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From Nuclear Mass Models to the Neutron-Star Outer Crust: New Equations of State and Crustal Composition

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Abstract

The outer crust of a neutron star provides a unique environment in which nuclear-mass predictions translate directly into the properties of stellar matter. To explore this connection, we construct four new equations of state based on relativistic nuclear mass models and a machine-learning-based mass table. For cold, catalyzed matter, the energetically favoured nucleus is identified at each pressure, establishing the equilibrium composition up to the onset of neutron drip. In regions supported by experimental mass data, the different models yield closely convergent predictions. Their equilibrium sequences begin to diverge only in the deepest layers of the outer crust, where increasingly neutron-rich nuclei beyond current experimental reach become energetically preferred. The resulting variations in composition and neutron-drip conditions reveal the influence of shell structure and the uncertainties inherent in nuclear-mass extrapolations. These microscopic differences nevertheless leave only a marginal imprint on minimum-mass neutron stars, with the variations induced by the outer-crust mass model remaining at the percent level. The new outer-crust equations of state therefore constitute reliable low-density inputs for stellar modelling, even where the detailed nuclear composition remains model dependent [1].

References

[1] P.S. Koliogiannis and N. Paar, *arXiv:2604.26952 [nucl-th]* (2026).