Size segregation in dense granular flows: The granular Saffman effect

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ABSTRACT

While the effects of size segregation in dense granular flows have been closely studied, the underlying mechanism(s) causing particles to segregate are still not fully understood. We aim to shed light on this topic by studying the migration of large particles in granular flows of smaller particles. Our three-dimensional discrete-particle-method simulations shed new light on the origin of segregation of large particles and the link between particle-scale behavior and macroscopic fields in polydisperse dense granular flows. A harmonic trap method [1] is employed to study the segregation forces on a single large particle. We find that the steady state flow of a large intruder is characterized by a surrounding non-hydrostatic pressure field, yielding a net upwards force and a reduction or lag in the downstream velocity with respect to the surrounding medium. By decomposing the pressure field in a hydrostatic and a non-hydrostatic pressure—the latter resulting from the drag of the surrounding granular medium—we show that the buoyancy force on a large grain is not enough to support it, but that a Saffman-like lift force [2], originating from the drag, allows it to segregate.

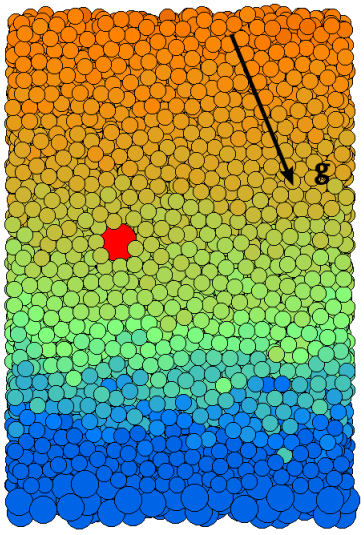

Figure 1: A large intruder particle (red) in a chute flow, simulated with periodic boundary conditions and gravity at an angle of 22°.

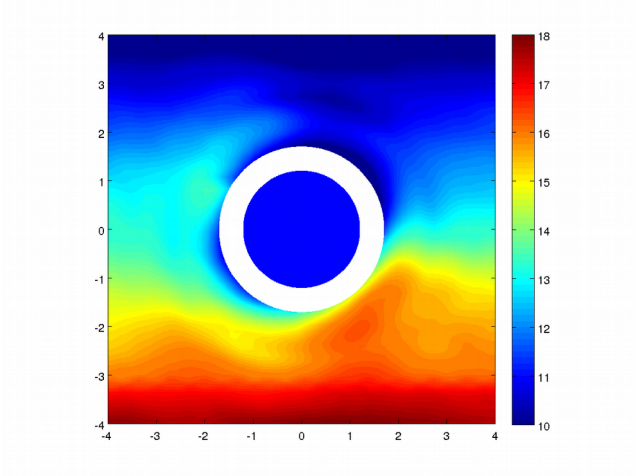

Figure 2: Pressure field of the surrounding granular fluid around the intruder particle (white circle) .

REFERENCES

[1] Guillard, F., Forterre, Y. and Pouliquen, O. (2016) 'Scaling laws for segregation forces in dense sheared granular flows', *Journal of Fluid Mechanics*, 807. doi: 10.1017/jfm.2016.605.

[2] Saffman, P.G. (1965) 'The lift on a small sphere in a slow shear flow', *Journal of Fluid Mechanics*, 22(2), pp. 385–400. doi: 10.1017/S0022112065000824.