A 25: Poster: Electron scattering and recombination

Time: Tuesday 16:30–18:30 Location: Spree-Palais

A 25.1 Tue 16:30 Spree-Palais

Hyperfine-induced modifications to the $K\alpha_1$ angular distribution following the radiative electron capture into hydrogen-like ions — •Zhongwen Wu[1], Andrey Surzhykov[1], and Stephan Fritzsche[1,2] — [1]Helmholtz-Institut Jena, D-07743 Jena, Germany — [2]Theoretisch-Physikalisches Institut, Friedrich-Schiller-Universität Jena, D-07743 Jena, Germany

The angular distribution of the $K\alpha_1$ ($1s2p_{3/2}\ ^{1,3}P_{1,2} \rightarrow 1s^2\ ^1S_0$) radiation following the radiative electron capture into initially hydrogen-like ions with nonzero nuclear spin has been studied within the density matrix theory and the multiconfiguration Dirac-Fock method. Emphasis is placed especially upon the hyperfine interaction and how this interaction of the magnetic moment of the nucleus with those of the electrons affects the angular properties of the $K\alpha_1$ emission for isotopes with non-zero nuclear spin $I \neq 0$. As an example, calculations were performed for selected isotopes of helium-like Sn^{48+}, Xe^{52+} and Tl^{79+} ions. A quite sizeable contribution of the hyperfine interaction upon the $K\alpha_1$ angular emission is found for isotopes with nuclear spin $I = 1/2$, while its effect is suppressed for (most) isotopes with larger nuclear spin $I > 1/2$. We therefore expect that accurate measurements of the $K\alpha_1$ angular distributions at ion storage rings can be utilized as a tool for determining the nuclear parameters of rare stable and radioactive isotopes with $I \geq 1/2$.

A 25.2 Tue 16:30 Spree-Palais

High resolution studies of resonant electron-ion recombination processes with an electron beam ion trap — •Stepan Dobrodey[1], Sven Bernitt[1], Chintan Shah[2], Holger Jörg[2], Stanislav Tashenov[2], and José Ramon Crespo López-Urrutia[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg, Germany — [2]Physikalisches Institut, Ruprecht-Karls-Universität, Heidelberg, Germany

Dielectronic recombination (DR) is a resonant electron capture process where a free electron recombines with a highly charged ion (HCI) into an excited intermediate state, transfering its kinetic energy to a bound electron. This state subsequently decays by emission of a photon with a characteristic energy. Electron beam ion traps (EBIT) are convenient devices for investigating this process. They use a monoenergetic electron beam for the production and trapping of HCIs, and at the same time as a source of electrons for recombination. Krypton, with an atomic number of 36, shows a coupling which is intermediate between Russel-Saunders- and jj-Coupling, and therefore challenging for theoretical atomic models. Furthermore in recent years it has become clear that higher order processes, like trielectronic or quadruelectronic recombination, have also to be taken into account [1,2]. We present high resolution measurements of Kr^{28+} up to Kr^{34+} carried out at the FLASH-EBIT.

[1] Beilmann et al., Phys. Rev. Lett. 107, 143201 (2011)
[2] Beilmann et al., Phys. Rev. A 88, 062706 (2013)

A 25.3 Tue 16:30 Spree-Palais

New method of measuring metastable states for electron impact on light targets at all scattering angles — •Marvin Weyland[1,2], Alexander Dorn[1], Hans Rabus[2], Xueguang Ren[1,2], Thomas Pflüger[1,2], and Woon Yong Baek[2] — [1]Max-Planck-Institute for Nuclear Physics, Heidelberg, Germany — [2]Physikalisch-Technische Bundesanstalt, Braunschweig, Germany

We apply a new method of measuring differential cross sections for metastable atom production by electron impact. A crossed beam setup with a supersonic helium jet and a pulsed electron beam at energies close to the excitation threshold of 19.82 eV is used. Measuring the momentum vectors of the metastable atoms instead of the scattered electrons removes common restrictions to the accessible scattering angles while reaching high detection efficiency. At impact energy of 22.2 eV we can distinguish between excitation of the 2^3S-state and 2^1S- or 2^3P-state. Using a photoemission electron source we reach an impact energy resolution of 200 meV at about 1 μA peak current. Results are compared with simulations of the experiment, using convergent-close-coupling (CCC) and R-matrix-pseudo-state (RMPS) calculations of differential scattering angles. Experimental results agree best with RMPS calculations. Although used here only with helium as a target, the instrument can be used to measure excitation cross sections in many light targets.

