High Harmonic Generation using 1425 nm sub-3 cycles laser pulses

F. Légaré*,[1], B. E. Schmidt[*,§], A. D. Shiner[†], C. Trallero[†], H. Worner[†], M. Giguère[*], P. B. Corkum[†,§], J-C. Kieffer[*], and D. M. Villeneuve[†]

[*] INRS, Énergie Matériaux et Télécommunications, 1650 Boulevard Lionel-Boulet, Varennes, Qc Canada J3X1S2
[†] National Research Council Canada, 100 Sussex Drive, Ottawa, On Canada K1A 0R6
[§]Department of Physics, 150 Louis Pasteur, University of Ottawa, Ottawa, On Canada K1N6N5

Synopsis: 13.1 fs pulses with 400 μJ pulse energy at 1425 nm have been generated using spectral broadening of OPA (Optical Parametric Amplifier) signal beam in an Ar filled hollow core fiber. Chirped mirrors are used for temporal compression and the IR few-optical-cycle pulses are applied to study the extension of the high harmonic cut-off frequency with noble gas.

Generation of intense few-optical-cycle laser pulses at 800 nm (Titanium-Sapphire) has been the key technological breakthrough for attosecond science – high harmonic generation [1]. At the moment, using carrier-envelope phase stabilized 1.5 cycle Ti-Sa laser pulses and an interaction media with a large ionization potential (neon, Ip = 21 eV), pulse duration of 80 attoseconds has been generated. Since the cut-off of the harmonic spectra scales with $I\lambda^2$ (I is the laser intensity and λ the laser wavelength), few-optical-cycle infrared laser pulses are required to further decrease the duration of attosecond laser pulses. Such development will also be highly beneficial for molecular orbital tomography since shorter harmonic wavelength implies better spatial resolution [2], and few-optical-cycle duration will allow using this promising approach in the context of high temporal resolution pump-probe imaging experiments.

We report generation and characterization of sub-3 optical cycle pulses at 1425 nm using the standard approach used at 800 nm, i.e. spectral broadening in a hollow core fiber followed by dispersion compensation using chirped mirrors. The experiment was conducted at the Advanced Laser Light Source (ALLS). Using 7 mJ of Ti-Sa, 1.2 mJ 60 fs 1425 nm laser pulses are produced using Optical Parametric Amplification. The IR laser beam is coupled into the hollow core fiber compressor using an f=1 m plano-convex lens. Using Argon at 1.7 Atm of pressure in the fiber, we have generated broadband spectra supporting 12.2 fs pulse duration (less than 3 optical cycles). After the hollow core fiber setup, newly designed chirped mirrors were introduced to compensate the quadratic spectral phase carried by the pulses due to self phase modulation.

Temporal characterisation of the laser pulses was performed using SHG-FROG. In Fig. 1, we are presenting the retrieved temporal profile of the laser pulses obtained using the SHG-FROG reconstruction. The fact that the obtained FWHM duration of 13.1 fs is only 1.07 times the Fourier limit (12.2 fs assuming flat spectral phase) proves the good compressibility of the SPM broadened spectra at 1425 nm. The intensity profile is asymmetric with a flat temporal phase covering the main pulse, shown as dash-dotted line. At 1425 nm, 13.1 fs is less than 3 optical cycles, equivalent to about 7.5 fs pulse duration at 800 nm.

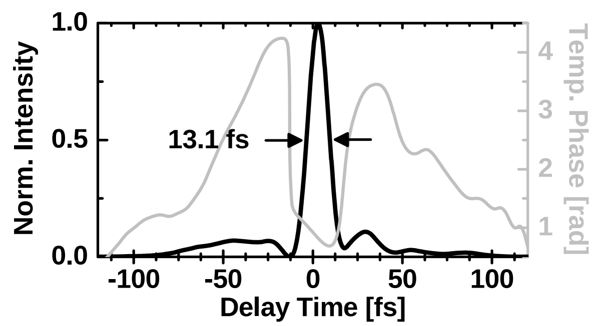

Fig. 1: Reconstructed temporal intensity (black line) and phase (gray line) of the sub-3 optical cycle pulses at 1425 nm.

Using few-optical-cycle pulses at 1425 nm, we measured that the HHG spectrum in Argon extends to 160 eV. Furthermore we are comparing the cut-off region generated by either few-optical-cycle pulses or with 60 fs pulses delivered from the OPA in different noble gas.

References

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[1]E-mail: legare@emt.inrs.ca