

Chirped-pulse supercontinuum generation with a 200-nJ Ti:sapphire oscillator

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Merging Ti:sapphire oscillator technology with the so-called long cavity oscillator concept brought significant advances in recent years. The main objective of these development efforts were the energy increase of femtosecond laser pulses directly available from Ti:sapphire oscillators. State-of-the-art lasers of this type deliver 30-60 fs pulses with energies approaching the μJ frontier [1]. Shorter durations could not be demonstrated from these lasers since there are some inherent limitations in the chirped pulse oscillator technology that set a boundary to the spectral content of the laser output. On the other hand, some spectroscopic, pump-probe and strong-field-like experiments [2] call for broadening the output spectrum (and eventually pulse compression in many cases). Therefore, extracavity solutions are needed. Nevertheless, this is not a trivial task since single-mode fibres are instantly damaged at these pulse energies, whereas their intensity is not enough to produce significant nonlinearities in hollow fibres or bulk samples. In this work we demonstrate supercontinuum generation in a single-mode fibre with chirped 200 nJ pulses, thus eliminating the damage threshold constraint.

Our experimental setup consisted of a chirped-pulse Ti:sapphire oscillator that delivered 200 nJ pulses at a repetition rate of 3.6 MHz with a limited spectral width (40 nm at the base). The inherent chirp of the outcoupled pulses was overcompensated by a 4-prism compressor to overcome damage threshold problems at the fibre entrance. We coupled the narrowband, negatively chirped, 150-fs pulses in a single-mode fibre with an achromatic objective. The resulting fibre output spectrum corresponds to a pulse length of 7-8 fs in the transform-limit (see Figure 1.). The observed highly efficient spectral broadening process of negatively chirped pulses in the fibre is supported by simulation data.

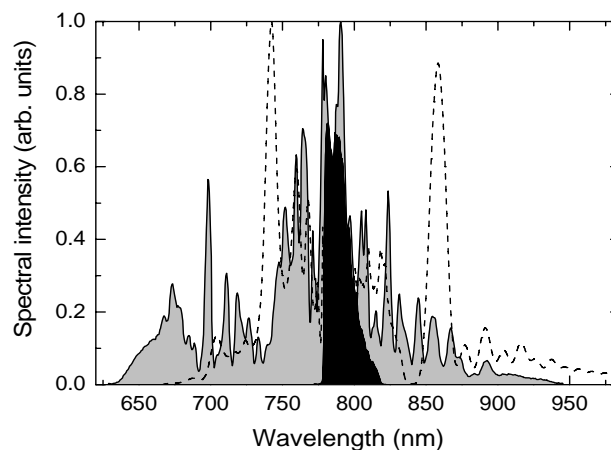


Fig. 1. Laser oscillator spectrum (black area), measured supercontinuum after a single-mode fibre (gray area) and simulated spectrum (dashed line) with input pulses carrying a -3000 fs^2 chirp.

Light propagation in the fibre sample was modeled by using a symmetric split-step Fourier method solving the generalized nonlinear Schrödinger equation. A Taylor-polynomial up to the third order described the fibre dispersion. The measured supercontinuum could be reproduced qualitatively with our simulations (apart from a slight redshift), as depicted in the Figure. Numerical results also suggest good potential compressibility of the broadened spectrum for shorter fibre lengths.

References

1. S. Naumov et al., "Approaching the μJ frontier with femtosecond laser oscillators" *New. J. Phys.* **7**, 216 (2005).
2. S. Dewald et al., "Ionization of noble gases with pulses directly from a laser oscillator", *Opt. Lett.* **31**, 2072-2074 (2006).