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Generation of nonclassical states of light using photonic crystal fibers

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Photonic crystal fibers (PCF) offer unique control of dispersion and nonlinearity and have revolutionized nonlinear optics. We present the possibility to use hollow-core and solid-core PCF for the generation of bright twin beams and photon triplet states.
One advantage to use optical fibers is that both signal and idler can be generated in a single spatial mode. By pumping close to the zero dispersion wavelength of the fiber, such sidebands can be created through modulation instability. However, signal and idler appear in the vicinity of the pump and Raman-scattering originated from the pump deteriorates the photon correlation by increasing the background level of photons of the idler. Here we use kagomé-lattice hollow-core PCF filled with argon to generate ultrafast bright twin beams [M.A. Finger *et al.* PRL. **115**, 143602 (2015)]. Since a monatomic gas provides the nonlinearity the source does not suffer from Raman-scattering and sidebands close to the pump are generated. We measure ~35% twin beam squeezing below shot noise. Another unique advantage of this source is the tunability of the sidebands through the gas-filling pressure.
Next, we address the challenging problem of generation of triplet states through spontaneous decay of one pump photon propagating in a $\chi^{(3)}$-material. This process is the reverse of third harmonic generation and phase-matching conditions are identical. Due to chromatic dispersion phase-matching cannot occur between two identical modes and this implies for the generation of triplet that the pump light has to be launched in a higher-order mode, leading to a reduced generation efficiency due to mode-mismatch between pump and triplets. Here we propose a hybrid solid-core PCF to circumvent this difficulty. The short-wavelength (~532 nm) is guided in a single-lobe mode by an all-solid photonic bandgap (PBG) while the guidance of the long-wavelengths relies on step-index. The inner PBG consists of a hexagonal array of high-refractive index glass (Schott SF6, n=1.81) embedded in a lower index host (Schott LLF1, n=1.55). The overall dispersion is strongly affected by these two distinct mechanisms and we demonstrated phase-matched third harmonic from fundamental mode at 1521 nm into the "fundamental"bandgap-guided mode (λ=507 nm), for which the field distribution is very similar to that of the LP01 mode of a step-index but with narrower mode-field diameter [A. Cavanna *et al.*, in preparation].

Primary author: Prof. JOLY, Nicolas (Max-Planck Institute for the Science of Light)

Co-authors: Mr CAVANNA, Andrea (University of Erlangen-Nuremberg); Mr JUST, Felix (University of Erlangen-Nuremberg); Dr CHEKHOVA, Maria (Max-Planck Institute for the Science of Light); Mr FINGER, Martin (Max-Planck Institute for the Science of Light); Prof. RUSSELL, Philip (Max-Planck Institute for the Science of Light); Dr ISKHAKOV, Timur (University of Erlangen-Nuremberg); Dr JIANG, Xin (Max-Planck Institute for the Science of Light)

Presenter: Prof. JOLY, Nicolas (Max-Planck Institute for the Science of Light)

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