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Quantum simulations of nuclear pasta

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Nuclear pasta is a series of phases of complex nuclear matter arranged in a number of different geometries and topologies. We present 3D quantum calculations of nuclear pasta in neutron star crusts and proto-neutron stars. We find that, when quantum effects are included, nuclear pasta occurs at lower densities than predicted in semi-classical or classical models, and we predict that over 50% of the mass of a neutron star crust is taken up by nuclear pasta independent of the value of nuclear symmetry energy. As a proton-neutron star cools, nuclear pasta tends to keep the outer layers of the star hotter for longer, resulting in an observable imprint on the later-time neutrino signal from supernovae. When the neutron star crust condenses, pasta likely forms microscopic domains characterized by different geometries, and these domains enhance the disorder of inner crust and contribute to an observable signal in the cooling of older accreting neutron stars in quiescence.

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