A 38: Atomic clusters (with MO)

Time: Thursday 10:30–12:30 Location: BEBEL E44/46

Invited Talk A 38.1 Thu 10:30 BEBEL E44/46
Unusual electron dynamics in He clusters induced by intense XUV pulses — •Yevheniy Ovcharenko[1], Aaron LaForge[2], Victor Lyamayev[3], Raphael Katzy[2], Patrick O'Keeffe[4], Oksana Plekan[5], Paola Finetti[5], Robert Richter[5], Kevin Prince[5], Marcel Drabbels[6], Carlo Callegari[5], Frank Stienkemeier[2], and Thomas Möller[1] — [1]IOAP, TU-Berlin, Germany — [2]Physikalisches Institut, Universität Freiburg, Germany — [3]European XFEL, Hamburg, Germany — [4]CNR IMIP, Monterotondo Scalo, Italy — [5]Elettra-Sincrotrone Trieste, Basovizza, Italy — [6]EPFL, Lausanne, Switzerland

The investigation of complex atomic and molecular systems in intense IR and XUV pulses has attracted considerable attention during the last decade, since it leads to a better understanding of light matter interaction. Recently, the first seeded Free Electron Laser FERMI became available for users and now offers unique possibility to perform detailed investigations in such systems due to the narrow bandwidth, fine energy tunability and high intensity in XUV energy range. By using this new source the ionization dynamics in He clusters has been explored with electron spectroscopy in a wide energy range. In addition to the conventional sequential multi-step ionization with a photon energy well above the first ionization potential (IP) a novel ionization process following resonant excitation below IP was observed. It is due to autoionization of two or more electronically excited cluster atoms as predicted recently [1]. The process is very efficient and can exceed the rate of direct photoionization above IP.[1] A.I. Kuleff et al., PRL 105, 043004 (2010)

A 38.2 Thu 11:00 BEBEL E44/46
Detecting interatomic Coulombic decay in neon clusters by photon measurement — •Andreas Hans[1], A. Knie[1], M. Förstel[2], P. Schmidt[1], P. Reiss[1], T. Jahnke[3], R. Dörner[3], A. I. Kuleff[4], L. S. Cederbaum[4], P. V. Demekhin[1], U. Hergenhahn[2], and A. Ehresmann[1] — [1]Institut f. Physik, Universität Kassel, Heinrich-Plett-Str. 40, 34132 Kassel — [2]Max-Planck-Institut f. Plasmaphysik, c/o HZB-Bessy II, Albert-Einstein Str. 15, 12489 Berlin — [3]Institut f. Kernphysik, Goethe Universität, Max-von-Laue-Str. 1, 60438 Frankfurt — [4]Physikalisch-Chemisches Institut, Universität Heidelberg, Im Neuenheimer Feld 229, 69120 Heidelberg

The role of interatomic Coulombic decay (ICD) in biological context is currently discussed due to anticipated genotoxic effects of low energy electrons typically produced in non-local autoionization processes. All unambiguous experimental observations of ICD so far relied on the detection of charged decay products. The further investigation of the biological relevance by this methods is constrained, since the mean free travel path of charged particles in dense media (e.g. biological samples) usually is very short. A complementary detection method for ICD, applicable to dense media, is therefore required. Here, we report the first unequivocal proof of ICD by measurements of fluorescence emission from neon clusters. In a proof of principle experiment, photon and electron emission of a supersonic neon cluster jet were measured simultaneously. Furthermore it is shown that the photon signal of clusters can easily be discriminated from the monomer's signal by its characteristic resonant excitation energies and lifetime measurements.

A 38.3 Thu 11:15 BEBEL E44/46
Electron re-localization dynamics in Xenon clusters under intense XUV pump-probe excitation — •M. Arbeiter, Ch. Peltz, and Th. Fennel — Institute of Physics, University of Rostock

Intense and temporally structured light fields from free-electron lasers enable the time-resolved investigation of ionization dynamics in finite systems at shortwavelength, as demonstrated in a recent femtosecond XUV pump-probe experiment on Xenon clusters [1] at FLASH. Subpicosecond relaxation dynamics in the XUV driven cluster nanoplasma are revealed via the delay dependent charge states of emitted atomic ions. Our semiclassical molecular dynamics study reveals that the process of electron re-localization in the ionized cluster is key to understand the delay-dependent ion charge states [2]. We show that nanoplasma expansion cooling rapidly diminishes three-body-recombinations within a few picoseconds leading to a bimodal electron energy distribution of strongly bound electrons (re-localized) and weakly bound (quasifree, Rydberg-like). A suitable criterion to account for electron re-localization is found by microscopic analysis of the local quasi continuum between neighboring atoms, leading to an appropriate definition of effective ion charge states. A systematic pump-probe analysis reveals that electron re-localization provides a fingerprint of electron cooling and nanoplasma rarefaction through cluster expansion and yield a good qualitative agreement with the observed experimental findings [1].

