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The abundance and disorder of nuclear pasta from quantum simulations

We present the most extensive set of 3D, microscopic quantum calculations of nuclear pasta to date, under conditions relevant to the crusts of neutron stars, and spanning the current uncertainty in nuclear models. We show that quantum shell effects and the small differences in surface energies of different pasta configurations lead to a large number of local minima in their energy surfaces at a given density. The minima are separated by barriers of order 10keV. As the crust freezes, we estimate that pasta freezes into microscopic domains of order tens of lattice spacings or less, likely leading to an enhanced electrical and thermal resistivity from electron scattering on domain boundaries. We find pasta phases are predicted to occur at lower densities than typically estimated, around one-quarter nuclear saturation density, and that they initially they coexist with spherical nuclei. We show that it is a robust prediction that pasta accounts for around 70% of the crust mass and moment of inertia, and 25% of its thickness.

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