HK 64: Struktur und Dynamik von Kernen

Zeit: Donnerstag 14:00–16:00 Raum: HSZ-301

Gruppenbericht HK 64.1 Do 14:00 HSZ-301

High-precision mass measurements of the heaviest elements with SHIPTRAP — •Christian Droese for the SHIPTRAP-Collaboration — Universität Greifswald

High-precision mass measurements in the region of the heaviest elements have been performed at the Penning-trap mass spectrometer SHIPTRAP. In recent experiments the masses of the isotopes $^{252-255}$No and ^{255,256}Lr have been measured directly for the first time with an uncertainty as low as 15 keV. In combination with the results of decay-spectroscopy experiments the mass values of superheavy elements up to ^{270}Ds can be pinned down. These mass values give access to the binding energies and provide valuable information on the nuclear structure of superheavy elements as well as input for theoretical models. The recent results allow a mapping of shell effects across the neutron number N=152. Direct mass measurements of superheavy elements (Z>103) are now within reach, as an increase of the overall efficiency of the SHIPTRAP setup will allow studying isotopes produced at a yet smaller production rate the those studied to date. A cryogenic stopping cell provides a gain in the stopping and extraction efficiency by a factor of three or more. The status of the commissioning and the results of the first efficiency determinations will be presented.

HK 64.2 Do 14:30 HSZ-301

Recent high-precision nuclear mass measurements at TRIGA-TRAP — •M. Eibach[1,2], T. Beyer[2,3], K. Blaum[2,3], M. Block[4], Ch. E. Düllmann[1,4,5], K. Eberhardt[1,5], Sz. Nagy[3,4], W. Nörtershäuser[1,4], D. Renisch[1], and C. Smorra[2,3] — [1]Institut für Kernchemie, Johannes Gutenberg-Universität, Mainz — [2]Fakultät für Physik und Astronomie, Ruprecht-Karls-Universität, Heidelberg — [3]Max-Planck-Institut für Kernphysik, Heidelberg — [4]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt — [5]Helmholtz-Institut Mainz, Mainz

Calculations on the astrophysical r-process, tests of nuclear mass models and predictions of neutrinoless double-beta decays require high-precision nuclear mass or Q value data. Penning-trap mass spectrometers such as TRIGA-TRAP, a branch of the TRIGA-SPEC experiment, are well-suited to provide such data with the requested precision. The nuclides of interest are either produced by thermal neutron-induced fission of e.g. ^{235}U at the research reactor TRIGA Mainz or ionized off-line by a non-resonant laser ablation ion source. In this contribution the present status of TRIGA-TRAP is outlined. Recent mass measurements of stable and long-lived nuclides as well as Q value measurements of their transitions will be presented.

HK 64.3 Do 14:45 HSZ-301

Nuclear structure studies of neutron-rich heavy nuclei by mass measurements of francium and radium isotopes — •Marco Rosenbusch for the ISOLTRAP-Collaboration — Ernst-Moritz-Arndt-Universität, Institut für Physik, 17487 Greifswald

The mass is a unique property of an atomic nucleus reflecting its binding energy and thus the sum of all interactions at work. Precise measurements of nuclear masses especially of short-lived exotic nuclides provide important input for nuclear structure, nuclear astrophysics, tests of the Standard Model, and weak interaction studies. The Penning-trap mass spectrometer ISOLTRAP at the on-line isotope separator ISOLDE/CERN has been set up for precision mass measurements and continuously improved for accessing more exotic nuclides. The mass uncertainty is typically $\delta m/m = 10^{-8}$ and the accessible half-life has been reduced to about 50 ms. In this contribution, the results of a measurement campaign of neutron-rich francium and radium isotopes will be presented, i.e. the masses of the isotopic chain of $^{224-233}$Fr and ^{233,234}Ra, one of the most neutron-rich ensemble obtainable at ISOL facilities. The mass ^{234}Ra denotes the heaviest mass ever measured with ISOLTRAP. Experimental data in the neutron-rich, heavy mass region is of great interest for studies of structural evolution far from stability, especially because the knowledge from nuclear mass models is scarce. The impact of the new data on the physics in this mass region as well as recent technical developments of ISOLTRAP will be discussed.

HK 64.4 Do 15:00 HSZ-301

Nuclear Excitation by a Strong Zeptosecond Laser Pulse: Theoretical Expectations — Adriana Pálffy and •Hans A. Weidenmüller — Max-Planck-Institut für Kernphysik, Heidelberg

At the Nuclear Physics Pillar of the Extreme Light Infrastructure, efforts are under way to generate a multi-MeV zeptosecond laser beam [1]. Which reactions may occur when such a laser pulse hits a medium–weight or heavy target nucleus? The laser pulse consists of $N \lesssim 10^4$ coherent photons and the nuclear response is characterized by the excitation rate $N\Gamma_{\rm dip}$ with the dipole width $\Gamma_{\rm dip} \approx 5$ keV, and by the spreading width $\Gamma^{\downarrow} \approx 5$ MeV. While the perturbative regime was addressed in Ref. [2], here we focus on the quasi-adiabatic regime $N\Gamma_{\rm dip} \approx \Gamma^{\downarrow}$ where the compound nucleus is excited to several 100 MeV above yrast.

