# HK 39: Structure and Dynamics of Nuclei VIII

Time: Thursday 16:15–18:00 Location: AM 00.011

HK 39.1 Thu 16:15 AM 00.011

**Electron-Induced Fission at the S-DALINAC - Status and Objectives** — •Diandra Richter, G. Steinhilber, N. Pietralla, J. Birkhan, B. Hesbacher, T. Ramaker, O. Möller, M. Arnold, and J. Isaak — IKP, Darmstadt, Germany

The origin of heavy chemical elements in the Universe remains a major open question. One of the main production mechanisms is the rapid neutron capture process. It takes place in neutron star mergers and terminates in the r-process fission cycle along very neutron-rich nuclei [1]. In the actinide region, neutron captures compete with nuclear fission, producing fragments that serve as neutron-rich r-process seeds. Accurate r-process models therefore require detailed fission data, but experimental information on fission from different excitation energies of transuranium actinides is scarce. At TU Darmstadt, a new setup for electron-induced fission is currently being developed, using electron beams from the superconducting linear accelerator S-DALINAC [2]. Silicon strip detectors will measure energies and timing of both fission fragments, while scattered electrons will be detected in coincidence using the QCLAM spectrometer. This arrangement will allow measurements of fission fragment masses as a function of excitation energy and momentum transfer. An overview of the current status will be presented in this contribution. This work is funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) under project-ID Nos. INST 163/754-1 FUGG and 499256822 GRK 2891 "Nuclear Photonics". [1] J. J. Cowan et al., Rev. Mod. Phys. 93, 015002 (2021); [2] N. Pietralla, Nucl. Phys. News 28, 4 (2018)

HK 39.2 Thu 16:30 AM 00.011

**Relative $^{232}$Th($\gamma$,f) and $^{234}$U($\gamma$,f) Cross-Sections using Quasi-Monoenergetic $\gamma$-ray Beams** — •Thorben Witzel[1], Dimiter Balabanski[4], Mihai Cuciuc[4], Joachim Enders[1], Sean W. Finch[2], Alf Göök[3], Calvin R. Howell[2], Annabel Ibel[1], Ronald C. Malone[7], Maximilian Meier[1], Forrest Q.L. Friesen[2], Andreas Oberstedt[4], Stephan Oberstedt[5], Marius Peck[1], Norbert Pietralla[1], Anthony P.D Ramirez[6], Jack A. Silano[6], Alexandru State[4], Gerhart Steinhilber[1], Anton P. Tonchev[6], Werner Tornow[2], and Vincent Wende[1] — [1]Institut für Kernphysik, Fachbereich Physik, TU Darmstadt, Darmstadt, Germany — [2]Triangle Universities Nuclear Laboratory, Duke University, Durham, NC, USA — [3]Uppsala Universitet, Uppsala, Sweden — [4]ELI-NP, IFIN-HH, Magurele, Romania — [5]EC-JRC Geel, Belgium — [6]Lawrence Livermore National Laboratory, Livermore, CA, USA — [7]U.S. Naval Academy, Annapolis, MD, USA

Precise and reliable data on photofisson cross-sections are essential for modeling of the r-process as well as technical applications of nuclear fission. Although fission cross-sections have been studied for over 80 years, there are still some discrepancies in the nuclear data libraries for some actinides. We analyzed count rates from ionisation chamber experiments using quasi-monochromatic $\gamma$-ray beams ranging from 6 to 12.8 MeV, investigating the shape of the cross-sections of $^{232}$Th($\gamma$,f) and $^{234}$U($\gamma$,f) using $^{238}$U($\gamma$,f) as a well known reference.
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HK 39.3 Thu 16:45 AM 00.011

**In-gas-jet laser ionization spectroscopy of the K = 8$^-$ isomer in $^{254}$No** — •Premaditya Chhetri for the JetRIS-Collaboration — Johannes Gutenberg Universität, Mainz, Germany

Decay and in-beam spectroscopy have provided extensive information on the level structure of heavy nuclei, but often cannot unambiguously determine the underlying single-particle structure of the nucleus. This limitation is particularly evident for the long-lived $K^\pi = 8^-$ isomer in $^{254}$No, whose quasiparticle structure has remained disputed for almost two decades. In fusion-evaporation experiments, the rotational band built of this isomer is only weakly populated preventing a reliable measurement of key observables such as M1/E2 branching ratios and $g$-factors. Consequently, previous configuration assignments mainly relied on indirect decay patterns and comparisons with nuclear models.

