HK 22: Nuclear Astrophysics III

Time: Tuesday 15:45–17:15 Location: SR 0.03 Erw. Physik

Group Report HK 22.1 Tue 15:45 SR 0.03 Erw. Physik
Neutron activations for nuclear astrophysics — •Tanja Heftrich — Goethe-Universität Frankfurt

About 50% of heavy elemental abundances are produced in the slow neutron capture process (s-process). The main component of the s-process takes place in low-mass thermally pulsing asymptotic giant branch (TP-AGB) stars during the He-shell burning phase. The weak component refers to massive pre-supernova stars during convective C-shell burning. In AGB stars, neutron densities of 10^{10} cm^{-3} and temperatures of k_BT = 5 and 25 keV are reached, whereas in massive stars neutron densities of 10^{12} cm^{-3} at temperatures of up to k_BT = 30 and 90 keV during C-shell burning are reached.
The activation method is a strong tool to investigate neutron capture measurements corresponding to the stellar sites of the s-process. Stellar neutron spectras are produced by accelerating protons with an energy of 1912 keV onto a metallic lithium target. The resulting neutron spectrum refers to temperatures of k_BT = 25 keV. We developed this working horse method further to measure neutron capture cross section at lower temperatures of k_BT = 5 keV and even higher temperatures of k_BT = 90 keV to cover the whole s-process temperature regime.

HK 22.2 Tue 16:15 SR 0.03 Erw. Physik
Feasibility Tool for Neutron Capture on Radioactive Isotopes — •Muaz Al Halabi — Goethe Universität, Frankfurt am Main, Germany

The slow neutron capture process (s-process) is particularly significant for understanding the production of elements heavier than iron across different astronomical environments. Neutron capture measurements can be used to study the s-process using the activation technique. Three key parameters define such an experiment: a sufficient neutron flux (ϕ_n), a target isotope for activation, and a detector to identify the newly produced product isotope through a direct neutron capture (n, γ) measurement.

It is particularly challenging, however, when both the target and product isotopes are radioactive. In such cases, emissions from the target can create a background that interferes with detecting emissions from the product isotope, making it difficult to identify the product. Therefore, accurately determining the required neutron flux for activation experiments is essential to ensure that detectors can distinguish the product isotope's emissions from those of the target.

This presentation introduces a simulation-based method to help experimentalists quickly estimate the required neutron flux for activation experiments and evaluate their feasibility.

HK 22.3 Tue 16:30 SR 0.03 Erw. Physik
Direct Measurements of Neutron Capture Rates in Unstable Astrophysical Nuclei: A New Frontier — •Abdallah Karaka[1], Timm-Florian Pabst[1], Devin Hymers[1], Erik Strub[2], Gereon Weingarten[1], Markus Schiffer[1], Martin Mueller[1], Michael Weinert[1], Stefan Heinze[1], Tom Sittig[1], and Dennis Muecher[1] — [1]Institute of Nuclear Physics, University of Cologne, Germany — [2]Institute of Nuclear Chemistry, University of Cologne, Germany

The intermediate neutron capture process (i-process) likely occurs in AGB stars and is crucial for explaining elemental abundances in certain CEMP stars. While most aspects of the i-process are well-constrained, neutron capture rates and cross sections remain significant unknowns in nuclear physics.

Indirect measurements have high uncertainties, while direct measurements are challenging as many key nuclei are a few neutrons away from stability and hence unstable.

This talk explores direct measurements of neutron capture cross sections for selected long-lived nuclei to better understand the i-process dynamics. We present the status and initial tests of a beamline designed to produce a high-density secondary neutron beam at the CologneAMS-6MV tandetron. The cross sections will be measured using a novel activation technique based on detection of beta-decay electrons, suited to suppress the high activity of the initial sample by six orders of magnitude. The first physics case is the $^{137}Cs(n_{st}, \gamma)^{138}Cs$ stellar neutron capture cross section, constraining the unusual Lanthanum over Barium abundance ratios observed in many CEMP stars.

HK 22.4 Tue 16:45 SR 0.03 Erw. Physik
3α decay study of resonances ^{12}C — •Joe Roob[1], Peter Reiter[1], Konrad Arnswald[1], Timo Biesenbach[1], Maximilian Droste[1], Madalina Enciu[3], Pavel Golubev[2], Rouven Hirsch[1], Hannah Kleis[1], Nikolas Königstein[1], Dirk Rudolph[2], Alessandro Salice[1], Luis Sarmiento[2], and David Werner[1] — [1]University of Cologne, Institute for Nuclear Physics, Cologne, Germany — [2]Lund University, Department of Physics, Lund, Sweden — [3]TU Darmstadt, Institute of Nuclear Physics, Darmstadt, Germany

Excited states in ^{12}C were populated using a ^{12}C(α,α*) reaction during two experiments conducted at the FN tandem in Cologne. Breakup of ^{12}C resonances into three α particles has been measured in complete kinematics with 18 highly segmented Si-strip detectors of the Lund York Cologne Calorimeter Array. Dalitz plots are used to visualize and analyse the data for the particle unbound states 3_1^- at 9.6 MeV, 1_1^- at 10.8 MeV 2_1^- at 11.8 MeV 1_1^+ at 12.7 MeV and 4_1^- at 13.3 MeV states of ^{12}C. The Dalitz plot intensity distribution features zero points characteristic of the total spin and parity of the 3α system. Comparison with previous results from [1] and theoretical predictions will be discussed. [1] O. S. Kirsebom, *et al.*, Phys. Rev. C **81**, 064313 (2010)

HK 22.5 Tue 17:00 SR 0.03 Erw. Physik
In-beam gamma-ray spectroscopy of neutron-rich nuclei around the N=20 island of inversion — •Bellona Bles for the e12003 experiment-Collaboration — GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany — Department of Physics, University of Novi Sad, Novi Sad, Serbia

The ground state wave function of nuclei in the island of inversion at N=20 is dominated by *fp* instead of *sp* configurations, contradictory to the normal shell filling observed near stability. At the center of this region is ^{32}Mg with a characteristic intruder ground state, however, the transition into the island of inversion, especially at the northern shore, is still a subject of discussion. Therefore, this work explores the structure of $^{30-35}$Al isotopes through in-beam gamma-ray spectroscopy, aiming to provide a consistent picture into the island of inversion. The experiment was performed at NSCL, MSU, using fragmentation reactions to create secondary radioactive cocktail beams of different Mg, Al, Si, and P isotopes. The cocktail beams were guided to the secondary Be target, where nucleon knockout reactions occurred, and the gamma rays were detected with the gamma-ray tracing array GRETINA. The reaction products were further directed toward the S800 spectrograph. From the experimental data, exclusive cross-sections and parallel momentum distributions will be extracted to determine the spectroscopic factors and updated level schemes with firmly assigned spin and parity to states. This talk reports on the status of the analysis and presents the first results on the level schemes of neutron-rich Al isotopes.