MS 6: New Developments

Time: Wednesday 14:00–15:45 Location: MS-H9

Invited Talk MS 6.1 Wed 14:00 MS-H9

PUMA: nuclear structure with low-energy antiprotons — •Alexandre Obertelli — Technische Universität Darmstadt

Nuclear halos are a fascinating manifestation of quantum physics. They belong to a subset of low-density clustering for which most of the probability to find the halo nucleon extends to a region of space that is classically forbidden. Their properties show universal aspects of few-body systems such as scaling laws. Advances in the production of radioactive isotope beams give access to loosely-bound neutron-rich systems at the nuclear driplines, where halos are found.

Low-energy antiprotons offer a very unique sensitivity to the neutron and proton densities in the tail of the nuclear density. Such studies with stable nuclei at ELENA, CERN, and with short-lived nuclei at ISOLDE, CERN, are the motivation of the recently-accepted experiment PUMA (antiProton Unstable Matter Annihilation). The concept, sensitivity and status of the experiment will be introduced.

MS 6.2 Wed 14:30 MS-H9

A novel transportable PI-ICR Penning-trap mass spectrometer — •D. Lange[1,2], M. Door[1], S. Eliseev[1], P. Filianin[1], J. Herkenhoff[1], K. Kromer[1], A. Rischka[1], Ch. Schweiger[1], and K. Blaum[1] — [1]Max-Planck-Institut for Nuclear Physics, Heidelberg, Germany — [2]Heidelberg University, Heidelberg, Germany

The new, transportable PILOT-trap (Phase-Imaging Located in One Transportable-trap) experiment aims to measure masses of short-lived nuclides with low production rates and half-lives down to 100 ms with relative uncertainties of about 10^{-8}. This should be realised with a Penning-trap based modified buffergas cooling and PI-ICR technique [1]. In order to deal with the low production rates of some isotopes a modified dynamic buffer gas cooling technique is used in only a single measurement trap. Therefore a fast piezo valve is being developed, which enables a fast and precisely timed helium injection into the Penning-trap, followed by a fast helium release to be directly able to measure in the same trap. This increases the overall efficiency by also avoiding the transport. The setup is situated in the warm bore of a 6T superconducting cryocooled magnet which ensures transportability to different radioactive beam facilities. Here, mass measurements of e.g. rare superheavy nuclides become possible contributing to nuclear physics and the search for the island of stability, see e.g. [2]. The current status as well as the developed dynamic cooling method of this experiment are presented.

[1] Eliseev, S. et al., Phys. Rev. Lett. 110, 082501 (2013).
[2] Block, M. et al., Nature 463, 785-788 (2010).

MS 6.3 Wed 14:45 MS-H9

New developments in radiation-detected resonance ionization towards the heaviest actinides — •Jessica Warbinek[1,2], Brankica Anđelić[1,3], Michael Block[1,2,4], Premaditya Chhetri[1,4], Arno Claessens[5], Rafael Ferrer[5], Francesca Giacoppo[1,4], Oliver Kaleja[1,6], Tom Kieck[1,4], EunKang Kim[2], Mustapha Laatiaoui[2], Jeremy Lantis[2], Andrew Mistry[1,7], Danny Münzberg[1,2,4], Steven Nothhelfer[1,2,4], Sebastian Raeder[1,4], Emmanuel Rey-Herme[8], Elisabeth Rickert[1,2,4], Jekabs Romans[5], Elisa Romero-Romero[2], Marine Vandebrouck[8], and Piet Van Duppen[5] — [1]GSI Helmholtzzentrum für Schwerionenforschung, Germany — [2]Johannes Gutenberg-Universität, Mainz, Germany — [3]KVI-CART, Groningen, The Netherlands — [4]Helmholtz Institut Mainz, Germany — [5]KU Leuven, IKS, Belgium — [6]Universität Greifswald, Germany — [7]TU Darmstadt, Germany — [8]CEA Saclay, France

Laser spectroscopy can be a powerful tool to get insight into atomic and nuclear structures of exotic elements such as the heavy actinides. However, commonly applied techniques often lack the required sensitivity as most of these nuclides are very short-lived and can only be produced in atom-at-a-time quantities. The efficient and sensitive RAdiation-Detected Resonance Ionization Spectroscopy (RADRIS) method enabled the first laser spectroscopy of nobelium and it was recently applied to study a chain of fermium isotopes. To expand this technique for the search of atomic levels in the heaviest actinide, lawrencium (Z=103), the sensitivity of the setup needs to be further improved. Therefore, a new movable double-detector setup was developed, which allows an enhancement in the overall efficiency by about 60 % compared to the single-detector design. Further development work was performed to enable the study of shorter-lived (<1 s) and longer-lived (>1 h) nuclides with the RADRIS method. The most recent results on the commissioning of the new setup will be presented.

