Dispersion relations of random waves in a vibrated 2D granular medium with magnetic dipolar interactions.

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We consider a quasi-2D system of macroscopic particles with tunable repulsive dipolar interactions controlled by an external magnetic field. In this out-equilibrium system, kinetic energy is provided by a continuous mechanical shaking. By increasing the magnetic field, the repulsive interaction strength between particles is increased. For sufficiently high ratio between magnetic interaction potential energy of particles and their kinetic energy, the system transits from a dissipative granular gas to a hexagonal crystal [1]. Similarly to the method evidencing a critical solid-liquid-like phase transition in a dense vibrated granular layer [2,3], we analyse the transition from a disordered granular gas to a solid-like hexagonal phase by studying in the spatial Fourier space, first the static structure factor and the 6-fold bond-orientational order parameter. Results are compared with the insights of the KTNHY theory describing the 2D-melting of a hexagonal crystal. Then, by extracting the longitudinal and transverse current correlations in dynamical regime, the spectrum of excitations can be measured to characterize how energy is distributed through the scales. Dispersion relations are obtained, showing longitudinal wave propagation in the two phases and transverse wave propagation in the solid-like phase only. These waves generated by the mechanical excitation, are analogous to phonon branches thermally excited in condensed matter. The corresponding "sound" velocity is found to increase with the applied magnetic field, as the rigidity of this system augments.

Références

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