A 32: Collisions, scattering and correlation phenomena

Time: Thursday 14:00–16:00 Location: S HS 3 Physik

Invited Talk A 32.1 Thu 14:00 S HS 3 Physik

Time-resolved dynamics of slow photoelectrons in the rescattering regime — •Martin Ranke[1,3], Sophie Walther[1,3], Anastasios Dimitriou[1,3], Mark J. Prandolini[1], Markus Pfau[1,3], Thomas Gebert[2], Marek Wieland[1,3], Markus Drescher[1,3], and Ulrike Frühling[1,3] — [1]Institut für Experimentalphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany — [2]Max-Planck-Institut für Struktur und Dynamik der Materie, Luruper Chaussee 149, 22761 Hamburg, Germany — [3]The Hamburg Centre for Ultrafast Imaging CUI, Luruper Chaussee 149, 22761 Hamburg, Germany

Acceleration of photoelectrons with intense light fields is an essential process in strong field laser physics. When the momentum change due to the light field acceleration is large, the electrons can be decelerated and scattered from the ionic core. This process is of fundamental importance, for example, in high harmonic generation. Here, we experimentally investigate the dynamics of slow photoelectrons generated by multi-photon ionization of Xe with an infrared (IR) laser pulse using a femtosecond streak camera. The ejected photoelectrons are superimposed with an intense carrier envelope phase stable terahertz (THz) light field strong enough to allow for rescattering. We observed a strong modulation of the photoelectron momentum distribution for different phases between the THz and IR laser fields. The angular momentum distribution is measured using a velocity map imaging (VMI) spectrometer with a novel gas injection design, which provides high target gas densities while preserving its momentum resolution.

A 32.2 Thu 14:30 S HS 3 Physik

The virtual photon approximation for three-body interatomic Coulombic decay — •Robert Bennett[1,2], Petra Votavová[3], Přemysl Kolorenč[3], Tsveta Miteva[4], Nicolas Sisourat[4], and Stefan Yoshi Buhmann[1,2] — [1]Albert Ludwigs University of Freiburg, Germany — [2]Freiburg Institute for Advanced Studies (FRIAS) — [3]Charles University, Prague, Czech Republic — [4]Sorbonne Université, Paris, France

Interatomic Coulombic decay (ICD) is an ultrafast process by which energy can be exchanged between microscopic systems. Computational quantum chemistry studies of the process usually use a 'virtual photon approximation' to determine the correct long-range asymptote of the ICD rate, which is then used as a consistency check. Using the macroscopic quantum electrodynamics formalism recently presented in [1], we extend the virtual photon approach to the case of three-body ICD [2], inspired by the prediction of a novel superexchange process from ab initio quantum chemistry [3]. The system we study is that in which a passive mediating atom is placed near the donor and acceptor species — the mediator's presence turns out to substantially enhance or suppress the rate. Our approach provides simple analytic formulae for the large-distance limits of three-body ICD, and allows for the inclusion of relativistic retardation. The latter turns out to have a strong effect, causing, for example, spatial oscillations in the ICD rate.

[1] J. L. Hemmerich et al., Nat. Commun. **9**, 2934 (2018). [2] R. Bennett et al., arXiv quant-ph 1811.09489, [3] T. Miteva et al., Phys. Rev. Lett. **119**, 083403 (2017).

A 32.3 Thu 14:45 S HS 3 Physik

Two-center resonant photoionization in slow atomic collisions and strong laser fields — Alexander B. Voitkiv[1], Jacqueline Fedyk[2], Shaofeng Zhang[3], Xinwen Ma[3], and •Carsten Müller[1] — [1]Institut für Theoretische Physik I, Heinrich-Heine-Universität Düsseldorf — [2]Physikalisch-Chemisches Institut, Ruprecht-Karls-Universität Heidelberg — [3]Institute of Modern Physics, Chinese Academy of Sciences, Lanzhou, China

Photoionization of an atom A by an electromagnetic field can be strongly enhanced in the presence of a neighbouring atom B, if the latter first is resonantly photoexcited and afterwards transfers the excitation energy radiationlessly to atom A. This two-center process is known to be very efficient, when the atoms constitute a bound system and a single photon of sufficient energy is absorbed from the field. In this contribution we show that, surprisingly, two-center photoionization can also dominate in slow collisions between the atoms A and B, even though the average interatomic distance in this situation exceeds the typical size of a bound system by orders of magnitude [1]. Besides we study two-center ionization by multiphoton absorption from bichromatic laser fields. Experimentally accessible parameter domains, where the process represents the dominant ionization mechanism, are identified here as well [2].

