HK 41: Structure and Dynamics of Nuclei VI

Zeit: Donnerstag 14:00–16:15 Raum: F 2

Gruppenbericht HK 41.1 Do 14:00 F 2

Recent Results From the FRS Ion Catcher — •Samuel Ayet San Andrés for the FRS Ion Catcher-Collaboration — GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany — Justus Liebig Universität, Gießen, Germany

At the Super-FRS, exotic nuclei far from stability will be produced and separated in-flight at relativistic energies. At the Low-Energy-Branch (LEB) of the Super-FRS, the ions will be slowed down, thermalized in a cryogenic stopping cell (CSC), extracted and transferred to the experiments MATS and LASPEC where high precision mass measurement of short-lived nuclei and laser spectroscopy will be performed.

The prototype of the CSC and a multiple-reflection time-of-flight mass spectrometer have been developed and commissioned recently as part of the FRS Ion Catcher experiment with fragments of ^{238}U and ^{124}Xe beams. The masses of more than 30 nuclides have been measured with accuracies down to the low 10^{-7} level, 7 of them directly measured for the first time. More than 15 isomers were observed with excitation energies down to few hundreds of keV. An overview of the latest developments, results and an outlook on the near future of the FRS Ion Catcher will be given.

HK 41.2 Do 14:30 F 2

Recent technical developments and mass measurements above the potentially doubly-magic nuclide ^{78}Ni at ISOLTRAP — •Andree Welker[1] and ISOLTRAP Kollaboration[2] — [1]TU-Dresden, Dresden, Deutschland — [2]CERN, TU-Dresden, MPIK Heidelberg, Universität Greifswald,

ISOLTRAP [1] mass measurements of neutron rich copper isotopes are presented. ^{79}Cu could be addressed by the first time using a Multi-Reflection Time-of-Flight Mass Spectrometer (MR-ToF MS) [2]. With only one proton above the Z = 28 core, the binding energies of the copper isotopes are sensitive to the evolution of nuclear shell structure close to the doubly-magic ^{78}Ni isotope. Preliminary results in combination with a shell-model theory will be shown. To reach even more exotic nuclides and to improve ISOLTRAP's mass precision limit, a position-sensitive ion detector was installed upstream the precision Penning-trap. It will allow the application of the Phase-Imaging Ion-Cyclotron-Resonance (PI-ICR) detection method developed at SHIPTRAP/GSI [3]. This new method offers compared to the presently used Time-Of-Flight Ion-Cyclotron-Resonance detection technique higher precision and resolution in shorter measurement time, and thus the ability to resolve low-lying isomers. The current status, first measurements, and an outlook on the implementation of the PI-ICR technique at ISOLTRAP will be presented. [1] S. Kreim et al. Nucl. Instrum. Methods B 317, 492-500 (2013). [2] R.N. Wolf et al. Int. J. Mass Spectrom. 349-350, 123-133 (2013). [3] S. Eliseev et al. Appl. Phys. B 114, 107-128 (2014).

HK 41.3 Do 14:45 F 2

Measurements of isomers at the FRS Ion Catcher — •Christine Hornung for the FRS Ion Catcher-Collaboration — Justus-Liebig Universität Gießen, Germany

Projectile fragmentation and fission reactions at in-flight facilities are important production mechanisms to access short-lived exotic nuclei. It is a challenge to describe the angular momentum distribution after the collision of relativistic nuclei. This can be experimentally accessed by measuring the population of isomeric states.

The relative population of the isomer and ground states and excitation energies of short-lived exotic nuclei can be determined via high resolution mass spectrometry at the FRS Ion Catcher at GSI. Here, projectile and fission fragments are produced at relativistic energies and separated in-flight. Ions are transported to a multiple-reflection time-of-flight mass spectrometer (MR-TOF-MS), where masses of the ground and isomeric states can be measured in a broad mass range simultaneously. This method gives access to long-lived isomers ($\geq$1 ms) directly ideally complementing gamma-ray spectroscopy. The MR-TOF-MS can also be used to spatially separate the ions in order to provide isomerically clean ion beams.

Results of isomeric ratios and excitation energies of uranium projectile and fission fragments measured with the MR-TOF-MS with a mass resolving power in excess of 400,000 will be presented. Furthermore ratios and excitation energies of isomers of xenon fragments were measured during a recent experiment.

HK 41.4 Do 15:00 F 2

High-resolution laser spectroscopy on neutron-rich nickel isotopes — •Simon Kaufmann for the COLLAPS-IS568-Collaboration — Institut für Kernphysik, TU Darmstadt, D-64289 Darmstadt, Germany

Laser spectroscopy of nickel isotopes was so far only performed for the stable isotopes ^{58,60,61,62,64}Ni. Studies of the nuclear charge radii and nuclear moments in the neighboring isotopic chains of Cu (Z=29) and Ga (Z=31) showed a weak effect of a possible $N = 40$ sub-shell closure in copper but nothing convincing in the Ga isotopes [1, 2]. The aim of this experiment was to complement the picture by studying the neutron-rich Ni isotopes with the magic proton number $Z = 28$ in order to understand the Z dependency of this behavior. The experiment on the isotopes $^{58-68,70}$Ni was carried out at the collinear laser spectroscopy (CLS) beamline COLLAPS at ISOLDE/CERN probing the $3d^94s\,^3\mathrm{D}_3 \rightarrow 3d^94p\,^3\mathrm{P}_2$ transition at 352.454 nm in atomic Ni. We used a bunched beam structure with bunch lenghts in the order of some μs produced by the radio frequency quadrupole cooler and buncher ISCOOL. During this measurement campaign a new time-resolved data acquisition system was successfully tested in parallel to the conventional data acquisition system. The time-resolved measurement allowed us to detect irregularities within the energy structure of the ion bunches and minimize those effects by optimizing ISCOOL.