We have developed a new approach [3] to nuclear level densities at high excitation energy and extended it beyond the constant-spacing model for the single-particle energies. This allows us to give a semi-quantitative description of the quasi-adiabatic process. The target nucleus is excited up to several hundred MeV energies close to the maximum of the level density. Photon-induced nucleon emission and neutron evaporation populate a range of daughter nuclei above the valley of stability. We expect that experimental data will shed light on the energy dependence of the level density at high excitation energies, and on the structure of proton-rich nuclei.

[1] G. Mourou and T. Tajima, Science 331 (2011) 41.
[2] H. A. Weidenmüller, Phys. Rev. Lett. 106 (2011) 122502.
[3] A. Pálffy and H. A. Weidenmüller, Phys. Lett. B (2012) in press.

HK 64.5 Do 15:15 HSZ-301

Photofission of ^{238}U induced by a brilliant, quasi-monochromatic, Compton-backscattered γ beam* — •Lorant Csige[1,2], D.M. Filipescu[3], T. Glodariou[3], J. Gulyas[4], M. Guenther[5], D. Habs[5], H.J. Karwowski[6], A. Krasznahorkay[4], G.C. Rich[6], L. Stroe[3], O. Tesileanu[3], and P.G. Thirolf[1] — [1]LMU München, Garching, Germany — [2]Excellence Cluster Universe, Garching, Germany — [3]IFIN-HH, Bucharest, Romania — [4]ATOMKI, Debrecen, Hungary — [5]MPI for Quantum Optics, Garching, Germany — [6]TUNL, Durham, USA

The photofission cross-section of ^{238}U was measured at sub-barrier energies as a function of the γ energy using, for the first time, a monochromatic, high-brilliance, Compton-backscattered γ beam. This prototype experiment was performed at the HIGS γ-beam facility, using the ^{238}U(γ,f) reaction at a beam energy varied between E=4.7-6.0 MeV and with an energy resolution of dE=150-200 keV. Clear indications of predicted resonance structures have been observed at excitation energies of E=5.1 and 5.6 MeV. With the significantly higher intensity of the beam, when comparing to a tagged-photon facility, the cross-section could be measured at deep sub-barrier energies. The triple-humped fission barrier parameters of ^{238}U have been determined by fitting EMPIRE3.1 nuclear reaction code calculations to the experimental photofission cross-section. Our present results on the fission barrier of ^{238}U support a deep third minimum (E_{III}=3.6 MeV) and a low inner barrier (E_A=4.3 MeV).

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HK 64.6 Do 15:30 HSZ-301

Collinear Laser Spectroscopy of Potassium Isotopes Beyond the $N = 28$ Shell Closure — •Kim Kreim for the COLLAPS-Collaboration — Max-Planck-Institut für Kernphysik, Heidelberg, Deutschland

The hyperfine structures and isotope shifts of Potassium from $N = 19$ to $N = 32$ ($^{38,39,42,44,46,47-51}$K) have been measured successfully. From these spins, magnetic moments and changes in root mean square charge radii $\delta\langle r^2\rangle$ have been extracted. The model independent spin determinations obtained in this work clarify the level schemes of neutron rich Potassium isotopes. For the first time the range and extend of the $\pi d_{3/2}$ to $\pi s_{1/2}$ ground state inversion has been established. The extracted $\delta\langle r^2\rangle$, in conjunction with those of Ca, Cr, Mn and Fe provide a first insight into the regional Z dependence of the evolution of nuclear size beyond $N = 28$.

HK 64.7 Do 15:45 HSZ-301

Bestimmung der Spins, Momente und Ladungsradien von $^{100-130}$Cd mittels kollinearer Laserspektroskopie — •Nadja

Frömmgen für die COLLAPS-Kollaboration — Institut für Kernchemie, Johannes Gutenberg-Universität Mainz, Deutschland

Die Hyperfeinstruktur und die Isotopieverschiebung der Cadmiumisotope (Z=48) mit Neutronenzahl N=52 bis N=82 wurden mittels kollinearer Laserspektroskopie an der COLLAPS-Apparatur an ISOLDE untersucht. Hierbei konnten sowohl die Grundzustände als auch die langlebigen $11/2^-$ Isomere der Isotope spektroskopiert werden. Dabei wurden erstmals langlebige $I=11/2^-$ Zustände der Isotope ^{127,129}Cd beobachtet. Ziel dieser Untersuchungen knapp unterhalb des Z=50 Schalenabschlusses ist ein besseres Verständnis der Kernstruktur in der Nähe der doppelt magischen Kerne $^{100}Sn_{50}$ und $^{132}Sn_{82}$.

Die elektromagnetischen Momente und die Ladungsradien der Grundzustände und der Isomere wurden aus den laserspektroskopischen Daten extrahiert. Diese Ergebnisse werden diskutiert.