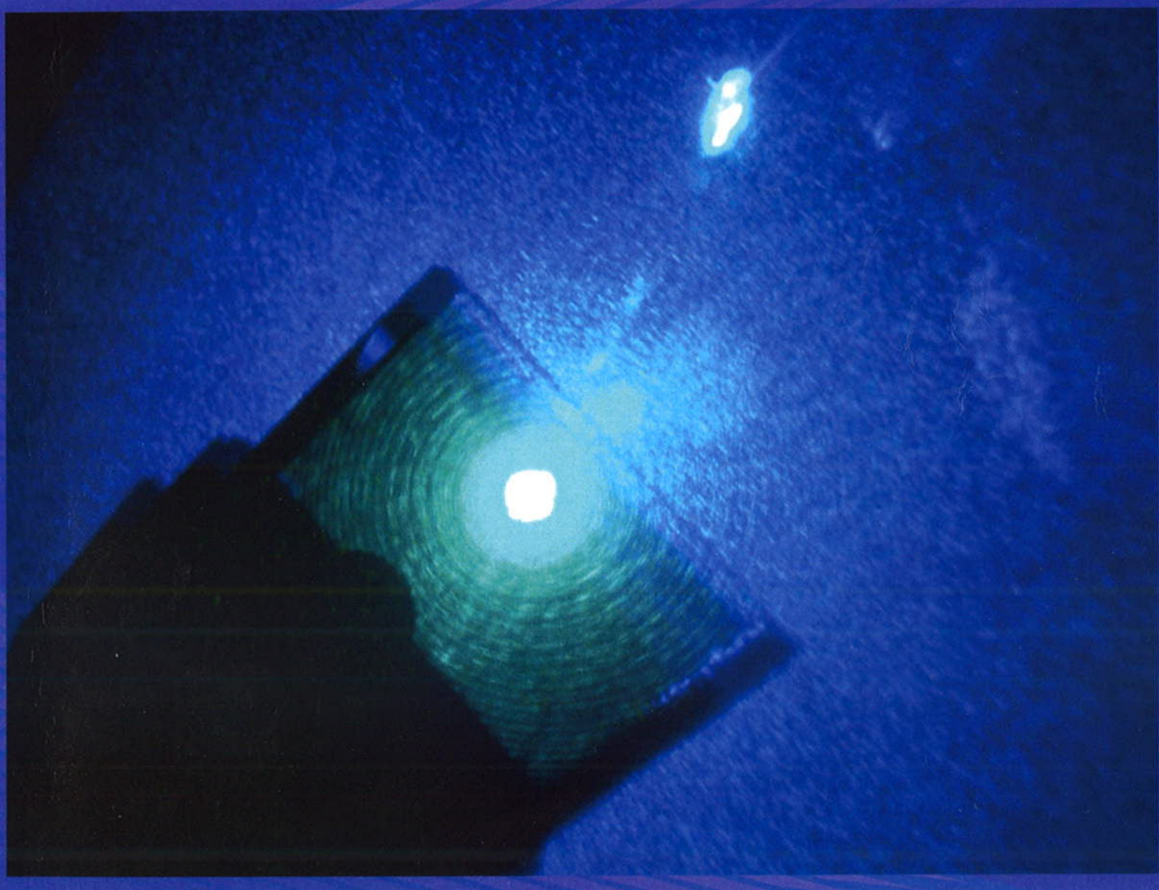
Program and Book of Abstracts



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Self-compression of 1.5 μm CEP stable OPCPA pulses in noble gases to sub-20 fs

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Self-compression of femtosecond laser pulses by filamentation in gases has attracted enormous attention for the generation of intense carrier-envelope phase (CEP)-stable few-cycle laser pulses for attosecond physics. In Ref. [1], we presented the first generation of a 600-nm-wide infrared supercontinuum from a multi-mJ filamentation in noble gases starting from CEP-stable ~1.5-μm pulses [2]. In particular, the transform limit of the supercontinuum obtained in argon at 5 bar absolute pressure was 8 fs, i.e., less than two optical cycles at 1.5 μm. However, a spectro-temporal characterization using SHG-FROG revealed that in those experiments the filamentation regime did not involve a plasma pulse self-recompression mechanism. Instead, the pulse had accumulated a significant amount of nonlinear phase which caused temporal pulse splitting but helped to keep the pulse intensity below the break-up threshold of a single filament.

