HK 3: Structure and Dynamics of Nuclei I

Zeit: Montag 14:00–16:00 Raum: HZO 70

Gruppenbericht HK 3.1 Mo 14:00 HZO 70

Status, Results and Perspectives of the FRS Ion Catcher — •Samuel Ayet San Andres for the FRS Ion Catcher-Collaboration — Justus-Liebig-Universität, Gießen — GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt

In the Fragment Separator (FRS) at GSI, exotic nuclei are produced and separated in-flight at relativistic energies. The ions are stopped and thermalized in a cryogenic stopping cell (CSC) and extracted to a Multiple-Reflection Time-of-Flight Mass Spectrometer (MR-TOF-MS) for high precision mass measurements or for isobar and isomer separation.

The FRS Ion Catcher serves as the prototype for the future Ion Catcher at the Low-Energy-Branch (LEB) of the Super-FRS. The masses of more than 40 short-lived isotopes have been measured with accuracies down to the low 10^{-7} level. More than 15 isomers with excitation energies down to the few hundreds of keV were observed. A new analysis method suitable for overlapping peaks and low number of events was developed.

An overview of the latest results and proposed experiments to be carried out in the FRS Ion Catcher at GSI during the upcoming beam time period 2018 - 2019 covering mass measurements, beta-delayed neutron emission probabilities and reaction studies with multi-nucleon transfer will be presented.

HK 3.2 Mo 14:30 HZO 70

Collinear laser spectroscopy of nickel isotopes at CERN-ISOLDE — •Simon Kaufmann for the COLLAPS-ISCOOL-Collaboration — TU Darmstadt, Darmstadt, Deutschland

Nickel isotopes $^{58-68,70}$Ni were measured using collinear laser spectroscopy at the COLLAPS setup at CERN-ISOLDE. Nickel has the magic proton number 28, the first magic number that is caused by the spin-orbit interaction, and the isotope chain is state-of-the-art in nuclear structure research. Of particular interest are recent ab initio calculations entering into the medium mass region and demonstrating a clear correlation between the charge radius, the neutron radius and the electric dipole polarizability α_D in the case of ^{48}Ca [1] which could be confirmed in good agreement in a recent measurement [2]. Our measurements of the mean-square charge radii across up to N=42 shed light into the effect of the sub-shell closure around the N=40 sub-shell closure and help to understand its Z dependence in relation to neighboring elements. Ab initio calculations now become feasible in the nickel mass region as well. Recent α_D measurements in ^{68}Ni [3] are now backed up by our experimental value for the mean-square charge radius making this a rare case where both observables are experimentally known and will therefore provide an important new benchmark for ab initio theory.

[1] G. Hagen et al., Nature Physics12, 186-190 (2016)
[2] J. Birkhan et al., Phys. Rev. Lett. 118, 252501 (2017)
[3] D.M. Rossi et al., Phys. Rev. Lett. 111, 242503 (2013)

HK 3.3 Mo 14:45 HZO 70

Phase-imaging ion-cyclotron-resonance detection with ISOLTRAP at CERN — •Jonas Karthein for the ISOLTRAP-Collaboration — CERN, Geneva, Switzerland — Universität Heidelberg, Germany — MPI für Kernphysik, Heidelberg, Germany

The Penning-trap mass spectrometer ISOLTRAP, located at the radioactive ion beam facility ISOLDE at CERN, performs high-precision mass measurements of short-lived nuclides. This gives access to the study of nuclear-structure effects and provides precision β-decay Q-values to test nuclear models and fundamental interactions. Previously the measurement principle has been the time-of-flight ion-cyclotron-resonance detection technique, which limits accessible half-lives and relative uncertainties. With the new phase-imaging ion-cyclotron-resonance (PI-ICR) detection technique [S. Eliseev et al., Phys. Rev. Lett. 110 082501 (2013)], experiments can be performed with fewer ions and higher resolving power, providing access to new areas of the nuclear chart and to new physics. This talk will report on the ion-optical improvements required for the implementation of PI-ICR at ISOLTRAP, as well as results from first on-line measurements in both the high-precision and high-accuracy regimes. During a systematic on-line study the Q-value of the ^{88}Sr-^{88}Rb β-decay was determined with an uncertainty of $< 130\,\text{eV}$. Furthermore, the separation of the low-lying isomeric states in ^{127}Cd and ^{129}Cd was achieved, from which their excitation energy was determined. A mass resolving power $\frac{m}{\Delta m} > 10^6$ was reached for only 100 ms measurement time compared to $\frac{m}{\Delta m} \sim 5 \cdot 10^4$ in ToF-ICR.