[1] M. Krikunova et al. J. Phys. B 45, 105101 (2012)
[2] M. Arbeiter, Ch. Peltz, Th. Fennel, to be submitted

A 38.4 Thu 11:30 BEBEL E44/46
Explosion of heteronuclear clusters irradiated by strong X-ray pulses — •Pierfrancesco Di Cintio, Ulf Saalmann, and Jan-Michael Rost — Max Planck Institute for the Physics of Complex Systems, Nöthnitzer Straße 38, 01187 Dresden, Germany

By means of N-body simulations we study the ion and electron dynamics in molecular first-row hydride clusters when exposed to intense and short X-ray pulses [1]. We find that, for a particular range of X-ray intensities, fast protons are ejected from the system on a considerably shorter time scale than that of the screened core. As a consequence, the structure of heavy atoms is kept "intact", which may be relevant in the context of X-ray based molecular imaging. Moreover the final charge states of the heavy ions are considerably lower than those of the ions in pristine atomic clusters exposed to the same laser pulses, which is in agreement with recent measurement of CH_4 cluster at the LCLS in Stanford.

[1] P. Di Cintio, U. Saalmann & J.M. Rost, Phys. Rev. Lett. 111, 3401 (2013)

A 38.5 Thu 11:45 BEBEL E44/46
THz field streaking implemented to studies of rare gas clusters — •T Oelze[1], B Schütte[2], M Müller[1], J P Müller[1], M Sauppe[1], L Flückiger[1], D Rupp[1], M Wieland[3], U Frühling[3], A Al-Shemmary[4], N Stojanovic[4], T Möller[1], M Drescher[3], and M Krikunova[1] — [1]IOAP TU Berlin — [2]MBI — [3]IEXP Uni Hamburg — [4]HASYLAB@DESY

Coherent, ultrashort and high flux photon pulses in the short-wavelength regime from free-electron lasers enable a wide range of experiments to study the interaction between light and matter with high spacial and temporal resolution. In our experiment at FLASH rare gas clusters were used as size-scalable model systems and were irradiated by XUV pulses at 92 eV in the presence of a THz field. At the beginning of the FEL pulse photoionized electrons escape the cluster leaving a positive charge behind. As a result further electron emission becomes frustrated and an electron nanoplasma is formed. Field-driven streaking camera allows to study how the temporal structure of the electron photoemission is altered by the cluster environment. In this approach the momentum of emitted electrons is changed according to the phase of the electric field of the THz radiation. Photoelectron spectra taken at different phases of the THz field are then used to create streaking spectrograms. From these spectrograms the temporal structure of the electron photoemission can be reconstructed providing insight into the nanoplasma formation.

A 38.6 Thu 12:00 BEBEL E44/46
Laser-induced delayed electron emission of metal cluster anions — •Christian Breitenfeldt[1], Klaus Blaum[2], Sebastian George[2], Michael Lange[2], Sebastian Menk[2], Christian Meyer[2], Lutz Schweikhard[1], and Andreas Wolf[2] — [1]Institut für Physik, Ernst-Moritz-Arndt Universität, 17487 Greifswald, Germany — [2]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany

Radiative cooling is a fundamental process that determines the internal temperature of vibrationally excited ions as a function of time, eventually bringing them into thermal equilibrium with their environment. We have investigated the cooling of Cu_n^- (n=4,5,6,7) and Co_n^- (n=3,4) anions in a crygenic electrostatic trap. The cluster ions were produced in a Cs sputter ion source, with a vibrational excitation corresponding to temperatures of several thousand Kelvins. They were then size-selected and transferred to the Cryogenic Trap for Fast ion beams CTF located at the Max-Planck-Institut fr̈ Kernphysik within 120 μs. They were stored at a kinetic energy of 6 keV. This electrostatic ion beam trap can be operated at a temperature below 15

K by a closed-cycle helium refrigeration system. The extremely low pressure (few 10^{-12}mbar) achieved by cryopumping resulted in a very low background of collision-induced ion loss and thus a beam lifetime of several minutes. We have studied vibrational autodetachment (also called delayed detachment) by recording the rate of neutral particles escaping from the trap as a function of the delay after the pulses from a laser emitting at wavelengths of 600 to 1300 nm.

A 38.7 Thu 12:15 BEBEL E44/46

Real-time observation of recombination in clusters exposed to intense HHG pulses — •Bernd Schütte[1], Mathias Arbeiter[2], Thomas Fennel[2], Filippo Campi[3], Marc J. J. Vrakking[1], and Arnaud Rouzée[1] — [1]Max-Born-Institut, Berlin, Germany — [2]Universität Rostock, Germany — [3]Lund University, Sweden

High-order harmonic generation (HHG) sources provide light pulses in the extreme-ultraviolet (XUV) spectral range with unique properties including a large wavelength tunability, extremely short pulses down to the attosecond range and a straightforward manner in which pump-probe measurements can be performed. Here we demonstrate that the advantageous features of HHG in combination with the velocity map imaging (VMI) technique lead to a significant improvement in the understanding of cluster dynamics.

The observation of very low kinetic energy electrons from rare-gas clusters exposed to intense HHG pulses is attributed to electron-ion recombination processes to Rydberg states in the expanding nanoplasma. Their subsequent reionization with the DC detector electric field known as frustrated recombination is observed experimentally for the first time. Moreover, using a time-delayed visible or infrared pulse, we investigate the recombination dynamics of quasifree electrons to atomic excited states during the nanoplasma expansion, a method termed reionization of excited atoms from recombination (REAR). In addition, we show that REAR can be used as a sensitive probe for tracing the cluster expansion up to the nanosecond range.