HK 45: Nuclear Astrophysics VI

Time: Thursday 14:00–15:15 Location: SR 0.03 Erw. Physik

HK 45.1 Thu 14:00 SR 0.03 Erw. Physik

Activation experiment for cross-section measurements of proton-induced reactions around A=110 — •Benedikt Machliner, Martin Müller, Darius Schneider, Svenja Wilden, and Andreas Zilges — University of Cologne, Institute for Nuclear Physics, Germany

Understanding the nucleosynthesis of stable isotopes on the proton-rich side of the valley of stability, the so called p-nuclei, is subject of current research. Most reactions relevant for the p-process take place far away from the valley of stability. Hence, theoretical calculations for cross sections and reaction rates are crucial. In order to adjust and verify theoretical models, a wide database of experimental results is needed [1]. In the context of p-nuclei, the Cd/Sn region (A≈110) is of particular interest, as it contains seven p-nuclei (^{102}Pd, ^{106}Cd, ^{108}Cd, ^{113}In, ^{112}Sn, ^{114}Sn and ^{115}Sn). To extend the experimental database in this mass region, the activation method is well suited. Using the University of Cologne's 10 MV FN Tandem accelerator and the Cologne Clover Counting setup [2], proton-induced reactions on four cadmium isotopes, ^{102}Pd, and ^{116}Sn were performed at astrophysically relevant energies. The cross section results will be presented and a method of analyzing reactions applicable to nuclei with long-lasting metastable states in the reaction product will be laid-out.

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[1] M. Arnould and S. Goriely, Progr. in Part. and Nucl. Phys. **112**, (2020) 103766.
[2] F. Heim *et al.*, Nucl. Instrum. Methods A **966** (2020) 163854.

HK 45.2 Thu 14:15 SR 0.03 Erw. Physik

The ^{2}H$(p,\gamma)^3$He reaction studied at Felsenkeller underground lab — •Maria Lukyanova[1,2], Daniel Bemmerer[1], Axel Boeltzig[1], Antonio Caciolli[3,4], Peter Hempel[1,2], Eliana Masha[1], Konrad Schmidt[1], Anup Yadav[1,2], and Kai Zuber[2] — [1]Helmholtz-Zentrum Dresden-Rossendorf (HZDR) — [2]TU-Dresden — [3]INFN Sezione di Padova, Italy — [4]Università degli Studi di Padova, Italy

The ^{2}H$(p,\gamma)^3$He reaction is one of the primary processes responsible for deuterium destruction during Big Bang Nucleosynthesis (BBN), significantly impacting the primordial deuterium abundance (^{2}H). Previously, this reaction has been directly measured at BBN energies at LUNA using a gas target system. However, experimental data obtained at higher energies using solid targets suggest a 10% higher extrapolated cross-section. Recently, at the Felsenkeller 5 MV shallow-underground accelerator lab in Dresden, we measured the ^{2}H$(p,\gamma)^3$He reaction in the proton beam energy range 300-1200 keV providing partial overlap with both low-energy and high-energy datasets. The experimental setup and preliminary results, including γ-ray angular distributions, will be presented.

HK 45.3 Thu 14:30 SR 0.03 Erw. Physik

Constraining the ^{95}Zr(n,γ) cross section via the Oslo-method — •Tom Sittig[1], Anna Bohn[1], Devin Hymers[1], Abdallah Karaka[1], Markus Müllenmeister[1], Sarah Prill[1], Sebastian Schröder[1], Artemis Spyro[2], Michael Weinert[1], Gereon Weingarten[1], and Dennis Mücher[1] — [1]Institute of Nuclear Physics, University of Cologne, Cologne, Germany — [2]Facility for Rare Isotope Beams, Michigan State University, East Lansing, Michigan, USA

Using the Oslo method we aim to constrain the neutron capture cross section of ^{95}Zr via the ^{96}Zr(p,p') reaction. This cross section is of pivotal understanding for the slow neutron capture process (s-process) as the long-lived ^{95}Zr isotope is a branching point at which β-decay is in competition with the production of ^{96}Zr. But thus far its stellar neutron capture cross section is not experimentally known.

