HK 14: Structure and Dynamics of Nuclei IV

Time: Tuesday 16:15–18:45 Location: AM 00.021

Group Report HK 14.1 Tue 16:15 AM 00.021

Collinear laser spectroscopy reveals signatures of triaxial deformation in neutron-rich Ru — •Kristian König for the ATLANTIS-Collaboration — TU Darmstadt

The region of refractory metals below tin exhibits a diverse spectrum of nuclear phenomena, i.e. quickly changing deformations and shape coexistence. Particularly, in the neutron-rich Ru isotopes, there are indications for triaxial ground state deformations. This was explored at a new collinear laser spectroscopy setup (ATLANTIS) installed at the low-energy branch of CARIBU at Argonne National Laboratory. There, a californium-252 fission source can uniquely produce sufficiently intense low-energy ion beams of neutron-rich isotopes in this part of the nuclear chart. Laser spectroscopy was performed in $^{96,98-102,104,106-114}$Ru and charge radii as well as electromagnetic moments were extracted. The findings are compared to the latest BSkG models, which are energy density functionals of the Skyrme type. These comparisons reveal clear signatures of triaxial ground states in the neutron-rich Ru isotopes.

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HK 14.2 Tue 16:45 AM 00.021

Investigating the GDR of ^{164}Dy using NRF — •M. Heumüller[1], J. Kleemann[1], N. Pietralla[1], A. D. Ayangeakaa[2,3], S. W. Finch[2,4], D. Gribble[2,3], J. Hauf[1], J. Isaak[1], X. K.-H. James[2,3], R. V. F. Janssens[2,3], S. R. Johnson[2,3], T. Kowalewski[2,3], B. Löher[5], O. Papst[1], K. Prifti[1], A. Saracino[2,3], D. Savran[5], N. Sensharma[2,3], and V. Werner[1] — [1]IKP, TU Darmstadt — [2]TUNL, Durham, NC, USA — [3]U. of NC, Chapel Hill, USA — [4]Duke U., Durham, USA — [5]GSI, Darmstadt

The GDR's geometrical model provides predictions for the γ-decay behavior in elastic photon and 2_1^+ Raman scattering reactions. To rigorously test these for the first time, a photonuclear experiment was recently performed on the GDRs of the spherical and deformed nuclides ^{140}Ce and ^{154}Sm, respectively, at the High Intensity γ-ray Source (HIγS) at TUNL, USA [1]. HIγS's quasi-monochromatic, polarized, and tunable photon beam was employed to selectively photoexcite energy slices of the GDR and subsequently measure their γ-decay. The results are in stunning agreement with the geometrical model predictions. A similar NRF experiment was conducted on the GDR of the strongly deformed ^{164}Dy at HIγS. ^{164}Dy is of particular interest due to its suspected higher degree of triaxiality. Experimental γ-ray spectra and the current status of the data analysis will be presented.

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[1]J. Kleemann *et al.*, Phys. Rev. Lett. **134**, 022503 (2025).

HK 14.3 Tue 17:00 AM 00.021

Vibrations, rotations and single-particle excitations in ^{168}Dy — •Johan Emil Linnestad Larsson[1,2,3], Helena Albers[3], Jeroen Bormans[1,2,3], Magdalena Górska[3], Tuomas Grahn[4], Costel M. Petrache[5], Norbert Pietralla[1], and Volker Werner[1,2] — [1]Technische Universität Darmstadt, 64289 Darmstadt, Germany — [2]Helmholtz Forschungsakademie Hessen für FAIR (HFHF), GSI, 64289 Darmstadt, Germany — [3]GSI Helmholtzzentrum für Schwerionenforschung, 64291 Darmstadt, Germany — [4]University of Jyväskylä and Helsinki Institute of Physics, P.O. Box 35, FI-40014 Jyväskylä, Finland — [5]Université Paris-Saclay, CNRS/IN2P3, IJCLab, 91405 Orsay, France

The low excitation energies of first excited 2^+ states in the rare-earth nuclei close to the mid-shell are an indicator of their degree of deformation, and it reveals more complicated dependencies on neutron number [1].

In order to further study these isotopes, we performed the first ever projectile-fragmentation of ^{170}Er with an energy of 1 GeV/u at the GSI Helmholtzzentrum für Schwerionenforschung GmbH. The key isotope of ^{168}Dy was cleanly separated, identified and implanted in the DESPEC setup [2]. The newly observed transitions and transition probabilities reveal novel structures in ^{168}Dy, as well as providing a new interpretation of the isotope.

