MS 9: Penning traps, highest precision, neutrino physics, storage rings, new facilities and approaches

Time: Friday 14:30–16:30 Location: F128

Invited Talk MS 9.1 Fri 14:30 F128

Developments to improve antiproton and other mass measurements — •Christian Smorra on behalf of the BASE collaboration — Johannes Gutenberg Universität Mainz — RIKEN Fundamental Symmetries Laboratory — Max-Planck Insititute for Nuclear Physics

Precision mass measurements in Penning traps have been performed on a wide variety of charged particles, and provide important input parameters for testing the fundamental interactions. For example, the most recent precision comparison of the proton and antiproton masses with 16 parts per trillion uncertainty provides the most stringent test of CPT invariance in the baryon sector and an antiparticle test of the weak equivalence principle with unprecedented resolution.

Common limitations to all mass measurements are uncertainties imposed by magnetic field fluctuations and finite particle temperatures. I will present the current efforts by the BASE collaboration to improve on these limitations for the antiproton mass measurements. This comprises the development of the transportable antiproton trap BASE-STEP that provides the possibility to relocate measurements of accelerator-produced particles away from the magnetic noise environment at the production site. Further, I will present the sympathetic cooling method for a single proton in a two-trap system using a cloud of laser-cooled beryllium ions. Here, we exchange energy by image currents between the traps in a coupled oscillator system. Presently, we cool the proton to a fraction of 1 K and plan to extend the cooling range down to the temperature of laser-cooled ions.

MS 9.2 Fri 15:00 F128

Preparations for ^{163}Ho implantation into 3-inch wafers for ECHo — •Sebastian Berndt[1], Nikolas Bittner[1], Holger Dorrer[1], Christoph E. Düllmann[1,2,3], Raphael Hasse[1], Tom Kieck[2,3], Nina Kneip[4], and Klaus Wendt[1] for the ECHo-Collaboration — [1]Johannes Gutenberg University Mainz — [2]GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt — [3]Helmholtz Institute Mainz — [4]Leibniz University Hannover

The "Electron Capture in ^{163}Ho" (ECHo) experiment aims at measuring the electron neutrino mass in the sub-eV range by the analysis of the calorimetrically measured energy spectrum following the electron capture process of ^{163}Ho. The radioisotope ^{163}Ho is produced from enriched ^{162}Er in the high-flux nuclear reactor at Institut Laue-Langevin (ILL) Grenoble in France. This production process is followed by chemical separation to remove all elements other than Ho and by mass spectrometric separation for removal of remaining trace amounts of ^{166m}Ho. The ^{163}Ho is finally implanted into the absorbers of the ECHo Metallic Magnetic Calorimeters with high purity. Mass separation and implantation is performed in a single step at the RISIKO mass separator at University Mainz. For the scalability of the ^{163}Ho implantation from a single ECHo-100k chip with 64 absorbers to a 3-inch wafer with 40 ECHo-100k chips, the implantation region at RISIKO had to be adapted. A x-y stage and a Mapping Aperture Detector (MAD) were installed in the implantation chamber. The MAD is a wire detector with 8 wires that are read out individually to constantly monitor the size and position of the ion beam.

MS 9.3 Fri 15:15 F128

Towards a Parts-per-trillion Atomic Mass Measurement of the ^{3}He Nucleus — •Olesia Bezrodnova[1], Sangeetha Sasidharan[1,2], Sascha Rau[1], Wolfgang Quint[2], Sven Sturm[1], and Klaus Blaum[1] — [1]Max Planck Institute for Nuclear Physics, Heidelberg, Germany — [2]GSI Helmholtzzentrum, Darmstadt, Germany

Masses of light nuclei provide a network of essential parameters used for the fundamental nature description. For example, the mass difference of T and ^{3}He is used as a consistency check for the model of systematics in the KATRIN experiment, aiming to set a limit on the $\bar{\nu}_e$ mass [1].

The most precise mass measurements of the lightest nuclei, including ^{3}He, revealed considerable inconsistencies between the values reported by different experiments [2]. In order to provide an independent cross-check, the multi-Penning-trap mass spectrometer LIONTRAP has obtained the masses of the proton [3], the deuteron and the HD^+ molecular ion [4].

Present activities of the experiment are directed at the atomic mass measurement of the ^{3}He nucleus with a relative uncertainty lower than 10 ppt. This contribution presents the status of the ongoing measurement campaign.

[1] M. Aker *et al.*, Nat. Phys. **18**, 160-166 (2022)
[2] S. Hamzeloui *et al.*, Phys. Rev. A **96**, 060501(R) (2017)
[3] F. Heiße *et al.*, Phys. Rev. A **100**, 022518 (2019)
[4] S. Rau *et al.*, Nature **585**, 43-47 (2020)

MS 9.4 Fri 15:30 F128

A novel transportable PI-ICR Penning-trap mass spectrometer — •Daniel Lange, Menno Door, Sergey Eliseev, Pavel Filianin, Jost Herkenhoff, Kathrin Kromer, Alexander Rischka, Chistoph Schweiger, and Klaus Blaum — Max-Planck-Institute for Nuclear Physics, Heidelberg, Germany

The new, transportable PILOT (Phase-Imaging Located in One Transportable) - trap experiment aims to measure masses of short-lived nuclides with low production rates and half-lives down to 100 ms with relative uncertainties of about 10^{-8}. This should be realised with a Penning-trap based modified buffer-gas cooling and PI-ICR technique [1]. In order to deal with the low production rates of some isotopes a modified dynamic buffer-gas cooling technique is used in only a single measurement trap. Therefore a fast piezo valve has been developed, which enables a fast and precisely timed helium injection into the Penning-trap, followed by a fast helium release to be directly able to measure in the same trap. This increases the overall efficiency by also avoiding the transport of ions between the traps. The setup is situated in the warm bore of a 6 T superconducting coldhead-cooled magnet which ensures transportability to different radioactive beam facilities. Here, mass measurements of e.g. rare superheavy nuclides become possible contributing to nuclear physics and the search for the island of stability, see e.g. [2]. The current status as well as the developed dynamic cooling method of this experiment are presented.

