Correlation engineering for a flexible Raman free fibered photon source

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Fibered sources of photon pairs would be easily integrable into future quantum communication networks. However, in silica-core fibres, the broadband spectrum of spontaneous Raman Scattering strongly contributes to uncorrelated noise photons degrading the quality of the source. To overcome the problem of the silica Raman Scattering, a new architecture was proposed with liquid-filled hollow-core photonic crystal fibers (LF-HCPF) in which the core and the cladding are filled with a non-linear liquid. As opposed to the Raman scattering spectrum of silica which is broadband and continuous, the Raman scattering spectrum of liquids is composed of narrow lines. Thus, generating photons pairs between these narrow lines permits to avoid the spectral overlap between the SFWM pairs and the Raman Photons. A near infra-red LF-HCPCF photon pair source was demonstrated, with a three orders of magnitude suppression of the Raman noise [1]. We also demonstrate the first non-linear LF-PCF with a transmission band and a zero-dispersion-wavelength (ZDW) in the telecom wavelength range combined with a non-linearity of the same order of magnitude as the one of silica, as a first step towards a Raman-free photon pairs source in the telecom band [2]. Injecting light on both side of this fiber in a Sagnac loop scheme is a way to obtain entanglement.

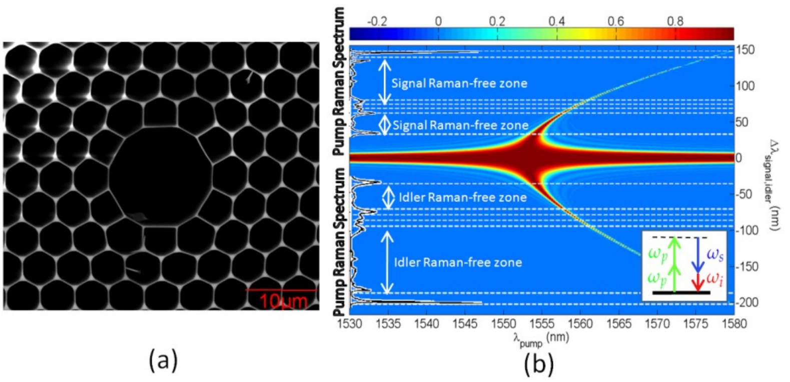

Fig. 1 (a) MEB image of the fiber's cross section (b) Spectral mapping of the FWM signal and idler photons for a monochromatic pump based on the measured dispersion of the fiber. The white dashed lines represent the position of the Raman lines

Photon pairs can be used as on-demand single-photons with one of the two photons detected to give a heralding signal. However, for this purpose one has to make sure that the two photons share no spectral correlation. Otherwise, the heralded photon would be in a statistical mixture of the allowed spectral modes which would be deleterious as many quantum protocols rely on the Hong-Ou-Mandel interferometry between single photons from different sources. Solutions have been proposed [3] in order to produce factorable SFWM pairs by satisfying the symmetric: $2\beta_1(\omega_p)=\beta_1(\omega_s)+\beta_1(\omega_i)$ or the asymmetric: $\beta_1(\omega_p)=\beta_1(\omega_i)$ group velocity matching, β_1 being the inverse of the group velocity $\beta_1(\omega)=\dfrac{1}{v_g(\omega)}$). In standard hollow core photonic crystal fiber (HCPCF), fulfilling these conditions requires the presence of several ZDWs or birefringence. Based on finite difference frequency domain simulation, we present a straightforward approach to design a HCPCF or a LF-HCPCF with three different bands. From a standard commercial HCPCF (NKT Photonics), a widening of 20% of the core thickness shifts inside the band two surface modes which normally lie outside the band. This results in a splitting of the band into three, leading to three differents ZDWs and possible fulfilments of the group velocity matching for both symmetric and asymmetric cases.

In conclusion, offering the possibility to engineer both the Ramam scattering and the spectral correlations, LF-PCF is a flexible source for the generation of entangled-photons and pure heralded single photons.

References

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