MS 1: Precision Mass Spectrometry 1

Time: Monday 11:30–13:00 Location: PH/HS2

Invited Talk MS 1.1 Mon 11:30 PH/HS2

Nuclear Masses and Neutron Stars — •Jürgen Schaffner-Bielich — Goethe Universität, Frankfurt am Main

Neutron stars are born in the aftermath of the explosion of massive stars in core-collapse supernovae. Stabilized by nuclear forces these compact stars can withstand the gravitational pull. During cool-down a crust forms at the outer layer of the neutron star consisting of a lattice of nuclei immersed in a surrounding bath of electrons thereby ensuring overall charge neutrality. The high electron degeneracy pressure enables neutron-rich nuclei to be stabilized in the neutron star crust which would be short-lived exotic isotopes in a terrestrial laboratory. In beta-equilibrium, it can be shown that the sequence of nuclei in the outer crust of neutron stars is solely determined by their masses. We report on the recent advances of measuring masses of neutron-rich isotopes and on determining their impact on the composition of the outer crust of neutron stars. A brief glimpse on the possible composition of the core of neutron stars and their relation to nuclear physics experiments are given as well as an outlook for future astrophysical observations of neutron stars.

MS 1.2 Mon 12:00 PH/HS2

TOF-Bρ mass measurements of neutron-rich nuclei at the NSCL — •Sebastian George for the TOF-BRho-Collaboration — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

Nuclear masses of exotic nuclei towards the driplines are important key parameters for the understanding of nuclear structure of very exotic nuclei and the description of astrophysical processes. Particularly the evolution of matter in the crust of accreting neutron stars incorporates nuclei far away from stability and is limited by the use of theoretical mass models. Time-of-flight-Bρ (TOF-Bρ) mass spectrometry allows the mass determination of such exotic species. The method has shown the potential to access short-lived and rarely produced nuclides at several radioactive beam facilities. Here the setup of the TOF-Bρ experiment at the National Superconducting Cyclotron Laboratory (NSCL) at the Michigan State University is presented. Results of mass measurements in the region of neutron-rich argon to iron are discussed in the context of their impacts on nuclear astrophysics and nuclear structure.

MS 1.3 Mon 12:15 PH/HS2

Probing the $N = 32$ shell closure below the magic proton number $Z = 20$: Mass measurements of the exotic isotopes ^{52,53}K — •M. Rosenbusch[1], P. Ascher[2], D. Atanasov[2], C. Barbieri[3], D. Beck[4], K. Blaum[2], Ch. Borgmann[2], M. Breitenfeldt[5], R. B. Cakirli[2,6], S. George[2], F. Herfurth[4], M. Kowalska[7], S. Kreim[2,7], D. Lunney[8], V. Manea[8], P. Navrátil[9], D. Neidherr[4], L. Schweikhard[1], V. Somà[10,11,12], J. Stanja[13], F. Wienholtz[1], N. R. Wolf[1,2], and K. Zuber[13] — [1]Institut für Physik, Ernst-Moritz-Arndt-Universität, 17487 Greifswald — [2]Max-Planck-Institut für Kernphysik, 69117 Heidelberg — [3]Department of Physics, University of Surrey, Guildford GU2 7XH, UK — [4]GSI Helmholtzzentrum für Schwerionenforschung GmbH, 64291 Darmstadt — [5]Katholieke Universiteit, 3000 Leuven, Belgium — [6]University of Istanbul, 334452 Istanbul, Turkey — [7]CERN, CH-1211 Geneva, Switzerland — [8]CSNSM-IN2P3-CNRS, Université Paris-Sud, 91406 Orsay, France — [9]TRIUMF, V6T 2A3 Vancouver, BC, Canada — [10]ExtreMe Matter Institute EMMI, GSI Helmholtzzentrum für Schwerionenforschung GmbH, 64291 Darmstadt — [11]Institut für Kernphysik, Technische Universität Darmstadt, 64289 Darmstadt, Germany — [12]CEA-Saclay, IRFU/Service de Physique Nucléaire, 91191 Gif-sur-Yvette, France — [13]Institut für Kern- und Teilchenphysik, Technische Universität Dresden, 01069 Dresden

