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Attosecond Electron Interferometry¹

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Attosecond light pulses have the potential to resolve the ultrafast electron dynamics that govern basic properties of atoms, molecules, and solids. Here we present three different interferometric pump-probe methods aiming to access not only the temporal dynamics, but also state specific phase information after excitation/ionization using attosecond pulses. These pulses have intrinsically very broad coherent bandwidths and in order to obtain state specific information we need to achieve a spectral resolution much better than the inverse of the pulse duration. We do this using either a train of pulses, which corresponds to a frequency comb in the spectral domain, or a pair of pulses, analog to traditional Ramsey spectroscopy, with the difference that the pulses have different frequencies. In the three experiments we: 1) measure the intensity dependence of the 2s-3p transition energy in helium using resonant two-color two-photon ionization [1]; 2) characterize an excited electron wave packet in helium by interfering it with a known reference [2]; and 3) measure the difference in time delay between electrons emitted from different sub-shells in argon [3]. In all three cases the spectral resolution is obtained by repeating the experiment many times for different delays between the attosecond pump pulses and the infrared probe pulses. The spectral resolution is then given either by the number of attosecond pulses [1] and [3] or the inverse of the pump-probe delay [2], which can easily be two orders of magnitude better than the Fourier limit of the excitation pulse.

[1] M. Swoboda, *et al.*, “Phase Measurements of Resonant Two-Photon Ionization in Helium”, Phys. Rev. Lett. **104**, 103003 (2010)

[2] J. Mauritsson, *et al.*, “Attosecond Electron Spectroscopy Using a Novel Interferometric Pump-Probe Technique”, Phys. Rev. Lett. **105**, 053001 (2010)

[3] K. Klünder, *et al.*, “Probing Single-Photon Ionization on the Attosecond Time Scale”, <http://arxiv.org/abs/1012.3863>

¹Swedish Research Council