A 14: Interaction with VUV and X-ray light II

Time: Tuesday 10:30–12:30 Location: V57.05

A 14.1 Tue 10:30 V57.05

Atomic photoionization in combined intense XUV free-electron and infrared laser fields — •Mathias Arbeiter and Thomas Fennel — Institute of Physics, University of Rostock

The electron emission process of noble gas atoms exposed simultaneously to ultrashort monochromatic extreme ultraviolet (XUV) and to intense near infrared (NIR) laser pulses can be seen as a two-step process consisting of XUV photoionization and subsequent electron-NIR-field interaction. Experiments at the free electron laser in Hamburg (FLASH) have shown that already at modest intensities of the NIR dressing field, the XUV induced photoionization lines are split into a sequence of peaks due to the emission or absorption of several additional infrared photons [1]. A systematic study reveals that this sequence of sidebands forms a plateau-shaped structure, which broadens with increasing field strength. We present a theoretical study of the electron emission based on the Simpleman's model and a fully quantum mechanical TDSE description in single-active-electron-approximation. We find that the quantum calculation well reproduces the formation of individual sidebands, the AC Stark shifts, and the overall shape of the sideband envelope [1]. Furthermore the intensity-dependent cut-off energies of the sideband plateau are in good agreement with the classical trajectory model. The results are compared to the experimental data.

[1] P. Radcliffe, M. Arbeiter, W. B. Li, S. Düsterer, H. Redlin, P. Hayden, P. Hough, V. Richardson, J. T. Costello, T. Fennel, M. Meyer, submitted 2011

A 14.2 Tue 10:45 V57.05

Coincident imaging and ion spectroscopy of single gas-phase clusters — •D Rupp[1], M Adolph[1], T Gorkhover[1], L Flückiger[1], M Krikunova[1], Y Ovcharenko[1], M Sauppe[1], S Schorb[1,2], D Wolter[1], M Harmand[3], S Toleikis[3], R Treusch[3], C Bostedt[1,2], T Möller[1], and Authors as in Ref. 1[1] — [1]TU Berlin — [2]LCLS @ SLAC — [3]HASYLAB @ DESY

Gas-phase clusters are an ideal target to study the fundamental mechanisms of the interaction between matter and strong light pulses. Novel Free-Electron Lasers (FELs) as FLASH and LCLS deliver highly intense ultrashort pulses in the high energy range. They provide the possibility of imaging single nanosized structures, enabling a completely new type of experiment. From the scattering patterns of an individual gas-phase cluster hit by an FEL pulse, we can extract its shape, size, the actual power density and even information on transient charge states in the developing nanoplasma. The imaging measurement is further combined in coincidence with additional detectors for reaction products as ions, electrons and fluorescent light. We overcome conventional averaging of cluster size distribution and power density profiles by sorting the single shots with the information from the scattering patterns. An unprecedented contrast is gained, for example in the ion spectra of single clusters hit by different intensities. In most recent experiments the setup was extended with pump-probe techniques to explore the timescales of cluster disintegration processes from the femtosecond to pico- and nanosecond range.

Ref.1: L Strueder et al. Nuc. Instr. and Meth. 614(3):483-496.

A 14.3 Tue 11:00 V57.05

XUV-fluorescence of a FEL pulse created nano plasma in rare gas clusters — •M. Müller[1], L. Schroedter[2], M. Adolph[1], D. Rupp[1], T. Oelze[1], L. Nösel[1], L. Flückiger[1], T. Gorkhover[1], M. Krikunova[1], A. Przystawik[2], A. Kickermann[2], T. Laarmann[2], and T. Möller[1] — [1]TU-Berlin IOAP, Hardenbergstr 36, 10623 Berlin — [2]HASYLAB at DESY, Notkestr. 85, 22607 Hamburg

FLASH, the first free electron laser operating at short wavelength (4nm-47nm) and intense pulses ($10^{16} W/cm^2$), has opened up many new fields of research in the last decade [1]. Nonlinear laser-matter processes, in particular the nonlinear response of nanosized systems to FEL pulses became a field of considerable interest.

