SYIB 1: Fast Ion Beams in Nuclear, Atomic and Molecular Physics Research I

Time: Tuesday 10:30–12:30 Location: V55.22

Invited Talk SYIB 1.1 Tue 10:30 V55.22

Nuclear physics with stored highly-charged radioactive ions — •Yuri Litvinov — GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt — Max-Planck Institut für Kernphysik, Heidelberg

Investigations with stored highly-charged radionuclides are presently possible at two storage ring facilities. These facilities are the experimental storage ring ESR at GSI in Germany and the cooler-storage ring CSRe at IMP in China.

Storage ring mass spectrometry is a powerful tool to address rare nuclear species with tiny production rates. Large-scale explorations of the nuclear mass-surface have been done in the last years providing a vast information for nuclear structure investigations.

Beta-decay of highly-charged ions can presently be only studied with storage rings. Such measurements are of direct importance in nuclear astrophysics, since in hot stellar environments the atoms are highly-ionized. Another important reason is that the decays of well-defined quantum systems, such as one-electron ions, where the interactions with other bound electrons are excluded, can be investigated.

New experiments are inevitably connected with new technical developments. For instance, a novel highly-sensitive resonant Schottky pick-up detector has been commissioned in the ESR and CSRe.

The physics motivation, the techniques, recent experiments, and the main results will be discussed. Plans for future experiments at the ESR, CSRe as well as at the future FAIR facility will be outlined.

Invited Talk SYIB 1.2 Tue 11:00 V55.22

High Precision Laser Spectroscopy at the Storage Ring ESR — •Wilfried Nörtershäuser — Institut für Kernchemie, Johannes Gutenberg-Universität Mainz, 55099 Mainz — GSI Helmholtzzentrum für Schwerionenforschung, 64291 Darmstadt

The Experimental Storage Ring (ESR) at GSI Darmstadt has proven to be a versatile tool for laser spectroscopy of highly charged ions and relativistic ion beams. During the last years, laser spectroscopy concentrated on experiments with relativistic lithium ions and the search for the hyperfine transition in lithium-like bismuth $^{209}Bi^{80+}$. The former aimed at an improved test for time dilation in Special Relativity, whereas the hyperfine transition will allow for a test of QED in highly charged ions. Both experiments have recently been successful and the latest results will be presented.

Invited Talk SYIB 1.3 Tue 11:30 V55.22

Storage-ring measurements of hyperfine-induced one-photon transitions in highly charged ions — •Stefan Schippers — Instiut für Atom- und Molekülphysik, Justus-Liebig-Universität Gießen

Hyperfine quenching in atoms and ions is the shortening of excited-state lifetimes by the interaction of the electron shell with the magnetic moment of the atomic nucleus. A particularly drastic hyperfine quenching effect is observed in alkaline-earth-like and, in general, divalent atoms and ions (with valence shell n) where the first excited level above the ground state is the $ns\,np\,^3P_0$ state. A total electronic angular momentum of $J = 0$ for this level makes a single-photon decay to the $(ns)^2\ ^1S_0$ ground state impossible. However, a nucleus with nonzero spin induces a mixing of the $ns\,np\ ^3P_0$ level with its neighboring $ns\,np\ ^3P_1$ state via the hyperfine interaction. In Be-like ions, calculated hyperfine induced (HFI) lifetimes of the $2s\,2p\ ^3P_0$ level decrease from about 3000 s to a few μs with increasing nuclear charge.

Accurate measurements of such long lifetimes require an experimental environment where the ions can be stored for sufficiently long times without external perturbations. The only laboratory measurements of HFI lifetimes in multiply charged ions were carried out at the heavy-ion storage ring TSR of the Max-Planck-Institute for Nuclear Physics in Heidelberg. In the talk, I will describe the experimental method which makes use of fast ion beams and state-selective, resonant electron-ion recombination. The experimental results will be compared with theoretical calculations, which — in particular for Be-like ions – are extremely sensitive to electron-correlation effects.

Invited Talk SYIB 1.4 Tue 12:00 V55.22

Low-Temperature Molecular Recombination from fast Electron and Ion Beams — •Oldrich Novotny — Columbia Astrophysics Laboratory, New York, USA — Max-Planck-Institute for Nuclear Physics, Heidelberg, Germany

Dissociative recombination (DR) of molecular ions plays a key role in controlling the composition and charge density of cold interstellar clouds. Experimental DR data are required in order to understand the chemical network in clouds and related processes such as star formation in the clouds. Needed data include reaction cross sections and also the chemical composition and excitation states of the neutral products. With the TSR storage ring in Heidelberg, Germany, we are measuring DR for astrophysically important molecular ions. We use a merged electron-ion beams technique to generate high-quality phase-space cooled, stored ion beams. This is combined with event-by-event fragment counting and fragment imaging. The neutral product count rate yields the absolute DR rate coefficient. Imaging the distribution of fragment separations provides information on the kinetic energy released and the states of both the initial molecule and the final products. Fragmentation channels are identified from the fragment-mass combination within each dissociation event. Such information is essential for studies on DR of polyatomic ions with multi-channel multi-fragment breakup. In this talk we will demonstrate these experimental capabilities on the recent DR results. Future experiments on the new cryogenic electrostatic storage ring CSR will be discussed.