A 41: Poster: Electron scattering and recombination

Time: Thursday 16:00–18:30 Location: Empore Lichthof

A 41.1 Thu 16:00 Empore Lichthof

Coupling Nuclei to the Atomic Shells in Stellar Environments — •Stephan Helmrich[1,2] and Adriana Pálffy[1] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg — [2]Physikalisches Institut, Universität Heidelberg, Im Neuenheimer Feld 226, 69120 Heidelberg

The role of processes coupling nuclear transitions to the atomic shells has been investigated in dense stellar plasma conditions. In particular addressed was the process of nuclear excitation by electron capture (NEEC) [1], in which the recombination of a free electron into a highly charged ion leads to the simultaneous excitation of the nucleus. In the context of isomer depletion, the role of NEEC in populating low-lying nuclear excited states under dense stellar plasma conditions has been previously investigated [2].

Here we study a different scenario, in which NEEC occurs not from the nuclear ground state but instead from highly excited states close to the neutron threshold. Such states are reached in dense astrophysical plasmas via neutron capture. The impact of such additional nuclear excitations on the neutron capture and gamma decay sequence which is relevant for s-process nucleosynthesis is investigated. Our results show that for electron fluxes typical for the s-process, NEEC does not influence the nucleosynthesis sequence. Higher plasma temperatures as typical for r-process nucleosynthesis also do not favor the coupling to the atomic shells, but rather processes like photoabsorption.

[1] A. Pálffy, W. Scheid and Z. Harman, Phys. Rev. A 73, 012715 (2006)
[2] G. Gosselin, P. Morel and P. Mohr, Phys. Rev. C 81, 055808 (2010)

A 41.2 Thu 16:00 Empore Lichthof

Electron-atom collisions studied in a MOTReMi apparatus — •Elisabeth Brühl, Natalia Ferreira, Johannes Goullon, Renate Hubele, Hannes Lindenblatt, Michael Schuricke, Alexander Dorn, and Daniel Fischer — Max-Planck Institut für Kernphysik, Heidelberg

Studying the dynamics of atomic collisions, reaction microscopes (ReMi) have been used as a powerful experimental tool for nearly two decades. ReMis make the momentum information of all collision products over the full solid angle accessible. In our experiment we combine a ReMi with a magneto-optically trapped (MOT) target of lithium atoms (MOTReMi). Due to its electronic structure with its two strongly correlated inner electrons and a single valence electron, lithium is an ideal candidate to examine electronic correlation and collision dynamics of simple few-body systems. In addition, this element has the advantage that it can be relatively easily cooled down to temperatures well below mK. One of the main technical challenges for the combination in a MOTReMi is the superposition of two magnetic fields. The inhomogeneous magnetic field of the MOT has to be switched off very fast allowing for the momentum reconstruction of the ejected electrons. The MOTReMi is currently integrated into the test storage ring (TSR) of the MPIK in Heidelberg and ion-atom collisions are observed in unprecedented details. In future experiments, an electron beam will be used as a projectile to study electron impact ionization for collision energies between 70 and 500 eV. The technical realization and the setup will be shown.

A 41.3 Thu 16:00 Empore Lichthof

Absolute Recombination Rate Coefficients Of Highly Charged Tungsten Ions — •Kaija Spruck[1], Arno Becker[2], Dietrich Bernhardt[1], Manfred Grieser[2], Michael Hahn[3], Claude Krantz[2], Michael Lestinsky[4], Alfred Müller[1], Oldřich Novotný[3], Roland Repnow[2], Daniel Wolf Savin[3], Andreas Wolf[2], and Stefan Schippers[1] — [1]Institut für Atom- und Molekülphysik, Justus-Liebig-Universität Giessen, 35392 Giessen, Germany — [2]Max-Planck-Institut für Kernphysik, 69117 Heidelberg, Germany — [3]Columbia Astrophysics Laboratory, Columbia University, New York, NY 10027, USA — [4]GSI Helmholtzzentrum, 64291 Darmstadt, Germany

Tungsten is commonly used as a material for plasma facing walls in nuclear fusion reactors as it can resist the typical high-temperatures and high neutron irradiation levels. As a result, impurities of highly charged tungsten ions in the plasma are inevitable. Radiation from these excited tungsten ions leads to plasma cooling. Modeling this cooling requires reliable ionization and recombination cross sections for tungsten ions. To date, most of the needed atomic data come from theory. Previously large discrepancies were found between experimental and theoretical values.

