A 1: Highly charged ions and their applications

Time: Monday 11:00–12:30 Location: a320

Invited Talk A 1.1 Mon 11:00 a320

Unraveling the mechanisms of single- and multiple-electron removal in energetic electron-ion collisions: from few-electron ions to extreme atomic systems. — •Alexander Borovik Jr — I. Physikalisches Institut, Justus-Liebig-Universität Gießen, 35392 Giessen, Germany

For over a half century, electron-impact ionization of ions remains an open topic in atomic physics [1]. While single-electron removal processes in light few-electron systems are currently understood and can be reliably described by theoretical approaches, ionization of many-electron ions, especially multiple ionization, are still not understood completely. In this situation, experiment, where available, is the only reliable source of information [2]. However, as we move to ions in high charge states, requirements on the experimental conditions rise, making new approaches and instrumentation necessary. In the present overview, we describe the current status in the field and report on recent activities that aim at expanding the experimental capabilities by the development of electron guns beyond the state-of-the-art and by employing large heavy-ion accelerator facilities such as FAIR [3].

[1] A. Müller, Adv. At. Mol. Phys. 55, 293 (2008). [2] D. Schury et al. J. Phys. B 53, 015201 (2019). [3] M. Lestinsky et al., Eur. Phys. J. ST 225, 797882 (2016).

A 1.2 Mon 11:30 a320

Electron-impact single ionization of W^{q+} ions: Experiment and theory for 11 ≤ q ≤ 18 — •Daniel Schury[1,2], Alexander Borovik Jr[3], Benjamin Ebinger[3,4], Fengtao Jin[3,5], Kaija Spruck[1], Alfred Müller[1], and Stefan Schippers[3] — [1]Institut für Atom- und Molekülphysik, Justus-Liebig-Universität Gießen, 35392 Giessen, Germany — [2]Institut des Nanosciences de Paris, Sorbonne Université, 75252 Paris, France — [3]I. Physikalisches Institut, Justus-Liebig-Universität Gießen, 35392 Giessen, Germany — [4]GSI Helmholtzzentrum für Schwerionenforschung GmbH, 64291 Darmstadt, Germany — [5]Department of Physics, National University of Defense Technology, 410022 Changsha, People's Republic of China

Cross sections for electron-impact single ionization (EISI) of multiply charged tungsten ions (W^{q+}) with charge states in the range 11 ≤ q ≤ 18 in the electron-ion collision energy ranges from below the respective ionization thresholds up to 1000 eV were measured using the crossed-beams method and extrapolated up to 150 keV using subconfiguration-averaged distorted-wave (SCADW) theory [1]. Ionization rate coefficients were derived from the combined experimental and scaled theoretical cross sections and compared to the data contained in the ADAS database. Significant discrepancies were found in the temperature range where the ions investigated here are expected to form in collisionally ionised plasmas. [1] D Schury *et al* 2020 *J. Phys. B: At. Mol. Opt. Phys.* **53** 015201

A 1.3 Mon 11:45 a320

Polarization effects in bound-free pair production — •Jonas Sommerfeldt[1,2], Robert Müller[1,2], Anton Artemyev[3], and Andrey Surzhykov[1,2] — [1]Technische Universität Braunschweig, Germany — [2]Physikalisch-Technische Bundesanstalt, Germany — [3]Universität Kassel, Germany

The study of electron-positron pair production in ion-ion and ion-photon collisions has a long history in accelerator physics. The bound-free e^-e^+ process is of special interest since it leads to the loss of ions from the beam. During the last decades, a large number of works has been performed to investigate the total and differential cross section of this process. In contrast, its polarization properties are way less known.

In this contribution, we present a theoretical study of bound-free e^-e^+ pair production in the interaction of γ rays with bare ions. A particular emphasis is placed on the longitudinal polarization of the produced positrons and final hydrogen-like ions. To evaluate this polarization we employed exact solutions of the relativistic Dirac equation and used first-order perturbation theory to treat the electron-photon coupling. Our results suggest that bound-free pair production can be a source of strongly polarized positrons and ions [1].

[1] J. Sommerfeldt *et al.*, Physical Review A **100**, 042511 (2019)

A 1.4 Mon 12:00 a320

FISIC - The Fast-Ion Slow-Ion Collision Experiment — •Daniel Schury[1,3], Emily Lamour[1], Stéphane Macé[1], Christophe Prigent[1], Sébastien Steydli[1], Dominique Vernhet[1], Alain Méry[2], Jean-Marc Ramillon[2], Jimmy Rangama[2], Jean-Yves Chesnel[2], Patrick Rousseau[2], Angela Bräuning-Demian[3], Alexandre Gumberidze[3], Uwe Spillmann[3], and Thomas Stöhlker[3,4,5] — [1]INSP/Sorbonne Université/CNRS UMR 7588, 75005 Paris, France — [2]CIMAP/CNRS/Université de Caen Normandie, 14032 Caen, France — [3]GSI Helmholtzzentrum für Schwerionenforschung, 64291 Darmstadt, Germany — [4]Friedrich-Schiller-Universität Jena, 07743 Jena, Germany — [5]Helmholtz Institute Jena, 07743 Jena, Germany

Ion-ion collisions in atomic physics were performed mainly in the context of magnetically confined plasmas or fast-ion/plasma-discharge experiments. Still no reliable experimental data exists for fast (MeV/u) and slow (keV/u) ion collisions in the regime where the ion stopping power is maximum and all the primary electronic processes reach their maximum, making the role of the individual processes on the collision almost impossible to disentangle, while being of high importance in ion-matter interaction. Therefore we designed a new ion-ion collision experiment, the **F**ast **I**on **S**low **I**on **C**ollisions project, a mobile experimental set-up, being able to conduct crossed beam ion-ion collisions at different high energy ion beam facilities. Today we present the current status of the set-up and performance of the low-energy branch of FISIC and present first planned experiments.

A 1.5 Mon 12:15 a320

Electron-impact single and double ionization of multiply charged xenon ions — •B. Michel Döhring[1,2], Benjamin Ebinger[1,2], Alexander Borovik Jr[1], Kurt Huber[1], Fengtao Jin[3], Alfred Müller[1], and Stefan Schippers[1] — [1]Justus-Liebig-Universität Gießen — [2]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt (Germany) — [3]Department of Physics, National University of Defense Technology, Changsha (China)

Electron-impact ionization cross sections are important for plasma physics applications, ranging from fusion research through ion thrusters. During recent years a new high-current electron gun [1] has been put into operation at the Giessen electron-ion crossed-beams experiment that extends the range of available electron-ion collision energies from previously 1 keV to now 3.5 keV. Thus, investigations of ions in charge states with ionization thresholds close to or beyond 1 keV are now possible. The present study comprises cross sections for single and double ionization of Xe^{q+} ions with $q = 12 - 14$. In addition, we have performed quantum calculations of these cross sections. Our experimental and theoretical results agree well with one another.

[1] B. Ebinger et al., 2017 Nucl. Instrum. Meth. B **408** 317.