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From hadrons to quarks: the neutron star equation of state

PHILIP POWELL, Lawrence Livermore National Laboratory, GORDON BAYM, University of Illinois at Urbana-Champaign, TETSUO HATSUDA, Theoretical Research Division, Nishina Center, RIKEN, Japan, TORU KOJO, University of Illinois at Urbana-Champaign, CHRIS PETHICK, Neils Bohr Institute, University of Copenhagen, Denmark, KOTA MASUDA, University of Tokyo, Japan, YIFAN SONG, University of Illinois at Urbana-Champaign, TATSUYUKI TAKATSUKA, Iwate University, Japan — Astronomical measurements of neutron star masses and radii are beginning to provide the first significant constraints on the neutron star equation of state. Meanwhile, the recent discovery of neutron stars with masses in excess of two solar masses are posing challenges to conventional models of dense nuclear matter. We present a method for constructing a unified neutron star equation of state valid across a wide range of densities by incorporating the results of both nuclear potential models valid for < 2 times nuclear density (n_0), and symmetry-based effective models of interacting quark matter, expected to be valid for $> (4-6)n_0$. We discuss processes favoring a gradual onset of quark degrees of freedom with increasing density and show that the possibility of quark-hadron continuity at low temperature is consistent with recent astronomical observations. In particular, we find that a smooth crossover between hadronic and quark matter at $\sim (2-3)n_0$, prevents the hyperonic-induced equation of state softening associated with convention nuclear models at $\sim 4n_0$, which limits the maximum neutron star mass. Finally, we investigate parameter constraints of an effective quark model imposed by astronomical observation and discuss implications for the QCD phase diagram.

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