HK 21: Nukleare Astrophysik

Zeit: Montag 16:45–18:45 Raum: HSZ-403

Gruppenbericht HK 21.1 Mo 16:45 HSZ-403

Neutrino Oscillations in Core-collapse Supernovae — •Meng-Ru Wu[1,2], Lutz Huther[1], Tobias Fischer[1,3], Gabriel Martinez-Pinedo[1,3], and Yong-Zhong Qian[2] — [1]TU Darmstadt, Darmstadt — [2]University of Minnesota, Minneapolis, USA — [3]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt

Neutrino oscillations play an important role in determining the spectra of neutrinos emitted from core-collapse supernova and must be considered in the analysis of supernova neutrino detection to understand both the supernova dynamics and the unknown neutrino mass hierarchy. We have studied neutrino oscillations in supernovae using the emission spectra of neutrinos and the dynamically evolving supernova density profile from a state-of-the-art supernova model. We find that in this model, different regions of neutrino oscillations are well separated. Collective neutrino oscillations happen at the innermost part such that the spectra of electron neutrinos and mu/tau neutrinos are partly swapped for the first few seconds in the cooling phase. Then, the high and low MSW resonances that occur after collective oscillations are both adiabatic. Using these results, we find that in this model, neutrino oscillations have little effect on the nucleosynthesis in the neutrino-driven winds. However, the detection of such a signal could possibly allow us to differentiate the neutrino mass hierarchy and to extract the shock revival time.

HK 21.2 Mo 17:15 HSZ-403

Neutral current neutrino reactions in neutrino driven wind nucleosynthesis — •Lutz Huther[1], Tobias Fischer[1], Gabriel Martinez-Pinedo[1,2], and Karlheinz Langanke[1,2,3] — [1]TU Darmstadt, Darmstadt — [2]GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt — [3]Frankfurt Institute for Advanced Studies, Frankfurt

Neutrino driven winds in core collapse supernovae are considered as one of the sources for the creation of elements heavier than iron. The detailed nucleosynthetic results are sensitive to various parameters coming from core collapse supernovae simulations, especially the electron neutrino and antineutrino spectra. Depending on the energy difference the ejecta can be proton or neutron rich. Proton rich ejecta constitute the site for the νp-process, while in neutron rich ejecta the r-process can operate. Furthermore neutrinos can interact with the ejecta, exciting them above particle emission thresholds, therefore changing the nucleosynthesis. We have computed the neutrino induced particle evaporation reactions using a two step approach based on the compound picture. In the first step the compound nucleus is formed by neutrino neutral current inelastic excitation of the nucleus. The relevant cross sections are computed within the random phase approximation. In the next step we use a statistical code for the calculation of the different deexcitation channels including emission of p, n and α particles both in the parent and in the successive daughter nuclei. We have explored the impact on the nucleosynthetic outcome. This work is supported by the Deutsche Forschungsgemeinschaft through contract SFB 634.

HK 21.3 Mo 17:30 HSZ-403

Charged-current weak interaction processes in hot and dense matter and its impact on the spectra of neutrinos emitted from proto-neutron star cooling — Gabriel Martinez-Pinedo[1,2], Tobias Fischer[2,1], •Andreas Lohs[1], and Lutz Huther[1] — [1]Institut für Kernphysik, Technische Universität Darmstadt — [2]GSI Helmholtzzentrum für Schwerioneneforschung, Darmstadt

We have performed three-flavor Boltzmann neutrino transport radiation hydrodynamics simulations covering a period of 3 s after the formation of a protoneutron star in a core-collapse supernova explosion. We show that a treatment of charged-current neutrino interactions in hot and dense matter as suggested by Reddy et al. has a strong impact on the luminosities and spectra of the emitted neutrinos. Compared with simulations that neglect mean field effects on the neutrino opacities, we find that the luminosities of all neutrino flavors are reduced while the spectral differences between electron neutrino and antineutrino are increased. Their magnitude depends on the equation of state and in particular on the symmetry energy at sub-nuclear densities. The proton-to-nucleon ratio of the outflow is reduced, increasing slightly their entropy. They are expected to have a substantial impact on the nucleosynthesis in neutrino-driven winds, even though they do not result in conditions that favor an r-process. Contrarily to previous findings, our simulations show that the spectra of electron neutrinos remain substantially different from those of other (anti)neutrino flavors during the entire deleptonization phase of the protoneutron star.

