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Article

On Feasibility of Quantum Computation and Quantum Communication

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Abstract

Bell tests and Bell's theorem used to interpret the test results opened the door to quantum information processing, such as quantum computation and quantum communication. Based on the erroneous interpretation of the test results, quantum information processing contradicts a well-established mathematical fact in point-set topology. In this study, the feasibility of quantum computation and quantum communication is investigated. The findings are as follows. (a) Experimentally confirmed statistical predictions of quantum mechanics are not evidence of experimentally realized quantum information processing systems. (b) Physical carriers of quantum information do not exist in the real world. (c) Einstein's ensemble interpretation of wave-function can eliminate inexplicable weirdness in quantum physics. The findings lead to an inevitable conclusion: Without carriers representing quantum information, physical implementations of quantum information processing systems are merely an unrealizable myth.

Keywords: Bell tests; Bell's theorem; Einstein-Bohr debate; quantum information processing; quantum information; quantum bit (qubit)

1. Introduction

Bell tests, namely, the experimental tests of Bell inequalities [1–4], are intended to resolve the Einstein-Bohr debate on the conceptual foundations of quantum mechanics [5,6]. According to the opinion of most physicists, Bell's theorem is the standard interpretation of the test results [1,7,8]. According to Bell's theorem, the Einstein-Bohr debate seems to have been resolved “in the way which Einstein would have liked least” [9]. But some researchers consider Bell's theorem questionable [10,11]. Although the Einstein-Bohr debate has not been resolved yet as we will see shortly, the Bell tests and Bell's theorem opened the door to quantum computation and quantum communication [12]. In this study, we investigate the feasibility of quantum computation and quantum communication. The results are formulated as two propositions.

Proposition 1. *Experimentally confirmed statistical predictions of quantum mechanics are not evidence of experimentally realized quantum information processing systems.*

Proposition 2. *Physical carriers of quantum information do not exist in the real world.*

Based on a well-established mathematical fact in point-set topology, we can justify the propositions and show that Einstein's ensemble interpretation of ψ -function can eliminate inexplicable weirdness in quantum physics. By justifying the propositions, we can also clarify confusion caused by a widespread opinion in a popular text [13]. According to this opinion, quantum information processing cannot be precluded unless quantum mechanics fails to be correct. It is not appropriate to connect quantum information processing with quantum mechanics. An inevitable conclusion then follows: Without carriers representing quantum information, physical implementations of quantum

information processing systems, such as quantum computers, quantum communication networks, quantum cryptography, and quantum teleportation, are merely an unrealizable myth.

In the rest of this paper, we first briefly explain why the Einstein-Bohr debate remains unsettled and why the unresolved debate suggests that Bell's theorem is problematic (Section 2). Then we justify the propositions (Section 3), examine the Bell tests and revisit Einstein's ensemble interpretation of ψ -function (Section 4). After illustrating the reported results with examples (Section 5), we conclude the paper (Section 6).

2. Unresolved Debate and Bell's Theorem

As we can see from [14] and from Ref./23/ in [15], Bell and his followers regarded Einstein as a proponent of hidden variables and tried to reinterpret quantum mechanics while keeping its current form intact by resorting to hidden-variables theories [7,9,16]; thus, the Bell tests presume the legitimacy of quantum superposition. However, Einstein never endorsed any hidden-variables theory ([17], p.254) and argued against the legitimacy of quantum superposition in his debate with Bohr. As indicated by the above historical fact, the Einstein-Bohr debate is actually irrelevant to the Bell tests. Therefore, the debate still remains unsettled.

Bell and his followers intended to reproduce statistical predictions of quantum mechanics in the Bell tests but failed. The failure of the Bell tests is an irrefutable experimental fact. Nowadays nobody doubts the correctness of experimentally confirmed quantum-mechanical predictions. However, Bell's theorem erroneously links Einstein's argument to the failure of the Bell tests. Misguided by such nonexistent linkage, most physicists consider Einstein's argument wrong. Also misguided by the nonexistent linkage, experimental physicists and quantum-information theorists have been attempting to realize physically unrealizable quantum information processing systems. As we shall see in the next section, quantum mechanics is a powerful tool for making statistical predictions on empirical results and has nothing to do with quantum information processing. Because Einstein's argument is irrelevant to the failure of the Bell tests, the unresolved debate suggests that Bell's theorem is problematic.

For the purpose of this study, we need only consider ideal experiments, focus on identical observables of individual quantum-mechanical systems taken from a pure ensemble, and adhere to the following terminology for ease of exposition.