Here, we report electron-ion recombination experiments for highly charged tungsten ions, performed at the TSR storage ring in Heidelberg, Germany. Absolute experimental rate coefficients of W^{q+} ions with $18 \leq q \leq 21$ will be presented.

A 41.4 Thu 16:00 Empore Lichthof

Untersuchung von Ionen-Lithium Dynamik mit einem in-Ring MOTReMi — •Hannes Lindenblatt[1], Elisabeth Bruehl[1], Natalia Ferreira[1], Johannes Goullon[1], Renate Hubele[1], Aaron LaForge[2] und Daniel Fischer[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg — [2]Physikalisches Institut, Universität Freiburg

Seit der Entwicklung der Rückstoßionen-Impulspektroskopie (engl. abgekürzt COLTRIMS) sowie von Reaktions-Mikroskopen (ReMi) kann die Dynamik von atomaren Viel-Teilchen-Coulomb-Systemen z.B. bei der stoßinduzierten Fragmentation atomarer oder molekularer Targets, experimentell mit großer Akzeptanz und mit hervorragender Genauigkeit untersucht werden. Bei dieser Technik kamen bisher größtenteils Überschall-Gasjet-Targets zum Einsatz. Das einfachste atomare Target, das hierbei zu den notwendigen Temperaturen gekühlt werden kann, ist Helium, das deshalb bereits in vielen Experimenten untersucht wurde. Das nächst-komplexere Atom, Lithium, war für solche Untersuchungen bisher nicht zugänglich. In unserem Experiment haben wir ein ReMi mit einer magneto-optischen Lithium Falle (MOT) kombiniert. Dieses MOTReMi ist zur kinematisch vollständigen Untersuchung von Ion-Atom-Stößen in einen Ionenspeicherring implemetiert. Aufgrund der optischen Anregung, die in der MOT induziert wird, können erstmals auch angeregte und sogar polarisierte Targets für Stoßexperimente benutzt werden. Auf diesem Poster werden die Ergebnisse der ersten Experimente mit dem MOTReMi vorgestellt.

A 41.5 Thu 16:00 Empore Lichthof

Spectroscopic investigation of resonant recombination processes on highly charged silicon — •Thomas M. Baumann, Zoltan Harman, Christian Beilmann, Julian Stark, Paul H. Mokler, Joachim Ullrich, and Jose R. Crespo Lopez-Urrutia — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

Spectroscopic studies of inter-shell (K-L) resonant electronic recombination processes for He-like to O-like Si ions (Si^{12+} to Si^{6+}) are presented and compared to theoretical predictions obtained from MCDF and FAC calculations. These measurements were performed at the HYPER-EBIT, the new cryogenic electron beam ion trap of the MPIK. The charge state evolution and charge-breeding process in this machine was further studied using the time resolved evolution of the resonant recombination spectra. Strong contributions of higher-order recombination processes (trielectronic recombination, TR) are compared to lines resulting from first order dielectronic recombination (DR) using the strength ratio S^{TR}/S^{DR}. For electronic recombination into B-like Si ions this ratio is in agreement with theory. For C-like Si, the measured value of $S^{TR}/S^{DR} = 1,2 \pm 0,1$ is about half the theoretical value. This deviation can be explained by barely resolvable contributions from long-lived metastable states in the recombining C-like ions.

A 41.6 Thu 16:00 Empore Lichthof

The spin-orbit interaction in bremsstrahlung and its application for electron beam polarimetry — •Stanislav Tashenov[1], Torbjörn Bäck[2], Bo Cederwall[2], Anton Khaplanov[2], Kai-Uwe Schässburger[2], Roman Barday[3], Joachim Enders[3], Yulia Fritzsche[3], Andrey Surzhykov[1,4], Vladimir Yerokhin[1,4,5], and Doris Jakubassa-Amundsen[6] — [1]Physics Institute, Heidelberg University, Heidelberg, Germany — [2]Royal Institute of Technology, Stockholm, Sweden — [3]Institut für Kernphysik, Technische Universität Darmstadt, Germany — [4]GSI Helmholtzzentrum, Darmstadt, Germany — [5]Center for Advanced Studies, St. Petersburg State Polytechnical University, St. Petersburg, Russia — [6]Mathematics Institute, University of Munich, Munich, Germany

Linear polarization of hard x-rays emitted in the process of the atomic field electron bremsstrahlung was measured with a polarized electron beam. The correlation between the initial orientation of the electron spin and the angle of photon polarization has been systematically studied by means of Compton and Rayleigh polarimetry techniques applied to a segmented germanium detector. The results are in a good agreement with the fully-relativistic calculations based on Dirac theory. They are also explained classically and in a unique way manifest that due to the spin-orbit interaction the electron scattering trajectory is not confined to a single scattering plane. Bremsstrahlung polarization correlations lead to a new method of polarimetry of electron beams which is sensitive to all three components of the electron spin.

