Neutron star structure explored with a family of unified equations of state of neutron star matter

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Neutron star structure, particularly the star's mass, radius, and crust, is investigated systematically by using unified equations of state (EOSs) of neutron star matter, namely, EOSs that meet the following conditions: (1) Unified description of matter in the crust and core based on the same EOS of nuclear matter with specific values of the incompressibility K_0 of symmetric nuclear matter and the parameter L that characterizes the density dependence of the symmetry energy. (2) Consistency of the masses and radii of stable nuclei calculated within the same theoretical framework with the empirical values. We systematically construct a family of such unified EOSs within the framework of the Thomas-Fermi theory. In this framework, we are allowed to connect the poorly known high density behavior of the EOS of neutron star matter, which is mainly controlled by L and K_0, to uncertain three-nucleon forces. With this EOS family, we calculate the neutron star structure and discuss its (K_0, L) dependence. The star's mass-radius relation is presented with caution because the central density of the star is significantly higher than the nuclear density except for low mass neutron stars. Also, the inner crust structure including the phase with pasta nuclei is systematically examined for typical neutron star masses and radii.