A 25.4 Tue 16:30 Spree-Palais

Giant Effect of the Spin-Orbit Interaction in Coulomb Scattering — •Oleksiy Kovtun[1], Stanislav Tashenov[1], Valery Tioukine[2], Andrey Surzhykov[1,3,4] und Vladimir Yerokhin[1,4,5] — [1]Physikalisches Institut der Universität Heidelberg, Germany — [2]Institut für Kernphysik Johannes Gutenberg-Universität Mainz, Germany — [3]Helmholtz-Institut Jena, Germany — [4]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany — [5]Center for Advanced Studies, St. Petersburg State Polytechnical University, Russia

Coulomb scattering of an electron in the field of the nucleus is influenced by the spin-orbit interaction. Due to the orbital momentum precession the electron trajectory is not confined to a single scattering plane as evidenced by the recent bremsstrahlung experiments. In that the angle of bremsstrahlung linear polarization is correlated with the spin direction of the incoming electron [S. Tashenov PRL 107, 173201 (2011), R. Maertin PRL 108, 264801 (2012)]. In the recent experiment we found this effect to be dramatically enhanced at relativistic energies. The scattering plane was turning by as much as several tenth of degrees. The results are in agreement with the full-order relativistic calculations. For this experiment we applied the novel techniques of the pulse shape analysis of the germanium detector signals and gamma-ray Compton imaging. The principles of the Compton imaging were invented in 1973 and our experiment marked their first application in a laboratory physics experiment.

A 25.5 Tue 16:30 Spree-Palais

Polarisation measurement of Dielectronic Recombination transitions into highly charged ions — •Holger Jörg[1], Chintan Shah[1], Sven Bernitt[2], Stepan Dobrodey[2], José R. Crespo López-Urrutia[2], and Stanislav Tashenov[1] — [1]Physikalisches Institut der Universität Heidelberg — [2]Max-Planck-Institut für Kernphysik Heidelberg

We report a measurement of hard X-ray linear polarisation produced by dielectronic recombination (DR) of free electrons into highly charged krypton ions. The ions in the He-like through O-like charge states were produced in an electron beam ion trap, FLASH-EBIT. The electron beam energy was adjusted to the maxima of well-resolved K-shell DR resonances. The X rays emitted during radiative stabilization at an energy of 13 keV were registered by a novel Compton polarimeter. This instrument uses an X-ray scattering target and an array of silicon detectors for sampling the azimuthal scattering angular distribution. The preliminary analysis indicates a large degree of linear polarisation of the DR X rays. These results can be used to benchmark atomic calculations, and can also be applied for polarisation diagnostics of hot astrophysical and laboratory fusion plasmas.

A 25.6 Tue 16:30 Spree-Palais

Observation of alignment in Dielectronic and Trielectronic recombination — •Chintan Shah[1], Pedro Amaro[1], René Steinbrügge[2], Sven Bernitt[2], Zoltan Harman[2,3], Stephan Fritzsche[4,5], Andrey Surzhykov[4,5], José Ramón Crespo López-Urrutia[2], and Stanislav Tashenov[1] — [1]Physikalisches Institut, Heidelberg, Germany — [2]Max-Planck-Institut für Kernphysik Heidelberg, Germany — [3]ExtreMe Matter Institute, Darmstadt, Germany — [4]Helmholtz-Institut, Jena, Germany — [5]GSI, Darmstadt, Germany

The photon angular distributions in dielectronic and trielectronic recombination with a K-shell excitation were systematically studied with highly charged ions. Fe and Kr ions in the He-like through O-like charge states were produced in an electron beam ion trap, and the electron beam energy was scanned over the dielectronic and trielectronic recombination resonances. Improving on earlier work [1, 2], the photons emitted from the decay of the resonance states were simultaneously recorded by two germanium detectors which were mounted both along and perpendicular to the electron beam axis. The measured anisotropy of photon emission indicates the alignment of the total angular momentum of each resonance state with respect to the beam axis. The results can be used to benchmark atomic calculations, and can be applied for polarization diagnostics of hot laboratory fusion and astrophysical plasmas.

[1] C. Beilmann et al., Phys. Rev. Lett. 107, 143201 (2011)
[2] C. Beilmann et al., Phys. Rev. A 88, 062706 (2013)

A 25.7 Tue 16:30 Spree-Palais

Development of novel Rayleigh and Compton polarimeters — •Stanislav Tashenov — Physikalisches Institut der Universität Heidelberg

To study fundamental processes in atomic collisions and perform polarisation diagnostics of hot fusion and astrophysical plasmas we develop a broad range of polarisation sensitive x-ray detectors. Two detectors are based on Silicon PIN diodes and Silicon Drift Detectors and dedicated to the energy range of 10-30 keV. This is the lowest energy range that was accessed by the Compton and Rayleigh polarimeters. For the energy range of 30 keV - 2 MeV we use a segmented planar germanium detector. It employs a novel technique of Pulse Shape Analysis of the detector signals for a 3D sensitivity to the positions of the x-ray interactions. With this detector we for the first time employed the techniques of Compton Imaging and background reduction in a laboratory physics experiment. It also achieved the polarisation resolution of 0.3 deg which is the record for Compton polarimetry. To improve this further we develop a high resolution polarimeter that is based on a rotationally symmetric annular planar segmented germanium detector.

