HK 13: Structure and Dynamics of Nuclei III

Time: Tuesday 16:15–18:45 Location: AM 00.011

Group Report HK 13.1 Tue 16:15 AM 00.011

Fast-Timing Lifetime Measurements Following Thermal-Neutron Capture: Probing Shape Coexistence in Mid-Shell Sn Isotopes — •V. Karayonchev[1], F. Wu[2], C. Andreoiu[2], C. Petrache[3], J.-M. Régis[4], C. Michelagnoli[5], M. Beuschlein[6], J. Jolie[4], and C.R. Ding[7] — [1]ANL, Lemont, IL, USA — [2]SFU, Burnaby, BC, Canada — [3]Université Paris-Saclay, CNRS/IN2P3, IJCLab, Orsay, France — [4]IKP, Köln, Germany — [5]ILL, Grenoble, France — [6]IKP, Darmstadt, Germany — [7]School of Physics and Astronomy, Sun Yat-sen University, Zhuhai, China

Thermal-neutron capture reactions produce high-energy primary γ rays that can be used as clean and selective gates, greatly reducing background in γ–γ coincidence measurements. When combined with the fast-timing technique using $LaBr_3$ detectors, this approach enables precise lifetime measurements of excited states populated through very weak decay branches — states that are often inaccessible with conventional methods. These measurements provide unique insight into the structure of stable nuclei.

This talk will present the methodology of fast timing following thermal-neutron capture and illustrate its capabilities through recent studies of mid-shell tin isotopes. In particular, lifetime and monopole ($E0$) strength measurements of low-lying 0^+ states shed new light on shape coexistence phenomena in ^{116,118,120}Sn. The experimental results will be compared with predictions from Multi-Reference Covariant Density Functional Theory (MR-CDFT).

Group Report HK 13.2 Tue 16:45 AM 00.011

γ-ray spectroscopy of neutron-rich radioactive isotopes using two-neutron transfer reactions — •C.M. Nickel[1], V. Werner[1], G. Rainovski[2], A. Blazhev[3], A. Esmaylzadeh[3], C. Fransen[3], K.E. Ide[1], J. Jolie[3], K. Gladnishki[2], V. Karayonchev[3], D. Kocheva[2], R. Lică[4], N.M. Mărginean[4], H. Mayr[1], C. Mihai[4], R.E. Mihai[4], S. Pascu[4], N. Pietralla[1], F. von Spee[3], T. Stetz[1], and R. Zidarova[1] — [1]TU Darmstadt — [2]U Sofia — [3]U Cologne — [4]IFIN-HH

Moderately neutron-rich radioactive nuclei can be efficiently populated by the (^{18}O,^{16}O) two-neutron transfer reaction. It allows measurements of γ-ray coincidences and angular correlations as well as excited-states' lifetimes, hence, electromagnetic matrix elements. We have recently applied it to Zr, Te, Sm, Er, Yb, Pt and Pb isotopes [1]. Lifetime data on the neutron rich isotopes ^{210}Pb [2] and ^{200}Pt [3] were obtained from recoil-distance Doppler-shift experiments at the Cologne and IFIN-HH tandem facilities. Data on ^{210}Pb solidify a discrepancy in shell-model descriptions of 2_1^+ and 4_1^+ states around ^{208}Pb, whereas the expected transition of γ-softness to sphericity towards N=126 is probed in ^{200}Pt.

[1] T. Stetz, H. Mayr *et al.*, Phys. Rev. C **112**, 034325 (2025).
[2] C.M. Nickel, V. Werner *et al.*, Phys. Rev. C. (2025, accepted).
[3] C.M. Nickel, V. Werner *et al.*, Phys. Rev. C. (2025, submitted).
*Supported by BMBF (Grant Nos. 05P21RDCI2 and 05P24RD3) and by DFG (GRK 2128 'Accelence', IRTG 2891 'Nuclear Photonics' and INST 216/988-1 FUGG).

HK 13.3 Tue 17:15 AM 00.011

Lifetime measurement of excited states of ^{172}W — •K. E. Ide[1], V. Werner[1], R. Abels[2], U. Ahmed[1], D. Bittner[2], T. Biesenbach[2], A. Blazhev[2], A. Esmaylzadeh[2], C. Fransen[2], J. Jolie[2], H. Kleis[2], C. -D. Lakenbrink[2], M. Ley[2], H. Mayr[1], M. Müllenmeister[2], C. M. Nickel[1], R. Novak[2], A. Pfeil[2], N. Pietralla[1], J. Roob[2], F. von Spee[2], T. Stetz[1], T. Sültenfuss[2], and R. Zidarova[1] — [1]IKP, TU Darmstadt — [2]IKP, Uni Köln

Nuclear quadrupole collectivity is identified from enhanced $E2$ decay rates. A sudden increase of the $E2$ strength of the $2_1^+ \to 0_1^+$ transition from N=96 (^{170}W) to N=98 (^{172}W) in the W isotopic chain is unexpected compared to the neighboring Hf isotopic chain. This discrepancy was investigated by lifetime measurements of ^{170}W [1] which confirmed the low $B(E2; 2_1^+ \to 0_1^+)$ value. In this work we investigate yrast $B(E2)$ values of ^{172}W to study the structural evolution of the yrast band in comparison to ^{170}W. The experiment was performed at the Cologne 10 MV FN-tandem accelerator facility and used the Cologne plunger device [2] and the CATHEDRAL spectrometer. The fast-timing method and the RDDS method are used complementarily to determine the lifetimes of yrast states. First results will be presented and compared to the confined β-soft (CBS) rotor model [3].

