Surface waves in a granular material under gravity

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Abstract:

Due to the nonlinearity of Hertzian contacts, the speed of sound c in granular matter is expected to increase with pressure as P1/6. A static layer of grains under gravity is thus stratified so that the bulk waves are refracted toward the surface. The reflection at the surface being total, there is a discrete number of modes (both sagittal plane and transverse ones) localized close to the free surface. The granular packing under gravity is a index gradient waveguide. The shape of these modes and the corresponding dispersion relation are investigated in the framework of an elastic description taking into account the main features of granular matter: the nonlinearity between stress and strain and the existence of a yield transition. We show in this context that the surface modes localized at the free surface exhibit a waveguide effect related to the nonlinear Hertz contact.

Sound propagation measurements in a laboratory scale allowed to get the dispersion relation of the fondamental mode using the geometric waveguide feature and by analysing the propagation of gaussian wavelets. I show that the scaling exponent related to Hertz non-linear contact force are consistent with the one expected by the mean-field calculation. Furthermore we observe that the shear modulus is abnormally weaker than expected by the mean-field calculation. However, the critical behavior predicted by the jamming theory was not observed on this propagation experiment.

Preliminary results on a tiltable resonant granular cell dedicated to investigate the behavior of the elastic moduli in the vicinity of the avalanche angle will be presented.

Key words: Surface waves, waveguides, granular matter, non-linear elastic properties, jamming theory, mean-field theory.

Contact dynamics with an interstitial fluid and wave propagation in wet granular media.

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Abstract:

The Physics of wet granular materials is a topic of growing interest and revealed new and interesting phenomena in recent years. Granular media naturally contain interstitial fluids, when immerged or simply exposed to humidity. Understanding precisely how waves propagate in such media is thus an important challenge. The fluid remaining located between grains due to capillarity, singular behaviors are expected. We focus our investigations on the characterization of the dynamical properties introduced by the presence of a thin layer of viscoelastic oils between elastic solids. I will present three configurations we studied experimentally, analytically and numerically. We first considered the propagation of a pulse in a one-dimensional chain of wetted beads. Our results agree with recently published experiments performed in three-dimensional granular materials, and confirm an enhancement of the dissipation and of the contact's stiffness. The later results in an increase of wave speed compared to the dry configuration. We then focused on the contact dynamics at the microscopic scale by considering a single wetted interface between a solid sphere and a flat wall. The singular contact region generates a rupture-like behavior of the fluid. More recently, we performed experiments at the interface between two flat solids, without any geometrical singularity, in order to check the fluid rheology.

Key words: Acoustics, Granular Media, Interstitial Fluids, Singularity.