A 21: Cluster II (joint session A/MO)

Time: Wednesday 16:15–18:15 Location: S Fobau Physik

A 21.1 Wed 16:15 S Fobau Physik

Investigation of 2p Auger decay in argon clusters by electron-electron and electron-photon coincidences — •Catmarna Küstner-Wetekam[1], Philipp Schmidt[1], Christian Ozga[1], Huda Otto[1], Arno Ehresmann[1], Uwe Hergenhahn[2,3], André Knie[1], and Andreas Hans[1] — [1]Institut für Physik und CINSaT, Universität Kassel, Heinrich-Plett-Str. 40, 34132 Kassel, Germany — [2]Max Planck Institute for Plasma Physics Wendelsteinstr. 1, 17491 Greifswald, Germany — [3]Leibniz Institute of Surface Modification, Permoserstr. 15, 04318 Leipzig, Germany

The response of prototype systems to ionizing soft X-ray irradiation is of crucial interest for the study of fundamental processes in radiation chemistry. Here we investigate Auger processes following 2p inner-shell ionization of argon atoms and clusters and discuss differences in the spectra of the atomic and the condensed sample. These Auger processes are important for the population of the initial states of various interatomic processes such as the Interatomic Coulombic Decay (ICD) and Radiative Charge Transfer (RCT). The coincident measurement of two electrons or one electron and one photon makes it possible to gain new insights into these processes.

A 21.2 Wed 16:15 S Fobau Physik

Modular He nanodroplet source and doping setup for the SQS instrument at the European XFEL — •Anatoli Ulmer[1], Rico Mayro P. Tanyag[1,2], Katharina Kolatzki[1,2], Georg Noffz[1], Patrick Behrens[1], Fabian Seel[1], Bruno Langbehn[1], Mario Sauppe[2], Yevheniy Ovcharenko[3], Daniela Rupp[2], and Thomas Möller[1] — [1]Technische Universität Berlin — [2]Max-Born-Institut Berlin — [3]European XFEL GmbH

Ultra-cold helium nanodroplets gain growing attention in many fields, which can be attributed to their fascinating properties: they are superfluid, form quantized vortices and can be doped with various atomic or molecular samples. With the advance of Free-Electron Lasers (FEL), it has become feasible to determine the outer shapes as well as the structures of embedded nanometer-sized samples by using flash X-ray imaging. This opens a variety of experimental roads, such as cluster growth in a superfluid environment, using different droplet sizes, shapes and dopants. We developed a modular source and doping setup, which will be permanently available for user experiments at the SQS instrument of the European XFEL. A wide range of experiments will be enabled by using either an Even-Lavie Valve, a commercial Parker Valve, or a continuous jet nozzle. Furthermore, a doping system, consisting of a gas cell and two metal ovens, was designed to explore the formation and interaction of structures nested inside superfluid He droplets. The layout and characterization measurements of the setup will be presented.

A 21.3 Wed 16:15 S Fobau Physik

Time-resolved imaging of the dynamics of free metal clusters and nanocrystals — I. Barke[3], N. Bernhardt[2], P. Behrens[2], •S. Dold[1], S. Düsterer[4], B. Erk[4], T. Fennel[3,5], H. Hartmann[3], L. Hecht[2], A. Heilrath[2], R. Irsig[3], B. v. Issendorff[1], N. Iwe[3], J. Jordan[2], B. Kruse[3], B. Langbehn[2], B. Manschwetus[4], F. Martinez[3], K.-H. Meiwes-Broer[3], T. Möller[2], K. Oldenburg[3], C. Passow[4], C. Peltz[3], D. Rupp[2,5], F. Seel[2,5], R. Tanyag[5], R. Treusch[4], A. Ulmer[2], and S. Walz[2] — [1]Univ. Freiburg — [2]TU Berlin — [3]Univ. Rostock — [4]FLASH@DESY — [5]MBI Berlin

Wide angle X-Ray diffraction has been proven a viable tool to determine the 3D structure of single metal clusters in gas phase with a single X-Ray Pulse. We utilize the fs X-Ray pulses at the FLASH Free-Electron Laser in Hamburg to resolve ultrafast processes in metal clusters by reconstructing their shape in a time-dependent manner and simultaneous time-of-fight spectrometry of the ionic fragments. Exploiting the plasmon resonance of silver nanoparticles we use optical picosecond-second laser pulses to efficiently pump their electronic system. Picoseconds later we retrieve the resulting shape of the cluster. For moderate pumping energies (0.5 eV/Atom) we expect so see melting effects, whereas high energy input leads to the formation of a nanoplasma and disintegration of the cluster. To meet the demanding requirements for such experiments a carefully taylored source for clusters was developed. This source as well as a novel optical cluster detector will be presented and an overview of preliminary results from our recent experiments at FLASH will be given.