- The term "repetitions" means "repeating a fixed experiment multiple times under the same experimental conditions".
- Quantum objects described by the same pure state and measured in different repetitions of a given experiment are called "identically prepared quantum-mechanical systems".
- An ensemble consisting of identically prepared quantum-mechanical systems is called "a pure ensemble".
- An experiment with quantum objects taken from a pure ensemble is called "an ideal experiment".

It is worth emphasizing that any single measurement performed in only one repetition of a fixed experiment can only produce a deterministic result and makes no sense statistically. This is why we need to explain the meaning of "repetitions" explicitly in the terminology.

3. Quantum Mechanics and Quantum Information

In quantum physics, physicists somehow treat continuous observables and continuous parameters involved in measuring the observables differently. As everybody knows, precise values of all continuous quantities cannot be obtained by measurements; their values are unattainable. However, physicists consider precise values of continuous parameters attainable. To see this, let us quote the late A. Peres ([18], p.39): "Quantum tests may depend on classical parameters which can be varied *continuously*, and nevertheless these tests have fixed, *discrete*, outcomes." He also gave two examples of continuous parameters used to specify experimental conditions. One example is the angle of orientation of a calcite crystal used to test the linear polarization of a photon; the other is the angle of orientation of a Stern-Gerlach magnet. The precise values of the angles are elements of $\mathbb{R}$, the set of all real numbers.

We will examine these two examples later in Section 5. Although experiments in classical physics with so specified experimental conditions allow us to obtain meaningful results, a concise point-set topological analysis can help us see clearly why using precise values of continuous parameters to specify experimental conditions is misleading in quantum physics. As a prelude to justifying the propositions formulated in Section 1, let us first recall a few definitions in point-set topology.

Denote by $\mathbb{R}^3$ the three-dimensional Euclidean space, which is the mathematical model of the space in which we live. The set of all values that a quantity can have is the range of the quantity. To avoid overusing mathematical notations, we will use the same symbol G to denote both the range of a continuous parameter and the range of a continuous observable. Let X be a topological space. A metric is defined on X . The metric is identical to the usual distance function. If X is the three-dimensional Euclidean space, the distance function is defined on $\mathbb{R}^3$. If X is the real line, the distance function is defined on $\mathbb{R}$. There exists a one-to-one correspondence between elements of G and elements of an uncountable set $S \subset X$. Suppose $s_0 \in S$.

Definition 1. *If there is a number $r > 0$ such that the distance between s_0 and any other point of S is at least r , then s_0 is an isolated point of S .*

A well-established mathematical fact in point-set topology follows immediately from Definition 1. We state this fact as a lemma.

Lemma 1. *The set S has no isolated points.*

An attainable element of G implies the existence of an isolated point of S , thus contradicting Lemma 1. Concerning experiments in quantum physics, the practical implication of Lemma 1 is self-evident; we state it as a theorem. The theorem looks trivial, but it is still worth emphasizing that continuous quantities mentioned in the theorem include both continuous observables and continuous parameters.

Theorem 1. *Precise values of all continuous quantities are unattainable.*

In the quoted examples [18], the observables are not continuous quantities. In contrast, the position and momentum of a particle are continuous observables. Neither the position nor the momentum can be measured perfectly accurately. It is Theorem 1 that prohibits us from obtaining precise values of the position or momentum. Theorem 1 also prohibits us from obtaining precise values of continuous parameters. Ironically, physicists and quantum-information theorists only consider precise values of continuous observables unattainable while considering precise values of continuous parameters such as the angles in the quoted examples attainable and capable of specifying experimental conditions in the Bell tests.

As a common practice in quantum physics, physicists use a fictitious quantum-mechanical system to represent all the members of a pure ensemble, because they believe that experimental conditions specified by precise values of continuous parameters are exactly the same in different repetitions of a given experiment [18,19]. The following corollary forbids such common practice; the corollary is an immediate consequence of Theorem 1.

Corollary 1. *Neither experimental conditions specified by precise values of continuous parameters nor fictitious quantum-mechanical systems exist in the real world.*

The use of fictitious quantum objects is largely responsible for Bell's erroneous interpretation of the test results. The above analysis paves the way for us to justify the propositions formulated in Section 1.