We investigate the formation of the FEL induced nanoplasma within rare gas clusters. Fluorescence spectroscopy is used as a promising approach to study the heating and relaxation dynamics, before the radiation damage leads to total destruction of the clusters. Thus we can complement the disciption obtained by ion spectroscopy and light scattering [2]. Xenon clusters excited with 90eV photons exhibit a variety of fluorescence lines between 10 and 100 eV, which show a clear dependence on the excitation power density and cluster size. For the highest power densities fluorescence lines occure even above the excitation energy.

1 Bostedt, C. et al. (2009) Nucl. Instrum. Methods Phys. Res. A 601 108-22

2 Bostedt, C. et al. (2010) J. Phys. B: At. Mol. Opt. Phys. 43 194011

A 14.4 Tue 11:15 V57.05

Seeded Multi-electron Ionization of Xenon Doped Helium Droplets — •Michael Kelbg[1], Sebastian Göde[1], Truong Nguyen Xuan[2], Josef Tiggesbäumker[1], and Karl-Heinz Meiwes-Broer[1] — [1]Universität Rostock, Institut für Physik, Universitätsplatz 3, Rostock, Germany — [2]Max-Born Institute, Max-Born-Strasse 2A, 12489 Berlin, Germany

Ionization process of minimally Xenon-doped helium nanodroplets is studied using ultrashort shaped laser pulses. With the technique of colored double pulse fitness landscape the dependencies on delay and energy distribution of the double pulse is systematically determined. As a result the transparent helium droplet turns into a strong absorber of infrared light and is avalanche-like ionized in a two step process due to the initially charged xenon core followed by resonant absorption of the second pulse. Furthermore dependencies on the amount of xenon doping and resonance conditions for xenon charge states are discussed.

A 14.5 Tue 11:30 V57.05

Autoionization dynamics of H2 and D2 molecules using XUV pulses — •Alexander Sperl, Andreas Fischer, Michael Schönwald, Helga Rietz, Philipp Cörlin, Arne Senftleben, Thomas Pfeifer, Robert Moshammer, and Joachim Ullrich — Max-Planck-Institut für Kernphysik, Heidelberg

Wave packet dynamics in molecules are studied by combining an XUV pulse source together with a Reaction Microscope detection system, which allows for coincident measurements of ions and electrons. Furthermore, it is capable of measuring the three dimensional momentum of each charged particle involved in the ionization process.

We used this technique to study the autoionization of doubly excited H2 and D2 molecules, a process with occurs on a timescale of a few femtoseconds [1]. Since this reaction time is of the order of the molecular motion, the nuclei can no longer be regarded stationary. The coupling of the dissociation dynamics of H2+ and D2+ to the corresponding electron, which is ionized through the autoionization channel, leads to a symmetry breaking in the dissociation. In order to study the temporal dynamics of these processes we probed the molecules with XUV pulses of different durations.

[1] J. Fernandez, F. Martin, New J Phys 11, 043020 (2009)

A 14.6 Tue 11:45 V57.05

Gas-Based Photoemission Spectrometer for Online Shot-to-Shot Photon Beam Diagnostics at the European XFEL — •Jens Buck, Jan Grünert, Cigdem Ozkan, Bin Li, Wolfgang Freund, and Serguei Molodtsov — European XFEL GmbH, Albert-Einstein-Ring 19, 22761 Hamburg, Germany

At free-electron laser facilities, non-invasive beam diagnostics on the basis of photoionization of rare gases has found broad applications in the past and is also under development at the future European X-ray Free Electron Laser (XFEL.EU) facility [1,2]. The Self-Amplified Spontaneous Emission (SASE) process utilized here is known to produce pulses with significant statistical variations of essential pulse properties such as energy, spectrum, temporal profile etc. Single-pulse resolved diagnostics data is therefore required as an essential reference for user experiments. The specifications of XFEL.EU, especially the high intra-bunch repetition rate of 4.5 MHz and the vast energy range between 280 eV and 25 keV pose particular challenges for the design of gas-based devices.

