Entanglement Between C-UV and NIR Photons

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Entangled photons are one of the main tools of quantum technologies. In particular, some entanglement-based techniques, like sensing with undetected photons [1] or ghost imaging, simplify access to 'inconvenient' frequency ranges: one photon (signal), at a visible or near-infrared (NIR) frequency, is detected with high spectral/spatial resolution, while its entangled partner (idler), in a hard-to-access range, is detected without high resolution or not detected at all. Entanglement has been demonstrated with idler photons in mid-infrared, far infrared, and even terahertz spectral domains. Meanwhile, ultraviolet (UV) range remained so far unaccessible for entangled photons. If pairs are obtained via spontaneous parametric down-conversion (SPDC), the bottleneck is the absence of a proper pump, which should be even shorter in wavelength. An alternative to SPDC, spontaneous four-wave mixing (FWM), avoids this problem: signal and idler photons are generated as sidebands spectrally equidistant from the pump, and the wavelength of one of them can be almost as short as half that of the pump.

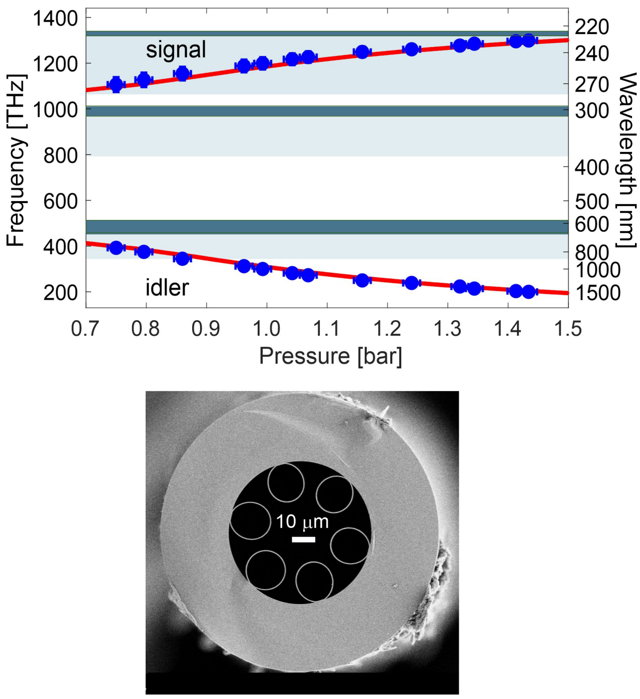

Figure 1: Top: Frequencies and wavelengths of the signal and idler photons as functions of the xenon pressure. Red lines are calculated dependences, teal lines are resonances of the fiber. Bottom: the single-ring fiber structure

Here we use FWM in a hollow-core single-ring fibre filled with xenon to generate photon pairs with one photon in the UV range. A noble gas used as a nonlinear medium helps to get rid of the Raman scattering, which otherwise contaminates the Stokes side of the spectrum. By varying the gas pressure, we change the dispersion of the fibre and easily tune the FWM phase matching.

Figure 1, top, shows the wavelengths of the signal and idler photons as functions of the xenon pressure. By pumping FWM at 400 nm and changing the pressure from 0.75 bar to 1.45 bar, we tune the signal wavelength in UV C-band, from 231 to 271 nm. Meanwhile, the idler photons are in the spectral range from 1500 to 750 nm, relatively easy to detect. The tunability range could be further broadened by modifying the parameters of the fiber. In the current design (bottom), the resonances of the glass rings (teal lines in the top panel) modify the dispersion dependence and increase the absorption in the UV range. Currently, the coincidence count rate does not exceed 15 Hz because, although the fiber is 30 cm long, only about 3 cm of it contribute to FWM. In the future, an optimized source can be used for sensing with undetected photons in the UV range of the spectrum.

Acknowledgements: This work was supported by Deutsche Forschungsgemeinschaft (CH-1591/9-1, JO-1090/6-1).

References

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