HK 37: Nuclear Astrophysics V

Time: Wednesday 17:30–19:00 Location: SR 0.03 Erw. Physik

Group Report HK 37.1 Wed 17:30 SR 0.03 Erw. Physik

Towards the Early- and First-Science experiments with the Super-FRS Ion Catcher — •Daler Amanbayev[1,2,3] and The FRS Ion Catcher Collaboration[1,2,3] — [1]Justus-Liebig Universität Gießen, Gießen, Germany — [2]Helmholtz Research Academy Hesse for FAIR (HFHF), Campus Gießen, Gießen, Germany — [3]GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany

The Super-FRS Ion Catcher (Super-FRS-IC) setup will enable the measurements of beta-delayed (multiple-)neutron emission probabilities (Pxn) i.e., data for r-process nucleosynthesis models that is lacking the most. Moreover, the setup will study multi-nucleon transfer (MNT) reactions driven by secondary beams as a promising method for accessing the unexplored heavy neutron-rich nuclei. These topics will be in focus in the Early- and First-Science programs at the Super-FRS at FAIR.

At the Super-FRS-IC, the exotic nuclei produced at relativistic energies and separated in-flight will be thermalized in the Cryogenic Stopping Cell (CSC), transported over a radio frequency quadrupole (RFQ) beamline and analyzed via in the Multiple-Reflection Time-Of-Flight Mass-Spectrometer (MR-TOF-MS). The combination of characteristics of the CSC and the MR-TOF-MS enable conducting experiments in new and effective ways e.g., MNT reactions in-cell and simultaneous measurments of Pxn, nuclear masses, half-lives and Q-values.

This contribution presents the status of the Super-FRS-IC setup and provides an overview of the proof-of-principle experiments conducted at GSI with the FRS Ion Catcher setup.

HK 37.2 Wed 18:00 SR 0.03 Erw. Physik

Fast neutrino flavor conversions in a supernova — •Zewei Xiong[1], Meng-Ru Wu[2,4,5], Manu George[2], Gabriel Martínez-Pinedo[1,6], Tobias Fischer[3], Noshad Khosravi Largani[3], and Chun-Yu Lin[7] — [1]GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany — [2]Institute of Physics, Academia Sinica, Taipei 11529, Taiwan — [3]Institute of Theoretical Physics, University of Wroclaw, plac Maksa Borna 9, 50-204 Wroclaw, Poland — [4]Institute of Astronomy and Astrophysics, Academia Sinica, Taipei 10617, Taiwan — [5]Physics Division, National Center for Theoretical Sciences, Taipei 10617, Taiwan — [6]Institut für Kernphysik (Theoriezentrum), Fachbereich Physik, Technische Universität Darmstadt, Schlossgartenstraße 2, 64289 Darmstadt, Germany — [7]National Center for High-performance Computing, Hsinchu 30076, Taiwan

Dense astrophysical environments such as core-collapse supernovae are profuse sources of neutrinos. When the neutrino flux is sufficiently intense, those neutrinos can undergo collective flavor transition, the so-called fast flavor conversions (FFCs), which have been found to generally exist in supernovae. In this work, we present a comprehensive study of the FFCs by solving the multi-energy and multi-angle quantum kinetic equations based on a static and spherically symmetric CCSN matter background profile. We investigate the emergence and evolution of FFCs. We also assess their potential impacts on the neutrino heating mechanism and nucleosynthesis.

HK 37.3 Wed 18:15 SR 0.03 Erw. Physik

Microscopic description of beta-decay rates of r process nuclei — •Diana Alvear Terrero[1,2], Gabriel Martínez-Pinedo[1,2], Caroline E. P. Robin[1,3], Ante Ravlić[4], Thomas Neff[1], Max Pallàs[5], and Ariel Tarifeño-Saldivia[6,5] — [1]GSI Helmholtzzentrum für Schwerionenforschung, Germany — [2]Technische Universität Darmstadt, Germany — [3]Universität Bielefeld, Germany — [4]Michigan State University, USA — [5]Universitat Politècnica de Catalunya (UPC), Spain — [6]Instituto de Física Corpuscular (IFIC), Spain

Beta decay rates are fundamental to understanding r-process nucleosynthesis, which is responsible for producing roughly half of the heavy elements. Existing theoretical global calculations of the rates use either Skyrme or relativistic quasiparticle random phase approximation (QRPA). These models yield very different predictions and are limited due to their treatment of nuclear many-body correlations. Many-body correlations are known to determine the low-lying beta-decay strength and consequently the decay half-lives due to their strong sensitivity to phase space. In this talk, I address the inclusion of deformation and the coupling of quasiparticles to like-particle phonons within relativistic QRPA linear response theory. The impact on the beta strength and half-lives will be discussed together with the competition of Gamow-Teller and forbidden transitions.

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HK 37.4 Wed 18:30 SR 0.03 Erw. Physik

Beta Spectroscopy Studies of Broad Energy Germanium (BEGe) Detectors and GEANT3 with ^{90}Sr — •Davud Sokolovic — Goethe Universität, Frankfurt am Main

Beta spectroscopy is a critical tool in nuclear astrophysics, particularly in the context of the activation method, as it allows the study of radioactive isotopes that decay predominantly or exclusively via beta decay, with minimal gamma emissions. Broad Energy Germanium (BEGe) detectors, which are primarily designed for gamma spectroscopy, offer precise energy resolution and low background noise, making them ideal for studying the beta spectrum of the isotope ^{90}Sr, which exclusively undergoes beta decay. However, to fully utilise these detectors in beta spectroscopy, a systematic characterisation of their response to beta radiation is required.

The primary objective of this research is to address discrepancies observed between experimental measurements and GEANT3 simulations. Therefore, a comprehensive study of energy loss mechanisms, including inelastic scattering and bremsstrahlung, is undertaken to refine simulation models and enhance our understanding of the interaction between beta particles and the detector material. In this talk, first results from this study are presented, providing insights into the potential of BEGe detectors for beta spectroscopy and the refinement of nuclear data.

HK 37.5 Wed 18:45 SR 0.03 Erw. Physik

Helium burning reactions: Results from Felsenkeller and future plans — •Eliana Masha[1], Simon Vincent[1,2], Aleksandra Skruch[1], Daniel Bemmerer[1], Axel Boeltzig[1], Peter Hempel[1,2], Konrad Schmidt[1], Anup Yadav[1,2], Jordan Marsh[3], and Kai Zuber[2] — [1]Helmholtz-Zentrum Dresden-Rossendorf (HZDR) — [2]TU-Dresden — [3]School of Physics and Astronomy, University of Edinburgh, United Kingdom

Helium burning is a crucial phase of stellar evolution, responsible for the synthesis of key elements such as carbon, oxygen, and fluorine, which significantly influence the chemical evolution of the Universe. Precise measurements of helium-burning reaction rate at astrophysical energies are essential to constrain stellar models and to understand nucleosynthesis pathways. At the Felsenkeller 5 MV accelerator lab in Dresden, we recently measured the $^{15}\mathrm{N}(\alpha,\gamma)^{19}\mathrm{F}$ reaction, which is one of the primary sources of fluorine production, an element whose origin remains a long-standing problem in nuclear astrophysics. Experimental details and results from resonances in the 0.8 - 2 MeV range, along with future plans to investigate other key helium-burning reactions, will be presented.