A 22: Electron scattering and recombination I

Time: Thursday 14:00–16:00 Location: BAR 106

Invited Talk A 22.1 Thu 14:00 BAR 106

Influence of two-center electronic correlations on atomic processes — •Carsten Müller, Alexander B. Voitkiv, Bennaceur Najjari, Jose R. Crespo Lopez-Urrutia, and Zoltan Harman — Max-Planck-Institut für Kernphysik, Heidelberg

When an atom is not isolated in space but close to another atom, the electronic structures at the two centers can be coupled by long-range electromagnetic interactions causing a variety of interesting phenomena. In particular, electron-ion recombination may proceed resonantly via excitation of an electron in a neighboring atom, which subsequently deexcites by photo-emission [1]. Using examples from different fields of physics, we demonstrate that this two-center dielectronic process can largely dominate over single-center radiative recombination at interatomic distances as large as several nanometers.

The corresponding time-reversed process is two-center resonant photo-ionization, where one of the reaction pathways for ionization is radiationless transfer of excitation from a neighboring atom (so-called interatomic Coulombic decay). Characteristic features are shown to arise in this process, both in its temporal development and the spectrum of emitted electrons [2].

[1] C. Müller, A.B. Voitkiv, J.R. Crespo López-Urrutia, Z. Harman, Phys. Rev. Lett. 104, 233202 (2010)
[2] B. Najjari, A.B. Voitkiv, C. Müller, Phys. Rev. Lett. 105, 153002 (2010)

A 22.2 Thu 14:30 BAR 106

Spin dynamics of electrons in strong fields studied via bremsstrahlung from a polarized electron beam — •Stanislav Tashenov[1,2,3], Torbjörn Bäck[1], Roman Barday[4], Bo Cederwall[1], Joachim Enders[4], Anton Khaplanov[1], Yuliya Poltoratska[4], Kai-Uwe Schässburger[1], and Andrey Surzhykov[3,5] — [1]Royal Institute of Technology, Stockholm, Sweden — [2]Stockholm University, Sweden — [3]Physikalisches Institut der Universität Heidelberg, Germany — [4]Institut für Kernphysik, Technische Universität Darmstadt, Germany — [5]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany

Linear polarization of the photons emitted in the process of the atomic field electron bremsstrahlung has been studied at the newly developed 100 keV polarized electron source of TU Darmstadt. A correlation between the initial orientation of the electron spin and the degree and the angle of photon linear polarization has been measured for the first time. For this purpose a hard x-ray Compton polarimeter consisting of a segmented high purity germanium detector and an external passive photon scattering target have been applied. Linear polarization sensitive Compton and Rayleigh photon scattering distributions have been sampled by the segmented detector. The observed polarization correlation reveals a precession of the electron spin as it moves in the field of the nucleus. The full-relativistic calculations for the case of radiative recombination into a Rydberg series limit have been corroborated by the measurement. The results of this experiment suggest a new method for electron beam polarimetry.

A 22.3 Thu 14:45 BAR 106

Dielectronic recombination involving two atomic centers — •Carsten Müller, Alexander B. Voitkiv, Jose R. Crespo Lopez-Urrutia, and Zoltan Harman — Max-Planck-Institut für Kernphysik, Heidelberg

In the presence of a neighboring atom, electron-ion recombination can proceed resonantly via excitation of an electron in the atom, which subsequently deexcites by photoemission. Using examples from different fields of physics, we demonstrate that this two-center dielectronic process can largely dominate over single-center radiative recombination at interatomic distances as large as several nanometers [1].

[1] C. Müller, A.B. Voitkiv, J.R. Crespo López-Urrutia, Z. Harman, Phys. Rev. Lett. 104, 233202 (2010)

A 22.4 Thu 15:00 BAR 106

Electron impact excitation of highly-charged ions — •Lalita Sharma[1,2], Andrey Surzhykov[1,2], Rajesh Srivastava[3], and Stephan Fritzsche[2,4] — [1]Physikalisches Institut der Universität Heidelberg — [2]GSI Helmholtzzentrum für Schwerionenforschung GmbH — [3]Indian Institute of Technology Roorkee, India — [4]Department of Physical Sciences, University of Oulu, Finland

During the last decade, electron impact excitation of few–electron ions has been explored intensively both at electron beam ion traps (EBIT) and ion storage ring facilities. In these studies, particular attention has been paid to the linear polarization of the subsequent characteristic photon emission. Such a (fluorescence) polarization can be used as a precise tool for the plasma diagnostic as well as for better understanding of the relativistic and many–body effects in electron-ion collisions. In this contribution, a fully–relativistic distorted–wave code was developed by us recently, and has been employed to investigate electron impact excitation of highly charged ions. Detailed calculations have been performed, in particular, for the $K \to L$ excitation of hydrogen–like Ar^{17+}, Ti^{21+} and Fe^{25+} ions for a wide range of collision energies. Apart from the total cross sections theoretical predictions were obtained for the alignment parameters of the excited ionic states and, hence, for the polarization of the characteristic Lyman–α lines. Results of our calculations are compared with the available experimental and theoretical data.

