A 39: Interaction with VUV and X-ray light

Time: Friday 11:00–13:15 Location: f303

Invited Talk A 39.1 Fri 11:00 f303

Enhanced ionization of embedded clusters by electron transfer mediated decay in helium nanodroplets — •A. C. LaForge[1], V. Stumpf[2], K. Gokhberg[2], J. von Vangerow[1], N. V. Kryzhevoi[2], P. O'Keeffe[3], A. Ciavardini[3], S. Krishnan[4], K. C. Prince[5], R. Richter[5], R. Moshammer[6], T. Pfeifer[6], L. S. Cederbaum[2], F. Stienkemeier[1], and M. Mudrich[1] — [1]Physikalisches Institut, Universität Freiburg, 79104 Freiburg, Germany — [2]Physikalisch-Chemisches Institut, Universität Heidelberg, 69120 Heidelberg, Germany — [3]CNR - Istituto di Struttura della Materia, CP10, 00016 Monterotondo Scalo, Italy — [4]Department of Physics, Indian Institute of Technology - Madras, Chennai 600 036, India — [5]Elettra-Sincrotrone Trieste, 34149 Basovizza, Trieste, Italy — [6]Max-Planck-Institut für Kernphysik, 69117 Heidelberg, Germany

Here, we report the observation of electron transfer mediated decay involving Mg clusters embedded in helium nanodroplets which is initiated by the ionization of helium followed by removal of two electrons from the Mg clusters of which one is transferred to the He environment neutralizing it while the other electron is emitted into the continuum. The process is shown to be the dominant ionization mechanism for embedded clusters for photon energies above the ionization potential of He. The photoelectron spectrum reveals a low energy ETMD peak. For Mg clusters larger than 5 atoms we observe stable doubly-ionized clusters. We argue that ETMD provides a new pathway to the formation of doubly-ionized cold species.

A 39.2 Fri 11:30 f303

Two-photon double ionization of Neon using an intense high harmonic source — •Bastian Manschwetus[1,3], Linnea Rading[1], Fillipo Campi[1], Helene Coudert-Alteirac[1], Sylvain Maclot[1], Lahl Jan[1], Piotr Rudawski[1], Christoph M. Heyl[1], Balasz Farkas[2], Mohamed Tarek[2], Anne L'Huillier[1], and Per Johnsson[1] — [1]Department of Physics, Lund University, Box 118, SE-22100 Lund, Sweden — [2]ELI-HU Non-Profit Ltd., Dugonics tér 13, 6720 Szeged, Hungary — [3]Deutsches Elektronen-Synchrotron, Notkestrasse 85, D-22603 Hamburg, Germany

We present first results of two-photon double ionization of neon using an attosecond pulse train (APT) with an intensity of 3x1012 W/cm2 using the high-intensity high harmonic beamline at the Lund High-Power Laser Facility. It allows the efficient generation of an APT in argon or krypton with approximately 1 μJ pulse energy in a spectrum between 17 and 50 eV by loosely focusing up to 80 mJ of infrared pulse energy. Focusing the generated XUV light tightly into a Neon gas jet leads to photoionization and we detect Ne^{2+} ions with an ion time of flight spectrometer. By changing the spectral shape of the generated harmonic radiation, we can change the contribution from two different double ionization channels and get an indication if the sequential two-photon process or the direct two-photon process is dominant in our experimental conditions. The observation of two-photon double ionization shows that the beamline provides a sufficiently XUV flux to enable pump-probe experiments and we are currently implementing a time delay unit.

