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A New Open-Source Nuclear Equation of State Framework based on the Liquid-Drop Model with Skyrme Interactions

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The equation of state (EOS) of dense matter is an essential ingredient for numerical simulations of many astrophysical phenomena. We implement a modular open-source Fortran 90 code to construct the EOS of hot dense matter for astrophysical applications. For high density matter we use a non-relativistic liquid-drop description of nuclei that includes surface effects in a single nucleus approximation (SNA). The model is based on the work of Lattimer and Swesty [Nucl. Phys. A 535, 331 (1991)] and has been generalized to accommodate most Skyrme parametrizations available in the literature. Low density matter is described as an ensemble of nuclei in nuclear statistical equilibrium (NSE). The transition between the SNA and NSE regimes is performed via a continuous function that smoothly blends their Helmholtz free energy. To account for the existence of 2 solar mass neutron stars, we extend the formalism to allow for a stiffening of the EOS at densities above 3 times nuclear saturation density, where the properties of matter are presently poorly constrained. We study how different Skyrme parametrizations affect the EOS, neutron star mass-radius relationships, and the spherically symmetric collapse and post-bounce supernova evolution of massive stars.

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