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Freezing and Melting in Granular Materials

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From bowls of nuts to eroding soil, granular materials are all around us. In spite of the fact that granular materials are dissipative and athermal, statistical mechanics allows considerable insight into their behavior. I will present experiments on particles which are vibrated from below and sheared from above within an annular channel. The vibrations have the remarkable effect of crystallizing the material, rather than melting it as temperature would an ordinary material. This freezing/melting transition is hysteretic, with the critical line corresponding to equal kinetic energies for vibration and shear. We characterize the transition between these two states, and observe features reminiscent of both a jamming transition and critical phenomena. Another remarkable property is the increase of pressure with volume over a continuum of partially and/or intermittently melted states, in contrast to standard thermodynamic behavior.