Measurements were performed at the 10 MV FN-Tandem accelerator of the Institute for Nuclear Physics at the University of Cologne using the SONIC@HORUS detector array [1]. For the main experiment a high purity ^{96}Zr target was irradiated with 15 MeV protons. Additionally, ^{90}Zr, ^{28}Si and ^{12}C foils were irradiated to perform background subtractions as well as calibrating the detector response for the statistical Oslo-type analysis. The preliminary results of these first measurements will be presented, along with a discussion of the impact of the achieved precision on our understanding of the s-process.

[1] Pickstone et al, 2017, 10.1016/j.nima.2017.09.016

HK 45.4 Thu 14:45 SR 0.03 Erw. Physik

Beam characterization of a DT neutron generator for Big Bang Nucleosynthesis studies — •Max Osswald[1,2], Daniel Bemmerer[2], Björn Lehnert[1], Steffen Turkat[1], and Kai Zuber[1] — [1]TU Dresden — [2]Helmholtz-Zentrum Dresden-Rossendorf (HZDR)

The intense DT neutron generator of TU Dresden is based on a duoplasmatron ion source, which can extract a deuteron beam with energies up to 350 keV. With beam currents of several milliamperes, it is an exceptional facility in Europe and can generate 14 MeV neutrons with up to 10^{12} n/s for fusion research. This contribution focuses on the characterization of the accelerator, including the calibration of beam energy, energy spread, and long-term stability, which are pivotal for precision studies of Big Bang Nucleosynthesis reactions. Additional key parameters such as beam spot size and position stability will also be reported enabling high-precision cross-section measurements.

Based on this characterization, the ^{2}H$(d,p)^3$H and ^{2}H$(d,n)^3$He reactions will be investigated at a new ASTRO beam line, which is currently being designed. These reactions currently limit our understanding of the primordial deuterium abundance in BBN modelings. Together with D/H precision data based on astronomical observations, these measurements will allow us to determine the cosmic baryon density $\Omega_b h^2$ with the same precision as obtained by the CMB survey of the PLANCK satellite. This independent determination of one of cosmology's most fundamental parameters will provide a cross-check between astronomy, cosmology & nuclear astrophysics, offering deeper insights into the early universe and the origin of our chemical elements.

HK 45.5 Thu 15:00 SR 0.03 Erw. Physik

Astrophysical and Nuclear Uncertainties of the r-Process — •Jan Kuske[1], Almudena Arcones[1,2,3], Takayuki Miyagi[4], Moritz Reichert[5], and Achim Schwenk[1,3] — [1]IKP, TU Darmstadt (DEU) — [2]GSI, Darmstadt (DEU) — [3]MPIK, Heidelberg (DEU) — [4]CCS, U. Tsukuba (JPN) — [5]Dep. Astronomia i Astrofisica, U. Valencia (ESP)

The rapid neutron capture (r-) process produced half of the elements heavier than iron in the Universe. Significant uncertainties remain in understanding the astrophysical environments capable of generating the necessary intense neutron fluxes. Detailed simulations of proposed astrophysical scenarios (e.g. binary neutron star mergers, magneto-hydrodynamical supernovae, and collapsars) are computationally intensive and subject to various uncertainties.

To address these challenges, we adopt an alternative approach that is instead based on a site-independent density profile. Our nuclear network calculations explore a wide range of initial electron fractions, entropies, and expansion timescales. The results align well with those of simulations and extend beyond conditions currently found in them.

Another important source of uncertainties arises from poorly constrained nuclear properties: Most nuclei along the r-process path are currently not experimentally accessible, making theoretical predictions essential, e.g. for nuclear masses, reaction rates, and fission properties. Here we show the impact of nuclear masses on r-process predictions and compare the results to observational data.