References: [1] Z. Patel et al., PRL 113, 262502 (2014). [2] A. Mistry et al., NIM A 1033, 166662 (2022).

HK 14.4 Tue 17:15 AM 00.021

Nuclear structure in heavy neutron-rich nuclei in the vicinity of N=126 and northwest of ^{132}Sn via multinucleon-transfer reactions — •Rainer Abels and Peter Reiter for the AGATA22.04-Collaboration — IKP, Universität zu Köln, Germany

Multinucleon-transfer (MNT) reactions offer a powerful tool to access to access exotic neutron-rich nuclei. Excited reaction products from the ^{136}Xe + ^{208}Pb system at 1 GeV were investigated using the high-resolution γ-ray tracking array AGATA coupled to the mass spectrometer PRISMA at LNL, Italy positioned at the grazing angle. For the beam-like fragments, energy E, atomic number Z, velocity β, charge state q, and mass number A were measured over the range $Z = 52$-58, enabling a clean selection of the nuclei of interest. Kinematic coincidences were exploited to enhance the identification of the hard-to-reach neutron-rich lead isotopes on the target-like side. Mass-yield distributions have been extracted and compared with calculations from the GRAZING model for MNT reactions. Based on the relative cross-section systematics for different transfer channels, the capabilities and limitations for the production of the hard-to-reach neutron-rich isotopes with this experimental method will be discussed. Preliminary results on excited states of beam-like nuclei in the Xe-Ba mass region will also be presented.

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HK 14.5 Tue 17:30 AM 00.021

***Ab initio* description of deformed nuclei from angular-momentum projection** — •Mualla Aytekin[1], Benjamin Bally[1], Thomas Duguet[2], and Alexander Tichai[1,3,4] — [1]Technische Universität Darmstadt, Department of Physics — [2]IRFU, CEA, Université Paris-Saclay — [3]ExtreMe Matter Institute EMMI, GSI Helmholtzzentrum für Schwerionenforschung GmbH — [4]Max-Planck-Institut für Kernphysik, Heidelberg

Atomic nuclei are complex quantum many-body systems that exhibit rich emergent collective behavior. To understand how such phenomena arise from the underlying nuclear forces, we investigate neon and magnesium isotopes using *ab initio* methods. We will present axially deformed mean-field calculations based on chiral two- and three-nucleon interactions and, via angular-momentum projection, explore the low-lying spectroscopy of the ground-state rotational bands. Finally, we will outline recent developments towards a projected coupled-cluster framework aimed at providing a unified description of both nuclear bulk properties and collective features. These developments open the door to a systematic and consistent treatment of deformed nuclei across the nuclear chart.

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HK 14.6 Tue 17:45 AM 00.021

Electromagnetic response of nuclei using Gogny energy density functionals — •Nithish Kumar Covalam Vijayakumar[1,2], Gabriel Martínez-Pinedo[2,1], Luis Miguel Robledo Martín[3], and Samuel Andrea Giuliani[3] — [1]Institut für Kernphysik,Technische Universität Darmstadt, Darmstadt, Germany — [2]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany — [3]Universidad Autónoma de Madrid, Madrid, Spain

Electromagnetic response of nuclei plays an important probe in the understanding of nuclear structure. This quantity is fundamental for the description of neutron capture and photodissociation rates for r-process nucleosynthesis. R-process studies require calculations of many nuclei and typically the response is extracted by using linear response approaches such as quasiparticle random phase approximation (QRPA). But the standard QRPA approach is computationally expensive. A more efficient way of solving the QRPA equations based on Finite amplitude method (FAM) was introduced and thus making its applications more advantageous for heavy nuclei. In this work, we have developed a FAM computer code using the finite range Gogny energy density functionals and axial symmetry preserving Hartree-Fock- Bogoliubov framework. Various test calculations of the new code and the comparison of electromagnetic response results with standard QRPA calculations and available experimental data was performed. We also plan to extend the approach of FAM in the context of nuclear fission for evaluating collective inertias.

