Noise-free frequency converters for the quantum internet

To set up a quantum internet, quantum systems must be entangled over long distances to share information efficiently and securely and to significantly raise the computing power of quantum computers. A prerequisite for such networks is the lossless transmission of information encoded in single photons through optical fibers. To achieve this, the frequency of these signals must be converted in wavelength while preserving their quantum state, without unintentionally generating additional photons that reduce the signal-to-noise ratio.

Development of novel QFC

Quantum frequency converters (QFCs) based on nonlinear optical processes are commonly used for this conversion. Previous systems used periodically poled crystals with waveguides. They achieve efficiencies up to 50 percent, but are the major source of noise photons. Novel QFCs for conversion from 637 nm to 1588 nm have been developed at Fraunhofer ILT for a quantum internet demonstrator in the Netherlands. In this setup, this approach combines a nonlinear crystal without periodic poling and waveguides with an enhancement cavity.

Key component for quantum technology

The novel converter was implemented as a compact, modular and stable system, tested at QuTech in Delft and subsequently integrated as a permanent component in the quantum internet demonstrator. The rate of generated noise photons was reduced by a factor of 100 down to 2 Hz/pm compared to previous QFCs, without sacrificing conversion efficiency; thus these novel QFCs define this system as the new state of the art. Compared to all other network components, the QFC is effectively noise-free.

Efficient, low-noise frequency converters are a key component for a quantum internet, quantum networks and quantum repeaters of the future. The novel design can be adapted to convert quantum signals at other wavelengths in the visible and near-infrared range.

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Adjustment of the converter using an attenuated red laser to emulate the single photons.