HK 19: Nuclear Astrophysics III

Zeit: Dienstag 14:00–16:00 Raum: S1/01 A02

Gruppenbericht HK 19.1 Di 14:00 S1/01 A02

Direkte Reaktionen für die Astrophysik — •Mario Weigand, Lukas Bott, Benjamin Brückner, Philipp Erbacher, Stefan Fiebiger, Matthias Fix, Jan Glorius, Kathrin Göbel, Tanja Heftrich, Ole Hinrichs, Jan Dominik Kaiser, Christoph Langer, Florian Ludwig, Thien Tam Nguyen, Markus Reich, René Reifarth, Kilian Scheutwinkel, Zuzanna Slavkovská, Benedikt Thomas, Meiko Volknandt, Daniel Veltum, Clemens Wolf und Ashkan Taremi Zadeh — Goethe-Universität Frankfurt a. M., Germany

Die Häufigkeitsverteilung der Elemente im Sonnensystem bildet einen Forschungsschwerpunkt der Nuklearen Astrophysik. Für das Verständnis der zugrunde liegenden Nukleosynthese in Sternen werden Daten über eine Vielzahl von Reaktionsraten benötigt. Die Elemente schwerer als Eisen werden primär durch sukzessive Neutroneneinfänge und Betazerfälle in Sternen verschiedener Stadien erzeugt. Darüber hinaus existieren Isotope, deren Entstehung mit Hilfe von Protonen- und Gamma-induzierten Reaktionen erklärt wird.
Die Forschungsgruppe „Experimentelle Astrophysik“ der Goethe-Universität Frankfurt bestimmt Reaktionsraten mit verschiedenen experimentellen Methoden. In diesem Beitrag werden bisherige Ergebnisse vorgestellt und ein Ausblick über künftige Projekte gegeben.
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HK 19.2 Di 14:30 S1/01 A02

Isospin-asymmetry expansion of the nuclear equation of state — •Corbinian Wellenhofer[1], Jeremy W. Holt[2], Norbert Kaiser[1], and Wolfram Weise[1,3] — [1]Technische Universität München — [2]University of Washington — [3]ECT*

The isospin-asymmetry dependence of the nuclear equation of state obtained from microscopic chiral two- and three-body interactions in many-body perturbation theory is examined in detail. The quadratic, quartic and hexic Maclaurin coefficients in the isospin-asymmetry expansion of the free energy per particle of homogeneous nuclear matter are calculated using finite difference approximations, and the resulting polynomials are compared to the full isospin-asymmetry dependent free energy. It is found that in the low-temperature and high-density regime where the radius of convergence of the isospin-asymmetry expansion is generically zero the inclusion of higher-order terms beyond the leading quadratic approximation leads to a worse description of the full isospin-asymmetry dependence. Only at high temperatures and densities below nuclear saturation density does the inclusion of the quartic and hexic coefficients lead to an improved approximation.

HK 19.3 Di 14:45 S1/01 A02

A comparison of equation of state models with different cluster suppression mechanisms — •Stefan Typel[1] and Helena Pais[2] — [1]GSI, Darmstadt — [2]University of Coimbra, Portugal

In order to model the transition from clustered matter at subsaturation densities to uniform nucleon matter at baryon densities above nuclear saturation, a mechanism for the dissolution of clusters has to be implemented in theoretical approaches for the equation of state. A widely used heuristic method is the excluded-volume mechanism that assumes a finite size of nucleons and nuclei. An alternative description introduces medium-dependent mass shifts that mainly originate from the action of the Pauli principle.

In this contribution the predictions for the chemical composition and the thermodynamic properties of neutron star matter at finite temperatures in a statistical excluded-volume model [1,2] are compared with those of a mass-shift approach in a generalized relativistic density functional [2,3,4]. Since both description use the same interaction model for the nucleons, the observed differences can be attributed to the cluster description.

[1] M. Hempel, J. Schaffner-Bielich, Nucl. Phys. A 837 (2010) 210.
[2] M. Hempel at al., Phys. Rev. C 84 (2011) 055804.
[3] S. Typel et al., Phys. Rev. C 81 (2010) 015803.
[4] S. Typel, arXiv:1504.01571[nucl-th] (2015).

