Essay: QUANTUM TELEPORTATION

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INTRODUCTION

Sending signals through optical fiber is reliable and fast, but because of internal absorption and other unwanted effects such as Atmospheric turbulence, they lose photons with the losses increasing the farther the signal must travel. Itâs very problematic when the number of photons being sent is small hence requires quantum repeaters. This is thoughtful issue in quantum networks as it typically involves a small number of entangled photons. Direct transmission through free space (vacuum or air) experiences less photon loss, but itâs very difficult to align a distant receiver perfectly with the transmitter so that photons arrive at their destination thus there is certainly requirement of a strong substitute.

As a result, there is an international quantum teleportation space race heating up. Around the world,

countries are investing time and money into the technology, which uses satellites to beam bits of quantum information down from the sky and could profoundly change worldwide communication.
Though it may be disappointing to hear, quantum teleportation is not about instantly sending a person or object between two places, Instead, the technique involves the perhaps even freakier task of separating a subatomic particle from its quantum state. In the future, quantum cryptography may become a widespread technology. Quantum mechanics can make the communication between two users intrinsically secure.

WHY ITâS REQUIRED? â”

Whatâs the purpose of such pseudo-teleportation, then? As always with such things: cryptography, and secure communication links. Modern cryptography is virtually unbreakable, unless the encryption key is compromised â” and it can be very hard to get that encryption key to the receiving partner without other people (other intelligence agencies) listening in. With quantum teleportation, you could teleport the encryption key, making man-in-the-middle attacks virtually impossible.
For quantum encryption to work, though, we need to be able to transmit entangled photons over a long distance â” and therein lies the crux: According to the researchers, their system should be able to scale up to distances that will reach orbiting satellites. Weâre talking years in the future â” weâd need to put a quantum communications satellite in orbit first â” but this would certainly be the first step towards building a global quantum network.

HISTORY â”

It was the physicist Charles Bennett from IBM's labs at Yorktown Heights in New York who introduced the world to the idea of quantum teleportation in 1993. The idea combined entanglement with the slower speed of light communication. This process does destroy information concerning the original particle; however, this information can be reconstructed, exactly, at the new location. And the reconstruction, or materialization, does not require the âteleported particles to travel the distance in-between.â
Nine years later, in 2002, the quantum optics group at the Australian National University used entanglement to teleport a laser beam in their laboratory. The experiment itself was extremely complicated being the culmination of a decade of work. This is the second time this effect has been observed, following earlier work at the California Institute of Technology. The research program is led by Dr. Ping Koy Lam, Prof. Hans Bachor and Dr. Timothy Ralph.
So, this experiment showed that you do the quantum equivalent of faxing particles within one laboratory by making photons from one location materialize at another. Larger distances have already been done by researchers at the University of Geneva in Switzerland and the University of Aarhus in Denmark. They have teleported photons from one laboratory to another lab 55 meters away, and their setup simulated a distance of two kilometers.
A group in China has made significant progress toward minimize the time and to avoid the problem of covering a physical distance further, via a high accuracy pointing and tracking system.
Using this method, Juan Yin and colleagues performed quantum teleportation (copying of a quantum state) using multiple entangled photons through open air between two stations 97km apart across a lake.
However, quantum communication sometimes also requires coordination between two distant receivers, so the researchers set up the transmitter on an island in the lake. The receivers were 51.2 and 52.2 km from the photon source respectively, on opposite shores of Qinghai lake, forming a triangle with the transmitter. The distance between the receivers — 101.8km — was far enough to create a 3 microsecond delay between measurements of the photon polarisation.
Given this setup, there was no possible way for the two receiving stations to communicate. Yet the photons they registered were correlated, indicating entanglement was maintained.
These experiments provide not only a proof of principle for free-space quantum communication, but also a means to test the foundations of quantum theory over larger distances than before. With very large detector separation, quantum entanglement experiments can help differentiate between standard and alternative interpretations of the quantum theory.
Their results achieved larger distances for multi-photon teleportation and three-point entanglement than before; the previous record for transmitting entangled qubits was 16 kilometers, performed by another Chinese team back in 2010.
The tracking system used may even enable ground-to-satellite quantum communication, at least if it

