MS 2: Precision Mass Spectrometry 2

Time: Monday 14:30–16:30 Location: PH/HS2

Invited Talk MS 2.1 Mon 14:30 PH/HS2

Precision Penning trap mass measurements of short-lived exotic isotopes — •Jens Dilling — TRIUMF & University of British Columbia — Max-Planck Institute for Nuclear Physics

Exotic isotopes offer unique research and science opportunities, for example related to the fundamental understanding of the strong force, or the generation of the chemical elements in the universe. However, since exotic or often-called rare isotopes have to be generated at accelerator facilities, and usually only in minuscule quantities, with half-lives as short as few milliseconds, the mass measurement methods have to be adjusted. For this, we have developed very sensitive and fast methods using ion trap techniques. Ion traps are employed to measure atomic masses, using one single ion in as short as a 1/100 of a second with 10 parts per billion precision, breaking a world-record for precision mass spectroscopy. We were able to do such experiments using a unique combination of traps, including a Paul trap, an electron beam ion trap (to generate highly charged ions), and a set of Penning traps. In this talk I will report on measurements, the novel techniques we have developed, in particular when using highly charged ions, and plans for the future.

MS 2.2 Mon 15:00 PH/HS2

Status of the high-precision Penning-trap mass spectrometer Pentatrap — •Alexander Rischka[1], Hendrik Bekker[1], Klaus Blaum[1], Christine Böhm[1,2], José R. López-Urrutia[1], Andreas Dörr[1], Sergey Eliseev[1], Mikhail Goncharov[1], Yuri N. Novikov[3], Rima Schüssler[1,4], Sven Sturm[1], and Stefan Ulmer[5] — [1]Max-Planck-Institut für Kernphysik, 69117 Heidelberg, Germany — [2]ExtreMe Matter Institute EMMI, Helmholtz Gemeinschaft, 64291 Darmstadt, Germany — [3]Petersburg Nuclear Physics Institute, 188300 Gatchina, Russia — [4]Universität Heidelberg, Fakultät für Physik und Astronomie, 69120 Heidelberg, Germany — [5]RIKEN, Ulmer Initiative Research Unit, Japan

The Penning-trap mass spectrometer PENTATRAP is currently in the commissioning phase at the Max-Planck-Institute for Nuclear Physics in Heidelberg. We are aiming at measurements of mass ratios of highly charged ions with a relative uncertainty of 10^{-11} and better, e.g. to probe, with the measurement of the Q-value of ^{163}Ho/^{163}Dy, the electron neutrino mass. In the first commissioning campaign we demonstrated the transport of the ions from the electron beam ion source to the trap. We succeeded as well in trapping a single $^{40}Ar^{8+}$ ion where trapping times up to 30 min were achieved. To improve the trapping time even further and thus, to achieve a full characterization of the trap and start first precision measurements, a major revision of the cryogenic setup is presently prepared. This includes a new detection and trap alignment system.

MS 2.3 Mon 15:15 PH/HS2

The detection systems of the Penning-trap mass spectrometer PENTATRAP — •Rima Schüssler[1,2], Hendrik Bekker[1], Klaus Blaum[1], Christine Böhm[1,3], José Crespo López-Urrutia[1], Andreas Dörr[1], Sergey Eliseev[1], Mikhail Goncharov[1], Yuri N. Novikov[4], Alexander Rischka[1], Sven Sturm[1], and Stefan Ulmer[5] — [1]Max-Planck-Institut für Kernphysik, Heidelberg, Germany — [2]Universität Heidelberg, Fakultät für Physik und Astronomie, Heidelberg, Germany — [3]ExtreMe Matter Institute EMMI, Helmholtz Gemeinschaft, Darmstadt, Germany — [4]Petersburg Nuclear Physics Institute, Gatchina, Russia — [5]Ulmer Initiative Research Unit , RIKEN, Wako, Saitama, Japan

The Penning-trap mass spectrometer PENTATRAP is currently in the commissioning phase at the Max-Planck-Institut für Kernphysik in Heidelberg. Measurements of mass ratios of single stable and long lived highly charged ions with a relative uncertainty below 10^{-11} are aimed for. The mass-ratio measurement is carried out by determining simultaneously the cyclotron frequencies of two ions in the magnetic fields of the Penning traps. For this purpose the ions' eigenfrequencies are measured by means of a non-destructive detection of image currents induced in the trap electrodes by the oscillating ions. Essential part of each detection circuit is a cryogenic high-quality resonator, realised as a superconducting or copper coil in a copper housing. Together with cryogenic GaAs FET amplifiers, the small image currents (∼fA) induced by a single ion become detectable. The design of a new detection system as well as first tests will be presented in the talk.

MS 2.4 Mon 15:30 PH/HS2

On-line coupling of the TRIGA-SPEC facility at the research reactor TRIGA Mainz — •Jessica Grund for the TRIGA-SPEC-Collaboration — Institut für Kernchemie, Johannes Gutenberg-Universität, Mainz — PRISMA Cluster of Excellence, Johannes Gutenberg-Universität, Mainz

Experimental data of ground-state properties of exotic nuclei are important to test current nuclear models. The double Penning-trap mass spectrometer TRIGA-TRAP allows precise mass measurements on neutron-rich radionuclides and long-lived transuranium isotopes.

