HK 8: Nuclear Astrophysics I

Time: Monday 16:30–18:00 Location: SCH/A419

Group Report HK 8.1 Mon 16:30 SCH/A419

Activation experiments for *p*-process nucleosynthesis at the University of Cologne — •Martin Müller, Felix Heim, Svenja Wilden, Pina Wüstenberg, and Andreas Zilges — University of Cologne, Institute for Nuclear Physics

For modeling the vast reaction networks involved in the production of heavy proton-rich isotopes in *p*-process nucleosynthesis, reaction cross sections for ten thousands of reactions are needed. It is impossible to measure all of these reactions in the laboratory because of which theoretical calculations of cross sections are imperative. To verify and adjust these calculations a comprehensive experimental database is needed [1]. A powerful method for extending the available database is the activation technique, which has been applied in various forms at the University of Cologne utilizing its 10 MV FN tandem and 6 MV HVE tandetron accelerators as well as the Cologne Clover Counting setup constisting of two clover-type HPGe detectors. Experiments combining the activation technique with in-beam measurements or the stacked-target method will be reported on, a method for utilizing two-step decays will be introduced, and results for the ^{168,170,172}Yb$(\alpha,n)^{171,173,175}$Hf, ^{55}Mn$(\alpha,(2)n)^{57,58}$Co, and ^{58}Fe$(p,n)^{58}$Co will be presented [2,3].
Supported by the DFG (ZI 510/8-2).

[1] M. Arnould and S. Goriely, *Phys. Rep.* **384**, 1 (2003)
[2] L. Netterdon *et al.*, *Nucl. Phys. A* **916**, 149-167 (2013)
[3] M. Müller *et al.*, submitted (2022)

HK 8.2 Mon 17:00 SCH/A419

New Cross Section Data for Radiative Proton Capture on Carbon for Nuclear Astrophysics at LUNA — •Axel Boeltzig[1] and Jakub Skowronski[2] for the LUNA-Collaboration — [1]Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany — [2]Università degli Studi di Padova and INFN Sezione di Padova, Padua, Italy

The observable ratio of ^{12}C/^{13}C can be used as a probe for stellar nucleosynthesis as well as for mixing processes during hydrogen burning, provided that the reaction rates of ^{12}C(p,γ)^{13}N and ^{13}C(p,γ)^{14}N are known. To obtain direct cross section measurements at low energies, which are required to better constrain these rates in astrophysical scenarios, both reactions were studied in a series of experiments at the LUNA-400 accelerator. Different targets and complementary detector setups were employed for a systematic study, and the sensitivity afforded by the low-background underground environment allowed for precise measurements at lower energies than previously available. We will present these experiments and their results for both reactions.

HK 8.3 Mon 17:15 SCH/A419

Cross section measurements of the ^{12}C(p,γ)^{13}N reaction in the energy range of 130 keV to 640 keV — •Simon Rümmler — Helmholtz-Zentrum Dresden-Rossendorf, Institute of Radiation Physics — TU Dresden, Institute of Nuclear and Particle Physics

The CNO-cycle is the dominant hydrogen burning process in stars above a temperature of 17 million Kelvin. The rate of this cycle in the initial phase and in the outer shells of the burning zone is dominated by the rate of the ^{12}C(p,γ)^{13}N reaction. Furthermore, this reaction affects the ratio of ^{12}C to ^{13}C abundances. Efforts are underway to re-measure the cross section of the ^{12}C(p,γ)^{13}N in the energy region of the 400 keV resonance, leading to an improved extrapolation to astrophysically relevant energies.

In 2017 the reaction was studied in inverse kinematics at the 3 MV Tandetron accelerator at Helmholtz-Zentrum Dresden-Rossendorf in an energy range of 130 keV to 450 keV. Further measurements in the energy range of 330 keV to 640 keV with low background were done at the 5 MV Pelletron accelerator at the Felsenkeller shallow-underground laboratory in Dresden in 2022. The methods and results of these measurements, as well as a conclusion of the two campaigns, will be presented.

HK 8.4 Mon 17:30 SCH/A419

3α-Zerfälle der angeregten 3^-_1, 1^-_1 und 4^-_1 Zustände von ^{12}C — •Joe Roob[1], David Werner[1], Peter Reiter[1], Konrad Arnswald[1], Maximilian Droste[1], Pavel Golubev[2], Rouven Hirsch[1], Hannah Kleis[1], Nikolas Königstein[1], Madalina Ravar[1,3], Dirk Rudolph[2], Alessandro Salice[1] und Luis Sarmiento[2] — [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

Die Eigenschaften des 3-Körper-Zerfalls der angeregten Zustände von ^{12}C ermöglichen einen direkten Vergleich mit theoretischen Modellen zur Struktur von ^{12}C. Es wurde ein Experiment mit einer $^{12}C(\alpha,\alpha')$ Reaktion mit einem 27 MeV α Strahl am 10-MV Tandem Beschleuniger des Instituts für Kernphysik der Universität zu Köln durchgeführt. Das Lund-York-Cologne-Calorimeter (LYCCA), mit 18 Silizium Streifen Detektoren (18432 Pixel), wurde für die Messung eingesetzt um die vollständige Rekonstruktion der 4 α-Kerne durch die hohe Raumwinkelabdeckung und gute Ortsauflösung zu ermöglichen. Es wurden der Hoyle-State und die höher liegenden 3^-_1, 1^-_1 und 4^-_1 Zustände bei 9641 keV, 10847 keV und 13316 keV in ^{12}C untersucht. Die Zerfälle der Zustände oberhalb des Hoyle-States werden insbesondere durch die Dalitz-Plots der 3 α-Teilchen charakterisiert. Vorläufige Ergebnisse werden diskutiert.

HK 8.5 Mon 17:45 SCH/A419

Analysis of the 3α-decay of the 0^+_2 state in ^{12} — •David Werner[1], Joe Roob[1], Peter Reiter[1], Konrad Arnswald[1], Maximilian Droste[1], Pavel Golubev[2], Rouven Hirsch[1], Hannah Kleis[1], Nikolas Königstein[1], Madalina Ravar[1,3], Dirk Rudolph[2], Alessandro Salice[1], and Luis Sarmiento[2] — [1]University of Cologne, Institute for Nuclear Physics, Cologne — [2]Lund University, Department of Physics, Lund, Sweden — [3]TU Darmstadt, Institute of Nuclear Physics, Darmstadt

The branching ratios between the direct and sequential three-particle decay of the 0^+_2 excited state in ^{12}C, the Hoyle state, are important probes for the inner structure of ^{12}C and provide insights into stellar nucleosynthesis. Two high-statistics experiments were performed at the 10 MV FN-tandem accelerator of the Institute for Nuclear Physics of the University of Cologne. A ^{12}C(α,α') reaction at a beam energy of 27 MeV was utilized to populate the state of interest. The Lund-York-Cologne-Calorimeter (LYCCA) was used to study the three-particle decay branches of the Hoyle state. The 18 segmented double-sided silicon strip detectors allowed individual detection of the reaction's four α particles with high angular precision. Results from particle spectra are compared with Geant4 Monte-Carlo simulations. Latest analysis results, in particular Dalitz plots and the search for the direct 3α decay, will be presented.