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Exploring Composition of Dense Nuclear Matter with Astrophysical Observations

Astrophysical observations of neutron stars allow us to study the physics of matter at extreme conditions which are beyond the scope of any terrestrial experiments. In this work, we perform a Bayesian analysis putting together the available knowledge from the nuclear physics experiments, observations of different X-ray sources, and gravitational wave events to constrain the equation of state of supranuclear matter. In particular, we employ a relativistic hadronic density functional to calculate the saturation properties of nuclear matter i.e. the symmetry energy and its slope parameter, the incompressibility, the effective mass of the nucleon, the binding energy per nucleon, and the saturation density. We further probe the fractions of different particle species within our model that the interior of a neutron star may contain, particularly the proton fraction in the core and the observational consequences of the allowed compositions. We also incorporate the possible emergence of hyperons in the system and the number of ways that the density functional can accommodate hyperons in the neutron star matter. Finally, we calculate the strangeness content in the star and discuss its observational implications.

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