A 11: Atomic clusters I (with MO)

Time: Monday 17:00–18:45 Location: f107

A 11.1 Mon 17:00 f107

Time-resolved luminescence detection from noble gas clusters after photon excitation — •Andreas Hans[1], Philipp Schmidt[1], Florian Wiegandt[2], Christian Ozga[1], Xaver Holzapfel[1], Till Jahnke[2], Martin Pitzer[1], Uwe Hergenhahn[3], Reinhard Dörner[2], Arno Ehresmann[1], and André Knie[1] — [1]Institut für Physik, Universität Kassel, Heinrich-Plett-Straße 40, 34132 Kassel — [2]Institut für Kernphysik, J.W. Goethe Universität, Max-von-Laue-Straße 1, 60438 Frankfurt — [3]Leibniz-Institut für Oberflächenmodifizierung e.V., Permoserstraße 15, 04318 Leipzig

Fluorescence spectrometry is a powerful technique to investigate the electronic structure and decay mechanisms of atomic clusters. In these clusters the lifetimes of excited states can deviate significantly from those in the atomic case. It was shown that time-resolved detection enables an efficient discrimination of cluster and monomer signal [1]. This way features can be seperated, even if they overlap in excitation energy or emission wavelength. The lifetimes of excited states can give further information about the nature of the emission mechanism, e.g. emission from excitonic states, from evaporated atoms, or due to radiative charge transfer. We illustrate the experimental technique of time-resolved fluorescence spectrometry upon excitation by synchrotron radiation and present results from experiment on neon and argon clusters.

[1] A. Knie, A. Hans, et al., New J. Phys. **16**, 102002 (2014)

A 11.2 Mon 17:15 f107

The X-Ray Movie Camera: filming exploding xenon clusters by using a novel XUV imaging setup — •Mario Sauppe[1], Leonie Flückiger[2,1], Katharina Kolatzki[1], Bruno Langbehn[1], Maria Müller[1], Björn Senfftleben[1], Anatoli Ulmer[1], Jannis Zimbalski[1], Julian Zimmermann[1], Tobias Zimmermann[1], Tais Gorkhover[1,3], Christoph Bostedt[4,3], Cédric Bomme[5], Stefan Düsterer[5], Benjamin Erk[5], Marion Kuhlmann[5], Daniel Rolles[6,5], Dimitrios Rompotis[5], Rolf Treusch[5], Torsten Feigl[7], Thomas Möller[1], and Daniela Rupp[1] — [1]TU Berlin — [2]La Trobe University, Melbourne — [3]SLAC — [4]Argonne National Laboratory, Northwestern University, Chicago — [5]DESY — [6]Kansas State University — [7]optiX fab

From the first theoretical concepts on, the development of x-ray free electron lasers has been accompanied by the vision of the "molecular movie". Here we present a very recently performed XUV pump-probe experiment at the free-electron laser FLASH, using a novel two-detector setup for capturing "two-frame movies". While the scattering image on the first detector shows the intact single xenon cluster, delivering information about initial size, shape and exposed intensity, the second detector images the same cluster at a later stage. The new, permanently at FLASH installed, multilayer based split and delay stage DESC was used to study the light induced dynamics in large xenon clusters up to the longest possible delay of 650 ps.

A 11.3 Mon 17:30 f107

Influence of wavelength and pulse duration on single-shot x-ray diffraction patterns from non-spherical nanoparticles — •Katharina Sander[1], Christian Peltz[1], Charles Varin[2], Stefan Scheel[1], Thomas Brabec[2] und Thomas Fennel[1] — [1]Institute of Physics, University of Rostock — [2]Institute of Physics, University of Ottawa

The availability of intense femtosecond x-ray laser pulses from FELs has made it possible to visualize the structure and dynamics of nanosystems via single-shot diffractive imaging. It has been demonstrated that such experiments can be conducted on single free clusters to measure their size as well as their three-dimensional shape and orientation [1]. To model the corresponding diffraction patterns we use a microscopic model based on the discrete dipole approximation (DDA) [2]. We introduce a complex scaling DDA (CSDDA) and study single-shot x-ray diffraction patterns from non-spherical, absorbing nanotargets in the limit of linear response [3]. We employed the method to the scattering by icosahedral silver clusters and compare the scattering pattern for soft and hard x-ray radiation. Our results confirm that 3D structure information is only accessible for long wavelength, i. e. with soft x-ray pulses, but remains visible even for attosecond pulse durations for which the interference fringes vanish.

[1] I. Barke *et al.*, Nat. Comm. **6**, 6187, (2015)
[2] E. M. Purcell *et al.*, Astrophysical Journal **186**, 705-714, (1973)
[3] K. Sander *et al.*, J. Phys. B **48**, 204004 (2015)

A 11.4 Mon 17:45 f107

Interatomic coulombic decay (ICD) in He nanodroplets — •Mykola Shcherbinin[1], Aaron Laforge[1], Sai Smruti Samantaray[2], Vandana Sharma[3], Robert Richter[4], and Marcel Mudrich[1] — [1]University of Freiburg - Faculty of Mathematics und Physics, Freiburg, Germany — [2]Indian Institute of Technology - Dept. of Physics, Chennai, India — [3]Indian Institute of Technology, Department of Physics, Ordnance Factory Estate, India — [4]Elettra - Sincrotrone Trieste, Basovizza, Trieste, Italy

ICD is an important relaxation process for electronically excited atoms which are weakly bound in molecules and clusters [1]. While ICD has been observed in van der Waals clusters containing Ne, Ar, and Xe before, for He, ICD has so far been studied only for the He dimer [2]. We present a synchrotron study of ICD induced in He nanodroplets by simultaneously ionizing and exciting one He atom of the droplet in a shakeup process. Subsequent transfer of internal energy to the neighbouring atoms leads to the formation of He^+ atomic ions as well as small He_n^+ cluster ions, which we observe in electron-ion-ion coincidence. The corresponding photoelectron as well as ion kinetic energy spectra reveal the details of the ICD and subsequent fragmentation processes.

