HK 31: Structure and Dynamics of Nuclei VII

Time: Thursday 13:45–15:45 Location: AM 00.011

Group Report HK 31.1 Thu 13:45 AM 00.011

Studying Exotic Nuclei with the FRS Ion Catcher: Recent Results and Developments — •Meetika Narang for the Super-FRS Experiment Collaboration-Collaboration — GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany.

At the Fragment Separator (FRS) of GSI/FAIR, exotic nuclei are produced at relativistic energies via projectile fragmentation or fission and are separated in-flight. The fragments are subsequently thermalized in the Cryogenic Stopping Cell (CSC) and delivered to the multiple-reflection time-of-flight mass spectrometer (MR-TOF-MS), which features a high resolving power of up to one million and mass accuracies down to 10^{-8} in short cycle times of a few tens of milliseconds.

A wide range of nuclides has been studied at the FRS Ion Catcher. Direct mass measurements of neutron-deficient isotopes near the $N = Z$ line below ^{100}Sn and neutron-rich nuclei close to the $N = 126$ shell closure below ^{208}Pb have been performed, providing new insights into the evolution of nuclear structure in these key regions. Mass measurements of fission products from a ^{252}Cf spontaneous fission source have shown evidence for shape phase transitions around $N \approx 90$ ($Z = 56$–63) and enabled the direct determination of independent isotopic fission yields (IIFYs). Recent proof-of-principle experiments were performed focusing on multi-nucleon transfer reactions and the study of fundamental laws of nature by employing radioactive molecules.

This contribution presents an overview of the experimental setup, technical developments, recent experimental highlights, and prospects for upcoming experiments.

Group Report HK 31.2 Thu 14:15 AM 00.011

Multinucleon transfer experimental campaigns at GSI — •Ali Mollaebrahimi for the Super-FRS Experiment Collaboration-Collaboration — FAIR facility, Darmstadt, Germany — GSI facility, Darmstadt, Germany

Studying exotic nuclei exhibiting an extreme ratio of neutrons to protons is one of the primary means for better understanding of fundamental nuclear properties, which is crucial to comprehend the formation and existence of heavy elements in our universe. Nevertheless, it is well understood that nuclei from certain regions on the chart of nuclei, e.g., neutron-rich actinides, will not be efficiently produced in commonly used fission and fragmentation production methods. The MultiNucleon Transfer (MNT) reaction mechanism is considered the most promising and more efficient pathway to reach this region.

The Super-FRS experiment collaboration is performing MNT experiments at GSI using beams at near Coulomb barrier energies. This is performed with primary and secondary slowed-down relativistic beams at the FRS with the FRS Ion Catcher [1] and with primary beams at the UNILAC. The ultimate goal of the MNT program is to conduct future experiments at Super-FRS at FAIR. This contribution will present the plans and preliminary results obtained with ^{238}U beam and the first test with ^{236}U secondary beam on a Bi target and identification via mass measurements at the FRS Ion Catcher; plus general description of experiments with α-spectroscopy and TOF-ΔE-E methods after the UNILAC.

[1] A. Mollaebrahimi et al., Nuclear Physics A 1057, 2025

HK 31.3 Thu 14:45 AM 00.011

Measurements of the reaction cross sections of neutron-rich Sn isotopes at the R^{3}B setup — •Eleonora Kudaibergenova[1], Thomas Aumann[1,2,3], Igor Gasparic[4], Andrea Horvat[4], Ivana Lihtar[5], Lukas Ponnath[1], and Dominic Rossi[1,2] for the R3B-Collaboration — [1]Institut für Kernphysik, TUDa, Germany — [2]GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany — [3]Helmholtz Forschungsakademie HFHF — [4]Rudjer Boskovic Institute, Zagreb, Croatia — [5]Facility for Rare Isotope Beams, MSU, USA

Constraining the parameters of the nuclear Equation of State (EoS) is one of the central issues in nuclear physics, especially since the slope parameter L is still poorly constrained experimentally. It has been identified that a precise determination of the neutron-removal cross section in neutron-rich nuclei, which correlates with the neutron-skin thickness, would provide constraints on L. To this end, an experiment was performed at the R^{3}B setup at GSI as a part of the FAIR Phase-0 program. The reactions are studied in inverse kinematics with neutron-rich tin isotopes in the mass range A=124-134 on carbon targets of different thicknesses. In this communication the total reaction, charge-changing and charge-exchange analysis of ^{124}Sn+ ^{12}C at 900 MeV/u is presented.

