NUCLEI FINITE SIZE EFFECTS IN ELASTICITY OF NEUTRON STAR INNER CRUST

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The elasticity of neutron star crust is important for adequate interpretation of observations. To describe elastic properties one should rely on theoretical models. The most widely used is Coulomb crystal model, in some works it is corrected for electron screening. Obviously, these models neglect finite size of nuclei. It is well justified except for the innermost crustal layers, where nuclei size becomes comparable with the inter-nuclear spacing. Still, even in those dense layers it seems reasonable to apply the Coulomb crystal result, if one assumes that nuclei are spherically symmetric: Coulomb interaction between them should be the same as interaction between point-like charges. We demonstrate that this argument is indeed correct, however, shear of crustal lattice generates (microscopic) quadrupole electrostatic potential in a vicinity of lattice cites, which induces deformation on the nuclei. To analyze this problem analytically we generalize well known ion sphere model and suggest ionic spheroid model. In particular, for ground state crust composition the effective shear modulus is reduced for a factor of $1 - u^{5/3}/(2 + 3\,u - 4\,u^{1/3})$, where u is the filling factor (ratio of the nuclei volume to the volume of the cell). Within applied approach, this result is universal and does not depend on the applied nucleon interaction model. For the innermost layers of inner crust $u \sim 0.2$ leading to reduction of the shear modulus by $\sim 25\%$, which can be important for correct interpretation of quasi-periodic oscillations in the tails of magnetar flares.

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