\uparrow\uparrow \cdots \downarrow > + \cdots + \gamma_{gN-1} | \downarrow\downarrow\downarrow \cdots \uparrow > + \gamma_{gN} | \downarrow\downarrow\downarrow \cdots \downarrow > \quad (8)$$

when its qubits are entangled [17]. The authors [17] accentuate that the number $g_N = 2^N - 1$ for $N = 500$ "*is larger than the estimated number of atoms in the Universe! Trying to store all these complex numbers would not be possible on any conceivable classical computer. Hilbert space is indeed a big place*" [17].

The authors of [17] and other publications about quantum computation are right from the point of view of mathematics. But the belief of these authors and the creators of a quantum computer that the quantum register (8) can have any relation to Nature is the false belief of naive realists: "*In* *principle, however, Nature manipulates such enormous quantities of data, even for systems containing only a few hundred atoms. It is as if Nature were keeping* 2^{500} *hidden pieces of scratch paper on the side, on which she performs her calculations as the system evolves*" [17]. There is no doubt that Hilbert space is a big place. But Nature exists in the real three-dimensional space rather than in a multidimensional Hilbert space. Any real quantum register must also exist in the real three-dimensional space. But its real existence is mathematically impossible. The number $g_N = 2^N - 1$ of independent variables γ_i in (8) increases exponentially with the number N due to the mathematical fact that only one normalization condition $|\gamma_1|^2 + |\gamma_2|^2 + \cdot\cdot \cdot|\gamma_{gN-1}|^2 + |\gamma_{gN}|^2 = 1$ is applied for all N entangled qubits. But the entangled spin states of the quantum register (8), as of the EPR pair (4), cannot exist in the real three-dimensional space.

If someone who believes in the reality of the quantum register would claim that the spin states of the quantum register exist in reality, he will have to answer the question to which coordinate system of the real three-dimensional space the amplitudes γ_i in the expression (8) refer. This question can be answered if only the states are not entangled and the expression (8) can be decomposed into factors $(\alpha_j| \uparrow_{z0}> +\beta_j| \downarrow_{z0}>)$ describing the states of each j particle with spin 1/2. But the normalization condition $|\alpha_j|^2 + |\beta_j|^2 = 1$ must be applied to each j particle in this case and therefore the number of the independent variables will increases linearly rather than exponentially with the number of qubits. Thus, the advantage of a quantum computer is in irreconcilable contradiction with its reality.

The idea of a quantum computer is connect with the remark made by Richard Feynman [36] and Yuri Manin [37], that the complexity of computing of quantum systems increases exponentially with the number of elements. Feynman and Manin did not understand that the exponential increasing of the complexity takes place not because the system is quantum, but because the probability of observation is calculated. The mathematical expression for the quantum register (8), as well as for the EPR pair (4), cannot depend on what is observed: the projections of spin 1/2, balls of two colors, or Schrodinger's cats, the result of the observation of which also has two possibilities - a live cat $\uparrow$ or a dead cat $\downarrow$. The knowledge of the observer about the probability of results of the observations can be entangled also regardless of what is observed. Therefore, anyone who believes in a possibility to create a quantum register on the base of particles with spin 1/2 should also believe that balls with two colors or Schrodinger's cats are quantum bits.

David Deutsch, the author of the idea of quantum computing, was right when he stated that a quantum computer can be real only in the reality of Many Universes: "*For those who is still inclined to think, that there is only one universe, I offer the following problem: explain a principle of action of the Shor's algorithm. I have no in a kind, predict, that it will work, as for this purpose it is enough to solve some of the consistent equations. I ask you to give an explanation. When the Shor's algorithm has factorized number, having involved about* 10^{500} *computing resources which can be seen, where this number was factorized? In the whole universe exists about* 10^{80} *atoms, the number is negligibly small in comparison with* 10^{500}. *Thus, if this single* *universe was a measure of a physical reality, the physical reality could not contain resources, sufficient for the factorization of such big number. Who then has factorized it? How and where the calculation was carried out?*" [38]. But the reality of multiple universes is not only not proven, but also raises reasonable doubts.

