HK 12: Nuclear Astrophysics II

Time: Monday 16:45–18:00 Location: SR 0.03 Erw. Physik

Group Report HK 12.1 Mon 16:45 SR 0.03 Erw. Physik

3α-decay of the 0_2^+ state in ^{12}C — •David Werner[1], Timo Biesenbach[1], Joe Roob[1], Alessandro Salice[1], Peter Reiter[1], Maximilian Droste[1], Madalina Enciu[3], Pavel Golubev[2], Hannah Kleis[1], Nikolas Königstein[1], Dirk Rudolph[2], 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 decays of the 0_2^+ excited state in ^{12}C, known as the Hoyle state, serve as key probes for the internal structure of ^{12}C and provide critical insights into stellar nucleosynthesis. To populate excited states in ^{12}C, especially the Hoyle state, a ^{12}C(α, α') reaction at a beam energy of 27 MeV was utilized in two high statistics-experiments at the 10 MV FN Tandem Accelerator at the University of Cologne. The decay products were detected using the Lund-York-Cologne-Calorimeter (LYCCA), which at the time featured 18 segmented double-sided silicon strip detectors, providing a high angular resolution and individual detection of up to four of the reaction's α particles. The data analysis is based on classical kinematic analysis methods as well as machine learning techniques to differentiate between the different decay modes. Results of the study, including the momentum distributions of the decay products and branching ratios of the different decay modes, will be presented.

HK 12.2 Mon 17:15 SR 0.03 Erw. Physik

Exploring CNO Cycle Reactions at the Felsenkeller Underground Accelerator Laboratory — •Axel Boeltzig[1], Daniel Bemmerer[1], Eliana Masha[1], Denise Piatti[2], Konrad Schmidt[1], Jakub Skowronski[2], Anup Yadav[1,3], Peter Hempel[1,3], and Kai Zuber[3] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Germany — [2]Università degli Studi di Padova and INFN Sezione di Padova, Italy — [3]Technische Universität Dresden, Germany

Nuclear reactions in the Carbon-Nitrogen-Oxygen (CNO) cycles are active during the hydrogen burning phase of stars at elevated stellar temperatures. With increasing temperature, the reaction networks extend to fluorine, and breakout reactions from the catalytic cycles move into focus as pathways for the synthesis of neon and heavier elements in stars.

At the Felsenkeller shallow-underground laboratory, jointly operated by HZDR and TU Dresden, a 5 MV Pelletron accelerator is dedicated to sensitive nuclear astrophysics studies in a laboratory with 45 m of rock shielding against cosmic radiation. The CNO cycle reactions ^{12,13}C$(\mathrm{p},\gamma)^{13,14}$N were recently studied at this laboratory, and an investigation of the breakout reaction ^{19}F$(\mathrm{p},\gamma)^{20}$Ne is being planned. We will present on the status and plans for these measurements, and the future potential at the Felsenkeller Laboratory to explore the CNO cycle reactions.

HK 12.3 Mon 17:30 SR 0.03 Erw. Physik

Assessing the role of composition in the collapse of massive stars — •Justin Schäfer[1,2], Gabriel Martínez-Pinedo[1,2], and Ante Ravlić[3] — [1]GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt — [2]Institut für Kernphysik (Theoriezentrum), TU Darmstadt — [3]Facility for Rare Isotope Beams, Michigan State University

The collapse of massive stars after iron core formation is determined by electron captures on a broad range of nuclei. To understand this, a description of electron captures and accurate determination of the composition is crucial. In this work we aim to explore the impact of compositional changes on the deleptonization rate. We show that different treatments of partition functions, which govern the distribution of nuclear states at given temperatures and densities, influence the individual composition substantially. However, the deleptonization rate and therefore the evolution of the collapsing star is rather unaffected by the detailed composition of matter. This behavior provides insight into the nuclear physics relevant for core-collapse supernovae modeling. This work is supported by the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (ERC Advanced Grant KILONOVA No.885281) and the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) - Project-ID 279384907 - SFB 1245, and MA 4248/3-1.

HK 12.4 Mon 17:45 SR 0.03 Erw. Physik

Multidimensional Hydrodynamical Simulations of Thermonuclear Ignition in Oxygen-Neon-Carbon Cores — •Paul Christians[1,2], Gabriel Martínez-Pinedo[1,2], Friedrich Konrad Röpke[3,4], Giovanni Leidi[3], and Róbert Andrássy[4,3] — [1]GSI Helmholtzzentrum für Schwerionenforschung — [2]Institut für Kernphysik, TU Darmstadt — [3]Heidelberger Institut für Theoretische Studien HITS gGmbH — [4]Zentrum für Astronomie der Universität Heidelberg

The fate of intermediate-mass stars ($7-11\,M_\odot$) depends on the evolution of their degenerate oxygen-neon cores, formed from the ashes of prior core carbon burning. Their evolution is mainly driven by electron capture reactions, which either cool or heat the core significantly, potentially determining the final fate of the star. Recently, it has been shown that forbidden electron capture transitions play a key role in the relevant temperature-density regimes, significantly altering the temperature evolution. Furthermore, residual carbon could lead to oxygen ignition at significantly lower densities. The ignition of this residual carbon is triggered by exothermic double electron capture on ^{24}Mg and ^{24}Na, which also heavily relies on the correct inclusion of forbidden rates and the treatment of convection. We study the impact of those key forbidden transitions using a low Mach multidimensional hydrodynamical code called Seven-League Hydro (SLH). This is needed, as highly subsonic convective flows play a crucial role during the final evolution. DFG Project-ID MA 4248/3-1; RO 3676/7-1. We acknowledge support by the Klaus Tschira Foundation.