Collective Motion of Granular Particles
Induced by Moving Interfaces

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The aggregation of particles has attracted considerable interest as a problem of non-equilibrium physics. In the case of particle aggregation in a multiphase system, particle motion can interact with phase boundary motion. For example, surfactant molecules in an oil-water system affect the motion of the oil-water phase boundary [1]. In this case, by changing the concentration of the surfactant, various structures are formed in the microemulsion system such as spheres, cylinders, and lamellae [2].

In order to understand the dynamical properties induced by the interaction between the particle and phase boundary motions, a definite and simple picture of the collective motion of particles should be developed. We consider the motion of the air front (i.e., air-water boundary) during water evaporation as an example of phase boundary motion. When granular particles exist in the water phase, they can prevent the motion of the air front. It should be noted that the role of the particles in the air front motion differs significantly depending on the particle concentration in the system; When the concentration is quite low, the particles are treated individually as an impurity that induces the pinning effect on the air front motion [3]. On the other hand, at a high concentration, the system is packed with the particles. Accordingly, the granular particles are treated as a porous medium, and the dynamics of the air front motion is considered as the dynamics of invasion percolation [4]. Evidently, there is a huge gap in the treatment of granular particles between low and high particle concentration cases. Therefore, at the intermediate concentration, it is difficult to characterize the collective motion of particles.

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Recently, we have studied the formation of the labyrinthine pattern which corresponds to a spatial distribution of aggregated granular particles at the intermediate concentration (see Fig. 1 for reference). The pattern is produced by the air front that sweeps granular particles during the evaporation process of the water-granule system [5]. In order to reproduce such a pattern formation, we constructed a dynamical model based on molecular dynamics and phase field model [6]. From the numerical simulation results of the model, one of which is shown in Fig. 2, it is found that the model can characterize the collective motion of particles induced by moving interfaces at the intermediate concentration.

References


