FRAUNHOFER INSTITUTE FOR APPLIED OPTICS AND PRECISION ENGINEERING IOF

PRESS RELEASE

Quantum keys for technological sovereignty

A network with various technologies for the transmission of quantum-encrypted data was demonstrated in Jena

Jena (Germany)

As part of the QuNET project, researchers have demonstrated how quantum key distribution works reliably via hybrid and mobile channels. The results are milestones for sovereign, quantum-secured communication in Germany and have now been published in the renowned journal New Journal of Physics.

Quantum communication is considered a crucial technology for long-term data security and thus also for technological sovereignty in Germany and Europe. At its core is the distribution of secure cryptographic keys based on quantum physical processes – quantum key distribution (QKD). QKD will not only be important for highly secure communication in government agencies, the military, and businesses, but will also help protect the data we use in our daily lives.

The German Federal Ministry of Research, Technology and Space (BMFTR) is funding the research of various technologies for generating and transmitting quantum keys as part of the QuNET research project with 125 million euros. The Fraunhofer IOF is involved in the project together with Fraunhofer HHI, the Max Planck Institute for the Science of Light in Erlangen, the Friedrich Alexander University of Erlangen-Nuremberg, and the DLR Institute of Communication and Navigation in Oberpfaffenhofen.

In 2021, the project partners demonstrated the first quantum-secured video conference between two federal authorities in Bonn, followed in 2023 by the demonstration of an ad hoc point-to-point connection in Jena. In 2024, personal data was transmitted from Berlin's metropolitan fiber optic network to the Federal Printing Office, and in 2025, quantum information were exchanged in another experiment using a research aircraft from the German Aerospace Center.

Based on these experiments, a scientific article has now been published in which the participating institutes show how they can use and combine a whole range of different technologies for quantum-secured communication. This is an important step on the way to the supraregional use of quantum technology.

Hybrid and mobile quantum channels successfully tested

Quantum signals are extremely fragile, often consisting of only a few photons (light

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particles). Their transmission via optical fiber is highly demanding, but proven, and offers an unprecedented level of security. Several systems have now been tested in Jena that allow quantum keys to be transmitted even through turbulent air. This is the path to highly mobile and ad hoc connections. For example, it can be used to bridge gaps in optical fiber networks. The challenge here is to connect fundamentally different hardware and software components.

"We have demonstrated that different QKD protocols and link types can be integrated into a functioning overall network. This heterogeneity has not yet been published anywhere in the world," comments Dr. Matthias Goy from Fraunhofer IOF on the technical article, which was published in the renowned journal New Journal of Physics.

One focus of the work is on the technical methods used to enable stable quantum channels in free-beam systems, even in the presence of atmospheric turbulence. In addition, the team integrated free-space links into existing fiber networks, thereby creating a future-proof urban network for the quantum age. The results are a key component in establishing technological sovereignty in the field of quantum communication as a key technology in cybersecurity research. "This allows us to build technological expertise in Germany and reduce dependencies in a security-critical field of the future," emphasizes Dr. Goy.

Next step: a hybrid Germany-wide quantum network

So far, quantum-secured connections have been tested via local fiber and free-space networks. The next step is to demonstrate the developed technologies in a Germany-wide network of nodes in Berlin, Jena, Erlangen, and Oberpfaffenhofen. To this end, a distributed network of fiber and free-space links as well as optical ground stations is planned for future satellite-based quantum communication. “We are thus preparing the transition from local test tracks to scalable networks,” says Goy. The long-term goal is to establish a sovereign quantum network that ensures secure communication for the state, the economy, and critical infrastructures.

Publication

"Ad-hoc hybrid-heterogeneous metropolitan-range quantum key distribution network," Matthias Goy et al. 2025 New J. Phys. **27**, 114510, DOI 10.1088/1367-2630/ae1864.

About the QuNET initiative

QuNET (Quantum Network) is a network funded by the Federal Ministry of Research, Technology and Space (BMFTR) for the research of highly secure communication systems based on quantum communication technologies. QuNET was launched in fall 2019 and was funded for a planned period of seven years. The BMFTR is funding QuNET with 125 million euros. In addition to the DLR Institute of Communications and Navigation, the Fraunhofer Institute for Applied Optics and Precision Engineering IOF, the Fraunhofer Heinrich Hertz Institute (HHI), the Max Planck Institute for the Physics of Light (MPL), and the Friedrich-Alexander University Erlangen-Nuremberg (FAU) are also involved.

QuNET aims to lay the foundations for secure and robust IT networks that are already resistant to cyber attacks of tomorrow. The security of IT communication networks is currently based primarily on mathematical assumptions. These do not offer protection against future technologies, such as powerful quantum computers, for example.

