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Rapid characterisation of Photonic Crystal Fibre dispersive properties by a stochastic and tunable picosecond pump source

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Photonic crystal fibre (PCF) are used in telecom, fibre lasers or nonlinear sources. Due to the silica20 nonlinearity, PCF support Raman conversion, four wave mixing (FWM) generation or continuum generation [1]. The dispersion properties governing these nonlinear effects strongly depend on the PCF transverse section profile. Slight changes in the geometry of the transverse section profile may occur during the fibre drawing process and may alter the generated spectra. It is thus crucial to characterise the dispersion and its higher order accurately and rapidly. Compared to conventional white light interferometry, FWM generation gives access to a wide range of wavelengths with a greater accuracy especially on the zero dispersion wavelength and other PCF characteristics [2]. Within this context, we propose a high-power and widely tunable source based on spectrally shaped amplified spontaneous emission (ASE) with a variable spectral width. Its unique characteristics lead to the observation of FWM with a greatly reduced threshold, and its tunability allows the reconstruction of the dispersion curve from the visible to the mid-infrared (MIR) [2]. The source is depicted in Fig.1(a). It consists in an Ytterbium-doped ASE seeder, emitting a spectrum from 1020 to 1070 nm. A programmable spectral filter is used to select a 0.1-1 nm bandwidth. After a pre-amplification stage, the light is injected in a main amplifier that also modulates the signal periodically thus delivering 50 ps bursts of ASE at 10 MHz. We can generate up to a maximum energy of 2 µJ per 50 ps burst for the PCF under study. At the PCF output, the pump, the signal and the idler waves resulting from the FWM are separated using dichroic mirrors and analysed in terms of spectrum, power and shot-to-shot statistics. Due to the stochastic nature of ASE bursts, a drastic increase of nonlinear effects is expected and observed [3]. The FWM threshold can be decreased by several orders of magnitude as compared to a non-stochastic source obtained from a CW laser (Fig.1(b)).

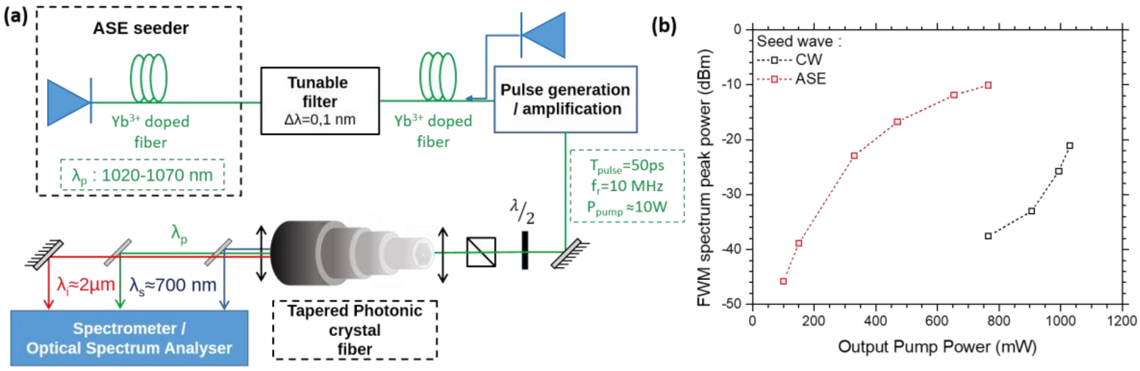

Fig. 1 (a) Experimental scheme of the PCF characterisation source. (b) Evolution of the signal power generated though FWM as a function of the pump power for an ASE seed or a Continuous Wave seed.

We used this source to characterise PCFs and tapered PCFs optimised for MIR generation (~2 um) in fibered Optical Parametric Chirped-Pulse Amplification. Indeed, in order to improve the spectral bandwidth of the PCF, we propose a microstructured air/silica fibre with a longitudinal gradient of its transverse section: a tapered fibre. During the fibre drawing, a homothety of the photonic structure allows to continuously vary the dispersion properties (including the zero-dispersion wavelength). This extends the usable range of the parametric gain over a spectral width of up to 100 nm, which is a key feature for generating few-cycle pulses in the MIR range.

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