A 22.5 Thu 15:15 BAR 106

Bestimmung von Elektronenstoßionisationsquerschnitten hochgeladener Eisenionen über Ionenextraktionsmessungen an einer EBIS — •Robert Mertzig[1], Alexandra Thorn[1], Falk Ullmann[2] und Günter Zschornack[1] — [1]Institut für Festkörperphysik, Technische Universität Dresden, Germany — [2]Dreebit GmbH, Dresden, Germany

EBIS (Electron Beam Ion Source) - Ionenquellen bieten hervorragende Voraussetzungen, Atomdaten von hochgeladenen Ionen experimentell zu bestimmen. Der Beitrag beschäftigt sich mit der Bestimmung von Elektronenstoßionisationsquerschnitten für die Ionisation von Eisenionen bis hin zu Fe^{23+} im Elektronenenergiebereich von 15keV bis 20keV. Derartige Atomdaten sind z.B. für die Astrophysik und für die Verifizierung von theoretischen Ansätzen zur Beschreibung der Elektronenstoßionisation von Interesse. Zur Bestimmung der Ionisationsquerschnitte erfolgten Messungen der extrahierten Teilchenzahlen für individuelle Ionenladungszustände als Funktion der Ionisationszeit in einer EBIS-Ionenquelle des Typs Dresden EBIS-A. Aus dem zeitlichen Intensitätsverlauf für Ionenströme der vermessenen Ionenladungszustände bei verschiedenen Ionisationszeiten lassen sich Wirkungsquerschnitte für die Elektronenstoßionisation von Eisenionen bestimmen. Die Ergebnisse werden vorgestellt, mit gängigen Theorien verglichen und diskutiert. Über die Messung der Querschnitte für Eisenionen hinaus wird demonstriert, dass die verwendete Methodik geeignet ist, Elektronenstoßionisationsquerschnitte für unterschiedlichste Ionen über einen weiten Ladungsbereich zu vermessen.

A 22.6 Thu 15:30 BAR 106

Electron Impact Ionization of Small Rare Gas Clusters — •Thomas Pflüger, Xueguang Ren, Alexander Dorn, and Joachim Ullrich — Max-Planck-Institut für Kernpysik

Atomic and molecular clusters present an excellent field of investigation bridging the gap between sole constituents and macroscopic matter. Therefore, structural as well as dynamical information can contribute to the understanding of more complex systems. Kinematically complete electron impact ionization experiments at projectile energies below 100 eV were performed and differential cross sections for various kinematics could be obtained. A highly efficient advanced reaction microscope (RM) was used to detect all charged final state particles over almost the complete solid angle. The selected targets were small Argon and Neon clusters where a variety of reaction channels could be explored. The ion signals show no indication for a direct creation of a respective cluster ion with a size larger than two. Due to the selected kinematic conditions a strong involvement of the residual ionic potential in the scattering process was forced and, therefore, structural differences of the target can result in diverse scattering dynamics. Focusing on the direct single ionization of the dimer, three-fold differential 3D cross sections will be presented. They reveal enhanced out-of-plane intensities with dramatically different features over the respective atomic data.

A 22.7 Thu 15:45 BAR 106

Multiple resonances in nuclei coupling to the atomic shells —

Srinivas K. Arigapudi[1,2] and •Adriana Pálffy[2] — [1]Indian Institute of Technology Delhi, New Delhi, India — [2]Max-Planck-Institut für Kernphysik, Heidelberg, Germany

Processes at the borderline between atomic and nuclear physics open the possibility to explore properties of exotic nuclei via experiments involving highly charged ions [1]. Among these, nuclear excitation by electron capture (NEEC) [2] or nuclear excitation by electron transition (NEET) [3] are coupling nuclei to the atomic shells. In the doubly resonant process of NEET, the decay of a bound electron into a lower atomic shell leads to the excitation of the nucleus [3]. This process requires on the one hand the overlap of an atomic and nuclear resonance and on the other hand the presence of an appropriate atomic hole. Due to its resonant character, NEET can be more efficient than NEEC as nuclear excitation mechanism.

Here we investigate a scenario in which the dielectronic recombination of a free electron into a highly charged ion creates the initial hole necessary for NEET. This multiply resonant process is quite efficient not last due to the interferences that may occur involving electron recombination mechanisms and radiative electronic and nuclear transitions. The consequences of this process on nuclear state population in dense plasma environments are discussed.

[1] A. Pálffy, Contemporary Phys. 51, 471 (2010)
[2] A. Pálffy, W. Scheid, Z. Harman, Phys. Rev. A 73, 012715 (2006)
[3] S. Kishimoto *et al.*, Phys. Rev. Lett. 85, 1831 (2000)