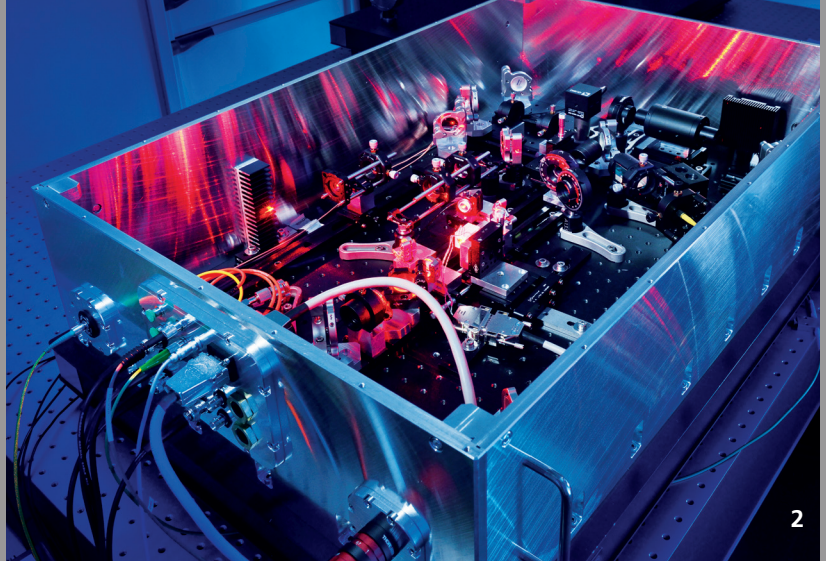

NOISE-REDUCED FREQUENCY CONVERTERS FOR THE QUANTUM INTERNET

Task

The development and construction of a quantum internet are overarching goals of the European quantum technology roadmap. To achieve this, quantum processors, sensors and network nodes must be interconnected over large distances to share information efficiently and securely, and to increase the performance and potential applications of quantum computers. A basis for implementing such networks is the low-loss transmission of quantum information encoded in single photons throughout an optical channel, e.g. optical fiber. In order to establish networks of heterogeneous nodes and to use wavelengths in the telecom band, the photon wavelength must be efficiently converted while maintaining the photon's quantum state. In the conversion process, the number of noise photons introduced by the converter setup must be minimized to optimize the signal-to-noise ratio.

Method

For efficient conversion, so-called quantum frequency converters (QFC) are used, which are based on nonlinear optical frequency conversion. In state-of-the-art devices, periodically poled crystals with waveguides are used, with which conversion efficiencies of up to over 90 percent can be achieved. However, these systems also generate high rates of noise photons.

Within the Fraunhofer ICON QFC-4-1QID project, Fraunhofer ILT and QuTech in Delft, the Netherlands, are developing novel low-noise QFCs. These converters are based on using nonlinear crystals without periodic poling and without waveguides in an enhancement cavity. With this approach, the basic physical process of introducing noise photons (spontaneous parametric down-conversion) can be effectively suppressed.

Results

A technology demonstrator of the converter was implemented as a compact, mobile and stable system and tested in a measurement campaign at QuTech in Delft. The converter achieves an internal photon conversion efficiency of about 50 percent, with the rate of noise photons reduced by a factor of four compared to the previous state of the art.

Applications

Efficient, low-noise frequency converters are a key component for a future quantum internet, for quantum networks and for quantum repeaters.

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Contact

Florian Elsen M. Sc., Ext: -224
florian.elsen@ilt.fraunhofer.de

Dr. Bernd Jungbluth, Ext: -414
bernd.jungbluth@ilt.fraunhofer.de

2 Demonstrator for an efficient, low-noise QFC.