MS 6.4 Wed 15:00 MS-H9

Commissioning and status of a gas-jet apparatus for laser spectroscopy of the heaviest elements — •Jeremy Lantis[1,2], Julian Auler[1], Michael Block[1,2,3], Premaditya Chhetri[4], Arno Claessens[4], Christoph E. Düllmann[1,2,3], Rafael Ferrer[4], Francesca Giacoppo[2,3], Magdalena Kaja[1], Oliver Kaleja[1,3,5], Tom Kieck[3], Nina Kneip[1], Sandro Kraemer[4], Mustapha Laatiaoui[2,3], Nathalie Lecesne[6], Vladimir Manea[6,7], Danny Münzberg[1,2,3], Steven Nothhelfer[1,2,3], Jekabs Romans[4], Herve Savajols[6], Simon Sels[4], Matou Stemmler[1], Dominik Studer[1], Barbara Sulignano[8], Piet Van Duppen[4], Marine Vandebrouck[8], Thomas Walter[9], Jessica Warbinek[1,3], Felix Weber[1], and Klaus Wendt[1] — [1]Johannes Gutenberg University Mainz, 55099 Mainz, Deutschland — [2]Helmholtz Institute Mainz, 55099 Mainz, Germany — [3]GSI Helmholtzzentrum für Schwerionenforschung GmbH, 64291 Darmstadt, Germany — [4]KU Leuven, Instituut voor Kern- en Stralingsfysica, B-3001 Leuven, Belgium — [5]Max-Planck-Institut für Kernphysik, 69117 Heidelberg, Germany — [6]Grand Accélérateur National d'Ions Lourds, 14000 Caen, France — [7]Laboratoire de Physique des 2 Infinis Irène Joliot Curie, 91400 Orsay, France — [8]CEA Saclay, 91190 Saclay, France — [9]TU Darmstadt, 64289 Darmstadt, Germany

Laser spectroscopy measurements can provide information about fundamental properties of both atomic and nuclear structure. These techniques are of particular importance for the heaviest actinides and superheavy elements, where atomic data are sparse. Recent resonance ionization spectroscopy experiments at GSI, Darmstadt have focused on in-gas-cell measurements using the RADRIS technique, with success measuring several nobelium and fermium isotopes. However, the resolution of these measurements is limited by collisional and Doppler broadening and cannot be applied to isotopes with half-lives shorter than one second. Simultaneously, work has been performed at KU Leuven performing laser spectroscopy on atoms in a hypersonic jet, allowing for high resolution measurements in an almost collision-free and reduced Doppler broadening environment. A new gas- jet apparatus has been constructed combining the sensitivity of the RADRIS technique with the resolution of in-gas jet spectroscopy to overcome these limitations. Commissioning experiments have been performed using thulium and dysprosium to optimize the experimental conditions, ensuring that the achievable resolution is sufficient for planned online experiments with nobelium. The most recent results will be presented.

MS 6.5 Wed 15:15 MS-H9

Efficiency measurements of in-gas-jet resonance ionization spectroscopy — •Julian Auler[1], Michael Block[1,2,3], Premaditya Chhetri[4], Arno Claessens[4], Rafael Ferrer[4], Magdalena Kaja[1], Tom Kieck[3], Nina Kneip[1], Jeremy Lantis[1,2], Vladimir Manea[5,6], Danny Münzberg[1,2,3], Steven Nothhelfer[1,2,3], Sebastian Raeder[2,3], Jekabs Romans[4], Simon Sels[4], Matou Stemmler[1], Dominik Studer[1], Piet Van Duppen[4], Jessica Warbinek[1,3], Felix Weber[1], and Klaus Wendt[1] — [1]Johannes Gutenberg-Universität Mainz, 55099 Mainz, Germany — [2]Helmholtz Institute Mainz, 55099 Mainz, Germany — [3]GSI Helmholtzzentrum für Schwerionenforschung GmbH, 64291 Darmstadt, Germany — [4]KU Leuven, Institutuut voor Kern- en Stralingsfysica, B-3001 Leuven, Belgium — [5]Laboratoire de Physique des 2 Infinis Irène Joliot Curie, 91400 Orsay, France — [6]Grand Accélérateur National d'Ions Lourds, 14000 Caen, France

We present a new gas-jet experiment intended to study optical transitions of the heaviest elements at the Separator for Heavy Ion reaction Products (SHIP) at GSI, Darmstadt. The novel aspect of the gas-jet experiment is the extraction of previously stopped and neutralized heavy ions in a well-defined, low-temperature, homogeneous, hypersonic gas-jet. Laser resonance ionization spectroscopy is performed in the gas jet, yielding high spectral resolution due to reduced Doppler broadening. Considering the limited production rate of heavy ions at on-line facilities, such as GSI, a high total efficiency is a crucial requirement for the gas-jet experiment. The overall efficiency can be factorized into different contributions, like the injection of heavy ions into the setup, the ion transport efficiency, the re-evaporation efficiency, the efficiency of resonance ionisation and the detector efficiency. Additionally, for radioactive elements the losses due to decay have to be taken into account. Efficiency measurements are performed with both stable and radioactive samples. The results of the efficiency measurements will be presented.

MS 6.6 Wed 15:30 MS-H9

Sympathetic cooling of single ions in a Penning trap using a self-cooled electron plasma — •Jost Herkenhoff, Menno Door, Sergey Eliseev, Pavel Filianin, Kathrin Kromer, Daniel Lange, Alexander Rischka, Christoph Schweiger, Sven Sturm, and Klaus Blaum — Max-Planck-Institut für Kernphysik, 69117 Heidelberg, Germany

The amazing evolution of precision in recent Penning-trap experiments is driving the need for ever-improving cooling techniques. In this talk, the prospect of a new sympathetic cooling technique using an electron-plasma coupled to a single ion is presented. Utilizing the synchrotron-radiation of electrons in a strong magnetic field enables cooling to very low motional quantum numbers, almost to their ground state. Using a common-resonator, the motion of this self-cooled electron plasma can be coupled to a single ion stored in a spatially separated Penning trap, allowing sympathetic cooling of all modes of the ion. The extremely low expected temperatures in the milllikelvin range open up an exciting new frontier of measurements in Penning traps.