

Elasticity of the neutron star mantle: the “spaghetti” phase

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A few calculations predict that in neutron stars a layer (the so-called mantle) can exist between the crystallized crust and the liquid core of the star, in which atomic nuclei have a substantially non-spherical shape. One of the possible options is the nuclei in the form of cylinders (the “spaghetti” phase). The elastic properties of the “spaghetti” phase are similar to the elastic properties of liquid crystals, so it can affect the oscillation spectrum of neutron stars. The report shows that for the “spaghetti” phase, within the framework of the Wigner-Seitz approximation, the transverse shear modulus can be obtained analytically, taking into account the effect of deformation of nucleus cross-sections (the results are described in [1]). These results are supplemented by a more precise calculation that explicitly takes into account the type of crystal lattice: elastic properties are presented semi-analytically in the form of lattice sums. The calculations based on them show that the accuracy of the analytical model turns out to be very high: it can be used to approximate numerical calculations without refinement. Similar results for the outermost layers, in which atomic nuclei retain a quasi-spherical shape (the neutron star crust), were presented in reports at Scientific-Coordination Workshop “Non-ideal Plasma Physics” in 2022 and 2023.

[1] Zemlyakov N A and Chugunov A I 2023 *Universe* **9** 220 (*Preprint* 2305.03603)