Tech

Breakthrough could make quantum data transmission a reality

by *Tara Seals* | Aug 24, 2017 10:00am

Researchers at the University of Ottawa have sent a quantum-secured message containing more than one bit of information per photon through the air above a city.

Imagine sending data over the air in the form of light rather than radio waves—a method that eliminates the restriction of spectrum availability in wireless networks.

Researchers at the University of Ottawa in Canada have taken a step forward toward that goal by sending a quantum-secured message containing more than one bit of information per photon through the air above a city. It may sound esoteric, but sending multiple bits per photon is a crucial requirement for this technology to move from theoretical to having real-world applications.

As the Optical Society details in its academic journal, Optica, quantum encryption uses photons to encode information.

"In its simplest form, known as 2D encryption, each photon encodes one bit: either a one or a zero. Scientists have shown that a single photon can encode even more information—a concept known as high-dimensional quantum encryption—but until now this has never been demonstrated with free-space optical communication in real-world conditions. With eight bits necessary to encode just one letter, for example, packing more information into each photon would significantly speed up data transmission."

If high-capacity, free-space quantum communications becomes practical, it paves the way to creating highly secure links between ground-based networks and satellites—and eventually, for a global quantum encryption network.

"Our work is the first to send messages in a secure manner using high-dimensional quantum encryption in realistic city conditions, including turbulence," said research team lead Ebrahim Karimi. "The secure, free-space communication scheme we demonstrated could potentially link Earth with satellites, securely connect places where it is too expensive to install fiber, or be used for encrypted communication with a moving object, such as an airplane."

The researchers were able to demonstrate 4D quantum encryption (which means that each photon encodes two bits of information instead of one) over a free-space optical network spanning two buildings 0.3 kilometers apart at the University of Ottawa. Taking laboratory optical setups to two different rooftops and covering them with wooden boxes to provide protection from the elements, through trial and error, they eventually achieved successful 4D transmission. The messages exhibited an error rate of 11%, below the 19% threshold needed to maintain a secure connection. And compared to 2D encryption, they were able to transmit 1.6 times more information per photon.

"After bringing equipment that would normally be used in a clean, isolated lab environment to a rooftop that is exposed to the elements and has no vibration isolation, it was very rewarding to see results showing that we could transmit secure data," said Alicia Sit, an undergraduate student in Karimi's lab.

As a next step, the researchers are planning to implement their scheme into a network that includes three links that are about 5.6 kilometers apart and that uses a technology known as adaptive optics to compensate for the turbulence. Eventually, they will expand citywide. One of the primary problems faced during any free-space experiment is dealing with air turbulence, which distorts the optical signal, so future testing will focus on how to mitigate that.

"Our long-term goal is to implement a quantum communication network with multiple links but using more than four dimensions while trying to get around the turbulence," said Sit.

Implementing the technology globally will require that transmissions are sent between ground-based stations and the satellite-based quantum communication networks, which would then link cities and countries. To test for the practicality of a global network, researchers will focus on horizontal testing to simulate satellite uplinks, with about three horizontal kilometers being roughly equal to sending a signal through Earth's atmosphere to a satellite.

In addition to what this 4D breakthrough means for the future of data transmission, it's also a big step forward when it comes to security; these links are by their nature almost bulletproof.

Encrypted communications today, for things like text messages, banking transactions and health information, are enabled by mathematical algorithms. However, those algorithms are hackable and crackable—especially in the age of artificial intelligence and machine learning. 4D quantum encryption on the other hand uses quantum key distribution, which uses properties of light particles known as quantum states to encode and send the key needed to decrypt encoded data.

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