HK 66: Structure and Dynamics of Nuclei XIII

Time: Thursday 15:45–17:15 Location: HBR 19: C 5b

HK 66.1 Thu 15:45 HBR 19: C 5b

Towards electron-induced fission at the S-DALINAC — •G. Steinhilber[1], N. Pietralla[1], M. Arnold[1], J. Birkhan[1], M. Block[2], M.L. Cortès[1], J. Isaak[1], T. Galatyuk[1], T. Ramaker[1], and M. Spall[1] — [1]IKP, Technische Universität Darmstadt — [2]GSI Helmholtzzentrum für Schwerionenforschung

The origin of heavy elements like rare-earth metals is a fundamental question for which direct evidence was found by observation of the gravitational-wave signal GW170817 and its associated kilonova electromagnetic transient. This established the r-process in binary neutron-star merger events for fast synthesis of heavy elements [1]. Mass accumulation due to neutron captures and associated fast beta-decays terminates in the actinide region when fission reactions start to compete. Fission fragments then form the new seed nuclei for the r-process. Detailed models of the r-process require reliable fission models. However, experimental data on nuclear fission as a function of excitation energy is scarce. To increase our understanding of the impact of fission to the r-process, a new setup for electron-induced fission is under development at the S-DALINAC at TU Darmstadt. Combining the large acceptance QCLAM spectrometer with fission fragment detectors allows for a coincident measurement of excitation energy and masses of both fragments. In this contribution, the development of the experimental setup and future physics cases will be discussed.

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[1] J. J. Cowan et al., Rev. Mod. Phys. 93, 015002 (2021).

HK 66.2 Thu 16:00 HBR 19: C 5b

Measurement of masses of fission products and isotopic yields from a ^{252}Cf spontaneous fission source at the FRS Ion Catcher — •Meetika Narang for the FRS Ion Catcher-Collaboration — University of Groningen, Netherlands — GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany.

The knowledge of independent isotopic fission yields (IIFYs) and their masses is crucial for understanding the astrophysical r-process of nucleosynthesis, nuclear structure and reactions, and nuclear reactor safety.

At the FRS Ion Catcher (FRS-IC) at GSI, fission fragments are produced by spontaneous fission (SF) from a ^{252}Cf source mounted inside a Cryogenic Stopping Cell (CSC), thermalized and stopped within the CSC. Their masses and IIFYs are measured using a Multiple-Reflection Time-Of-Flight Mass-Spectrometer (MR-TOF-MS). Incorporating several novel and unique concepts, the MR-TOF-MS resolves isobars, even with limited statistics. Its broadband nature ensures minimal relative systematic uncertainties among fission products. Extracting IIFYs includes isotope-dependent efficiency corrections for all the components of FRS-IC.

In this talk, I will present our results of the high-accuracy mass measurements, as they include the first direct mass measurement at the N=90 and Z=56-62 region, and our IIFYs results, which cover several tens of fission products in the less-accessible high-mass peak down to fission yields at the level of 10^{-5}. Future experiments will extend our results to wider Z and N ranges, lower fission yields, and other spontaneously-fissioning actinides.

HK 66.3 Thu 16:15 HBR 19: C 5b

Search for the double-alpha decay of radium isotopes — •Makar Simonov for the Double Alpha-Collaboration — Justus-Liebig-Universität Gießen, Gießen, Germany

Double-alpha decay is a predicted nuclear decay mode where the nucleus emits two α-particles simultaneously. This process was first considered in the 1980s as a sequence of ^{8}Be-cluster emission followed by its disintegration. According to a recent study (Mercier *et al.*, PRL 127, 012501 (2021)), immediate double-alpha decay is more likely to occur than ^{8}Be-like cluster decay by more than 9 orders of magnitude, and it might be detected as a back-to-back emission of two α-particles.

To verify the prediction, two complementary experiments were conducted: an offline one at the FRS Ion Catcher (GSI, 4 months, 2022) and an online one at the ISOLDE (CERN, 1 week, 2023). At the FRS Ion Catcher, a ^{228}Th source was used to produce recoil nuclei of ^{224}Ra. The filtered beam was implanted on a foil, and two double-sided silicon strip detectors (DSSDs) located around the foil registered the energy, time, and spatial position of α-particles observed by the detectors. At ISOLDE, beams of ^{222}Ra and ^{220}Ra were generated by impinging a proton beam on a uranium target. The setup included four DSSDs triggered by coincidence events only. The expected number of detected double-alpha decays for both experiments is about 100.

