Towards quantum Internet: Researchers teleport particle of light six kilometres

September 21 2016, by Drew Scherban

Wolfgang Tittel, professor in the Department of Physics and Astronomy at the University of Calgary. Credit: Riley Brandt, University of Calgary

What if you could behave like the crew on the Starship Enterprise and teleport yourself home or anywhere else in the world? As a human, you're probably not going to realize this any time soon; if you're a photon, you might want to keep reading.

Through a collaboration between the University of Calgary, The City of Calgary and researchers in the United States, a group of physicists led by

Wolfgang Tittel, professor in the Department of Physics and Astronomy at the University of Calgary have successfully demonstrated teleportation of a photon (an elementary particle of light) over a straight-line distance of six kilometres using The City of Calgary's fibre optic cable infrastructure. The project began with an Urban Alliance seed grant in 2014.

This accomplishment, which set a new record for distance of transferring a quantum state by teleportation, has landed the researchers a spot in the prestigious *Nature Photonics* scientific journal. The finding was published back-to-back with a similar demonstration by a group of Chinese researchers.

"Such a network will enable secure communication without having to worry about eavesdropping, and allow distant quantum computers to connect," says Tittel.

Experiment draws on 'spooky action at a distance'

The experiment is based on the entanglement property of quantum mechanics, also known as "spooky action at a distance"—a property so mysterious that not even Einstein could come to terms with it.

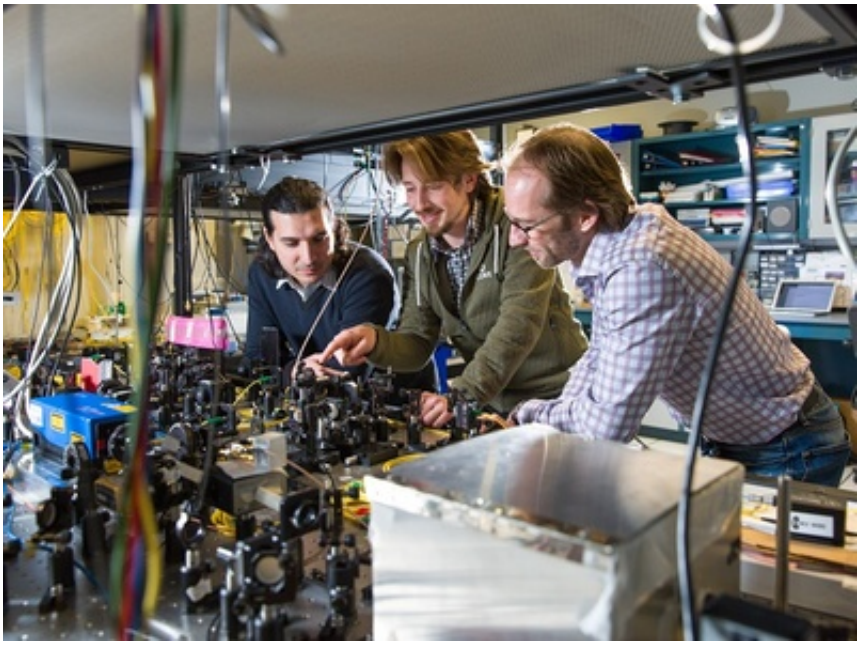
"Being entangled means that the two photons that form an entangled pair have properties that are linked regardless of how far the two are separated," explains Tittel. "When one of the photons was sent over to City Hall, it remained entangled with the photon that stayed at the University of Calgary."

Next, the photon whose state was teleported to the university was generated in a third location in Calgary and then also travelled to City Hall where it met the photon that was part of the entangled pair.

"What happened is the instantaneous and disembodied transfer of the photon's quantum state onto the remaining photon of the entangled pair, which is the one that remained six kilometres away at the university," says Tittel.

City's accessible dark fibre makes research possible

The research could not be possible without access to the proper technology. One of the critical pieces of infrastructure that support quantum networking is accessible dark fibre. Dark fibre, so named because of its composition—a single optical cable with no electronics or network equipment on the alignment—doesn't interfere with quantum technology.



A group of physicists led by Wolfgang Tittel have successfully demonstrated teleportation of a photon, an elementary particle of light, over a straight-line distance of six kilometres. Credit: Riley Brandt, University of Calgary

The City of Calgary is building and provisioning dark fibre to enable next-generation municipal services today and for the future.

"By opening The City's dark fibre infrastructure to the private and public sector, non-profit companies, and academia, we help enable the development of projects like quantum encryption and create opportunities for further research, innovation and economic growth in Calgary," said Tyler Andruschak, project manager with Innovation and Collaboration at The City of Calgary.

"The university receives secure access to a small portion of our fibre optic infrastructure and The City may benefit in the future by leveraging the secure encryption keys generated out of the lab's research to protect our critical infrastructure," said Andruschak. In order to deliver next-generation services to Calgarians, The City has been increasing its fibre optic footprint, connecting all City buildings, facilities and assets.

Timed to within one millionth of one millionth of a second

As if teleporting a photon wasn't challenging enough, Tittel and his team encountered a number of other roadblocks along the way.

Due to changes in the outdoor temperature, the transmission time of photons from their creation point to City Hall varied over the course of a day—the time it took the researchers to gather sufficient data to support their claim. This change meant that the two photons would not meet at City Hall.

"The challenge was to keep the photons' arrival time synchronized to within 10 pico-seconds," says Tittel. "That is one trillionth, or one millionth of one millionth of a second."

Secondly, parts of their lab had to be moved to two locations in the city, which as Tittel explains was particularly tricky for the measurement station at City Hall which included state-of-the-art superconducting single-photon detectors developed by the National Institute for Standards and Technology, and NASA's Jet Propulsion Laboratory.

"Since these detectors only work at temperatures less than one degree above absolute zero the equipment also included a compact cryostat," said Tittel.

Milestone towards a global quantum Internet

This demonstration is arguably one of the most striking manifestations of a puzzling prediction of quantum mechanics, but it also opens the path to building a future quantum internet, the long-term goal of the Tittel group.

The Urban Alliance is a strategic research partnership between The City of Calgary and University of Calgary, created in 2007 to encourage and co-ordinate the seamless transfer of cutting-edge research between the university and The City of Calgary for the benefit of all our communities. The Urban Alliance is a prime example and vehicle for one of the three foundational commitments of the University of Calgary's Eyes High vision to fully integrate the university with the community. The City sees the Alliance as playing a key role in realizing its long-term priorities and the imagineCALGARY vision.

More information: Raju Valivarthi et al. Quantum teleportation across a metropolitan fibre network, *Nature Photonics* (2016). DOI: 10.1038/nphoton.2016.180

Qi-Chao Sun et al. Quantum teleportation with independent sources and prior entanglement distribution over a network, *Nature Photonics* (2016).

DOI: 10.1038/nphoton.2016.179