

PHYSICS UPDATE

These items, with supplementary material, first appeared at www.physicstoday.org.

INTERCONTINENTAL QUANTUM COMMUNICATION

In 2016 Jian-Wei Pan of the University of Science and Technology of China and colleagues launched *Micius* into low-Earth orbit to investigate the potential of satellite-initiated quantum communication. Now, just months after setting a distance record for the distribution of entangled photons (see *PHYSICS TODAY*, August 2017, page 14), Pan's team has

demonstrated a more important and practical capability: the establishment of a secure quantum communication channel between distant parties. By employing the satellite as a photon emitter and relay, team members in Graz, Austria, and Xinglong, China, developed and shared a 100-kilobyte key that they used to securely exchange photos and hold a video conference.

Micius initiated the link between Graz and Xinglong through a combination of quantum and classical signals, following a version of the BB84 protocol devised by Charles Bennett and Gilles Brassard (see the article by Daniel Gottesman and Hoi-Kwong Lo, *PHYSICS TODAY*, November 2000, page 22). As the satellite passed over a station, it emitted photons that were each prepared in a random polarization state; the station (the Graz one is shown in the composite photo) performed one of two polarization measurements on each received photon. Using the measurement types and results for the exchanged photons, the satellite and station established a unique key. Once *Micius* developed a key with both stations, it performed a logic operation (specifically, an exclusive OR) on the two strings

of bits and sent the results via a classical radio channel to one of the stations. The station with that extra information compared those bits with its own key to determine its counterpart's key.

To test the secure connection, the Austrian and Chinese researchers exchanged 5-kilobyte JPEG images that were indecipherable without the shared quantum key. They then used most of the remaining bits of the key to ensure the security of a 75-minute intercontinental video conference.



Micius is just one step toward achieving a secure global quantum network, which would require multiple satellites and ground stations working in parallel. Ideally, those satellites would orbit at higher altitudes to cover more ground area and would transmit at longer, telecom wavelengths to enable daytime operation. (S.-K. Liao et al., *Phys. Rev. Lett.* **120**, 030501, 2018.) —AG

EARTHQUAKES CAN BE DETECTED WITH FIBER-OPTIC CABLE



Over the past decade, researchers in the oil and gas industry developed a technique, distributed acoustic sensing (DAS), to solve a range of on- and offshore reservoir imaging problems. In essence, DAS transforms a straight fiber-optic cable into a one-dimensional array of strain-rate sensors. Here's how: An electro-optic device illuminates one end of the fiber with short light pulses and performs interferometry on any photons that are backscattered from microscopic heterogeneities in the fiber's glass core. The interferometric signal changes if the fiber undergoes local strain. By record-

ing the photons' return times, the device determines the position of any linear stretch or compression on the cable. And by repeatedly firing pulses into the fiber, it can resolve the speed of sound waves.

A team of researchers led by Nate Lindsey (University of California, Berkeley, and Lawrence Berkeley National Laboratory) and Eileen Martin (Stanford University) has now demonstrated that DAS can detect earthquakes nearly as accurately as conventional seismometers. In a field test in Alaska, they buried a 4000 m fiber-optic cable in shallow, orthogonally oriented trenches 20 cm belowground and compared its measurements with those recorded by seismometers placed in the same trenches. When a magnitude 3.8 earthquake occurred after the installation, they converted the fiber strain rates into ground accelerations and found a strong correlation in amplitude and phase with the seismometer records. (The figure shows coauthor Jonathan Ajo-Franklin preparing

to install a fiber-optic array for a similar experiment.)

Optical fibers are appealing seismometer proxies because they sense changes along their entire length—potentially tens of kilometers—and are inexpensive, flexible, and insensitive to electrical noise. An additional advantage is that a vast network of currently unused fiber-optic cables already exists in the oceans and throughout the US and other countries—one that may be put back into service for detecting and quantifying earthquakes, the presence of groundwater, changes in permafrost, and other subsurface activities. By comparison, seismometers are sparse and clustered on continents. The researchers have already conducted a proof-of-principle test for leveraging that advantage. Following the trench installations, they ran experiments using a fiber installed inside a preexisting telecommunications infrastructure under Stanford's campus. The fiber detected events as varied as nearby quarry blasts, small earthquakes in the Bay Area, and larger seismic events across the US. (N. J. Lindsey et al., *Geophys. Res. Lett.* **44**, 11792, 2017.) —RMW PT