[1] K. E. Ide *et al.*, LNL report 2019 (2020).
[2] A. Dewald, O. Möller, and P. Petkov, PPNP **67** (2012) 786.
[3] N. Pietralla and O. M. Gorbachenko, PRC **70** (2004) 011304.
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HK 13.4 Tue 17:30 AM 00.011

First measurement of lifetimes of excited states in ^{176}Hg — •C.-D. Lakenbrink[1], C. Müller-Gatermann[2], C. Fransen[1], M. P. Carpenter[2], A. Didik[1], C. Heymer[1], J. Jolie[1], D. Seweryniak[2], and K. Wimmer[1] — [1]Institute for Nuclear Physics, University of Cologne — [2]Physics Division, Argonne Nat'l Laboratory

The neutron-deficient mercury isotopes are known to exhibit shape coexistence between a weakly-deformed oblate π(0p-2h) and a prolate π(4p-6h) configuration [1]. For the very neutron-deficient nucleus ^{176}Hg the excitation energies of the 4_1^+ and 6_1^+ states lie at the crossing of these two configurations making an assignment from energy systematics ambiguous [1,2]. Also from the kinematic moments of inertia a structural change is expected between the 2_1^+ and 8_1^+ states. Transition strengths in the neighboring ^{178}Hg suggest a configuration mixing in the 2_1^+ state and different theoretical models predict this to be the onset of a shape transition with decreasing neutron number [3].
Thus an investigation of transition strengths between the low-lying yrast states in ^{176}Hg was conducted. The experiment was performed at ANL employing the recoil distance method and recoil-decay tagging.

This work was supported by the German Research Foundation (DFG) under contract number FR 3276/3-1 and by the U.S. Department of Energy under contract number DE-AC02-06CH11357. It used resources of ANL's ATLAS facility, which is a DOE User Facility.

[1] R. Julin *et al.*, J. Phys. G **27**, R109 (2001)
[2] L.P. Gaffney *et al.*, Phys. Rev. C **89**, 024307 (2014)
[3] C. Müller-Gatermann *et al.*, Phys. Rev. C **99**, 054325 (2019)

HK 13.5 Tue 17:45 AM 00.011

Lifetimes of Excited States in the Normal and Superdeformed Bands of Doubly Magic ^{40}Ca — •Timon Sültenfuss[1], Maximilian Droste[1], Peter Reiter[1], Andrey Blazhev[1], Duy Duc Dao[2], Frédéric Nowacki[2], Konrad Arnswald[1], Anna Bohn[1], Ramona Burggraf[1], Hannah Kleis[1], Sarah Prill[1], Michael Weinert[1], and David Werner[1] — [1]Institut für Kernpyhsik, Universität zu Köln, Zülpicher Straße 77, 50937 Köln, Germany — [2]Université de Strasbourg, IPHC, 23 rue du Loess, 67037 Strasbourg, France

Lifetimes of excited states in the doubly magic nucleus ^{40}Ca have been measured in an experiment performed at the FN tandem accelerator of the University of Cologne. Excited states were populated via the $(p, p'\gamma)$ reaction at a proton beam energy of 15 MeV. The detector array SONIC@HORUS, comprising 12 silicon detectors for charged-particle identification and 14 HPGe detectors for high-resolution γ-ray spectroscopy, was used to measure scattered protons and emitted γ-rays, respectively. Lifetimes of the first excited 2^+, 4^+, and 6^+ states were extracted using the Doppler-Shift Attenuation Method. The new results were compared with recent large-scale shell model calculations, showing excellent agreement for the level scheme as well as the new lifetimes which are identified as members of a normal-deformed structure in ^{40}Ca. In addition, preliminary lifetime results for states in the superdeformed band of ^{40}Ca will be presented and compared with state-of-the-art shell-model predictions.

