A 30: Interaction with VUV and X-ray light I

Time: Wednesday 14:00–16:00 Location: BEBEL E42

Invited Talk A 30.1 Wed 14:00 BEBEL E42

Stimulated electronic x-ray Raman scattering using x-ray free-electron lasers — •Nina Rohringer — Max Planck Institute for the Physics of Complex Systems, 01187 Dresden — Center for Free-Electron Laser Science, 22761 Hamburg

X-ray free-electron lasers (XFELs) open the pathway to transfer nonlinear spectroscopic techniques to the x-ray domain, to study the interplay of electronic and vibrational degrees of freedom by time-domain spectroscopy. A promising all x-ray pump probe technique is based on coherent electronic x-ray Raman scattering. I will present the first experimental demonstration of stimulated electronic x-ray Raman scattering. By tuning the relatively broad XFEL pulses to the core-excited Rydberg resonances in the pre K-edge region of neon, resonance scattered photons drive an avalanche of inelastic x-ray scattering events, resulting in exponential amplification of the scattering signal by 6-7 orders of magnitude. Analysis of the line profile of the emitted radiation permits to demonstrate the cross over from amplified spontaneous emission to coherent resonance scattering: In case of coherent scattering, the emitted x-ray radiation shows a pulse-to-pulse fluctuation of the line shape and the spectral peak position, resulting from a stochastic detuning of spectrally structured XFEL pulses from resonance. In combination with statistical covariance mapping, a high-resolution spectrum of the resonant inelastic x-ray scattering process can be obtained, opening the path to coherent stimulated x-ray Raman spectroscopy. An extension of these ideas to molecules will be discussed.

A 30.2 Wed 14:30 BEBEL E42

Time-resolved x-ray imaging of laser-driven hydrogen nanoclusters: a microscopic particle-in-cell analysis — •Christian Peltz[1], Charles Varin[2], Thomas Brabec[2], and Thomas Fennel[1] — [1]Institute of Physics, University of Rostock, Germany — [2]Department of Physics and Centre for Photonics Research,University of Ottawa, Canada

We investigate the time-dependent evolution of laser-heated R = 25 nm solid-density hydrogen clusters via coherent diffractive imaging for an infrared pump/x-ray probe scenario. Our microscopic particle-in-cell analysis provides a full electromagnetic description of both the droplet ionization and expansion induced by the intense few-cycle pump pulse as well as the coherent light scattering by the x-ray probe in the expanding nano-plasma [1]. Unexpectedly, the time-resolved scattering images show Mie-like diffraction pattern with increasing fringe separations as function of delay that indicate a shrinking of the cluster. Our analysis reveals that this effect results from continuous ion ablation on the cluster surface which generates a simple self-similar radial density profile whose evolution can be reconstructed precisely by fitting the time-resolved scattering images using a simplified scattering model in Born approximation. Our findings suggest, that time-resolved diffractive imaging experiments on nano-droplets will provide unprecedented insights into the physics of ion expansion and surface ablation in laser-driven plasmas.

[1] C. Varin, C. Peltz, T. Brabec and T. Fennel , Phys. Rev. Lett. **108**, 175007 (2012)

A 30.3 Wed 14:45 BEBEL E42

Fluorescence as a probe for massive electron impact ionization and excitation in FEL-irradiated xenon clusters — •M Müller[1], L Schroedter[2], T Oelze[1], L Nösel[1], M Adolph[1], F Flückiger[1], T Gorkhover[1], M Krikunova[1], D Rupp[1], M Sauppe[1], A Prystawik[2], A Kickermann[2], S Schorb[1,3], C Bostedt[3], T Laarmann[2], and T Möller[1] — [1]TU Berlin — [2]DESY Hamburg — [3]LCLS@SLAC Stanford

Short-wavelength free-electron lasers allow studying highly excited plasma states far from ground state properties. The nanoplasma dynamics induced in rare-gas clusters by intense XUV pulses from FLASH is complex, evolving on different timescales from fs to ns. Previous experiments on xenon clusters at 90eV photon energy indicate that massive ionization takes place while already early in the pulse direct electron emission becomes frustrated. A dense nanoplasma builds up with electron temperatures of some 10eV with dominant recombination in particular in the slowly expanding cluster core.

The question how the residual electron energy is transferred to enable recombination has been adressed with fluorescence measurements. The fluorescence spectra of xenon clusters irradiated with 90eV photon energy exhibit lines of charge states up to 11+ with photon energies exceeding the excitation energy by up to 25eV. Their behavior is directly connected to the plasma driving parameters, indicating that these energetic photons are products of electron impact ionization and excitation. Plasma calculations allow for tracing the electron temperature in the nanoplasma.