8 Conclusion

Why can the authors of numerous publications about quantum computing, for example [17], ignore the convincing arguments David Deutsch [38] about the possibility of a quantum computer only in the reality of Many Universes? And why can numerous 'creators' of a quantum computer be sure that a real device can be made on the base on the quantum principle that contradicts realism? This ignoring and this confidence can only be explained by the assumption that all these authors and all the 'creators' are supporters of the instrumentalist view.

Although it is unlikely that most of them realize that they are instrumentalists, as well as most physicists who believe in quantum mechanics have never realized that they follow the instrumentalist view. Most physicists did and do not understand the sense of the instrumentalist view. The famous philosopher of the twentieth century Karl Raimund Popper wrote in Chapter 3 "Three Views Concerning Human Knowledge" of the book [39]: "*Very few physicists who now recognize the instrumentalist point of view of Cardinal Bellarmino and Bishop Berkeley realize that they accept some philosophical theory. They also do not realize that they are breaking with the Galilean tradition*".

Speaking about breaking with the Galilean tradition, Popper meant that according to the instrumentalist point of view no difference was between the Ptolemaic system and the Copernican system in the time of Galileo, since both systems successfully described the results of observations known in that time. The reason for the conflict with the Catholic Church was Galileo's assertion that the Copernican system is not just a more convenient instrument for describing the results of observations, but is a description of reality. The Galilean tradition led to space flights, which would hardly have been possible if the instrumentalist point of view had won.

Karl Popper believed that the rejection by Heisenberg, Bohr and other creators of quantum mechanics from realism and following the instrumentalist view was a fundamental mistake. David Deutsch, following Popper, criticizes the instrumentalist point of view in Chapter 1 "The Theory of Everything" of the book [38]. Deutsch is sure that "*one of the most valuable, significant and also useful attributes of human thought generally is its ability to reveal and explain the fabric of reality*" [38]. In contrast to Deutsch "*some philosophers and even some scientists disparage the role of explanation in science. To them, the basic purpose of a scientific theory is not to explain anything, but to predict the outcomes of experiments: its entire content lies in its predictive formulae. They consider that any consistent explanation that a theory may give for its predictions is as good as any other or as good as no* *explanation at all so long as the predictions are true. This view is called instrumentalism (because it says that a theory is no more than an 'instrument' for making predictions)*" [38].

Deutsch stated: "*For even in purely practical applications, the explanatory power of a theory is paramount and its predictive power only supplementary*" [38]. He argued that a real device, for example an interstellar spaceship, can be made on a theory explaining experimental results rather than a theory which only predicts the outcomes of experiments. He is sure that "*Prediction even perfect, universal prediction is simply no substitute for explanation*" [38] when creating a real device. According this point of view of the author of the idea of quantum computing a quantum computer cannot be created on the base of the orthodox quantum mechanics which only predicts the outcomes of experiments but cannot explain some quantum phenomena, for example, the Stern-Gerlach effect [33]. Instrumentalists, in contrast to Deutsch, are sure that existing experiments are apparently supporting the view that quantum computers can be built, despite the fact that quantum mechanics cannot explain the results of these experiments, in particular the EPR correlation and violations of Bell's inequalities.

This work proves that rather Deutsch than instrumentalists is right. Of course, philosophical arguments, such as qubits cannot exist because their reality is based on the refutation of realism, are not arguments for instrumentalists. But even instrumentalists must not ignore mathematical and logical arguments presented in this work. The mathematical argument is based on the mathematical fact that the operators of finite rotations of the coordinate system [18] can be applied only to non-entangled spin states. In order to substantiate a possibility of a quantum register instrumentalists must answer on the question: "To which coordinate system of the real three-dimensional space can the probability amplitudes in the expression (8) for a quantum register be referred?"

Even instrumentalists must answer on this question since the outcomes of experiments, i.e. the probability to observe spin up and spin down depend on a direction in which spin projections are measured in the case when particles with spin $1/2$ are not entangled. The probability amplitudes in (8) can be unambiguously connected with the direction of measurement of spin projections only in this case, with the help of the operators of finite rotations of the coordinate system [18]. The mathematical fact that these operators cannot be applicable to entangled spin states means that the probability amplitudes in (8) cannot be connected with any direction of measurement when the states of qubits in the quantum register are entangled. The goal of a quantum computer is to find the probability amplitudes in (8). But these probability amplitudes have no sense when they cannot be connected with the direction in which the spin projections of all qubits are measured.

