High Harmonic Generation seeded by a XUV pulse train

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Synopsis In the process of high harmonic generation multiple interfering quantum paths are responsible for the harmonic emission. In a theoretical study from 2004 it was shown that attosecond pulse trains can be used to select a single quantum path. The first experiment to demonstrate this effect showed an enhancement of harmonics emission by seeding it with an attosecond pulse train. Here we present for the first time the delay dependence of this enhancement, demonstrating quantum path control.

The result of a strong-field process can normally be described as the coherent sum of a few quantum orbits. In a theoretical study by Schafer et al. [1] it was shown that attosecond pulse trains (APT) can be used to selectively launch a single quantum path. In the proposed experiment harmonic generation in He is controlled in such a way that only one of the trajectories contributes to the emission of harmonics. This proposal led to the first experiment where it was shown that in HHG in He, when seeded with an APT pulse train, certain harmonics are enhanced. To date however, control of the seeding exploiting the APT-IR time delay remains to be demonstrated.

The control mechanism is based on the fact that the electrons are not launched in the continuum by tunneling ionization but by a single-photon ionization by the APT. Choosing a specific delay with respect to the phase of the IR-field, the moment of ionization can be controlled and a certain quantum path is selected. The continuum electrons are subsequently accelerated by the IR driving field. Here we show the first experimental indication that quantum path control in HHG can be achieved by combining an APT with an IR field.

In the experiment an APT consisting of harmonics 11-19 was produced by HHG in xenon. The APT was recombined with the IR driving field at a chosen delay and collinearly focused into a helium gas cell. Harmonic emission resulting from this was detected by a flat field XUV spectrometer. Additional harmonics are created when APT and the IR fields are overlapped (see figure 1). When we zoom in on the time axis we observe that the intensity of these harmonics oscillate as a function of the APT-IR delay with a period of half the optical cycle of the IR field. This is a strong indication that these harmonics indeed result from ionization by the APT followed by acceleration and recombination in the IR field.

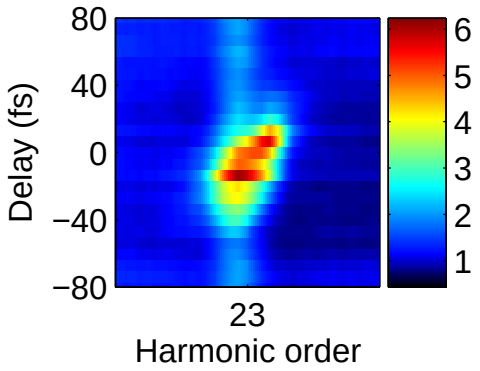

Fig. 1. Appearance of the harmonic 23 from HHG in He seeded by an attosecond pulse train produced in Xe.

In the future we are planning to extend this work in a way such that conditions are created in which a harmonic seeding experiment can be accompanied - in one and the same setup - by an experiment where photoelectrons from two-color APT-IR ionization can be measured, thereby allowing to connect the observations in the harmonic seeding experiment to information on the atomic ionization as revealed in streaking/wavepacket interferometry experiments [3].

References

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