SYDI 2: Diffractive Imaging of complex molecules in the gas-phase

Time: Friday 14:00–16:00 Location: E 415

Invited Talk SYDI 2.1 Fr 14:00 E 415

High Harmonic Generation from Molecules: Prospects for ultra-fast imaging of molecular structure and dynamics — •Jonathan Marangos — Imperial College London, UK

High harmonic generation (HHG) in a strong laser field is a coherent and highly non-linear process. It is initiated by laser ionisation and the key component of the process is the laser driven recombination of an energetic (10 - 100 eV) electron with the molecular ion. This results in emission of a broad spectrum of coherent XUV radiation that encodes within it information on the electronic and nuclear wavefunctions of the molecule. In this presentation I will talk about recent results from my own group using molecular HHG for measuring molecular structure and dynamics and speculate about the future prospects for this method for attosecond reolved atomic scale imaging of matter.

Invited Talk SYDI 2.2 Fr 14:30 E 415

Time-resolved diffraction from selectively aligned molecules — •Ernst Fill[1], Martin Centurion[2], Peter Reckenthäler[1], Werner Fuss[1], and Ferenc Krausz[1] — [1]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching — [2]Dept. of Physics and Astronomy, University of Nebraska, Lincoln, NE 68588-0111, USA

The random directions of molecules in a gas result in diffraction patterns in the form of isotropic rings. Their evaluation yields information only on the radial distribution function i.e. on interatomic distances. However, by dissociation with linearly polarized light molecules are partially aligned and the pattern becomes anisotropic. In our experiments the iodide C2F4I2 is dissociated by fs UV pulses and molecular difference intensities and difference radial distribution curves are measured for directions parallel and perpendicular to the direction of polarization. The curves clearly demonstrate transient anisotropy of the diffraction pattern. The anisotropy decays by molecular rotation with a time constant depending on the rotational temperature. In our experiments we measure decay within 2.6 ps. This experiment is a first step towards the determination of the structure of complicated molecules by alignment methods.

Invited Talk SYDI 2.3 Fr 15:00 E 415

Imaging Molecules from Within: Ultra-fast Structure Determination of Molecules via Photoelectron Holography with Free Electron Lasers. — •Joachim Ullrich[1,2], Faton Krasniqi[2], Bennaeur Najjari[1], Alexander Voitkiv[1], Sascha Epp[2], Daniel Rolles[2], Artem Rudenko[2], and Lothar Strüder[3] — [1]Max-Planck-Institut für Kernphysik, Heidelberg, Germany — [2]Max Planck Advanced Study Group, Center for Free Electron Laser Science, Hamburg, Germany — [3]MPI Halbleiterlabor, München

A new scheme is suggested based on (i) brilliant X-ray Free Electron Laser sources, (ii) novel energy and angular dispersive, large-area electron imagers and (iii) the well-known photoelectron holography that shall provide time-dependent three-dimensional structure determination of small to medium sized molecules with sub-Angström spatial and femtosecond time resolution. Inducing molecular dynamics, i.e. wave-packet motion, dissociation, passage through conical intersections or isomerization, by a pump pulse this motion is visualized by the X-ray - laser probe pulse launching keV photoelectrons within few femtoseconds from specific and well-defined sites, deep core levels of individual atoms, inside the molecule. On their way out the photoelectrons are diffracted generating a hologram on the detector that encodes the molecular structure at the instant of photoionization, thus providing femtosecond snapshot images of the molecule from within. The technology allows obtaining time-dependent structure information for classes of samples not accessible otherwise such as aligned, oriented or conformer selected molecules or ultra-cold ensembles.

Invited Talk SYDI 2.4 Fr 15:30 E 415

Ultrafast processes and imaging of clusters — •Thomas Möller — IOAP, Technische Universität Berlin

The understanding of the interaction of high intensity, short-wavelength, short-pulse radiation with matter is essential for virtually all experiments with new superintense X-ray sources [1], in particular for flash imaging of nm sized particles. Clusters as a form of matter intermediate between atoms and bulk solids are ideal samples to study fundamental light matter interaction processes. They are finite systems with the density of bulk solids allowing the investigation of inner- and interatomic phenomena. Very recently, initial experiments have shown that in nm-sized gas phase particles can be imaged by single shot scattering. X-ray lasers and advanced detectors [2] allow improving the resolution and going to smaller particles. This opens new fields in cluster and nanometer-scale science. Ultrafast electron and ion dynamics can be studied with nm spatial resolution by means of time-resolved scattering using pump-probe techniques as well as time of flight spectroscopy [3].

[1] Bostedt, C. et al. Experiments at FLASH. Nucl. Instr. Meth. 601, 108-122 (2009).

[2] Strüder, L. et al. Large-Format, High-Speed, X-ray pnCCDs Combined with Electron and Ion Imaging Spectrometers in a Multi-purpose Chamber for Experiments at 4th Generation Light Sources. Nucl. Instr. Meth. A, accepted (2009).

[3] Bostedt, C. et al. Multistep ionization of argon clusters in intense femtosecond extreme ultraviolet pulses. Phys. Rev. Lett. 100 (2008).