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Few-cycle isolated attosecond pulses

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In the last few years the field of attosecond science has shown impressive and rapid progress, mainly due to the introduction of novel experimental methods for the characterization of extreme ultraviolet (XUV) pulses and attosecond electron wave packets. This development has been also triggered by significant improvements in the control of the electric field of the driving infrared pulses. Particularly interesting for the applications is the generation of isolated attosecond XUV pulses using few-cycle driving pulses [1]. In this case significant progresses have been achieved thanks to the stabilization of the carrier-envelope phase (CEP) of amplified light pulses [2].

In this work we demonstrate that the polarization gating (PG) method [3,4] with few-cycle phase-stabilized driving pulses allows one to generate few-cycle isolated attosecond pulses tunable on a very broad spectral region. The PG method is based on temporal modulation of the ellipticity of a light pulse, which confines the XUV emission in the temporal gate where the polarization is close to linear. The time-dependent polarization of phase-stabilized sub-6-fs pulses, generated by the hollow fiber technique, has been obtained using two birefringent plates. It is possible to create a linear polarization gate, whose position is imposed by the intensity profile of the pulse whilst the emission time is linked to the CEP of the electric field. The pulses have been focused onto a gas cell (Argon or Neon). The generated XUV radiation has been analyzed by using a flat-field spectrometer. Continuous XUV spectra, corresponding to the production of isolated attosecond pulses, have been generated for particular CEP values [5]. Upon changing the rotation of the first plate it was possible to tune the XUV emission in a broad spectral range.

We have then achieved a complete temporal characterization of the generated isolated attosecond pulses using frequency-resolved optical gating for complete reconstruction of attosecond bursts (FROG CRAB) [6]. The measured parabolic phase indicates the presence of a predominant second order dispersion (positive chirp), which is intrinsic to the XUV generation process. As recently demonstrated in the case of trains of attosecond pulses [7], the positive chirp of the radiation produced by high-order harmonic generation can be compensated for by the negative group delay dispersion of thin aluminum foils. Upon increasing the thickness of an aluminum plate we have obtained XUV pulses with duration shorter than 300 as (at 37 eV), thus corresponding to few cycles of the electric field.

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