Engineering four-wave mixing spectral entanglement in hollow-core fibers

***M. Cordier*[1], *A. Orieux*[2], *B. Debord*[3], *F. Gérome*[3], *A. Gorse*[4], *M. Chafer*[3], *E. Diamanti*[2], *P. Delaye*[5], *F. Benabid*[3] *and I. Zaquine*[1]**

[1]*Laboratoire de Traitement et Communication de l'Information, Télécom ParisTech, Univ Paris-Saclay, 75013 Paris, France*
[2]*Laboratoire d'Informatique de Paris 6, CNRS, Univ Pierre et Marie Curie, Sorbonne Universités, 75005 Paris, France*
[3]*GPPMM Group, XLIM Research Institute, CNRS UMR 7252, Univ Limoges, Limoges, France*
[4]*GLOphotonics S.A.S., 123 rue Albert Thomas, Limoges, France*
[5]*Laboratoire Charles Fabry, Institut d'Optique Graduate School, CNRS, Univ Paris-Saclay, 91127 Palaiseau cedex, France*

Parametric photon-pair sources have been extensively used as heralded single photon source, where one photon is heralded by the detection of its twin. Caution is nevertheless required when multiplexing such sources, to start from identical and pure heralded photons. This is possible only if no entanglement exists between signal and idler photons from each pair, in any degree of freedom (spatial, spectral, polarization). Spatial and polarization entanglement can be easily removed, but getting rid of spectral entanglement requires a specific engineering of the source dispersion properties [1]. In this context, great progress was achieved using four-wave-mixing in silica-core microstructured fiber thanks to their easily tailored dispersion. However, the performance of such sources is limited by Raman-scattering noise. Here, we demonstrate, for the first time to our knowledge, a novel technique to control spectral entanglement in a gas-filled hollow-core photonic-crystal fiber. Such medium has the advantage of being devoid of Raman while exhibiting a similar non-linearity as silica (10^{-21}m^2/W for 10 bar of xenon).

The inhibited-coupling (IC) guidance mechanism of hollow-core fibers is associated with a discontinuous multi-band dispersion profile (see Fig 1.a). The position of the discontinuities can be well controlled as they are dictated by the silica strut thickness [2]. Such exotic dispersion opens new possibilities to satisfy the FWM phase matching condition, and thus for tailoring the Joint Spectral Amplitude of the photon pair, describing the spectral correlation between the two photons. More specifically, the ability to have the pump and the generated signal and idler photons lye in different branches of the dispersion curve allows to satisfy the group-velocity matching conditions required to erase spectral entanglement. As a first experimental demonstration in such gas-filled IC

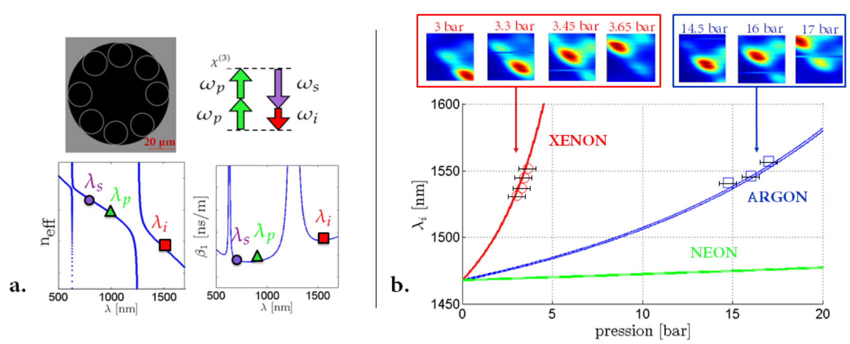

Figure 1: Left: Cross section and dispersion properties of the fiber. Right: Measured central position of the JSI idler wavelength as a function of the gas pressure, for xenon (red circle) and argon (blue square and comparison with the simulation. The insets give the corresponding JSI measurements.

fibers, we experimentally reconstruct the Joint Spectral Intensity (JSI) using a stimulated emission tomography setup [3]. As predicted by our model, the obtained JSI is nearly factorable. Moreover, by adjusting the filling gas pressure, we demonstrate an active tunability on the signal and idler wavelengths generated in the 771 nm and 1550 nm ranges (Fig 1.b).

References

[1] W. P. Grice et al, Physical Review A 64, 063815 (2001).
[2] B. Debord et al, Optica, 4, 209 (2017).
[3] M. Liscidini, and J. E. Sipe, PRL 111(19), 193602 (2013)