# MS 5: Precision Mass Spectrometry and Fundamental Applications II

Time: Tuesday 14:00–16:00 Location: V57.06

**Invited Talk** MS 5.1 Tue 14:00 V57.06

**Präzisionsmassenmessungen an ISOLTRAP für Kernstrukur- und Astrophysik** — •Susanne Kreim — Max-Planck Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

Penningfallen-Massenmessungen liefern u.a. für neutronenreiche Kerne schwerer als Blei hochpräzise Massenwerte, die uns Aufschluss über die Kernstruktur und Nukleosyntheseprozesse in dieser Region geben. Von besonderem Interesse ist hier der schnelle Neutroneneinfangprozess (r-Prozess). Änderungen in der Bindungsenergie, welche aus der Bestimmung der Masse extrahiert werden kann, geben Information über die im Kern wirkenden Kräfte. Mit dieser Motivation wurden Hochpräzisionsmassenmessungen an langen Isotopenketten von Rn, Fr und Ra mit ISOLTRAP durchgeführt, die im Vortrag mit theoretischen Vorhersagen verglichen werden.

Außerdem kann die in diesem Massenbereich stattfindende Kernspaltung zur Erklärung für ein Wiederaufleben des r-Prozess gereichen. Mit den sechs neuen, jüngst gemessenen Massen von Ra und Fr Isotopen können Betazerfallsenergien berechnet und deren Auswirkung auf den r-Prozess-Pfad untersucht werden. Es wird außerdem erwartet, dass die kürzlich am ISOLTRAP-Experiment bestimmte Masse und Halbwertszeit von Zn-82 eine große Auswirkung auf den r-Prozess um den Abschluss der Neutronenschale N=50 haben wird.

MS 5.2 Tue 14:30 V57.06

**Direct mass measurements above Z = 100** — •E. Minaya Ramirez[1], D. Ackermann[2], K. Blaum[3,4], M. Block[2], C. Droese[5], Ch.E. Düllmann[1,2,6], M. Dworschak[2], M. Eibach[6], S. Eliseev[3], E. Haettner[2,7], F. Herfurth[2], F.P. Hessberger[2], S. Hofmann[2], J. Ketelaer[3], J. Ketter[3], G. Marx[5], M. Mazzocco[8], D. Nesterenko[9], Yu. Novikov[9], W.R. Plass[2,7], S. Rahaman[10], D. Rodríguez[11], C. Scheidenberger[2,7], L. Schweikhard[5], P.G. Thirolf[12], G.K. Vorobjev[2,9], and C. Weber[12] — [1]Helmholtz-Institut Mainz — [2]GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt — [3]Max-Planck-Institut für Kernphysik, Heidelberg — [4]Ruprecht-Karls-Universität Heidelberg — [5]Ernst-Moritz-Arndt-Universität, Greifswald — [6]Johannes Gutenberg-Universität Mainz — [7]Justus-Liebig-Universität Gießen — [8]Dipartimento di Fisica and INFN Sezione di Padova — [9]PNPI RAS Gatchina, St. Petersburg — [10]LANL, Los Alamos — [11]Universidad de Granada — [12]Ludwig-Maximilians-Universität München

High-precision mass measurements of radionuclides are a direct way to obtain the nuclear binding energy, a crucial parameter to investigate the nuclear shell structure. Furthermore, the combination of $\alpha$-decay spectroscopy and directly measured masses above fermium ($Z > 100$) allows determining the masses of higher-$Z$ nuclides to support the search for the island of stability of superheavy elements. Besides, mass measurements of the heaviest actinides allow studying the deformed shell gap $N = 152$ connected to the spherical shell gap in much heavier nuclei by the same single-particle orbitals. Recently, the masses of the nuclides $^{255}$No and $^{255,256}$Lr have been measured with high accuracy using the Penning trap mass spectrometer SHIPTRAP at GSI Darmstadt. In addition, the accuracy of the $^{252}$No and $^{254}$No masses (previously measured at SHIPTRAP) was further improved. The radionuclides were produced in fusion-evaporation reactions and separated from the primary beam by the velocity filter SHIP. Until now the masses of the lawrencium isotopes were only estimated from systematic trends and the extension to $^{256}$Lr represents a new stage in mass measurements of elements with very low cross sections performed with a Penning trap. Work supported in part by BMBF (06ML9148).