[1] A. B. Voitkiv, C. Müller, S. F. Zhang, X. Ma, arXiv:1809.06526
[2] J. Fedyk, A. B. Voitkiv, C. Müller, Phys. Rev. A 98, 033418 (2018)

A 32.4 Thu 15:00 S HS 3 Physik

Resonance strengths for dielectronic recombination of highly charged ions and improved empirical *Z*-scaling law — •Zoltán Harman[1], Chintan Shah[1], Antonio J. González Martínez[1,2], Ulrich D. Jentschura[1,3], Hiro Tawara[1], Christoph H. Keitel[1], Joachim Ullrich[1,4], and José R. Crespo López-Urrutia[1] — [1]Max Planck Institute for Nuclear Physics, Heidelberg, Germany — [2]Instituto de Instrumentación para Imagen Molecular, Universitat Politècnica de València, València, Spain — [3]Department of Physics, Missouri University of Science and Technology, Rolla, USA — [4]Physikalisch-Technische Bundesanstalt, Braunschweig, Germany

Theoretical and experimental resonance strengths for *KLL* dielectronic recombination (DR) into He-, Li-, Be-, and B-like mercury ions are presented, based on state-resolved DR x-ray spectra recorded at the Heidelberg electron beam ion trap. The DR resonance strengths were experimentally extracted by normalizing them to simultaneously recorded radiative recombination signals. The results are compared to multiconfiguration Dirac-Fock and relativistic configuration interaction calculations that include electron correlation and mixing effects. Combining the present data with other existing ones, we derive an improved semi-empirical scaling law for DR resonance strength as a function of the atomic number Z, taking into account higher-order relativistic corrections, which are especially relevant for heavy highly charged ions. — Z. Harman *et al.,* submitted (2018); arXiv:1807.03366

A 32.5 Thu 15:15 S HS 3 Physik

Progress in Time-Resolved Interatomic Coulomb Electron-Capture by Ba^{2+} near Rb — •Axel Molle[1,2], Oriol Vendrell[3], and Annika Bande[1] — [1]Institute for Methods for Material Development, Helmholtz-Zentrum Berlin — [2]Institute for Chemistry and Biochemistry, Freie Universität Berlin — [3]Physikalisch-Chemisches Institut, Universität Heidelberg

Results of a time-resolved numerical investigation of the Interatomic Coulomb Electron Capture (ICEC) is presented. In the ICEC process, a species A captures a free electron by long-range energy transfer through Coulomb interaction to a bound electron in a neighbouring species B. From a theoretical perspective, ICEC was first predicted for atoms and molecules through scattering theory resulting in an asymptotic approximation [1], and then successfully modelled by electron dynamics in low-dimensional semiconductor systems [2]. We do, however, foresee high relevance for ICEC in the field of ultracold atoms and further the need for a full dynamics description of the process. From the experimental side, techniques for trapping ultracold ions and atom clouds are advancing. Employing MCTDH for fermions, we present progress in the electron dynamics of such an exemplary experiment of a barium(II) cation trapped in a cloud of rubidium atoms at ultracold temperatures. In contrast to the previous theoretical studies, this comprises four continuum dimensions and the Coulomb interaction in its electric dipole-dipole approximation.

[1] Gokhberg, and Cederbaum, Phys. Rev. A **82** (2010).
[2] Pont, Bande, and Cederbaum, J. Phys. Cond. Matter **28** (2016).

A 32.6 Thu 15:30 S HS 3 Physik

Novel and efficient scheme for the optical quenching of metastable helium in the 2^1S_0 state — •Jiwen Guan, Vivien Behrendt, Pinrui Shen, Simon Hofsäss, Jonas Grzesiak, Frank Stienkemeier, and Katrin Dulitz — Physikalisches Institut, Universität Freiburg, Hermann-Herder-Str.3, 79104 Freiburg i. Br.

Metastable helium in the 2^3S_1 state is the longest-lived neutral atomic state and the most energetic metastable state of an atomic species. These characteristics make this species an important source of stored energy in ionospheric and discharge plasmas. Such energetic species are excellent candidates for the study of reactive scattering processes. Recently, we have produced a supersonic beam of metastable He in an

electron-seeded discharge. However, the atomic beam also contains He in another metastable state, $2^1\mathrm{S}_0$, which prevents detailed quantum-state-controlled reactive scattering studies.

In this talk, I will describe the experimental characterization of a new optical quenching scheme which makes it possible to fully deplete the population of He($2^1\mathrm{S}_0$) via optical excitation to the $4^1\mathrm{P}_1$ state. The scheme is based on simple and inexpensive diode laser technology which can be implemented in many laboratories in a straightforward manner. I will also show preliminary results on the reactive scattering of He($2^3\mathrm{S}_1$) with a cloud of stationary, ultracold Li atoms.

A 32.7 Thu 15:45 S HS 3 Physik

Ab initio calculation of electron-impact-ionization cross sections for ions in exotic electron configurations — •John Jasper Bekx[1,2], Sang-Kil Son[1,3], Robin Santra[1,2,3], and Beata Ziaja[1,3,4] — [1]Center for Free-Electron Laser Science, Deutsches Elektronen-Synchrotron DESY, Notkestrasse 85, 22607 Hamburg, Germany — [2]Department of Physics, University of Hamburg, Jungiusstrasse 9, 20355 Hamburg, Germany — [3]The Hamburg Centre for Ultrafast Imaging, Luruper Chaussee 149, 22761 Hamburg, Germany — [4]Institute of Nuclear Physics, Polish Academy of Sciences, Radzikowskiego 152, 31-342 Kraków, Poland

We provide ab initio calculations of electron impact ionization cross sections for ions in exotic electron configurations, with the purpose of exploring their effect on ionization dynamics triggered by inelastically scattered electrons in plasmas.