[1] Eliseev, S. et al., Phys. Rev. Lett. 110, 082501 (2013).
[2] Block, M. et al., Nature 463, 785-788 (2010).

MS 9.5 Fri 15:45 F128

MOCCA - A 4k-pixel microcalorimeter detector for the Cryogenic Storage Ring CSR — •Christopher Alexander Jakob[1], Lisa Gamer[1], Klaus Blaum[1], Christian Enss[2], Andreas Fleischmann[2], Oded Heber[3], Daniel Kreuzberger[2], Ansgar Lowack[2], Michael Rappaport[3], Andreas Reifenberger[2], Dennis Schulz[2], Abhishek Shahi[3], Yoni Toker[4], Andreas Wolf[1], and Oldřich Novotný[1] — [1]MPIK Heidelberg — [2]KIP Heidelberg University — [3]Weizmann Institute of Science, Rehovot, Israel — [4]Bar-Ilan University, Ramat Gan, Israel

The low temperatures and low gas densities in cold interstellar clouds allow the present molecules to relax into their vibrational and rotational ground states. At the Max Planck Institute for Nuclear Physics in Heidelberg, these conditions can be reproduced in the Cryogenic Storage Ring CSR, where heavy molecular ions can cool down while stored for thousands of seconds and electron-ion recombination can be investigated. To reconstruct the full kinematics of these processes, position- and energy-sensitive coincident detection of multiple neutral reaction products is required. For this purpose, MOCCA, a 4k-pixel molecule camera based on metallic magnetic calorimeters with a detection area of 45 mm×45 mm, was developed at the Kirchhoff Institute for Physics in Heidelberg. We present the detector readout scheme, characterization measurements, and the implementation of MOCCA into the CSR-independent MOCCA standalone setup, that will be used to study photon- and collision-induced ion fragmentation processes before MOCCA will be integrated into CSR.

MS 9.6 Fri 16:00 F128

Nuclear two-photon decay of ^{72m}Ge with an isochronous heavy-ion storage ring — •David Freire-Fernández for the E143-Collaboration — MPIK, Heidelberg, Germany — Heidelberg University, Heidelberg, Germany

The nuclear two-photon (2γ) decay is a rare decay mode in atomic nuclei whereby a nucleus in an excited state emits two gamma rays simul-

taneously. First order processes usually dominate the decay, however two-photon emission may become significant when first order processes are forbidden or strongly suppressed, which can be achieved at the experimental storage ring ESR (GSI/FAIR).
Within this work we will present the implemented methodology and the obtained results of a beam time performed in 2021, when for the first time the isochronous mode of the ESR alongside two non-destructive Schottky detectors were operated for the study of short-lived isomers. We investigated specifically the isotope ^{72}Ge, as it is the most easily accessible nucleus having a first excited 0^+ state below the pair creation threshold paramount for the study of 2γ decay without competition of first order decays.
Preliminary results point out that its half-life is considerably shorter than expected from the extrapolation of previously studied $0^+ \rightarrow 0^+$ transitions. Therefore, new theoretical investigations are required which, in combination with our experimental measurements, will allow us to determine the transition nuclear polarizabilities. In addition, the most precise mass measurements obtained by isochronous mass spectrometry will be presented.

MS 9.7 Fri 16:15 F128

Plan of collinear fast beam laser spectroscopy on neutron rich La isotopes to explore the onset and evolution of triaxiality in nuclear ground states using RAON CLS system — •Jung-Bog Kim[1], Jens Lassen[2], Rouhong Ki[2], Hans A. Schuessler[3], SeongGi Jo[4], Sinbee Choi[1], Sung Jong Park[4], A Takamine[5], M Wada[5], H Limura[6], and Duck-Hee Kwon[7] — [1]Korea National University of Education, Cheongju, Rep. Korea — [2]TRIUMF Canada Particle Accelerator Laboratory, Vancouver BC, V6T2A3, Canada — [3]Dept. of Physics & Astronomy, Texas A&M University, College Station TX, 77843-4242, USA — [4]Institute of Basic Science, RISP, Daeheon, Rep. Korea — [5]Atomic Physics Laboratory, RIKEN, 2-1 Hirosawa, Wako, Saitama 351-0198, Japan — [6]Japan Atomic Energy Agency, Tokai-mura, Naka-gun, Ibaraki 319-1195, Japan — [7]Korea Atomic Energy Research Institute, Daejeon, Rep. Korea

The RAON radioactive ion beam facility with resonant ionization laser ion source and a dedicated collinear fast beam laser spectroscopy facility will be the ideal place to carry out challenging, state-of-the-art experiments. One such experiment is to investigate nuclear structure beyond quadrupolar deformation. The neutron-deficient La isotopes are in the mass region where an axially asymmetric shape of nuclei is predicted theoretically. To clarify the deformation of 129La and even more neutron-deficient La isotopes, we are now planning to extend the laser spectroscopy to these nuclides.