Researchers Set New Distance Record for Quantum Key Distribution

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Scientists have demonstrated a new QKD prototype that can distribute quantum keys over a distance of 250 km in the lab. Credit: Wikimedia.

(PhysOrg.com) -- Quantum key distribution (QKD) could be the next commercial success of quantum physics, and a recent study has taken the field a step closer to this reality. Researchers from the University of Geneva in Switzerland and Corning Incorporated in New York have demonstrated a new QKD prototype that can distribute quantum keys over a distance of 250 km in the lab, improving upon the previous record of 200 km. The scientists hope that the achievement will lead to the goal of distributing quantum keys over intercity distances of 300 km in the near future.

As the researchers explained, the purpose of QKD schemes is to distribute a secret quantum key between two distant locations with security relying on the laws of quantum physics. The idea of QKD was first proposed in 1984, and in 1992, scientists could distribute quantum keys over 32 cm, while the technology has improved from there. Despite these advances, the scientists say, the main challenge is still to achieve higher bit rates over longer distances.

To reach their new record of 250 km, the scientists made three significant improvements to their QKD technique. First, they developed a coherent one way (COW) protocol tailored specifically for quantum communication over optical fiber networks. In addition, they used an improved superconducting single-photon detector to decrease noise, as well as ultra low loss fibers made by Corning to minimize channel loss and improve the distribution rate.

By making these improvements, the physicists could distribute quantum keys in the lab at a rate of 15 bits per second over 250 km of optical fiber, or 6,000 bits per second over 100 km, with low error rates. The system is also fully automated, and can run for hours without human intervention.

In the COW protocol, Alice, the transmitter, sends a pair of pulses, one empty and one non-empty (containing a mean photon number of 0.5). The bits are encoded in the pair of pulses, with the bit value define by the position of the non-empty pulse: first position = 0 and second position = 1. Bob, the receiver, uses a detector to distinguish the pulses.

For true quantum communication, Alice and Bob also verify the coherence of the pulses. Bob randomly selects a small fraction of pulses, not used as data, to send to an interferometer, which measures the coherence between adjacent qubits. Due to this security measure, an eavesdropper could not perform “photon number splitting attacks,” such as removing or blocking photons, without disturbing the system and being detected. This heightened security means that quantum key distribution could have applications in quantum cryptography, explained Hugo Zbinden of the University of Geneva.

“As the name says, QKD enables the distribution of a secret key,” Zbinden told *PhysOrg.com*. “This key can be used for the encryption and decryption of secret messages. … Since QKD allows for a secure and convenient key exchange, it enables changing the used keys frequently and therefore improves the security of the system.”

As the researchers noted, the high performance of the COW QKD prototype shown here depended on a team of experts, including theoretical and experimental physicists, telecom engineers, and electronic and software specialists. They hope that this diverse set of skills will continue to improve the performance of quantum key distribution for useful applications.

“In order to improve commercial QKD, we need convenient, fast and low noise photon detectors,” Zbinden said. “The superconducting detectors are not very practical. Then, going to higher repetition rates, high speed electronics and logic become mandatory, and you need fast key distillation algorithms. Another issue is to combine QKD with classical links on the same fiber using WDM (wavelength division multiplexing). The development of a QKD system is therefore a multi-disciplinary task, requiring physicists as well as electronics, software and telecom engineers.”

More information: D. Stucki, N. Walenta, F. Vannel, R.T. Thew, N. Gisin, H. Zbinden, S. Gray, C.R. Towery, and S. Ten. “High rate, long-distance quantum key distribution over 250 km of ultra low loss fibres.” *New Journal of Physics*. 11 (2009) 075003.