A 41.7 Thu 16:00 Empore Lichthof

First observation of correlated photons emitted by a heavy highly charged ion — •Stanislav Tashenov[1], Dariusz Banas[2], Heinrich Beier[3], Karl-Heinz Blumenhagen[3], Carsten Brandau[3,5], Alexandre Gumberidze[3,5], Tobias Habermann[3], Siegbert Hagmann[3], Pierre-Michel Hillenbrand[3], Ivan Kojouharov[3], Christophor Kozhuharov[3], Michael Lestinsky[3], Yury Litvinov[3], Shizu Minami[3], Henning Schaffner[3], Uwe Spillmann[3], Thomas Stöhlker[3,4], and Andrey Surzhykov[1,3] — [1]Physics Institute, Heidelberg University, Heidelberg, Germany — [2]Institute of Physics, Jan Kochanowski University, Kielce, Poland — [3]GSI Helmholtzzentrum, Darmstadt, Germany — [4]Helmholtz-Institut Jena, Germany — [5]ExtreMe Matter Institute EMMI, GSI, Darmstadt, Germany

Two correlated photons emitted in the process of Radiative Electron Capture (REC) into an excited state $2p_{3/2}$ of an initially bare uranium ion followed by its radiative decay were detected in coincidence. For this a relativistic beam of bare uranium ions, stored in the GSI storage ring ESR, collided with a gas target of N_2 atoms. The photons were detected by a setup of segmented large area germanium detectors. This experiment for the first time allows to determine the alignment of the states produced by REC where the recombination photon is observed. It represents a significant step towards the complete experiment of REC as well as of the photoelectric effect in time reversal.

A 41.8 Thu 16:00 Empore Lichthof

Measurement of the angular distribution of Dielectronic Recombination into highly charged Krypton ions — •Pedro Amaro[1], Christian Beilmann[1,2], René Steinbrügge[2], Chintan Shah[1], Jan K. Rudolph[2], Sven Bernitt[2], Oleksiy Kovtun[1], José R. Crespo López-Urrutia[2], and Stanislav Tashenov[1] — [1]Ruprecht-Karls-Universität Heidelberg, Germany — [2]Max-Planck-Institut für Kernphysik, Heidelberg, Germany

We report studies of the angular distribution of X-rays produced by dielectronic recombination (DR) of highly charged ions. Krypton ions in He-like through N-like charge states were generated in an electron beam ion trap, and the electron-ion collision energy scanned over a range of DR resonances exciting K-shell electrons. The subsequent photon emission was recorded both along and perpendicular to the electron beam axis. The asymmetries observed indicate an alignment of the total angular momentum vector of the intermediate excited state with respect to the electron beam propagation axis. This alignment probes the dynamics of the DR process due to the electron-electron interaction in the strong electromagnetic field of the target ion.

A 41.9 Thu 16:00 Empore Lichthof

Unexpected high strength of inter-shell trielectronic recombination — C. Beilmann[1], P.H. Mokler[1], T.M. Baumann[1], S. Bernitt[1], C.H. Keitel[1], J. Ullrich[1], Z. Harman[1,2], and •J.R. Crespo López-Urrutia[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg, Germany — [2]ExtreMe Matter Institute (EMMI), Darmnstadt, Germany

Intershell KL-LLL trielectronic recombination (TR) in highly charged ions, where a K-shell and a L-shell electron are simultaneously excited by the capture of a free one, was studied at electron beam ion traps. In our experiments and accompanying MCDF calculations, we show that these higher-order contributions to the total recombination yield grow to an unexpected strength in light and mid-heavy ions. The experimental results of TR measurements in Ar, Fe and Kr allow for the deduction of a scaling law for the TR strength in dependence of Z. In C-like ions with $Z \leq 20$, TR even dominates over the first-order dielectronic process (DR) [1]. The strong sensitivity of the TR process to eletron-electron interaction gives new experimental access to the study of inner-atomic electron correlation effects. Therefore, the importance of Breit interaction becomes measurable already for lighter ions around Fe ($Z = 26$) focussing on TR resonances. Beside this, considering the strong selection rules for TR, the measurements can be used as a proof for the importance of configuration interaction. We present theoretical considerations using the flexible atomic code as well as experimental investigations of C-like TR in iron.

[1] C. Beilmann et al., Phys. Rev. Lett. 107, 143201 (2011)