HK 21.4 Mo 17:45 HSZ-403

Axions from cooling compact stars: pair-breaking processes — •Jochen Keller and Armen Sedrakian — Institut für Theoretische Physik, Goethe-Universität, Frankfurt am Main

Once formed in a supernova explosion, a neutron star cools rapidly via neutrino emission during the first $10^4 - 10^5$ years of its life-time. Here we compute the axion emission rate from baryonic components of a star at temperatures below their respective critical temperatures T_c for normal-superfluid phase transition. The axion production is driven by a charge neutral weak process, associated with Cooper pair breaking and recombination. The requirement that the axion cooling does not overshadow the neutrino cooling yields a lower bound on the axion decay constant $f_a > 6 \times 10^9\, T_{c9}^{-1}$ GeV, with $T_{c9} = T_c/10^9$ K. This translates into an upper bound on the axion mass $m_a < 10^{-3}\, T_{c9}$ eV.

HK 21.5 Mo 18:00 HSZ-403

Neutrino interactions with dense nuclear matter based on chiral effective field theory* — •Alexander Bartl[1,2], Christopher J. Pethick[3,4], and Achim Schwenk[2,1] — [1]Institut für Kernphysik, Technische Universität Darmstadt, Germany — [2]ExtreMe Matter Institute EMMI, GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany — [3]The Niels Bohr International Academy, The Niels Bohr Institute, Copenhagen, Denmark — [4]NORDITA, Royal Institute of Technology and Stockholm University, Stockholm, Sweden

Neutrino pair bremsstrahlung and absorption ($NN \leftrightarrow NN\nu\bar{\nu}$) and 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. While the rates of these processes are very important, most simulations are based on the one-pion-exchange approximation for the nucleon-nucleon part of the interaction. In this talk, we will present results on neutrino rates at subnuclear densities that are calculated using the framework of chiral effective field theory for nuclear forces, including first results for mixtures of neutrons and protons. In addition, we consider the impact of chiral two-body currents on the neutrino rates.

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HK 21.6 Mo 18:15 HSZ-403

Systematics of netrinoless double beta decay matrix elements in a major shell — •Tomas Rodriguez — Technische Universität Darmstadt, Darmstadt, Germany

We analyze nuclear matrix elements (NME) of neutrinoless double beta decay calculated for the Cadmium isotopes. Energy density functional methods including beyond mean field effects such as symmetry restoration and shape mixing are used. Strong shell effects are found associated to the underlying nuclear structure of the initial and final nuclei. Furthermore, we show that NME for two-neutrino double beta decay evaluated in the closure approximation, $M^{2\nu}_{\rm cl}$, display a constant proportionality with respect to the Gamow-Teller part of the neutrinoless NME, $M^{0\nu}_{\rm GT}$. This opens the possibility of determining the $M^{0\nu}_{\rm GT}$ matrix elements from $\beta^{\mp}$ Gamow-Teller strength functions. Finally, the interconnected role of deformation, pairing, configuration mixing and shell effects in the NMEs is discussed.

HK 21.7 Mo 18:30 HSZ-403

The Δ Resonance Response Function in Charge-Changing Weak Interactions — •Andreas Fedoseew and Horst Lenske — Institut für Theoretische Physik, Justus-Liebig-Universität Giessen, Heinrich-Buff-Ring 16, D-35392 Giessen

We investigate the response of charge-changing excitations in nuclei in the Δ-resonance region. The N-N, Δ-N and Δ-Δ correlations are treated within the RPA framework. In our approach nuclear density functional theory is used for the self-consistent description of the ground state of nuclear matter and excitations. We include the self-energies in the baryon-propagators and calculate the residual p-h in-

teraction self-consistently by applying Landaus Fermi-Liquid theory. With this approach our fully quantum mechanical calculations of the response functions are free of additional adjustable model parameters. We present our results for inclusive neutrino scattering on nuclei at the valley of stability and with high neutron excess.