# Long-distance record -- 'Quantum keys' sent 200 kilometers

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Particles of light serving as “quantum keys”—the latest in encryption technology—have been sent over a record-setting 200-kilometer fiber-optic link by researchers from the National Institute of Standards and Technology (NIST), NTT Corp. in Japan, and Stanford University. The experiment, using mostly standard components and transmitting at telecommunications frequencies, offers an approach for making practical inter-city terrestrial quantum communications networks as well as long-range wireless systems using communication satellites.

The demonstration, described in Nature Photonics, was conducted in a Stanford lab with optical fiber wrapped around a spool. In addition to setting a distance record for quantum key distribution (QKD), it also is the first gigabit-rate experiment—transmitting at 10 billion light pulses per second—to produce secure keys.

The rate of processed key production—the keys corrected for errors and enhanced for privacy—was much lower due to the long distance involved, and the key was not used to encrypt a digital message as it would be in a complete QKD system.

QKD systems transmit a stream of single photons with their electric fields in different orientations to represent 1s and 0s, which are used to make quantum keys to encrypt and decrypt messages. Properly executed, quantum encryption is “unbreakable” because eavesdropping changes the state of the photons.

A key aspect of the experiment is the use of ultrafast superconducting single-photon detectors developed in Russia, with packaging and cooling technology custom-made at NIST labs in Boulder, Colo. Counting single photons (the smallest particles of light) rapidly and reliably has been a major challenge limiting the development of practical QKD systems.

The Russian detectors have very low false count rates because of their low-noise cryogenic operation, as well as superior timing resolution due to the physics of superconductors, in which electrons can switch from excited to relaxed states in just trillionths of a second.

Each detector consists of a superconducting niobium nitride nanowire operating just below the “critical current” at which it conducts electricity without resistance. When a single photon hits the wire, a hot spot is formed, and the current density increases until it exceeds the critical current. At this point, a non-superconducting barrier forms across the wire, and a voltage pulse is created. The starting edge of the voltage pulse pinpoints the photon’s arrival time.

Sae Woo Nam, a NIST physicist who packaged the detectors, said NIST offers unique expertise in connecting the single-photon detector chips to optical fiber and in designing refrigeration systems to operate at -270 degrees C (-454 degrees F) without liquid cryogens. “You need to know how to efficiently get light to the detector and how to amplify the signals,” he says.

Source: National Institute of Standards and Technology