MS 5.3 Tue 14:45 V57.06

**Status of THe-Trap** — •Jochen Ketter[1], Tommi Eronen[1], Martin Höcker[1], Sebastian Streubel[1], Robert S. Van Dyck Jr.[2], and Klaus Blaum[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg — [2]Department of Physics, University of Washington, Seattle, WA 98195-1560, USA

Originally developed at the University of Washington and relocated to the Max-Planck-Institut für Kernphysik in 2008, the Penning-trap spectrometer THe-Trap [1] is specially tailored for a $^3$H/$^3$He mass-ratio measurement, from which the $Q$-value of the beta-decay of $^3$H to $^3$He can be derived. Improving the current best value [2] by at least an order of magnitude will provide an important independent test parameter for the determination of the electron-antineutrino's mass by the Karlsruhe Tritium Neutrino Experiment (KATRIN) [3]. However, Penning-trap mass spectrometry has to be pushed to its limits in a dedicated experiment for a sufficiently accurate mass-ratio measurement with a relative uncertainty of $10^{-11}$. Unlike the closed-envelope, single-trap predecessor, the new spectrometer features an external ion source, owing to the radioactive nature of tritium, and two traps in order to speed up the measurement cycle. While the double-trap technique holds great promise, it also calls for more intricate procedures, such as ion transfer. Details about the recent progress of the experiment will be given.

[1] C. Diehl *et al.*, Hyperfine Interactions (2011) 199:291–300
[2] Sz. Nagy *et al.*, Europhys. Lett., **74** (3), pp. 404–410 (2006)
[3] E. W. Otten *et al.*, Int. J. Mass Spectrom. 251 (2006) 173–178

MS 5.4 Tue 15:00 V57.06

**Extraction of neutron-rich fission products from a nuclear reactor: status of the online-coupling at TRIGA-SPEC** — •T Beyer[1,2], K Blaum[1,2], M Block[4], K Eberhardt[3], M Eibach[2,3], Ch Düllmann[3,4], F Herfurth[4], D Lunney[5], Sz Nagy[1,4], W Nörtershäuser[3,4], D Renisch[1,3], and Ch Smorra[1,2] — [1]Max-Planck-Institut für Kernphysik, 69117 Heidelberg — [2]Physikalisches Institut, Universität Heidelberg, 69120 Heidelberg — [3]Institut für Kernchemie, Universität Mainz, 55128 Mainz — [4]GSI Helmholtzzentrum für Schwerionenforschung GmbH, 64291 Darmstadt — [5]CSNSM, Université de Paris Sud, 91495 Orsay, France

Precise experimental data of the ground-state properties of short-lived nuclei are required to test the predictive power of nuclear mass models and to support astrophysical nucleosynthesis calculations. Besides the measurement of these properties with high precision, the creation and preparation of the nuclides of interest is one of the biggest challenges in this field of physics. The TRIGA reactor in Mainz provides high neutron fluxes for the production of exotic nuclei by neutron-induced fission of suitable actinoide targets. The extraction and preparation of these nuclei for both a double-Penning-trap mass spectrometer and a collinear-laser-spectroscopy setup is achieved by using an aerosol-loaded gas-jet system, a high-temperature surface ion source, a separator magnet, and an RF quadrupole cooler/buncher. The status of the online-coupling as well as intermediate test results will be presented.

MS 5.5 Tue 15:15 V57.06

**The multi-Penning trap experiment PENTATRAP** — •Christine Böhm[1,2,3], José R. Crespo López-Urrutia[1], Andreas Dörr[1,2], Sergey Eliseev[1], Mikhail Goncharov[1,2], Jochen Ketter[1,2], Yuri N. Novikov[3,4], Julia Repp[1,2], Christian Roux[1,2], Sven Sturm[1,5], Stefan Ulmer[6], and Klaus Blaum[1,2] — [1]Max-Planck-Institut für Kernphysik, 69117 Heidelberg — [2]Fakultät für Physik und Astronomie, Ruprecht-Karls-Universität, Heidelberg — [3]ExtreMe Matter Institute EMMI, Helmholtz Gemeinschaft, 64291 Darmstadt — [4]Petersburg Nuclear Physics Institute, 188300 Gatchina, Russia — [5]Johannes Gutenberg-Universität Mainz, Institut für Physik, 55099 Mainz — [6]Atomic Physics Laboratory, RIKEN Advanced Science Institute, Hirosawa, Wako, Saitama 351-0198, Japan