Here, we report on in-gas-jet laser ionization spectroscopy measurements of the $K = 8^-$ isomer in $^{254}$No performed with the JetRIS setup at the SHIP velocity filter at GSI. After stopping and neutralization in argon gas, the atoms are re-ionized in a supersonic gas jet using a two-step laser ionization scheme. The resulting hyperfine structure provides direct, nuclear-model-independent access to the magnetic dipole moment, electric quadrupole moment, and isomer shift of the $K = 8^-$ state. The deduced intrinsic $g$-factor allowed an unambiguous assignment of configuration of the isomer, resolving a long-standing ambiguity in the nuclear structure of $^{254}$No.

HK 39.4 Thu 17:00 AM 00.011

**Evolution of changes in mean-square charge radii in californium isotopes** — •Kenneth van Beek for the RADRIS-Collaboration — Technische Universität Darmstadt, Deutschland — GSI Helmholtzzentrum für Schwerionenforschung, Deutschland

The experimental determination of atomic and nuclear properties such as atomic energy levels, ionization potentials, electromagnetic moments, trends in mean-square charge radii, and isotope shifts for nuclei in the region of heavy elements ($Z \gtrsim 100$) remains difficult. The main challenges are low production rates at accelerator facilities and unfavorable half-lifes of the fusion products. This necessitates the use of highly efficient and selective laser spectroscopy techniques. At GSI-FAIR in Darmstadt, Germany, the **RA**diation **D**etected **R**esonance **I**onization **S**pectroscopy (RADRIS) apparatus has been succesfully used to study aforementioned properties in $^{245,246,248-250,254}$Fm and $^{252-255}$No. The employed detection of laser ions via their $\alpha$-decay became impractical for nuclei with half-lives on the order of several tens of hours using a single detector. Thus, a more versatile detector design was developed to increase the method's reach towards longer-lived nuclei. In a recent measurement campaign, the new setup was used to investigate isotope shifts in a long isotopic chain in the element californium, including $^{246}$Cf with a half-life of $t_{1/2} = 35.7\,$h. This talk will present laser spectroscopic results in $^{240,241,242,244,246}$Cf and the extracted information for trends in changes of mean-square charge radii, complementing former investigations of $^{249-253}$Cf at the RISIKO mass separator of the Johannes Gutenberg-University Mainz, Germany.

HK 39.5 Thu 17:15 AM 00.011

**First Limits on Double Alpha Decay of Ra-224** — •Makar Simonov[1] and Heinrich Wilsenach[2] for the Double Alpha at FRS Ion Catcher-Collaboration — [1]Justus-Liebig-Universität Gießen, Gießen, Germany — [2]The Hebrew University of Jerusalem, Jerusalem, Israel

The simultaneous emission of two alpha particles was proposed as an exotic way for heavy nuclei to decay about 45 years ago, and the initial conservative estimate for the branching ratio was less than $10^{-20}$. Recent microscopic calculations have yielded an experimentally accessible estimate of $10^{-8}$ for radium isotopes with mass numbers $A = 220, 222, 224$, and an experiment to search for double alpha decay of Ra-224 was conducted at the FRS Ion Catcher, GSI, Germany.

Over four months of data taking, a 34 kBq radioactive source of Th-228 was used to produce Ra-224 ions. These ions, filtered from other Th-228 descendants by a radio-frequency quadrupole and electrostatically focused, were delivered to a thin carbon implantation foil. Two double-sided silicon strip detectors were used to record alpha and beta particles. The number of registered alpha decays of Ra-224 was approximately $10^9$, which should be sufficient to verify the theoretical estimate.

