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Pasta phases in neutron stars: Extented Thomas-Fermi vs Compressible Liquid Drop approaches

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The mantle – a layer of nonspherical (pasta-like) nuclear shapes – can exist in neutron stars and play an important role in their dynamics and evolution. We analyze accuracy of the Compressible Liquid Drop Model (CLDM), based on the thermodynamically consistent description of the surface properties calculated for the two-phase plane interface for given energy-density functional (for numerical illustration, we apply Skyrme-type functional SLy4). For this aim we compare CLDM results with direct calculation of the pasta phases within Extended Thomas-Fermi (ETF) method. Our ETF calculations found a significant mantle layer, consisting of the pasta phases in cylindrical form (both normal and inverse phases, aka spaghetti and bucatini). Meanwhile, within the applied CLDM framework, which neglects curvature corrections, the inverse phases are absent while the spaghetti phase was found to be energetically favourable only in the small density range prior to crust-core transition. On the other hand, the recent CLDM of Dinh Thi et al. 2021, which, on the opposite, accounts for curvature term predicts pasta phases in better agreement with the ETF, however this model neglects thermodynamically required effect of neutron adsorption and employs additional data to describe the surface properties. This fact highlights the importance of the curvature effects in analysis of the pasta properties within CLDMs. This research was funded by Russian Science Foundation, grant number 22-12-00048.

Primary author(s) : Mr. NIKOLAI, Shchechilin (Institut d'Astronomie et d'Astrophysique, CP-226, Universit\'e Libre de Bruxelles); Mr. NIKITA, Zemlyakov (Ioffe Institute); CHUGUNOV, Andrey (Ioffe Institute); Dr. GUSAKOV, Mikhail (Ioffe Institute)

Presenter(s) : CHUGUNOV, Andrey (Ioffe Institute)

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