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The symmetry energy between 0.1 and 2 times nuclear saturation density from nuclear and astrophysical theory and measurements nuclear using unified equations of state

We have entered the era of multi-messenger nuclear astrophysics; bringing a host of astrophysical observations and nuclear experimental data to collectively measure the properties of neutron star matter and the nuclear force in neutron-rich systems. In order to combine disparate data sets with meaningful uncertainty quantification, over the past decade the statistical inference techniques employing ensembles of models have been increasingly employed. In order to minimize systematic model uncertainty, where possible the same underlying model should be used to construct neutron star and nuclear models. We present an example of such an approach, using an Energy-Density Functional to model bulk properties of neutron stars such as the maximum mass, radii, tidal deformabilities and moments of inertia, crust properties of neutron stars, and nuclear properties including nuclear masses, neutron skins and dipole polarizabilities. We allow independent variation of the first four parameters of the symmetry energy and account for possible variation in the symmetric nuclear matter parameters; we fit surface parameters of the crust model to mass fits and semi-infinite matter calculations. We extend the model beyond 2 times nuclear saturation density using both polytropic and speed of sound parameterizations of the high density EOS. We demonstrate how different observables constrain the symmetry energy in different density ranges, and discuss some of the remaining model uncertainties.

Auteur principal: NEWTON, William (Texas A&M University-Commerce)

Orateur: NEWTON, William (Texas A&M University-Commerce)

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