Attosecond Streaking of Soft-X-ray Pulses Generated by a mid-IR Laser

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Synopsis Isolated attosecond pulses are generated from passively CEP-stable few-cycle MIR pulses. The CEP stability is measured with a phasemeter. As-streaking is used to sample the laser electric field and to characterize XUV pulses reaching 180eV.

Attosecond metrology has so far remained limited to Ti:Sa lasers combined with an active stabilization of the carrier-envelope phase (CEP), where the achievable photon energy is limited to ~100eV. This is too low to access X-ray absorption edges of most second- and third-row elements which are central to chemistry, biology and material science. The quadratic scaling of the ponderomotive energy with wavelength enables to generate photon energies in the soft-X-ray domain with MIR laser sources.

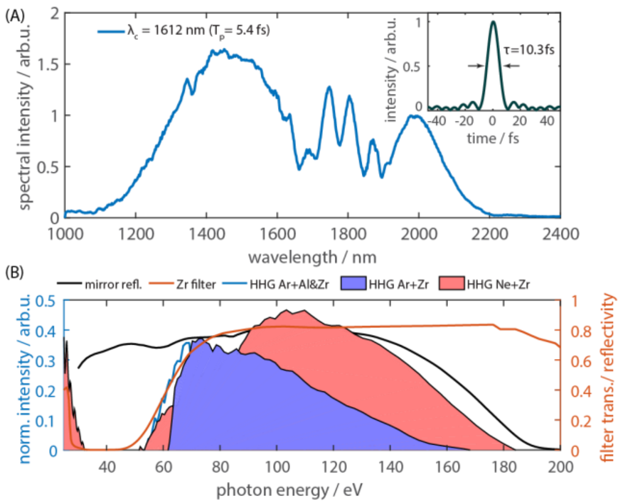

Figure 1. (A) Measured MIR spectrum with corresponding Fourier limited pulse duration. (B) Corresponding HHG spectra generated in Ar (red) and Ne (blue) with the calculated reflectivity curve (black) of the gracing incidence reflector.

We use our commercial TiSa laser system (5mJ, 1kHz) to generate 1.8µm mid-IR pulses with an OPA (TOPAS HE, η~34%), which is spectrally broadened to an octave in a static filled hollow core fiber delivering pulse energies of up to 540µJ. Recompression to the few-cycle regime is performed by a pair of fused-silica wedges. A fraction of the beam is used to measure the CEP stability with a single-shot stereo-ATI phase meter. The CEP stability was found to be better than 300 mrad rms, remarkably better than most previously reported values [1].

Using a 2-cycle MIR pulse centered at 1.6µm after spectral broadening, cf. figure 1(A), for high-harmonic generation in Ar and Ne within an existing beamline [2, 3], allows to generate SXR supercontinua reaching up to 180 eV photon energy, as presented in figure 2(B).

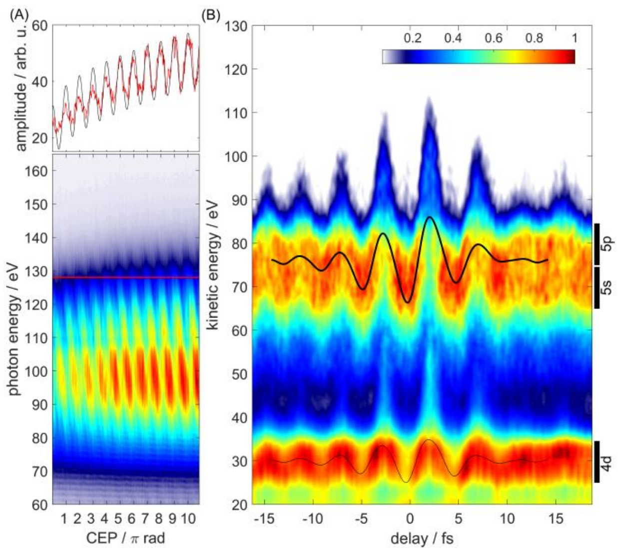

Figure 2. (A) CEP scan for SXR spectra in argon after transmission through 100nm zirconium filter. (B) Photoelectron streaking spectra from xenon.

To obtain an isolated SXR pulse spectral filtering with metallic filters (Zr, Ag, Nb) was explored. By scanning the CEP of the mid-IR driver, the longest cut-off continuum was found, c.f. figure 2(A), and used for as-streaking with different gases (Xe, Ne, He). The obtained streaking curve in Xe is presented in figure 2(B). Using the FROG CRAB [4], and VTGPA [5], the XUV pulse duration could be determined to be below 100as. In addition to the streaking, the XUV spectrum is saved for each delay step of the streaking measurement, which allows to investigate the obtained data in terms of transient-absorption spectroscopy [6].

References

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