Research demonstrates a new technique for improving long-distance quantum key distribution in a real-world field

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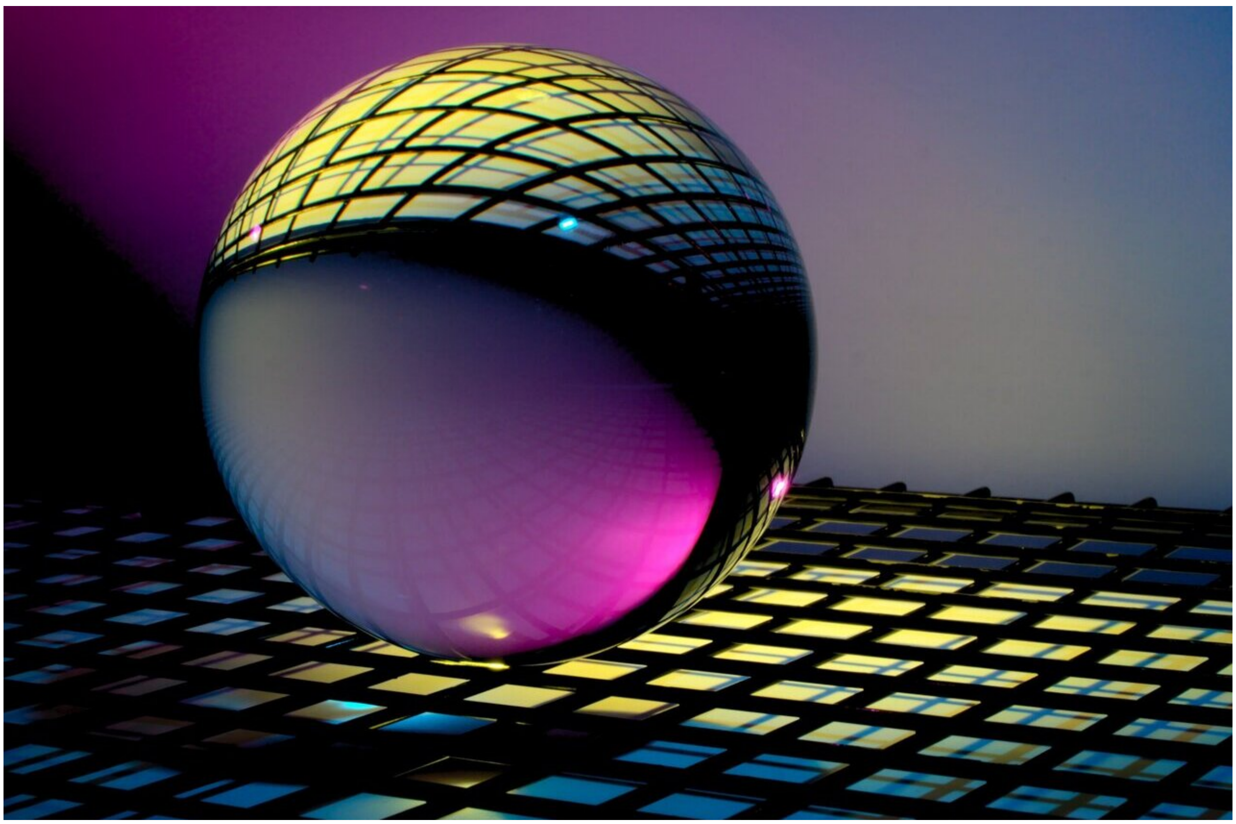

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An experiment, performed by Istituto Nazionale di Ricerca Metrologica (INRIM) on 200 km of the Italian Quantum Backbone, in collaboration with Toshiba Europe, shows that coherent laser interferometry considerably improves the performances of quantum key distribution protocols in long-distance, real-world networks. The study has been published in *Nature Communications*.

Quantum Key Distribution (QKD) protocols enable cryptographic keys to be shared between distant parties with an intrinsic security guaranteed by the laws of quantum mechanics. This is made possible by the transmission of single photons, the elementary particles of which light is made of.

The interest for this subject extends well beyond the scientific community, and has now a strong strategic and commercial relevance. The European Commission, within the "European Quantum Communication Infrastructure" intitative, aims at integrating quantum key distribution technologies into specific services throughout the European Union within the next 10 years, and INRIM will take part in the design of this infrastructure with the OQTAVO project.

One of the main obstacles towards the realization of a long-reach quantum network is the "fragility" of quantum signals: Single-photon states carry an extremely low energy, which makes them hardly detectable, even moreso considering that 99% is lost after traveling 100 km via telecommunication optical fibers. In addition, the information carried by the remaining single-photon states is severely distorted.

INRIM has already investigated these problems in a metrological context, and has developed, in collaboration with other NMIs, specific laser interferometry techniques that allow recovering the information which is transmitted through long-distance optical fiber. Nowadays, these techniques are at the core of state-of-the-art atomic clock comparisons.

Now, with a synergistic exploitation of coherent laser interferometry, single-photon technologies and quantum metrology, INRIM shows that the information contained in single photon states can be significantly improved, allowing lower error rates and increasing the length of exchanged messages. These improvements pave the way for more efficient QKD protocols exploiting the twin-field quantum key distribution technique, which is currently seen as the most promising candidate for long-reach quantum networks.

The experiment was conducted along a 200-km span of the Italian Quantum Backbone, an 1800-km infrastructure developed by INRiM for the atomic time and frequency distribution to research facilities and high-tech companies in Italy and science applications in fundamental physics, geophysical remote sensing, and quantum technologies.

This study is also the result of a collaboration with Toshiba Europe, leading company in the development of commercial quantum technology products, and the network provider TOP-IX Consortium, active throughout northern Italy, which dedicated part of its infrastructure to this research.

This synergy enabled the researchers to achieve an outstanding result on the road to developing a European quantum communication infrastructure.

More information: Cecilia Clivati et al, Coherent phase transfer for real-world twin-field quantum key distribution, *Nature Communications* (2022). DOI: 10.1038/s41467-021-27808-1

Provided by INRIM - Istituto Nazionale di Ricerca Metrologica