Attosecond control of electron dynamics in enhanced nanolocalized fields

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Synopsis: We investigated the waveform control of the electron emission from isolated SiO_2 nanoparticles in intense few-cycle laser fields and compare the results to experiments in Xe for the same laser parameters. The cut-off for the emission of electrons from the nanoparticles is found to be significantly higher as compared to Xe. Model calculations indicate that the high-energy electrons arise from electron recollision in a locally enhanced field near the particle surface.

We report on first experiments on the interaction of isolated SiO_2 nanoparticles with strong few-cycle waveform-controlled light fields. Few-cycle laser light with a controlled evolution of the electric field $E(t) = a(t)\cdot\cos(\omega t + \varphi)$ with amplitude $a(t)$, frequency ω and carrier-envelope phase (CEP) φ has recently allowed steering the motion of electrons in and around atoms, the emission of electrons from surfaces and has been applied to steer electron localization in molecules on a sub-femtosecond timescale [1]. Here, we report on first experiments on isolated SiO_2 nanoparticles (100 nm diameter) in strong ($4\cdot10^{13}$ W/cm^2), linearly polarized few-cycle (<5 fs) laser fields using velocity-map-imaging which allows the reconstruction of their full 3d momentum distributions. SiO_2 nanoparticles have been prepared by wet chemical techniques yielding a narrow particle size and shape distribution. The nanoparticles are inserted into the gas phase by state-of-the-art aerosol preparation and aerodynamic lens focusing. Our approach delivers a beam of isolated nanoparticles and was successfully used to study the VUV-light scattering from ultrafine SiO_2 particles [2].

In the current experiments a significant increase in the cut-off in the electron energy spectra of SiO_2 particles as compared to Xe for the same laser conditions is observed (Fig. 1a). The asymmetry of the electron emission towards the directions along the laser polarization axis (Fig. 1b) shows a pronounced CEP dependence, which oscillates in-phase for the high energy electrons (a behavior different to Xe).

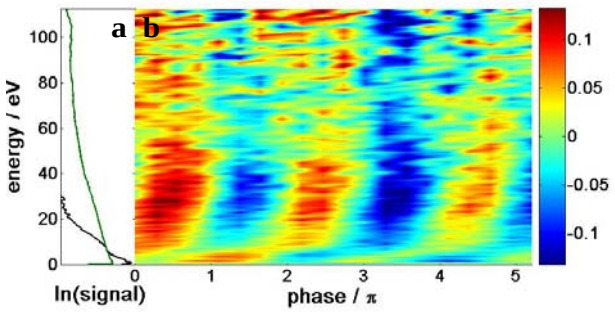

Fig. 1. a) Electron kinetic energy spectrum obtained from SiO_2 nanoparticles (green) and Xe (black); b) Asymmetry in the emission direction of electrons from SiO_2 vs. electron kinetic energy and CEP.

Model calculations are presented that indicate an important role of field enhancement near the nanoparticle surface for the creation of the extended cut-off and the observed CEP dependence.

References

[1] M.F. Kling and M.J.J. Vrakking, *Annu. Rev. Phys. Chem.* **59**, 463 (2008).
[2] J. Shu *et al.*, *J. Chem. Phys.* **124**, 034707 (2006).

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