MS 9: Resonance Ionization Mass Spectrometry

Time: Thursday 14:00–16:00 Location: U A-Esch 2

Invited Talk MS 9.1 Thu 14:00 U A-Esch 2

Precision Spectroscopy of Boron Atoms — •Bernhard Maass[1], Jason Clark[2], Thomas Hüther[1], Phillip Imgram[1], Simon Kaufmann[1], Kristian König[1], Jörg Krämer[1], Jan Krause[1], Alessandro Lovato[2], Peter Müller[2], Krzysztof Pachucki[3], Mariusz Puchalski[3], Robert Roth[1], Rodolfo Sánchez[4], Guy Savard[2], Robert Wiringa[2], and Wilfried Nörtershäuser[1] — [1]IKP, TU Darmstadt, DE — [2]ANL, Lemont, IL, USA — [3]University of Warsaw, PL — [4]GSI Darmstadt, DE

We report on the first determination of the nuclear charge radius of stable boron isotopes by resonance ionization mass spectrometry (RIMS). By combining high-resolution measurements of the isotope shift in an atomic ground state transition and high-accuracy *ab initio* mass-shift calculations of the five-electron system, the difference in the mean-square charge radius between the stable isotopes ^{10,11}B can be extracted. The result is then used to benchmark new *ab initio* nuclear structure calculations using the no-core shell model and Greens-Function Monte Carlo approaches. In near future, collinear laser spectroscopy will be performed in the same transition on the short-lived (770 ms) proton halo candidate ^{8}B at Argonne National Laboratory. The difference in mean-square charge radius will deliver a model-independent test of its proton halo character.

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MS 9.2 Thu 14:30 U A-Esch 2

On-line results from ISOLDE's Laser Ion Source and Trap LIST — •Reinhard Heinke[1], Valentin Fedosseev[2], Bruce Marsh[2], Sebastian Raeder[3], Sebastian Rothe[2], and Klaus Wendt[1] — [1]Institute of Physics, JGU Mainz — [2]EN Department, CERN — [3]HIM Mainz

Laser resonance ionization today is a well-established core technique for efficient and highly selective radioactive ion beam production at the worldwide leading facilities. Nevertheless, in experiments demanding highest beam purity, suppression of beam contaminations from competing ionization processes inside the hot ion source cavity is essential. Corresponding techniques therefore imply spatial separation of the high temperature atomization region from a fully shielded clean and cold laser ionization volume located inside an RFQ ion guide structure: The Laser Ion Source and Trap LIST.

Derived from previous operation experiences, systematic off-line studies and simulations, a next generation of the LIST went on-line at ISOLDE in 2018. Highly pure ^{22}Mg beams were provided for measurements on its super-allowed branching ratio and half-life. Exceptional contamination suppression of up to a factor of 10^6 was shown. Moreover, the LIST unit undergoes additional tests to eventually further increase its performance: Using high-resistance cavity materials and a LIST body of well adapted length as field-free drift volume also enables time-of-flight operation mode with shortest ion bunches and offers the possibility for subsequent beam purification by laser pulse synchronized ion beam gating. Implementation at ISOLDE is in progress.

MS 9.3 Thu 14:45 U A-Esch 2

Automated Grating-Tuned Intra-Cavity Doubled Ti:Sapphire Laser for Fast Element Switching in RIMS — •Felix Weber, Vadim Gadelshin, Dominik Studer, Tom Kieck, and Klaus Wendt — Johannes Gutenberg Universität, Mainz

Laser resonance ionization mass spectroscopy is a versatile technique for efficient and selective ionization, used for atomic and nuclear physics studies of exotic species as well as for elemental ultra-trace analysis. This technique uses the unique atomic energy level systems for a multi-step ionization scheme in combination with mass spectrometry for selection of the isotope of interest. All lanthanide elements can be easily and efficiently ionized by two-step excitation schemes using second harmonic generation (SHG) of Ti:sapphire laser light. An automated grating-tuned laser with intra-cavity second harmonic generation provides high output power up to 1W over a wavelength range from 375 nm to 475 nm with a single BBO crystal. The combination of grating tuning with closed loop operation of the SHG piezo actuator allows rapid switching between different excitation wavelengths. The successive addressing of a specific element in one sample with switching times of just a few seconds has been demonstrated on mixtures of nine lanthanide elements. The properties of the laser system, excitation scheme development and results for a successive extraction of a single lanthanide from the mixture will be discussed.

MS 9.4 Thu 15:00 U A-Esch 2

Highly selective 2-step ionization schemes for analyis of actinide mixture — •Nina Kneip, Dominik Studer, and Klaus Wendt — Institute of Physics, JGU Mainz

In order to perform ultra trace analysis of radionuclides in environmental samples based on resonance ionization mass spectrometry (RIMS), efficient and highly element-selective laser excitation schemes are required. To analyze different all-relevant actinides within a single sample during one measurement, simple and versatile 2-step ionization schemes were developed at the Mainz Atomic Beam Unit. The use of fully automated grating assisted Ti:sapphire lasers featuring intracavity SHG allow for an easy instantaneous change of the ionization scheme and therefore the element of interest during the measurement. The new ionization schemes were tested in synthetic actinide mixture containing actinide cocktails consisting of 10^{16} uranium atoms, 10^{12} plutonium atoms and 10^{12} americium atoms.

