HK 49: Nuclear Astrophysics IV

Time: Wednesday 17:30–19:15 Location: HBR 14: HS 4

Group Report HK 49.1 Wed 17:30 HBR 14: HS 4

First study of the ^{139}Ba(n,γ)^{140}Ba reaction to constrain the conditions for the astrophysical i process — •Dennis Muecher[1], Artemis Spyrou[2], Pavel Denissenkov[3], Falk Hervig[3], Magne Guttormsen[4], Ann-Ceceilie Larsen[4], and Mathis Wiedeking[5] — [1]Institut für Kernphysik, Universität zu Köln — [2]FRIB, Michigan State University, USA — [3]Department of Physics and Astronomy, University of Victoria, Canada — [4]Department of Physics, University of Oslo, Norway — [5]SSC Laboratory, iThemba LABS, South Africa

The intermediate "i" process was proposed as a plausible scenario to explain some of the unusual abundance patterns observed in metal-poor stars (Denissenkov et al, ApJ Letters 2017). The most important nuclear physics properties entering i-process calculations are the neutron-capture cross sections and they are almost exclusively not known experimentally. In this talk we demonstrate results (Spyrou et al., under review at PRL, 2023) from an experiment using RIBs from CARIBU, Argonne National Laboratory, allowing to experimentally constraint the ^{139}Ba(n,γ)^{140}Ba reaction rate using the newly developed "Shape" method (Muecher et al., PRC 107, L011602, 2023). Our results remove the dominant source of uncertainty for the production of lanthanum, a key indicator of i-process conditions. Our results show that the observed elemental abundances in metal-poor stars are consistent with an i-process scenario at neutron densities of $10^{13} n/cm^3$.

HK 49.2 Wed 18:00 HBR 14: HS 4

A Trap System for Measuring Neutron Capture Cross Sections for the r-process — •Heinrich Wilsenach[1,4], Timo Dickel[1,2], Israel Mardor[4,5], Emma Haettner[2], Wolfgang Plass[1,2], Christoph Scheidenberger[1,2,3], and Mikhail Yavor[6] — [1]Justus-Liebig-Universität Gießen, Gießen, Germany — [2]GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany — [3]HFHF, Gießen, Germany — [4]Tel Aviv University, Tel Aviv, Israel — [5]Soreq Nuclear Research Center, Yavne, Israel — [6]St. Petersburg, Russia

One of the current limitations of predicting the nuclear astrophysics r-process abundance is the lack of experimental data of neutron-capture cross-sections of radioactive neutron-rich isotopes. Their measurement is currently considered very challenging due to the instability of the targets and projectile. To overcome this limitation, we plan to stop and thermalise fission fragments in a cryogenic stopping cell. These fragments will then form a cooled low-energy beam, which will be transported into an RF trap system (coined "NG-Trap"). An intense neutron beam will consequently irradiate this trapped "cloud target". The reacted ions will be mass-selected, identified and counted using a multiple-reflection time-of-flight mass-spectrometer (MR-TOF-MS), thus extracting (n,γ) cross-sections. The talk will discuss the current status of a triple-RFQ system operating at Tel-Aviv University and present a measured trap capacity of more than 10^{10} ions. The system is the first step in designing the final NG-Trap system to be installed at the Soreq Applied Research Accelerator Facility (SARAF).

HK 49.3 Wed 18:15 HBR 14: HS 4

Towards direct measurements of astrophysical neutron capture rates in unstable nuclei — •Timm-Florian Pabst[1], Abdallah Karaka[1], Markus Schiffer[1], Stefan Heinze[1], Erik Strub[2], and Dennis Mücher[1] — [1]University of Cologne, Institute of Nuclear Physics, Cologne, Germany — [2]University of Cologne, Division of Nuclear Chemistry, Cologne, Germany

The intermediate neutron capture process (i process) is presumably taking place in AGB stars and is required to explain elemental abundances of certain CEMP stars. With most quantities along the i process being well constrained experimentally, neutron capture rates are among the largest unknowns in terms of the nuclear physics input. While indirect measurements suffer from higher uncertainties, direct measurements are hindered by the fact that many key nuclei along the i process are unstable.

In this talk we will discuss the possibilities for direct measurements of neutron capture cross sections for selected long-lived target nuclei, with the goal to constrain the astrophysical conditions of the i process. We discuss the status and first tests of a new beamline for the production of a high density secondary neutron beam at the CologneAMS 6MV tandetron. Cross sections will be measured via a new activation technique based on beta-decay electron detection. Our first physics case is the ^{137}Cs$(n,\gamma)^{138}$Cs cross section with the goal to shed light into understanding the observed Lanthanum and Barium abundances in AGB stars.

