# HK 11: Nuclear Astrophysics 1

Time: Monday 17:00–18:45 Location: K/HS2

**Group Report** HK 11.1 Mon 17:00 K/HS2

**Investigation of proton- and $\alpha$-capture reactions for the astrophysical $\gamma$ process via in-beam $\gamma$-ray spectroscopy** — •Lars Netterdon[1], A. Endres[2], J. Mayer[1], P. Scholz[1], and A. Zilges[1] — [1]Institute for Nuclear Physics, University of Cologne — [2]Institute for Applied Physics, Goethe University Frankfurt am Main

The $p$ nuclei, about 30 to 35 neutron-deficient stable nuclei, are bypassed by the $s$ and $r$ process. It is believed, that the majority of these nuclei is produced via photodisintegration reactions and subsequent $\beta$ decays during the $\gamma$ process. Reaction rates for the $\gamma$-process reaction network are to a large extent calculated within the scope of the Hauser-Feshbach statistical model. The nuclear-physics input, such as optical-model potentials and $\gamma$-ray strength functions, must be constrained experimentally in order to reduce the uncertainties of reaction-rate calculations. A dedicated setup for in-beam nuclear astrophysics experiments aiming at the aforementioned input parameters using the $\gamma$-ray spectrometer HORUS will be introduced [1]. The $^{112}$Sn($\alpha$,$\gamma$)$^{116}$Te reaction will be presented, being the first successful in-beam $\alpha$-capture experiment on a heavy nucleus to date. In addition, an experiment on the $^{89}$Y(p,$\gamma$)$^{90}$Zr reaction is presented, where special emphasis is put on the partial cross-sections. With the aid of partial cross-sections, a method is shown which allows an experimental constraint on the $\gamma$-ray strength function in the compound nucleus $^{90}$Zr. Supported by the ULDETIS project within the UoC Excellence Initiative institutional strategy.

[1] L. Netterdon *et al.*, Nucl. Instr. Meth. A **754** (2014) 94

HK 11.2 Mon 17:30 K/HS2

**Untersuchung der Reaktion $^{90}$Zr(p,$\gamma$) mit In-beam Gammaspektroskopie** — •Philipp Erbacher[1], Anne Endres[1], Jan Glorius[1], Lars Netterdon[2], Kerstin Sonnabend[1], Benedikt Thomas[1] und Andreas Zilges[2] — [1]Institut für Angewandte Physik, Goethe Universität Frankfurt am Main — [2]Institut für Kernphysik, Universität zu Köln

Nach dem aktuellen Stand der Forschung wird der $p$-Kern $^{92}$Mo zum größten Teil durch Photodesintegrationsreaktionen in Typ II Supernovae produziert. Netzwerkrechnungen zeigen jedoch, dass dieses Produktionszenario alleine nicht ausreicht, um die solare Häufigkeit von $^{92}$Mo zu erklären. Als zusätzliches Produktionsszenario wurden daher Protoneneinfangreaktionen während Typ Ia Supernovae vorgeschlagen. Um diese Annahme zu überprüfen, ist eine genaue Kenntnis der relevanten Wirkungsquerschnitte notwendig. Aus diesem Grund wurde ein zu 97.65% angereichertes $^{90}$Zr-Target mit Protonen mit Energien von 2.5 MeV bis 5.1 MeV bestrahlt, um die Wirkungsquerschnitte der Reaktion in den Grundzustand und das Isomer von $^{91}$Nb zu bestimmen. Die Messungen wurden am Horus-Spektrometer an der Universität zu Köln durchgeführt. Die Ergebnisse des Experiments werden vorgestellt und diskutiert.

gefördert durch DFG (SO907/2-1) und HIC for FAIR.

HK 11.3 Mon 17:45 K/HS2

**Neutron-Capture Rates with the R$^3$B-CaveC Setup** — •Marcel Heine for the R3B-Collaboration — TU, Darmstadt

Recent research has shown that the (n,$\gamma$) transition-rates on light nuclei can have an influence on the neutron-balance during the $r$-process. Especially neutron-rich carbon isotopes play an important role in $r$-process nucleosynthesis network calculations which include light nuclei, since these nuclei are aligned along major flow-paths. In particular $^{18}$C is of interest, because it can be interpreted as a waiting point. The $^{17}$C(n,$\gamma$)$^{18}$C rate could so far only be estimated theoretically and has an uncertainty of a factor of ten [1]. At the R$^3$B-CaveC setup at GSI we have measured the time reversed reaction, i.e. $^{18}$C($\gamma$,n)$^{17}$C *via* the Coulomb dissociation of $^{18}$C beam. The kinematically complete measurement allows extracting exclusive energy dependent neutron-capture cross section with respect to the excitation energy by using the invariant-mass method. Experimental results will be presented in comparison to theoretical calculations and the influence on $r$-process nucleosynthesis products will be discussed. This work is supported by HIC for FAIR, GSI-TU Darmstadt cooperation, and the BMBF project 05P12RDFN8