A 25.8 Tue 16:30 Spree-Palais

Electron impact ionization of ultra-cold lithium — •Michael Schuricke, Elisabeth Brühl, Johannes Goullon, Renate Hubele, Hannes Lindenblatt, Alexander Dorn, and Daniel Fischer — Max Planck Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

Collisions of simple atomic systems with photons or charged particles and the correlated motion of the ejected electrons are among the most fundamental yet challenging problems in quantum dynamics. In this regard Li is particularly interesting due to the strongly correlated K-shell electrons and the loosely bound valence electron. Thus, ionization dynamics can be probed for very different regimes of initial-state correlation. As it also marks the next step in complexity compared to He, it is an ideal test case to extend the theoretical methods developed for that system to more complex systems.

To study electron impact ionization of Li an electron gun was implemented in a combination of a magneto-optical trap (MOT) and a Reaction Microscope (ReMi), which records the momenta of all charged particles created over the full solid angle. Despite the incompatible magnetic field geometries of the MOT (quadrupole field) and electron detection in a ReMi (constant field), the MOTReMi allows for coincident detection of ions and electrons with unprecedented resolution.

Here, we will present results on single and double ionization of lithium at an electron energy of 500 eV. In the future the electron energy will be reduced toward the double ionization threshold, where the final state is governed by the correlation of the charged particles.

A 25.9 Tue 16:30 Spree-Palais

A single particle detector for electron-ion collision experiments in the Cryogenic Storage Ring — •Kaija Spruck[1], Claude Krantz[2], Arno Becker[2], Alfred Müller[1], Oldřich Novotný[3], Stephen Vogel[2], Andreas Wolf[2], and Stefan Schippers[1] — [1]Institut für Atom- und Molekülphysik, Justus-Liebig-Universität Gießen — [2]Max-Planck-Institut für Kernphysik, Heidelberg — [3]Columbia Astrophysics Laboratory, New York, USA

The study of ion chemistry in the interstellar medium requires, among others, knowledge about cross sections for the recombination of atomic and molecular ions with low temperature ($\sim$ 10 K) electrons. Especially the database on singly charged atomic ions relevant to the chemistry of molecular clouds is incomplete in this respect. The electrostatic Cryogenic Storage Ring (CSR), currently being commissioned at the Max-Planck-Institute for Nuclear Physics in Heidelberg, will allow experiments with atomic, molecular and cluster ions at beam energies up to 300 keV per unit charge in a cryogenic extremely high vacuum (XHV) environment. Collisions of stored atomic ions with electrons provided by an electron cooler will lead to reaction products with charge states that differ from those of the parent particles. The detection of these products will be carried out behind a bending deflector of the storage ring by a high-efficiency movable single-particle detector, based on a secondary electron converter backed by heatable microchannel plates. The designs of the mechanical actuator and the detector are compatible with the cryogenic operating conditions at 10 K and a bakeout temperature of up to 530 K.

A 25.10 Tue 16:30 Spree-Palais

Spin dynamics in photoelectric effect — •Stanislav Tashenov[1], Holger Jörg[1], Darius Banas[2], Heinrich Beier[3], Carsten Brandau[3], Alexandre Gumberidze[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], Andrey Surzhykov[3,4], and Sergiy Trotsenko[3] — [1]Physics Institute, Heidelberg University, Germany — [2]Institute of Physics, Jan Kochanowski University, Kielce, Poland — [3]GSI Helmholtzzentrum, Darmstadt, Germany — [4]Helmholtz-Institut Jena, Jena, Germany

Atomic photoelectric effect is the dominant mechanism in which matter absorbs electromagnetic radiation ranging from visible light up to gamma rays. At relativistic energies its dynamics must be influenced by the spin-orbit interaction – the spin of the photoelectron should precess in the field of the nucleus. However, such spin dynamics was never evidenced in the photoelectric effect. Here we show its first experimental observation. The photo effect was studied in a time-reverse process of Radiative Recombination (RR) of quasi-free electrons into the $2p_{3/2}$ state of H-like uranium ion. The RR x-ray was detected in a coincidence with the Lyα decay x-ray. This is the first observation of the correlated x-rays emitted by a heavy ion. The experiment revealed how the total orbital momentum of the final state is correlated with the directions of the incoming electron and the emitted photon.