HK 28: Nuclear Astrophysics II

Zeit: Dienstag 16:30–18:00 Raum: HS 16

Gruppenbericht HK 28.1 Di 16:30 HS 16

Core-collapse supernovae and equation of state effects — •Hannah Yasin[1], Sabrina Schäfer[1,2], Almudena Arcones[1,3], and Achim Schwenk[1,2,4] — [1]Institut für Kernphysik, Technische Universität Darmstadt — [2]ExtreMe Matter Institute EMMI, GSI Helmholtzzentrum für Schwerionenforschung GmbH — [3]GSI Helmholtzzentrum für Schwerionenforschung GmbH — [4]Max-Planck-Institut für Kernphysik, Heidelberg

Core-collapse supernovae (CCSN) are cosmic laboratories for physics at the extremes and numerical simulations are essential to help us understand the underlying mechanisms in these events. A key ingredient in simulations is the equation of state (EOS), which determines the contraction behavior of the proto-neutron star (PNS) and thus impacts neutrino energies and explosion dynamics. However, the EOS for hot and dense matter is still not fully understood and CCSN simulations rely on EOS models that differ in their underlying theory and nuclear matter properties.

We present the first systematic study on the impact of different nuclear matter properties of the EOS in CCSN simulations. This allows us to examine possible reasons for differences in commonly used EOS in simulations. We find that the contraction behavior of the PNS is mainly governed by the effective mass, which impacts the shock propagation.

⋆ Supported by the Deutsche Forschungsgemeinschaft through SFB 1245 (Projektnummer 279384907) and the European Research Council Grant No. 677912 EUROPIUM.

HK 28.2 Di 17:00 HS 16

Impact of the equation of state in core-collapse supernovae — •Sabrina Schäfer[1,2], Hannah Yasin[1], Almudena Arcones[1,3], and Achim Schwenk[1,2,4] — [1]Institut für Kernphysik, Technische Universität Darmstadt — [2]ExtreMe Matter Institute EMMI, GSI Helmholtzzentrum für Schwerionenforschung GmbH — [3]GSI Helmholtzzentrum für Schwerionenforschung GmbH — [4]Max-Planck-Institut für Kernphysik, Heidelberg

Neutron stars originate in core-collapse supernovae, which are one of the most energetic events in the universe. In core-collapse supernova simulations, the equation of state is a key ingredient. However, matter at high densities is only poorly constrained and the nuclear equation of state is still not fully understood. Equations of state that are available for supernova simulations differ considerably in their underlying theory as well as nuclear physics input. We investigate the impact of different nuclear matter properties on the equation of state in core-collapse supernovae. To this end, we introduce a range of equations of state based on the Lattimer and Swesty equation of state that vary the nucleon effective mass, incompressibility, symmetry energy, and nuclear saturation point. Larger effective masses lead to lower pressures at nuclear densities and a lower thermal index. This has an important impact on the proto-neutron star contraction and shock evolution.

*This work was supported by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) - Projektnummer 279384907 - SFB 1245 and the European Research Council Grant No. 677912 EUROPIUM.

HK 28.3 Di 17:15 HS 16

Astrophysical implications of the forbidden transition between ^{20}Ne and ^{20}F — •Dag Fahlin Strömberg[1,2] and Gabriel Martínez-Pinedo[1,2] — [1]Institut für Kernphysik (Theoriezentrum), Technische Universität Darmstadt, Schlossgartenstraße 2, 64289 Darmstadt, Germany — [2]Gesellschaft für Schwerionenforschung Darmstadt, Planckstr. 1, D-64259 Darmstadt, Germany

Following carbon burning, intermediate-mass stars (initial mass ∼7–11 solar masses) form degenerate cores composed primarily of ^{16}O and ^{20}Ne. When such cores grow massive and dense enough various electron capture reactions occur due to the high chemical potential of the electron gas. In addition to absorbing electrons these reactions also affect the temperature of the core. Most notably, the double electron capture $^{20}\mathrm{Ne} \rightarrow {}^{20}\mathrm{F} \rightarrow {}^{20}\mathrm{O}$ releases enough heat to ignite runaway oxygen burning resulting in either a collapse to a neutron star or a thermonuclear explosion.

In this talk we will discuss the implications of the newly measured forbidden transition ($0^+ \rightarrow 2^+$) between the ground states of ^{20}Ne and ^{20}F. Its effects are twofold: the ignition occurs at lower central densities and the point of ignition is shifted away from the centre. We will discuss how this happens, the role played by the composition and growth rate of the core, and what this means for the final outcome.

This work is supported by the Deutsche Forschungsgemeinschaft through contract SFB 1245 and the EU COST Action CA16117 (ChETEC).

HK 28.4 Di 17:30 HS 16

Influence of astrophysical and nuclear physics uncertainties on the nucleosynthesis in the νp-process⋆ — •Maximilian Jacobi[1], Julia Bliss[1], and Almudena Arcones[1,2] — [1]Institut für Kernphysik, TU Darmstadt, Germany — [2]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany

The spectra of very old stars often show a robust abundance pattern for the elements beyond barium which is associated with the r-process, but exhibit a star-to-star scatter in the abundances of the elements between strontium up to (possibly) silver (the so-called lighter heavy elements). This scatter can be explained by an additional primary process which might occur in the neutrino-driven wind following a successful core-collapse supernova. Motivated by recent supernova simulations, we investigate proton-rich neutrino-driven ejecta where the νp-process can contribute to the production of lighter heavy elements. We use steady-state neutrino-driven wind trajectories to systematically study the influence of astrophysical uncertainties on the nucleosynthesis evolution in proton-rich conditions and present possible abundance patterns. In the νp-process the nucleosynthesis evolves mainly by (p, γ) and (n, p) reactions and variations in the reaction rates of the latter have a critical influence on the final abundance patterns. We perform a sensitivity study based on a Monte Carlo approach and present a list with key (n, p) reactions for representative astrophysical conditions.

⋆ Supported by the Deutsche Forschungsgemeinschaft through SFB 1245 (Projektnummer 279384907) and the European Research Council Grant No. 677912 EUROPIUM.

HK 28.5 Di 17:45 HS 16

Parametrized Core-Collapse Supernova Simulations in Spherical Symmetry — •Kevin Ebinger[1], Sanjana Curtis[2], Carla Fröhlich[2], Matthias Hempel[3], Albino Perego[4], Matthias Liebendörfer[3], and Friedrich-Karl Thielemann[1,3] — [1]GSI Helmholtzzentrum für Schwerionenforschung, D-64291 Darmstadt, Germany — [2]Department of Physics, North Carolina State University, Raleigh NC 27695 — [3]Department für Physik, Universität Basel, CH-4056 Basel, Switzerland — [4]Istituto Nazionale di Fisica Nucleare, Sezione Milano Bicocca, Gruppo Collegato di Parma, I-43124 Parma, Italy

Core-collapse supernovae (CCSNe) are explosions of stars that have reached their lives' end. These extreme events lead to the formation of a neutron star or a black hole and allow for the synthesis of elements heavier than iron that can be ejected and contribute to the galactic chemical evolution. To investigate the complex explosion mechanism of CCSNe, computationally expensive multi-dimensional simulations are required. If one wants to investigate the outcome, global trends and the dependency on the progenitor star for large samples of CCSNe, such multi-dimensional simulations become prohibitively resource consuming. We use a parametrized framework, the PUSH method, to investigate CCSNe for a large sample of progenitor models with solar and lower metallicities. This method allows us to identify trends of CCSNe with progenitor properties, compute nucleosynthesis yields that can be used in galactic chemical evolution models and predict remnant properties that can be compared with observations.