Mathematical Breakthrough Sets Out Rules for More Effective Teleportation

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For the last ten years, theoretical physicists have shown that the intense connections generated between particles as established in the quantum law of 'entanglement' may hold the key to eventual teleportation of quantum information.

Now, for the first time, researchers have worked out how entanglement could be 'recycled' to increase the efficiency of these connections. Published in the journal *Physical Review Letters*, the result could conceivably take us a step closer to sci-fi style teleportation in the future, although this research is purely theoretical in nature.

The team have also devised a generalised form of teleportation, which allows for a wide variety of potential applications in quantum physics.

Once considered impossible, in 1993 a team of scientists calculated that teleportation could work in principle using quantum laws. Quantum teleportation harnesses the 'entanglement' law to transmit particle-sized bites of information across potentially vast distances in an instant.

Entanglement involves a pair of quantum particles such as electrons or protons that are intrinsically bound together, retaining synchronisation between the two that holds whether the particles are next to each other or on opposing sides of a galaxy. Through this connection, quantum bits of information - qubits - can be relayed using only traditional forms of classical communication.

Previous teleportation protocols, have fallen into one of two camps, those that could only send scrambled information requiring correction by the receiver, or more recently, "port-based" teleportation that doesn't require a correction, but needed an impractical amount of entanglement – each object sent would destroy the entangled state.

Now, physicists from Cambridge, University College London, and the University of Gdansk have developed a protocol to provide an optimal solution in which the entangled state is 'recycled', so that the gateway between particles holds for the teleportation of multiple objects.

They have even devised a protocol in which multiple qubits can be teleported simultaneously, although the entangled state degrades proportionally to the amount of qubits sent in both cases.

"The first protocol consists of sequentially teleporting states, and the second teleports them in a bulk," said Sergii Strelchuck from Cambridge's Department of

Applied Mathematics and Theoretical Physics, who led the research with colleagues Jonathan Oppenheim of Cambridge and UCL and Michal Horodecki of the University of Gdansk.

"We have also found a generalised teleportation technique which we hope will find applications in areas such as quantum computation."

Einstein famously loathed the theory of quantum entanglement, dismissing it as "spooky action at a distance". But entanglement has since been proven to be a very real feature of our universe, and one that has extraordinary potential to advance all manner of scientific endeavor.

"There is a close connection between teleportation and quantum computers, which are devices which exploit quantum mechanics to perform computations which would not be feasible on a classical computer," said Strelchuck.

"Building a quantum computer is one of the great challenges of modern physics, and it is hoped that the new teleportation protocol will lead to advances in this area."

While the Cambridge physicists' protocol is completely theoretical, last year a team of Chinese scientists reported teleporting photons over 143km, breaking previous records, and quantum entanglement is increasingly seen as an important area of scientific investment. Teleportation of information carried by single atoms is feasible with current technologies, but the teleportation of large objects - such as Captain Kirk - remains in the realm of science fiction.

Adds Strelchuck: "Entanglement can be thought of as the fuel, which powers teleportation. Our protocol is more fuel efficient, able to use entanglement thriftily while eliminating the need for error correction."

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