MS 8: Precision Mass Spectrometry

Time: Thursday 10:30–12:30 Location: U A-Esch 2

Invited Talk MS 8.1 Thu 10:30 U A-Esch 2

Penning-Trap Mass Spectrometry of the Heaviest Elements with SHIPTRAP — •Oliver Kaleja[1,2,3], Brankica Andjelić[4,5], Olesya Bezrodnova[6,7], Klaus Blaum[1], Michael Block[2,3,5], Stanislav Chenmarev[2,6], Premaditya Chhetri[3,8], Christian Droese[9], Christoph E. Düllmann[2,3,5], Martin Eibach[3,9], Julia Even[4], Sergey Eliseev[1], Pavel Filianin[1], Francesca Giacoppo[3,5], Stefan Götz[2,3,5], Yuri Gusev[6], Manuel Gutiérrez[10], Frank Herfurth[3], Fritz-Peter Hessberger[3,5], Nasser Kalantar-Nayestanaki[4], Jadambaa Khuyagbaatar[3,5], Jacques J.W. van de Laar[2,5], Mustapha Laatiaoui[5], Steffen Lohse[2,5], Natalia Martynova[6,7], Enrique Minaya-Ramirez[11], Andrew Mistry[3,5], Tobias Murböck[3], Yuri Novikov[6,7], Sebastian Raeder[3], Daniel Rodriguez[10], Fabian Schneider[2,5], Lutz Schweikhard[9], Peter Thirolf[12], and Alexander Yakushev[3,5] — [1]MPIK Heidelberg — [2]JGU Mainz — [3]GSI Darmstadt — [4]KVI-CART/Univ. Groningen — [5]HI Mainz — [6]PNPI KI Gatchina — [7]SPbSU St. Petersburg — [8]TU Darmstadt — [9]Univ. Greifswald — [10]Univ. de Granada — [11]IPN Orsay — [12]LMU München

Superheavy elements (Z≥104) owe their very existence to an enhanced stability resulting from nuclear shell effects. Direct high-precision Penning-trap mass spectrometry (PTMS) in this region can provide indispensable knowledge on the nuclear binding energy of these elements. This will eventually help to constrain theoretical predictions for the so-called island of stability, a region of long-lived nuclides expected around Z=114-126, N=184. However, due to their low production rates, PTMS of these elements requires the highest levels of efficiency and sensitivity. In a beam-time campaign in 2018, recent developments at SHIPTRAP allowed us to extend PTMS to heavier and more exotic nuclides with production rates as low as one ion per minute. For the first time, direct mass spectrometry of ^{251}No, ^{254}Lr and the superheavy nuclide ^{257}Rf (Z=104) were performed using the Phase-Imaging Ion-Cyclotron Resonance technique. The latter allowed to directly resolve the low-lying isomeric states ^{251m,254m}No and ^{254m,255m}Lr from their ground states. In this contribution an overview of the recent measurements will be given.

MS 8.2 Thu 11:00 U A-Esch 2

Improved ion thermalization and preparation with the cryogenic buffer-gas stopping cell of SHIPTRAP — •Francesca Giacoppo[1,2], Brankica Andelić[1,3], Klaus Blaum[4], Michael Block[1,2,5], Premaditya Chhetri[6], Christian Droese[7], Christoph E. Düllmann[1,2,5], Martin Eibach[2,7], Julia Even[3], Stephan Götz[1,2,5], Nasser Kalantar-Nayestanaki[3], Oliver Kaleja[2,4,5], Mustapha Laatiaoui[1,2,5], Andrew K. Mistry[1,2], Enrique Minaya Ramirez[8], Tobias Murböck[1,2], Sebastian Raeder[1,2], Lutz Schweikhard[7], and Peter G. Thirolf[9] — [1]HIM Mainz — [2]GSI Darmstadt — [3]KVI-CART, RU Groningen — [4]MPIK Heidelberg — [5]JGU Mainz — [6]TU Darmstadt — [7]Univ. Greifswald — [8]IPN Orsay — [9]LMU München

During summer 2018 direct mass measurements of very heavy elements such as ^{251}No (Z=102), ^{254}Lr (Z=103) as well as the first superheavy element ^{257}Rf (Z=104) have been successfully achieved, for the first time, with the SHIPTRAP mass spectrometer. Such challenging experiments face the problem of very low production rates, down to few ions per hour(s) and demand a very efficient ion preparation and manipulation. In particular the ion thermalization after production and prior to transfer to the Penning traps is the most crucial step. The latter is achieved slowing down the ions into a buffer-gas stopping cell. In this talk the latest optimization of the recently implemented SHIPTRAP cryogenic buffer-gas stopping cell and its enhanced performance in term of efficiency and purity will be presented.

