A 5: Atomic clusters (together with MO)

Time: Tuesday 16:30–18:30 Location: P

A 5.1 Tue 16:30 P

Competition of photon and electron emission in interatomic decay of heterogeneous noble gas clusters — •Lutz Marder[1], André Knie[1], Christian Ozga[1], Christina Zindel[1], Clemens Richter[2], Uwe Hergenhahn[2,3], Arno Ehresmann[1], and Andreas Hans[1] — [1]Institute of Physics, University of Kassel, Kassel, Germany — [2]Leibniz Institute of Surface Modification, Leipzig, Germany — [3]Max Planck Institute for Plasma Physics, Greifswald, Germany

Noble gas clusters represent prototype systems for the investigation of fundamental atomic and molecular processes. Van-der-Waals bonds enable new relaxation pathways not available in isolated systems. In recent years many of these have been studied, often using coincidence measurement techniques.

Here, we present our state-of-the-art experiment where both electrons and photons were detected in coincidence, which allows for investigation of multi-particle decay pathways after excitation with synchrotron radiation. The results show that the addition of krypton to pure neon clusters strongly alters the emission by the opening of a faster ionizing decay channel compared to the radiative decay.

A 5.2 Tue 16:30 P

Atomic Physics in geographical systems — •Raquel Bustamante — Universidad Nacional de Lujan, Buenos Aires, Argentina

Silica microcombs have a high potential for generating tens ofgigahertz ofoptical pulse trains with ultralow timing jitter, which is highlysuitable for higher speed and higher bandwidth information systems. So far, the accurate characterization of timing jitter in microcombs has been limited by the mea- surement methods although theoretically predicted to be >20dB better performance, the true erformance has not been accurately measured until now. Here, using a self-heterodyne-based measurement method with 20 resolution, wehow that 2.6-fs rms timing jitter is possible for 22-GHz silica microcombs. We identified their origins, which suggests that silica microcombs may achieve 200-as-level jitter by better intensity noise control. This jitter performance can greatly benefit many high-speed and high-bandwidth applications including analog-to-digitalconversion, microwave generation, and optical ommunications.

A 5.3 Tue 16:30 P

Time-resolved dynamics in xenon clusters induced by intense XUV pulses — •M Sauppe[1], T Bischoff[2], C Bomme[3], C Bostedt[4], B Erk[5], T Feigl[6], L Flueckiger[7], T Gorkhover[8], K Kolatzki[1], B Langbehn[2], D Rompotis[9], B Senfftleben[10], R Treusch[5], A Ulmer[2], J Zimbalski[2], J Zimmermann[1], T Moeller[2], and D Rupp[1] — [1]ETH Zurich — [2]TU Berlin — [3]IRAMIS — [4]PSI, EPFL — [5]DESY — [6]optiXfab — [7]La Trobe University — [8]Uni Hamburg — [9]XFEL — [10]MBI

Short-wavelength free-electron laser (FEL) enable the investigation of laser-matter-interaction at high photon energies with an unprecedented high spatial and temporal resolution. Rare gas clusters are an ideal testbed for such studies, e.g. due to their tunability in size and lag of paths for energy dissipation. Clusters exposed to tightly focused FEL pulses are quickly transformed into a non-equilibrium state. Photoionization and emission of kinetic electrons occurs within (sub-)femtoseconds, followed by the formation of a nanoplasma of ions and Coulomb-trapped electrons. Energy redistribution and expansion processes may last up to nanoseconds. Using two XUV pulses in a pump-probe scheme with a maximum time-delay of 650 ps, we were able to trace electron-ion recombination and the cluster expansion in a so far unexplored time-regime. As a result of the preceding expansion we found a reduced electron-ion-recombination for increasing time-delays. Further, the analysis of ion kinetic energies showed a plasma driven expansion for smaller clusters. For larger clusters, we found a growing importance of a coulomb explosion of the outer cluster shells.