This report will provide final assessments of the time and energy resolution of the detector system. The main focus is the evaluation of the random-coincidence background to set a limit on the branching ratio of the double alpha decay of Ra-224.

HK 39.6 Thu 17:30 AM 00.011

**Evidence for $M1$ scissors mode states in $^{242}$Pu from nuclear resonance fluorescence** — •M. Beuschlein[1], J. Birkhan[1], J. Kleemann[1], O. Papst[1], N. Pietralla[1], R. Schwengner[2], S. Weiss[2], V. Werner[1], U. Ahmed[1], T. Beck[1,3], I. Brandherm[1], A. Gupta[1], J. Hauf[1], K. E. Ide[1], P. Koseoglou[1], H. Mayr[1], C. M. Nickel[1], K. Prifti[1], D. Savran[4], T. Stetz[1], and R. Zidarova[1] — [1]IKP, Darmstadt, Germany — [2]HZDR, Dresden, Germany — [3]FRIB, East Lansing, MI, USA — [4]GSI, Darmstadt, Germany

The availability of nuclear structure information on transuranium actinides supports stellar nucleosynthesis modeling and isotope-selective material inspection via photonuclear reactions. However, experimental data in this region remain scarce. The first nuclear resonance fluorescence (NRF) experiment on $^{242}$Pu was conducted at the S-DALINAC at TU Darmstadt to probe its low-energy dipole response. A 1 g sample of $^{242}PuO_2$ was irradiated with bremsstrahlung up to an endpoint energy of 3.7 MeV. By comparing NRF spectra with the sample activity and natural background, photo-excited $J = 1$ states of $^{242}$Pu were identified. From the assignment of the intrinsic projection quantum number $K$ based on measured decay branching ratios, evidence was found for five fragments of the $M1$ scissors mode as well as for low-lying $E1$ excitations. Experimental details, $\gamma$-ray spectra, and measured transition strengths of newly observed $^{242}$Pu states will be presented.

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HK 39.7 Thu 17:45 AM 00.011

**Excitation-Energy Dependence of Fission Fragment Observables in the $^{234}$U($\gamma$,f) Reaction** — •Vincent Wende[1], Dimiter Balabanski[4], Mihai Cuciuc[4], Joachim Enders[1], Sean W. Finch[2], Alf Göök[3], Calvin R. Howell[2], Annabel Ibel[1], Ronald C. Malone[7], Maximilian Meier[1], Forrest Q.L. Friesen[2], Andreas Oberstedt[4], Stephan Oberstedt[5], Marius Peck[1], Norbert Pietralla[1], Anthony P.D Ramirez[6], Jack A. Silano[6], Alexandru State[4], Gerhart Steinhilber[1], Anton P. Tonchev[6], and Werner Tornow[2] — [1]Institut für Kernphysik, Fachbereich Physik, TU Darmstadt, Darmstadt, Germany — [2]Triangle Universities Nuclear Laboratory, Duke University, Durham, NC, USA — [3]Uppsala Universitet, Uppsala, Sweden — [4]ELI-NP, IFIN-HH, Magurele, Romania — [5]EC-JRC Geel, Belgium — [6]Lawrence Livermore National Laboratory, Livermore, CA, USA — [7]U.S. Naval Academy, Annapolis, MD, USA

Advancing the microscopic understanding of the nuclear fission process relies on high-precision experimental data. This contribution shows results of an experimental campaign at HI$\gamma$S, using linearly-polarized quasi-monochromatic photon beams between 6.2 and 13 MeV in the entrance channel. Mass, total kinetic energy, and angular distributions of fission fragments have been measured simultaneously using a position-sensitive twin Frisch-grid ionization chamber, exploring the dependence of fragment observables on the excitation energy.

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