A 33: Interaction with strong or short laser pulses III

Time: Thursday 11:00–12:45 Location: f303

Invited Talk A 33.1 Thu 11:00 f303

Imaging single nanoparticles with intense XUV pulses from a high-order harmonic generation source — •D. Rupp[1], B. Langbehn[1], M. Sauppe[1], N. Monserud[2], A. Ulmer[1], J. Zimmermann[1], T. Möller[1], F. Frassetto[3], A. Trabattoni[3], F. Calegari[3], M. Vrakking[2], and A. Rouzee[2] — [1]TU Berlin — [2]Max-Born-Institut, Berlin — [3]Politecnico di Milano

Single shot imaging of individual nanoparticles in free flight has become possible using highly intense, femtosecond short-wavelength pulses from free-electron-lasers (FELs). This method allows the study of transient and rare phenomena in gas-phase nanosized objects, such as particle shape evolutions during growth processes, non-equilibrium melting phenomena or ultrafast changes of optical or electronic properties after pulsed laser excitation. Up to now, FELs were seen as the only light sources with this desired ultrafast imaging capability. With only four X-FEL-facilities worldwide, this exciting field of research has so far been constrained to a few experiments only.

For the first time we performed single-shot imaging of individual gas-phase nanoparticles with a table-top light source. Single suprafluid helium nanodroplets were imaged using intense XUV pulses from high-order harmonic generation (HHG) with up to 1μJ pulse energy. The high-quality images generated in this proof-of-principle experiment promote exciting future prospects such as using the phase stable multicolor pulses from HHG and even attosecond XUV flashes to create, steer, and follow ultrafast coherent plasma dynamics.

A 33.2 Thu 11:30 f303

Charge Migration in Diffractive XFEL imaging — •Abraham Camacho Garibay, Ulf Saalmann, and Jan-Michael Rost — MPI-PKS, Dresden

The possibility of using XFEL sources for diffractive imaging has been suggested long ago by Neutze et. al. with the scheme known as "diffraction before destruction". For this to become a reality, a proper understanding of the dynamics triggered from the pulse is fundamental. Recent results have suggested that both field ionization and charge transfer can have a huge impact over the time evolution of finite systems such as clusters, which can be exploited do reduce the radiation damage for the duration of the pulse. In the present work we study the dynamics of Lysozyme under XFEL pulses, a system that is multicomponent, non-symmetric and non-homogeneous. We have observed that a systematic migration of electrons from hydrogen (abundant in biological environments) to heavier, more absorbing and diffractive elements, take place. This migration has a consequence the stabilization of the heavy ion backbone, which allows for the use of longer pulses and/or weaker intensities in single-particle diffraction experiments, and has interesting implications for the coulomb explosion of heavier ions.

A 33.3 Thu 11:45 f303

In-flight-holography – a novel approach to image single nanoparticles with highly intense X-ray pulses — •A Ulmer[1], K Ferguson[2], M Bucher[2], T Ekeberg[3], M Hantke[3], B Daurer[3], C Nettelblad[3], J Andreasson[3], A Barty[4], J Bielecki[3], G Bortel[5], G Carlsson[3], D DePonte[2], G Faigel[5], D Hasse[3], D Larsson[3], M Liang[4], A Morgan[4], K Mühlig[3], M Müller[1], K Okamoto[3], G Oszlanyi[5], A Pietrini[3], D Rupp[1], M Sauppe[1], M Seibert[3], J Sellberg[3], M Svenda[3], A Szoke[6], M Tegze[5], E Timneanu[3], G van der Schot[3], A Zani[3], H Chapman[4], J Hajdu[3], F Maia[3], C Bostedt[2], T Möller[1], and T Gorkhover[1,2] — [1]TU Berlin — [2]LCLS@SLAC — [3]Uppsala University — [4]CFEL@Desy Hamburg — [5]Hungarian Academy of Sciences — [6]LLNL

Free-Electron Lasers (FEL) open the door to study the morphology of non-crystalline gas phase nanoparticles by single-shot coherent diffraction imaging. To extract full structural information the phase information has to be retrieved, as it is lost due to the imaging process. Hereby sophisticated techniques and the use of constraints were necessary in former approaches. For solid targets holographic methods were applied successfully which retrieve the phase directly by encoding it in the probe exit wave's amplitude. In-flight-holography (IFH) is a novel approach where the scattered light from xenon nanoclusters is used as a holographic reference. This talk will report on the first IFH experiment, where the LCLS FEL was used to image single free nanoparticles, e.g. viruses. First results and resolution limits through experimental constraints will be discussed.

