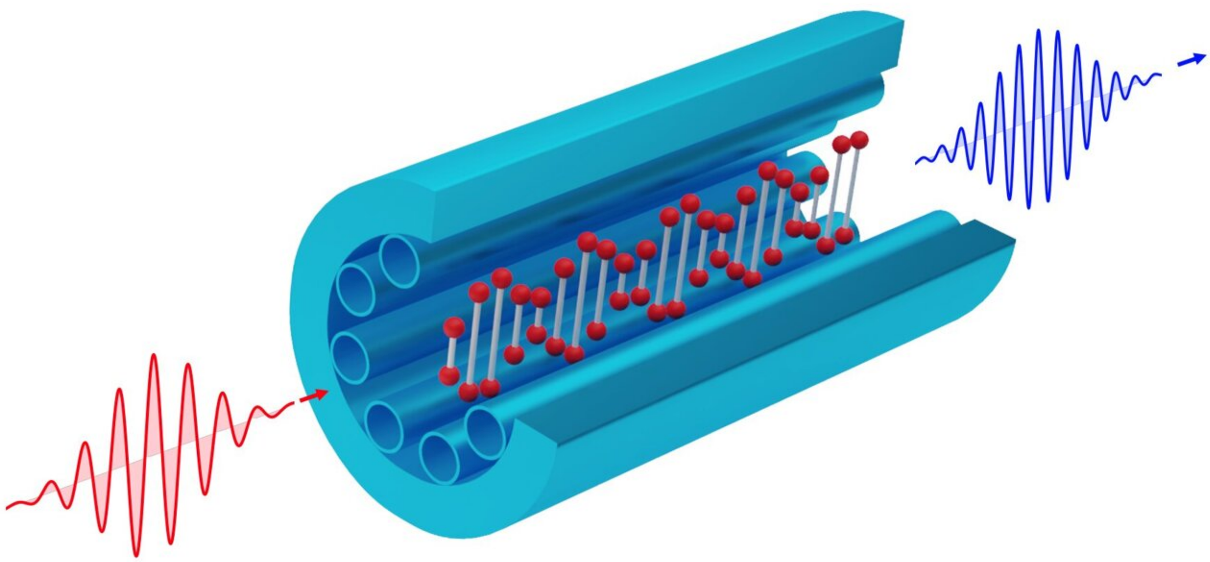
A step forward in modern quantum technology: Frequency conversion of single photons at arbitrary wavelengths

May 6 2022



A spatio-temporal hologram of molecular vibrations is created in the gas by stimulated Raman scattering. This hologram is then used for highly efficient, correlation-preserving frequency conversion of single photons. Credit: Nicolas Joly/Max Planck Institute for the Science of Light

Quanta of light—photons—form the basis of quantum key distribution in modern cryptographic networks. Before the huge potential of quantum technology is fully realized, however, several challenges remain. A solution to one of these has now been found.

In a paper published in the journal *Science*, teams led by David Novoa, Nicolas Joly and Philip Russell report a breakthrough in frequency up-conversion of single photons, based on a hollow-core photonic crystal fiber (PCF) filled with hydrogen gas. First a spatio-temporal hologram of molecular vibrations is created in the gas by stimulated Raman scattering. This hologram is then used for highly efficient, correlation-preserving frequency conversion of single photons. The system operates at a pressure-tuneable wavelength, making it potentially interesting for quantum communications, where efficient sources of indistinguishable single-photons are unavailable at wavelengths compatible with existing fiber networks.

The approach combines quantum optics, gas-based nonlinear optics, hollow-core PCF, and the physics of molecular vibrations to form an efficient tool that can operate in any spectral band from the ultraviolet to the mid-infrared—an ultra-broad working range inaccessible to existing technologies. The findings may be used to develop fiber-based tools in technologies such as quantum communications, and quantum-enhanced imaging.

More information: R. Tyumenev et al, Tunable and state-preserving frequency conversion of single photons in hydrogen, *Science* (2022). DOI: 10.1126/science.abn1434

Provided by Max Planck Institute for the Science of Light