Tracing attosecond bound electronic dynamics by sub-cycle electron wavepacket interferometry

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We experimentally and theoretically demonstrate a self-referenced wavefunction retrieval of a valence-electron wave packet created by moderately strong-field ionization with a cycle-sculpted two-color laser pulse [1]. We isolate sub-cycle interferences [2,3] in the three-dimensional electron momentum spectra measured for helium and neon (see Fig. 1) as a function of the relative phase φ between the two colors. These sub-cycle interferograms encode the quantum phase difference of pairs of electron wavepackets that are timed to each other with attosecond precision. As a result, we are able to extract the sub-cycle phase-evolution of the laser-driven complex bound-state wavefunction during strong-field ionization. We find a strong deviation from the usually assumed linear rise which we attribute to a minute (<1%) but significant transient population of excited states. Thus, our experiment characterizes the formation of a bound electronic wavepacket as it occurs.

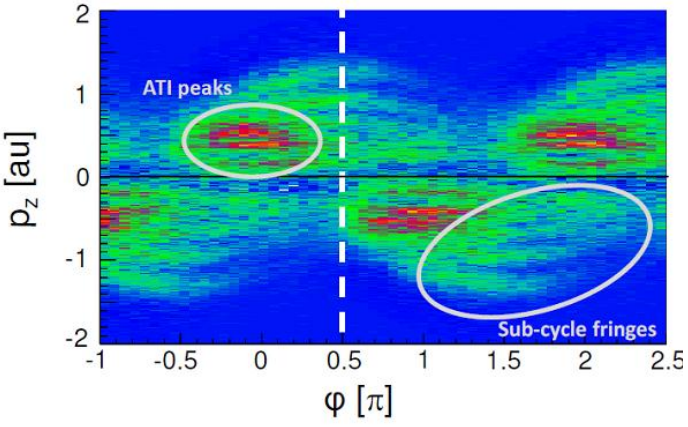

Fig. 1. Measured interference fringes as a function of the longitudinal momentum p_z and phase φ.

By using the semiclassical connection between the momentum and the time of birth of the wavepacket [5], the phase difference can be expressed as a function of the time delay between the emission of the two wavepackets within the same cycle. For the present two-color sculpted pulse, delay times between 50 as and 800 as can be probed with an estimated precision of less than 10 as at the longest delay times. From the observed phase difference detailed insight into the bound-state dynamics during its sub-cycle evolution can be gained.

At the conference we will show that the measured interferograms for helium and neon allow not only to reconstruct the phase-evolution of the bound-state during strong-field ionization, but also give access to the structure of the bound states. The sensitivity of the interferogram on both attosecond-scale dynamical and structural information will be most useful when applied to molecules and the investigation of multi-electron effects.

Rerences:
[1] X. Xie et al, Phys. Rev. Lett. 108, 193004 (2012)
[2] D. G. Arbó et al, Phys. Rev. A 81, 021403 (2010)
[3] D. G. Arbó et al, Phys. Rev. A 82, 043426 (2010)
[5] P. Corkum, Phys. Rev. Lett. 71, 1994 (1993)