Clustering and symmetry-breaking instabilities in a granular gas: hydrodynamics and fluctuations

Manuel Díez-Minguito[1] and Baruch Meerson[2]

(1) Institute 'Carlos I' for Theoretical and Computational Physics, and Departamento de Electromagnetismo y Física de la Materia, Universidad de Granada, E-18071 - Granada, Spain.

(2) Racah Institute of Physics, Hebrew University of Jerusalem, Jerusalem 91904, Israel

e-mail: mdiez@onsager.ugr.es

We consider a rapid granular flow and focus on the clustering instability, which is a striking tendency of granular gases to form dense clusters. We address this interesting phenomenon in a model system of inelastically colliding hard disks inside an annular box, driven by the inner, thermal wall at zero gravity. Event-driven molecular dynamics simulations show a clustered granulate, fluctuating in space and isolated from the driving wall by a low-density gas. In spite of the small number of particles employed, the density profile and the phase diagram of the system agrees well with the solution of granular hydrodynamic equations employing constitutive relations by Enskog-type. However, simulations give a slightly broader instability region than hydrodynamics. This is due to the predominant role played by the fluctuations caused by the discrete-particle noise, unaccounted in the hydrodynamic description. Both clustering and symmetry breaking instabilities should be observable in actual experiments. In fact, the model we proposed is experimentally accessible, and, therefore, if brought to the attention of the appropriate community, might motivate experiments. Further studies may exploit the similarities between the phenomenology observed in our model system and the one in planetary rings, in which clustering, spontaneous symmetry breaking, oscillations, and many other instabilities occur.

[1] M. Díez-Minguito and B. Meerson submitted to Phys. Rev. E (2006)