We report on our conceptual design [3] and our recent developments of a photoelectron time-of-flight spectrometer for spectroscopy of single SASE pulses and give a first assessment of the expected performance of the device as derived from detailed simulations in a realistic environment and first commissioning experiments with synchrotron radiation.

[1] M. Altarelli et. al., *The European XFEL Technical Design Report* (2006). [2] J. Grünert, Proc. FEL09, Liverpool (2009). [3] J. Buck,

Conceptual Design Report: Photoemission Spectrometer, in prep.

A 14.7 Tue 12:00 V57.05

X-ray Photon Beam Diagnostics Devices for the Commissioning and User Operation of the Multi-Undulator facility European XFEL — •Jan Grünert, Cigdem Ozkan, Bin Li, Wolfgang Freund, Jens Buck, and Serguei Molodtsov — European XFEL GmbH, Albert-Einstein-Ring 19, 22761 Hamburg, Germany

The X-ray Free-Electron-Lasers (XFELs) LCLS [1], SACLA [2], and the European XFEL [3] open new opportunities in the research of very small structures and at the same time extremely fast phenomena (Ångström and femtosecond resolution). Unlike pulses from a conventional laser radiation is here created by Self-Amplified Spontaneous Emission when electron bunches pass through very long segmented undulators. Shot noise at the origin of this process leads to pulse-to-pulse variations of intensity, spectrum, wavefront, etc. Any XFEL diagnostics is susceptible to single-shot damage due to the extreme brilliance. Apart from the large facility energy range (280eV to 25keV), the particular challenge for the European XFEL diagnostics is the 4.5 MHz intra-bunchtrain repetition rate, causing additional damage by high heatloads and making shot-to-shot diagnostics very demanding [3]. We report on concepts [4,5], developments, and compromises between resolution/accuracy and energy range / shot-to-shot capabilities.

[1] P. Emma et. al.,Nature Photonics, vol. 4, pp. 641 (2010). [2] T. Ishikawa et. al., *XFEL/SPring-8 Beamline TDR* (2010). [3] M. Altarelli et. al.,*The European XFEL TDR* (2006). [4] J. Grünert, Proc. FEL09, Liverpool (2009). [5] J. Buck, *CDR Photoemission Spectrometer*, in prep. [6] C. Ozkan, *CDR Imagers*, in prep.

A 14.8 Tue 12:15 V57.05

Charakterisierung eines Iod-Überschallgasjets für ein Reaktionsmikroskop am Freie-Elektronen-Laser in Hamburg — •Georg Schmid[1], Kirsten Schnorr[1], Arne Senftleben[1], Moritz Kurka[1], Artem Rudenko[2], Joachim Ullrich[1], Claus-Dieter Schröter[1] und Robert Moshammer[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg — [2]Max-Planck-Advanced Study Group, Hamburg

Unter Ausnutzung des thermodynamischen Effekts der Überschallexpansion lassen sich kalte und gerichtete Gasstrahlen erzeugen, die u.a. zur Impulsspektroskopie in Reaktionsmikroskopen verwendet werden. Hier wurde der Betrieb eines Überschallgasjets mit Iod charakterisiert. Dabei wurden sowohl die Abhängigkeit der Targetdichte als auch der Targettemperatur als Funktion der wesentlichen Betriebsparameter des Jets (Temperatur des Iodreservoirs, verwendetes Trägergas und Vordruck des Trägergases) untersucht.

In ultraschnellen IR/XUV-Pump-Probe-Experimenten am Freie-Elektronen-Laser in Hamburg wurde die Dissoziationsdynamik von Iodmolekülen bei Photonenenergien von 88 eV untersucht. Dabei zeigte sich eine Abhängigkeit sowohl der Ausbeute als auch der Winkelverteilung der Iodionen als Funktion der Zeitverzögerung des IR-und des FEL-XUV-Pulses.