Phase diagrams of nuclear pasta phases in neutron star matter

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Neutron stars are the remnants of the supernova explosion of a massive stars and gravitational collapse and have densities that approach that of atomic nuclei. Nuclear pasta is a theoretical type of nuclear matter that is hypothesized to exist within their core. We performed classical molecular dynamics simulations with modified Pandharipande potentials at temperatures from 0.2 to 4 MeV, densities from 0.04 to 0.08 nucleons/fm^3, and proton fraction from 0.1 to 0.5. We built a dataset of configurations by selecting 9,600 uncorrelated instants from the simulations and calculated the Minkowski functionals (volume, surface, integral mean curvature, and Euler characteristic) from which the phase of the nuclear pasta at each instant can be determined. We then used the dataset to train a neural network that allowed us to build phase diagrams for nuclear pasta phase similar to those that are used in traditional materials research.