In any given experiment with quantum objects taken from a pure ensemble, experimental conditions specified by precise values of any continuous parameter do not exist in the real world, and

outcomes of measuring identical observables of the quantum objects correspond to mutually exclusive properties represented by orthogonal vectors spanning a Hilbert space. The outcomes are obtained in different repetitions of the experiment. The Hilbert space is the mathematical setting of quantum mechanics. Attaching the outcomes measured in different repetitions to a fictitious quantum object, physicists unable to understand the exhibited random phenomena. Thus Bell and many other physicists interpreted the random phenomena exhibited in the Bell tests as inherent randomness. Einstein disliked such interpretation; this is why Einstein questioned current quantum theory by calling it “the fundamental dice-game” [20].

In fact, the random phenomena are due to lack of knowledge about precise values of the continuous parameters used to specify the experimental conditions. Therefore, the existence of purported inherent randomness can be excluded. In current quantum theory, the logical relation between the superposed orthonormal vectors is conjunction (“and”). Experimentally confirmed statistical predictions of quantum mechanics are correct, because we can replace conjunction (“and”) with disjunction (“or”). Using disjunction (“or”) to replace conjunction (“and”) can keep quantum-mechanically calculated probabilities remain unchanged while not modifying the mathematical setting essentially. As a powerful tool for predicting empirical results, quantum mechanics is irrelevant to quantum information processing; there is no evidence to support experimentally realized quantum information processing systems. In addition, using a fictitious quantum object to represent all the members taken from a pure ensemble is misleading. In quantum information theory, fictitious quantum objects are supposed to carry quantum information but none of them exists in the real world. By examining one of the Bell tests in the next section, we shall address the issues further in more detail and show that Einstein’s ensemble interpretation of ψ -function can remove inexplicable weirdness in quantum physics.

4. Bell Tests and Einstein’s Ensemble Interpretation of ψ -Function

Consider the experimental test of the CHSH inequality [2]. Like all other Bell inequalities, the CHSH inequality is not a result about quantum mechanics, but it can be tested by real experiments using technologies of modern optics. In experiments with single pairs (v_1, v_2) of correlated photons, experimental physicists have intensively tested this inequality [3,4]. Each pair can at most be detected once in only one repetition. The photons are analyzed by two linear polarizers. For simplicity, the polarizers are assumed to be perfectly efficient.

With conjunction (“and”) serving as the logical relation between the superposed components of the polarization part of the state vector, namely, $\frac{1}{\sqrt{2}}|x, x\rangle$ and $\frac{1}{\sqrt{2}}|y, y\rangle$, a quantum superposition expresses an entangled state, see Fig. 1 in [12].

$$|\Psi(v_1, v_2)\rangle = \frac{1}{\sqrt{2}}\{|x, x\rangle + |y, y\rangle\} \quad (1)$$

where $|x\rangle$ and $|y\rangle$ are linear polarizations states. The entangled state describes the single pairs and is used to calculate, quantum-mechanically, the probabilities of obtaining the corresponding outcomes by measuring the polarizations of the photons. In the experiment designed to test the CHSH inequality, the parameters used by the experimental physicists to specify the experimental conditions can be varied continuously. The values of the parameters are coordinates of points on a unit sphere $E \subset \mathbb{R}^3$. This unit sphere is not the “Bloch sphere” in quantum information theory [13]. The “Bloch sphere” is not contained in $\mathbb{R}^3$ and should not be confused with E . The coordinates of some points on E specify the polarizations and propagating directions of different photons detected in different repetitions of the experiment, and the coordinates of some other points specify the orientations of the polarizers used to analyze the polarizations of the photons. When interpreting the experimental results, the experimental physicists take the experimental conditions specified by the coordinates for granted and believe that the experimental conditions can be kept exactly the same in different repetitions of the experiment.

However, by Theorem 1, the precise coordinates of points on E are unattainable. The random phenomenon observed in this Bell test is actually due to lack of knowledge about the coordinates used to specify the experimental conditions. For a pair of correlated photons described by the entangled state with conjunction (“and”) serving as the logical relation between the superposed components $\frac{1}{\sqrt{2}}|x, x\rangle$ and $\frac{1}{\sqrt{2}}|y, y\rangle$, physicists do not know how to assign any polarization to either photon. Based on the legitimacy of quantum superposition, they claim that no well-defined state can be ascribed to each photon. However, the legitimacy of quantum superposition is exactly what Einstein argued against in his debate with Bohr. Based on reduction of the state vector, physicists assert that any polarization measurement performed on a photon will trigger an abrupt collapse of the entangled state [4]. The collapse of the entangled state in such a telepathic way is a typical situation unspeakable in current quantum theory. So long as the logical relation between the superposed components is conjunction (“and”), the entangled state cannot describe anything physically meaningful in the real world.