[1] L. S. Cederbaum et al., Phys. Rev. Lett. 79, 4778 (1997) [2] T. Havermeier et al., Phys. Rev. Lett. 104, 133401 (2010)

A 11.5 Mon 18:00 f107

Control of NIR avalanching in clusters by XUV-driven seed electrons — •Bernd Schütte[1,2], Mathias Arbeiter[3], Alexandre Mermillod-Blondin[1], Marc Vrakking[1], Thomas Fennel[3], and Arnaud Rouzée[1] — [1]Max-Born-Institut Berlin, Germany — [2]Imperial College London, UK — [3]Universität Rostock, Germany

The interaction of intense NIR laser pulses with clusters induces highly nonlinear dynamics on attosecond to nanosecond timescales. Recently, we made progress in understanding the relaxation dynamics of clusters in the picosecond to nanosecond range, where electron-ion recombination [1] and correlated electronic decay [2] play an important role.

Novel experimental approaches are required in order to gain access to the ionization dynamics on an attosecond to femtosecond timescale. Here we report on a method, in which cluster ionization is ignited by generating a few (< 10) seed electrons using an XUV pulse. The clusters become strongly ionized (charges up to Ar^{4+} are observed) by a time-delayed NIR laser pulse at an intensity of 3×10^{12} W/cm^2. This is far below the tunnel ionization threshold and corresponds to a ponderomotive potential of only 170 meV. The results are explained by avalanching via efficient inverse bremsstrahlung and electron impact ionization, as well as by resonant absorption of laser energy [3]. In the future, we will apply our concept in order to time-resolve the strong-field ionization of solid-density targets with attosecond resolution.

[1] B. Schütte *et al.*, Phys. Rev. Lett. **112**, 253401 (2014).
[2] B. Schütte *et al.*, Nat. Commun. **6**, 8596 (2015).
[3] B. Schütte *et al.*, arXiv:1509.03250 (2015).

A 11.6 Mon 18:15 f107

Ionization avalanching in clusters ignited by extreme-ultraviolet driven seed electrons — •Mathias Arbeiter[1], Bernd Schütte[2], Alexandre Mermillod-Blondin[3], Marc J. J. Vrakking[3], Arnaud Rouzée[3], and Thomas Fennel[1] — [1]University of Rostock, Germany — [2]Imperial College London, United Kingdom — [3]Max-Born-Institut, Berlin, Germany

Nanoplasma formation in rare-gas clusters under intense near-infrared (NIR) fields is triggered by atomic tunnel ionization. Subsequently, the ionization dynamics is dominated by impact ionization avalanching, efficient heating via inverse Bremsstrahlung (IBS), and resonant collective plasmon excitation. This ionization ignition, however, requires high intensities to reach the tunnelling threshold [1].

Recent experiments show that a few photo-activated seed electrons from an additional weak XUV pulse allow the control of ionization avalanching [2]. In this two-color scenario, highly charged ion emission occurs at NIR intensities far below the tunnel ionization thresh-

old and is switched by the XUV field. We studied the XUV-induced nanoplasma formation as well as its subsequent NIR-driven evolution by molecular dynamics simulations. We find that avalanching starts with even very few seed electrons and that resonance effects are crucial to explain the observed ion emission. Further, our results support that the XUV-NIR scenario might enable the so far unprecedented investigation of IBS at low ponderomotive potentials.

[1] Rose-Petruck et al., Phys. Rev. A 55:1182 (1997).
[2] B. Schütte et al., arXiv:1509.03250 (2015)

A 11.7 Mon 18:30 f107

Cluster size determination of clusters by fluorescence spectrometry — •Xaver Holzapfel[1], Andreas Hans[1], Philipp Schmidt[1], Florian Wiegandt[2], Ltaief Ben Ltaief[1], Philipp Reiss[1], Reinhard Dörner[2], Arno Ehresmann[1], and André Knie[1] — [1]University of Kassel, Institute of Physics and Center of Interdisciplinary Nanostructure Science and Technology (CINSaT), D-34132 Kassel, Germany — [2]Institute of Nuclear Physics, J. W. Goethe University, D-60438 Frankfurt, Germany

Clusters are finite aggregates and cover the gap between molecular and condensed matter physics and are thus used to study microscopic phenomena for many decades [1]. Rare gas clusters are created randomly by supersonic expansion and a scaling law is widely applied to express the mean cluster size of the distribution [2]. Different experiments report deviations between calculated and measured mean cluster size and further investigations are necessary for quantification [3]. Resonant excitation of outer valence electrons in rare gas clusters by synchrotron radiation yield characteristic informations in the resulting fluorescence yield about the mean cluster size. In the ongoing contribution we present a novel way of cluster size determination of clusters by photon induced fluorescence spectrometry (PIFS) [4].

[1] J. Jortner: Z. Phys. D 24, 247 (1992). [2] U. Buck et al.: J. Chem. Phys. 105, 5408 (1996). [3] H. Bergersen et al.: PCCP 8, 1891 (2006). [4] A. Knie et al.: New Journal of Physics 16, 102002 (2014).