A 26: Electron Scattering and Recombination / Interaction of Matter with Ions (with MO)

Time: Friday 10:30–12:45 Location: B 302

Invited Talk A 26.1 Fr 10:30 B 302

Electron-initiated Chemistry — Slim Chourou[1], Valery Ngassam[1], Asa Larson[2], and •Ann Orel[1] — [1]University of California, Davis, CA, USA — [2]Stockholm University, Stockholm, Sweden

Electron collisions with molecules and molecular ions that lead to dissociation play a key role in a number of environments, since they produce the radicals and molecular fragments that initiate and drive the relevant chemistries. These processes are dominated by resonances, that is, where the electron temporarily attaches to the molecule and change the forces felt between its atoms leading to a large coupling between the electron interaction with the target and the nuclear dynamics of the target. In our calculations, we carry out *ab initio* electron scattering calculations at fixed internuclear geometries to determine the resonant energy surfaces and the corresponding surface of autoionization widths, using the Complex Kohn variational method. These resonance positions and widths are then used as input to a dynamics study to determine the cross section and product distributions for the dissociation or excitation process. We will present results on a number of systems, including HCCH, HCN/HNC and HCCCN as examples of dissociative attachment, and CF^+ for dissociative recombination.

Invited Talk A 26.2 Fr 11:00 B 302

Astrophysically motivated electron collisions studies on M-shell iron ions — •Michael Lestinsky[1], Oldřich Novotný[1], Michael Hahn[1], Dietrich Bernhardt[2], Stefan Schippers[2], Alfred Müller[2], Claude Krantz[3], Manfred Grieser[3], Roland Repnow[3], Andreas Wolf[3], Nigel Badnell[4], and Daniel Wolf Savin[1] — [1]Columbia Astrophysics Laboratory, New York — [2]Institut für Atom- und Molekükphysik, Justus-Liebig-Universität, Gießen — [3]Max-Planck-Institut für Kernphysik, Heidelberg — [4]Department of Physics, University Strathclyde, Glasgow

Satellite X-ray observatories routinely observed spectroscopic features from M-shell iron ions in various cosmic sources. These observations are used to determine the properties of the observed objects. However, this requires accurate ionization balance calculations for the source which in turn necessitates reliable data for the electron-ion recombination process known as dielectronic recombination (DR) and also for electron impact ionization (EII). Utilizing the ion storage ring TSR, we are carrying out a series of energy-resolved DR and EII measurements in order to provide reliable for the astrophysics community. We compare our recent results for Fe^{11+} with modern theoretical calculations and with widely used models. Large differences are found in the low energy DR where an array of resonances enhances the measured DR by 10^2 as compared to theory. From our experimental data we derive plasma rate coefficients for both DR and EII for use in astrophysical models.

A 26.3 Fr 11:30 B 302

Finite basis set approach to the two–center Dirac problem — •Anton Artemyev and Andrey Surzhykov — Universität Heidelberg and GSI Helmholtzzentrum für Schwerionenforschung

Owing to the recent experimental advances in ion accelerator and storage ring techniques, more possibilities arise to study formation of quasi–molecules in (relatively) slow collisions of highly–charged, heavy ions. Extremely strong electromagnetic fields produced in these collisions are expected to cause a "decay" of unstable physical vacuum and a spontaneous creation of electron-positron pairs. Theoretical understanding of such an overcritical–field phenomenon requires, in general, solution of the two–center time–dependent Dirac equation. For low velocities of colliding ions this equation may still be treated adiabatically and, hence, can be traced back to the static (two–center) problem. In our work we developed an efficient method for dealing with this problem by utilizing finite basis sets constructed from B–splines. We argue that B–spline analysis can be performed most naturally in Cassini coordinates that are very efficient for the description of two–center Coulomb potential [1, 2]. To underline the advantages of the present approach, detailed calculations will be presented for quasi–molecular energy spectra obtained for slow symmetric (Z1 = Z2) as well as asymmetric (Z1 > Z2) ion–ion collisions.

[1] P. Schlüter, K.-H. Wietschorke, and W. Greiner, J. Phys. A v. 16, 1999, (1983).

[2] K.-H. Wietschorke, P. Schlüter, and W. Greiner, J. Phys. A v. 16, 2017, (1983).