In contrast, according to Einstein’s argument based on his separability principle [21], the correlation between the photons in each pair is determined by the common source that emits the photons, and either of the correlated photons in each pair possesses its autonomous polarization state independent of whatever happened non-locally, and measuring the polarization of either photon cannot affect the other photon in anyway. Consequently, corresponding to the autonomous polarization states simultaneously possessed by both correlated photons in each single pair to be detected jointly in the real world, the outcome $(+, +)$ or $(-, -)$ is obtained in one repetition of the experiment, even though the precise coordinates used to detect the pair are unattainable by measurements and unknown. However, we can never detect $(+, +)$ and $(-, -)$ for the same pair in the same repetition; thus the observed random phenomenon should not be characterized as inherently randomness. As we will see below, this is actually Einstein’s ensemble interpretation of ψ -function.

In Einstein’s ensemble interpretation, different pairs of correlated photons constitute an ensemble. The autonomous polarization states of the correlated photons in each pair are detected in different repetitions of the experiment. For each detected pair taken from the ensemble, the logical relation between $\frac{1}{\sqrt{2}}|x, x\rangle$ and $\frac{1}{\sqrt{2}}|y, y\rangle$ is disjunction (“or”). We still need probabilities to describe the observed random phenomenon, and the probabilities in Einstein’s ensemble interpretation are exactly the same as those quantum-mechanically calculated probabilities in current quantum theory. However, there is no longer what Einstein called “spooky actions at a distance” ([20], p.158), i.e., inexplicable telepathic collapse of the entangled state triggered by measurements. Everything is intuitively understandable and nothing remains illusive in Einstein’s ensemble interpretation.

5. Examples

Relying on experimental conditions specified by precise values of continuous parameters, fictitious quantum-mechanical systems are supposed to be physical carriers of quantum information. Such objects do not exist in the real world, and quantum information has no physical carriers as we have seen in the previous sections based on the point-set topological analysis. If the reader is unfamiliar with point-set topology and has difficulty in understanding the above results, concrete examples may alleviate the difficulty.

Experiments in quantum mechanics can always confirm the correctness of quantum mechanics. But this fact is misinterpreted in quantum information theory. Consequently, some experiments with two-level quantum systems are considered evidence for the physical existence of qubits. A qubit is supposed to have two states simultaneously, used to code quantum information. As illustrated by the following examples, the so-called qubit is nothing but a fictitious quantum-mechanical system.

Example 1. According to quantum information theory, photons are supposed to be highly stable carriers of quantum information [13]. Let us consider the experiment with single photons. In this experiment, a photon is described by a superposition with conjunction (“and”) serving as the logical relation between two superposed polarization states. A polarizer (i.e., a crystal) is used to measure the linear polarization of each photon. Precise

values of a continuous parameter are supposed to specify the experimental condition. The parameter is the angle of the polarizer axis relative to the polarization plane [18]. In the real world, the photons are measured in different repetitions of the experiment; each photon can at most be detected only once. Taking the experimental condition specified by precise values of the angle for granted, quantum-information theorists are unaware that the experimental condition cannot be the same in different repetitions and use a fictitious photon to represent all the photons in the experiment. There is no such fictitious photon in the real world. But this does not necessarily imply that the photons are not real physical objects. If disjunction (“or”) is the logical relation between the superposed polarization states describing each photon, Einstein’s ensemble interpretation of ψ -function will eliminate the inexplicable weirdness in the experiment. Therefore, photons are not physical carriers of quantum information.

Example 2. Consider the famous Stern–Gerlach experiment with single spin-1/2 particles. In this experiment, a spin-1/2 particle is described by a superposition with conjunction (“and”) serving as the logical relation between two eigenvectors spanning a Hilbert space. Similar to Example 1, precise values of a continuous parameter are supposed to specify the experimental condition. The parameter is the angle of orientation of a Stern–Gerlach magnet [18]. Like single photons in Example 1, the particles are measured in different repetitions of the experiment; each particle can at most be measured only once. Taking the experimental condition specified by precise values of the angle for granted, the experimental condition is considered exactly the same in different repetitions, and quantum-information theorists use a fictitious particle to represent all the particles in the experiment [13]. Such fictitious particle does not exist in the real world and cannot be a physical carrier of quantum information. Nevertheless, this does not necessarily imply that the particles are not real physical objects. Again, if the logical relation between the superposed eigenvectors spanning the Hilbert space is disjunction (“or”) rather than conjunction (“and”), Einstein’s ensemble interpretation of ψ -function will remove the inexplicable weirdness in the experiment.

