MS 1: Precision Mass Spectrometry and Fundamental Applications I

Time: Monday 11:00–13:00 Location: f128

Invited Talk MS 1.1 Mon 11:00 f128

Towards a nuclear clock: On the direct detection of the Thorium-229 isomer — •Lars von der Wense[1], Benedict Seiferle[1], Mustapha Laatiaoui[2,3], and Peter G. Thirolf[1] — [1]Ludwig-Maximilians-Universität München, 85748 Garching — [2]Helmholtz Institut Mainz, 55099 Mainz — [3]GSI Helmholtzzentrum für Schwerionenforschung GmbH, 64291 Darmstadt

In the whole landscape of atomic nuclei, ^{229}Th possesses the only known transition which by today could allow for the development of a nuclear frequency standard. The corresponding isomeric state has an energy of just 7.8 eV, which is even accessible by laser and frequency-comb technology. The isomer to ground-state transition, however, could not be directly detected within the past 40 years, despite significant efforts. In the presentation the first time unambiguous direct detection of the isomeric transition is described. This detection will allow for the determination of the decay parameters and in this way pave the way for the development of a nuclear clock.
This work was supported by DFG (Th956/3-1) and by Horizon 2020 grant agreement no 664732 "nuClock".

MS 1.2 Mon 11:30 f128

High resolution MC-ICP-MS of ultra-trace amounts of silicon isotopes with lowest associated measurement uncertainty — •Axel Pramann — Physikalisch-Technische Bundesanstalt (PTB), 38116 Braunschweig, Germany

The redefinition of the Si-unit of the mass - the kilogram - awaited for 2018 will be performed via the Planck constant and the Avogadro constant.(1) The Avogadro-Project (counting Si atoms in a Si sphere) seems to be the canditate resulting in lowest uncertainties for that purpose. PTB developed several complementary methods for the mass spectrometric determination of the isotopic distribution, the molar mass M of the silicon crystal material used for the preparation of the Avogadro silicon spheres with silicon highly enriched in 28Si.(2) In order to reduce the uncertainties further, new silicon crystal material with extended enrichment in 28Si was produced in a cooperation with external companies and institutes in Russia. This work presents the improved MS techniques and current results performed on new crystal material with x(28Si) = 0.999995 mol/mol accompanied with a comprehensive uncertainty analysis showing a reduction in u(rel,M) by three orders of magnitude in ten years.

(1)Y. Azuma et al., Metrologia, 52, 360 (2015). (2)O. Rienitz, A. Pramann, D. Schiel, Int. J. Mass Spectrom., 289, 47 (2010). (3)A. Pramann, K.-S. Lee, J. Noordmann, O. Rienitz. Metrologia, 52, 800 (2015).

MS 1.3 Mon 11:45 f128

High-precision mass measurements around $N = 152$ at TRIGA-TRAP — •Dennis Renisch[1], Klaus Blaum[2], Michael Block[1,3,4], Christoph Düllmann[1,3,4,5], Klaus Eberhardt[1,4], Jessica Grund[1,5], Jacques van de Laar[1,5], Szilard Nagy[2], Fabian Schneider[1,5,6], and Klaus Wendt[5,6] — [1]Institut für Kernchemie, Johannes Gutenberg-Universität, Mainz — [2]Max-Planck-Institut für Kernphysik, Heidelberg — [3]GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt — [4]Helmholtz-Institut Mainz, Mainz — [5]PRISMA Cluster of Excellence, Johannes Gutenberg-Universität, Mainz — [6]Institut für Physik, Johannes Gutenberg-Universität, Mainz

The heaviest nuclei owe their existence to stabilizing nuclear shell effects. The mapping of the strength of these shell effects in the heaviest elements and their extension in atomic number is possible e.g. by the measurement of neutron separation energies using high-precision mass spectrometry. The Penning-trap mass spectrometer TRIGA-TRAP, located at the TRIGA Mainz research reactor, is used to perform such measurements on long-lived transuranium isotopes that are still available in weighable quantities.

The ongoing measurement campaign comprises ten different nuclides from $Z = 94$ (Pu) to $Z = 98$ (Cf) in the vicinity of the deformed shell closure at $N = 152$. The masses of seven of the investigated nuclides are directly measured for the first time. In this contribution, the status of the measurements and selected results will be presented.

MS 1.4 Mon 12:00 f128

Towards a mass ratio measurement of tritium and helium-3 at THe-Trap — •Tom Segal, Martin Höcker, Jochen Ketter, Marc Schuh, Sebastian Streubel, and Klaus Blaum — Max-Planck-Institut für Kernphysik Saupfercheckweg 1 69117 Heidelberg Germany

THe-Trap is a precision Penning-trap mass spectrometer [1] at the Max Planck Institute for Nuclear Physics (MPIK) in Heidelberg. It aims to measure the mass ratio of tritium to helium-3 with a relative uncertainty of a few tens parts per trillion (10ppt). This value will provide a systematic check for the KATRIN experiment, which seeks to measure the anti-electron neutrino's mass. In 2014, in order to determine the systematic shifts occuring in the mass measurements, we measured the mass ratio of the non-mass doublet carbon-12 to oxygen-16 [2]. This measurement is one of the most precise mass measurements in the world [2]. In January 2015 our superconducting magnet quenched. Additional problems with the cryostat forced us to start a maintenace phase which lasted ten months. In October 2015 the magnet was successfuly charged and shimmed, and the experiment returned to a fully functioning state. In the talk we will present the current status of the experiment and ideas for future measurements.

