SYAP 1: Attosecond Physics: Atoms, Molecules, Condensed Matter

Time: Monday 10:30–13:00 Location: HSZ 01

Invited Talk SYAP 1.1 Mon 10:30 HSZ 01

Observing Intra-atomic Electron Correlation by Tunnelling and Re-collision — •Paul Corkum — Joint Attosecond Science Lab, 100 Sussex Drive, Ottawa, ON. Canada

Laser induced tunnelling imposes two filters on a quantum system * a directional filter in momentum space and an ionization potential filter. Together they allow us to preferentially address specific orbitals or to launch valence electron wave packets in the ion. Using sequential ionization, we show how circular polarized light can image electron correlations in rare gas atoms and HCl [1]

In linear polarized light the tunnelled electron re-collides. During the re-collision it can probe its correlated hole through high harmonic generation [2]. If the hole moves the dynamics shows up in the structure of the high harmonic spectrum. We show how attosecond dynamics can be observed experimentally.

[1] A. Fleischer, H. Worner, D.M. Villeneuve A. Staudte and P. B. Corkum, *Probing Electron Correlations by Laser-Induced Tunnel Ionization* submitted for publication.

[2] O. Smirnova, Y. Mairesse, S. Patchkovskii, N. Dudovich, D. M. Villeneuve, P. B. Corkum, and M. Y. Ivanov, *Probing Inner Orbitals and Electron Tunnelling in Molecules with High Harmonic Interferometer*, Nature, 460, 972 (2009).

Invited Talk SYAP 1.2 Mon 11:00 HSZ 01

Attosecond time-resolved molecular electron dynamics — •Marc Vrakking — Max-Born-Institut, Berlin

Using attosecond light sources based on high-harmonic generation (HHG), pump-probe experiments can be performed where electron dynamics is studied on its natural timescale, providing insight into the fundamental role that electrons play in photo-induced processes.

In my talk I will present some of the first applications of these techniques in molecular science, focusing on two-color experiments where several small molecules were exposed to a sequence of one or more attosecond pulses and an infrared field. In addition to the attosecond time-structure accompanying HHG, the short wavelengths in HHG allow to use ejected photoelectrons as a probe of the (time-evolving) molecular structure, which amounts to *illuminating the molecule from within*. I will present the present status of our experiments on this topic.

Invited Talk SYAP 1.3 Mon 11:30 HSZ 01

Opportunities in Attosecond Science using Core Level Spectroscopy — •Anders Nilsson — SLAC National Accelerator Laboratory, Stanford University, USA

I will give an overview how core level spectroscopy can be used to probe ultrafast processes on surfaces and in the liquid phase. In the frequency domain, we observe electronic transfer and nuclear motions of hydrogen atoms in the decay spectra based on the concept of using the life time of the inner shell hole as an internal clock. This has been used to follow dissociation events in gas phase molecules, electron transfer processes of adsorbates on surfaces, in liquid water and ions in aqueous systems. There are new opportunities with x-ray free electron lasers, such as LCLS, where x-ray pulses into attosecond regime opening up for new class of studies that will be discussed.

Invited Talk SYAP 1.4 Mon 12:00 HSZ 01

Attosecond spectroscopy on solid surfaces — •Reinhard Kienberger — Fakultät für Physik, TUM, James Franck Str., 85748 Garching

The generation of ever shorter pulses is a key to exploring the dynamic behavior of matter on ever shorter time scales. Attosecond XUV pulses together with the few-cycle (few-femtosecond) IR laser pulses used for their generation have opened the way to the development of a technique for attosecond sampling of electrons ejected from atoms or molecules or solids. Atoms exposed to a few oscillation cycles of intense visible or near-infrared light are able to emit a single electron and XUV photon wavepacket of sub-femtosecond duration [1]. After the full characterization of these tools, first experiments have been carried out to measure sub-femtosecond behavior of matter. Recently, the dynamics of the photoionization process on solids has been studied [2]. Not only that attosecond metrology now enables clocking on surface dynamics, but also the individual behaviour of electrons of different type (core electrons vs. conduction band electrons) can be resolved. Here, we measured a time delay of about 100 as on the emission of the aforemention two types of electrons. For absolute determination of the emission process, the *travel* time of electrons through defined numbers of adlayers is investigated.

[1]*R. Kienberger et al., Nature 2004, 427, 817. [2]*A. Cavalieri et al., Nature 2007, 449, 1029.

Invited Talk SYAP 1.5 Mon 12:30 HSZ 01

Condensed matter effects in attosecond physics — •Pedro M. Echenique — Donostia International Physics Center (DIPC) and Unidad de Fisica de Materiales CSIC-UPV/EHU, Manuel de Lardizabal Pasealekua, E-20018 Donostia, Basque Country, Spain

Recent theoretical and experimental spectroscopic experimental results will be discussed with an emphasis on the relative importance of atomic versus condensed matter physics.