The logical argument reveals that the instrumentalist view is misleading. Richard Feynman, Yuri Manin and all authors of publications about quantum computing have not understood that the exponential increasing of the complexity of computing with the number of elements of quantum systems takes place not because the system is quantum, but because the probability of observation is calculated. To refute this logical argument, instrumentalists must explain how the mathematical description of the probabilities of observing spin projections differs from the same description of the observation of Schrodinger's cats or any other systems with two possible results of observations. In this explanation, instrumentalists should not go beyond the instrumentalist view.

Most authors of publications about quantum computing not only go beyond this point of view, but follow naive realism rather than instrumentalism. For example, the authors of the book [17] are sure that we know that systems with the properties of qubits exist in Nature due to the Stern-Gerlach experiment [33]: "*A decisive (and very famous) early experiment indicating the qubit structure was conceived by Stern in 1921 and performed with Gerlach in 1922 in Frankfurt*" [17]. The authors of [17] and most other publications are sure, like Deutsch and unlike to instrumentalists, that systems with the properties of qubits should exist in Nature in order a quantum computer can be possible. The instrumentalist point of view is misleading primarily because most scientists are naive realists, like the authors [17], and do not follow this point of view.

Naive realists, in contrast to non-naive realists such as Popper and Deutsch, do not understand that quantum mechanics only predicts the outcomes of experiments but cannot explain them. For example, quantum mechanics cannot explain why only discrete values on the magnetic moment of atoms are observed in the Stern-Gerlach experiment [33]. The confidence of the authors [17] that particles with spin 1/2 are systems with the properties of qubits existing in Nature is refuted by the fact that we cannot even think that spin projections exist before observation.

Even more doubtful is the confidence of numerous 'creators' of a quantum computer that some superconducting structures have the properties of qubits that exist in Nature. The idea of the flux qubits [19–22] contradicts not only the basis of the orthodox quantum mechanics and macroscopic realism [40, 41] but also the law of angular momentum conservation [42, 43] and even to the principle of operation of an electric motor [44]. The latter contradiction became possible since quantum mechanics uses different definitions of the Hamiltonian to describe the behavior of an atom and a quantum ring in a magnetic field [45].

Einstein, like Popper and Deutsch, was realist, but not naive realist. He understood that realism is "*the presupposition of every kind of physical thinking*" [23]. According to Einstein's understanding, the rejection of realism of the creators of quantum mechanics means the rejection of physical thinking. The degradation of physical thinking which is observed now indicates that Einstein was right. The degradation has become possible because science has become mass. No more than three hundred physicists were in the whole world at the late 19th century, number is negligible compared to the number of modern physicists. Jose Ortega y Gasset (the great Spanish philosopher according to Schrodingers opinion) predicted in his famous book "The Revolt of the Masses" published 1930 the crisis of science as a consequence of the increase in the number of scientists: "*And now it turns out that the actual scientific man is the prototype of the mass-man. Not by chance, not through the individual failings of each particular man of science, but because science* *itself the root of our civilisation - automatically converts him into mass-man*" [46].

The mass-man believes in what the majority believes and is not inclined to be somewhat critical of the theories recognized by the majority. The belief in a possibility of a quantum computer is based on the belief of the majority in quantum mechanics. Instrumentalists, naive realists, supporters of QBism, of the quantum logic, of the ensemble interpretation, of the transactional interpretation, of the von Neumann-Wigner interpretation and of other numerous interpretations alike believe in quantum mechanics because of its successfulness. The faith of supporters of such different worldviews cannot be based on understanding. Most physicists always rather believed in quantum mechanics than understood it.

Einstein foresaw this mass belief in his 1928 letter to Schrodinger [47]: "*The soothing philosophy - or religion? - of Heisenberg-Bohr is so cleverly concocted that for the present it offers the believers a soft resting pillow from which they are not easily chased away. Let us therefore let them rest.* ··· *This religion does damned little for me*", see also page 99 of [15]. The idea of quantum computing arose and became popular because the majority believed in quantum mechanics and ignored arguments of Einstein, Schrodinger, Bell and other its critics. But the blind faith without understanding sooner or later leads to the delusion not only in physics, but also in technology. The scientific community should realize that the new quantum information technologies testify to the degradation of physical thinking rather than technological breakthrough.

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Data Availability Statement

All data generated or analysed during this study are included in this article.

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