HK 58: Nuclear Astrophysics II

Time: Friday 11:00–12:45 Location: J-HS B

Group Report HK 58.1 Fri 11:00 J-HS B

Experimental techniques for Nuclear Astrophysics in Cologne — •Felix Heim, Jan Mayer, Marco Menen, Martin Müller, Philipp Scholz, and Andreas Zilges — Institute for Nuclear Physics, University of Cologne

The universe was born with just hydrogen, helium, and small traces of lithium. The question of how the remaining elements were created by nuclear reactions in stars, stellar explosions, and stellar collisions is one of the main problems addressed by the interdisciplinary field of nuclear astrophysics. Most of the heavy nuclei beyond the iron-peak region are synthesized within complex nucleosynthesis networks which include thousands of nuclear reactions on stable and unstable nuclei. At present, most of the reactions rates involved are taken from theory in the framework of the Hauser-Feshbach model. Therefore, it is essential to extend the available experimental database on the one hand and to constrain the nuclear physics parameters entering the theoretical calculations on the other hand. Radiative proton-capture reactions are well-suited for this purpose, as the emitted prompt γ-rays yield important information about the statistical γ-decay behavior in the compound nucleus. α-induced reactions can be used to constrain the α-optical model potential. In this contribution, details of the experimental techniques will be presented as well as recent experimental results for the ^{107}Ag(p,γ)^{108}Cd, ^{63,65}Cu(p,γ)^{64,66}Zn, and ^{144}Sm(α,γ)^{148}Gd reactions.

Supported by the DFG (ZI 510/8-1).

HK 58.2 Fri 11:30 J-HS B

Study of the ^{2}H$(p,\gamma)^3$He reaction at LUNA — Klaus Stöckel[1,2], •Daniel Bemmerer[1], and Tamás Szücs[1] for the LUNA-Collaboration — [1]Helmholtz-Zentrum Dresden-Rossendorf (HZDR), Dresden — [2]Technische Universität Dresden

Highly precise measurements of the primordial ^{2}H abundance in damped Lyman-α systems have rekindled hope to decisively improve the precision of Big Bang nucleosynthesis (BBN) constraints on the primordial baryon to photon ratio. However, the interpretation of the ^{2}H abundance data is limited by the imprecise knowledge on ^{2}H destruction by the ^{2}H$(p,\gamma)^3$He reaction.

The present contribution will report on the recently completed measurement of the ^{2}H$(p,\gamma)^3$He cross section using a windowless gas target and a high-purity germanium detector in close geometry at the LUNA 400 kV accelerator, deep underground in the Gran Sasso laboratory, Italy. The new data are directly in the energy range of Big Bang nucleosynthesis and present an important step towards improving the precision of cosmological constraints from BBN.

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HK 58.3 Fri 11:45 J-HS B

Study of ^{3}He(α,γ)^{7}Be at Dresden Felsenkeller — •Konrad Schmidt[1], Steffen Turkat[1], Daniel Bemmerer[2], and Kai Zuber[1] — [1]TU Dresden, Germany — [2]Helmholtz-Zentrum Dresden-Rossendorf (HZDR), Germany

One of the key reactions in both Big-Bang nucleosynthesis (BBN) and p-p-chain hydrogen burning is the ^{3}He(α,γ)^{7}Be reaction. The aim of the present study is a comprehensive data set covering the entire BBN range. In a first campaign, γ-ray angular distributions have been measured at the 3 MV Tandetron accelerator of Helmholtz-Zentrum Dresden-Rossendorf (HZDR) with implanted ^{3}He targets. Activated samples of ^{7}Be ($\approx$ 53 d half-life) have been counted at the shallow-underground laboratory Dresden Felsenkeller using a new 163% HPGe detector shielded from cosmic rays by ultra-low background copper and lead, active plastic scintillation veto detectors and 140 m water equivalent of rock. A second campaign is planned underground at the new 5 MV Pelletron accelerator Dresden Felsenkeller with a gas target currently under construction that can be operated as an extended gas chamber or as a gas-wall jet. Preliminary results of the angular distribution and activation data from the first campaign will be presented as well as the latest status of the Felsenkeller gas-target setup. This work is supported by DFG (ZU 123/21-1).

