Topographical effects on granular gravity currents

J. M. F. Tsang, S. B. Dalziel, N. M. Vriend

Particles 2017: Micro-macro: From Discrete Particles to Continuum Models of Granular Mechanics

Abstract

Granular gravity currents occur throughout geophysics, with the most dramatic examples being landslides and avalanches. It is therefore important to understand their properties. A theory of their behaviour was first given by Ralph Alger Bagnold. Studying granular flows down an inclined plane, Bagnold found a certain velocity profile within the current. Since then, much progress has been made towards continuum modelling of granular flows in more general contexts, with widely-accepted models including the $\mu(I)$ rheology (Jop *et al.* 2006) and its depth-averaged form, analogous to the shallow water equations (Gray and Edwards 2014).

When the $\mu(I)$ rheology is applied to a flow over an inclined plane, Bagnold's velocity profile is recovered. However, different behaviours arise when the plane is replaced by a more general surface with nonzero curvature. These topographical features arise naturally in geophysical contexts, where they may represent both natural bumps and artificial defences such as dams. In studying flows over topography, it is useful to combine continuum models with discrete particle methods. The latter allow us to generate topographies with arbitrary shapes, and also to characterise mathematically any randomisation that we may wish to introduce. They also give us the internal velocity profile of a current, which is difficult to measure in a lab experiment.

This talk will present the authors' recent research on flows over simple examples of topographical features. This includes DPM simulations which show that topography has strong, nonlocal effects on the velocity profiles of flows, including the formation of a bottom boundary layer. The speaker will also present a continuum model for the boundary layer which has many similarities to the boundary layer theory of classical hydrodynamics.