[1] T. J. Procter et al., Phys. Rev. C 6, 034329 (2012)
[2] M. L. Bissell et al., Phys. Rev. C 93, 064318 (2016)

HK 41.5 Do 15:15 F 2

Nuclear charge radii and quadrupole moments of neutron-rich tin isotopes — •Christian Gorges for the COLLAPS-IS573-Collaboration — Institut für Kernphysik, TU Darmstadt, D-64289 Darmstadt, Germany

The tin isotopes have a magic proton number (Z=50) and the most stable isotopes of all elements. Therefore tin has always been a key element in the understanding of nuclear theory. Laser spectroscopy measurements have been performed previously with low resolution up to the doubly magic nucleus ^{132}Sn [1]. To extract magnetic dipole and electric quadrupole moments, these measurements have now been repeated using high-resolution laser spectroscopy at the COLLAPS beam line at ISOLDE, CERN. Furthermore, isomers along the chain from $^{113m-131m}$Sn have been investigated and the data is extended up to ^{134}Sn allowing the investigation of the strength of the characteristic kink at $N = 82$. In the elements above tin a clear change in the slope is observed in the mean square charge radius when crossing the magic neutron number $N = 82$. It is, however, weaker for tellurium ($Z = 52$) than in xenon ($Z = 54$). Hartree-Fock-Bogoliubov calculations have recently been performed confirming this behaviour and predicting such a kink in the nuclear charge radii also for the tin isotopes [1,2]. The nuclear charge radii as well as the isomer shifts will be presented.

[1] F. Le Blanc et al., Phys Rev C **72**, 034305 (2005)
[2] N. Schunck et al., Comput. Phys. Commun. **183**, 166 (2012)
[3] M. Kortelainen et al., Phys. Rev. C **85**, 024304 (2012)

HK 41.6 Do 15:30 F 2

Lifetime measurement of the internal conversion decay channel of ^{229m}Th — •Benedict Seiferle, Lars v.d. Wense, and Peter G. Thirolf — Ludwig-Maximilians-Universität München, Am Coulombwall 1, 85748 Garching b. München, Germany

Among all so far known excited nuclear states, the first isomeric state of ^{229}Th exhibits the lowest excitation energy, which has been reported to be 7.8±0.5 eV. This energy range is accessible with today's laser technology and could allow for a direct nuclear laser excitation. However, at present, the knowledge of the spectroscopic properties of the isomer are not sufficient to allow for the latter. The isomer decays to its ground-state via three decay channels: (i) internal conversion (IC), (ii) γ emission and (iii) bound internal conversion (BIC). The strength of the decay channels and thus the lifetime of the isomer depends strongly on its charge state. For neutral ^{229m}Th the dominant decay channel is IC. In this talk, lifetime measurements of the internal conversion decay channel are presented. A half-life of 7±1 μs has been measured for neutral ^{229m}Th which is well in agreement with theoretical predictions.

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HK 41.7 Do 15:45 F 2

A new nuclear laser excitation scheme for ^{229m}Th — •Lars von der Wense[1], Benedict Seiferle[1], Adriana Pálffy[2], and Peter G. Thirolf[1] — [1]Ludwig-Maximilians-Universität München, 85748 Garching, Germany — [2]Max-Planck-Institut für Kernphysik, 69117 Heidelberg, Germany

The measurement of time has always been an important tool in science and society. ^{229m}Th offers the potential for the development of an ultra-precise nuclear clock that may outperform existing atomic clock technology. However, despite 40 years of past research, no direct decay detection of this nuclear state was achieved. Only recently, measurements were performed that have led to the direct detection of the ground-state decay of ^{229m}Th [1] and a first characterization of the isomeric decay parameters [2]. Based on this information, a new nuclear laser excitation scheme for ^{229m}Th is proposed. This excitation scheme circumvents the general assumed requirement of a better knowledge of the isomeric energy value, thereby paving the way for nuclear laser spectroscopy of ^{229m}Th.

[1] L. v.d.Wense et al., Nature 533 (2016) 47-51.
[2] B. Seiferle et al., submitted for publication.

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HK 41.8 Do 16:00 F 2

Laser-nucleus reactions in coherent gamma-ray fields — Adriana Pálffy[1], •Hans A. Weidenmüller[1], and Paul G. Reinhard[2] — [1]Max-Planck-Institut für Kernphysik, Heidelberg — [2]Universität Erlangen

Doppler backscattering of optical laser photons on a “flying mirror” of relativistic electrons promises to yield coherent photons with MeV-range energies. We compare the nuclear interaction of such a laser pulse with the standard atom-laser interaction. The mean-field description of atoms must be replaced by a rate equation and the classical field strength, far too faint in nuclei, by the dipole transition rate. Significant nuclear excitation occurs for photon numbers much smaller than typical for atoms. That drastically reduces the requirements on the experimental realization of a “flying mirror”.