MS 1: Precision Mass Spectrometry 1

Time: Monday 10:30–12:00 Location: R 1.020

Invited Talk MS 1.1 Mon 10:30 R 1.020

An Improved Value of the Atomic Mass of the Proton — •Florian Köhler-Langes — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany

In combination with the neutron and the electron, the proton is one of the basic building blocks of atomic matter. The precise knowledge of its properties, e.g. its mass, is of utmost importance for tests of fundamental physics and the clarification of 3 to 4 sigma discrepancies between high-precision mass measurements of various light atoms.

Therefore, a new cryogenic five-fold Penning trap setup was constructed. The measurement principle is based on a phase-sensitive comparison of the proton's cyclotron frequency to that of a bare carbon nucleus. In order to measure both frequencies in the same electric and magnetic field configuration, both single ions are transported alternately into an ultra-harmonic Penning trap, consisting of seven cylindrical electrodes. Exactly the same electric field configuration for both ions with different charge/mass ratio requires two separate, precisely tuned axial resonators for non-destructive frequency detection.

At this conference, the new experimental setup will be introduced and the latest result on the atomic mass of the proton will be presented. This new value is 3 times more precise than the current literature value and reveals a disagreement of about 3 standard deviations to it [1]. Aiming for relative precisions of a few parts per trillion the next upgrade will be discussed.

[1] F. Heiße et al., Phys. Rev. Lett. 119, 033001 (2017)

MS 1.2 Mon 11:00 R 1.020

Towards parts per trillion mass measurements on light nuclei — •Sascha Rau[1], Fabian Heisse[1,2], Florian Köhler-Langes[1], Wolfgang Quint[2], Günter Werth[3], Michael Jentschel[4], Sven Sturm[1], and Klaus Blaum[1] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, D-69117 Heidelberg, Germany — [2]GSI-Helmholtzzentrum für Schwerionenforschung, D-64291 Darmstadt, Germany — [3]Institut für Physik, Johannes Gutenberg-Universität Mainz, D-55099 Mainz, Germany — [4]Nuclear and Particle Physics Group, Institut Laue-Langevin, Grenoble, France

Light nuclei play a fundamental role in physics. The proton and the neutron, together with the electron make up all matter we encounter in our everyday life, making their properties highly interesting for metrology. Another application is the determination of the electron-antineutrino mass at KATRIN [1], where the mass difference of tritium and helium-3 is required.

We developed a cryogenic Penning-trap setup dedicated to mass measurements on light ions. With this setup we were recently able to measure the proton's atomic mass at a relative uncertainty of 3×10^{-11} by comparing the cyclotron frequencies of a proton and a $^{12}C^{6+}$-ion utilizing a phase-sensitive measurement technique [2].

In this talk I will present our progress to push relative mass uncertainties down to the 10^{-12}-regime and extend the measurement to other light ions.

[1] E. W. Otten & C. Weinheimer, Rep. Prog. Phys. 71, 086201 (2008)
[2] F. Heiße et al., Phys. Rev. Lett. 119, 033001 (2017)

MS 1.3 Mon 11:15 R 1.020

Precision Measurements of Neon Isotopes at THe-Trap — •Tom Segal, Martin Höcker, Jochen Ketter, Marc Schuh, Sebastian Streubel, and Klaus Blaum — Max-Planck-Institut für Kernphysik

THe-Trap is a precision Penning-trap mass spectrometer [1] at the Max-Planck-Institut für Kernphysik (MPIK) in Heidelberg. It aims to solve the 4-σ discrepancy in the mass measurements of helium-3 [2,3] by measuring its mass with a relative uncertainty of about 10^{-10}. Left unresolved, the discrepancy increases the uncertainties of the hydrogen and deuterium masses, as well as the values of physical constants such as h, k_B and N_A. A new gas injection system was developed in preparation for the helium measurement. To test it, neon gas was successfully injected into the traps region and ionized by a field emission point. The produced ions were trapped and their cyclotron frequency measured. The measurement process will be presented, as well as preliminary mass results for ^{20}Ne, ^{22}Ne and future plans.