The project was supported by the BMFTR via Project No. 05P24RD1, the Helmholtz Research Academy Hessen for FAIR and the GSI-TU Darmstadt cooperation agreement.

HK 31.4 Thu 15:00 AM 00.011

Simulation of nucleon knockout reactions in a semiclassical eikonal approach — •Stefan Typel — TU Darmstadt, Fachbereich Physik, Institut für Kernphysik — GSI Helmholtzzentrum für Schwerionenforschung, Theorie

Nucleon knockout reactions are a valuable tool to study atomic nuclei, in particular their single-particle structure and neutron skin thickness. At beam energies of a few hundred MeV per nucleon, the reaction cross section can be calculated conveniently in the eikonal approach using the imaginary part of nucleus-nucleus or nucleus-nucleon optical potentials. These are obtained from recently improved parameterizations of nucleon-nucleon scattering cross sections including their angular distribution and Pauli-blocking effects. Cross sections of various processes, e.g., one- and two-nucleon removal or charge-changing reactions are calculated using nuclear structure input from a relativistic energy density functional. The reaction process is described in a Monte-Carlo simulation to take higher-order effects into account. Results for various reactions will be presented.

Supported by the Helmholtz Forschungsakademie Hessen für FAIR (HFHF).

HK 31.5 Thu 15:15 AM 00.011

Production cross-sections of N≈126 fragments from 1 GeV/u ^{208}Pb at FRagment Separator FRS — •Suraj Kumar Singh for the Super-FRS Experiment-Collaboration — GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany — Justus-Liebig-Universität Gießen, Germany

Studies of nuclei far from the valley of stability are crucial for understanding nuclear reactions and nuclear structure, with implications ranging from fundamental physics to nuclear astrophysics and applications. In particular, neutron-rich nuclei near the N = 126 shell closure play a key role as potential waiting-point nuclei in the rapid neutron-capture (r-) process, strongly influencing the formation of the heaviest elements in the universe. Accessing these isotopes requires reliable predictions of production rates, which in turn depend on accurate production cross-sections. Since theoretical calculations in this region remain challenging, experimental cross-section measurements provide essential input for planning future studies of these exotic nuclides and for improving reaction models.

In this contribution, cross-section measurements from 1 GeV/u ^{208}Pb projectiles on a ^{9}Be target, performed at the Fragment Separator (FRS) at GSI will be presented. The new data provide insights into the underlying production mechanisms and serve as important benchmarks for state-of-the-art theoretical models used to predict yields of yet-unmeasured isotopes.

HK 31.6 Thu 15:30 AM 00.011

Production cross section measurements with a 170Er beam at the GSI FRS — •Justus Eder for the Super-FRS Experiment-Collaboration — GSI Helmholtzzentrum für Schwerionenforschung — Justus-Liebig Universität Giessen

New production cross section results are presented from the FAIR Phase-0 experiment *"Structure of neutron-rich, rare-earth nuclei far from stability"* (G-22-00100), performed at the GSI Fragment Separator (FRS) using the newly developed 1080 MeV/u ^{170}Er beam on a beryllium target. The measurements probe the exotic, highly deformed nuclear region near Z=68, employing both the $B\rho - \Delta E - B\rho$ separation and $B\rho - \Delta E^* - TOF$-identification techniques. Particle identification has been significantly improved through refined delay-line corrections in the tracking detectors TPCs, which enhance position resolution, as well as position-dependent timing corrections in the scintillators, leading to more accurate time-of-flight measurements. Preliminary production cross sections obtained with these refinements are reported. Remaining corrections, systematic uncertainties, and prospects for further refinement are briefly discussed. These develop-

ments support future high-precision cross section studies, which are of relevance for reliable yield predictions for future NUSTAR experiments at FAIR.