HK 58.4 Fri 12:00 J-HS B

Study of the direct 3-α decay of the 0_2^+ state in ^{12}C with LYCCA — •Madalina Ravar[1], David Werner[1], Peter Reiter[1], Stefan Thiel[1], Christoph Goergen[1], Konrad Arnswald[1], Maximilian Droste[1], Herbert Hess[1], Rouven Hirsch[1], Levent Kaya[1], Lars Lewandowski[1], Michael Seidlitz[1], Kai Wolf[1], Dirk Rudolph[2], Pavel Golubev[2], Luis Sarmiento[2], and Patrick Coleman-Smith[3] — [1]University of Cologne, Institute for Nuclear Physics, Cologne, Germany — [2]Lund University, Department of Physics, Lund, Sweden — [3]Science and Technology Facilities Council, Daresbury, England

The topic of alpha-decay of the 0_2^+ state in ^{12}C, the so-called "Hoyle State", gained a lot of interest in the past few years. The mechanism of the 3-α decay and the branching ratio of the direct and the sequential decay have a direct impact on the calculated rates for the triple-alpha process in Helium burning in stars. The Lund-York-Cologne-CAlorimeter (LYCCA), a 24-DSSSDs array, was employed for this kind of measurement at the 10-MV FN-tandem accelerator at the Institute for Nuclear Physics, University of Cologne. The excited state of ^{12}C is obtained via an inelastic alpha scattering on a $^{nat.}$C target and the outgoing alpha particles are detected in coincidence. LYCCA, a NUSTAR device, planned for FAIR@GSI, is a powerful setup coming with better angular coverage and better detector granularity compared to other measurements performed for the 3-α decay of the Hoyle state until now. Preliminary results from recent beam times are being presented in this talk. Supported by GSI F&E KREITE 1416.

HK 58.5 Fri 12:15 J-HS B

In-beam cross section measurements in the Mo-Ru region for p-process nucleosynthesis — •Martin Müller, Felix Heim, Jan Mayer, Philipp Scholz, and Andreas Zilges — Institute for Nuclear Physics, University of Cologne

In spite of many years of research, nucleosynthesis simulations are still not able to reproduce many p-nuclei abundances accurately [1]. Among the most extreme cases are the light Molybdenum and Ruthenium p-isotopes. The ^{93}Nb(p,γ)^{94}Mo reaction is one of the key reactions affecting the ^{94}Mo abundance. Hence an in-beam experiment at the HORUS γ-spectrometer located at the University of Cologne [2] was performed. A second experiment measuring total cross sections of the ^{98}Ru(α, γ)^{102}Pd reaction was conducted at the RUBION facility of the Ruhr-Universität Bochum utilizing the 4π-summing technique [3]. Preliminary results for both measurements have been compared to Hauser-Feshbach statistical model calculations [4] in an attempt to further constrain its input parameters.

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[1] M. Arnould and S. Goriely, *Phys. Rep.* **384**, 1 (2003)
[2] L. Netterdon *et al.*, *Nucl. Instr. Meth.* A **754**, 94 (2014)
[3] A. Spyrou *et al.*, *Phys. Rev. C* **76**, 1 (2007)
[4] W. Hauser and H. Feshbach, *Phys. Rev.* **87**, 366 (1952)

HK 58.6 Fri 12:30 J-HS B

α-spectroscopy to determine ^{144}Sm(α,γ)^{148}Gd production — •Heinrich Wilsenach[1], Philipp Scholz[2], Andreas Zilges[2], and Kai Zuber[1] — [1]TU Dresden, Institut für Kern- und Teilchenphysik, Germany — [2]University of Cologne, Institute for Nuclear Physics, 50937 Köln, Germany

Measurements of p-nuclei production rates help to shed some light on the observed abundances and help to constrain predictions made with extended reaction networks. One of the outstanding measurement is the ^{144}Sm(α,γ)^{148}Gd cross section [1]. The predicted cross section varies from the measurement by more than an order of magnitude [2], making this cross section the most uncertain p-process nuclide production. For this reason a re-measurement was performed using isotopically enriched ^{144}Sm, activated at various energies close to the Gamow window. The ^{148}Gd α-decay was used to determine the amount of the produced material. The decay rates were expected to be in the range of 4 per hour. To measure such a low count-rate an ultra-low background ionisation chamber at IKTP TU Dresden was used. The chamber achieved a background rate in the region of interest (1 MeV to 4 MeV) of around 0.27 counts per day per MeV. The subject of this talk is to describe the method used to determine the amount of ^{148}Gd produced in the (α,γ) activation of enriched ^{144}Sm samples. Advanced simulations are fitted to data to help constrain systematic uncertainties. [1] E. Somorjai *et al.* Astron. Astrophys. 333, (1998) 1112-1116 [2] T. Rauscher *et al.* Rep. Prog. Phys. 76, (2013) 066201 (38pp)