PRESS RELEASE

Foundation for the future quantum network: quantum channels tested in flight

QuNET project reaches another milestone with key experiment

Oberpfaffenhofen / Erlangen (Germany)

The latest key experiment of the QuNET initiative was successfully completed today with a flight experiment between Oberpfaffenhofen and Erlangen. The aircraft formed a mobile node in a quantum network and established a connection to a ground station. There, the photons were successfully received and measured. The technologies from the demonstrated key experiment are groundbreaking for future secure quantum communication.

It is not easy to send individual photons from an aircraft in a targeted manner, capture them in a ground station, and also detect them. Researchers have now succeeded in doing this: they have even measured various quantum channels between an aircraft and a ground station several times, sent photons to an ion trap, and tested technologies for quantum key distribution. The flight experiment took place as part of the QuNET initiative, which develops technologies for quantum-secure communication. Photons, or particles of light, can be used to generate quantum cryptographic keys that make future communication practically tap-proof. The technologies are also groundbreaking for a future quantum internet that connects quantum computers with each other.

Scientists from the German Aerospace Center (DLR), the Max Planck Institute for the Science of Light (MPL), Friedrich Alexander University Erlangen (FAU), as well as the Fraunhofer Institutes for Applied Optics and Precision Engineering (IOF) and Heinrich Hertz Institute (HHI) participated in the experiment. The results have now been presented to the Federal Ministry of Research, Technology, and Space (BMFTR), which funds the QuNET initiative. Quantum key distribution is particularly important for communication between governments and authorities, but also in general for protecting infrastructure and data in everyday life in the future.

"We are working on practical solutions for satellite-based quantum communication, which can be used to transmit quantum states over long distances and generate secure keys. In fiber optics, this is only possible over a few hundred kilometers. Quantum encryption via satellite, on the other hand, enables arbitrarily greater distances on Earth," says Florian Moll from the DLR Institute of Communications and Navigation, explaining the future technology. To cover long distances, satellites, aircraft, or other mobile platforms are to become part of quantum networks in the future.

The current experiment was flown using a DLR research aircraft from the Flight Experiments facility. The scientists installed an optical communication terminal in the

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Dornier 228. The aircraft formed a mobile node in a quantum network and established a connection to an optical receiving station on the ground. This ground station is a mobile container with an integrated receiving terminal, known as the QuBUS, provided by Fraunhofer IOF in Jena.

Fraunhofer IOF responsible for tracking and fiber coupling

Research into modern systems for highly secure quantum communication has been a research focus at Fraunhofer IOF for many years. IOF researchers contributed their expertise to the latest flight campaign of the QuNET initiative on several levels: A module developed in Jena with an integrated photon pair source for generating quantum-entangled light particles flew on board the DLR research aircraft. These particles were sent from the aircraft to the QuBUS. There, a special tracking system ensures that the ground station's receiving terminal tracks the aircraft's movements and maintains the connection. When the particles are exchanged through the air, atmospheric turbulence and interference inevitably occur. Correcting these and thus ensuring a stable connection is the task of adaptive optics developed specifically in Jena.

For the current experiment, several research flights have taken place over Erlangen in recent months, as the ion trap for measuring the received light particles is set up in the laboratory of the local MPL. From the QuBUS, the signals captured by free beam were then fed into a fiber optic cable and forwarded to the experimental setups in the QuBUS and the MPL laboratories. The Fraunhofer researchers were also responsible for coupling the signals into the fiber optic cable. "The tracking and fiber coupling provided by Fraunhofer IOF thus offered the necessary environment for the actual experiments," explains Christopher Spiess from the Fraunhofer Institute in Jena.

Technically highly complex

Individual photons are difficult to handle: for quantum communication, they must be generated with high quality and also be clearly detectable even under strong external interference. For the best possible results, the wavelength of the photons must also be precisely adjusted. "We have shown in various experiments that this is possible. The approach we tested can be used not only from aircraft, but also from satellites," adds Florian Moll.

The states of the "flying" particles were successfully verified in measurements at the MPL ion trap – which was one of the goals of the experiment. This communication technology can also be used, for example, to connect quantum memories or quantum computers in a future quantum network.

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 the quantum communication technologies. QuNET was launched in fall 2019 and was funded for a period of planned for 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 offer protection against future technologies, such as powerful quantum computers, for example.

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.

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Press photos

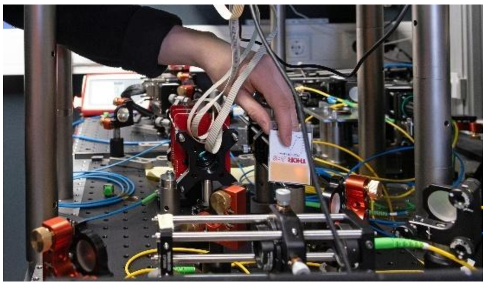
The following images are available for download in the press section of Fraunhofer IOF at: https://www.iof.fraunhofer.de/de/presse-medien/pressemitteilungen.html.

The flight experiment was carried out using a DLR research aircraft. © DLR

The QuBUS, a mobile container, is the optical ground station for receiving the signals. © DLR

The receiving telescope for the quantum channel is located on the roof of the QuBUS. © MPL

As an optical ground station, QuBUS (white container on the right) receives the signals sent by the aircraft and forwards them to the neighboring MPL (building in the background). © MPL



Optical setup for signal processing with adaptive optics inside the QuBUS. © MPL

Inside the QuBUS, IOF researchers check the reception of the signals and their coupling into the fiber optic cable. © MPL