A 9: Interaction with VUV and X-ray light (FEL) II

Time: Tuesday 10:30–13:00 Location: BAR 205

Invited Talk A 9.1 Tue 10:30 BAR 205

Ultraintense X-Ray Induced Multiple Ionization and Double Core-Hole Production in Molecules — •Nora Berrah[1], Mats Larsson[2], Raymond Feifel[3], Kiyoshi Ueda[4], and Kevin Prince[5] — [1]Western Michigan University — [2]Stokholm University — [3]Uppsala University — [4]Tohoku University — [5]Sincrotron Trieste

We used the world first hard X-ray FEL, the Linac Coherent Light Source (LCLS), to investigate the response of molecular systems to the ultraintense, femtosecond X-ray radiation. We report sequential multiphoton ionization, frustrated absorption and double core hole production mechanisms.

We observed intense X-ray induced ionization and dissociation dynamics leading to various charge states up to fully-stripped fragment ions. By measuring partial ion yields from nitrogen molecules as a function of laser pulse duration ($\sim$ 4 fs - 280 fs), a molecular mechanism of frustrated absorption that suppresses the formation of high charge states at short pulse durations is revealed. Our work will also report on multiple X-ray ionization of molecules and the observation of DCH produced via sequential two-photon absorption on diatomic and triatomic molecules. The production and decay of these states was characterized by using photoelectron spectroscopy and Auger electron spectroscopy.

Invited Talk A 9.2 Tue 11:00 BAR 205

Experiments at SPring-8 FEL: from EUV to X rays — •Kiyoshi Ueda — IMRAM, Tohoku University, Sendai 980-8577, Japan

In 2008, the SPring-8 Compact SASE Source (SCSS) test accelerator, started operation in Japan. It provides linearly polarized EUVFEL pulses in the wavelength region of 51-61 nm. In the last three years, we have been investigating multiphoton processes in atoms, molecules, and clusters irradiated by EUVFEL pulses, using ion and electron momentum spectroscopy and pump-probe techniques. In 2011, SCSS XFEL will start operation. Our scientific program at the XFEL is largely based on research problems which constitute a bridge between atoms and small molecules and more complex systems. We plan to study, for example, light-induced phase transition in nanoclusters and light-induced structural change of single photoreactive biomolecules, using time-resolved coherent X-ray imaging combined with Coulomb-explosion ion imaging and photoelectron diffractions. The talk will describe current status of our EUVFEL experiments as well as plans and preparations for our XFEL experiments.

Invited Talk A 9.3 Tue 11:30 BAR 205

Coupling dependence regarding the Cooper minima positions in two-photon ionization of rare gases — •Markus Braune[1], Toralf Lischke[1], Ande Meissner[1], Markus Ilchen[2], Sascha Deinert[2], Jens Viefhaus[2], Andre Knie[3], and Uwe Becker[1] — [1]Fritz-Haber-Institut, Berlin — [2]DESY, Hamburg — [3]Uni Kassel

Cooper-Minima in partial cross sections in single photoionization are known to arise from the decrease of the overlap integral of the two possible wave functions with different angular momentum of the outgoing electron. Reflections of these intensity variations along photon energy are also exhibit in the angular distribution of photoelectron emission. Such radial effects should actually not show severe deviations for different angular momentum coupling multiplets of the same electron configuration. This is in fact the case for the single-photon ionization of all rare gases. However, open-shell atoms show larger deviations due to so called anisotropic interactions of the outgoing electron and the ionic core in the final state. Very little is known on the strength and behaviour of these anisotropic final state interactions. The second step of sequential two-photon ionization can be regarded as the ionization of an open shell system, namely the singly charged ion of the first ionization step. Hence such interactions are expected to occur. Indeed some recent calculations predict large effects with respect to the higher order anisotropy parameter β_4 showing completely different behaviour in the region of the Cooper minima for the different multiplets. Results of our very recent angle resolved photoelectron spectroscopy measurements are presented.

A 9.4 Tue 12:00 BAR 205

XUV-multiphoton ionization at atomic giant resonances at different timescales — •Nils Gerken, Stephan Klumpp, Vera Linsenmann, Ricarda Laasch, Karolin Mertens, Wilfried Wurth und Michael Martins — Institut für Experimentalphysik, Luruper Chaussee 149, 22761 Hamburg, Germany

We present multi-ionization processes of Xenon in the region of the Xe giant resonance measured with ion mass-to-charge spectroscopy at ultrahigh intensities. At the free-electron laser facility FLASH Peak intensities of 10^{12} - 10^{13} W/cm^2 were reached whereas the pulse lengths of a few hundred femtoseconds were longer than in previous Xe^{n+} multiphoton excitations [1,2]. In our experiment we observe strong differences of the relative ion distribution compared to earlier experiments. We concentrate on the mid pulse energy regime, where sequential processes dominate the multiphoton ionization and the resonant structure of the different ions are of importance. Especially Xe^{6+} and Xe^{7+} ion signal intensities are much stronger at pulse lengths in the order of a few hundred femtoseconds compared to previous experiments with one order of magnitude shorter pulse lengths. Furthermore we extended the experiment to other atoms with similar giant resonant excitation behaviour.

