QUANTUM ENTANGLEMENT AND STRING THEORY

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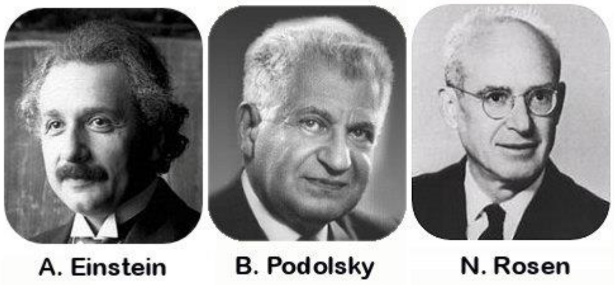
https://doi.org/10.5281/zenodo.14870600

Abstract

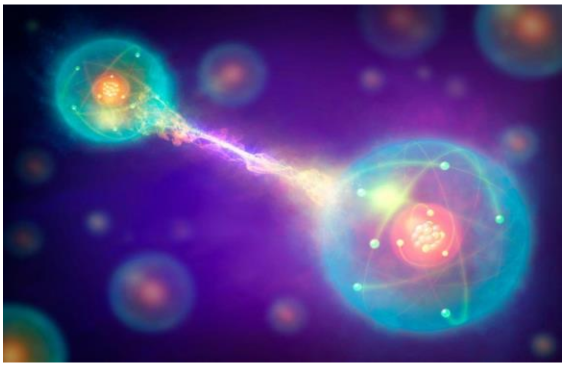
At the beginning of the 20th century, A. Einstein revealed the theory of special relativity. According to this theory, the speed of movement of objects in the Universe has a limit value. According to A. Einstein, no object or interaction in the Universe can move at a speed higher than the speed of light. For a long time, this claim of special relativity was not in doubt. But in the following years, due to the discovery of new particles or phenomena, scientists doubt the accuracy of this limit speed. Is the speed of light in a vacuum the fastest in the vast Universe? Based on this question, numerous experiments were conducted on this issue. Quantum entanglement, which finally emerged at the end of the 20th century, proved this claim of special relativity to be false. According to quantum entanglement, the transmission of interaction occurs at a speed greater than the speed of light. That is, we can say with certainty that the speed of light propagation in a vacuum is not the limit speed of the Universe. The phenomenon of quantum entanglement still attracts attention today with its mysterious properties. To answer all the questions about this phenomenon, it is necessary to approach it through different theories. This phenomenon can be fully explained by the String theory, the biggest theory of the universe. In the presented work, an attempt was made to fully explain the important features of quantum entanglement with string theory. At the same time, a convenient way of calculating the limit speed is mentioned.

Keywords: Special relativity, speed of light, quantum entanglement, string theory, limit speed.

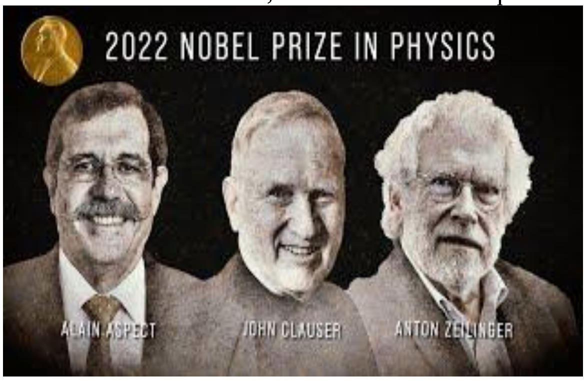
İntroduction. Albert Einstein published his special theory of relativity in 1905, based on many theoretical and empirical results obtained by Albert A. Michelson, Hendrik Lawrence, Henri Poincaré and others. This theory was put forward in the article "On the Electrodynamics of Moving Bodies". The theory of special relativity is based on two contradictory postulates in classical mechanics: 1. Laws describing physical phenomena do not change when moving from one inertial system to another; 2. The speed of light propagation in a vacuum is constant regardless of the speed of movement of the source and the receiver. The final theory is in better agreement with experiment than classical mechanics. For example, postulate 2 explains the results of the Michelson-Morley experiment. An important conclusion is drawn from this postulate. The maximum speed is finite: no physical object, information or field lines can be transmitted faster than the speed of light in a vacuum [1]. In the following years, as quantum mechanics developed, Einstein's ideas began to be questioned. It is known that Einstein and Niels Bohr had a long disagreement about the nature of quantum mechanics. Based on these discussions, Einstein came up with the idea of a photon-emitting box thought experiment. The essence of the experiment is that the photons emitted from the box, even if they are far from each other, were based on the possibility of changing the properties of one of them by changing the properties of the other. This idea, put forward by Einstein in 1931, was the first introduction of the phenomenon that would later be called entanglement [2]. In the same year, Herman Weyl, in his textbook on group theory and quantum mechanics, noted that quantum systems in multiple communications exhibit a kind of Gestalt where "the whole is greater than the sum of its parts" [3]. In 1932, Erwin Schrôdinger wrote his own proposals for quantum entanglement, but abandoned these equations before publishing them [4]. In 1935, Grete Hermann mathematically refined the interaction of an electron with a photon and observed a phenomenon called entanglement [5]. That same year, Albert Einstein, Boris Podolsky, and Nathan Rosen wrote a paper we know today as the Einstein-Podolsky-Rosen (EPR) contradiction.