A 26.4 Fr 11:45 B 302

Relativistic electron-ion recombination assisted by an intense laser field — •Carsten Müller, Alexander B. Voitkiv, and Bennaceur Najjari — Max-Planck-Institut für Kernphysik, Heidelberg

Radiative recombination of a relativistic electron with a highly charged ion in the presence of a strong laser field is considered. Various relativistic effects, arising from the high energy of the incoming electron and its strong coupling to the intense laser field, are found to clearly manifest themselves in the energy spectra of the emitted γ-photons. Moreover, characteristic shifts in the angular distributions are caused by the impact of the laser photon momentum.

[1] C. Müller, A.B. Voitkiv and B. Najjari, J. Phys. B 42, 221001 (2009)

A 26.5 Fr 12:00 B 302

Theory of higher-order resonant recombination processes in highly charged ions — •Zoltán Harman[1,2], Octavian Postavaru[1,2], Jacek Zatorski[1], and Christoph H. Keitel[1] — [1]Max-Plank-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany — [2]ExtreMe Matter Institute EMMI, Planckstrasse 1, 64291 Darmstadt, Germany

We report theoretical calculations on trielectronic recombination with simultaneous excitation of a K-shell and an L-shell electron, hence involving three active bodies. This process was identified in the x-ray emission spectrum of recombining highly charged Ar, Fe and Kr ions. For Kr^{30+}, inter-shell trielectronic recombination contributions of nearly 6% to the total resonant photorecombination rate were found [1]. We predict even higher contributions for lighter elements.

[1] C. Beilmann, O. Postavaru, L. H. Arntzen, *et al.*, Phys. Rev. A (R), **80**, 050702 (2009)

A 26.6 Fr 12:15 B 302

Measuring recoil ion momenta with high precision — •Simone Götz[1], Christoph S. Hofmann[1], Terry Mullins[2], Matthias Weidemüller[1], Alexey Sokolov[3], Wolfgang Quint[2], and Thomas Amthor[1] — [1]Universität Heidelberg, Philosophenweg 12, 69210 Heidelberg — [2]Universität Freiburg, Hermann-Herder Str. 3, 79104 Freiburg — [3]GSI Helholtzzentrum für Schwerionenforschung GmbH, Darmstadt

We present a transportable setup combining a dark SPOT (spontaneous optical trap) for Rubidium atoms with a recoil ion momentum spectrometer [1]. The very low thermal spread of the atoms in the trap, allows to measure the atom recoil momenta after interaction with photons or highly charged ions with very high precision. In collaboration with the GSI in Darmstadt we will investigate correlation effects in multiple charge transfer between the Rubidium atoms and highly charged ions.

In addition to the recoil ion momentum spectrometer with high resolution we discuss several other improvements of our setup, including enhanced optical access and a new mechanism for efficient loading of the magneto-optical trap with high flux.

[1] J. Ullrich *et al.*, J Phys. B **30**, 2971 (1997)

A 26.7 Fr 12:30 B 302

Collisions of low-energy antiprotons with He atoms — •Armin Lühr and Alejandro Saenz — Humboldt-Universität zu Berlin, Institut für Physik, Moderne Optik, Hausvogteiplatz 5-7, D-10117 Berlin

During the last two decades advances have been achieved in the understanding of antiproton ($\bar{p}$) collisions with the simplest one- and two-electron atoms H and He. However, in the case of $\bar{p}$ + He experiment and theory did not agree for impact velocities below the mean electron velocity for more than a decade stimulating a vivid theoretical activity.

Theoretical investigations for collisions of $\bar{p}$ with helium atoms in an energy range from 1 keV to 6 MeV have been performed. The He atom is described with a full two-electron approach which was recently applied in nonperturbative time-dependent calculations of $\bar{p}$ + H_2 collisions [1]. The scattering wave function is expanded in timeindependent eigenstates of the target. The impact-parameter method is employed to describe the collision process. The present results for excitation and ionization are compared to experimental as well as theoretical data highlighting persisting inconsistencies among these data. The influence of two-electron effects as well as of expansion parameters on the outcome of the calculations is discussed.

[1] A. Lühr and A. Saenz, Phys. Rev. A **80**, (Rapid Communication) (2009)