Scientists cite progress in refuting Einstein

Dutch experiment shows consistent success in sending quantum data

BY JOHN MARKOFF

Scientists in the Netherlands have moved a step closer to overriding one of Albert Einstein's most famous objections to the implications of quantum mechanics, which he described as "spooky action at a distance."

In a paper published Thursday in the journal Science, physicists at the Kavli Institute of Nanoscience at the Delft University of Technology reported that they were able to reliably teleport information between two quantum bits separated by three meters, or about 10 feet.

Quantum teleportation is not the "Star Trek"-style movement of people or things; rather, it involves transferring so-called quantum information — in this case what is known as the spin state of an electron — from one place to another without moving the physical matter to which the information is attached.

Classical bits, the basic units of information in computing, can have only one of two values — either 0 or 1. But quantum bits, or qubits, can simultaneously describe many values. They hold out both the possibility of a new generation of faster computing systems and the ability to create completely secure communication networks.

Moreover, the scientists are now closer to definitively proving Einstein wrong in his early disbelief in the notion of entanglement, in which particles separated by light-years can still appear to remain connected, with the state of one particle instantaneously affecting the state of another.

They report that they have achieved perfectly accurate teleportation of quantum information over short distances. They are now seeking to repeat their experiment over a distance of more than a kilometer. If they are able to show repeatedly that entanglement works at this distance, it will be a definitive demonstration of the entanglement phenomenon and quantum mechanical theory.

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chanical theory.

Succeeding at greater distances will offer an affirmative solution to a thought experiment known as Bell's theorem, proposed in 1964 by the Irish physicist John Stewart Bell as a method for determining whether particles connected via quantum entanglement communicate information faster than the speed of light.

"There is a big race going on between five or six groups to prove Einstein wrong," said Ronald Hanson, a physicist who leads the group at Delft. "There is one very big fish."

In the past, scientists have made halting gains in teleporting quantum information, a feat that is achieved by forcing physically separated quantum bits into an entangled state.

But reliability of quantum teleportation has been elusive. For example, in 2009, University of Maryland physicists demonstrated the transfer of quantum information, but only one of every 100 million attempts succeeded, meaning that transferring a single bit of quantum information required roughly 10 minutes.

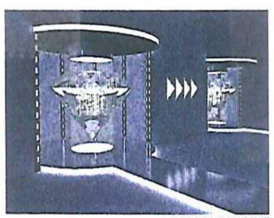
In contrast, the scientists at Delft have achieved the ability "deterministically," meaning they can now teleport the quantum state of two entangled electrons accurately 100 percent of the time.

They did so by producing qubits using electrons trapped in diamonds at extremely low temperatures. According to Dr. Hanson, the diamonds effectively create "miniprisons" in which the electrons were held. The researchers were able to establish a spin, or value, for electrons, and then read the value reliably.

In addition to the possibility of an impregnable quantum Internet, the research holds out the possibility of networks of quantum computers.

To date, practical quantum computers, which could solve certain classes of problems far more quickly than even the most powerful computers now in use, remain a distant goal. A functional quantum computer would need to entangle a large number of qubits and maintain that entangled state for relatively long periods, something that has so far not been achieved.

A distributed quantum network might also offer new forms of privacy, Dr. Hanson suggested. Such a network would make it possible for a remote user to perform a quantum calculation on a server, while at the same time making it impossible for the operator of the server to determine the nature of the calculation.



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A rendering of the quantum teleportation of a spin state between two diamonds.