STRUCTURE OF THE MANTLES OF NEUTRON STARS

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The layer between the crust and core of a neutron star, which is called the mantle, may contain so called pasta phases with nonspherical atomic nuclei [1]. We study them using the modern nuclear energy density functional BSk24 [2]. Fourth-order extended Thomas-Fermi (ETF) calculations are performed for cylindrical and plate-like Wigner-Seitz cells. Unlike in our previous calculations with spherical cells [3], we do not include nuclear shell and pairing corrections, but there are grounds for expecting these corrections to be relatively small for the pasta phases. It is therefore meaningful to compare the ETF pasta results with the full spherical-cell results including the corrections, but it is also of interest to compare results for the nonspherical cells with the ETF part of the corresponding calculations for the spherical cells. In the latter case we find that, as the density increases, the cell shapes pass through the usual sequence 'sphere → cylinder → plate' before the transition to the homogeneous core of a neutron star. On the other hand, when we compare with the full spherical-cell results, we find the sequence 'sphere → cylinder → sphere → cylinder → plate'. In neither case do any 'inverted', i.e., bubble-like, configurations appear.

The analytic fitting formulas for the equation of state and composition that we derived in [3] for the entire crust are found to remain valid for pasta shapes to the same accuracy level. Now we additionally construct more accurate fitting formulas for each of the three phases especially for the density range where the nonspherical shapes encounter, which capture the differences between the equation of state and composition in different phases.

The results are published in Ref. [4].

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