The on-line coupling to the research reactor TRIGA Mainz offers the possibility to measure short-lived nuclides produced by neutron-induced fission of U-235, Pu-239 or Cf-249, respectively. Fission products are extracted by an aerosol-based gas-jet system and are guided through a skimmer system to a high-temperature surface ion source. By means of an aerodynamic lens the aerosols containing the activity are collimated and introduced into the ion source with high efficiency. The low-energy ion beam from the ion source is mass separated with a 90° dipole magnet, followed by a radio-frequency quadrupole cooler/buncher and a pulsed drift tube.

Here we report recent efficiency measurements and performance tests of different parts of the beamline.

MS 2.5 Mon 15:45 PH/HS2

Recent high-precision mass measurements of transuranium nuclides at TRIGA-TRAP — •Dennis Renisch for the TRIGA-SPEC-Collaboration — Institut für Kernchemie, Johannes Gutenberg-Universität Mainz

The heaviest nuclei owe their existence to shell effects, without which they would immediately decay. The strength of shell effects is directly accessible through high-precision mass measurements, using Penning-trap mass spectrometers. TRIGA-TRAP is such an experiment, installed at the research reactor TRIGA Mainz. It is optimized for measurements of long-lived transuranium isotopes and of neutron-rich nuclides produced by neutron-induced fission inside the research reactor. Recent results of high-precision mass measurements of transuranium nuclides, including Pu-242, Bk-249, Cm-245/246/248 and Cf-249/250/251, will be presented. Direct mass measurements in this region of the chart of nuclei are important for mapping the evolution of the deformed shell closure at N=152 over several units in Z and as anchor points of α-decay chains for superheavy element (SHE) research.

MS 2.6 Mon 16:00 PH/HS2

Performance of the Cryogenic Buffer-Gas Stopping Cell at SHIPTRAP — Christian Droese[1], Klaus Blaum[2], Michael Block[3,4], Premaditya Chhetri[5], Sergey Eliseev[2], Frank Herfurth[4], •Mustapha Laatiaoui[3], Felix Lautenschläger[5], Enrique Minaya Ramirez[2], Lutz Schweikhard[1], and Peter Thirolf[6] — [1]Ernst-Moritz-Arndt-Universität Greifswald — [2]Max-Planck-Institut für Kernphysik Heidelberg — [3]Helmholtz-Institut Mainz — [4]GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt — [5]Technische Universität Darmstadt — [6]Ludwig-Maximilians-Universität München

The Penning-trap mass spectrometer SHIPTRAP is employed for high-precision mass measurements of exotic nuclides, in particular in the region above fermium. In recent experiments, the masses of $^{252-254}$No and ^{255,256}Lr were measured directly for the first time in a Penning trap. These achievements paved the way for the development of a new-generation gas-stopping cell aiming for mass measurements in the superheavy element region. As the expected production rates are below one per hour, the stopping and extraction of the evaporation residues becomes a bottleneck for the entire setup's performance. With the new gas cell operated at cryogenic temperatures an extraction efficiency of 74(3)% was obtained, an increase by a factor of 2.5 compared to the old setup. In this talk, results from the off-line commissioning of the new cell will be presented.

MS 2.7 Mon 16:15 PH/HS2

PIPERADE: A large Penning trap isobar separator for the

future low-energy facility DESIR of SPIRAL2 — •Antoine de Roubin[1,2], Mehdi Aoudi[2], Pauline Ascher[2], Bertram Blank[2], Klaus Blaum[1], Pierre Dupré[3], Mathias Gerbaux[2], Stéphane Grévy[2], Hugo Guérin[2], David Lunney[3], and Enrique Minaya Ramirez[1] — [1]MPIK, Heidelberg, Germany — [2]CENBG, Gradignan, France — [3]CSNSM, Orsay, France

Exotic nuclei currently not accessible will be delivered to the future DESIR facility for nuclear structure and astrophysics studies using beta decay spectroscopy, laser spectroscopy and trap-based experiments. For most of them, a high precision is needed and can be reached only if highly pure samples of exotic nuclei are available. Some particular physics cases will be presented.

In addition of the HRS, located upstream, PIPERADE will be a system placed at the DESIR hall entrance to purify the radioactive ion beam from undesired contaminants. It will consist of an RFQ for bunching and cooling and of a double Penning trap to separate the isobaric species and accumulate the ions of interest. The purified beam will then be sent to the various experiments of the low-energy DESIR facility.

The challenge for the present double-Penning trap system consists of being able to separate very large amounts of short-lived nuclei ($< 10^5$ ions per bunch) while maintaining the resolving power necessary for isobar selection of 10^5. For this purpose, research about space charge effects and new excitation schemes are ongoing and will be presented.