HK 59: Structure and Dynamics of Nuclei XI

Zeit: Freitag 14:00–16:00 Raum: HS 14

Gruppenbericht HK 59.1 Fr 14:00 HS 14

High-Precision Nuclear Structure Studies for Neutrinoless Double-Beta ($0\nu\beta\beta$) Decay — •U. Gayer[1], J. Kleemann[1], T. Beck[1], S. Finch[2], J. Isaak[1], FNU Krishichayan[2], B. Löher[1], H. Pai[3], O. Papst[1], N. Pietralla[1], P. C. Ries[1], D. Savran[4], W. Tornow[2], M. Weinert[5], and V. Werner[1] — [1]IKP, TU Darmstadt — [2]TUNL, Durham, NC, USA — [3]SINP, Kolkata, India — [4]GSI, Darmstadt — [5]IKP, Universität zu Köln

Apart from the unknown neutrino mass, the uncertainty of predicted decay rates for the $0\nu\beta\beta$-process is dominated by input from nuclear structure theory [1]. Our experimental campaign aimed at improving the data on electromagnetic observables of the $0\nu\beta\beta$-decay candidates ^{82}Kr/^{82}Se and ^{150}Nd/^{150}Sm to test theoretical models. We focused on γ-decay branches of the nuclear scissors mode (ScM), which can be determined in high-precision nuclear resonance fluorescence experiments using the γ^3 setup at the High-Intensity γ-Ray Source (HIγS). Due to the isovector character of the ScM and its relation to deformation, its decay probes isovector parameters and the description of shape coexistence in nuclear models such as the Interacting Boson Model-2 [2–4]. This contribution will summarize the experimental method, present the results, and discuss the impact on predicted $0\nu\beta\beta$ decay rates.

Supported by DFG research grant SFB 1245

[1] J. Engel, J. Menéndez, Rep. Prog. Phys. **80** (2017) 046301
[2] J. Beller *et al.*, Phys. Rev. Lett. **111** (2013) 172501
[3] T. Beck *et al.*, Phys. Rev. Lett. **118** (2017) 212502
[4] F. Iachello, A. Arima, Cambridge University Press (1987)

HK 59.2 Fr 14:30 HS 14

Decay Characteristics of the Scissors Mode of the $0\nu\beta\beta$-Decay Partner Isotopes ^{150}Nd and ^{150}Sm* — •J. Kleemann[1], T. Beck[1], U. Gayer[1], N. Pietralla[1], V. Werner[1], S. Finch[2], FNU Krishichayan[2], B. Löher[1], H. Pai[1,3], O. Papst[1], W. Tornow[2], and M. Weinert[4] — [1]IKP, TU Darmstadt — [2]TUNL, Duke University, Durham NC, USA — [3]SINP, Kolkata, India — [4]IKP, Universität zu Köln

To investigate the decay characteristics of the scissors mode of the hypothesized neutrinoless double beta ($0\nu\beta\beta$) decay mother nucleus ^{150}Nd and its daughter ^{150}Sm, two nuclear resonance fluorescence experiments were conducted at the γ^3-setup [1] at the High Intensity γ-ray Source (HIγS) of the Triangle Universities Nuclear Laboratory in Durham, NC, USA. By using HIγS' intense, nearly monochromatic, linearly polarized γ-ray beam, dipole states were selectively excited and their parities determined through the azimuthal distribution of their ground-state decay intensities. Our new data on the scissors mode's decay characteristics, especially its branching ratios to the 0_2^+ states, allows constraining nuclear structure model calculations involved in an extraction of the neutrino mass from a $0\nu\beta\beta$-decay rate. In particular, a determination of the Majorana parameters of the Interacting Boson Model-2 (IBM-2) is rendered possible [2]. Preliminary results and IBM-2 calculations will be presented and discussed.

*Supported by the DFG through the research grant SFB 1245.

