The Enskog–Vlasov equation: a kinetic model describing gas, liquid, and solid

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The Enskog–Vlasov (EV) kinetic equation has been derived to describe gas–liquid phase transitions. In the framework of the EV equation, these correspond to an instability with respect to infinitely long perturbations, developing in a gas state when the temperature drops below (or density rises above) a certain threshold.

In this paper, we show that the EV equation describes one more instability, with respect to perturbations with a finite wavelength and occurring at a higher density. This instability corresponds to fluid–solid phase transitions and the perturbations' wavelength is essentially the characteristic scale of the emerging crystal structure. Interestingly, this wavelength is virtually independent of the temperature and density of the fluid state where the transition takes place – just like it is in real world.

Thus, even though the EV model is not designed to describe the fundamental physics of the solid state, it can 'mimic' it – and, thus, be used in applications involving both evaporation and solidification of liquids. Our results also predict to which extent a pure fluid can be overcooled before it definitely turns into a solid.