In their theoretical experiments, they assumed that the two systems interacted and then separated, and then showed that the two systems of quantum mechanics do not determine each other separately. After this paper was published, Erwin Schrödinger wrote a letter to Einstein in German, in which he used the term "entanglement" to describe a situation such as the EPR contradiction [6]. Schrödinger then published a paper clarifying the term entanglement. In this paper, he referred to entanglement as a characteristic feature of quantum mechanics, not as an embedded concept [7]. Most people interested in quantum mechanics have encountered the principle of quantum entanglement at least once. According to this theory, two substances or bodies created at the same time or from the same source exist in a state of constant entanglement with each other. For example, photons emitted at the same time are continuously connected to each other. This part may not seem like a very important detail. To explain with an example, thinking that two electrons ejected from the same source rotate due to each other's influence. The further apart we spin one of these electrons, the other changes at the same time.



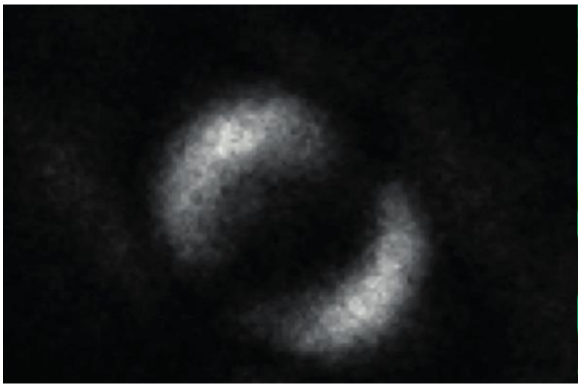
One thing to note here is that when one turns, the other reacts at the same time. Schrödinger, like Einstein, was not convinced that entanglement exists, as it is not found in classical mechanics, but only in quantum mechanics. Because, as we mentioned above, in the theory of relativity, the maximum speed for the transmission of information was considered to be the speed of light [8]. In its simplest definition, quantum entanglement is when two objects are inextricably bound and perturbing one perturbs the other, regardless of the distance between them. Einstein later called this entanglement the "spooky effect at a distance." Of course, experimental results are needed to prove the truth of this fact. In 1946, John Archibald Wheeler proposed to refine the polarization of photon pairs of gamma rays produced by the annihilation of the electron-positron pair [9]. Chien-Shiung Shu and J. Shakna performed this experiment in 1949 and thus showed that the entangled particle pairs predicted by EPR can be created in the laboratory [10]. However, very few articles have been written in this field during the last decades. In 1964, John S. Bell formulated a theorem called "Bell's inequality" [11]. This theory has been repeatedly reflected in practice. It should be noted that quantum entanglement is still not fully understood and researched enough for the scientific world. Quantum entanglement shows that two or more quantum systems are integrated by their effects on each other, even if they are very far apart. This integration creates correlations of the states of quantum systems with each other, and these correlations are the most striking feature of quantum entanglement. Many experiments have been carried out to test Bell's inequality in practice, such as the research of Stuart Freedman and John Clauser in 1972 and the experiments of Alain Aspect in 1982 [12]. Since the mid-1990s, Anton Zeilinger has used the creation of entanglement by parameter downconversion to explain the nature of entanglement [13]. For this reason, the 2022 Nobel Prize in Physics was awarded to Aspect, Clauser and Zeilinger "for experiments with wandering photons, the determination of violations of Bell's inequalities and the first quantum information science" [14].

