HL 1: Tutorial: Attosecond Electron Dynamics

Attosecond physics aims at probing and manipulating electronic motion driven by strong laser fields on nanometer length and extremely short time scales. For some years, this field has captured the attention of atomic and molecular physicists. Very recently, several experimental and theoretical studies have started to explore strong-field attosecond electron dynamics in solid state nanostructures. It is the aim of this tutorial to give an introduction into this emerging field, to connect gas-phase and solid state attosecond science and to give perspectives for future work, in particular - but not exclusively - for young scientists. (Organizer: Christoph Lienau, University of Oldenburg)

Time: Sunday 16:00–17:55 Location: EW 201

Tutorial HL 1.1 Sun 16:00 EW 201

Time delays in ionization: real, imaginary, and imagined — •Misha Ivanov — Department of Physics, Imperial College London, South Kensington Campus, London, UK

I will review recent work on trying to understand how much time does it take to liberate an electron from an atom or a molecule. I will focus on two ionization regimes: one-photon and tunneling, and on different ways to address this question both technically and conceptually. In particular, I will show how our attempts to tag an electron as it becomes free after tunneling have led to a better understanding of attosecond core rearrangement during tunneling.

Short Break (5 min)

Tutorial HL 1.2 Sun 16:40 EW 201

Control of Electron Emission from Nanoscopic Systems by Ultrashort Laser Pulses — •Eckart Rühl — Physikalische Chemie, Freie Universität Berlin, Takustr. 3, 14195 Berlin, Germany

Recent progress in control of electron emission from nanoscopic dielectric systems by ultrashort laser pulses and related work is reviewed. Coherent control strategies of laser-induced processes of gas phase species have been established before. Such gas phase species are not limited to atoms, molecules, or clusters. More recently it has been shown that intense nanoparticle beams can be prepared in narrow size distributions as gas phase targets. Ultrashort, intense, and carrier envelope phase-stabilized laser pulses of 4-6 fs in the near infrared regime lead to novel electron emission processes as well as the control of electron motion in the attosecond time regime. This goes beyond well-known photoemission induced by one-photon absorption of ionizing radiation, where the electron spectra of nanoparticles and macroscopic condensed matter are dominated by low kinetic energy, inelastically scattered electrons. In contrast, few-cycle laser pulses yield electron spectra with phase-dependent emission of high kinetic energy electrons. This process has been shown to be unique for condensed matter and is not possible for atomic species. Details of the processes occurring on ultra-short time scales have been assigned by using semiclassical Monte-Carlo simulations. These results indicate that tunnel ionization, the laser field, dielectric near-field enhancement, and the Coulomb field of the liberated charges contribute. Prospects of these results are briefly discussed.

Short Break (5 min)

Tutorial HL 1.3 Sun 17:20 EW 201

Attosecond science at nanometric needle tips — •Peter Hommelhoff — Max-Planck-Institut für Quantenoptik

Attosecond science, namely the steering of electrons with the electric field of well-controlled femtosecond laser pulses, has led to the generation of high-harmonic radiation, even to the generation of single isolated extreme-ultraviolet pulses with durations below 100 attoseconds ($1\,\mathrm{as} = 10^{-18}\,\mathrm{s}$), as well as to the measurement of intramolecular dynamics and ultrafast electron holography. These effects have been observed with atoms, molecules and clusters in the gas phase. We will report on the steering of electrons emitted from *nanoscale metal tips* with the help of phase-controlled low-power few-cycle femtosecond laser pulses. We will highlight the commonalities as well as the differences to the atomic physics system, and will give an outlook on future techniques such as ultrafast surface imaging.