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Numerical analysis at the particle scale of granular flow hysteresis on an inclined plane

Granular media are ubiquitous in environmental processes and geophysical phenomenon such as sediment transport, landslides or avalanches. Granular media can be classified into three different regime : solid (quasi-static), liquid (dense flow) and gas (dilute flow). The transition between the motionless solid state and the dense flow state corresponding to the initiation of motion is an important issue for the study of natural hasards such as snow avalanches or landslides. In particular, this transition is subjected to a phenomenon of hysteresis : the angle at which an avalanche starts on an inclined plane is greater than the one at which the flow stops. While this hysteretical behavior has a major influence on avalanche or
debris flow propagation, both its description and the underlying basic physical mechanisms still remain open questions.

In this framework, the present work focuses on the fundamental small scale mechanisms related to the hysteresis observed in granular media at the transition between dense granular flow and rest.

Hysterical behavior has been highlighted in laboratory experiments using either a rotating drum configuration [1], [3] or an inclined plane configuration [5], [4] as the difference of critical angles obtained to initiate and stop granular flow made of monodisperse solid grains. This mechanism has since been often
attributed to particle inertia [1], [2]. Yet, more recent works [3], [4] show on that the inter-particle friction is a dominant mechanism in the hysteresis at the expense of the inertia of grains.

To understand this apparent contradiction and the mechanisms at play, the present study focuses on inclined plane simulation at the particle scale. Using a discrete element method modelling the behavior of each particles, flow arrest and avalanche onset are studied by varying the inclination angle of the inclined plane with respect to gravity. Studying the influence of inter-particle friction, it is shown that the inter-particle friction is not the dominant mechanisms responsible for the hysteresis in dry granular flows. Variation of grains inertia are also studied in order to explain the different results on the subject.

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