6. Conclusion

Bell’s theorem interpreted the test results of the Bell tests erroneously, which opened door to quantum information processing, such as quantum computation and quantum communication. In this study, we investigated the feasibility of quantum computation and quantum communication. The findings are as follows. (a) Experimentally confirmed statistical predictions of quantum mechanics are not evidence of experimentally realized quantum information processing systems. (b) Physical carriers of quantum information do not exist in the real world. (c) Einstein’s ensemble interpretation of ψ -function can eliminate inexplicable weirdness in quantum physics. A regrettable conclusion then follows inevitably: Without carriers representing quantum information, physical implementations of quantum information processing systems are merely an unrealizable myth.

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References

1. Bell, J.S. On the Einstein-Podolsky-Rosen paradox. *Physics* **1964**, *1*, 195–200. <https://doi.org/10.1103/PhysicsPhysiqueFizika.1.195>.
2. Clauser, J.F.; Horne, M.A.; Shimony, A.; Holt, R.A. Proposed experiment to test local hidden variable theories. *Physical Review Letters* **1969**, *23*, 880–84. <https://doi.org/10.1103/PhysRevLett.23.880>.
3. Aspect, A. Bell’s inequality test: more ideal than ever. *Nature* **1999**, *398*, 189–190. <https://doi.org/10.1038/18296>.
4. Aspect, A. Bell’s theorem: the naive view of an experimentalist. In *Proceedings of the Quantum [Un]speakables-From Bell to Quantum information*; Bertlmann, R.; Zeilinger, A., Eds., Berlin, 2002.

5. Einstein, A.; Podolsky, B.; Rosen, N. Can quantum-mechanical description of physical reality be considered completed? *Physical Review* **1935**, *47*, 777–780. <https://doi.org/10.1103/PhysRev.47.777>.
6. Bohr, N. Can quantum-mechanical description of physical reality be considered complete? *Physical Review* **1935**, *48*, 696–702. <https://doi.org/10.1103/PhysRev.48.696>.
7. Clauser, J.F.; Shimony, A. Bell's theorem: experimental tests and implications. *Reporting Progress Physics* **1978**, *41*, 1881–1927. <https://doi.org/10.1088/0034-4885/41/12/002>.
8. Clauser, J.F.; Horne, M.A. Experimental consequences of objective local theories. *Physical Review D* **1974**, *10*, 526–35. <https://doi.org/10.1103/PhysRevD.10.526>.
9. Bell, J.S. On the Problem of Hidden Variables in Quantum Mechanics. *Reviews of Modern Physics* **1966**, *38*, 447–452.
10. Christian, J. *Disproof of Bell's Theorem: Illuminating the Illusion of Entanglement*; Brown Walker Press: Boca Raton, FL USA, 2014.
11. Hess, K. A Critical Review of Works Pertinent to the Einstein-Bohr Debate and Bell's Theorem. *Symmetry* **2022**, *14*, 163.
12. Aspect, A. Closing the door on Einstein and Bohr's quantum debate. *Physics* **2015**, *8*, 123. <https://doi.org/10.1103/Physics.8.123>.
13. Nielsen, M.A.; Chuang, I.L. *Quantum Computation and Quantum Information*; Cambridge University Press: Cambridge, 2000.
14. Bell, J.S. Einstein-Podolsky-Rosen experiments. In Proceedings of the Proceedings of the Symposium on Frontier Problems in High Energy Physics, Pisa, June 1976; pp. 33–45.
15. Bell, J.S. Bertlmann's socks and the nature of reality. *Journal de Physique* **1981**, *42*(C2), C41–C62. <https://doi.org/10.1051/jphyscol:1981202>.
16. Bell, J.S. Introduction to the hidden-variable question. In Proceedings of the Foundations of Quantum Mechanics; d'Espagnat, B., Ed., New York, 1971; pp. 171–81.
17. Jammer, M. *The Philosophy of Quantum Mechanics*; John Wiley & Sons: New York, 1974.
18. Peres, A. *Quantum Theory: Concepts and Methods*; Kluwer Academic Publishers: New York, 2002.
19. Feynman, R. *The Character of Physical Law*; MIT Press: Cambridge, MA, 1965.
20. *The Born-Einstein Letters*; MACMILLAN: London, 1971.
21. Howard, D. Einstein on Locality and Separability. *Stud. Hist. Phil. Sci* **1985**, *16*, 171–201.

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