MS 1: Precision Mass Spectrometry

Time: Monday 11:00–13:00 Location: HS 3042

Invited Talk MS 1.1 Mon 11:00 HS 3042

High precision determination of nuclear mass ratios of stable even Yb isotopes to probe for fifth force mediators — •Menno Door[1], Lucia Ensmann[1,2], Pavel Filianin[1], Zoltán Harman[1], Jost Herkenhoff[1], Christoph H. Keitel[1], Kathrin Kromer[1], Daniel Lange[1], Chunhai Lyu[1], Jan Nägele[1], Alexander Rischka[1], Christoph Schweiger[1], Sergey Eliseev[1], and Klaus Blaum[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg, Germany — [2]Universität Heidelberg, Fakultät für Physik und Astronomie, Heidelberg, Germany

Measurements with the Penning-trap mass spectrometer Pentatrap at the Max-Planck-Institut für Kernphysik in Heidelberg allow to determine mass-ratios of long-lived nuclides with a relative uncertainty of a few parts per trillion (ppt) using highly charged ions. These mass-ratio determinations of selected nuclides allow, among others, to contribute to stringent tests of bound-state quantum electrodynamics, neutrinophysics research, and physics beyond the Standard Model in general. The results that will be presented aim at the search for a new spinless boson, coupling electrons and neutrons, causing additional isotope shifts in the spectral lines of ytterbium. The required precision of a few ppt for the determination of even isotope mass-ratios was reached using a tunable cryogenic image-current detection system with single ion sensitivity, phase-sensitive measurement techniques, and remarkably stable trapping fields. The talk will present the experimental methods and results, and give an outlook in the context of King plot analysis and the interpretation for limits on proposed fifth force mediators.

MS 1.2 Mon 11:30 HS 3042

The Mass of ^{3}He - the Last Missing Piece in the Light Ion Mass Puzzle — •Olesia Bezrodnova[1], Sangeetha Sasidharan[1,2], Wolfgang Quint[2], Sven Sturm[1], and Klaus Blaum[1] — [1]Max Planck Institute for Nuclear Physics, Heidelberg, Germany — [2]GSI Helmholtzzentrum, Darmstadt, Germany

The masses of light nuclei form a network of parameters used in fundamental physics. $m(\mathbf{T}) - m(^3\mathbf{He})$, for example, must be known with the highest precision to check for systematic uncertainties in experiments such as KATRIN [1] or Project 8 [2], which study **T** β-decay to set a limit on the $\bar{\nu}_e$ mass. A Penning-trap measurement involving the bound electron g-factor can improve the precision of m_e if the mass of the reference nucleus, ^{4}**He**, is known with sufficient precision.

Penning trap mass measurements of the lightest nuclei have revealed considerable inconsistencies between the values reported by different experiments. To restore confidence in the literature values, the mass spectrometer LIONTRAP has measured the masses of the proton [3], the deuteron, the $\mathbf{HD}^+$ molecular ion [4], and most recently, ^{4}**He** [5]. This contribution presents the preliminary results of the ongoing ^{3}**He** mass measurement campaign, aimed at resolving the discrepancy of literature values known as the “Light Ion Mass Puzzle”.

[1] M. Aker *et al.*, Nat. Phys. **18**, 160-166 (2022)
[2] Project 8 Collaboration, Phys. Rev. Lett. **131**, 102502 (2023)
[3] F. Heiße *et al.*, Phys. Rev. A **100**, 022518 (2019)
[4] S. Rau *et al.*, Nature **585**, 43-47 (2020)
[5] S. Sasidharan *et al.*, Phys. Rev. Lett. **131**, 093201 (2023)

MS 1.3 Mon 11:45 HS 3042

High-precision mass measurements with the PENTATRAP experiment — •Lucia Enzmann, Jan Nägele, Kathrin Kromer, Menno Door, Pavel Filianin, Christoph Schweiger, Sergey Eliseev, and Klaus Blaum — Max Planck Institute for Nuclear Physics, Heidelberg, Germany

The PENTATRAP experiment at the Max Planck Institute for Nuclear Physics in Heidelberg is one of the most precise Penning-trap mass spectrometers in the world capable of determining mass ratios of stable and long-lived highly charged ions with relative uncertainties in the low 10*12 regime. The data acquired by this state-of-the-art apparatus contributes to different fields of fundamental physics, e.g., fifth force search, neutrino physics, and highly charged ion clocks. In this contribution we will present latest results of PENTATRAP and its future perspectives. Some examples of our recent measurements are ^{163}Ho, the isotopic chain of Yb, ^{208}Pb, and ^{238}U.

