Phononic Band Gaps in Liquids

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While physicists have a good theoretical understanding of the heat capacity of both solids and gases, a general theory of the heat capacity of liquids has always remained elusive. Apart from being an awkward hole in our knowledge of condensed-matter physics, heat capacity – the amount of heat needed to change a substance's temperature by a certain amount – is a technologically relevant quantity that it would be nice to be able to predict. I will introduce a phonon approach to liquids and describe its thermodynamics in terms of phonon excitations. I will show that the effective Hamiltonian has a transverse phononic band gaps and explain their evolution with temperature variations. I will explain how the introduced formalism covers the Debye theory of solids, the phonon theory of liquids, and thermodynamic limits such as the Delong-Petit and the ideal gas thermodynamic limits. The experimental evidence for the new thermodynamic boundary (the Frenkel line) on the pressure-temperature phase diagram will be demonstrated. Finally, I will discuss the phonon propagation and localisation effects in liquids above and below the Frenkel line, and outline new directions towards phonon band gaps engineering.