happens at night as they didnât properly quote about day time.
BASICS OF QUANTUM TELEPORTATION â"
Quantum teleportation does not move atoms, but it can transfer information about the state of an atom or particle from one place to another without that information moving in between. Quantum teleporting of particles can't happen faster than light, something Einstein would be pleased to learn.
â¢ Entanglement
Researchers use laser light to âentangleâ two electrons trapped inside small synthetic diamonds. A change made to one electron will instantaneously affect or change the properties of the other electron, no matter how far away they are.
â¢ Encoding
The piece of information to be teleported is encoded in a nearby nitrogen atom that is also trapped inside the diamond crystal.
â¢ Measurement
Researchers measure the state of the atom and its neighboring electron and send the measurement to the distant location. The original information is destroyed but not transmitted, so it is safe from interception or eavesdropping.
â¢ Quantum Teleportation
The measurements are used to determine what type of manipulation should be performed on the distant entangled electron to recreate the encoded information. The information is considered âteleportedâ because it did not travel the distance between the two locations.
Still if you arenât clear about Quantum teleportation then I would like you to see this cartoon which will help me to explain you about recent research by NASA Jet Propulsion Laboratory about it.
RESEARCH & DEVELOPMENT â"
â¢ Scientists at Toshiba Research Europe have developed the first practical semiconductor device that can count the photons in light signals. The device is claimed as a significant step towards creating viable quantum computers and communication systems. Dr Andrew Shields, leader of the Quantum Information Group, said: âA simple semiconductor device that can count the photons in a light signal is important for several quantum applications. We plan to apply the new device, in conjunction with our semiconductor photon source technology, in practical quantum communication gates that can extend the distance of quantum key distribution and in quantum computers based on photons.â
Determining the number of photons in a light signal is of crucial importance for many of these applications. Quantum computers based on photons, for example, need to distinguish between one and two photons on each output. In quantum teleportation, which may be used to send secret digital keys over longer distances than currently possible.
According to the researchers, the lack of a suitable photon number resolving detector has been a major obstacle to the deployment of quantum technologies. The breakthrough has been enabled by a technique developed by Toshiba to detect weak photon induced avalanches. The Toshiba device, by contrast, can detect photon induced avalanches that are 20 times weaker than conventionally and the strength of which scales linearly with the incident number of photons.
â¢ A team LPN of the French National Centre for Scientific Research CNRS has developed a light source for entangled photons said to be 20 times brighter than all existing systems. The researchers have developed a 'photonic molecule' system in which a semiconductor quantum dot emits a pair of entangled photons per excitation pulse from a laser. This photonic molecule constitutes a trap for each of the photons of the pair and allows them to be collected efficiently. The source can generte one pair of photons for every eight pulses, compared to fewer than one pair every 100 pulses for other approaches. In the future, the researchers believe they should be able to reach a rate close to one pair of photons per pulse. Using this device could make it possible to manufacture electroluminescent diodes of entangled photon pairs, with rates close to 1GHz. LPN scientists have also shown that the photonic molecule concept allows the quality of the entanglement of the emitted photon pairs to be improved. Entanglement has far reaching application in fields such as quantum cryptography, quantum computation and quantum teleportation.
The image represents, in the top right hand corner, the new component produced in the LPN experiment: two pillars of micrometric size are coupled to form the 'photonic molecule'. The semiconductor quantum dot

(of Nano metric size) is inserted into one of the pillars (visible as the bright spot in the right hand pillar). The lower part of the image shows the radiation pattern of the entangled photons emitted by the component.
â¢ Physicists passed a milestone in the development of a 'quantum internet' by transmitting quantum states between telescopes on La Palma and Tenerife â" a record distance of 143km. The visible laser beam was used to stabilize the telescopes sending and receiving the quantum signal.
In theory, 'quantum teleportation' will enable the exchange of messages with greater security, and allow calculations to be performed much more efficiently than is currently possible.
â¢ China plans to launch a satellite with a quantum teleportation experiment payload in 2016 and the European, Japanese, and Canadian space agencies are hoping to fund their own quantum teleportation satellite projects in the coming years. Conspicuously, the US is far behind the pack because of a bureaucratic reshuffling that left quantum communication research experiments without government support in 2008. Whoever loses this new competition could fail to capitalize on the promise of quantum communication altogether.
â¢ With scientists extending quantum teleportation to such distances, many are already considering the next step: zapping particles and information from an orbiting satellite to a relay station on Earth. If developed, quantum teleportation satellites could allow spies to pass large amounts of information back and forth or create unhackable codes. Should we ever build quantum computers — which would be smaller and exponentially more powerful than modern computers, able to model complex phenomenon, rapidly crunch numbers, and render modern encryption keys useless — they would need quantum teleporters in order to be networked together in a quantum version of the internet.
LIMITATIONS â"
Though the long-distance aspect is promising, the facts that they set up on the shores of a lake (where no intervening obstacles exist) and that the experiment could only be performed successfully at night indicate its limitations. However they are working on solving the problem for daytime communication, but since the signal consists of single photons, itâs not clear how this will work — the number of received photons fluctuated with the position of the Moon, so noise appeared to be a significant problem for them. Point-to-point communication will need to solve that problem as well before satellite-to-ground quantum networks are practical.
SUMMERY â"
Quantum teleportation has been proven experimentally many times over and researchers are now eyeing the heavens as their next big leap forward. Most of what remains are the nuts and bolts engineering challenges (and some more money) before it becomes a thing of the present. Teleportation has numerous possible applications. Perhaps the most promising are in the communication and computer industries. Quantum teleportation could potentially allow fiber optic communication with faster bit transfer rates, and 100% secure encryption of messages, and quantum computers with the ability to crunch complex mathematical problems millions of times faster than present day computers.

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