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From grain scale to mesoscale modelling of immersed granular flows: application to granular avalanche and sediment transport

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The physical characterization and modelling of granular flows immersed in a viscous fluid remain a challenging task due to the large range of spatial scales involved in these systems, i.e. from the description of the flow around each individual grain to the scale of deformation of the granular medium. In order to overcome this challenging issue, we propose here to use dedicated numerical methods at different scales with respect to the fluid phase, while the granular phase is always modelled using a Lagrangian description including multi-contacts force modelling. These approaches are referred to as a resolved IBM/DEM approach and an unresolved VANS/DEM approach [1,2]. The fluid phase is then solved either at the grain scale (IBM) or at the scale of several grains (VANS). For the unresolved approach, closure terms have to be prescribed at small scale (typically the grain scale) to model the effective fluid viscosity and the drag force. However, it allows simulating larger systems then more representative of laboratory experiments. These different approaches can then be used to provide the rheology of both the granular phase and the mixture phase, which is required for large scale continuum modelling (see figure 1).

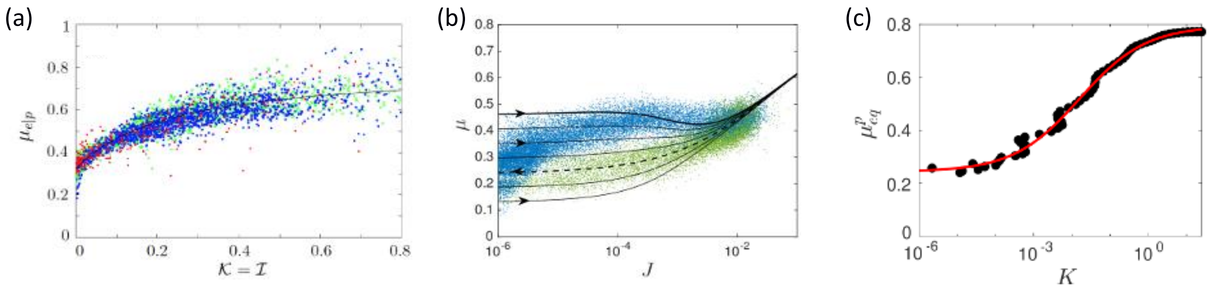

Figure 1 : Test case of $\mu - I$ type rheology for (a) dry granular collapses, (b) immersed collapses and (c) granular transport by a shear flow, from [3-5]

The above-mentioned upscaling methodology is used to provide physical features of shear-driven and gravity driven granular transport situations, as encountered in many natural flows such as sediment transport and avalanches. More particularly, two canonical flows -- the shear-Couette flow and the granular collapse -- are considered because of their aesthetic simplicity while capturing most physical processes of these natural phenomena.

[1] E. Izard et al., J. Fluid Mech. **747**, 422-446 (2014)
[2] F. Charru et al., Meccanica **51**, 3055-3065 (2016)
[3] L. Lacaze R.R. Kerswell, Phys. Rev. Lett. **102**, 108305 (2009)
[4] L. Lacaze et al., J. FLuid. Mech. **912**, A15 (2021)
[5] B. Fry et al., submitted.