MS 1: Heavy and Superheavy Elements

Time: Monday 15:00–16:30 Location: HS 2 Chemie

Invited Talk MS 1.1 Mon 15:00 HS 2 Chemie

Recent technical developments and precision mass measurements at Isoltrap — •Christoph Schweiger for the ISOLTRAP-Collaboration — Max-Planck-Institut for Nuclear Physics, Heidelberg, Germany — CERN, Geneva, Switzerland

The Isoltrap experiment [1] is a multi-ion-trap mass spectrometer located at ISOLDE/CERN for high-precision mass measurements of artificially produced, short-lived, exotic radionuclides far from stability. Experimentally, Isoltrap uses multi-reflection time-of-flight and Penning-trap mass spectrometry for absolute and relative mass measurements. Following Einstein's famous mass-energy equivalence, $E = mc^2$, the measured masses can be related to nuclear binding energies which reflect the underlying interactions and structure in the nucleus. Knowledge of the binding energies therefore allows the study of nuclear structure and nuclear astrophysics while precise mass measurements have also applications in fundamental physics such as neutrino or weak interaction studies.

In this contribution, the experimental setup, recent technical developments such as the commissioning of a linear Paul trap for mass-selective re-trapping [2], as well as selected results from recent beamtimes will be presented. These include the neutron-deficient ^{97,98}Cd ground states in vicinity of the self-conjugate doubly-magic ^{100}Sn and the high-lying 25/2+ isomer ^{97n}Cd as well as the first mass measurements of the neutron-rich ^{209,210,212}Hg.

[1] Lunney, D. et al., J. Phys. G: Nucl. Part. Phys. 44, 064008 (2017)
[2] Dickel, T. et al., J. Am. Soc. Mass Spectrom. 28, 1079 (2017)

MS 1.2 Mon 15:30 HS 2 Chemie

Mass Measurements of Actinides at TRIGA-Trap — •Tanvir Sayed[1], Klaus Blaum[1], Michael Block[2,3], Burcu Cakirli[1], Stanislav Chenmarev[1], Christoph Düllmann[2,3], Szilard Nagy[1], and Dennis Renisch[2,3] — [1]Max-Planck-Institut für Kernphysik, Heidelberg, DE — [2]Helmholtz-Institut Mainz, DE — [3]Department Chemie - Standort TRIGA, Mainz, DE

TRIGA-Trap is a high-precision, double Penning-trap mass spectrometer. Masses of actinides including ^{244}Pu, ^{241}Am, ^{243}Am, ^{248}Cm, and ^{249}Cf have been measured using the Phase-Imaging Ion-Cyclotron-Resonance (PI-ICR) technique with parts-per-billion precision [1]. The precise mass measurements allow to explore nuclear structure through trends in mass filters, such as S_{2n} (two-neutron separation energies) and $\delta V_{p,n}$ (average p-n interaction of the most loosely-bound two nucleons), as well as their differentials. Measurements of nuclei in the neutron-deficient Pu isotopic chain – ^{238}Pu, ^{239}Pu, ^{240}Pu, and ^{242}Pu – are in preparation to enhance the current dataset and complement ongoing nuclear structure studies. In particular, the shell evolution with increase in neutron number N towards the N=152 sub-shell closure for proton number Z=94 can be investigated, and the predictive capabilities of nuclear shell models for heavy, deformed nuclei can be assessed. In this talk, an overview of the current status of the experiment, as well as future directions, will be discussed.

References: [1] S. Chenmarev, K. Blaum, M. Block et al. Masses of transuranium nuclides measured with the PI-ICR technique at TRIGA-Trap. Eur. Phys. J. A 60, 204 (2024).