Transitions between different quantum states are constrained by optical dipole transition selection rules. Thus, for even isotopes as e.g. ^{244}Pu, with $J = 0$ at the ground state and nuclear spin of $I = 0$, the J of the final auto-ionizing state was determined using different relative polarization of the incident laser beams. Exploiting this dependence also opens up an additional path to discriminate even Z isotopes against interfering background.

MS 9.5 Thu 15:15 U A-Esch 2

TOF-SIMS and resonant laser-SNMS analysis for isotope ratio measurements on insulators — •Hauke Bosco[1], Martin Weiss[1], Manuel Raiwa[1], Klaus Wendt[2], and Clemens Walther[1] — [1]Institute of Radioecology and Radiation Protection, Leibniz University Hannover — [2]Institute of Physics, Johannes-Gutenberg University Mainz

Radionuclides can interact with natural minerals via, e.g., sorption or incorporation. It is a key interest of radioecology to determine binding strengths and preferred sorption sites. Static SIMS is a well-suited and quasi non-destructive technique for measuring these properties by imaging spatial correlations of radionuclides with different mineral phases. By bombarding the surface with highly energetic ions, atomic and ionic fragments are ejected from the surface. The composition and distribution of isotopes is analyzed subsequently by MS. Isobaric interferences, however, can hinder precise isotope identification, as is the case for Pu-241 and its radioactive daughter isotope Am-241. Instead of analyzing the sputtered secondary ions, the secondary neutrals are resonantly post ionized by absorbing the light of precisely tuned lasers, selecting one element only (so called resonant laser secondary neutral mass spectrometry, rl-SNMS). While the spatial resolution of the sputter process of typically down to 70 nm is retained, isobaric interferences can be suppressed by several orders of magnitude. However, many of the samples of interest, e.g. the aforementioned minerals, are nonconducting, causing surface charging during the analysis. At the IRS such a setup has been developed and successfully tested.

MS 9.6 Thu 15:30 U A-Esch 2

In-situ extraction and TOF-SIMS-characterization of uranium-containing particles — •Paul Hanemann, Hauke Bosco, Martin Weiss, Manuel Raiwa, Laura Leifermann, and Clemens Walther — Institute of Radioecology and Radiation Protection, Leibniz University Hannover

Uranium bearing particles are omnipresent in the environment. However, they can be of natural or anthropogenic origin. Thus, identification poses a challenge. By combining SEM, EDX and micromanipulation, single particles are separated from the sample and deposited on um-diameter tungsten needles. The method does not require any sample preparation. Non-destructive mapping of elemental composition and isotopic ratios is performed by static time-of-flight secondary-ion mass-spectrometry (TOF-SIMS). This technique combines lateral resolution on the 100nm scale with ultratrace sensitivity and minimal invasiveness. A commercial IONTOF instrument has been modified and

improved at the IRS [1, 2]. A broad spectrum of forensic data, including particle morphology and isotopic fingerprints of single particles was obtained. Extraction of uranium-containing particles was successfully performed on samples from the Chernobyl exclusion zone. The isotopic ratios of U-235, U-236 and U-238 were determined by TOF-SIMS measurements on the extracted particles. Comparing the obtained results to published data gives information on the origin and history of the particles. After the analysis, particles remain intact and are available for further experiments. [1] Franzmann et al., DOI: 10.1039/C7JA00423K [2] Franzmann et al., DOI: 10.1016/j.ijms.2017.10.003

MS 9.7 Thu 15:45 U A-Esch 2

MELISSA at CERN-MEDICIS: current status and recent results — •Vadim Gadelshin[1], Vincent Barozier[2], Roberto Formento Cavaier[3,4,5], Valentin Fedosseev[2], Ferid Haddad[3,4], Bruce Marsh[2], Thierry Stora[2], Dominik Studer[1], Felix Weber[1], and Klaus Wendt[1] — [1]Johannes Gutenberg-Universität Mainz — [2]CERN, Switzerland — [3]GIP ARRONAX, France — [4]SUBATECH, Nantes University, France — [5]Advanced Accelerator Applications, Novartis Group, France

2018 was the first operational year of the CERN-MEDICIS facility, which aims for a regular production of 500 MBq batches of innovative medical radionuclides. During this year, several important milestones were achieved: the production of a high specific activity of Er-169, the delivery of Tb-149 and Tb-155 for medical R&D to members of the MEDICIS Collaboration, successful tests of new types of highly efficient production targets, and Machine Development runs, preparing future upgrades.

The first year of the operation confirmed the necessity to optimize the output to reach a high separation efficiency and a best possible purity. As an effect, the construction and installation of the MEDICIS Laser Ion Source MELISSA were strongly boosted.

In the talk, the current status of the MELISSA is introduced. An overview on the accomplished work as well as the ongoing and planned activities is presented. Key benefits of the laser ion source are highlighted, possible modifications for the design of the target ion source unit are discussed. (EU H2020 grant #642889 MEDICIS-PROMED)