Generation of Coherent Tunable UV Supercontinuum

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Abstract: We demonstrate all-normal supercontinuum spanning 715-1400 nm. The 740-880 nm range is compressed, and second harmonic generation is achieved with a max average power of 4.3 mW and a tuning range of 370-440 nm.

1. Introduction

Extending supercontinuum sources into the UV region is of interest for a number of applications such as quantum OCT [1]. Different approaches include using gas-filled hollow core fiber pumped using micro-joule femtosecond pulses directly generating low-noise dispersive waves in the deep UV region [2]. Another approach is to use the second harmonic generation (SHG) of the anomalous dispersion pumped supercontinuum in a solid core photonic crystal fiber [3]. However, this approach suffers from intrinsically low conversion efficiency due to the nonlinear temporal break-up of the pulse, preventing efficient compression and SHG. All-normal dispersion supercontinuum consisting of a linearly polarized coherently-broadened pulse with self-phase modulation (SPM) and optical wave breaking (OWB) has significantly lower pulse-to-pulse noise [4].Furthermore, the coherent nature of these supercontinuum pulses allow effective pulse compression [5], thus enabling efficient frequency conversion even using ultra-thin, broadly phase-matched $\chi^{(2)}$ crystals. Here we demonstrate, to the best of our knowledge, the first second harmonic generation pumped by compressed all-normal supercontinuum.

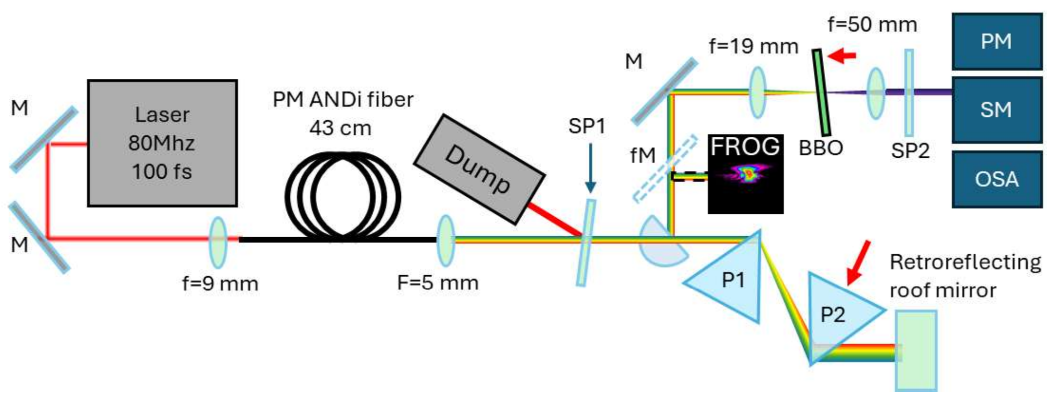

Fig. 1. Diagram of experimental setup: f denotes focal length of lenses. SP1: short pass 950 nm cut-off, SP2: short pass 650 nm cut-off, P1,P2: First and second SF11 prisms, BBO: beta-BaB2O4 crystal, PM: thermal power meter, SM: spectrometer, OSA: optical spectrum analyser, FROG: frequency resolved optical gating system, fM: (dashed outline) denotes flip mirror for pump beam FROG measurement.

2. Experimental Description

In figure 1, a diagram of the system is shown. The supercontinuum is generated by pumping using an 80 MHz, modelocked laser delivering 100 fs transform-limited pulses at 1050 nm. The fiber is a 43 cm long NL-PM-1050-NEG polarisation maintaining all-normal dispersion fiber (NKT Photonics A/S) pumped along a principal axis. Light is coupled into the fiber with a coupling efficiency of 60%, resulting in an output power of 500 mW. The output supercontinuum is filtered by a 950 nm shortpass filter (to 150 mW), and the axis of the fiber are rotated to

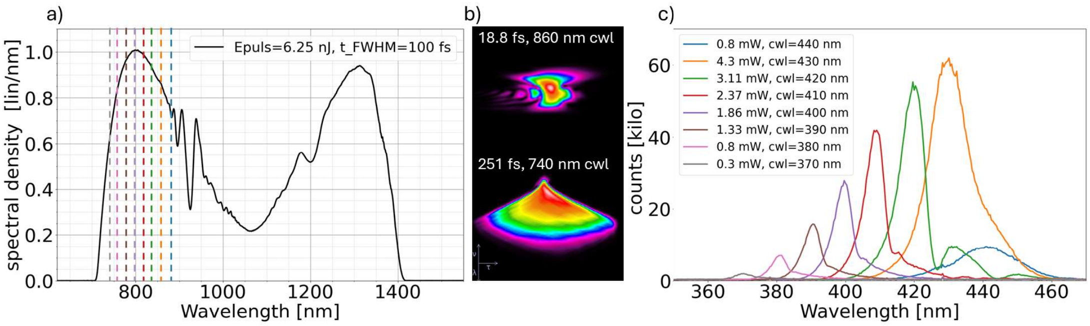

Fig. 2. a) Supercontinuum spectrum out of the all-normal fiber, with colored lines denoting center wavelength of an optimally compressed subspectrum. b) Example of FROG spectrogram at 860 nm with 18.8 fs FWHM, and FROG spectrogram maximally compressed at 740 nm. c) Output spectrum of the second harmonic crystal, with the legend denoting average SHG power and center wavelength (CWL).

provide a horizontal polarisation output required for the compression system. This system consists of a 43 cm long (apex to apex) folded two-prism compressor with equilateral SF11 glass prisms. The compressed supercontinuum pulses are focused onto a 150 μm long, beta-BaB2O4 (BBO) crystal (Thorlabs NLC01), cut for $\theta = 30.5°$. The output spectra of the SHG crystal and fiber are analysed using an optical spectrum analyser, a spectrometer, and a thermal power meter. The compressed super continuum is characterized using a FROG. (Femto Easy)

3. Results

In figure 2a the linear spectrum of the all-normal supercontinuum is shown with the two "wings" constituting the spectrum due to OWB, while the center depleted part consists of SPM broadened light and residual pump.
Figure 2b shows two FROG traces, with a maximal compression when centered at 860 nm, resulting in an 18.8 fs pulse, and the optimal compression at 740 nm, resulting in a large "tail" of uncompressed light due to the poor match in third-order dispersion.
In figure 2c the tuned blue/UV spectrum from the SHG is shown with average power and center wavelength (CWL). The corresponding center pump wavelength is shown on 2a as lines in matching colors. The different spectra are recorded by inserting P2 in figure 1 further into the beam path. This blueshifts the optimal compression wavelength by lowering the applied group delay dispersion (GDD). Secondly, the angle of the SHG BBO crystal is tuned to phase-match the optimally compressed wavelength. The maximum conversion efficiency is not achieved at the highest spectral density, but at the optimal compression. As is evident from the FROG spectrograms the third order dispersion is very poorly matched when the GDD is optimized for 740 nm. A redesigned compression system with better third order matching would significantly increase conversion efficiency and bandwidth.

4. Conclusion

We demonstrate compression to 18.8 fs of the high frequency side OWB lobe of the all-normal supercontinuum, and show tunable compression and frequency conversion spanning 370-440 nm, with a maximum average power of 4.3 mW.

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