[1] S. Streubel *et al.*, Applied Physics B: Lasers and Optics (2014), 114(1-2), 137-145
[2] R.S. Van Dyck *et al.*, Metrologia (2015), Volume 52, Number 2
[3] E.G. Meyers *et al.*, Phys. Rev. Lett (2015), 144,013003

MS 1.4 Mon 11:30 R 1.020

Current status of the high-precision Penning-trap mass spectrometer Pentatrap — •M. Door[1], J. R. Crespo López-Urrutia[1], S. Eliseev[1], P. Filianin[1], Y. Novikov[2], A. Rischka[1], R. X. Schüssler[1], Ch. Schweiger[1], S. Sturm[1], S. Ulmer[3], and K. Blaum[1] — [1]Max-Planck-Institut für Kernphysik, 69117 Heidelberg, Germany — [2]Peterburg Nuclear Physics Institute, 188300 Gatchina, Russia — [3]RIKEN, Ulmer Fundamental Symmetries Laboratory, Wako, Saitama 351-0198, Japan

The high-precision Penning-trap mass spectrometer Pentatrap [1] is being commissioned at the Max-Planck-Institut für Kernphysik in Heidelberg. We are aiming at mass ratio measurements of stable and long-lived highly charged ions with relative uncertainties of 10^{-11}. This allows, among others, contributions to neutrino physics research, i.e. the mass difference of the mother and daughter nuclide of the electron capture decay of ^{163}Ho to ^{163}Dy or a direct test of special relativity [2], i.e. via the mass difference of the mother and daughter nuclide of the neutron capture in ^{35}Cl to ^{36}Cl. After a revision of the cryogenic setup and the ion transfer beamline we have recently trapped the first single ion in our trap system, demonstrated transport between traps and showed full control over the three eigenmotions by means of resonant dipolar and quadrupolar radiofrequency excitations.

This contribution will report on the experimental setup and current to near future measurements at Pentatrap.

[1] Repp, J. et al., Appl. Phys. B 107, 983 (2012)
[2] Rainville, S. et al., Nature 438, 1096, (2005)

MS 1.5 Mon 11:45 R 1.020

SHIPTRAP upgrades for mass measurements beyond Z=103 — •M. Eibach[1,2], K. Blaum[3], M. Block[2,4,5], S. Chenmarev[3], P. Chhetri[6], S. Eliseev[3], P. Filianin[3,7], F. Giacoppo[2,4], S. Götz[2,4,5], Yu. Gusev[7], F.-P. Hessberger[2,4], O. Kaleja[3,5], M. Laatiaoui[8], S. Lohse[4,5], E. Minaya Ramirez[9], A. K. Mistry[2,4], T. Murböck[2,4], Yu. Novikov[7,10], S. Raeder[2,4], D. Rodriguez[11], F. Schneider[2,4], L. Schweikhard[1], and P. Thirolf[12] — [1]Universität Greifswald — [2]GSI Darmstadt — [3]MPIK Heidelberg — [4]Helmholtz Institut Mainz — [5]Universität Mainz — [6]TU Darmstadt — [7]PNPI KI Gatchina — [8]KU Leuven — [9]IPN Orsay — [10]SPbSU St.Petersburg — [11]Universidad de Granada — [12]LMU München

With the goal of locating the island of stability, it is essential to study the predictive power of nuclear mass models. This for example is carried out with precise mass measurements of the heaviest nuclei which provide anchor points for nuclear masses. In previous experiments, the masses of several $_{102}$No and $_{103}$Lr isotopes have been measured directly for the first time with the Penning-trap mass spectrometer SHIPTRAP. Further extending mass spectrometry towards the superheavy elements required accommodating the low production rates through major modifications. The Penning-trap system was moved to a new location in order to integrate a cryogenic buffer-gas cell for a more efficient thermalization of the fusion-evaporation products of interest.

An overview of the technical developments and the latest high-precision off-line measurements in the context of neutrino and nuclear astrophysics will be presented in this contribution.