A 15: Atomic clusters II (with MO)

Time: Tuesday 14:30–16:30 Location: f107

A 15.1 Tue 14:30 f107

Laser-induced delayed electron emission of Co_4^- clusters — •Christian Breitenfeldt[1,2], Klaus Blaum[2], Sebastian George[2], Jürgen Göck[2], Jonas Karthein[2], Thomas Kolling[3], Christian Meyer[2], Jennifer Mohrbach[3], Gereon Niedner-Schatteburg[3], Lutz Schweikhard[1], and Andreas Wolf[2] — [1]Institut für Physik, Ernst-Moritz-Arndt Universität, Felix-Hausdorff-Str. 6, 17487 Greifswald, Germany — [2]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany — [3]Fachbereich Chemie, Universität Kaiserslautern, 67663 Kaiserslautern, Germany

The Cryogenic Trap for Fast ion beams CTF located at the Max-Planck-Institute for nuclear physics is an electrostatic ion beam trap setup for the study of dynamical processes of stored ion beams. A tunable optical parametric oscillator laser is used to induce delayed electron detachment, monitored by the rate of neutralized particles leaving the trap region as a function of time after laser excitation. By comparing the count rates after laser excitation at various photon energies ranging from 0.95 eV to 1.88 eV and different storage times the ions' internal energy distribution can be reconstructed. Two types of ion sources have been used to produce Co_4^-: First, a caesium ion sputter source, known to produce ro-vibrationally excited ions at temperatures of more than 1000 K, and second, a laser vaporization source with helium expansion to produce ions with ro-vibrational excitation levels corresponding to low temperatures. The cooling and heating process of Co_4^- has been observed.

A 15.2 Tue 14:45 f107

Quantum Monte Carlo study of Mg-doped droplets of helium-4 at zero temperature — •Yaroslav Lutsyshyn and Dieter Bauer — Institut für Physik, Universität Rostock, 18051 Rostock, Germany

Mg-doped helium droplets are believed to have an observable metastable state in which the alkali atoms remain separated by a considerable distance, thus forming so-called "atomic foam". The exact nature of such a state is not well understood. We study the long-distance interaction induced between a pair of Mg atoms due to the confinement effects in the superfluid. We will present quantum Monte Carlo results for the effective interaction of the dopants.

A 15.3 Tue 15:00 f107

Slow electrons from intense NIR laser-cluster interactions — •B. Schütte[1,2], M. Arbeiter[3], T. Fennel[3], A. I. Kuleff[4], J. Lahl[5,6], T. Oelze[5], M. Krikunova[5], D. R. Austin[1], C. Strüber[1], P. Ye[1], M. J. J. Vrakking[2], J. P. Marangos[1], and A. Rouzée[2] — [1]Imperial College London, UK — [2]Max-Born-Institut Berlin, Germany — [3]Universität Rostock, Germany — [4]Universität Heidelberg, Germany — [5]TU Berlin, Germany — [6]Lund University, Sweden

Clusters in intense NIR fields absorb laser energy extremely efficiently, resulting in the observation of keV electrons. Here we report on a surprisingly dominant contribution of slow electrons with kinetic energies < 2 eV following the ionization of rare-gas clusters by NIR pulses ($I = 5 \times 10^{14}$ W/cm^2). Our THz streaking results reveal that these electrons are emitted with a significant delay in the picosecond to nanosecond range. We show that the emission of slow electrons can be expected from correlated electronic decay (CED) [1], which may involve autoionization processes [2]. In comparison to CED, where one electron relaxes from a Rydberg state to the ground state and transfers its excess energy to a nearby electron [1], the rates of intra-Rydberg CED processes can be orders of magnitude larger, and are associated with slow-electron emission. Our results may be the key to explaining the emission of highly charged ions from clusters that are observed in spite of the very efficient recombination of ions and electrons [3].

[1] B. Schütte *et al.*, Nat. Commun. **6**, 8596 (2015).
[2] B. Schütte *et al.*, Phys. Rev. Lett. **114**, 123002 (2015).
[3] B. Schütte *et al.*, Phys. Rev. Lett. **112**, 253401 (2014).

A 15.4 Tue 15:15 f107

Photo excitation of size and charge-state selected multi-anionic aluminum clusters — •Markus Wolfram[1], Stephan König[1], Franklin Martinez[2], Gerrit Marx[1], Lutz Schweikhard[1] und Albert Vass[1] — [1]Felix-Hausdorff-Straße 6,Institut für Physik, Greifswald, Deutschland — [2]University of Rostock, Germany

Studies of photo excited di-anionic gold clusters indicated that in addition to the well known competing mechanisms of electron detachment and cluster fragmentation the simultaneous emission of two electrons is another possible decay channel. However, in this case the neutral product cluster was no longer stored in the Penning trap and therefore could not be detected. In the meantime, by simultaneously storing cluster anions and electrons the production of gold and aluminum cluster anions of up to the sixth and tenth charge state, respectively, has been achieved. Furthermore, the experimental procedures for cluster preparation have been refined using the SWIFT (Stored Waveform Inverse Fourier Transform) technique. Thus, it is now possible to investigate the photo-induced decay pathways of stored anionic clusters as a function of cluster size n and charge state z beyond the dianions. After preliminary experiments with Nd:YAG laser beams, it is planned to extend the available photon energies by use of an OPO laser. In this contribution the recent modifications of the experimental setup and first results on the photo excitation of size and charge-state selected multi-anionic aluminum clusters will be presented. The project is funded by the Collaborative Research Center (SFB) 652

