Spontaneous formation of density waves in granular matter under swirling excitation

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Owing to its non-equilibrium nature, granular materials exhibit phenomena of spontaneous clustering across orders of magnitude of length scales, from gold panning to astrophysics. Though the clustering of granular matter exhibits some generic features across various systems, there are peculiarities in any particular system that need to be taken into account, *e.g.,* the type of energy input.

We study a submonolayer of beads under horizontal agitations. The continuous frictional driving of the substrate distinguishes it from vertically vibrated systems. Strip-like patterns were reported in such a system subjected to a one-dimensional oscillation (Krengel, 2013). Under two-dimensional oscillations, the clustering of grains occurs when increasing the oscillation amplitude beyond a threshold, similar to the previously reported structure transition (Aumaître, 2003). The clustering transition here is abrupt and sensitive to the oscillation amplitude (see Figure 1). It is revealed that the observed clustering is a result of the formation of density waves. The underlying mechanism is explored by analyzing the motion of individual particles, a phenomenological model and DEM Simulations.

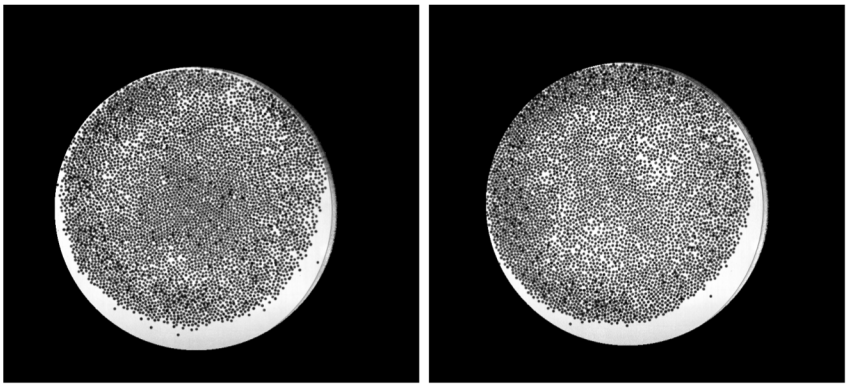

Figure 1: Snapshots of a packing consisting of ceramic particles of $d_g = 0.9$mm and the global packing fraction $\phi_{tot} = 0.51$. Left panel: A snapshot of the system at $A = 11$mm. Here, the density wave travels in a circular path at the oscillation frequency, 5 Hz. Right panel: A snapshot of the same system after decreasing A to 10.5mm for 5 cycles.

References

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