Through the targeted involvement of companies, QuNET is creating a central innovation ecosystem in quantum communication. The accompanying QuNET+ projects involve 47 partners, 27 of which are from German industry. This promotes the targeted transfer of technologies into application and enables industrial value creation. In addition, QuNET represents Germany's research contribution to EuroQCI, a future European quantum communication infrastructure.

The partners of the QuNET initiative

The **Fraunhofer Institute for Applied Optics and Precision Engineering IOF**, based in Jena, Germany, conducts research on the development of light as a means of solving a wide range of problems and application scenarios. The work of the research institute, founded in 1992, therefore focuses on application-oriented research on light generation, light guidance and light measurement. Together with researchers from basic research and industry, innovative solutions are developed that provide a technological advantage in science and industry and open up new fields of application for photonics.

Innovations for the digital society of tomorrow are the focus of the research at the **Fraunhofer Heinrich Hertz Institute (HHI)** in Berlin. Founded in 1928, the institute is a world leader in research on mobile and optical communication networks and systems, as well as in the coding of video signals and data processing. Together with international partners from research and industry, Fraunhofer HHI works across the entire spectrum of the digital infrastructure - from basic research to the development of prototypes and solutions. The institute contributes significantly to the standards for information and communication technologies and creates new applications as a partner of industry.

The **Max Planck Institute for the Science of Light (MPL)** covers a broad spectrum of research, including nonlinear optics, quantum optics, nanophotonics, photonic crystal fibers, optomechanics, quantum technologies, biophysics and - in collaboration with the Max Planck Center for Physics and Medicine - links between physics and medicine. The MPL was founded in January 2009 and is one of over 80 institutes of the Max Planck Society that conducts basic research in natural sciences, biotechnology, humanities and social sciences for the benefit of the general public. Today, almost 400 people from around 40 nations work at the institute. Some of the researchers look back on decades of experience in the field of quantum communication. They also use telecom technology for the exchange of quantum keys, which allows the procedures to be quickly commercialized. In addition, the researchers from Erlangen have been investigating for more than ten years how the keys can be transmitted on the ground with laser light over several kilometers (known as a free-beam connection) or by satellite over greater distances. The MPL is playing a major role in many large national and international projects, also in cooperation with national industry.

The **DLR Institute of Communications and Navigation** is dedicated to mission-oriented research in selected areas of communications and navigation. Its work ranges from the theoretical foundations to the demonstration of new procedures and systems in real-world environments and is embedded in DLR's Space, Aeronautics, Transport, Digitization and Security programs. The institute currently employs around 200 people, including 150 scientists, at its sites in Oberpfaffenhofen and Neustrelitz. The institute develops solutions for the global networking of man and machine, for high-precision and reliable positioning for future navigation applications, as well as methods for autonomous and cooperative systems in transport and exploration. In addition, the institute is concerned with cyber security. Focal points in this area include post-quantum cryptography and the transmission of quantum keys via satellite.

Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), founded in 1743, is one of the largest universities in Germany with around 40,000 students, over 600 professors and around 16,000 employees. The research-intensive Department of Physics cooperates closely with the Max Planck Institute for the Science of Light (MPL). The Chair of Optical Quantum Technologies, headed by Prof. Dr. Christoph Marquardt, focuses on the implementation of quantum protocols. Global quantum communication requires the integration of QKD devices into existing infrastructures, consisting of fiber optic networks, encryption hardware and satellite links. The chair is one of the world's leading groups in satellite-based quantum communication.

Facts and figures about the QuNET initiative

- Start: Fall 2019
- Duration: 7 years
- Funding body: Federal Ministry of Research, Technology and Space (BMFTR)
- Volume: €125 million in funding (planned)
- Website: www.qunet-initiative.de

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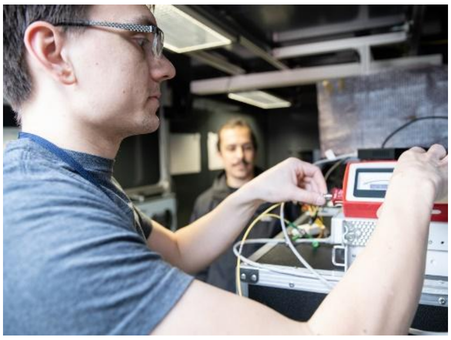
Press photos

The following images are available for download in the press section of the Fraunhofer IOF website at https://www.iof.fraunhofer.de/en/pressrelease.html.

Creating highly secure and mobile quantum networks is possible thanks to a special container module with an integrated telescope for sending and receiving quantum keys, developed at Fraunhofer IOF. © Fraunhofer IOF



In the QuNET project, researchers from Fraunhofer and Max Planck are collaborating with the German Aerospace Center and Friedrich Alexander University Erlangen-Nuremberg. © Fraunhofer IOF