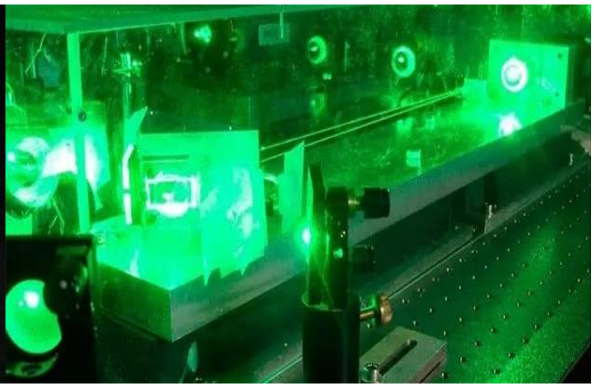


Problem setting: It becomes clear that the existence of quantum entanglement is no longer a matter of debate. Quantum entanglement is already being used to encrypt quantum computers. The importance of quantum entanglement has been recognized as a phenomenon in which two or more quantum systems are interconnected and can even influence each other. Let's explain the experience in simple language. Suppose that two electrons are located at a distance of 100 meters from each other. The speed of light takes about 300 nanoseconds to travel this distance. So, if the spin of the first electron goes up, this information must reach it after about 300 nanoseconds for the spin of the second electron to go down. However, experiments show that the transmission of this information takes place in less than 300 nanoseconds. Therefore, information transfer occurs at a speed greater than the speed of light. But how does this happen? There are two popular approaches to this situation. The first of these claims that there is an energy that we cannot observe. This energy connection is so fast that the speed of light is negligible next to it. However, given our technologies today, this approach is quite difficult to prove. Another view claims that this movement is an illusion. The reason for this is the existence of theories that confirm that everything in the Universe is already intertwined.

Solving the problem: The main issue here is to find out how the interaction is greater than the speed of light and how the particles interact with each other regardless of the distance. In the first claim, invisible communication can be thought of as dark energy. However, dark energy is only the creator of the gravitational field [15]. And since the mass of the particles is very small, the space-time piece wrapped by them will cover a very small area. At the same time, dark matter belongs to higher dimensional spaces. In short, it would not be correct to say that this approach is correct. Second claim holders believe that everyone in the Universe is connected to each other. It is known that according to the String theory, all objects in the Universe are strings that vibrate in different patterns. String theory is the possibility of obtaining a quantum-freedom of the entire organization of matter with the 4 main forces of influence in the universe [16]. So, the transmission of influence is possible through strings. Since all strings are vibrating single energy resources, they are all connected to each other. Then, we determine that the particles are related to each other depending on the distance. There are approximately $6.4 \cdot 10^{53}$ strings in one electron [17]. We have seen that strings are much larger than photons, electrons, and other particles. Therefore, we can get the fact that the speed of energy transfer in the wire mesh is greater than the maximum speed of movement of the particles

It is the existence of quantum entanglement that once again confirms this fact. Therefore, the speed of energy transfer in the wire mesh can be considered the maximum speed of interaction transfer, and this speed can be considered the limit speed of the Universe (in 3D space). Note that an attempt was made to measure this speed in experiment. Together with a Chinese research group, Joachim Burdörfer managed to measure the speed of quantum entanglement. According to their experiment, the entanglement of two particles occurs in a very short period of 232 attoseconds [18]. In addition, scientists have also obtained an image of the phenomenon of quantum entanglement.





Result: String theory proves that all particles in the Universe are interconnected. The speed of energy transmission through wires can be considered the maximum speed of information transmission. This speed is the maximum speed of the Universe in 3D space. By noting the distance between the particles in the above experiment $\mathbf{V^*=S/t}$ **($\mathbf{t=232 \cdot 10^{-18}}$ Sec)** the limit speed can be calculated using the formula. However, in order for a particle to acquire a state, information from another particle must reach it at this speed. That is, since we are calculating at a finite speed, it can be said that nothing happens instantaneously in the Universe. For each process, a certain time should pass, even if it is small. Combining these facts, we can say that there may be a connection between quantum entanglement and matter teleportation. If we consider matter as a quantum system and note that all bodies are made of strings, if we could convert matter into a field system, we could move it to a certain distance with a velocity of approximately V* and convert it back into matter form. However, even if this process were possible, we would need very high energy.

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