The PENTATRAP experiment is under construction at the Max-Planck-Institut für Kernphysik Heidelberg. It aims for high-precision mass ratio measurements of long-lived and stable, highly charged nuclides with masses up to uranium with an accuracy of $\delta m/m \approx 10^{-12}$. Primary goals are for example tests of quantum electrodynamics and neutrino oriented mass measurements. In order to reach the desired accuracy the PENTATRAP experiment contains a stack of five cylindrical cryogenic Penning traps and a dedicated detection system. The current status of the experimental setup will be presented.

MS 5.6 Tue 15:30 V57.06

**Ion production at the mass spectrometer PENTATRAP** — •Julia Repp[1,2], Christine Böhm[1,2,3], José Crespo López-Urrutia[1], Andreas Dörr[1,2], Sergey Eliseev[1], Mikhail Goncharov[1,2], Christian Roux[1,2], and Klaus Blaum[1,2] — [1]Max-Planck-Institut für Kernphysik, 69117 Heidelberg — [2]Fakultät für Physik und Astronomie, Ruprecht-Karls-Universität, 69120 Heidelberg — [3]ExtreMe Matter Institute EMMI, Helmholtz Gemeinschaft, 64291 Darmstadt

A main feature of the high-precision mass spectrometer PENTATRAP is an access to highly charged long-lived and stable ions. Well proven sources for highly charged ions are electron beam ion traps (EBITs). PENTATRAP has access to two EBITs for ion production: a small commercial room temperature Dresden-EBIT3 with an additional Wien filter and the Heidelberg-EBIT. The Dresden-EBIT3 is limited to the production of helium- and neon-like ions for medium- and high-Z elements, respectively. Therefore, this ion source will be used for the commissioning of PENTATRAP and for the investigation of its performance. Moreover, it can be used to produce ions for measurements in the field of neutrino physics. For physics applications, which require extremely high charge states of long-lived and stable nuclides, e.g., bare or hydrogen-like lead or uranium, PENTATRAP will obtain ions from the Heidelberg-EBIT. The talk will focus on the Dresden-EBIT3 and first measurements will be presented.

MS 5.7 Tue 15:45 V57.06

**Detection electronics at the Penning-trap mass spectrometer PENTATRAP** — •Andreas Dörr[1,2], Christine Böhm[1,2,3], Sergey Eliseev[2], Mikhail Goncharov[2], Julia Repp[1,2], Christian Roux[1,2], Sven Sturm[2,4], Stefan Ulmer[5], and Klaus Blaum[1,2] — [1]Fakultät für Physik und Astronomie, Ruprecht-Karls-Universität, 69120 Heidelberg, Germany — [2]Max-Planck-Institut für Kernphysik, 69117 Heidelberg, Germany — [3]ExtreMe Matter Institute EMMI, Helmholtz Gemeinschaft, 64291 Darmstadt, Germany — [4]Institut für Physik, Johannes Gutenberg-Universität, 55099 Mainz, Germany — [5]Atomic Physics Laboratory, RIKEN Advanced Science Institute, Hirosawa, Wako, Saitama 351-0198, Japan

The five Penning-trap mass spectrometer PENTATRAP is currently being built at the Max-Planck-Institut für Kernphysik in Heidelberg. Measurements of masses of single stable and long lived highly charged ions with a relative uncertainty on the order of $10^{-11}$ are aimed for. The experiment is based on the non-destructive detection of image currents the ion induces in the trap electrodes. Essential part of each detection circuit is a cryogenic high-$Q$ inductance, configured either as a copper wire coil or as a superconducting toroid, in both cases mounted in a copper housing. The following amplification stages consist of cryogenic GaAs FET amplifiers, which provide high input impedances and have low input-related noise densities. With these cryogenic detection systems, the tiny image currents ($\sim$fA) induced by a single ion become detectable. The current status of the detection electronics as well as future perspectives will be presented in the talk.