HK 14.7 Tue 18:00 AM 00.021

Coulomb excitation of ^{212}Ra at HIE-ISOLDE — •H. Mayr[1], G. Rainovski[2], N. Pietralla[1], and V. Werner[1] for the ISOLDE IS748-Collaboration — [1]TU Darmstadt — [2]Sofia University, Bulgaria

The generalised seniority scheme is a truncated version of the nuclear shell model [1] applicable to the structure of atomic nuclei in the vicinity of shell closures. The number of unpaired nucleons, the seniority ν, is considered an approximate quantum number. The region of the even-even Po-Rn-Ra nuclei with $N=124$ exhibits strong signs of seniority-like behaviour, e.g. the energy spacing between yrast states decreases with increasing angular momentum. However, no data is available to confirm or falsify the anticipated parabolically increasing trend in the absolute $E2$ transition strength with the filling of the j-shell for the $\Delta\nu=2$ seniority-changing $2_1^+\to 0_1^+$ transition [2]. Therefore, a Coulomb-excitation experiment was conducted at HIE-ISOLDE in 2024 in order to obtain the $B(E2;2_1^+\to 0_1^+)$ value of ^{212}Ra. The ^{212}Ra beam was impinged on a ^{120}Sn target with 4.5 MeV/u. γ rays of deexciting ^{212}Ra nuclei were observed by the Miniball array [3]. Particles were recorded by a DSSD. The $B(E2;2_1^+\to 0_1^+)$ value is deduced from γ-ray yields. The status of the analysis will be presented.

[1] I. Talmi, Nucl. Phys. A **172**, 1 (1971).
[2] J. J. Ressler *et al.*, Phys. Rev. C **69**, 034317 (2004).
[3] N. Warr *et al.*, Eur. Phys. J. A **49**, 40 (2013).

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HK 14.8 Tue 18:15 AM 00.021

The vanishing ν11/2$^-$[505] extruder orbital — •Jeroen Peter Bormans[1,2,3], Johan Emil Linnestad Larsson[1,2,3], Magdalena Górska[2], Helena Albers[2], Tuomas Grahn[4], Costel Marian Petrache[5], Norbert Pietralla[1], and Volker Werner[1] — [1]Technische Universität Darmstadt, 64289 Darmstadt, Germany — [2]Helmholtz Forschungsakademie Hessen für FAIR (HFHF), GSI, 64289 Darmstadt, Germany — [3]GSI Helmholtzzentrum für Schwerionenforschung, 64291 Darmstadt, Germany — [4]University of Jyväskylä and Helsinki Institute of Physics, P.O. Box 35, FI-40014 Jyväskylä, Finland — [5]Université Paris-Saclay, CNRS/IN2P3, IJCLab, 91405 Orsay, France

The single-particle structure of neutron-rich odd$-N$ Sm isotopes is of interest for judging the structural role of the $\nu 11/2^-[505]$ orbital in describing the sudden onset of deformation. In the mass $A\sim 150$ region, this sudden onset has been attributed to the interplay between the spherical-driving extruder ($h_{11/2}$) orbital and deformation-driving intruder orbital(s) ($i_{13/2}$) [1]. We have conducted a gamma-ray spectroscopy experiment with the DESPEC setup at GSI, where excited states of the neutron-rich rare-earth nuclei were populated with the projectile fragmentation of a ^{170}Er beam impinging on a thick ^{9}Be target. The results of the measurement on ^{157,159}Sm will be presented and discussed.

[1] P. Kleinheinz et al., PRL 32, 68 (1974).

HK 14.9 Tue 18:30 AM 00.021

Shell Evolution towards N = 32: Inelastic Scattering of ^{49}K$_{30}$ and ^{51}K$_{32}$ — •Debajyoti Das[1,2], Kathrin Wimmer[2,3], Sidong Chen[4], Ting Gao[4], and Marina Petri[4] for the RIBF249-Collaboration — [1]IKP, TU Darmstadt, Darmstadt, Germany — [2]GSI, Darmstadt, Germany — [3]IKP, Universität zu Köln, Germany — [4]University of York, UK

The evolution of nuclear shell structure far from stability provides key insights into nuclear forces. In recent years, significant experimental and theoretical efforts have been focused on the emergence of sub-shell closures at neutron numbers N = 32 and 34 in neutron-rich Ca isotopes. In particular, the strength of the shell gap and the extent of the validity of these new magic numbers for neighboring proton numbers have been under investigation. In neutron-rich potassium isotopes, the proton $1s_{1/2}$ and $0d_{3/2}$ single-particle orbitals are inverted compared to the normal ordering. At ^{51}K, with N = 32, the ground state reemerges as $3/2^+$. How this re-inversion of proton single-particle levels between ^{49}K and ^{51}K influences the development of the neutron subshell closure at N = 32 remains an open question. To address this, we investigate the collective nature of ^{49,51}K and compare it with ^{50,52}Ca nuclei studied in the same experiment. Inelastic scattering in inverse kinematics at relativistic beam energies was performed at the RNC/RIBF facility. γ rays from excited states were detected using the DALI2$^+$ array together with the newly developed HYPATIA detectors. In this talk, I will present an overview of the experiment and show preliminary results for ^{49,51}K Coulomb and nuclear excitations.