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ORIGINAL ARTICLE

Constraints the properties of neutron star matter from the mass of neutron star PSR J1614-2230

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Abstract The constraints on the properties of neutron star matter from the mass of neutron star PSR J1614-2230 are examined in the framework of the relativistic mean field theory. We find that there are little differences between the σ potentials of large mass neutron star and those of canonnical mass neutron star. For potentials of ω, ρ, neutrons and electrons, the values corresponding to the large mass neutron star are larger than those to the canonnical mass neutron star as the baryon number density is more than a certain value. We also find that for the relative particle number density of electrons, muons, neutrons and protons and the pressure of the neutron star, the values corresponding to the large mass neutron star are far larger than those to the canonnical mass neutron star. For the relative particle number density of hyperons Λ, Σ^-, Σ^0, Σ^+ and Ξ^-, the values corresponding to the large mass neutron star are far smaller than those to the canonnical mass neutron star. These mean that the larger mass of neutron star is more advantageous to the production of protons but is not advantageous to the production of hyperons.

Keywords Nucleon coupling constant · Relativistic mean field theory · Neutron star

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1 Introduction

The large-mass neutron star PSR J1614-2230 was observed by Demorest et al. (2010). We know that the properties between the large mass neutron star and the canonical mass neutron star have large difference. For example, the low mass neutron stars may be uniquely strong sources of gravitational waves (Horowitz 2010). So, many theoretical researches on large mass neutron star have been done since then (Massot et al. 2012).

The calculations show that the hadronic degrees of freedom and the quark degrees of freedom can be considered together as studying on the large mass neutron stars.

Using the idea of smooth crossover from the hadronic matter with hyperons to quark matter with strangeness, Masuda et al. showed that the maximum mass ($M_{\max}$) of neutron stars with quark matter core can be larger than those without quark matter core (Masuda et al. 2012). With the hadronic matter (having hyperons) equation of state (EOS) being described by relativistic mean field (RMF) theory and the quark phase being used the simple MIT bag model, the upper mass limit for a hybrid stars having a quark-hadron mixed phase was calculated by Mallick (2012). Whittenbury et al. examined the large mass of the neutron star PSR J1614-2230 in the most recent development of the quark-meson coupling model. By a relativistic Hartree-Fock approach and including the full tensor structure at the vector-meson-baryon vertices, they found that not only must hyperons appear in matter at the densities relevant to such a massive star but that the maximum mass predicted is completely consistent with the observation (Whittenbury et al. 2012).

On the other hand, for the uncertainties in the strength of interactions of hyperons among themselves and with nucle-