MS 1.4 Mon 12:00 HS 3042

Re-measuring the nuclear masses of transuranium isotopes in the vicinity of the *N*=152 deformed neutron shell-closure — •Stanislav Chenmarev[1], Szilard Nagy[1], Klaus Blaum[1], Michael Block[2,3,4], Christoph E. Düllmann[2,3,4], and Dennis Renisch[3] — [1]Max-Planck-Institut für Kernphysik, Heidelberg, Germany — [2]Helmholtz-Institut Mainz, Germany — [3]Department Chemie - Standort TRIGA, Johannes Gutenberg-Universität, Mainz, Germany — [4]GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany

We have re-visited the region of actinides in the vicinity of the N=152 deformed neutron shell-closure, and repeated high-precision mass measurements using the newly implemented Phase Imaging Ion Cyclotron Resonance (PI-ICR) technique [1].

With our greatly improved apparatus we have measured the masses of ^{244}Pu, ^{241}Am, ^{243}Am, ^{248}Cm, ^{249}Cf, taking ^{208}Pb and ^{238}U as mass references. The masses of these reference ions were recently determined with ultra-high-precision at Pentatrap [2].

Our results are in good agreement with the latest Atomic Mass Evaluation. The recent mass measurements as well as their comparison to the AME2020 values will be presented and discussed.

[1] Chenmarev, S., *et al.* Eur. Phys. J. A **59.2** (2023): 29.
[2] Kromer, K., *et al.* Eur. Phys. J. A **58.10** (2022): 202.

MS 1.5 Mon 12:15 HS 3042

High-precision mass measurements of heavy and superheavy elements with SHIPTRAP — •Francesca Giacoppo for the SHIPTRAP-Collaboration — GSI Darmstadt, Germany — HIM Mainz, Germany

Probing the limit of existance at the uppermost corner of the nuclear chart requires a deep understanding of the nuclear properties of very heavy nuclides and their evolution in the superheavy region. Superheavy nuclei owe their existence to nuclear shell effects, which enhance their stability. The latter is also expressed in terms of increased binding energies, which can be experimentally investigated through direct mass measurements performed with Penning traps, providing information on the nuclear shell structure. If sufficient mass resolving power is achieved, the excitation energies of low-lying, long-lived metastable nuclear states, very common in the heaviest nuclei, can be obtained from the directly measured masses.

The SHIPTRAP experiment was developed to study heavy and superheavy nuclei produced via fusion-evaporation reactions at rates well below one particle per hour through Penning trap mass spectrometry. Thanks to the implementation of a cryogenic buffer-gas stopping cell and the development of the Phase-Imaging Ion-Cyclotron-Resonance technique, more exotic nuclei can be studied with even better precision and higher resolving power. In this contribution, a summary of the latest results, obtained as part of the FAIR phase-0 campaigns, will be presented.

MS 1.6 Mon 12:30 HS 3042

Recent mass measurements at ISOLTRAP — •Daniel Lange for the ISOLTRAP-Collaboration — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

High-precision mass measurements of radioactive ions are used to determine nuclear binding energies, which reflect all forces acting in the nucleus and are used to study among others nuclear structure, nuclear astrophysics, and weak interaction.

For this, the ISOLTRAP mass spectrometer at ISOLDE/CERN [1] uses various ion traps, including a tandem Penning-trap system and a multi-reflection time-of-flight mass spectrometer (MR-ToF MS), where the latter is suitable of both mass separation and fast, precise mass measurements.

In this contribution, the first direct mass measurements of neutron-deficient ^{97}Cd and the excitation energy of the $^{97\mathrm{m}}$Cd high-lying isomer along with a precise measurement of ^{98}Cd in the immediate vicinity of self-conjugate doubly magic $N = Z = 50$ ^{100}Sn will be presented together with measurements of neutron-rich ^{209,210}Hg.

Additionally, the current setup of the ISOLTRAP experiment is introduced together with the future re-bunching system using a new Mini-RFQ behind the MR-ToF MS to enable measurements of extremely contaminated beams.

[1] Lunney D. *et al.*, J. Phys. G: Nucl. Part. Phys. 44 (2017) 064008

MS 1.7 Mon 12:45 HS 3042

Analyzing a 30-year-old thorium foil with MR-ToF mass spectrometry — •Paul Fischer[1], Jonas Stricker[2,3], Dennis Renisch[2,3], Christoph Düllmann[2,3,4], and Lutz Schweikhard[1] — [1]Inst. f. Physik, Universität Greifswald, Germany — [2]Department Chemie, Johannes Gutenberg-Universität Mainz, Germany — [3]Helmholtz-Institut Mainz, Germany — [4]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany

A foil of ^{232}Th produced roughly thirty years ago is investigated by high-vacuum laser-ablation and multi-reflection time-of-flight (MR-ToF) mass analysis. Cat- and anions are identified by precision mass measurements: By storing ions of interest between two opposing electrostatic mirrors, their flight time is increased, leading to mass resolving powers on the order of $100,000$ and a corresponding rise in mass-measurement accuracy.

A number of thorium-monomer- and thorium-dimer-based molecules including carbon, nitrogen, oxygen, or fluorine atoms are found. Additionally, a small uranium contamination is observed, leading to compound molecules incorporating both Th and U. Selected species are excited with a 532-nm laser pulse to probe their photodissociation behavior and determine relative fragment abundances.