HK 79: Nukleare Astrophysik

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

Gruppenbericht HK 79.1 Do 16:45 HSZ-403

Equation of state constraints based on chiral effective field theory interactions* — •Ingo Tews[1,2], Thomas Krüger[1,2], Kai Hebeler[3], and Achim Schwenk[2,1] — [1]Institut für Kernphysik, Technische Universität Darmstadt — [2]ExtreMe Matter Institute EMMI, GSI Helmholtzzentrum für Schwerionenforschung GmbH — [3]Department of Physics, The Ohio State University, Columbus, USA

Neutron matter presents a unique system for chiral effective field theory (EFT), because all many-body forces among neutrons are predicted to next-to-next-to-next-to-leading order (N^3LO). We present the first complete N^3LO calculation of the neutron matter energy. This includes the subleading three-nucleon (3N) forces for the first time and all leading four-nucleon (4N) forces. Our results provide constraints for the equation of state of neutron-rich matter in astrophysics and for the properties of neutron stars, with controlled theoretical uncertainties.

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Gruppenbericht HK 79.2 Do 17:15 HSZ-403

Equation of state of stellar matter in an effective relativistic density functional approach — •Stefan Typel[1], Maria Voskresenskaya[1], Gerd Röpke[2], Thomas Klähn[3], David Blaschke[3], and Hermann H. Wolter[4] — [1]GSI Darmstadt — [2]Universität Rostock — [3]Uniwersytet Wrocławski — [4]LMU München

The simulation of astrophysical processes such as supernovae explosions and compact star formation requires realistic models for the equation of state of stellar matter in a wide range of density, temperature and isospin asymmetry. The properties of dense matter, in particular the chemical composition and phase transitions, are strongly affected by correlations. They can be considered partly by using quasi-particle concepts. Explicit correlations are treated in the model by introducing additional degrees of freedom with medium-dependent properties. In this contribution, the formation and dissolution of clusters, i.e. many-nucleon correlations, and the crystallization of matter due to long-range Coulomb correlations will be described in an effective way using a relativistic density functional approach taking into account various experimental constraints.

HK 79.3 Do 17:45 HSZ-403

correlations in nuclear matter at low densities in an extended relativistic mean-field model — •Maria Voskresenskaya and Stefan Typel — GSI, Darmstadt

The knowledge of the equation of state of strongly interacting matter is required for the description of the variety of nuclear matter phases in a wide range of densities, temperatures and proton fractions. In this work we extend the generalized relativistic mean-field (gRMF) model with density dependent couplings by including two-body scattering correlations and pairing effects self-consistently in the model. We show that these two-body correlations modify the composition and thermodynamic properties of matter. Scattering states are represented by quasiparticles with density and temperature dependent properties. The correct low-density behavior of nuclear matter at finite temperatures is considered within a virial expansion. The comparison of the virial equation of state with the gRMF approach by means of a series expansion of the grand canonical potential in powers of the nucleon fugacities is performed. Consistency relations are derived which connect quasiparticle parameters with the meson-nucleon couplings in the vacuum and the phase shifts or effective-range parameters of nucleon-nucleon scattering. Pairing effects are considered with the Yamaguchi separable potential for $^1S_0$ nn channel. Corresponding pairing gaps are computed for various temperatures. The overall effect of the pairing correlations on thermodynamic properties is estimated.

HK 79.4 Do 18:00 HSZ-403

Chiral condensate in neutron matter* — •Thomas Krüger[1,2], Ingo Tews[1,2], Bengt Friman[3], Kai Hebeler[4], and Achim Schwenk[2,1] — [1]Institut für Kernphysik, Technische Universität Darmstadt — [2]ExtreMe Matter Institute EMMI, GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt — [3]GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt — [4]Department of Physics, The Ohio State University, Columbus, USA

The chiral condensate is the order parameter of spontaneous chiral symmetry breaking. We present results for the chiral condensate at nuclear and subnuclear densities in neutron matter based on chiral effective field theory (EFT). The calculations are based on a complete neutron matter calculation at next-to-next-to-next-to-leading order (N^3LO) with estimates of the theoretical uncertainties. Our results provide constraints for astrophysics, and limit the possibility of a phase transition to quark matter at nuclear densities ($n \lesssim 0.2\,\mathrm{fm}^{-3}$).

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HK 79.5 Do 18:15 HSZ-403

Low- and high-density nuclear equation of state and the hyperon puzzle — •Giuseppe Colucci and Armen Sedrakian — Institut für Theoretische Physik, Goethe-Universität Frankfurt, Max-von-Laue-Straße 1, D-60438 Frankfurt, Germany

The measurements of the unusually high mass of the millisecond pulsar PSR J1614-2230 ($1.97 \pm 0.04 M_\odot$) imposes a strong constraint on the nuclear Equation of State (EoS), in particular for what concerns the finite density behaviour of nuclear and neutron matter. In my talk I will first discuss a model for the low-density part of the EoS, based on chiral one-pion exchange. I consider a self-consistent approach at finite temperature and density and show that even in a fully-relativistic theory the one-pion exchange contribution is dominated by a contact interaction. Then, a relativistic mean-field approach will be used to discuss the high-density part of the EoS, including the presence of hyperons. In the latter, a density dependent parametrization is used and a parameter study on the hyperon-scalar meson coupling is performed. Supported by the Hessian LOEWE initiative through the Helmholtz International Center for FAIR (HIC for FAIR).

HK 79.6 Do 18:30 HSZ-403

Phase diagram of dilute nuclear matter: Unconventional pairing and the BCS-BEC crossover — •Martin Stein and Armen Sedrakian — Institut für Theoretische Physik, Goethe-UniversitätFrankfurt, Max-von-Laue-Straße 1, D-60438 Frankfurt, Germany

We report on a comprehensive study of the phase structure of cold, dilute nuclear matter featuring a $^3S_1$-$^3D_1$ condensate at non-zero isospin asymmetry, within wide ranges of temperatures and densities. We find a rich phase diagram comprising three superfluid phases, namely a LOFF phase, the ordinary BCS phase, and a heterogeneous, phase-separated BCS phase, with associated crossovers from the latter two phases to a homogeneous or phase-separated Bose-Einstein condensate of deuterons. The phase diagram contains two tri-critical points (one a Lifshitz point), which may degenerate into a single tetra-critical point for some degree of isospin asymmetry.