HK 49.4 Wed 18:30 HBR 14: HS 4

Neutron-star merger models including all phases of matter ejection — •Oliver Just[1,2], Vimal Vijayan[1,3], Zewei Xiong[1], Stephane Goriely[4], Theodoros Soultanis[1], Andreas Bauswein[1,5], Jerome Guilet[6], Hans-Thomas Janka[7], and Gabriel Martinez-Pinedo[1,5,8] — [1]GSI, Darmstadt, German — [2]RIKEN, Saitama, Japan — [3]Ruprecht-Karls-Universität, Heidelberg, Germany — [4]ULB, Brussels, Belgium — [5]FAIR HFHF, Darmstadt, Germany — [6]Paris University, France — [7]MPA, Garching, Germany — [8]IKP, Darmstadt, Germany

Collisions of two neutron stars, as first observed in 2017, are unique nuclear physics laboratories. The material ejected during these events is believed to undergo the rapid neutron-capture (r-) process, and the nuclear equation of state (EOS) has a crucial impact on the lifetime of the hyper-massive merger remnant until it collapses to a black hole. In order to predict the observational signature, e.g. the kilonova signal, of r-process nucleosynthesis and the nuclear EOS, detailed numerical simulations are necessary, ideally covering all phases of matter ejection. Most existing simulations, however, focus only on the first tens of milliseconds and neglect the subsequent ("post-merger") evolution. This contribution presents our recent study where we developed models of delayed-collapse mergers, which cover about 100 seconds, i.e. all relevant phases of matter ejection. Such "end-to-end" models are essential for reliably predicting the total r-process yields, the geometric distribution of different chemical elements in the ejecta, and for assessing the impact of the remnant lifetime on the kilonova.

HK 49.5 Wed 18:45 HBR 14: HS 4

Decoding the HESS J1731-347 compact object's equation of state — •Ishfaq Ahmad Rather[1], Grigoris Panotopoulos[2], and Ilidio Lopes[3] — [1]Institute of Theoretical Physics, Goethe University, Frankfurt am main — [2]Departamento de Ciencias Fisicas, Universidad de la Frontera, Casilla 54-D, 4811186 Temuco, Chile — [3]CENTRA, Instituto Superior Tecnico, Universidade de Lisboa, 1049-001 Lisboa, Portugal

The recently announced measurement of HESS J1731-347 with $M = 0.77^{+0.20}_{-0.17} M_\odot$ and $R = 10.4^{+0.86}_{-0.78}$ km challenges our understanding of the EoS at densities (1-2) times the nuclear saturation density [1]. This estimate of maximum mass, 0.77 $M_\odot$, is intriguing, given the previous analysis revealed that the minimum possible mass of a neutron star is 1.17M*. The HESS J1731-347 measurement is also interesting as the first simultaneous measurement of the mass, radius, and surface temperature of a compact star and opens the possibility to study its thermal evolution. We examine the nature of HESS J1731-347 as a strange star and study the radial properties at its maximum mass [2]. We also explore the possibility of HESS J1731-347 CCO to be a Dark Matter admixed Strange star.

References:

1) V. Doroshenko, V. Suleimanov, G. Pühlhofer, A. Santangelo, Nat. Astron. 6(12), 1444-1451 (2022)

2) I. A. Rather, G. Panotopoulos, I. Lopes, EPJ C, 83:1065 (2023)

HK 49.6 Wed 19:00 HBR 14: HS 4

Towards a Doppler shift measurement of the 1 fs lifetime of the 6.79 MeV state in ^{15}O — •Max Osswald[1,2], Daniel Bemmerer[1], Antonio Caciolli[3,4], Eliana Masha[1], Jakub Skowronski[3,4], Elia Pilotto[3,4], Steffen Turkat[2], and Bruno Poser[1,2] — [1]Helmholtz-Zentrum Dresden-Rossendorf (HZDR) — [2]TU Dresden — [3]INFN Sezione di Padova, Italy — [4]Università degli Studi di Padova, Italy

The 6.79 MeV excited state in ^{15}O plays an important role in nuclear astrophysics, because it is a subthreshold resonance that is significant for the low-energy extrapolation of the ^{14}N$(p,\gamma)^{15}$O reaction. This reaction controls the rate of the Bethe-Weizsäcker cycle of hydrogen burning. Its lifetime is on the level of 1-3 fs, with many recent experiments giving conflicting data. The present contribution will report on the first steps of the data analysis of a recent experiment using the AGATA γ-ray tracking array coupled with the CD silicon detector at Legnaro National Lab, Italy. The contribution will also cover some target stability measurements carried out at Dresdener Felsenkeller, Germany, prior to the Legnaro experiment.