

Patrick Richard

From Alignment to Friction: The Role of Angular Dynamics in Confined Granular Flows

Dense granular flows composed of elongated particles exhibit a striking reduction in particle rotation compared to spherical grains, a feature that has important consequences for flow behavior but whose origin remains debated. Using three-dimensional discrete element simulations, we investigate how particle shape anisotropy influences angular motion and frictional properties in confined granular flows under shear. Our results show that the inhibition of rotation cannot be understood by considering particle shape, friction, or packing density alone. Instead, it emerges from the collective alignment of the grains induced by shear, which we quantify using a nematic order parameter. Based on this observation, we propose a simple scaling law linking the average angular velocity to the local shear rate through a hampering parameter that depends solely on the orientational order. We further demonstrate that effective friction at the sidewalls, though influenced by particle geometry and flow pattern, scales according to the balance between sliding and rolling motion of the grains. This highlights the fundamental importance of angular motion of the particles for understanding the behavior of granular flows at interfaces and points out the strong coupling between sliding and rolling motion of grains. Remarkably, these two scalings hold across a wide range of particle properties, boundary conditions, and flow configurations, highlighting the central role of collective grain rotation in dense granular flows of anisotropic particles.