HK 3.4 Mo 15:00 HZO 70

Laser spectroscopy of the heaviest elements — •P. Chhetri[1,2], D. Ackerman[2,3], H. Backe[4], M. Block[2,4,5], B. Cheal[6], Ch. E. Düllmann[2,4,5], M. Eibach[2,7], J. Even[8], R. Ferrer[9], F. Giacoppo[2,5], S. Götz[2,4,5], F. P. Hessberger[2,5], O. Kaleja[2], J. Khuyagbaatar[2], P. Kunz[10], M. Laatiaoui[2,5,9], F. Lautenschläger[1,2], W. Lauth[4], L. Lens[2,4], N. Lecesne[3], A. K. Mistry[2,5], E. Minaya Ramirez[11], T. Murböck[2], S Raeder[2,5], Th. Walther[1], A. Yakushev[2,5], and Z. Zhang[12] — [1]TU Darmstadt — [2]GSI — [3]GANIL — [4]Universität Mainz — [5]Helmholtz-Institut Mainz — [6]University of Liverpool — [7]Universität Greifswald — [8]KVI-CART — [9]KU-Leuven — [10]TRIUMF — [11]IPN Orsay — [12]IMP Lanzhou

Laser spectroscopy of the heaviest elements with $Z > 100$ allows studying the influence of relativistic and QED effects on the atomic shell structure but is hampered by the low production rates available. Applying the sensitive Radiation Detected Resonance Ionization Spectroscopy technique at the SHIP velocity filter at GSI, we identified optical transitions in the element nobelium ($Z = 102$) for the first time [1]. Besides the identification of a strong optical ground state transition, its hyperfine structure splitting in the isotope ^{253}No was measured along with the isotope shifts in $^{252-254}$No. These results will be discussed and an outlook on first attempts in extending laser spectroscopy to the next heavier element, lawrencium ($Z = 103$), will be given.

[1] M. Laatiaoui *et al.*, Nature **538**, 495 (2016)

HK 3.5 Mo 15:15 HZO 70

Towards direct mass spectrometry of superheavy elements at SHIPTRAP — •Oliver Kaleja for the SHIPTRAP-Collaboration — MPIK Heidelberg — JGU Mainz — GSI Darmstadt

The Penning-trap mass spectrometer SHIPTRAP enables direct high-precision measurements of the heaviest elements produced at the velocity filter SHIP. The results allow us to probe and refine nuclear theories and contribute to the quest of finding the predicted island of stability. In order to extend direct mass measurements to superheavy elements ($Z \geq 104$) in the upcoming beamtime period in 2018 the setup was modified to accommodate the low production rates. In parallel, a second setup is being developed to adapt a non-destructive detection technique with single-ion sensitivity to this mass region. In this contribution an overview of the recent activities will be presented.

HK 3.6 Mo 15:30 HZO 70

Decay Spectroscopy at SHIP using the COMPASS set-up — •A. K. Mistry for the SHIP Decay Spectroscopy-Collaboration — Helmholtz Institut Mainz, Mainz, Germany — GSI Helmholtzzentrum, Darmstadt, Germany

A vital tool in the study of the structure of the nucleus is experimental decay spectroscopy in the focal plane after online separation of reaction products. In the heavy element region of the nuclear chart, a variety of theoretical models predict location of the enhanced shell stabilization region above the spherical closure at 208Pb (Z=82, N=126). Studies on the properties of nuclei at the edges of this enhanced superheavy region constrain these models by examining the evolution of shell closures in experimentally accessible regions of the nuclear landscape . Whilst current understanding of the spherical shell closures up to 208Pb is well established, towards the proton dripline, experimental knowledge on the evolution of the shell closures remains limited. To this end, recent efforts have focused on examining the N=126 shell closure at extreme proton numbers i.e. Z=92. The new focal plane detection system at SHIP COMPAct decay Spectroscopy Setup (COMPASS) was employed during a period of parasitic beam time at GSI, with the two-fold purpose of performing an advanced commissioning of the setup, and to subsequently produce neutron deficient isotopes around the region of U, Np, and Pu. Results will be presented from the production of heavy, neutron deficient actinide isotopes with short lived decays in their corresponding chains.

HK 3.7 Mo 15:45 HZO 70

Accurate isotope shift measurement in the D1 and D2 line of Ba^+ — •Phillip Imgram, Kristian König, Jörg Krämer, Tim Ratajczyk, and Wilfried Nörtershäuser — Institut für Kernphysik, TU Darmstadt

The binding energy especially of *s*-electrons are affected by the finite nuclear size. Isotope shift measurements of electronic transitions provide therefore information about the nuclear charge radius. The sensitivity of the $S_{1/2} \rightarrow P_{1/2}$ (D1) and the $S_{1/2} \rightarrow P_{3/2}$ (D2) transitions in earth alkaline ions to this finite nuclear size effect should be identical apart from a small relativistic contribution, which can be explained with the relativistic admixture of the $S_{1/2}$ wave function to the $P_{1/2}$ configuration and has been measured for the first time by K. Wendt *et al.* [1] in Ba^+. Recent measurements of this effect in Ca^+ ions have revealed a considerable discrepancy to theoretical predictions [2]. To check whether such a discrepancy is also apparent in the Ba^+ system, measurements of higher accuracy as in [1] are required. Therefore, the absolute transition frequencies in several stable barium isotopes have been measured with a collinear/anti-collinear laser spectroscopy approach [3].

[1] K. Wendt *et al.*, Z. Phys. A 318, 125 - 129 (1984)
[2] C. Shi *et al.*, Appl. Phys. B (2017), 123:2
[3] A. Krieger *et al.*, Appl. Phys. B (2017) 123:15