[1] B. Löher *et al.* Nucl. Instr. Meth. Phys. Res. A **723**, 136 (2013)
[2] J. Beller *et al.* Phys. Rev. Lett. **111**, 172501 (2013)

HK 59.3 Fr 14:45 HS 14

Untersuchung der Quadrupolkollektivität der Scherenmode von ^{152}Sm — •K. Ide[1], T. Beck[1], S. Finch[2], U. Gayer[1], J. Kleemann[1], FNU Krishichayan[2], B. Löher[1], O. Papst[1], N. Pietralla[1], D. Savran[3], W. Tornow[2], M. Weinert[4] und V. Werner[1] — [1]IKP, TU Darmstadt — [2]TUNL, Duke University, Durham NC, USA — [3]GSI, Darmstadt — [4]IKP, Universität zu Köln

Die Scherenmode ist eine isovektorielle Kernanregung, deren Zerfall unter Aussendung elektrischer Quadrupolstrahlung kürzlich erstmalig beobachtet wurde [1]. Im Interacting Boson Model II (IBM-2) sind isovektorielle $E2$-Übergänge sensitiv auf die effektiven Bosonenladungen des $E2$-Übergangsoperators und können, gemeinsam mit der üblicherweise bekannten isoskalaren Anregungsstärke des 2_1^+-Zustands, für die Festlegung dieser Modellparameter verwendet werden.

Im vorgestellten Experiment wurde nach isovektoriellen $E2$-Zerfällen der Scherenmode des Kerns ^{152}Sm geforscht. An der High-Intensity γ-Ray Source wurde eine Kernresonanzfluoreszenzmessung mit einer mittleren Photonenstrahlenergie von 2.99(5) MeV durchgeführt.

Es konnte ein isovektorieller $E2$-Übergang der Scherenmode beobachtet werden. Durch eine Anpassung der IBM-2 Parameter an die neuen experimentellen Befunde von ^{152}Sm können die effektiven Bosonenladungen des $E2$-Übergangsoperators bestimmt werden.

[1] T.Beck *et al.*, Phys. Rev. Lett. **118** (2017) 212502

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HK 59.4 Fr 15:00 HS 14

Projectile Coulomb Excitation of Radioactive ^{140}Nd at HIE-ISOLDE — •R. Kern[1], R. Stegmann[1], G. Rainovski[2], N. Pietralla[1], L. Gaffney[3], A. Blazhev[4], K. Gladnishki[2], J. Jolie[4], V. Karayonchev[4], T. Kröll[1], P. Reiter[4], P.-A. Söderström[1], M. Scheck[5], P. Spagnoletti[5], A. Vogt[4], N. Warr[4], A. Welker[3], V. Werner[1], J. Wiederhold[1], and R. Zidarova[2] — [1]Technische Universität Darmstadt — [2]University of Sofia — [3]CERN — [4]Universität zu Köln — [5]University of the West of Scotland

Projectile Coulomb excitation (CoulEx) is a powerful tool for investigating valence-shell excitations of unstable nuclei. The full-symmetry 2_1^+ state and the so-called mixed-symmetry $2_{1,\mathrm{ms}}^+$ state are the two fundamental quadrupole-collective valence-shell excitations of near-spherical nuclei. They can be understood as a mixture of the collective 2^+ proton and 2^+ neutron excitations. Near-spherical even-even $N = 80$ isotones with $50 < Z < 58$ exhibit an isolated $2_{1,\mathrm{ms}}^+$ state, due to a mechanism called shell-stabilization. This situation changes at ^{138}Ce, where at the $\pi(g_{7/2})$ sub-shell closure at $Z = 58$ the lack of shell-stabilization causes the fragmentation of the $2_{1,\mathrm{ms}}^+$ state. It is of great interest, whether the shell stabilization reoccurs in the $N = 80$ isotones for $Z > 58$, i.e. ^{140}Nd ($Z = 60$). To answer this question, a CoulEx experiment was performed to identify the $2_{1,\mathrm{ms}}^+$ state of ^{140}Nd at the radioactive ion beam facility ISOLDE at CERN using MINIBALL. Preliminary results from the experiment will be shown.