MS 8.3 Thu 11:15 U A-Esch 2

Improving the laser ablation ion source at SHIPTRAP — •Brankica Andelić[1,2], Michael Block[2,3,4], Premaditya Chhetri[3,5], Holger Dorrer[2,4], Christoph Düllmann[2,3,4], Julia Even[1], Francesca Giacoppo[2,3], Nasser Kalantar-Nayestanaki[1], Oliver Kaleja[2,3,6], Andrew Mistry[2,3], Tobias Murböck[2,3], Sebastian Raeder[2,3], Fabian Schneider[2,4], and Klaus Blaum[6] — [1]KVI-CART, RU Groningen — [2]HI Mainz — [3]GSI Darmstadt — [4]JG University Mainz — [5]TU Darmstadt — [6]MPIK Heidelberg

One of the possible approaches to determine the neutrino mass is to study the electron capture process where the nucleus decays by capturing an atomic electron and emitting an electron neutrino. Its calorimetrically measured energy spectrum allows to investigate the electron neutrino mass in the sub-eV range if the Q-value of this decay is known with sufficient precision. To eliminate systematic uncertainties, an independent determination of the Q-value is necessary and can be achieved only using Penning-trap mass spectrometry.

The Penning-trap mass spectrometer SHIPTRAP coupled to a laser ablation ion source allows mass measurements with the required precision. To enable measurements on rare isotopes, the laser ablation and injection of the ions have to be efficient. Therefore, we capture the laser-ablated ions in a gas-filled miniature Radio-Frequency Quadrupole that was recently implemented. In this contribution, an overview of the technical developments and optimization of the laser ion source will be given.

Invited Talk MS 8.4 Thu 11:30 U A-Esch 2

Comissioning of and Preparations for First Experiments at CRYRING@ESR — •Michael Lestinsky — GSI Helmholtzzentrom für Schwerionenforschung GmbH, Darmstadt, Germany

The CRYRING@ESR project has been started about six years ago by moving and mordernizing the original parts of the former Stockholm-installation of the low-energy heavy-ion storage ring CRYRING to Darmstadt. Installed behind ESR, the synergy of the combined facilities yields access to a hitherto unavailable low-energy-domain and intensity for heavy, highly charged ions in isotopically pure beams with well-defined charge state and quantum level.

The project is quickly progressing towards full operation as an experimental facility and first measurements will already be performed in 2019. A prospective research program on unique experiments has been initiated and first new experiments are becoming available. These include e.g. atomic collisions spectroscopy in strong fields of high-Z atoms, nuclear physics at the Coulomb barrier and p-process nucleosynthesis, furthermore also materials science with surface modifications and biophysics.

This talks shall give an overview of the CRYRING@ESR facility, it*s performance, status, and a glimpse at the future experiments.

MS 8.5 Thu 12:00 U A-Esch 2

Studying of the position-sensitive resonant Schottky cavity — •Dmytro Dmytriiev[1], Shahab Sanjari[1], Yuri Litvinov[1,2], and Thomas Stöhlker[1,3] — [1]GSI Helmholtzzentrum für Schwerionenforschung, 64291 Darmstadt, Germany — [2]Max-Planck-Institut für Kernphysik, 69117 Heidelberg, Germany — [3]Helmholtz-Institut Jena, 07743 Jena, Germany

Studying the r-process in stellar environment, that leads to the creation of elements heavier than 56-Fe, remains one of the fundamental questions of modern physics and therefore an active field of research within nuclear astrophysics. Apart from other key measurables like neutron capture cross section and decay lifetimes, nuclear masses are of outmost importance for pinpointing the r-process using theoretical and experimental approaches. Exotic nuclides which participate in the r-process due to their low production yield and short half-life can efficiently be investigated in storage rings. Due to the low signal level the detectors should be very sensitive and fast. Resonant Schottky cavity pickups fulfill such requirements. Apart from their applications in the measurements of beam parameters, they can be used in non-destructive in-ring decay studies of radioactive ion beams. In addition, position sensitive Schottky pick-up cavities can enhance precision in the isochronous mass measurement technique. The goal of this work is to construct and test such a position sensitive resonant Schottky cavity pickup based on theoretical calculations and simulations. A brief description of the detector and its application in mass and lifetime measurements will be provided in this contribution.

MS 8.6 Thu 12:15 U A-Esch 2

Electron-ion merged beam experiments at the Cryogenic Storage Ring (CSR) — •Daniel Paul[1], Patrick Wilhelm[1], Oldřich Novotný[1], Sunny Saurabh[1], Ábel Kálosi[1,3], Klaus Blaum[1], Manfred Grieser[1], Robert von Hahn[1], Claude

Krantz[1], Holger Kreckel[1], Daniel Zajfman[2], and Andreas Wolf[1] — [1]Max Planck Insitute for Nuclear Physics, Heidelberg, Germany — [2]Weizmann Institute of Science, Rehovot, Israel — [3]Visitor from Charles University of Prague, Czech Republic

Molecules up to water and organic species are produced in binary collisions in the cold interstellar medium (ISM), i.e. at ambient temperatures of $\approx 10 - 100$ K. They influence the cooling of gas clouds and the formation of stars and planets. One of the key molecular reactions in the ISM is dissociative recombination (DR). Laboratory studies on DR are needed for understanding molecular evolution in space.

The cryogenic storage ring (CSR) provides a nearly perfect environment for DR studies at ISM-relevant conditions. With internal wall temperatures of 6 K most stored molecular ions radiatively cool to their rovibrational ground state. Moreover, a technically challenging, low-energy electron cooler was recently implemented into CSR that allows to perform electron-ion merged beam experiments in a cryogenic environment. Here we report on its electron cooling capabilities as well as on first rovibrational-state-selected DR rate coefficient measurements.