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ABSTRACT

A granular material is simple yet complex composition of discrete macroscopic and mesoscopic particles called 'grains'. Important features that make granular material different from molecular systems, first is inelastic short range interaction among grains i.e. particles comprising granular material collide dissipatively and second, the particles are athermal i.e. ordinary temperature is irrelevant. These features lead to various interesting phenomena like pattern formation, clustering etc. From the physics point of view, unlike solids, liquids and gases where a comprehensive theory exists, there is no coherent theory of granular media that could explain the vast variety of behavior that these systems exhibit. Rather, different theories depending on the phenomenon addressed have been proposed.

We investigated the linear spring-dashpot model (LSD model) of force-free granular gas using conventional molecular dynamics simulations. Clustering in the density field and local ordering in velocity field is observed due to dissipation and cooling of system. The energy relaxation exhibit power-law behavior as a function of time in all the dimensions $1 \leq d \leq 4$. The exponents satisfy Carnevale et al. predictions $(2d/(d+2))$ only for dimension $d \leq 3$. The morphology of domain growth in the density field is studied in $d = 2$ and 3 dimension via structure factor and correlation function. The simulation data at various times shows self-similarity and dynamical scaling. The system is characterized by a unique length scale that grows in time. The characteristic length scale of density field exhibits diffusive growth law: $L(t) \sim t^{1/3}$. Similarly, results were

obtained for velocity field.

Next we studied granular gas comprising of viscoelastic spheres is studied in two dimensions. The aging behavior of the autocorrelation function in velocity field is studied for two different models. In the first model, the coefficient of restitution depends on the current temperature of granular gas, in second model, the coefficient of restitution depends on the impact velocity. The results were compared with simple model of granular gas where the coefficient of restitution is a constant. The velocity autocorrelation function depends explicitly on both collision time and waiting time showing aging property. This is due to presence of correlations in the velocity field. The decay of the function depends on the dissipation in the system. More dissipative system shows stronger memory and aging effects as compared to weak dissipative system. The decay of the function is slower in simple model of constant coefficient of restitution and correlations and aging are overestimated.We also study the aging behavior of the autocorrelation function in velocity field is studied for driven granular gas. The particles were subjected to Gaussian white noise to compensate for the energy loss. Backscattering effect was observed in $d = 2$ dimension due to local caging of a particle within it's neighbors. For stronger inelasticity, the backscattering effect is more pronounced and it vanishes near elastic limit. Backscattering effect is absent in $d = 3$ dimension. The autocorrelation function shows aging property and in the steady state, the system stops aging. The correlations in the velocity field are present even in the steady state. These correlations are less pronounced in 3 dimensional system.

Lastly we study granular gas comprising of soft spheres in the presence of long-ranged potential which is extended over all particles. The introduction of gravity among particles enhances inter-particle collisions and clustering process is accelerated. Clustering is prominent in the case of larger dissipation parameter and strong self-gravity. The morphology of domains in the density field is studied by structure factor and correlation function. The simulation data at various times show self-similarity and dynamical scaling. The characteristic length scale of density field shows growth law: $L(t) \sim t$ and structure factor follows Porod's law.