Versatile dual stage tunable NOPA with pulse duration down to 17 fs and energy up to 3 µJ at 500 kHz repetition rate

J. Nillon[1,2], O. Crégut[1], C. Bressler[2] and S. Haacke[1]

1. Institut de Physique et Chimie des Matériaux de Strasbourg,Unité Mixte 7504 CNRS, Université Strasbourg BP. 43, 23 rue du Loess, 67034 Strasbourg Cedex, France

2. European XFEL, Albert Einstein Ring 19, 22761 Hamburg, Germany

Noncollinear optical parametric amplification (NOPA) is now established as a unique technology to generate ultrashort tunable pulses with high flexibility for spectroscopic applications. With the availability of commercial ultrafast fiber lasers delivering energies of several tens of microjoules, such devices can be designed to operate at unprecedented repetition rates of several MHz [1], enabling shorter acquisition time as well as better signal-to-noise ratio. Fiber laser-pumped tunable sources are also valuable tools for X-ray time resolved studies, to match the MHz repetition rate of synchrotrons or free electrons laser facilities. We report here on the development of a new tunable ultrashort NOPA pumped by a fiber laser at 500 kHz repetition rate with improved performances over previously published similar designs [2].

The experimental setup is composed of two independent NOPA stages, pumped and seeded by the same Ytterbium-doped fiber laser delivering 350 fs pulses with an average power of 22 W at a repetition rate adjustable between 200 kHz and 2 MHz (Tangerine, Amplitude Systèmes). The first NOPA is pumped by the second harmonic of the fiber laser at 515 nm (40% SHG efficiency) and performs best in the 650 to 950 nm spectral range while the second one is pumped by the third harmonic at 345 nm (25% THG efficiency) and works best between 500 and 700 nm. Both stages are seeded by the same white-light continuum with a cut-off wavelength at 480 nm generated through filamentation in a 4 mm thick YAG plate.

At a 500 kHz repetition rate, the THG-pumped NOPA is able to deliver a maximum energy of 0,7 µJ at 620 nm (Fig. 1 a) with energies higher than 200 nJ in its 510 to 1000 nm tuning range, and supports Fourier-limited pulse durations below 20 fs in the 510 to 700 nm spectral window. The SHG-pumped NOPA has a maximum output energy of 3,1 µJ at 900 nm (or 1,55 W at 500 kHz) with energies greater than 2 µJ between 700 and 1000 nm and supports Fourier-limited pulse durations below 25 fs in this spectral range.

The pulses have been compressed using a low losses fused silica Brewster-angled prism compressor and characterized with a short pulse autocorrelator (PulseCheck, APE Berlin). Assuming a Gaussian temporal profile, compressed pulse durations between 17 fs (at 900 nm) and 36 fs (at 700 nm) were measured at the output of the SHG-NOPA (Fig. 1 b), which is 1,4 times the Fourier limited pulse duration. The remaining third order dispersion could be compensated by replacing the flat end-mirror of the prism compressor by a deformable one enabling even shorter pulse durations [3].

With its high repetition rate, high energy and ultrashort pulse duration, such source is a great spectroscopy tool. Optional SHG of the amplified pulses would extend the tunability to a huge 250 to 1000 nm spectral range. Work is in progress to increase the repetition rate to the 2 MHz allowed by our fiber laser.

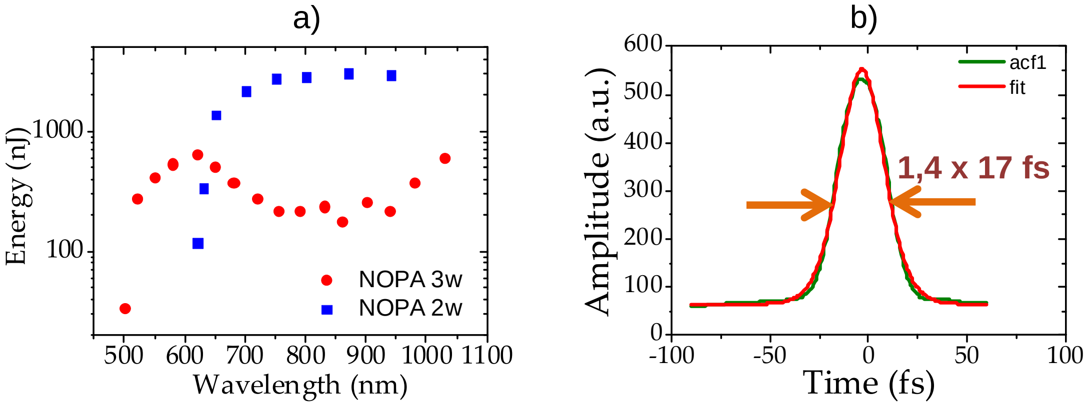

Fig. 1 a) Output energy at 500 kHz repetition rate for the THG-pumped (red dots) and the SHG-pumped NOPA (blue squares). b) Autocorrelation trace of the compressed SHG-NOPA amplified pulses at 900 nm.

References

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