A 39.3 Fri 11:45 f303

Relativistic effect on x-ray multiphoton ionization dynamics of xenon atoms — •Koudai Toyota, Sang-Kil Son, and Robin Santra — Center for Free-Electron Laser Science, DESY, Notkestrasse 85, Hamburg 22607, Germany

In this talk, we further investigate the previous experimental results on charge state distribution of Xe created by X-ray free-electron laser (XFEL) pulses at 5.5 keV, which was conducted at SACLA in Japan [1]. It was found that the theoretical yields for highly charged ionic states clearly underestimate the experimental results. It was considered that these come from non relativistic treatment in theory and lack of shake-off mechanism [1]. We recently have implemented relativistic energy corrections, within perturbative approach, into our computer code, XATOM. The relativistic energy corrections introduce several effects in multiphoton multiple ionization dynamics induced by XFEL pulses. First, some Coster-Kronig channels open, which are energetically forbidden in non relativistic treatment. Second, our preliminary calculations show that a combination of relativistic treatment and resonant excitation may enhance ionization. We will present our formulation and numerical results compared with experimental data.

[1] H. Fukuzawa, S.-K. Son et al., Phys. Rev. Lett. 110. 173005 (2013).

A 39.4 Fri 12:00 f303

Dynamical Control Of Nuclear Line Shapes — •Kilian P. Heeg[1], Andreas Kaldun[1], Patrick Reiser[1], Stephan Goerttler[1], Johann Haber[2], Cornelius Strohm[2], Hans-Christian Wille[2], Rudolf Rüffer[3], Christoph H. Keitel[1], Ralf Röhlsberger[2], Thomas Pfeifer[1], and Jörg Evers[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg, Germany — [2]Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany — [3]ESRF-The European Synchrotron, Grenoble, France

Signatures in spectroscopy arise from the interference between the probing light and the field scattered by the sample. Imprinting relative phases to the two channels enables one to engineer the spectrum, e.g., by turning absorption lines into Fano profiles [1,2].

In this contribution, we report on recent experiments, in which we implemented the phase control by mechanically displacing a target of Mössbauer nuclei after its excitation with resonant x-rays.

[1] C. Ott et al., Science **340**, 716 (2013).
[2] K. P. Heeg et al., Phys. Rev. Lett. **114**, 207401 (2015).

A 39.5 Fri 12:15 f303

Phase retrieval algorithms to reveal the temporal structure of the electron photoemission from atoms and clusters. — •Tim Oelze[1], Bernd Schütte[2,3], Jan Lahl[4], Stefan Apostel[1], Arnaud Rouzée[2], Marc Vrakking[2], and Maria Krikunova[1] — [1]Berlin Institute of Technology — [2]Max Born Institut Berlin — [3]Imperial College London — [4]Lund University

Light field streaking is a very powerful technique for the temporal characterization of ultrashort extreme ultraviolet (XUV) pulses. Upon ionization of atoms by the XUV pulse the electron distribution is created as a replica of the XUV pulse. In the presence of an oscillating electric field the released electrons acquire an additional momentum i.e. become streaked by the laser dressing field. By measuring electron spectra at different time-delays between the ionizing XUV pulse and the dressing field a streaking spectrogram is then obtained. It contains information about the temporal structure of the electron photoemission. Various algorithms can be then applied to retrieve the time and energy distribution of the electron photoemission from measured spectra. In our experiment argon atoms and medium-sized clusters were ionized by intense femtosecond XUV pulses produced through the high harmonic generation (HHG) and a single-cycle terahertz (THz) field is used for streaking. In this talk an iterative and a non iterative algorithm are compared by their performance on reconstruction of the streaked spectra. A particular focus of the talk is on the discussion of data post-processing routines needed to achieve reliable reconstruction results from measured spectra.

