Oscillation of ellipsoidal grains

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The mechanical response of ellipsoidal grains has an additional complexity associated with the microstructure alignment and orientation of the grains. These additional kinematic degrees of freedom give rise to a more complex macroscale response than spherical grains [1]. The alignment of grains with respect to each other and the ambient flow governs the characteristics of the grain-to-grain contacts and relative slipping. The rheological response of ellipsoidal grains has been investigated recently, using experiential techniques and Discrete Element Method (DEM), however, these studies mainly focus on the steady-state response while the transient response is typically ignored. When ellipsoidal grains are subjected to oscillation, their corresponding alignment and orientation give rise to an additional timescale that is observed on the macroscale response.

In this presentation, a mathematical model for the kinematic response of ellipsoidal grains [2] and anisotropic inertia rheology model [3] will be used to study the transient reversal shear response of ellipsoidal grains. The grains orientation is described by the structural tensor which is the second moment of the orientation density function. The anisotropic inertial rheology model depends explicitly on the microstructure of the grain orientation which is an evolving property that depends on the flow and the grain interactions. This gives rise to a coupled system that shows a complex transient response to oscillations.

The response of the grains orientation when subjected to transient shear reversal is depicted in Figure 1. The response shows that the orientation evolves at different rate than the velocity field. These results provide insight into the evolution of the microstructure and the conditions for jamming. It suggests that explicit consideration of the microstructure is essential for an accurate rheological model of ellipsoidal grains.

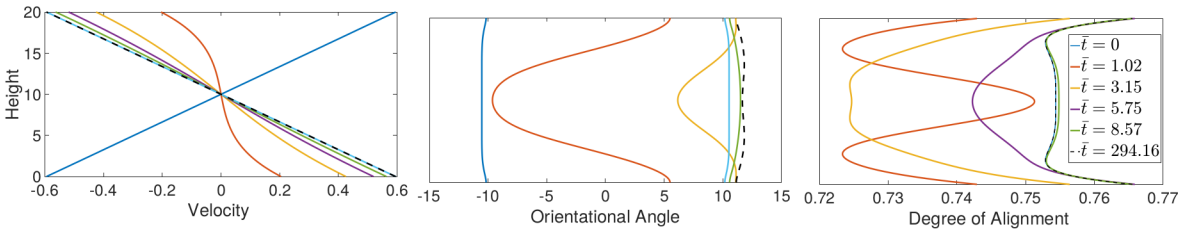

Figure 1. Transient response of shear reversal for dimensionless time $\bar{t} = |\dot{\gamma}|t$.

References

[1] P. Jop, Y. Forterre and O. Pouliquen, A constitutive law for dense granular flows, Nature, 441: 727-730, 2006.

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[3] B. Nadler, Anisotropic inertia rheology of ellipsoidal grains. Granular Matter, 23:14, 2021