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HK 59.5 Fr 15:15 HS 14

$E2$ strength of the scissors mode and F-vector quadrupole charges over a shape-phase transition* — •T. Beck[1], N. Cooper[2,3], U. Gayer[1], FNU Krishichayan[4], O. Papst[1], N. Pietralla[1], D. Savran[5], W. Tornow[4], and V. Werner[1] — [1]IKP, TU Darmstadt — [2]Yale University, New Haven, CT, USA — [3]University of Notre Dame, Notre Dame, IN, USA — [4]Duke University, Durham, NC, USA — [5]GSI, Darmstadt

The properties of the nuclear scissors mode provide an essential insight into the nature of the restoring forces between the proton and neutron subsystems. Especially the behavior at the quantum phase transition (QPT) from spherical to quadrupole-deformed nuclear shape is of interest due to the quadrupole-collective origin of the scissors mode. Recently, the first measurement [1] of an F-vector $E2$ transition in axially deformed nuclei yielded direct information on the magnitude of the quadrupole boson charges for deformed nuclei in the framework of the Interacting Boson Model-2 [2]. New data on ^{154}Gd and ^{162,164}Dy corroborate and extend the work on the evolution of F-scalar and F-vector quadrupole boson charges over the QPT. The obtained results will be presented in detail and discussed in terms of the underlying nuclear physics. An outlook to future research will be given.

[1] T. Beck *et al.*, Phys. Rev. Lett. **118**, 212502 (2017).
[2] T. Otsuka and J.N. Ginocchio, Phys. Rev. Lett. **54**, 777 (1985).

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HK 59.6 Fr 15:30 HS 14

Nuclear photon strength functions: a model-independent approach via $(\vec{\gamma}, \gamma'\gamma'')$ reactions — •J. Isaak[1], T. Beck[1], M. Bhike[2], I. Brandherm[1], U. Gayer[1], F. Krishichayan[2], B. Löher[1,3], N. Pietralla[1], D. Savran[3], M. Scheck[4], W. Tornow[2], V. Werner[1], and A. Zilges[5] — [1]IKP, TU Darmstadt — [2]TUNL, Durham, NC, USA — [3]GSI, Darmstadt — [4]UWS, Paisley, UK — [5]University of Cologne

Photon strength functions (PSFs) serve as an essential input for nuclear astrophysical model calculations and play an important role in the calculation of capture and photo-disintegration reaction rates as well as in the description of the nucleosynthesis of heavy nuclei. Differ-

ent experimental methods have been used in the past to study PSFs. In this contribution, a model-independent approach is presented for the extraction of the PSF in $(\vec{\gamma}, \gamma'\gamma'')$ reactions using quasi-monochromatic photon beams. The measurements were performed with the γ^3 setup [1] at the High Intensity γ-ray Source at Duke University, Durham, USA [2]. The experimental method and results are presented and compared to statistical model calculations [3].

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[1] B. Löher *et al.*, NIMA 723 (2013) 136.
[2] H. R. Weller *et al.*, PPNP 62 (2009) 257.
[3] J. Isaak *et al.*, PLB 788 (2019) 225.

HK 59.7 Fr 15:45 HS 14

From Hans alpha-neutron coincidences to the superheavy boson — Genevieve Mouze[1] and •Jean-Francois Comanducci[2] — [1]Universite de Nice, 06108 Nice cedex 2, France — [2]LE- AIEA, 4 Quai Antoine Premier, 98000 Monaco

The study, by Hongyin Han et al., of the coincidences between the alpha-particles and neutrons emitted by 252Cf has led to the discovery that a heavy boson, of lifetime 0.17 yoctosecond and mass at least 160.9 GeV/c2 plays a crucial role in the fission reaction. These authors reported that up to 3.25 neutrons are in coincidence with alphas of 15.9 MeV on average. This suggests that the harmonic oscillator, made of the 82-proton and 126- neutron phases of the 208Pb core can reach its four-phonon level, and de-excite by two D.G.D.R. of 26 MeV. But in our study of 258Fm we have shown that the two phases have moved away, so that the 50Ar cluster can interact with the bare 82-proton phase and form a 132Sn-126Sn pair. This interaction triggers the intervention of a superheavy boson field and the creation of a W+ , W- boson pair, since changes have occurred in the quark flavours.