"Granular turbulence" in a driven system of magnetized particles

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Driven granular media constitute archetypal systems to study out-of-equilibrium physics at the macroscopic scale. We developed an experimental device, in which the competition between mechanical agitation of and remote repulsive interactions between macroscopic particles can be studied [1,2]. In this device, strongly magnetized particles self-organize into a quasi-two-dimensional pattern (Figure 1, left). We find that the space-time power spectra of the longitudinal and transverse velocity fluctuations of the particles define dispersion relations (e.g. Figure 1, right). Thus, we show that the random motions of the particles correspond to the propagation of mechanical waves, analogous to the phonons in condensed matter. The continuous spectra showing propagation of random waves at different scales and the nonlinearity suggest a turbulent dynamic of waves. For moderate applied magnetic field, in a collision-less granular gas regime, we observe also power-law velocity spectra both in space and in time. However, the time scale separation between linear time and damping time is small, likely due to the strong dissipation inherent to granular media. The "granular" turbulence observed here would not correspond to an energy flux through the scales, but rather a response to the forcing by the waves dynamics. A similar interpretation has been recently proposed in active matter for turbulent-like spectra at low Reynolds number [3].

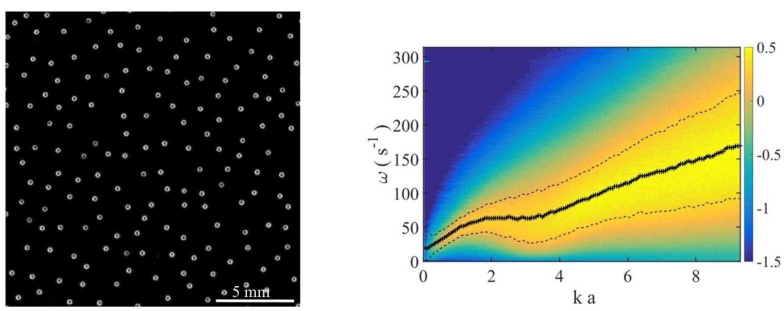

Figure 1. Left, Snapshot of the experiment viewed from above in a collision-less granular gas regime. Steel spheres of diameter a=1 mm are mechanically shaken and interact with each-other through a magnetic dipolar potential. 2D particle positions and velocities are obtained by particle tracking. **Right**, Space-time power spectrum of longitudinal velocity fluctuations. The maxima of signal energy define a dispersion relation (black crosses) in the (k, ω) space. The large width of the dispersion relation (dashed lines) denotes significant wave damping.

Références

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