A 9: Electron scattering and recombination

Time: Monday 16:30–18:00 Location: V57.05

A 9.1 Mon 16:30 V57.05

Parity violation in the radiative electron capture of H-like heavy ions — •Jonas Gunst[1,2] and Andrey Surzhykov[1,2] — [1]Universität Heidelberg — [2]GSI Helmholtzzentrum, Darmstadt

Measurements of parity-violation (PV) effects in atomic systems attract considerable attention as a valuable tool for testing of the Standard Model in the low-energy regime. In the past, however, most of these PV experiments have dealt with neutral atoms. Much less attention was paid to highly-charged heavy ions which are alternative and very promising candidates for atomic PV studies. Most of the proposals for PV-experiments with such heavy few-electron species still require the application of spin-polarized ion beams and/or of circular polarization x-ray measurements. These experimental tasks, however, cannot be easily accomplished today. In this contribution, therefore, we propose and discuss a new method for observing the PV effects in highly-charged ions. The method employs the measurement of a *linear* polarization of the photons emitted due to the radiative electron capture (REC) into the $1s2p\,^3P_0$ state of unpolarized helium-like heavy ions. For such a scenario, significant mixing of opposite-parity levels 2^3P_0 and 2^1S_0 may manifest itself in the rotation of the polarization out of the reaction plane that can be observed by the present-day solid-state detectors. In order to describe this PV-induced rotation, a theoretical model has been developed within the framework of the density matrix approach and relativistic Dirac equation. Detailed calculations have been performed for relativistic collisions of unpolarized (initially) hydrogen-like Gadolinium ions with an electronic target.

A 9.2 Mon 16:45 V57.05

Angular correlations in radiative cascades following resonant electron capture — •Oliver Matula[1,2], Stephan Fritzsche[2,3], and Andrey Surzhykov[1,2] — [1]Physikalisches Institut, Universität Heidelberg, D-69120 Heidelberg — [2]GSI Helmholtzzentrum für Schwerionenforschung, D-64291 Darmstadt — [3]Department of Physical Sciences, University of Oulu, FI-90014 Oulu

Dielectronic recombination (DR) into highly charged ions has been studied intensively in the last decades, both in experiment and theory. Whereas in the past these studies dealt mainly with the total DR rates, much of today's interest is focused on the angular properties of the characteristic x-ray photons. The angle-resolved investigations provide a unique tool to probe relativistic, many-body and QED effects in heavy atoms. For example, a strong E1-M2 multipole mixing in the radiative cascades following K-LL DR of U^{91+} has been recently identified by analyzing the angular distribution of the emitted hypersatellite (HS) photons. Apart from the *individual* HS and satellite (S) transitions, mixing phenomena may also significantly affect the angular correlations *between* the characteristic photons. In this contribution, we present a theoretical study of the γ-γ angular correlations for DR of highly charged ions, based on a density matrix approach and relativistic Dirac's theory. Within this framework, we pay special attention to nondipole effects in the expansion of the electron-photon interaction. To illustrate these effects, detailed calculations will be presented for K-LL DR of (initially) hydrogenlike Xe, Au and U ions. Work is supported by the Helmholtz Gemeinschaft (Nachwuchsgruppe VH-NG-421).

A 9.3 Mon 17:00 V57.05

Dissociative recombination of NH^+: collision energy dependence of atomic product states — •Bian Yang[1,2,4], Oldřich Novotný[1,3], Max Berg[1], Dennis Bing[1], Henrik Buhr[1,6], Christian Domesle[1], Wolf D. Geppert[5], Florian Grussie[1], Claude Krantz[1], Mario Mendes[1], Christian Nordhorn[1], Daniel Wolf Savin[3], Dirk Schwalm[1,6], and Andreas Wolf[1] — [1]MPI, MPIK, D-69117 Heidelberg, Germany — [2]IMP, CAS, Lanzhou 730000, People's Republic of China — [3]Columbia Astrophysics Laboratory, Columbia University, New York 10027, USA — [4]Graduate University of CAS, Beijing 100049, People's Republic of China — [5]Molecular Physics, Stockholm University, SE-10691 Stockholm, Sweden — [6]Weizmann Institute of Science, 76100 Rehovot, Israel