[1] A. A. Sorokin et al., Phys. Rev. Lett. 99, 213002 (2007)
[2] M. Richter et al., Phys. Rev. Lett. 102, 163002 (2009)

A 9.5 Tue 12:15 BAR 205

Momentum spectroscopy of ion photo-fragmentation products at XUV energies — •Christian Domesle[1], Hernik B. Pedersen[2], Lutz Lammich[2], Brandon Jordan-Thaden[1], Marko Förstel[3], Tiberiu Arion[3], Uwe Hergenhahn[3], Natalia Guerassimova[4], and Andreas Wolf[1] — [1]Max-Planck Institut für Kernphysik, Heidelberg, Germany — [2]Department of Physics and Astronomy, University of Aarhus, Denmark — [3]Max-Planck Institut für Plasmaphysik, Garching, Germany — [4]HASYLAB at DESY, Hamburg, Germany

Fragmentation of protonated water and small water clusters $H^+(H_2O)_{(n=1,2,3)}$ in the gas phase at XUV energies are of direct relevance in interstellar media and planetary atmospheres. With Free Electron Laser light sources, as FLASH at DESY in Hamburg, investigations of break up processes initiated by ionization of inner valence electrons have become possible. In the crossed beams ion beam infrastructure TIFF at FLASH, the photon and ion beam are temporally and spatially overlapped within a newly designed interaction region. This interaction region, also acting as a saddle point electron spectrometer, allows for trapping the ions and for position and time resolved electron detection. In combination with a serial arrangement of two fragment detectors, charged and neutral fragments can also be time and position analyzed. We report on measurements we performed on protonated water molecules and small clusters, for which fragmentation pathways and branching ratios of the various observed decay channels could be obtained.

A 9.6 Tue 12:30 BAR 205

Laser-based terahertz-feld-driven streak camera for the temporal characterization of fs HHG pulses — •Bernd Schütte, Ulrike Frühling, Marek Wieland, Armin Azima, and Markus Drescher — Universität Hamburg, Hamburg, Germany

We report on a new measurement technique for the temporal characterization of femtosecond (fs) pulses from a high-order harmonic generation (HHG) source. This method is borrowed from attosecond metrology and was first transferred to the fs range at the Free Electron Laser in Hamburg (FLASH) [1]. On a laboratory scale, we now superimpose the 59^{th} order of a HHG source ($\lambda = 13.5\,\mathrm{nm}$) with terahertz (THz) pulses originating from optical rectification in a lithium niobate crystal via the tilted-pulse front method ($\lambda = 250\,\mu\mathrm{m}$) [2]. The generation of HHG and THz radiation with the same laser pulse ensures an inherent synchronization. In contrary to a conventional streak camera, rare gas atoms serve as a photocathode, which are ionized by the HHG pulses. The created electrons are then accelerated by the THz feld, where the momentum gain depends on the THz phase at the ionization time. In this way, the temporal distribution of the HHG pulses is mapped into a distribution of electron energies. By scanning the delay between HHG and THz pulses, the electric feld of the THz pulses could be sampled. In addition, a reconstruction of HHG pulse durations was performed at low photon fluxes where techniques based on nonlinear autocorrelation

do not work.

[1] U. Frühling *et al.*, Nature Photonics, Vol. **3**, 523, 2009.
[2] J. Hebling *et al.*, Opt. Express, Vol. **10**, 1161, 2002.

A 9.7 Tue 12:45 BAR 205

Molecular clusters in strong X-ray pulses — •Pierfrancesco Di Cintio, Christian Gnodtke, Ulf Saalmann, and Jan Michael Rost — Max Planck Institute for the Physics of Complex Systems, Dresden, Germany

Atomic cluster in short and intense laser pulses have received much attention in recent years as they are tunable targets for intense laser-matter interaction. This applies to "conventional" near infrared pulses as well as to VUV and X-ray pulses available from new and upcoming free-electron laser machines. Molecular cluster add another degree of freedom and may thus be a tool to approach the damage processes of large organic molecules as they occur during coherent diffractive imaging with intense X-ray pulses.

Here we present theoretical studies of methane clusters under short X-ray pulses. We observe the segregation of carbon ions and protons in agreement with recent measurements at LCLS by Ditmire et al. [1]. Our microscopic calculations allow for quantitative studies of the proton emission as well as the localization of trapped electrons around the carbon ions which may lead to effective recombination.

[1] T. Ditmire, private communication (2010).