MS 1.3 Mon 15:45 HS 2 Chemie

Analysis and quantification of a transcurium breeding solution after intense neutron irradiation at ORNL via RIMS — •Sebastian Berndt[1], Christoph E. Düllmann[1,2,3], Raphael Hasse[1], Andrea T. Loria Basto[1,2], Christoph Mokry[1,2], Thorben Niemeyer[1], Sebastian Raeder[2,3], Dennis Renisch[1,2], Jörg Runke[1,3], Samantha K. Schrell[4], Matou Stemmler[1], and Klaus Wendt[1] — [1]Johannes Gutenberg University Mainz, Mainz, Germany — [2]Helmholtz-Institut Mainz, Mainz, Germany — [3]GSI, Darmstadt, Germany — [4]Oak Ridge National Laboratory, Oak Ridge, TN, USA

The High Flux Isotope Reactor at Oak Ridge National Laboratory produces trans-Cm samples through intense neutron irradiation. The expected isotope yields are modeled, but these models require experimental benchmark data. In this context, a trans-Cm sample was characterized using α- and γ-spectrometry as well as Resonance Ionization Mass Spectrometry (RIMS) for an isotopically resolved determination of the Np, Pu, Am, Cm and Cf content. Such a characterization of the isotopic composition of a mixed actinide solution by α- and γ-spectrometry can be difficult due to large differences in the half-lives of the individual nuclides ranging from a few up to 10^7 years. In addition, the individual α- or γ-lines of several nuclides overlap. In contrast, RIMS is an efficient and, due to the ionization process, element-selective technique with the capability of resolving the elemental and isotopic composition avoiding such disadvantages. The results of the combined approach of classical radioanalytics and RIMS will be presented.

MS 1.4 Mon 16:00 HS 2 Chemie

Status and prospects for laser spectroscopy with RADRIS — •Kenneth van Beek for the SHE Laser-Collaboration — TU Darmstadt — GSI Helmholtzzentrum für Schwerionenforschung GmbH

The experimental determination of atomic and nuclear properties such as atomic energy levels, ionization potentials, electromagnetic moments, trends in mean-square charge radii, and isotope shifts for nuclei in the region of heavy actinides ($Z \geq 100$) remains limited. The main challenges are low production rates in accelerator facilities and the short half-life of the fusion products. This necessitates the use of highly efficient and selective laser spectroscopy techniques. At GSI-FAIR in Darmstadt, Germany, the **RA**diation **D**etected **R**esonance **I**onization **S**pectroscopy (RADRIS) apparatus has been succesfully used to study aforementioned properties in $^{245,246,248-250,254}$Fm and $^{252-255}$No.

This contribution deals with the latest results with RADRIS, which include laser spectroscopy of $^{152-154}$Tm and, for the first time, of ^{152}Tm. Here, the isotope shift was measured in three different optical transitions. These results are discussed in particular with regard to a planned search for atomic levels in the chemical element Md (Z=101), for which Tm is the chemical homolog.

MS 1.5 Mon 16:15 HS 2 Chemie

High precision laser ionisation spectroscopy with JetRIS at GSI — •Alexandre Brizard for the SHE Laser-Collaboration — GANIL, CEA/DRF-CNRS/IN2P3, Caen, France

Resonance Ionization Spectroscopy (RIS) probes the atomic structure through multi-step laser ionization of neutralised atoms. When performed in a hypersonic gas jet, the technique's precision is enhanced by minimizing Doppler and pressure broadening [1].

At the SHIP velocity filter at GSI, JetRIS utilizes ion guiding and filament neutralization to inject the fusion products into the gas jet [2]. The photoions are studied using an alpha detector for efficient detection with low background. Future upgrades include an MR-ToF-MS, enabling mass-selected ion detection and access to long-lived as well as beta-decaying nuclides.

Following online commissioning in 2022, which revealed a transport efficiency of about 0.2% [3], significant effort has been put in improving the extraction and neutralisation of ions from the stopping gas cell. This work is being carried out in collaboration with KU Leuven.

Here we present the latest developments on the setup in preparation for the beamtime in February 2025.

[1] R. Ferrer et al., Nat Commun, 8, 14520 (2017)
[2] S. Raeder et al., NIMB, 463, 272-276 (2020)
[3] J. Lantis et al., Phys. Rev. Research 6, 023318 (2024)