The dissociative recombination (DR) of NH^+ has been experimentally investigated at the storage ring TSR of the MPIK in Heidelberg, using fast merged ion and electron beams. A newly developed mass sensitive imaging detector enabled us to map the branching ratios over collision energies E_d = 0 - 12 eV showing unprecedented detail. Fragment ground states, $N(^4S^o)$ + $H(^2S)$, are almost not populated at all collision energies covered. At $E_d < 0.02$ eV, product channels $N(^2D^o)$ + $H(^2S)$ and $N(^2P^o)$ + $H(^2S)$ dominate at nearly equal fractions. For $E_d > 0.02$ eV additional product channels become energetically accessible. Their branching ratios display rich structure highly sensitive to collision energy. We combine the branching ratios with an independently measured total absolute DR rate coefficient, providing partial rate coefficients towards particular atomic product states.

A 9.4 Mon 17:15 V57.05

Spin phenomena in the Kapitza-Dirac effect — •Sven Ahrens, Heiko Bauke, Carsten Müller, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

The prediction of the Kapitza-Dirac effect [1], which is the diffraction of electrons by a standing wave of light, has been confirmed experimentally in recent years [2, 3]. The laser intensities, which were used in these experiments, are far below the highest intensities attainable with modern laser facilities and laser pulses with shorter wavelength are available today. These new developments call for a relativistic treatment of the Kapitza-Dirac effect, also accounting for spin effects. We determine the time-evolution of the electron wavefunction by solving the Dirac equation. The relativistic dynamics is compared with corresponding results of the Pauli equation.

[1] P. L. Kapitza, P. A. M. Dirac, Proc. Cambridge Philos. Soc. **29**, 297–300 (1933)
[2] D. L. Freimund, K. Aflatooni, H. Batelaan, Nature **413**, 142–143 (2001)
[3] P. H. Bucksbaum, D. W. Schumacher, M. Bashkansky, Phys. Rev. Lett. **61**, 1182–1185 (1988)

A 9.5 Mon 17:30 V57.05

Polarimetry of electron beams by means of bremsstrahlung — •Stanislav Tashenov[1], Torbjörn Bäck[2], Roman Barday[3], Bo Cederwall[2], Joachim Enders[3], Anton Khaplanov[2], Yulia Poltoratska[3], Kai-Uwe Schässburger[2], and Andrey Surzhykov[1,4] — [1]Physikalisches Institut Universität Heidelberg, Germany — [2]Royal Institute of Technology, Stockholm, Sweden — [3]Institut für Kernphysik, Technische Universität Darmstadt, Germany — [4]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany

The dominant photon emission process in electron-atom collisions, bremsstrahlung has long been considered to be sensitive to the spin of the electron [1]. However only recently experimental studies in this direction became possible. The first measurement of the correlation between the orientation of the electron spin and photon linear polarization in bremsstrahlung will be presented [2]. The particular attention will be given to the applications of this technique for polarimetry of electron beams. The results of the proof-of-principle measurement will be presented.

[1] H.K. Tseng and R.H. Pratt PRA 7 (1973) 1502
[2] S. Tashenov et al., PRL 107 (2011) 173201

A 9.6 Mon 17:45 V57.05

Overlapping resonances and interference in nuclei coupling to the atomic shell — 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

A new aspect of electron recombination into highly charged ions (HCI) involving the coupling of the atomic shell to the nucleus in the process of nuclear excitation by electron transition (NEET) is investigated. In NEET, a bound electronic decay transition occurs with the simultaneous excitation of the nucleus, provided that the energies of the atomic and nuclear transition match [1]. Our scenario involves the resonant process of dielectronic capture (DC) into HCI to create the electronic hole needed for NEET. HCI present the advantage that the atomic level energies are very sensitive to the ion charge state and offer the possibility to optimize the match between atomic and nuclear transition energies. The NEET probability can thus be enhanced by several orders of magnitude compared to neutral atoms. The total and interference cross section terms for the processes of radiative and dielectronic recombination, DC followed by NEET and γ decay and nuclear excitation by electron capture (NEEC) followed by γ decay were deduced and their magnitude investigated for the case of ^{237}Np [2]. Our results show that NEEC may be the most important contribution to the total recombination cross sections in HCI and that the interference terms, although small, are still larger than the NEET cross section.

[1] S. Kishimoto *et al.*, Phys. Rev. Lett. 85, 1831 (2000).
[2] S. K. Arigapudi and A. Pálffy, arXiv:1109.2894 (2011).