The Penning-trap mass spectrometer ISOLTRAP at the on-line isotope separator ISOLDE/CERN has been set up for precision mass measurements of short-lived nuclides and has been continuously improved for accessing more exotic species. A crucial step forward has been made with the installation of a multi-reflection time-of-flight mass separator/spectrometer (MR-ToF MS), which enables fast mass separation and a direct mass determination of the involved species. With new mass measurements of the exotic isotopes ^{52,53}K, the recent investigations of the neutron-shell closure at $N = 32$ for calcium [1] could be extended for an element below the magic proton number $Z = 20$ for the first time. The resulting two-neutron separation energies reveal a 3 MeV shell gap at $N = 32$, which is slightly lower than for ^{52}Ca, highlighting the doubly-magic nature of this nuclide. While Hartree-Fock-Boguliubov calculations have difficulties to reproduce these findings, fully *ab initio* calculations in the framework of Gorkov-Green function theory performed for the first time beyond $N = 32$ agree with the measured shell effect.

[1] F. Wienholtz *et al.*, Nature 498, 346-349 (2013)

MS 1.4 Mon 12:30 PH/HS2

Präzisionsmassenmessungen mit Penning-Fallen unterstützter Zerfallsspektroskopie, für fundamentale Fragestellungen — •Andree Welker für die ISOLTRAP-Kollaboration — Technische Universität Dresden, Deutschland

Atomkerne sind einzigartige Vielteilchensysteme, welche mit den ersten Experimenten von J. J. Thomson im vorherigen Jahrhundert erste tiefere Beachtung erlangten. Im Allgemeinen sind Massenmessungen heutzutage eine der größten Forschungsschwerpunkte der Physik, wodurch die Interesse stets nach tieferen Hintergründen verlangt, um das Zusammenspiel der starken, schwachen und elektromagnetischen Wechselwirkung, welche zur Bindungsenergie resultieren, in den Nukleonen besser verstehen zu können. Mit Hilfe von Penning-Fallen werden Massen mit Unsicherheiten von $\frac{\delta m}{m}$=10^{-9}-10^{-11} erreicht, um diese Unsicherheiten weiter zu verbessern und Nuklidmessungen von exotischeren Kernen zu ermöglichen, bedarf es in einigen Isotopen die Unterscheidung einzelner Isomere sowie Bestimmung der Halbwertszeiten zwischen Mutter- und Tochternukliden. Das Konzept des geplanten Aufbaues der Alpha-, Beta- und Gammaspektroskopieeinheit an ISOLTRAP/CERN sowie erste Simulationen der Strahlführung, sind Gegenstand dieses Vortags. Die durch ISOLTRAP gewonnenen physikalischen und technischen Erkenntnisse werden Richtungsweisend für bestehende als auch zukünftige Experimente dieser Art wie MATS@FAIR (Precision Measurements of Very Short-Lived Nuclei using an Advanced Trapping System for Highly-Charged Ions) sein.

MS 1.5 Mon 12:45 PH/HS2

Image charge shift simulations for Penning traps and current status of THe-Trap — •Marc Schuh, Tommi Eronen, Martin Höcker, Jochen Ketter, Tom Segal, Sebastian Streubel, and Klaus Blaum — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

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 systematic uncertainties [2]. Within the last year we were able to reduce the systematic uncertainties down to a few ten ppt through increased ion lifetimes and lower motional amplitudes. Further, the electrostatic properties of THe-Trap were investigated by extensive finite element simulations performed with Comsol Multiphysics. One limiting effect for the mass measurements of non mass doublets are the image charges on the electrodes created by the ion present in the trap. It is possible to simulate this effect reliably. The result is in excellent agreement with experimental values [1].

[1] R.S. Van Dyck Jr., International journal of mass spectrometry (2006), doi:10.1016/j.ijms.2006.01.038

[2] S. Streubel *et al.*, Appl. Phys. B, doi:10.1007/s00340-013-5669-x