A 15.5 Tue 15:30 f107

Energetic Highly-charged Ion Emission from Laser-induced Coulomb Explosion of Silver Clusters — •Dzmitry Komar, Josef Tiggesbäumker, and Karl-Heinz Meiwes-Broer — Universitaet Rostock, Institut fuer Physik, Albert-Einstein-Str. 24, D-18059 Rostock

Silver nanoparticles of about 4000 atoms are exposed to intense 130 fs optical single and double laser pulses (in the range 10^{13}-10^{14} W/ cm^2). The detection system includes a newly developed momentum spectrometer which operates similar to a classical Thomson parabola spectrometer. However, the new setup features practically underground free measurement which allows for a huge dynamic range, an improved energy resolution and a significantly enhanced transmission. Charged resolved energy ion spectra from the laser-exposed Coulomb explosion of small silver clusters have been recorded. Under single laser pulse excitation conditions, multiply charged ions Ag q+ (up to q=12) with energies exceeding 14 keV have been detected. Optical delay studies show the impact of nanoplasmonic oscillations on the ionization dynamics which reflects in the ion charge states as well as the recoil energies. Under optimal pump-probe conditions, i.e. when the Mie-frequency of the expanding nanoplasma matches the laser-nanoparticle resonance, significantly higher charge states (up to q=19) and more energetic ions (up to 300 keV) are observed. The collective electron motion most pronounced at the plasmon resonance has an impact on the angular emission distribution of the ions. Especially the highly charged ions are predominantly emitted along the laser polarization axis.

A 15.6 Tue 15:45 f107

Slow electrons from direct photoionization in clusters — •Abraham Camacho Garibay, Ulf Saalmann, and Jan-Michael Rost — MPI-PKS, Dresden

Sequential ionization of clusters by intense XFEL pulses is known to give a broad plateau like photoelectron spectrum. For sufficiently high charge states, the coulomb potential can be deep enough to trap the outgoing photoelectron, giving rise to a nanoplasma (an effect known as frustrated ionization). This nanoplasma eventually thermalizes and evaporates, giving rise to a high peak near zero. We have found that this high peak is formed not only by evaporating plasma electrons, but it also has a component from directly emitted photoelectrons that naturally arises during the transition between the sequential ionization regime into the frustrated ionization one. We have found that this effect can be explained in a simple way by noting that plasma electrons do not increase the system charge, which requires a small modification in the probability of electron emission as a function of position. By making a simple approximation it is possible to obtain an analytical formula with good agreement with the results obtained by means of molecular dynamics simulations.

A 15.7 Tue 16:00 f107

Surface composition of free mixed $NaCl/Na_2SO_4$ nanoscale aerosols — •Burkhard Langer, Egill Antonsson, Christopher Raschpichler, Dmitry Marchenko, and Eckart Rühl — Physikalische Chemie, Freie Universität Berlin

Nanoscopic $NaCl/Na_2SO_4$ aerosols (d ≈ 70 nm) serve as a model for marine salt aerosols. The crystallization process of droplets of such binary salt solutions was measured using synchrotron radiation from BESSY II by photoelectron spectroscopy, which is particularly surface sensitive. Intensities of the chlorine 2*p* and the sulfur 2*p* lines in photoelectron spectra taken at a photon energy of 270 eV are compared for different mixing ratios of the salts. This allows us to determine the chemical surface composition of free, mixed $NaCl/Na_2SO_4$ aerosols grown by drying aqueous saline droplets. It turns out that the ratio of the surface constituents deviates significantly from the mixing ratio in the aqueous solution, whereby the minority species in droplets are increasingly found on the surface of the solid mixed aerosols. This result can be explained by the nucleation process during crystallization, in which each of the two salts produces its own pure crystal nuclei rather than crystallizing together. The variation of the surface ion concentration as a function of the mixing ratio in the droplets, as observed here for nanoscopic aerosols, is in contrast to earlier findings suggesting a core-shell structure of mixed salt aerosols that are in the micron range [1].

[1] Z. Ge *et al.*, J. Colloid Interface Sci. **183**, 68-77 (1996).

A 15.8 Tue 16:15 f107

Assigning cluster size and laser intensity specific features to single cluster ion spectra — •M. Müller[1], M. Sauppe[1], A. Ulmer[1], B. Langbehn[1], Y. Ovcharenko[1], L. Flückiger[1], S. Toleikis[2], H. Höppner[2], S. Stephan[2], T. Gorkhover[1], J.-P. Müller[1], D. Rupp[1], and T. Möller[1] — [1]TU Berlin, Hardenbergstr. 36, 10623 Berlin — [2]DESY, Notkestr. 85, 22607, Hamburg

Intense laser-cluster interaction results in nanoplasma formation which is a topic of current interest. Due to the finite size of clusters and their availability in the gas phase, no energy can dissipate into surroundings. An inherent difficulty in the analysis of most experimental results of laser-cluster interaction has been the convolution of the cluster size distribution and focal density distribution. Single-shot-single-particle experiments avoid averaging over the two mentioned distributions and allows for uncovering a large variety of individual processes. We present results from an experiment at the Free-Electron Laser FLASH (Hamburg, Germany) with a strong NIR and XUV-FEL source available at the same time. The ion-time-of-flight (TOF) spectra from clusters induced by intense and short NIR laser pulses taken in the single-shot-single-particle mode exhibit features depending either mainly on the laser intensity or the cluster size. For the latter we will compare our results with the size distribution derived from the FEL induced diffraction patterns. These assignments will be relevant for all kinds of single cluster experiments using optical lasers.