A 30.4 Wed 15:00 BEBEL E42

Ultrafast nanoplasma dynamics in large clusters driven by highly intense laser pulses — •L. Flückiger[1], T. Gorkhover[1], M. Müller[1], M. Krikunova[1], M. Sauppe[1], S. Schorb[2], S. Düsterer[3], M. Harmand[3], H. Redlin[3], R. Treusch[3], C. Bostedt[2], D. Rupp[1], and T. Möller[1] — [1]Technische Universität, Berlin — [2]LCLS, SLAC National Accelerator Laboratory — [3]Deutsches Elektronen-Synchrotron, Hamburg

In a newly developed experimental approach we study the dynamics of individual clusters irradiated with highly intense laser pulses on three different timescales, from femto over pico to nanoseconds. In a two-color pump-probe setup single-shot diffractive imaging with simultaneous ion spectroscopy were performed on single xenon clusters. This technique enables to reveal cluster morphology and energy absorption as well as ionization and fragmentation dynamics of the same target without integration over focal-volume and cluster-size distribution [1].

Highly ionized by a 800 nm Ti:Sa pulse a large cluster transforms into a hot dense nanoplasma expelling surface ions by hydrodynamic forces. Subsequent the fully screened interior of the sample recombines completely. What remains is a cold skinned and neutral core. Its fragmentation evolution is probed directly by imaging snapshots with a 90 eV free-electron-laser pulse. This study helps to shed new light on cluster ionization dynamics and laser induced sample damage.

[1] Gorkhover et al., PRL 108, 245005 (2012)

A 30.5 Wed 15:15 BEBEL E42

Tracing Charge Transfer in Dissociating Multiply Charged Iodine Molecules by XUV Pump-Probe Experiments — •Kirsten Schnorr[1], Arne Senftleben[1], Moritz Kurka[1], Georg Schmid[1], Thomas Pfeifer[1], Artem Rudenko[2], Kristina Meyer[1], Matthias Kübel[3], Matthias Kling[3], Björn Siemer[4], Michael Wöstmann[4], Stefan Düsterer[5], Joachim Ullrich[6], Claus-Dieter Schröter[1], and Robert Moshammer[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg — [2]J.R. Macdonald Laboratory, Kansas State University — [3]Max-Planck-Institut für Quantenoptik, Garching — [4]Westfälische Wilhelms-Universität, Münster — [5]Deutsches Elektronen-Synchrotron, Hamburg — [6]Physikalisch-Technische Bundesanstalt, Braunschweig

The dynamics of dissociating multiply charged iodine molecules, I_2^{n+}, is induced and probed by intense XUV pulses delivered by the free-electron laser in Hamburg (FLASH). A first pulse multiply ionizes I_2 and thereby triggers the fragmentation of the molecule. During the dissociation a probe pulse further ionizes the fragments after an adjustable time-delay. Depending on their internuclear distance the probe pulse may also initiate charge transfer between the ions. In this way we determine the critical separation and time scales up to which charge transfer along the internuclear axis takes place. These scales are particularly important for understanding the radiation damage occurring in X-ray single-molecule imaging.

A 30.6 Wed 15:30 BEBEL E42

XUV-pump/IR-probe studies of photoionization and dissociation of N_2O — •Michael Schoenwald[1], Philipp Coerlin[1], Andreas Fischer[1], Alexander Sperl[1], Arne Senftleben[1,2], Joachim Ullrich[3], Thomas Pfeifer[1], and Robert Moshammer[1] — [1]Max-Planck Institut fuer Kernphysik, Heidelberg, Deutschland — [2]Institut fuer Physik, Universitaet Kassel, Deutschland — [3]Physikalisch-Technische Bundesanstalt, Braunschweig, Deutschland

Single and double photoionization of nitrous oxide (N_2O) has been investigated by means of kinematically complete XUV-pump/IR-probe experiments using a reaction microscope. A train of attosecond XUV pulses, produced via high harmonic generation in an Ar-filled gas cell, covers the energy range from 20-50 eV. Here, we concentrate

on the XUV induced creation of excited cations N_2O^{+*} in a state near the double ionization threashold. Besides stable N_2O^{+*} ions, which can be detected directly, the molecular ions can either dissociate into a charged and a neutral fragment or they autoionize into N_2O^{2+}. The latter leads to Coulomb-explosion into two charged fragments that are detected in coincidence ($N_2O^{2+} \rightarrow N^+ + NO^+$ or $N_2O^{2+} \rightarrow N_2^+ + O^+$). An enhancement of double ionization in the presence of the IR-probe pulse was observed. The strength of the influence of the IR pulse seems to be different for the two different decay channels[1]. First results of our measurements will be presented and discussed.

[1] X.Zhou et al., Nature Physics Vol.8, March 2012

A 30.7 Wed 15:45 BEBEL E42

Multiphoton ionization of Argon in the XUV: Theoretical study of ATI processes seen at FLASH — •Antonia Karamatskou[1,2], Stefan Pabst[1], and Robin Santra[1,2] — [1]Center for Free-Electron Laser Science, DESY, Hamburg, Germany — [2]Department of Physics, Universität Hamburg, Hamburg, Germany

Recent experiments at the free-electron laser in Hamburg FLASH have succeeded in measuring direct multiphoton ionization and above-threshold ionization (ATI) in the XUV. We present a theoretical description of the phenomena seen in Argon and Xenon in an ab initio approach. Upon solving the time-dependent Schrödinger equation the photoelectron spectrum is calculated. Multiphoton absorption cross sections are derived and employed to quantify the ATI process for different photon energies.