MO 20: Clusters III (with A)

Time: Friday 14:30–16:30 Location: N 3

Invited Talk MO 20.1 Fri 14:30 N 3

Experimental studies of Interatomic Coulombic Decay — •Till Jahnke — Goethe Universität Frankfurt, Institut für Kernphysik, Max-von-Laue-Str. 1, 60438 Frankfurt

Interatomic (or intermolecular) Coulombic Decay (ICD) has become an extensively studied electronic decay process during the last 15 years. Originally proposed by Cederbaum et al. [1] it was experimentally identified by means of different techniques [2,3,4] in the early 2000s. In ICD an excited atom or molecule deexcites by transferring its excitation energy to a loosely bound atomic neighbor and leads to the emission of an electron at that neighbor. Since that time a wealth of experimental and theoretical studies have shown that ICD is a rather common decay path in nature, as it occurs "almost everywhere" in loosely bound matter.

The talk will give a short introduction on ICD and report on recent experimental advances in the field covering time-resolved studies on the cluster size dependence of the efficiency of the decay and more detailed studies of different decaying systems.

[1] Cederbaum, L. S., Zobeley, J., and Tarantelli, F., Phys. Rev. Lett., 79, 4778 (1997). [2] Marburger, S., Kugeler, O., Hergenhahn, U., and Möller, T., Phys. Rev. Lett., 93, 203401 (2003). [3] Jahnke, T., Czasch, A., Schöffler, M. S., Schössler, S., Knapp, A. Käsz, M., Titze, J., Wimmer, C., Kreidi, K., Grisenti, R. E., Staudte, A., Jagutzki, O., Hergenhahn, U., Schmidt-Böcking, H., and Dörner, R., Phys. Rev. Lett., 93, 163401 (2004). [4] G. Öhrwall et al., PRL 93 173401 (2004)

MO 20.2 Fri 15:00 N 3

Correlated decay processes in helium nanodroplets — •Marcel Mudrich[1], Nikolay Shcherbinin[1], Aaron LaForge[1], and Robert Richter[2] — [1]Physikalisches Institut, Uni Freiburg — [2]Elettra Synchrotrone Trieste

Helium nanodroplets are commonly used as inert nanometer-sized cryo-matrices for spectroscopy of embedded atoms, molecules, and clusters. Upon irradiation with extreme-ultraviolet synchrotron radiation, though, ultrafast energy and charge exchange processes between embedded species and helium atoms or even among the helium atoms can occur. In this talk we give examples of such correlated decay processes: Interatomic Coulombic decay of pure helium droplets and Auger decay of embedded rare gas atoms.

MO 20.3 Fri 15:15 N 3

Laser initiation of the interatomic Coulombic decay process in quantum dots — •Anika Haller[1], Ying-Chih Chiang[2], Maximilian Menger[3], Emad F. Aziz[1,4], and Annika Bande[1] — [1]Helmholtz-Zentrum Berlin, Germany — [2]The Chinese University of Hong Kong, Hong Kong — [3]University of Pisa, Italy — [4]Freie Universität Berlin, Germany

The interatomic Coulombic decay (ICD) has originally been predicted as ultrafast energy transfer process between atoms and molecules. Recent studies show laser-induced ICD in paired quantum dots (QD) to be possible. We investigate a system of two GaAs QDs with two same-spin electrons each bound to one of the confining potentials. After resonant excitation of one electron by a time-dependent laser the system decays via ICD - interelectron energy transfer causes excitation of the other electron into the continuum. We show the field strength dependence of ICD from weak to strong-field intensities. The Fano peak profile shapes of the photoelectron spectra give a hint on the relative importance of ICD compared to the competing direct ionization. In addition, we study the impact of the laser focus. The electron dynamics is theoretically investigated by means of the space-resolved antisymmetrized multiconfiguration time-dependent Hartree method (MCTDH). As complementary approach we developed a state-resolved representation. We find multi-photon processes to be unimportant. Further, weak pulses display the highest ICD efficiency while direct ionization becomes less dominant. Focusing the laser on the light-absorbing QD further minimizes the probability for direct ionization.

MO 20.4 Fri 15:30 N 3

Time-resolved photoelectron spectroscopy on resonantly excited He nanodroplets — •A. C. LaForge[1], Y. Ovcharenko[2], B. Langbehn[2], O. Plekan[3], R. Cucini[3], P. Finetti[3], D. Iablonskyi[4], A. Clark[5], V. Oliver Álvarez de Lara[5], P. Piseri[6], T. Nishiyama[7], M. Di Fraia[3], C. Callegari[3], K. C. Prince[3], K. Ueda[4], F. Stienkemeier[1], M. Mudrich[1], and T. Möller[1] — [1]Universität Freiburg — [2]TU Berlin — [3]Elettra-Sincrotrone Trieste — [4]Tohoku University, Sendai — [5]EPFL, Lausanne — [6]Università di Milano — [7]Kyoto University

The ionization dynamics of helium droplets resonantly excited by intense, XUV radiation has been investigated. Depending on the intensity, the excited atoms can decay by interatomic Coulombic decay (ICD) or form a network of excited atoms which then collectively autoionize leading to nanoplasma formation [1,2]. Recently, we have extended our studies to time resolve the processes using a pump-probe technique. Using a UV laser to deplete the excited states, we observe a signal loss in the ICD signal in the photoelectron spectrum for short time delays followed by its reappearance at longer time delays (> 1 ps).