A 5.4 Tue 16:30 P

A compact UV/VUV spectrometer with fixed VLS gratings for overview luminescence measurements — •Nils Kiefer, Andreas Hans, André Knie, and Arno Ehresmann — Institut für Physik und Center for Interdisciplinary Nanostructure Science and Technology (CINSaT), Universität Kassel,Heinrich-Plett-Straße 40, 34132 Kassel, Germany

We present a design study for the energy resolved photon detection in the UV and XUV energy regime. A grating with Variable Line Spacing (VLS) allows for dispersion of a wide spectral range onto flat detector surfaces. With two VLS gratings in parallel, spectra from 30nm to 120nm and 120nm to 300nm can be imaged simultaneously, but spatially separated. Managing coincidence capabilities and single photon detection, two position and time resolving MCP-based detectors will be used. Exemplary showcase-applications at FAIR (Facility of Antiproton and Ion Research) and synchrotron radiation facilities will be outlined. With this compact spectrometer with high efficiency and high resolution from 30nm to 300nm, it will be possible to collect time efficiently wide range luminescence spectra in experiments for the characterization of the highly charged ion beams and synchrotron radiation served AMO experiments.

A 5.5 Tue 16:30 P

Quantum Coherent Diffractive Imaging — •Björn Kruse[1], Benjamin Liewehr[1], Christian Peltz[1], and Thomas Fennel[1,2] — [1]Institute for Physics, University of Rostock, Albert-Einstein-Str. 23, D-18059 Rostock, Germany — [2]Max-Born-Institut, Max-Born-Str. 2A, D-12489 Berlin, Germany

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 strong laser fields and especially for resonant excitation, population dynamics of bound electrons and stimulated emissions may become important, violating the assumptions underlying a linear and classical description.

We developed a density matrix-based scattering model in order to include such quantum effects in the local medium response and explore the transition from linear to non-linear CDI for the resonant scattering from Helium nanodroplets [3]. The resulting substantial departures from the linear response case for already experimentally reachable pulse parameters leads to the proposal of quantum coherent diffractive imaging (QCDI) as a promising novel branch in strong-field XUV and x-ray physics.

[1] D. Rupp et al., Nat. Commun. 8, 493 (2017)
[2] I. Barke et al., Nat. Commun. 6, 6187 (2015)
[3] B. Kruse et al., J. Phys. Photonics 2, 024007 (2020)

A 5.6 Tue 16:30 P

Investigation of virtual photon dissociation in van der Waals clusters by electron photon spectroscopy — •Carolin Honisch, Nils Kiefer, Dana Bloss, Catmarna Küstner-Wetekam, Lutz Marder, Arno Ehresmann, and Andreas Hans — Institut für Physik und CINSaT, Universität Kassel, Heinrich-Plett-Straße 40, 34132 Kassel, Germany

Within the natural environment, atoms or molecules do not occur in isolation and the influence of the presence of neighboring atoms or molecules is of high interest. A good prototypical system for this situation is represented by van der Waals clusters. In recent years, several novel processes have been discovered to occur in these weakly bound systems that are discussed to play an important role in the study of radiation damage due to charge or energy transfer to distant neighbors and subsequent slow electron emission. Within this context, the process of virtual photon dissociation was also predicted, in which ionization or excitation of an atom or molecule followed by energy transfer can dissociate a neighboring molecule. Here we present a scheme to experimentally detect this process using the coincident detection of electrons and photons. For this purpose, we use a setup developed for electron-photon coincidence experiments, which has been successfully used for experiments of this kind recently.

A 5.7 Tue 16:30 P

Analysis of x-ray single-shot diffractive imaging using the propagation multislice method — •Paul Tuemmler, Björn Kruse, Christian Peltz, and Thomas Fennel — Institut für Physik, Universität Rostock

Single-shot wide-angle x-ray scattering has enabled the three-dimensional characterization of free nanoparticles from a single scattering image [1,2,3]. Key to this method is the fact, that the scattering patterns contain information of density projections on differently oriented projection planes. Wide-angle scattering typically requires XUV photon energies where absorption and attenuation cannot be neglected in the description of the scattering process [4,5].

The multislice Fourier transform (MSFT) method, which provides a fast scattering simulation within the Born approximation, can be extended to also include these propagation effects. In this presentation the performance of conventional MSFT and propagation MSFT will be discussed and compared to exact results obtained from Mie theory. As a first application, selective resonant scattering from core shell systems is explored.

[1] I. Barke , Nat. Commun. **6**, 6187 (2015).
[2] K. Sander , J. Phys. B **48**, 204004 (2015).
[3] C. Peltz , Phys. Rev. Lett. **113**, 133401 (2014).
[4] D. Rupp , Nat. Commun. **8**, 493 (2017).
[5] B. Langbehn , Phys. Rev. Lett. **121**, 255301 (2018).

