A numerical study of the Navier-Stokes transport coefficients for 2D granular hydrodynamics

GENERAL SCIENTIFIC SUMMARY

Introduction and background. Granular materials in very rapid flow situations behave like fluids. One of the paradigmatic examples of this behavior is the Faraday instability. The energy source in the granular material comes from the vertical oscillation of a piston. The flat state is destabilized by tuning the amplitude and the frequency of the oscillations leading to the periodic wave-patterns shown in Figure 1.

The main results. Hydrodynamic systems for granular rapid flows can be obtained from kinetic theory descriptions leading to compressible Navier-Stokes equations. We focused in two different sets of transport coefficients, namely the traditional Jenkins-Richman (JR) theory for moderately dense quasi-elastic grains, and the improved Garzó-Dufty-Lutsko (GDL) theory for arbitrary inelasticity. We numerically study how these two systems reproduce the wave-patterns for the Faraday instability. We demonstrate that the heat transfer mechanism coupled to the density gradient in the GDL theory is responsible for a major discrepancy in the temperature, and hence in the diffusion mechanisms for the Faraday instability.

Wider implications. The fact that the transport coefficients computed by GDL are not capable of reducing the discrepancy between particle and hydrodynamic simulations in the highly non-linear Faraday instability might be attributed to a lack of validity of the Navier-Stokes description. Further studies need to be addressed to fully clarify this issue, for instance, by solving the kinetic description by Monte Carlo simulations in even simpler problems such as shear flow.

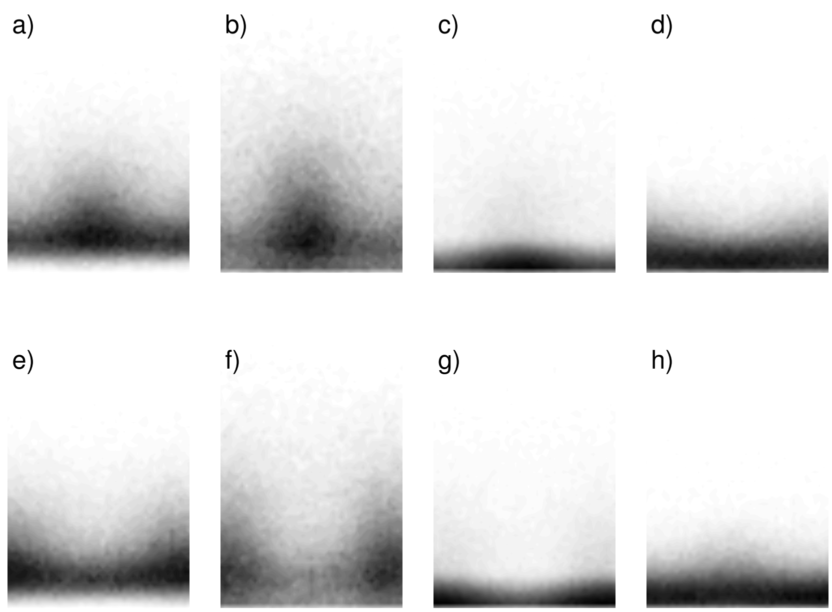

Figure 1: Density field obtained by phase- and space-averaging particle positions from the molecular dynamics simulation. One single wavelength is shown along eight equidistant phases (a) to (h).