HK 19.4 Di 15:00 S1/01 A02

Quartic isospin-asymmetry energy of nuclear matter from chiral pion-nucleon dynamics — •Norbert Kaiser — Physik Department T39, Technische Universität München

Based on a chiral approach to nuclear matter, the quartic term in the expansion of the equation of state of isospin-asymmetric nuclear matter is calculated [Phys. Rev. C **91**, 065201 (2015)]. The contributions to the quartic isospin asymmetry energy $A_4(k_f)$ arising from 1π-exchange and chiral 2π-exchange in nuclear matter are calculated analytically together with three-body terms involving virtual $\Delta(1232)$-isobars. From these interaction terms one obtains at saturation density $\rho_0 = 0.16\,\mathrm{fm}^{-3}$ the value $A_4(k_{f0}) = 1.5\,\mathrm{MeV}$, more than three times as large as the kinetic energy part. Moreover, iterated 1π-exchange exhibits components for which the fourth derivative with the respect to the isospin-asymmetry parameter δ becomes singular at $\delta = 0$. The genuine presence of a non-analytical term $\delta^4 \ln|\delta|$ in the expansion of the energy per particle of isospin-asymmetric nuclear matter is demonstrated by evaluating a s-wave contact interaction at second order.
Work supported in part by DFG and NSFC (CRC110).

HK 19.5 Di 15:15 S1/01 A02

Nuclear matter within the self-consistent Green's function approach using chiral interactions* — •Arianna Carbone — Institut für Kernphysik, TU Darmstadt

The combination of ab initio many-body approaches and chiral interactions derived from the underlying quantum theory, QCD, has provided for the past two decades a promising framework to obtain a realistic description of infinite nuclear matter. This analysis is fundamental to shed light on many aspects of nuclear systems, from the limits of nuclear existence to the astrophysical processes in neutron-star mergers. To address these questions, we have recently extended the scope of self-consistent Green's function theory (SCGF) to include three-body forces. I will present studies of the microscopic and bulk properties of symmetric nuclear and pure neutron matter, both at zero and finite temperature. The results show how the inclusion of three-body forces is crucial to predict the empirical properties of symmetric nuclear matter. These also contribute to stiffen the neutron matter equation of state, which is important for neutron stars.

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HK 19.6 Di 15:30 S1/01 A02

Neutron drops with the optimized effective potential method* — •Thomas Krüger[1,2], Kai Hebeler[1,2], and Achim Schwenk[1,2] — [1]Institut für Kernphysik, Technische Universität Darmstadt — [2]ExtreMe Matter Institute EMMI, GSI Helmholtzzentrum für Schwerionenforschung

Neutron drops are a unique benchmark system to test nuclear interactions and constrain energy-density functionals, especially in the neutron-rich regime of the nuclear chart. We use the optimized effective potential method for the first time to second order with local chiral interactions to calculate neutron drops in harmonic traps. Our calculations are a first step towards calculations of nuclei in ab initio density functional theory, which connects energy density functionals to chiral effective field theory interactions.

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HK 19.7 Di 15:45 S1/01 A02

Large-scale HFB calculation with exact blocking for odd-A nuclei — •Alexander Arzhanov[1,2], Gabriel Martínez-Pinedo[1,2], Tomás R. Rodríguez[3], and Luís M. Robledo[3] — [1]Institut für Kernphysik, Technische Universität Darmstadt, D-64289 Darmstadt, Germany — [2]GSI Helmholtzzentrum für Schwerionenforschung, Planckstraße 1, D-64291 Darmstadt, Germany — [3]Departamento de Física Teórica, Universidad Autónoma de Madrid, E-28049 Madrid, Spain

Any realistic model of r-process nucleosynthesis requires accurate predictions of nuclear masses for isotopes beyond the reach of currently available experimental facilities, thus one has to rely on theoretical nuclear masses. Self-consistent mean-field (SCMF) theories based on energy density functionals (EDF) were actively developing in the recent decades. However, due to computational comlexity most of systematic surveys did not treat the odd-A nuclei at the same self-consistent level as the even-even isotopes. We performed a fully self-consistent large-scale calculation of nuclear masses using the exact blocking presciption with time-reversal symmetry breaking for odd-A nuclei within Hartree-Fock-Bogolyubov (HFB) framework with Gogny EDF. We analyse and compare the results for odd-A nuclei with the experimental values as well as commonly employed equal filling approximation. Supported by Helmholtz Association through Nuclear Astrophysics Virtual Institute (VH-VI-417).