[1] Y. Ovcharenko et al., Phys. Rev. Lett. 112, 073401 (2014)
[2] A. LaForge et al., Sci. Rep. 4, 3621 (2014)

MO 20.5 Fri 15:45 N 3

Photoelectron elastic scattering probed by angle resolved X-ray photoemission from free SiO_2 nanoparticles — •Burkhard Langer, Egill Antonsson, Ina Halfpap, Jaqueline Gottwald, and Eckart Rühl — Physikatische Chemie, Freie Universität Berlin

We report on measurements of the angular distributions of photoelectrons emitted from SiO_2 nanoparticles. A beam of free nanoparticles is crossed with a beam of X-rays from the BESSY II synchrotron facility. The studies were carried out over a wide energy range above the Si 2*p* and O 1*s* absorption edges, respectively. The photoelectron angular anisotropy is found to be lower for photoemission from SiO_2 nanoparticles than the theoretical values for isolated Si and O atoms. This can be explained by elastic scattering of the outgoing electrons at neighboring atoms. We will discuss a simple model that allows us to determine the number of elastic scattering events. In addition, a Monte Carlo calculation using literature values for scattering cross sections can be applied to quantitatively describe the measured angular distributions.

MO 20.6 Fri 16:00 N 3

Tracing strong-field processes in nanoparticles in real time — •Bernd Schütte[1], Björn Thorben Kruse[2], Christian Peltz[2], Marc J. J. Vrakking[1], Arnaud Rouzée[1], and Thomas Fennel[1,2] — [1]Max-Born-Institut, Berlin — [2]Universität Rostock

Strong-field ionization of solid-density targets is fundamentally different from strong-field ionization of atoms, and can result in highly efficient absorption of laser energy. In order to understand fundamental strong-field phenomena, the investigation of isolated nanoparticles is advantageous, as energy is not dissipated into the environment, allowing one to focus on the primary laser-matter coupling mechanisms.

Here we trace the charging of Ar and Xe nanoparticles directly in the time domain by applying the recently developed ionization ignition method [1]. Seed electron generation by an intense XUV pulse allows us to temporally control the heating and ionization induced by a 1.5-ps NIR pulse, whose intensity ($I = 1.5 \times 10^{13}$ W/cm^2) is not sufficient to ionize neutral clusters. Surprisingly, we find that highly charged ions up to Xe^{15+} are produced. The average ion charge state increases exponentially during the rising edge of the NIR pulse, which is the first real-time observation of ionization avalanching. The experimental results will be compared with molecular dynamics calculations.

Our method provides new perspectives for the time-resolved investigation of strong-field phenomena in nanostructures, liquids and solids. It could e.g. be used to record the ablation of material in real time, which is relevant for practical applications such as laser machining.

[1] B. Schütte *et al.*, Phys. Rev. Lett. **116**, 033001 (2016).

MO 20.7 Fri 16:15 N 3

Photo excitation of size selected lead clusters — •Markus Wolfram[1], Stephan König[1], Franklin Martinez[2], Gerrit Marx[1], and Lutz Schweikhard[1] — [1]Ernst-Moritz-Arndt Universität, Greifswald, Deutschland — [2]Universität Rostock, Rostock, Deutschland

At ClusterTrap [1] the photodissociation of positively and negatively charged lead clusters has been investigated. In addition to monomer

evaporation we observe a further decay mode: At intermediate sizes (Pbn+, n=19-25, Pbn-, n=16-31) the main fragmentation pathway is the breaking off of a neutral heptamer, Pb*7. After preliminary experiments with a Nd:YAG laser (532nm), we plan to extend the available photon energies by use of an OPO laser system. Furthermore, by electron impact ionization of stored metal cluster cations [2] and simultaneous storage of cluster anions and electrons in the Penning Trap [3] the production of cluster cations and anions, respectively, of higher charge states has been achieved. Thus, it will be possible to extend the current studies to multiply charged lead clusters where further decay pathways are expected. In this contribution, recent modifications of the experimental setup and first results on the photo-excitation of size selected mono-anionic and cationic lead clusters will be presented.

The project is funded by the Collaborative Research Center (SFB) 652.

[1] F. Martinez et al., Int. J. Mass Spectrom. 365-366 (2014) 266 [2] L. Schweikhard et al., Hyp. Int. 99 (1996) 97 [3] A. Herlert et al., Phys. Scripta T80 (1999) 200