A 21.4 Wed 16:15 S Fobau Physik

Correlation method for velocity map imaging of electrons and time- of-flight detection of ions emitted by individual mid-IR induced helium nanoplasmas. — •Cristian Medina[1], Dominik Schomas[1], Marcel Mudrich[3], Marcus Debatin[1], Frank Stienkemeier[1], Robert Moshammer[2], and Thomas Pfeifer[2] — [1]Albert-Ludwigs- University of Freiburg, Freiburg im Breisgau, Germany — [2]Max plank Institute for nuclear physics, HEIDELBERG, GERMANY — [3]Aarhaus University, Aarhus, Denmark

Velocity map imaging (VMI) and time-of-flight (TOF) are standard techniques to probe the photodynamics of molecules and clusters. Using a combined VMI-TOF setup, we study nanoplasmas created from doped helium nanodroplets irradiated with intense mid-infrared femtosecond laser pulses. Quasi-free electrons created by tunnel ionization couple very efficiently to the laser field, thereby acquiring high energy and resulting in an avalanche of impact ionization. The large number of charged particles emitted from a single helium nanoplasma allows us to collect both full electron energy distributions (VMI) and ion mass-over-charge distributions (TOF) from a single hit. Our technique relies on linking the camera used for VMI to the oscilloscope that measures TOF spectra. We discuss the impact of doping the He nanodroplets with various species (Xe, Ca and H2O) to trigger the nanoplasma formation.

A 21.5 Wed 16:15 S Fobau Physik

Coherent diffractive imaging of excited state population dynamics in a helium droplet — •Björn Kruse[1], Benjamin Liewehr[1], Christian Peltz[1], and Thomas Fennel[1,2] — [1]University of Rostock, Albert-Einstein-Straße 23, D-18059 Rostock — [2]Max-Born-Institute, Max-Born-Straße 2A, D-12489 Berlin

Just recently, coherent diffractive imaging (CDI) of isolated helium nanodroplets has been successfully demonstrated with a lab-based HHG source [1] operating in the vicinity of the 1s - 2p transition of helium. To reconstruct the shape and orientation of nanoparticles, CDI experiments have so far been analyzed in terms of a classical linear response description [2]. However, for high intensities and especially for resonant excitation, population dynamics of bound electrons and stimulated emissions may become important, violating the assumptions underlying a linear description. To what extend and how nonlinear processes influence CDI scattering images is currently largely unknown. In our theoretical analysis, we describe the quantum-mechanical few-level bound state dynamics using a density matrix formalism and incorporate this into a 3D Maxwell solver based on the finite-difference time-domain method (FDTD). We discuss the spatio-temporal population dynamics and its impact on scattering images in both single-shot and pump-probe scenarios.

[1] D. Rupp et al., Nat. Commun. **8**, 493 (2017)
[2] I. Barke et al., Nat. commun. **6**, 6187 (2015)

A 21.6 Wed 16:15 S Fobau Physik

Coulomb interaction in the photoemission of polyanionic silver clusters — •Norman Iwe[1], Madlen Müller[2], Klara Raspe[1], Franklin Martinez[1], Steffi Bandelow[2], Josef Tiggesbäumker[1], Lutz Schweikhard[2], and Karl-Heinz Meiwes-Broer[1] — [1]Institut für Physik, Universität Rostock, Albert-Einstein-Str. 23-24, 18059 Rostock — [2]Institut für Physik, Universität Greifswald, Felix-Hausdorff-Str. 6, 17489 Greifswald

Not only the size but also the charge state is an important parameter of free, nanoscopic particles. In particular the properties of negatively charged metal clusters are strongly influenced by Coulomb interaction between the cluster components. For two and more excess electrons, this results in a Coulomb barrier potential, whose detailed properties are however largely unknown.

This contribution presents photoelectron spectroscopy studies on mass separated silver clusters, after they have been multiply negatively charged in a radiofrequency ion trap. The emitted electron interacts with the still negatively charged cluster which leads to a Coulomb cut-off, as known from molecular anions. To investigate this effect, PE spectra for different photon energies are compared. These spectra are qualitatively described by electrons coming from a Fermi distribution in a Jellium-like potential that either overcome or tunnel through the Coulomb barrier. The project has been supported by the collaborative research center SFB 652 of the DFG.

A 21.7 Wed 16:15 S Fobau Physik

Time-resolved X-ray Imaging of Anisotropic Nanoplasma Expansion

— •Christian Peltz[1], Christoph Bostedt[2], Mathias Kling[3], Thomas Brabec[4], Eckart Ruehl[5], Artem Rudenko[6], Tais Gorkhover[7], and Thomas Fennel[1] — [1]Institute of Physics, University of Rostock, Germany — [2]Paul Scherrer Institute, Villigen, Switzerland — [3]Faculty of Physics, LMU Munich, Germany — [4]Department of Physics and Centre for Photonics Research, University of Ottawa, Canada — [5]Physical Chemistry, FU Berlin, Germany — [6]Department of Physics, Kansas-State University, USA — [7]LCLS, SLAC National Accelerator Laboratory, Menlo Park, USA

