Generation and characterization of isolated attosecond pulses for coincidence spectroscopy at 100 kHz repetition rate

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Synopsis An attosecond pump-probe beamline with 100 kHz repetition rate for coincidence experiments has been developed. It is based on non-collinear optical parametric chirped pulse amplification and delivers 100 μJ sub-4 fs to an high-harmonic generation source. Details on the generation and characterization of isolated attosecond pulses will be presented.

The generation of attosecond laser pulses in the extreme ultraviolet (XUV) via high-order harmonic generation (HHG) has enabled time-resolved studies of electronic processes in atoms, solids and molecules on the attosecond scale. We plan to combine an attosecond beamline with a reaction microscope. Detection of electrons and ions in coincidence will allow the retrieval of correlated momentum distributions of charged particles, giving access to channel-resolved photoelectron angular distributions and kinetic energy spectra. This wealth of information can help to better interpret experimental results when studying molecular systems, often involving coupling between electronic and nuclear degrees of freedom or multi-electron correlations. However, for detection in coincidence, only one atom or molecule should be ionized per laser shot. As a result, light sources with high repetition rate are required for pump-probe experiments to be completed in finite acquisition time.

Here we present an attosecond pump-probe beamline driven by a high power non-collinear optical parametric chirped pulse amplification (NOPCPA) system capable of running at a repetition rate of 100 kHz with a maximum output power of 24 W. The system delivers carrier-envelope phase (CEP) stable 7 fs pulses at 800 nm with pulse energies of 190 μJ after compression [1, 2]. We show further pulse compression to near single-cycle pulses with 100 μJ pulse energies (10 W) using the multiple plate continuum generation technique [3] and hollow core fibre compression. The CEP has been characterised on a single-and-every shot basis at full repetition rate using stereo ATI [4]. Using the compressed pulses we generate isolated attosecond pulses via HHG in krypton gas. We reach an XUV photon flux of 1.8×10^{13} photons/sec at the source. The emitted XUV attosecond pulses have been characterized by attosecond streaking. Using a time-domain ptychography algorithm we reconstruct the infrared streaking field and the isolated XUV attosecond pulse with a FWHM of 160 as. The XUV satellite (spaced at 1/2 a period of the IR driving field) pulse contrast is $1 : 10^{-2.4}$.

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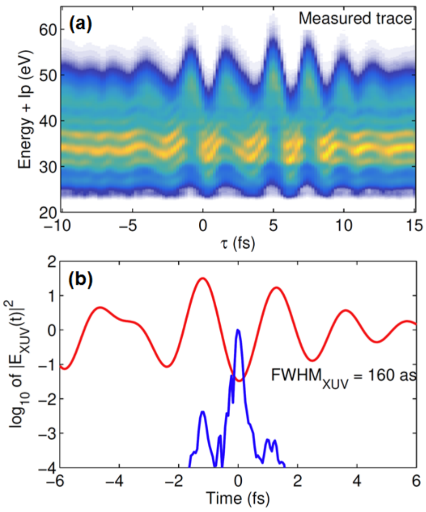

Figure 1. Recorded streaking trace (a), the retrieved infrared laser field (red line) and retrieved attosecond pulse intensity (b).

References

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