[1] T. Sasaqui et al., APJ 634 (2005) 1173

HK 11.4 Mon 18:00 K/HS2

**Neutroneneinfangsquerschnitte von $^{85}$Kr** — •Stefan Fiebiger[1], Ulrich Giesen[2], Tanja Heftrich[1], René Reifarth[1], Stefan Schmidt[1], Zuzana Slavkovská[1], Benedikt Thomas[1] und Mario Weigand[1] — [1]Goethe-Universität Frankfurt — [2]Physikalisch-Technische Bundesanstalt, Braunschweig

Neutroneneinfang und $\beta^-$-Zerfall sind zwei konkurrierende Reaktionen in der s-Prozess Nukleosynthese des $^{85}$Kr, was es zu einem wichtigen Verzweigungspunkt macht. Die Kenntnis des Neutroneneinfangsquerschnitts von $^{85}$Kr ist deswegen ein essentielles Werkzeug, um die Modelle der stellaren Nukleosynthese besser zu verstehen. Ziel ist es $^{85}$Kr(n,$\gamma$) mit der Flugzeitmethode zu messen.
Dazu werden zunächst Methoden zur Produktion von $^{85}$Kr untersucht. Eine davon ist die Bestrahlung einer $^{82}$Se Probe mit einem $\alpha$-Strahl, wobei das produzierte $^{85}$Kr in der Kristallstruktur gefangen bleibt. Aufgrund von technischen Schwierigkeiten und geringen Ausbeuten dieser Methode besteht weiterhin die Möglichkeit, reaktorproduziertes $^{85}$Kr zu verwenden.
Für zukünftige Messungen des Neutroneneinfangsquerschnitts von $^{85}$Kr an FRANZ (Frankfurter Neutronenquelle am Stern-Gerlach-Zentrum) ist das Ziel, möglichst isotopenreine Proben zu verwenden, um den Untergrund bei der Messung zu reduzieren. Hierbei stellt vor allem $^{83}$Kr ein Problem dar.
Dieses Projekt wurde unterstützt vom ERC Grant Agreement n. 615126.

HK 11.5 Mon 18:15 K/HS2

**Chiral 3N forces in Quantum Monte Carlo calculations**$^\star$ — •Ingo Tews[1,2], Stefano Gandolfi[3], Alexandros Gezerlis[4], and Achim Schwenk[1,2] — [1]Institut für Kernphysik, Technische Universität Darmstadt — [2]ExtreMe Matter Institute EMMI, GSI Helmholtzzentrum für Schwerionenforschung GmbH — [3]Theoretical Division, Los Alamos National Laboratory — [4]Department of Physics, University of Guelph

Chiral effective field theory (EFT) provides a systematic framework that describes low-energy hadronic interactions and allows calculations with controlled theoretical uncertainties. It explicitly includes chiral physics and, thus, is directly linked to Quantum Chromodynamics. We recently have studied local chiral NN potentials at next-to-next-to-leading order (N$^2$LO) and used this to calculate the energy per particle of neutron matter using the auxiliary-field diffusion Monte Carlo (AFDMC) method. In addition to two-nucleon interactions, chiral EFT naturally predicts consistent many-body interactions. We show how to include the leading chiral 3N forces into an AFDMC calculation and present results for the equation of state of pure neutron matter at N$^2$LO including NN and 3N forces.

$^\star$This work was supported in part by the ERC Grant No. 307986 STRONGINT, by the Helmholtz Alliance HA216/EMMI, by NSERC, the US DOE SciDAC-3 NUCLEI project, and the LANL LDRD program. Computations were performed at the Jülich Supercomputing Center and at NERSC.

HK 11.6 Mon 18:30 K/HS2

**Study of the $^{22}$Ne(p,$\gamma$)$^{23}$Na reaction at LUNA with a 4$\pi$ BGO summing detector** — •Marcell Peter Takács, Daniel Bemmerer, and Tamás Szücs for the LUNA-Collaboration — Helmholtz-Zentrum Dresden-Rossendorf (HZDR), Dresden

The $^{22}$Ne(p,$\gamma$)$^{23}$Na reaction takes part in the neon-sodium cycle of hydrogen burning. This cycle is active in asymptotic giant branch stars as well as in novae and contributes to the nucleosythesis of neon and sodium isotopes. In order to reduce the uncertainties in the predicted nucleosynthesis yields, new experimental efforts to measure the $^{22}$Ne(p,$\gamma$)$^{23}$Na cross section directly at the astrophysically relevant energies are needed. In the first, recently completed phase of the LUNA $^{22}$Ne(p,$\gamma$)$^{23}$Na experiment, selected low-energy resonances were studied with two high-purity germanium detectors. In the present talk, the preparations for the second experimental phase are reported. In this phase, a 4$\pi$ bismuth germanate summing detector will be used to address the lowest-energy resonances as well as direct capture. — Supported by DFG (BE 4100/2-1) and NAVI (HGF VH-VI-417).