Quantum key distribution network accurately measures ground vibration

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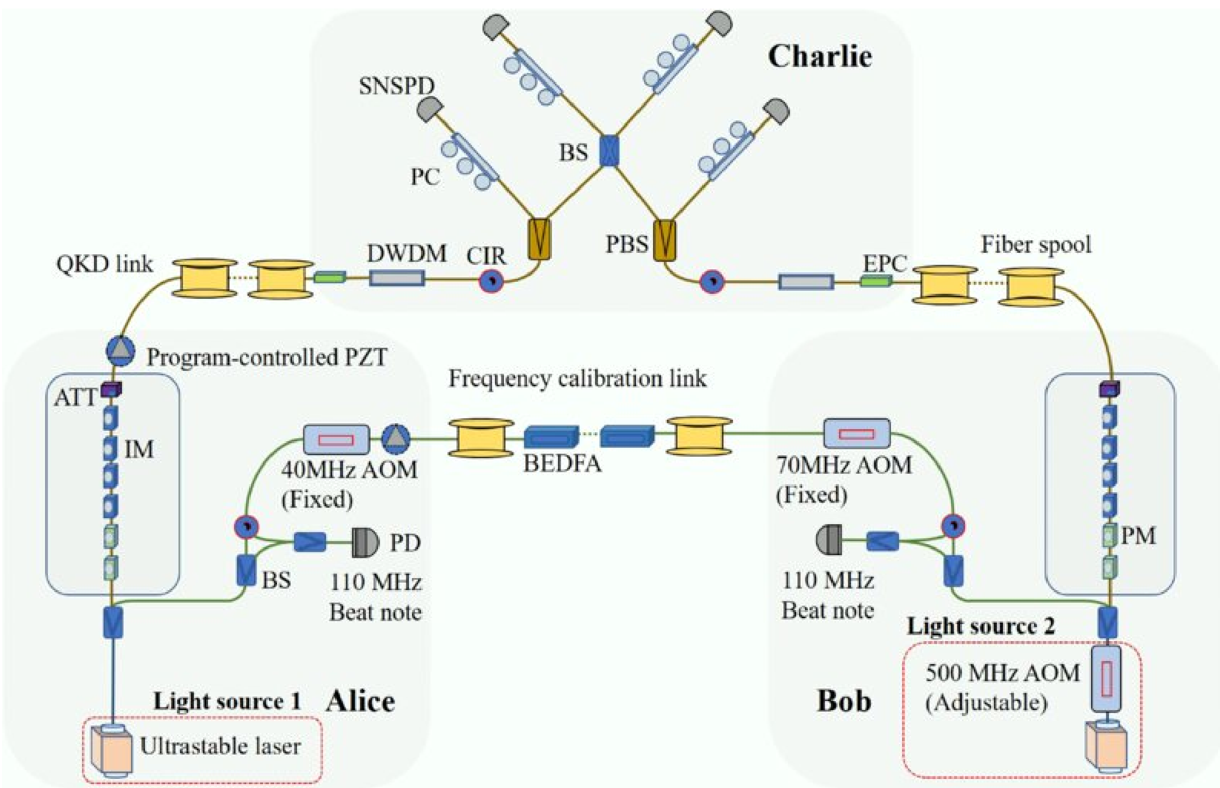

Schematic of experimental setup. In Alice's (Bob's) lab, a seed laser is locked to an ultra-low-expansion (ULE) glass cavity to achieve a subhertz linewidth by using the Pound-Drever-Hall (PDH) [41, 42] technique. After PDH locking, a 500 MHz acoustic-optic modulator (AOM) with adjustable carrier frequency is inserted at Bob to eliminate the frequency difference of the two stable lasers. Then, the ultrastable light sources are split into two parts, respectively; one is used for QKD, the other is sent to the other user via a 500 km frequency calibration fiber link for heterodyne interference. Bidirectional erbium-doped fiber amplifiers (BEDFAs) are inserted every 50 km to maintain the power of the transmitted light, two AOMs with fixed carrier frequency of 40 and 70 MHz are inserted at both ends of the link to filter the reflection in the channel. PD: photodiode. In the QKD part, the light is modulated with phase modulators (PMs) and intensity modulators (IMs) and attenuated to a single photon level with an attenuator (ATT), to generate the quantum signals with the phase reference signals. The light is finally sent to Charlie via 329.3 and 329.4 km ultra-low-loss fiber spools (658.7 km) for detection. Charlie uses a dense wavelength division multiplexer (DWDM), a circulator (CIR) to filter the noises before the polarization beam splitter (PBS) and the beam splitter (BS). The interference results are detected by superconducting nanowire single-photon detectors (SNSPDs). Additionally, the fiber stretchers are inserted into the QKD channel and the wavelength calibration channel, as the artificial vibroseis. EPC: electric polarization controller; PC: polarization controller. Credit: *Physical Review Letters* (2022). DOI: 10.1103/PhysRevLett.128.180502

A team of researchers affiliated with several institutions in China has found that quantum key distribution (QKD) networks can be used to accurately measure ground vibration. In their paper published in the journal *Physical Review Letters,* the group describes their implementation of a twin-field, fiber-based QKD network over a distance of 658 km. They also determined that the network could be used as a means for sensing ground vibrations associated with earthquakes or landslides.

QKD networks make use of unique quantum properties of photons to encrypt data sent between communication devices. Because of their quantum properties, such networks are nearly impossible to hack without the system hosts noticing the activity and ceasing transport of messages. Because of this feature, scientists in several countries have been working to improve the technology for widespread use. In this new effort, the researchers developed and installed a twin-field, fiber-based QKD network that takes advantage of the way photons interfere as a means of encrypting data, and were surprised to find that the fiber network could also be used to sense ground vibration.

In their work, the researchers successfully sent encrypted data over a 658-km fiber cable, extending the previous distance record by approximately 100 km. In such a network, fluctuations in the phase of the light passing through the fiber cable must be noticed and corrected by stretching the cable in order for the key distribution to work correctly. Such fluctuations, the researchers noted, typically arise due to ground vibrations.

In their system and others like it, a separate fiber cable is used to lock the frequencies between nodes on the network. The researchers found that the timing information in the second cable can accurately determine, to within approximately 1 kilometer, where along the cable the fluctuation was created. That suggests that systems such as theirs could also serve as ground vibration sensors, possibly warning of an ongoing earthquake or landslide. Notably, for real-world application, the data transfer rate would have to be improved.

More information: Jiu-Peng Chen et al, Quantum Key Distribution over 658 km Fiber with Distributed Vibration Sensing, *Physical Review Letters* (2022). DOI: 10.1103/PhysRevLett.128.180502