HK 67: Nuclear Astrophysics VI

Zeit: Freitag 14:00–15:45 Raum: S1/01 A02

Gruppenbericht HK 67.1 Fr 14:00 S1/01 A02

Neutrino interactions with supernova matter* — •Alexander Bartl[1,2], Christian Drischler[1,2], Kai Hebeler[1,2], and Achim Schwenk[2,1] — [1]Institut für Kernphysik, Technische Universität Darmstadt — [2]ExtreMe Matter Institute EMMI, GSI Helmholtzzentrum für Schwerionenforschung GmbH

Neutrino pair bremsstrahlung and absorption ($NN \leftrightarrow NN\nu\bar{\nu}$) as well as inelastic scattering of neutrinos ($NN\nu \leftrightarrow \nu NN$) are of great relevance for the generation of and energy transport by neutrinos in core-collapse supernovae. In this talk, we will present improved interaction rates including the first calculation of neutrino rates in mixtures of protons and neutrons that includes chiral three-nucleon forces. We will also discuss the impact of these improved rates in supernova simulations.

*This work was supported by the Studienstiftung des Deutschen Volkes, BMBF ARCHES and the ERC Grant No. 307986 STRONGINT.

HK 67.2 Fr 14:30 S1/01 A02

Microphysics of neutrino-nucleon interactions in supernova matter — •Andreas Lohs[1] and Gabriel Martinez-Pinedo[2,3] — [1]Universität Basel, Schweiz — [2]Technische Universität Darmstadt — [3]GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt

In core-collapse supernova (CCSN) simulations, neutrino-nucleon interactions are mostly described by simplified microphysics, such as the so called elastic approximation. Further subleading order contributions, resulting from tensor couplings in the weak hadronic current and from nucleon recoil, are often included in the form of analytic correction factors. We compare these approximations with exact calculations of the mean free path in the picture of quasi free nucleons. We find that deviations to the approximations of the order of 10% appear already at relatively low temperatures of a few MeV or densities around $10^12\,\mathrm{g/cm^3}$. It is therefore recommended to include the exact neutrino-nucleon microphysics in order to achieve e.g. reliable predictions for the emitted neutrino spectrum during the first hundred milliseconds to several seconds postbounce. Eventually we discuss possible improvements to the analytic approximations to improve their applicability.

HK 67.3 Fr 14:45 S1/01 A02

Neutrino-induced nucleosynthesis in Core-Collapse Supernovae — •Andre Sieverding[1], Gabriel Martínez-Pinedo[1,2], and Karlheinz Langanke[2] — [1]1 Institut für Kernphysik (Theoriezentrum), Technische Universit*at Darmstadt, Schlossgartenstraße 2, 64289 Darmstadt, Germany — [2]Gesellschaft für Schwerionenforschung Darmstadt, Planckstr. 1, D-64259 Darmstadt, Germany

We study influence of an extensive set of neutrino induced reactions on nucleosynthesis calculations for the outer layers of supernovae. We use cross sections calculated for almost the whole nuclear chart including multi-particle evaporation. Some of the critical cross-sections e.g. for ^{26}Mg, could be constrained by experimental data. We explore the sensitivity to the neutrino spectra and stellar structure for a large set of solar metallicity progenitor models.

Our studies confirm the fact that ^{7}Li, ^{11}B and ^{19}F, ^{138}La and ^{180}Ta are produced by neutrino processes. However, calculations with neutrino spectra consistent with state-of-the-art Supernova simulations predicting substantially reduced average energies, we find a significant reduction of the yields of these nuclei.

Despite the lower neutrino energies we find significant contributions of neutrino-nucleosynthesis for the production of ^{26}Al and ^{22}Na.

This work is supported by the Helmholtz Association through the Nuclear Astrophysics Virtual Institute and by the Helmholtz International Center for FAIR in the context of the LOEWE initiative.

HK 67.4 Fr 15:00 S1/01 A02

Short gamma ray bursts triggered by neutrino-antineutrino annihilation* — •Hannah Yasin[1], Albino Perego[1], and Almudena Arcones[1,2] — [1]Institut für Kernphysik, TU Darmstadt, Germany — [2]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany

Gamma ray bursts (GRB) are one of the most energetic events in the universe. Neutron star mergers are the most favourable candidate for the subclass of GRBs that last less than two seconds. It has been suggested that the annihilation of neutrino-antineutrino pairs emitted by the hot and dense merger remnant could be enough to launch a relativistic jet, producing such a burst [1]. We calculate the energy deposition by neutrino-antineutrino annihilation based on the results of a Newtonian simulation of the aftermath of a binary neutron star merger [2]. In addition, we investigate the necessary requirements for launching a GRB and compare with our numerical results.

[1] D. Eichler, M. Livio, T. Piran, and D. N. Schramm, Nature 340 (1989) 126.
[2] A. Perego, S. Rosswog, R. M. Cabezon, O. Korobkin, R. Käppeli, A. Arcones, and M. Liebendörfer, MNRAS 443 (2014) 3134.

* Supported by Helmholtz-University Young Investigator grant No. VH-NG-825.

HK 67.5 Fr 15:15 S1/01 A02

Moments of inertia of neutron stars — •Svenja Kim Greif[1,2], Kai Hebeler[1,2], and Achim Schwenk[1,2] — [1]Institut für Kernphysik, Technische Universität Darmstadt — [2]ExtreMe Matter Institute EMMI, GSI Helmholtzzentrum für Schwerionenforschung GmbH

Neutron stars are unique laboratories for matter at extreme conditions. While nuclear forces provide systematic constraints on properties of neutron-rich matter up to around nuclear saturation density, the composition of matter at high densities is still unknown. Recent precise observations of 2 $M_\odot$ neutron stars made it possible to derive systematic constraints on the equation of state at high densities and also neutron star radii.

Further improvements of these constraints require the observation of even heavier neutron stars or a simultaneous measurement of mass and radius of a single neutron star. Since the precise measurement of neutron star radii is an inherently difficult problem, the observation of moment of inertia of neutron stars provides a promising alternative, since they can be measured by pulsar timing experiments. We present a theoretical framework that allows to calculate moments of inertia microscopically, we show results based on state of the art equations of state and illustrate how future measurements of moments of inertia allow to constrain the equation of state and other properties of neutron stars.

*This work is supported by the ERC Grant No. 307986 STRONGINT.

HK 67.6 Fr 15:30 S1/01 A02

Equation of state of neutron-rich nuclear matter from chiral effective field theory — Norbert Kaiser and •Susanne Strohmeier — Technische Universität München

Based on chiral effective field theory, the equation of state of neutron-rich nuclear matter is investigated systematically. The contributing diagrams include one- and two-pion exchange together with three-body terms arising from virtual $\Delta(1232)$-isobar excitations. The proper expansion of the energy per particle, $\bar{E}(k_f,\delta) = \bar{E}_n(k_f) + \delta B_1(k_f) + \delta^{5/3}B_{5/3}(k_f) + \delta^2 B_2(k_f) + \ldots$, for the system with neutron density $\rho_n = k_f^3(1-\delta)/3\pi^2$ and proton density $\rho_p = k_f^3\delta/3\pi^2$ is performed analytically for the various interaction contributions. One observes essential structural differences to the commonly used quadratic approximation. The density dependent coefficient $B_1(k_f)$ turns out to be unrelated to the isospin-asymmetry of nuclear matter. The coefficient $B_{5/3}(k_f)$ of the non-analytical $\delta^{5/3}$-term receives contributions from the proton kinetic energy and from the one- and two-pion exchange interactions. The physical consequences for neutron star matter are studied.