A 39.6 Fri 12:30 f303

Nuclear excitation with x-ray free-electron lasers — •Yuanbin Wu, Jonas Gunst, Naveen Kumar, Christoph H. Keitel, and Adriana Pálffy — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, D-69117 Heidelberg, Germany

The direct and secondary nuclear excitation by an x-ray free electron laser interacting with a solid-state nuclear target is analyzed theoretically. When driven at the resonance energy, the x-ray free electron laser can produce direct photoexcitation. However, in this laser-target interaction, the dominant process is the photoelectric effect producing a cold and very dense plasma. In such a plasma, secondary processes such as nuclear excitation by electron capture may also occur [1]. We develop a realistic theoretical model to quantify the magnitude of the secondary excitation taking into account the temporal plasma dynamics after the laser pulse [2]. Numerical results show that depending on the nuclear transition energy and the temperature and charge states reached in the plasma, secondary nuclear excitation by electron capture may exceed by several orders of magnitude the direct photoexcitation, as it is the case for the 4.8 keV transition from the isomeric state of ^{93}Mo, or it can be negligible, as it is the case for the 14.4 keV Mössbauer transition in ^{57}Fe. These findings are most relevant for future nuclear experiments at x-ray free electron laser facilities.

[1] J. Gunst, Y. A. Litvinov, C. H. Keitel, and A. Pálffy, Phys. Rev. Lett. 112, 082501 (2014).

[2] J. Gunst, Y. Wu, N. Kumar, C. H. Keitel, and A. Pálffy, Physics of Plasmas 22, 112706 (2015).

A 39.7 Fri 12:45 f303

Ionization and fragmentation dynamics of molecules at high x-ray intensity — •Ludger Inhester[1,2], Kota Hanasaki[1,2], Oriol Vendrell[1,2], and Robin Santra[1,2,3] — [1]Center for Free-Electron Laser Science, DESY, Notkestrasse 85, 22607 Hamburg, Germany — [2]The Hamburg Centre for Ultrafast Imaging, Luruper Chaussee 149, 22761 Hamburg, Germany — [3]Department of Physics, University of Hamburg, Jungiusstrasse 9, 20355 Hamburg, Germany

X-ray free-electron lasers (XFELs) provide ultraintense and ultrashort x-ray pulses, which can sequentially ionize molecular samples many times. A molecule that is charged up by these many ionizations will dissociate rapidly into highly charged ion fragments. We have developed an ab-initio electronic structure toolkit, XMOLECULE [1], to describe coupled ionization and fragmentation dynamics induced by intense XFEL pulses. In this approach we solve rate equations for the electronic state populations using a kinetic Monte Carlo scheme while the nuclei are propagated classically. For all the visited electronic states transitions rates and forces on the nuclei are calculated on the fly based on the Hartree-Fock-Slater model. Our calculations show that charge rearrangement effects play an important role for the ion yield distribution. Remarkably, we also find that the total charge yield of a molecule is enhanced compared to the sum of charge yield of its constituent isolated atoms. These findings are supported by recent experiments with methyl iodide (CH3I) at LCLS.

[1] Struct. Dyn. 2, 041707 (2015).

A 39.8 Fri 13:00 f303

Non-adiabatic relaxation of multi-electronic dynamics in benzene cations — •Martin Galbraith[1], Christopher Smeenk[1], Geert Reitsma[1], Nickolai Zhavoronkov[1], Jochen Mikosch[1], Marc Vrakking[1], Oleg Kornilov[1], and Franck Lepine[2] — [1]Max-Born-Institut, Berlin, Germany — [2]Institut Lumiere Matiere, Universite Lyon 1, Villeurbanne Cedex, France

We experimentally investigate ultrafast relaxation dynamics in benzene cations. Neutral benzene molecules are ionised by XUV photons produced by high harmonic generation. At higher XUV photon energies ($\hbar\omega > 15$ eV) electron correlation effects begin to play a significant role leading to the excitation of satellite states. The relaxation dynamics of these electronic states are probed either by further excitation or ionisation with IR pulses. Previous theoretical studies predicted lifetimes for multiple states to be in the range of 10 fs. For this purpose the temporal resolution of the experiment was improved by IR pulse compression in a hollow-core fibre setup. This leads to XUV-IR cross correlations down to 6 fs. The non-adiabatic relaxation of the satellite states is found to occur on time scales of around 20 fs. The relaxation time scales accessed in this experiment have direct relevance to the recent theoretical investigations, which propose benzene as an interesting candidate for attosecond charge migration.