HK 34: Nuclear Astrophysics III

Zeit: Mittwoch 14:00–15:45 Raum: HZO 100

Gruppenbericht HK 34.1 Mi 14:00 HZO 100

High Density Fluctuations in Neutron Stars — •Konstantin Otto[1], Micaela Oertel[2], Mario Mitter[3], and Bernd-Jochen Schaefer[1] — [1]Institut für Theoretische Physik, Justus-Liebig-Universität Gießen, Germany — [2]Observatoire de Paris, CNRS, Meudon, France — [3]Department of Physics, BNL, Upton, NY 11973

The impact of thermal and quantum fluctuations at high baryon chemical potential on neutron stars is studied in the framework of the functional renormalization group (FRG) analysis with a quark-meson model truncation. Results for both $N_f = 2$ and $N_f = 2 + 1$ quark flavors are compared with each other such that the role of strangeness in compact objects can be addressed. The effect of vacuum fluctuations on the equation of state is investigated with corresponding mean-field approximations.

HK 34.2 Mi 14:30 HZO 100

Large scale DFT calculations and twist-averaged boundary conditions — •Bastian Schuetrumpf — Institut für Kerphysik, Technische Universität Darmstadt, Schlossgartenstraße 2, 64289 Darmstadt, Germany — GSI Helmholzzentrum für Schwerionenforschung, Planckstraße 1, 64291 Darmstadt, Germany

Density functional theory is a powerful tool to study nuclear structure and dynamics, because such calculations can cover the entire nuclear landscape. Its applicability is not limited to finite nuclei. Also infinite systems, e.g. nuclear pasta matter as present in the inner crust of a neutron star can be covered. These infinite systems are usually simulated using a finite box with periodic boundary conditions. Despite computational resources have advanced tremendously in the last years, the size of the simulation boxes for such calculations are still limited. The consequences for the simulations are twofold: On the one hand the limited boxes introduces finite-volume effects due to the spurious quantization of the wave functions in the box. We show, that this effect can be immensely reduced by utilizing the twist-averaged boundary conditions for static and time-dependent calculations. Second, the finite size of the boxes limit the possible emerging shapes of the pasta matter. In order to make calculations with larger boxes we parallelized Sky3D and optimized its performance on distributed memory architectures. The parallelisation allows not only to simulate much larger systems, but also enables to include finite temperature or the pairing interaction.

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HK 34.3 Mi 14:45 HZO 100

Nuclear uncertainties in the r-process nucleosynthesis — •Stylianos Nikas[1,2], Gabriel Martinez-Pinedo[1,2], André Sieverding[1,2], and Alexander Arzhanov[1,2] — [1]Institute of Nuclear Physics, Technische Universität Darmstadt, Darmstadt, Germany — [2]Theory Division, GSI Helmholzzentrum für Schwerionenforschung, Darmstadt, Germany

Neutron capture rates are one of the key ingredients to model the r-process nucleosynthesis. The Hauser-Feshbach theory allows us to model these reaction rates for nuclei out of the reach of the current experimental facilities. However, nuclear properties that are used to calculate the corresponding reaction rates using the Hauser-Feshbach theory are not well known for the majority of the nuclei in the path of the r-process. We explore the impact of a newly developed fully microscopic mass model on Hauser-Feshbach calculations of (n,γ) reaction rates and consequently on r-process yields.

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HK 34.4 Mi 15:00 HZO 100

Electron capture processes in stellar degenerate cores — •Dag Fahlin Strömberg[1,2], Heiko Möller[1,2], and Gabriel Martinez-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

Electron capture reactions play an important role in the evolution of degenerate stellar cores. These reactions do not only reduce the degeneracy pressure by removing electrons, but can also heat and cool the core through double electron capture and Urca processes.

In this talk we will focus on accreting ONe white dwarfs and their evolution until the ignition of oxygen. Following carbon burning, the composition of such cores is ^{16}O, ^{20}Ne, ^{23}Na, ^{24}Mg and ^{25}Mg. In addition, there can also be other nuclear species in the core due to a non-zero metallicity of the progenitor. We will discuss the effects of the above mentioned weak processes on the temporal evolution of the stellar core. In particular, we will focus on metallicity dependent effects. To do this we need accurate weak interaction rates, which at these conditions can be computed from a small number of dominant transitions.

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HK 34.5 Mi 15:15 HZO 100

Pushing Core-Collapse SNe to Explosions in spherically symmetric simulations — •Kevin Ebinger[1], Sanjana Curtis[2], Carla Fröhlich[2], Matthias Hempel[3], Albino Perego[4], and Friedrich-Karl Thielemann[3] — [1]GSI Helmholtzzentrum für Schwerionenforschung GmbH ,Planckstrasse 1, 64291 Darmstadt, Germany — [2]Department of Physics, North Carolina State University, Raleigh NC 27695 — [3]Departement 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 violent explosions that occur at the end of the evolution of massive stars. After decades of research the detailed mechanism behind the explosion is still not fully understood. To investigate global properties of these events for a large sample of progenitor stars, multi-dimensional simulations are computationally too demanding and thus one has to rely on one-dimensional simulations in order to study large samples of progenitors. The PUSH method represents a suitable parametrized framework to investigate the neutrino-driven mechanism in spherically symmetric simulations to efficiently study many important aspects of CCSNe: the effects of the shock passage through the star, explosive nucleosynthesis and the progenitor-remnant connection. After calibrating the method to SN1987A and other observed CCSNe we explore a large mass range of available solar metallicity progenitors and investigate their explodability and the resulting explosion properties.

HK 34.6 Mi 15:30 HZO 100

Pre-supernova neutrino signal as a probe of neutrino mass hierarchy — •Gang Guo[1] and Yong-Zhong Qian[2] — [1]GSI, Darmstadt, Germany — [2]School of Physics and Astronomy, University of Minnesota, USA

Pre-supernova neutrinos provide an important probe of stellar interior as well as properties of neutrino. In this work, we investigate the possibility of using pre-supernova $\bar{\nu}_e$ signals at JUNO to probe neutrino mass hierarchy. We find for the 4 given stellar models, i.e., 12, 15, 20 and 25 $M_\odot$, if the progenitor and distance can be well measured, neutrino mass hierarchy can be determined at 5σ (3σ) C. L. for stars within about $0.25-0.75$ ($0.4-1.1$) kpc. Take Betelgeuse as a realistic case, we find the normal hierarchy case can be distinguished at 5σ C. L. via pre-supernova neutrino signals, even both the progenitor and/or the distance of Betelgeuse are not well determined.