Properties of neutron stars with hyperons and quarks using relativistic Hartree-Fock approximation and MIT bag model

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We construct the equation of state (EoS) for neutron stars with hyperons and quarks. In order to solve the so-called *hyperon puzzle*, the EoS for hadronic matter is derived by including of the strange (σ^* and ϕ) mesons as well as the light non-strange (σ, ω, $\boldsymbol{\pi}$ and $\boldsymbol{\rho}$) mesons using the quark-meson coupling model within relativistic Hartree-Fock approximation [1]. Relevant coupling constants are determined to reproduce the experimental data of nuclear matter and hypernuclei in SU(3) flavor symmetry [2]. For quark matter, we employ the MIT bag model with one-gluon-exchange interaction and Gibbs criteria for equilibrium in the phase transition from hadrons to quarks [3]. In addition, the phase transition is determined by the density-dependent bag constant, and six cases under a variation parameter β between 0 to 0.2 are shown in Fig. 1. We find that the strange vector (ϕ) meson and the Fock contribution make the hadronic EoS stiff, and thus, the maximum mass of a neutron star can support $2M_\odot$ even if hyperons and quarks as well as nucleons and leptons are taken into account in the core. Furthermore, the maximum masses of a neutron star lie on the densities around 1.0 fm^{-3} in the mixed phase, and the transition to pure quark matter does not occur in stable neutron stars.

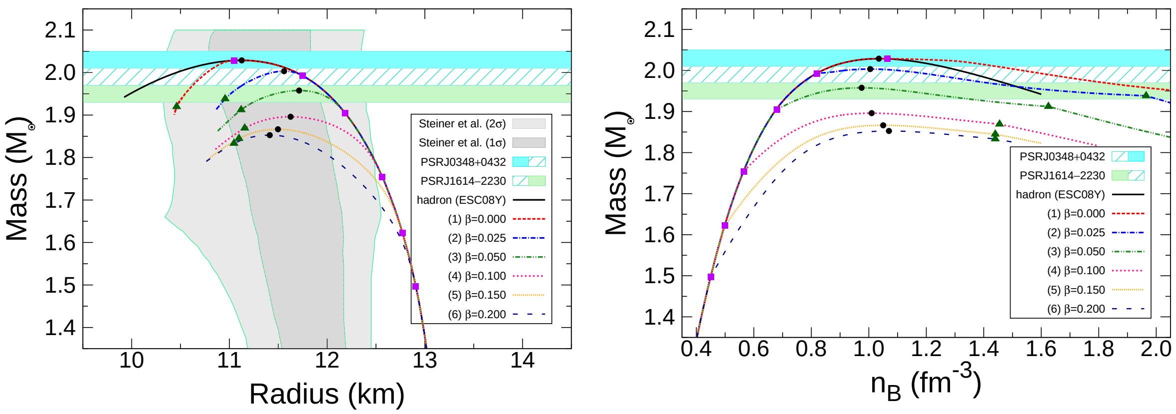

Figure 1: The left (right) panel is the mass of a neutron star as a function of the neutron-star radius (total baryon density, n_B). The filled circles show the points with the maximum mass of a neutron star, and the squares (triangles) mean the beginning (end) points of the mixed phase. The shaded bands show the recent $2M_\odot$ constraint from the astrophysical observations.

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