HK 19: Nuclear Astrophysics II

Zeit: Dienstag 14:00–15:30 Raum: HZO 100

Gruppenbericht HK 19.1 Di 14:00 HZO 100

Constraining the nuclear equation of state through the tidal deformability of neutron stars — •Svenja Kim Greif[1,2], Kai Hebeler[1,2], and Achim Schwenk[1,2,3] — [1]Institut für Kernphysik, Technische Universität Darmstadt — [2]ExtreMe Matter Institute EMMI, GSI Helmholtzzentrum für Schwerionenforschung GmbH — [3]Max-Planck-Institut für Kernphysik, Heidelberg

The pioneering gravitational wave observation from a binary neutron star merger opens up new possibilities to constrain the equation of state of dense matter. In particular, the observed signal allows to extract an upper bound for the dimensionless tidal deformability of neutron stars. In this work, we study to what extent simultaneous measurements of neutron star masses and tidal deformabilities can constrain radii of neutron stars and the equation of state. To this end, we consider equations of state up to nuclear densities based on chiral effective field theory interactions and extend them in a general way to higher densities. Based on a large set of equations of state, we systematically incorporate the constraints from observations and causality to derive model-independent limits for the equation of state over a wide range of densities and for the properties of neutron stars.

*This work is supported by the DFG through Grant SFB 1245 and ERC Grant No. 307986 STRONGINT.

HK 19.2 Di 14:30 HZO 100

Classification of Twin Star Solutions — •Jan-Erik Christian, Andreas Zacchi, and Jürgen Schaffner-Bielich — Goethe Universtität Frankfurt

With the recent measurement of the gravitational wave GW170817 by LIGO the investigation into the inner workings of neutron stars becomes increasingly active. In that light we explore the possible mass radius relation of compact stars for the equation of states with a first order phase transition. Low density matter is described by a nuclear matter equation of state resulting from fits to nuclear properties. A constant speed of sound parametrization is used to describe the high density matter phase with the speed of sound $c_s^2 = 1$. A classification scheme of four distinct categories including twin star solutions, i. e. solutions with the same mass but differing radii, is found which are compatible with the $M \geq 2M_\odot$ pulsar mass constraint. We show the dependence of the mass and radius differences on the transition parameters and delineate that higher twin star masses are more likely to be accompanied by large radius differences. These massive twin stars are generated by high values of the discontinuity in the energy density and the lowest possible values of the transition pressure that still result in masses of $M \geq 2M_\odot$ at the maximum of the hadronic branch.

HK 19.3 Di 14:45 HZO 100

Structure of slowly rotating magnetized neutron stars in a perturbative approach — •Martin Jakob Steil[1], Micaela Oertel[2], and Michael Buballa[1] — [1]Theoriezentrum, Institut für Kernphysik, Technische Universität Darmstadt, Germany — [2]LUTH, Observatoire de Paris, PSL Research University, CNRS, Université Paris Diderot, France

With their extreme densities, fast rotation and strong electromagnetic fields, neutron stars (NS) provide a unique laboratory for probing strongly interacting matter under extreme conditions. Understanding the fundamental interactions that govern matter under those extreme conditions is one of the major challenges of modern physics. Extracting information about the underling micro physics and equation of state (EoS) of NS matter from NS bulk requires a detailed theoretical understanding of NS structure.

In this work we explore the possibility and viability of describing the effects of strong magnetic fields and rotation on NS structure as perturbations around a spherical symmetric background star. We solve the Einstein-Maxwell equations up to first order in rotation frequency f and second order in the central magnetic field B_c for simple field configurations and compare our perturbative results to numerical results obtained within the framework of numerical relativity. We report a good quantitative agreement for slow rotation frequencies $f \lesssim 10\,\mathrm{Hz}$ and moderate central magnetic fields $B_c \lesssim 10^{13}\,\mathrm{T}$. Further we explore the possibility of modeling the structure of NS based on realistic microscopic EoS with analytic models for compact fluid spheres.

HK 19.4 Di 15:00 HZO 100

Core-collapse supernovae and the impact of the equation of state* — •Hannah Yasin[1] and Almudena Arcones[1,2] — [1]Institut für Kernphysik, TU Darmstadt, Germany — [2]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany

Core-collapse supernovae represent one of the most energetic events in the universe and are the production site of many elements. The evolution during and after the supernova explosion is key for nucleosynthesis. In both phases, the equation of state (EOS) plays an important role determining the contraction and cooling of the neutron star and thus affecting the ejecta conditions. However, the EOS is still not fully understood and topic of current research in nuclear physics as well as in astrophysics. We investigate the impact of the equation of state in the context of the long-time evolution of core-collapse supernovae.

* Supported through grant SFB 1245.

HK 19.5 Di 15:15 HZO 100

Investigation of thermal effects on the equation of state and radii of neutron stars — •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

Recently, a set of cold representative equations of state have been derived from calculations based on chiral effective field theory, combined with constraints from neutron star observations. This made it possible to derive an uncertainty band for the equation of state and the radius of cold neutron stars. In this work, we study finite temperature effects on realistic equations of state of hot and dense matter and the resulting behavior in a core-collapse supernova. Using a method for including thermal effects in the equation of state, we investigate the impact of finite-temperature microphysics on the radii of neutron stars.

*This work is supported by the DFG through Grant SFB 1245.