LIQUID-PHASE EPITAXY OF NEUTRON STAR CRUSTS AND WHITE DWARF CORES

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Near-equilibrium bottom-up crystallization of fully-ionized neutron star crusts or white dwarf cores is considered. We argue that this process is similar to liquid-phase epitaxial (i.e. preserving order of previous layers) crystal growth or crystal pulling from melt in Earth laboratories whereby lateral positions of newly crystallizing ions are anchored by already solidified layers. Their vertical positions are set by charge neutrality. Consequently, interplane spacing of a growing crystal either gradually increases, tracing $n_{\rm e}$ decrease, as the crystallization front moves away from the stellar center, or decreases, tracing decrease of $\langle Z \rangle$, when the crystallization front crosses a boundary between layers of different compositions. This results in a formation of stretched Coulomb crystals, in contrast to the standard assumption of cubic crystal formation which is based on energetics argument but does not take into account crystal growth kinetics. Overstretched crystals break, which limits the vertical sizes of growing crystallites. We study breaking shear strain and effective shear modulus of stretched matter and discuss possibility of macrocrystallite formation. The latter has interesting astrophysical implications, for instance, appearance of weak crustal layers, whose strength may increase by a few orders of magnitude upon breaking and refreezing at a late-time event. We also analyze interaction of adjacent Coulomb crystals having different ion compositions and estimate the strength of such interfaces.