Properties of Asymmetric Nuclear Matter

Wei Zuo

Institute of Modern Physics, Chinese Academy of Sciences, Lanzhou 730000, China, and University of Chinese Academy of Sciences, Beijing, 100049, China

E-mail: zuowei@impcas.ac.cn

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We give a review of our investigation on the single-particle properties and the equation of state (EOS) of asymmetric nuclear matter within the framework of the Brueckner theory extended to include a microscopic three-body force. Especially, we discuss the three-body force effect. It is shown the three-body force is crucial for reproducing the empirical saturation properties within nonrelativistic microscopic frameworks and may enhance strongly the stiffness of symmetry energy at high densities. As for the single particle properties, the three-body force turns out to induces a strongly repulsive and momentum-dependent rearrangement contribution to the single particle potential and enhances significantly the depletion of nuclear Fermi sea, at high densities.

KEYWORDS: asymmetry nuclear matter, Brueckner theory, symmetry energy, three-body force effect, superfluidity

1. Introduction

The properties of asymmetric nuclear matter are not only important for understanding the structure and decay properties of heavy nuclei and neutron-rich nuclei, but also play a crucial role in numerical simulations of core-collapse supernovae and in modeling the structure and cooling of neutron stars. For example, the equation of state (EOS) of asymmetric nuclear matter is a basic input for the structure model of neutron stars, and determines essentially the predicted mass-radius relation and maximum mass of neutron stars consisting of nucleons and leptons [1]. In β-stable (n,p,e,μ) neutron star matter, the proton fraction has been shown to be essentially determined by the density dependence of symmetry energy [2], which describes the isovector part of the EOS. Consequently, the symmetry energy at high densities may play a decisive role in understanding the cooling mechanism via neutrino emission in the inner part of neutron stars [3]. Besides, the nucleon superfluidity and the depletion of nuclear Fermi sea in asymmetric nuclear medium are also expected to affect significantly the cooling properties of neutron stars.

Theoretically, the properties of asymmetric nuclear matter have been studied in the framework of various *ab initio* approaches (for a review, see Ref. [4] and references therein), such as the Brueckner-Hartree-Fock (BHF) and the extended BHF approaches, the relativistic Dirac-BHF (DBHF) theory, the in-medium T-matrix and Green function methods, and the variational approach. In our investigation, the BHF approach has been adopted. We have improved the BHF approach in two aspects. First, the calculation of the effect of ground state correlations has been extended to asymmetric nuclear matter [5]. Second, microscopic three-body forces (TBF) have been included in the BHF scheme [6–8] and the calculation of the TBF-induced rearrangement contribution to the s.p. properties has been realized in Brueckner theory [9, 10]. In the present paper, we shall give a review of our research work on the properties of asymmetric nuclear matter.