In this talk, we will focus on data analysis for the FRS Ion Catcher experiment. We will examine key factors of DSSD calibration: detector geometry, energy and time resolution, and the use of Monte Carlo simulation as a tool to estimate the background.

HK 66.4 Thu 16:30 HBR 19: C 5b

Realistic Coalescence model for deuteron formation — •Maximilian Horst and Laura Fabbietti — Technische Universität München

Coalescence is one of the main models to describe the formation of light nuclei in high-energy collisions. It assumes that protons and neutrons are formed at chemical freeze-out, and bind together if they are close in phase-space. In the past, simplistic models, such as the spherical approximation and box-coalescence, have been used to describe this process. However, all of these models fail to describe the measured results without fitting free parameters. As such, they lack predictive power in regimes where nuclear production yields are not yet measured. This is problematic since one of the most intriguing applications of coalescence is looking for signatures of dark matter in cosmic ray antinuclei. This application requires extrapolation from the current high energy measurement at LHC energies at the TeV scale to the astrophysically relevant collision energies of ~20 GeV. A promising advanced coalescence model is one that employs the Wigner function formalism to predict deuteron yields without free parameters as long as the size of the emission source and the nucleon momentum distributions are measured. However, the source size has never been measured in small systems outside the LHC energies. In this talk, we present a newly developed Toy Monte Carlo model called ToMCCA, which we use to fit the source size and predict deuteron yields for arbitrary energies. This work is funded by BMBF Verbundforschung (05P21WOCA1 ALICE) and DFG SFB1258

HK 66.5 Thu 16:45 HBR 19: C 5b

Measurement of ^{3}H and ^{3}He production in pp collisions at $\sqrt{s} = 13$ TeV with ALICE at the LHC — •Matthias Herzer for the ALICE Germany-Collaboration — Institut für Kernphysik, Goethe Universität, Frankfurt, Germany

The production of (anti)nuclei in pp collisions at the LHC has become a major topic in the high-energy physics community. In fact, there is a huge overlap between different research directions, from astrophysics, particle and nuclear physics. For instance, the observation of antinuclei in space is considered as possible signature for dark matter, since they would originate from collisions of potential dark matter candidates among each other. We show the study of the production of ^{3}H and ^{3}He in pp collisions at 13 TeV in two data sets that were taken in LHC Run 2, i.e. in high-multiplicity events and one from a dedicated online trigger on nuclei. Furthermore, we will show the measurement of the ratio of these nuclei. This is an important test of isospin symmetry, which is expected to hold at LHC energies, but can not be tested directly since neutrons are not accessible experimentally.

HK 66.6 Thu 17:00 HBR 19: C 5b

Fission Isomer Studies at IGISOL and at the FRS — •Nazarena Tortorelli for the I290 Collaboration-Collaboration — LMU Munich, Germany

A century from the discovery of nuclear isomers, amongst them strongly deformed fission isomers in the actinides, they are still under high scientific interest. So far 35 fission isomers with lifetimes between 5 ps and 14 ms have been observed. The longest-lived fission isomer known so far, with a half-life of 14 ms, was found in ^{242}Am populated via the $^{242}Pu(d,2n)$ reaction, while for ^{240f}Am, populated via the $^{240}Pu(d,2n)^{240}Am$ reaction, a 0.9 ms half-life was predicted. Recently, at IGISOL an experiment was performed investigating the fission isomer states in $^{240,242}Am$. The isomeric states have been populated via deuteron induced fusion-evaporation reactions on a ^{242}Pu target and the decay time and the kinetic energy of the fission isomers have been measured. Moreover, at the FRS, a new isomer population scheme was investigated: projectile fragmentation (i.e., the collision of a heavy relativistic beam of $1 GeV/u$ ^{238}U on a light Be target). This scheme offers rapid production, hence access to isomers with short half-lives, and most importantly, highly pure fragmented beams and event-by-event identification. In this talk the recent experiment at IGISOL will be presented together with a preliminary overview of the experiment performed at the FRS showing the status of the fission isomers studies and the possibilities for future investigations. Supported by GSI F&E (LMTHI2023).