Here, in contrast to [1], we demonstrate self-compression of CEP-stable 74.4-fs 1.57-μm input pulses down to 19.5 fs duration in a single filament in argon with 0.5-mJ output energy and a 66% energy throughput (including reflection losses from the uncoated output window). The compressed to 74.4 fs (TL 72.6 fs) OPCPA multi-mJ output was focused into a gas cell of fixed 138-cm length filled with argon (ionization potential 15.76 eV) at an absolute pressure of 5 bar using a 50-cm lens placed 4 cm in front of cell. For these self-compression experiments, 0.8-mJ pulse energy measured behind a variable aperture was used. A 3-mm-thick infrasil input window had an antireflection coating with transmission >99.8% over the full input pulse spectrum, and the 1-mm-thick output window was an uncoated BK7 window.

Results of self-compression of 0.5-mJ pulses by filamentation in argon at 5 bar pressure are shown in Fig. 1. For these experimental conditions, a supercontinuum was created in a 12-15 cm long single filament (visible with the naked eye) resulting in self-compressed pulses of sub-20-fs duration, i.e., approximately 4 optical cycles at 1.5 μm. This represents a temporal compression of the input pulses by a factor of 3.8. The spectral phase is reproducible which will allow further recompression of the pulses using custom-designed chirped mirrors in the near future.

In conclusion, we demonstrated self-compression of CEP-stable multi-mJ 74.4-fs 1.57-μm input pulses down to 19.5 fs duration in a single filament in argon with 0.5-mJ output energy and a 66% energy throughput. The output energy and energy throughput can be further increased by replacing the uncoated output window of the gas cell with an AR coated one and by further optimizing the experimental conditions (input pulse energy and beam diameter, focusing lens and position, gas type and pressure, etc.). By varying the position of the output window with respect to the filament channel we expect to observe even shorter pulse durations.

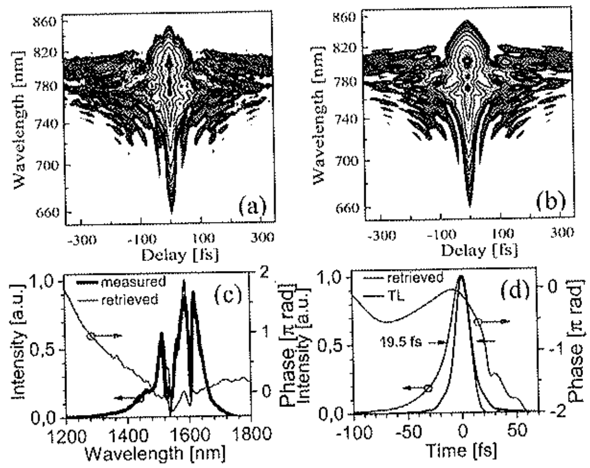

Fig. 1. Self-compression of 0.5-mJ pulses by filamentation in argon at 5 bar: (a) measured and (b) retrieved FROG traces, (c) retrieved spectral intensity (blue) and phase (red), (d) retrieved temporal intensity (blue) and phase (red) profiles.

References:

[1] O. D. Mücke, S. Ališauskas, A. J. Verhoef, A. Pugžlys, V. Smilgevičius, J. Pocius, L. Giniūnas, R. Danielius, and A. Baltuška in "*Infrared Multimillijoule Single-Filament Supercontinuum Generation*" talk JWD6, *CLEO2009*.

[2] O. D. Mücke, D. Sidorov, P. Dombi, A. Pugžlys, A. Baltuška, S. Ališauskas, V. Smilgevičius, J. Pocius, L.Giniūnas, R. Danielius and N. Forget., Opt. Lett. **34**, 118 (2009).