MS 1.5 Mon 12:15 f128

Image charge shift simulations for THe-Trap — •Marc Schuh, Martin Höcker, Jochen Ketter, Tom Segal, Sebastian Streubel, Sven Sturm, and Klaus Blaum — Max-Planck-Institut für Kernphysik, 69117 Heidelberg

Tritum-Helium-Trap (THe-Trap) is a precision Penning-trap mass spectrometer [1] at the Max-Planck-Institut für Kernphysik in Heidelberg. While the main goal is to measure the tritium/helium-3 mass ratio with a relative uncertainty of 10 parts per trillion (ppt), the experiment is not limited to the measurement of mass doublets.
In 2014 we reported a measurement of the mass ratio of carbon-12 to oxygen-16 with an uncertainty of 120 ppt, limited by uncertainties of systematic shifts [1]. A later measurement decreased this uncertainty significantly (to be published). One significant systematic shift for the measurements of non mass doublets is caused by image charges on the trap electrodes, which are created by the ion present in the trap. It is possible to simulate this effect reliably by extensive finite element simulations performed with Comsol Multiphysics. The results are in excellent agreement with experimental values [2]. The simulations have been extended to the Mainz g-factor Penning-trap [3], where, where an image charge shift measurement is in progress. In this talk the concept of the simulation and its results are presented.
[1] S. Streubel *et al.*, Appl. Phys. B, doi:10.1007/s00340-013-5669-x
[2] R.S. Van Dyck Jr., International journal of mass spectrometry (2006), doi:10.1016/j.ijms.2006.01.038
[3] S. Sturm *et al.*, Phys. Rev. A 87, doi:10.1103/PhysRevA.87.030501

MS 1.6 Mon 12:30 f128

Status of the on-line coupling of the TRIGA-SPEC experiment to the research reactor TRIGA Mainz — •Jessica Grund[1,2], Klaus Blaum[3], Michael Block[1,4,5], Christoph Düllmann[1,2,4,5], Klaus Eberhardt[1,5], Christopher Geppert[1], Christian Gorges[6], Simon Kaufmann[1,6], Jacques van de Laar[1,2], Szilard Nagy[3], Pascal Naubereit[7], Wilfried Nörtershäuser[1,6], Dennis Renisch[1], Fabian Schneider[1,2,7], and Klaus Wendt[2,7] — [1]Institut für Kernchemie, Johannes Gutenberg-Universität, Mainz — [2]PRISMA Cluster of Excellence, Johannes Gutenberg-Universität, Mainz — [3]Max-Planck-Institut für Kernphysik, Heidelberg — [4]GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt — [5]Helmholtz-Institut Mainz, Mainz — [6]Institut für Kernphysik, Darmstadt — [7]Institut für Physik, Johannes Gutenberg-Universität, Mainz

The TRIGA-SPEC experiment - comprising the collinear laser spectroscopy setup TRIGA-LASER and the double Penning-trap mass spectrometer TRIGA-TRAP - allows determining ground-state properties of exotic nuclei. On-line coupling to the research reactor TRIGA Mainz offers the possibility to perform high-precision measurements on short-lived nuclides produced by neutron-induced fission of U-235. Fission products are extracted by an aerosol-based gas-jet system, collimated by an aerodynamic lens and guided through a skimmer system to a high-temperature surface ion source. To improve the ionization

efficiency, a new ion source is beeing bulit in collaboration with JAEA Tokai, Japan. An overview of the current status will be given.

MS 1.7 Mon 12:45 f128

On-line commissioning of the cryogenic buffer-gas stopping cell at SHIPTRAP — •Oliver Kaleja[1], Klaus Blaum[2], Michael Block[3,4,5], Premaditya Chhetri[1], Sergey Eliseev[2], Francesca Giacoppo[5], Fritz-Peter Hessberger[5], Mustapha Laatiaoui[5], Felix Lautenschläger[1], Enrique Minaya Ramirez[6], Andrew Mistry[5], Sebastian Raeder[5], Lutz Schweikhard[7], and Peter Thirolf[8] — [1]TU Darmstadt — [2]MPIK Heidelberg — [3]Helmholtz-Institut Mainz — [4]Universität Mainz — [5]GSI Darmstadt — [6]IPN Orsay — [7]Universität Greifswald — [8]LMU München

In previous experiments the masses of $^{252-255}$No (Z=102) and ^{255,256}Lr (Z=103) were measured directly for the first time with the Penning-trap mass spectrometer SHIPTRAP [1,2]. In order to proceed to even heavier elements with $Z \geq 104$ the overall efficiency of the setup, currently dominated by the combined stopping and extraction efficiency from the gas stopping cell, has to be increased. Therefore, a new cryogenic buffer-gas stopping cell with a larger stopping volume has been developed [3]. Its combined stopping and extraction efficiency was recently measured for the first time under on-line conditions using fusion-evaporation reaction products from SHIP. In this talk, results from the on-line commissioning of the new cell will be presented.

[1] M. Block et al., Nature 463 (2010) 785
[2] E. Minaya Ramirez et al., Science 337 (2012) 1207
[3] C. Droese et al., Nucl. Instr. Meth. Sec. B 338 (2014) 126