Chirp-controlled polarization gating for isolated attosecond pulse generation

Florian Schapper[1]**, Mirko Holler, Lukas Gallmann, and Ursula Keller**

Physics Department, ETH Zurich, 8093 Zurich, Switzerland

Synopsis: We generate continuous high harmonic spectra in Argon by a superposition of two time-delayed, cross-polarized 12 fs pulses with a small imbalance of group delay dispersion (GDD) between the pulses. Our technique improves overall harmonic flux compared to traditional polarization gating methods. Recorded spectra indicate that the continuum generation is insensitive to the carrier-envelope offset phase (CEP).

The nonlinear interaction of strong ultrashort laser pulses with a target medium leads to the emission of a train of pulses with attosecond duration. To generate single attosecond pulses, one ideally has to restrict the harmonic emission to one half-cycle of the driving laser pulse. Up to now, two different schemes have been implemented. The first approach recently culminated in the generation of sub-100 as pulses with a nearly single-cycle driving laser pulse (duration 3.3 fs) and suitable spectral filtering [1]. In a different approach, the strong dependence of the efficiency of the harmonic generation process on the ellipticity of the driving laser pulse was exploited [2]. With a combination of two quarter-wave plates, the linearly polarized part of the driving laser field could be restricted to a sub-cycle window, thus forming a suitable temporal gate.

We propose a new scheme to generate a temporal gate within a few-cycle laser pulse, which does not lack from the low overall harmonic flux of the traditional polarization gating method and works with longer input pulses. We demonstrate the generation of harmonic continua with 12-fs pulses centered at 770 nm and show that our technique is insensitive to the carrier-envelope offset phase (CEP).

In our setup, we overlap two time-delayed replica of a 12 fs driving laser pulse with crossed polarization (see Fig. 1). A small amount of chirp is added on one of the replicas through the linear dispersion of a thin glass plate. For properly chosen delays between the two replicas, this leads to an overall electric field which is linearly polarized at only one or few positions within the laser pulse. Our approach is similar to the idea put forward by Altucci *et al.* [3], which uses self-phase modulation to generate the chirp. In contrast to traditional polarization gating, we can freely choose the instant of linear polarization within the pulse envelope, thereby alleviating the intensity limitation imposed by ionization of the medium.

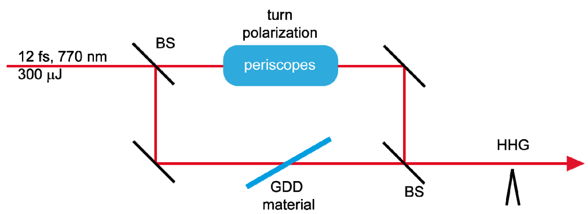

Fig. 1. Schematic of the optical setup.

In Fig. 2, two typical harmonic spectra generated in Argon are shown. When changing the delay between the two cross-polarized pulses, we can generate a continuum (Fig. 2a), discrete harmonics (Fig. 2b) or even suppress the emission by one order of magnitude (not shown). When changing the CEP of the driving laser pulse, the spectra recorded do not change significantly (data not shown), indicating that the continuum generation is insensitive to the CEP. Indeed, the only effect of changing the CEP is expected to be a small change of intensity of the linear polarization component of the waveform.

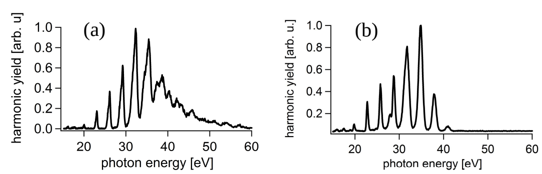

Fig. 2. Harmonic spectra for two different delay times.

In conclusion, we implement a new method that presumably enables isolated attosecond pulse generation in a simple and robust manner with higher harmonic flux, longer pulses, and reduced CEP sensitivity compared the traditional polarization gating technique.

References

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[1] E-mail: **schapper@phys.ethz.ch**