HK 19: Nuclear Astrophysics II

Time: Tuesday 17:00–18:30 Location: SCH/A419

Group Report HK 19.1 Tue 17:00 SCH/A419

Neutrino flavor instability and nucleosynthesis associated with charged-current weak interactions in black hole accretion disks — •Zewei Xiong[1], Lucas Johns[2], Meng-Ru Wu[3], Huaiyu Duan[4], Gabriel Martínez-Pinedo[1,5], and Oliver Just[1] — [1]GSI Helmholtzzentrum für Schwerioneneforschung, Darmstadt, Germany — [2]UC Berkeley, CA, USA — [3]Academia Sinica, Taipei, Taiwan — [4]University of New Mexico, Albuquerque, NM, USA — [5]Technische Universität Darmstadt, Germany

Charged-current weak interactions destroy the flavor coherence among the weak-interaction states of a single neutrino. In a dense neutrino gas, however, these collision processes can trigger flavor conversion in cooperation with the strong neutrino-neutrino refraction. We show that the collisional flavor instability can exist in black hole accretion disks. As a result, large amounts of heavy-lepton flavor neutrinos can be produced through flavor conversion, which can have important ramifications in the subsequent evolution of the remnant.

In addition to the charged-current neutrino interactions with nucleons, the neutrino-nucleus interactions can possess larger cross sections in neutron-rich nuclei and affects the r-process nucleosynthesis. We investigate those neutrino-nucleus interactions in black hole accretion disks and show that they can affect electron fraction moderately in specific trajectories with high neutrino fluxes.

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HK 19.2 Tue 17:30 SCH/A419

Nuclear equation of state from Δ-full chiral interactions — •Yannick Dietz[1,2], Jonas Keller[1,2], Kai Hebeler[1,2,3], and Achim Schwenk[1,2,3] — [1]Technische Universität Darmstadt, Department of Physics — [2]ExtreMe Matter Institute EMMI, GSI Helmholtzzentrum für Schwerionenforschung GmbH — [3]Max-Planck-Institut für Kernphysik, Heidelberg

We report results for infinite homogeneous nuclear matter calculations for the energy per particle at zero temperature using a set of recently developed Δ-full interactions based on chiral effective field theory that exhibit smaller chiral uncertainties compared to previous calculations using Δ-less potentials. Our computations are carried out in many-body perturbation theory, where we include contributions from nucleon-nucleon forces up to third and three-nucleon forces up second order.

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HK 19.3 Tue 17:45 SCH/A419

Gaussian processes for the nuclear equation of state — •Hannah Göttling[1,2], Jonas Keller[1,2], Kai Hebeler[1,2,3], and Achim Schwenk[1,2,3] — [1]Technische Universität Darmstadt, Department of Physics — [2]ExtreMe Matter Institute EMMI, GSI Helmholtzzentrum für Schwerionenforschung GmbH — [3]Max-Planck-Institut für Kernphysik, Heidelberg

We use Gaussian processes as a non-parametric emulator for the nuclear equation of state based on chiral effective field theory interactions and to provide statistical uncertainties based on the effective field theory truncation. Moreover, the Gaussian process enables us to calculate observables that are obtained via thermodynamic derivatives. We use this to calculate properties relevant to neutron stars and properties of symmetric nuclear matter.

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HK 19.4 Tue 18:00 SCH/A419

Magnetar crusts - influence of the magnetic field on the composition and the unified equation of state — •Yuliya Mutafchieva[1], Zhivko Stoyanov[1], Nicolas Chamel[2], John Michael Pearson[3], and Lyubomir Mihailov[4] — [1]Institute For Nuclear Research And Nuclear Energy, Bulgarian Academy of Sciences, Sofia, Bulgaria — [2]Institute of Astronomy and Astrophysics, Universite Libre de Bruxelles, Brussels, Belgium — [3]Departement de Physique, Universite de Montreal, Montreal, Canada — [4]Institute of Solid State Physics, Bulgarian Academy of Sciences, Sofia, Bulgaria

At the end point of stellar evolution, strongly magnetised neutron stars - magnetars, are not only among the most compact stars in the universe, but also the strongest magnets. These conditions can significantly alter the properties of the outermost regions of a neutron star. We have recently studied the influence of a very strong magnetic field on the equilibrium properties of magnetar crusts when taking into account the Landau-Rabi quantization of electron motion. Both the outer and inner regions of the crust are treated consistently within the framework of the nuclear-energy density functional theory, thus allowing us to calculate their composition and their equation of state in a unified way. Our study covers a wide range of magnetic-field strengths necessary for modelling astrophysical phenomena. Results using accurately calibrated Brussels-Montreal nuclear energy density functionals, which were constructed from generalized Skyrme effective nucleon-nucleon interactions, will be presented.

HK 19.5 Tue 18:15 SCH/A419

Supernova Simulations with Consistent Six Species Neutrino Transport — •Ignacio L. Arbina[1,2], Gabriel Martinez-Pinedo[2,1], and Tobias Fischer[3] — [1]Institut für Kernphysik (Theoriezentrum), Fachbereich Physik, Technische Universit *at Darmstadt, Schlossgartenstraße 2, 64289 Darmstadt, Germany — [2]GSI Helmholtzzentrum für Schwerioneneforschung, Planckstraße 1, 64291 Darmstadt, Germany — [3]Institute of Theoretical Physics, University of Wroclaw, Pl. M. Borna 9, 50-204 Wroclaw, Poland

Core-Collapse Supernova (CCSN) are expected to explode by the delayed neutrino-driven mechanism. It requires an accurate treatment of the neutrino-matter interactions together with a solution to the neutrino radiation transport for all lepton flavours. Typical implementations usually consider four species neutrino schemes assuming identical distributions for the muon and tau neutrino flavours. However, the conditions shortly after bounce allow for the production of muons as discussed in the studies by Bollig et al. (2017) and Fischer et al. (2020). This muon formation adds new reaction channels in the lepton sector that couple the electron and muon flavours through weak interaction processes. For this purpose, we implement a Boltzmann neutrino transport scheme for the six neutrino species that are evolved consistently with the internal energy, and the electron and muon abundances. We explore the sensitivity to different sets of opacities computed consistently with the underlying equation of state and determine the most important reactions contributing to the muonization of supernova matter.