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Jamming and Fluidization in Granular Flows

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Granular materials exist all around us, from avalanches in nature to the mixing of pharmaceuticals, yet the behavior of these "fluids" is poorly understood. While the interaction of individual particles is simply through friction and inelastic collisions, the non-linear forces and large number of particles leads to an unpredictable, complex system. Flow can be characterized by the continuous forming and breaking of a strong force network resisting flow, leading to jamming, avalanching and shear banding. I'll present recent work on quasi-static shear and free-surface granular flows under the influence of external vibrations as well as related experiments on particle-fluid suspensions. By using photoelastic grains, we are able to measure both particle trajectories and the local force network in 2D flows. We find through particle tracking that dense granular flow is composed of comparable contributions from the mean flow, elastic deformations, and permanent, plastic deformations. Vibration typically weakens granular materials and removes hysteresis, though small vibrations can lead to strengthening of a pile. Flows of particle-fluid suspensions allow another avenue to probe failure of granular piles and additional control parameters, such as the surface chemistry of the particles.