We investigate the time-dependent evolution of laser-heated solid-density nanoparticles via coherent diffractive x-ray imaging, theoretically and experimentally. Our microscopic particle-in-cell calculations for R = 25 nm hydrogen clusters reveal that infrared laser excitation induces continuous ion ablation on the cluster surface. This process generates an anisotropic nanoplasma expansion that can be accurately described by a simple self-similar radial density profile. It's time evolution can be reconstructed precisely by fitting the time-resolved scattering images using a simplified scattering model in Born approximation [1]. Here we present the first successful high resolution reconstruction of corresponding experimental results, obtained at the LCLS facility with SiO2 nanoparticles (D=120 nm), giving unprecedented insight into the spatio-temporal evolution of laser-driven nanoplasma expansion.

[1] C. Peltz, C. Varin, T. Brabec and T. Fennel , Phys. Rev. Lett. **113**, 133401 (2014)

A 21.8 Wed 16:15 S Fobau Physik

Characterisation of a doping oven for embedding metals in helium droplets for the SQS instrument at the European XFEL

— •Georg Noffz[1], Anatoli Ulmer[1], Rico Mayro Tanyag[1,2], Katharina Kolatzki[1,2], Daniela Rupp[1,2], Yevheniy Ovcharenko[3], and Thomas Möller[1] — [1]IOAP, Technische Universität Berlin, Germany — [2]MBI, Berlin, Germany — [3]European XFEL, Hamburg, Germany

One of the most fascinating applications of the European XFEL is the study of nanostructures by means of scattering experiments using ultra-short and extremely intense X-ray pulses. A challenge in these experiments is the loss of phase information needed for image reconstructions in order to make statements about the morphology of the diffracting object. The Droplet Coherent Diffracitve Imaging (DCDI) [Struct. Dyn. 2, 051102 (2015)] technique provides a fast method for retrieving phase information of nanostructures, such as clusters grown in helium droplets. In this case, the droplet serves as a reference object and as a container. This poster deals with the design and characterisation of a doping oven for embedding metals in helium droplets for an approved XFEL beamtime. Quadrupole mass analyzer and time-of-flight mass spectrometer measurements are performed for the investigation of the doping process. Furthermore, the structures of the embedded metals are deposited and afterwards investigated by transmission electron microscopy. This setup will be available at the SQS instrument at the European XFEL. In a final beamtime nanostructure formation in the droplets will be investigated.

A 21.9 Wed 16:15 S Fobau Physik

Setup and characterization of a helium liquid jet for diffractive imaging experiments

— •Katharina Kolatzki[1,2], Rico Mayro P. Tanyag[1,2], Georg Noffz[2], Anatoli Ulmer[2], Daniela Rupp[1,2], and Thomas Möller[2] — [1]MBI, Germany — [2]IOAP TU Berlin, Germany

State-of-the-art XUV and X-ray facilities like high-harmonic generation sources and free-electron lasers enable the in-depth investigation of light-matter interaction via novel methods such as single-particle coherent diffractive imaging.

For such experiments, large helium droplets constitute a suitable target; they have a simple electronic structure and exhibit interesting properties like superfluidity. One way of creating these droplets is a helium liquid jet, which disintegrates in a Rayleigh-type breakup, forming large droplets with diameters of a few microns. Compared to the other regimes of helium droplet generation, droplets produced from jet disintegration have a narrower size distribution. This makes them eligible for time-resolved diffractive imaging experiments, where a reproducible target is indispensable.

Recently, we have constructed and characterized a source for a helium liquid jet, which will be put into use for example at the SQS endstation at the European XFEL. Via shadowgraphy methods, we can analyze the jet's shape and the droplet size. Complementary, our setup allows to determine the average droplet size via collision with external gas particles. First results will be presented.

A 21.10 Wed 16:15 S Fobau Physik

Direct evidence of radiative charge transfer in heterogenous noble gas clusters

— •Xaver Holzapfel[1], Andreas Hans[1], Christian Ozga[1], Vasili Stumpf[2], Huda Otto[1], Catmarna Küstner-Wetekam[1], Arno Ehresmann[1], and André Knie[1] — [1]Institut für Physik und CINSaT, Universität Kassel, Heinrich-Plett-Str. 40, 34132 Kassel, Germany — [2]Physikalisch-Chemisches Institut, Universität Heidelberg, Im Neuenheimer Feld 229, 69120 Heidelberg, Germany

Weakly bound noble gas clusters are artificial systems which can be used for the understanding of non-local energy transfer processes. In the case of the so called radiative charge transfer (RCT) the system can relax by redistributing the charges by emitting the excessive energy as a photon. Therefore, these photons can be used as a fingerprint of the electronic structure of the system if they are measured energy resolved. Here we present the direct observation of (RCT) in heterogeneous NeKr and NeXe clusters by dispersed ultravioletphoton detection.