A 33.4 Thu 12:00 f303

Imaging dynamics in xenon doped helium nanodroplets — •B. Langbehn[1], Y. Ovcharenko[1], D. Rupp[1], A. LaForge[2], O. Plekan[3], R. Cucini[3], P. Finetti[3], D. Iablonskyi[4], A. Matthews[5], V. Oliver Álvarez de Lara[5], P. Piseri[6], N. Toshiyuki[7], M. DiFraia[8], C. Callegari[3], K. C. Prince[3,9], K. Ueda[4], F. Stienkemeier[2], and T. Möller[1] — [1]TU Berlin — [2]Universität Freiburg — [3]Elletra-Sincrotrone Trieste — [4]Tohoku University, Sendai — [5]EPFL, Lausanne — [6]Università di Milano — [7]Kyoto University — [8]University of Trieste — [9]IOM-CNR TASC Laboratory, Trieste

With the recent availability of femtosecond x-ray pulses at free-electron laser (FEL) facilities, an insight into a new regime of laser-matter interaction has become feasible. Ultrashort and intense pulses allow for novel kind of experiments, as for example to study the structure and dynamics in gas-phase nanoparticles with x-ray imaging. In particular, helium nanodroplets are very interesting targets. On one hand, they have a simple electronic and geometric structure, on the other hand they are superfluid and can serve as an ultracold nanolaboratory for embedding atoms and molecules and growth studies. This talk will report on a pump-probe experiment using resonant XUV imaging of single helium nanodroplets with the FERMI FEL. The droplets were doped with xenon atoms and a plasma is ignited with a high power optical laser pulse. Using the single particle imaging technique we could follow the nanoplasma propagation and destruction of the droplet from fs to hundreds of ps after IR excitation.

A 33.5 Thu 12:15 f303

Towards multidimensional spectroscopy in the XUV and soft-X-ray spectral range — •Thomas Ding, Kristina Meyer, Christian Ott, Andreas Kaldun, Alexander Blättermann, Veit Stooss, Marc Rebholz, Lennart Aufleger, Paul Birk, Maximilian Hartmann, Martin Laux, and Thomas Pfeifer — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

As first steps towards multidimensional spectroscopy with extreme ultraviolet (XUV) pulses, we present time-resolved four-wave-mixing experiments on inner-valence transitions in neon with attosecond XUV and femtosecond near-infrared (NIR) pulses. The first two pulses (XUV-NIR) coincide in time and act as coherent excitation fields, while the third pulse (NIR) acts as a probe. This new approach allows for the coherent control of otherwise inaccessible coupling dynamics between odd- and even-parity states.

In addition, we present the design of a multidimensional XUV/soft-X-ray spectroscopy setup which will be applicable for both attosecond high-harmonic sources and ultra-intense free-electron lasers (FELs). The heart of the setup is a dynamic four-quadrant split mirror to generate temporally well-controlled pulse sequences for four-wave-mixing experiments as a function of multiple time delays. First experiments will again target benchmark systems such as helium, neon and small molecules. In the near future, one key application with FEL pulses will be the femtosecond-time-resolved multidimensional site-specific spectroscopy of molecules to follow charge migration as a function of time.

A 33.6 Thu 12:30 f303

Highly nonlinear nano-plasma formation and EUV light generation in gas-filled plasmonic waveguides — •Murat Sivis, Frederik Busse, and Claus Ropers — 4th Physical Institute - Solids and Nanostructures, University of Göttingen, 37077 Göttingen

Plasmonic nanostructures offer new means to study nonlinear optical phenomena in highly confined light fields. Specifically, resonant nanoantennas and tapered hollow waveguides allow for an efficient strong-field excitation and ionization of gas atoms accompanied by extreme-ultraviolet (EUV) light generation. Contrary to initial studies reporting plasmon-enhanced coherent high-harmonic generation [1, 2], it was shown that incoherent fluorescence photons dominate the EUV radiation under such conditions [3, 4].

Here, we present a detailed study of atomic gas excitation and EUV light generation in tapered plasmonic waveguides. In addition to the EUV emission, we record and analyze both photoelectron and ion yields from these structures as a function of incident intensity and gas pressure. Together with the experimental findings, finite element calculations of the local field distributions in the waveguides provide a comprehensive picture of the underlying excitation mechanisms.

[1] S. Kim *et al.*, Nature **453**, 757(2008). [2] I.-Y. Park *et al.*, Nat. Photon. **5**, 677 (2011). [3] M. Sivis *et al.*, Nature **485**, E1 (2012). [4] M. Sivis and C. Ropers, Phys. Rev. Lett. **111**, 085001 (2013).