A 5.8 Tue 16:30 P

X-ray induced dissociation dynamics of isoelectronic homo- and heteronuclear clusters — •Frederic Ussling[1] and Coauthors of Community Beamtime Proposal No. 2176[2] — [1]ETH Zurich, Switzerland — [2]European XFEL, Germany

With the development of X-ray free-electron lasers (FELs) high-resolution coherent diffractive imaging (CDI) of individual nanometer-sized specimen like viruses or large biomolecules within a single exposure has become possible [1]. However, the intense X-ray pulse quickly alters the target's structure and subsequent dissociation dynamics may blur the diffraction pattern thus limiting the resolution [2]. Hence, a profound understanding of the interaction between matter and intense X-rays is indispensable for an unambiguous interpretation of the data. In order to investigate the interaction of light with matter, atomic and molecular clusters can serve as an ideal testbed. In particular, neon and methane are interesting systems for a comparative study of homonuclear and heteronuclear specimen [3], since they have comparable masses and number of electrons. We studied neon and methane clusters irradiated with intense FEL pulses at 1 keV photon energy by recording the resulting ionic fragments. We find that in a certain intensity regime, the fast ejection of protons from the methane cluster strongly influences the dynamics, in line with theoretical work [3].

[1] H.N. Chapman et al., Nature 470, 73-77 (2011)
[2] R. Neutze et al., Nature 406, 752-757 (2000)
[3] P. Di Cintio et al., PRL 111, 123401 (2013)

A 5.9 Tue 16:30 P

Diffractive imaging of large neon clusters with a high harmonic generation source — •Leonie Werner[1], Bruno Langbehn[1], Alessandro Colombo[2], Ehsan Hassanpour Yesaghi[2], Andreas Hoffmann[3], Katharina Kolatzki[2], Martin Kretschmar[3], Tamás Nagy[3], Mario Sauppe[2], Bernd Schütte[3], Björn Senfftleben[3], Rudi Tschammer[4], Johannes Tuemmler[3], Marc Vrakking[3], Ingo Will[3], Thomas Möller[1], and Daniela Rupp[2,3] — [1]TU Berlin — [2]ETH Zürich — [3]MBI Berlin — [4]BTU Cottbus-Senftenberg

Coherent diffractive imaging of individual nanoparticles, such as viruses, nanocrystals or clusters, has become feasible with the intense X-ray or extreme ultraviolet (XUV) light pulses free-electron lasers provide. Only recently, the development of powerful high harmonic generation sources delivering intense harmonics up to the XUV regime enabled laboratory-based imaging experiments. The scattering of multiple harmonics leads to multicolor diffraction patterns containing information on the nanoparticle shape. In an experiment at the Max-Born-Institute, Berlin, we studied the structure of large neon clusters. By comparing simulated scattering patterns with the experimental data we identified structures typical for rare gas cluster growth by coagulation. In addition when the neon clusters are produced from the liquid phase, scattering patterns indicating facet-like structures are observed.

A 5.10 Tue 16:30 P

Angular resolved photoemission of metal atoms embedded in helium nanodroplets in the MPI regime — •Bennet Krebs, Michael Zabel, Lev Kazak, and Josef Tiggesbäumker — Institut für Physik, Universität Rostock, Germany

Angular resolved photoelectron emission spectra of single metal atoms embedded in helium nanodroplets are measured, analyzed and compared to free atoms. A femtosecond laser system provides 110 fs, linear polarised laser pulses, which are used to ionize the atomic targets in the multiphoton regime (I$\approx 10^{13...14}$W/cm^2) without ionizing the helium nanodroplet itself. Furthermore a time delay controlled two color setup with overlapping $2\omega/\omega$ (400 nm/800 nm) fields is used to probe the attosecond dynamics. For this we apply the highly sensitive Phase-of-the-Phase (PoP) method, which has been previously used to extract information about photoelectron trajectories. Compared to the anisotropic above-threshold-ionization (ATI) signals from free atoms a near isotropic emission is obtained for the embedded species. Furthermore, an enhancement of ATI signals and additional ATI orders can be observed. In the same vein we see a reduction of relative phase contrast. The impact of elastic scattering of the electrons with the surrounding helium environment will be discussed.