HK 13.6 Tue 18:00 AM 00.011

RDDS Lifetime Measurements in Neutron-Deficient ^{172}Os — •Alina Didik[1], Christoph Fransen[1], Casper-David Lakenbrink[1], Dania Al Daas[1], Andrey Blazhev[1], Jan Jolie[1], Carina Heymer[1], Franziskus von Spee[1], Katarzyna Hadynska-Klek[2], Grzegorz Jaworski[2], Michalina Komorowska[2], Michal Kowalczyk[2], Adam Nalecz-Jawecki[2], Pawel Napiorkowski[2], Marcin Palacz[2], Krysztof Rusek[2], and Katarzyna Wrzosek-Lipska[2] — [1]IKP, University of Cologne, Germany — [2]Heavy Ion Laboratory, University of Warsaw, Poland

In the lighter isotopes ^{168,170}Os the $B_{4/2} = B(E2; 4_1^+ \to 2_1^+)/B(E2; 2_1^+ \to 0_1^+)$ ratios drop far below the values expected for

collective nuclei, indicating a rapid structural change, explained only very recently to result from strong band mixing including triaxiality. The nucleus ^{172}Os appears to lie just at the boundary of this evolution. Earlier data on transition strengths [1] suggest rotor-like behavior for the 2_1^+ and 4_1^+ states, but a sharp increase of the $B(E2)$ values from the 6_1^+ and 8_1^+ states hints for structural changes within the lower yrast states. However, the latter is not expected from the level energy systematics. To clarify this discrepancy, we performed a new RDDS experiment on ^{172}Os at HIL using the Cologne plunger combined with the EAGLE γ-ray spectrometer. For the first time, level lifetimes were determined from a $\gamma\gamma$ coincidence analysis to eliminate the need for assumptions on delayed feeding in contrast to the earlier dataset. Supported by the DFG, Grant No. FR 3276/3-1.

[1] A. Virtanen et al., Nucl. Phys. A591, 145 (1995)

HK 13.7 Tue 18:15 AM 00.011

Determination of ground-state decay level width in ^{27}Al using the temperature-dependent self-absorption technique — •K. Prifti[1], V. Werner[1], N. Pietralla[1], U. Ahmed[1], M. Baumann[1], M. Beuschlein[1], J. Bormans[1,2], I. Brandherm[1], M. L. Cortes[1], B. Götz[1], A. Gupta[1], J. Hauf[1], B. Hesbacher[1], M. Heumüller[1], K. E. Ide[1], J. Isaak[1], I. Jurosevic[1], J. Kleemann[1], P. Koseoglou[1], J. Lu[1], H. Mayr[1], C. M. Nickel[1], O. Papst[1], T. Ramaker[1], M. Rech[1], D. M. Richter[1], T. M. Sebe[3,4], T. Stetz[1], and R. Zidarova[1] — [1]IKP, TU Darmstadt — [2]GSI, Darmstadt — [3]ELI-NP, IFIN-HH, Romania — [4]Politehnica Bucharest, Romania

The first temperature-dependent relative self-absorption (TRSA) measurement was conducted at the Darmstadt High-Intensity Photon Setup (DHIPS) at the superconducting Darmstadt linear electron accelerator (S-DALINAC) on the nucleus ^{27}Al using a bremsstrahlung photon beam with an endpoint energy of 5.5 MeV. This technique enables the separation of the natural linewidth of the nuclear transition from the Doppler broadening caused by the thermal motion of atoms in the solid target. The present work aims to measure the ground-state decay width of the 3957 keV level with high precision. Measurements were performed with and without an absorbing target at three different temperatures: 77 K, 320 K, and 600 K. The technique and its connection to both nuclear and atomic theory will be presented with a discussion of the results. This work was supported by the DFG under Project-ID 279384907–SFB 1245 and Project-ID 499256822–GRK 2891 "Nuclear Photonics".

HK 13.8 Tue 18:30 AM 00.011

Results and recent updates for electron-gamma coincidence experiments at the S-DALINAC — •Bastian Hesbacher[1], J. Birkhan[1], J. Isaak[1], D. H. Jakubassa-Amundsen[2], O. Möller[1], N. Pietralla[1], T. Ramaker[1], D. Richter[1], X. Roca-Maza[3], D. Schneider[1], and G. Steinhilber[1] — [1]Institut für Kernphysik, TU Darmstadt, Germany — [2]Mathematisches Institut, LMU München, Germany — [3]INFN, Sezione di Milano, Italy

The all-electromagnetic $(e, e'\gamma)$ reaction had first been used for nuclear structure measurements in the 1980s [1]. Since then very few experiments were based on this reaction. In 2021 first successful $(e, e'\gamma)$ measurements were performed at the S-DALINAC with improved resolution of electron energy, gamma energy and coincidence time by two orders of magnitude [2]. The scattered electrons were registered with the QCLAM spectrometer. The γ-radiation was detected by $LaBr_3$:Ce detectors. Measurements on ^{12}C and ^{96}Ru targets were performed and demonstrated the superior performance of the new facility over previous attempts to study $(e, e'\gamma)$ reactions. Results on the γ-decay behaviour and angular distributions of ^{96}Ru will be presented. In addition, recent updates for the experimental setup will be presented which enhance the performance for upcoming experimental campaigns.

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[1] C. N. Papanicolas et al., Phys. Rev. Lett. **54**, 26 (1985).
[2] B. Hesbacher et al., Nucl. Instrum. Methods Phys. Res. A **1078**, 170574 (2025).