Fractures in cohesive granular flows

From cohesion-tunable particles to environmental applications

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Among the different types of avalanches, the "slab avalanches", made of dense snow, initiate by a long crack perpendicular to the slope, and then quickly propagate downhill during the flow (Fig. 1A). Difficult to predict, they are therefore especially dangerous for skiers and others. Prediction of their behavior remains difficult and relies mainly on empirical observations. To improve our understanding of this phenomenon, we need to understand the physics at the grain scale, and the cohesive forces involved. The objective of this project is to study how fractures appear in a cohesive granular material, how they evolve, and how they influence the flow back. These questions surpass the particular case of slab avalanches and apply to many other examples of fractured flows such as landslides of cohesive soil, or, in a more industrial context, self-leveling concrete flow.

This project aims at understanding crack formation and evolution in a flow of cohesive granular material and addresses the following questions:

- What is the threshold for crack initiation in a cohesive granular material?
- How fractures' shape depends on the material properties? What is their density and the associated dissipated energy? How do they evolve while flowing?
- How these fractured flows can be modeled from a continuous approach and a local rheology?

To address these questions, we will combine experiments and theory-based numerical simulations. We have already established an experimental setup using cohesion-controlled granular material, specifically designed to explore the formation of fractures within a thin layer (Fig. 1B). The objective of this internship will be (i) to improve the experimental setup and implement digital image correlation measurements, (ii) to develop a comprehensive model and numerical simulations, depending on your interests, to elucidate the relationship between the wavelength of fractures and the interparticle cohesion, (iii) to explore the system dynamics in a rotating-drum experiment, and observe how fractures evolve and interact under dynamic conditions.

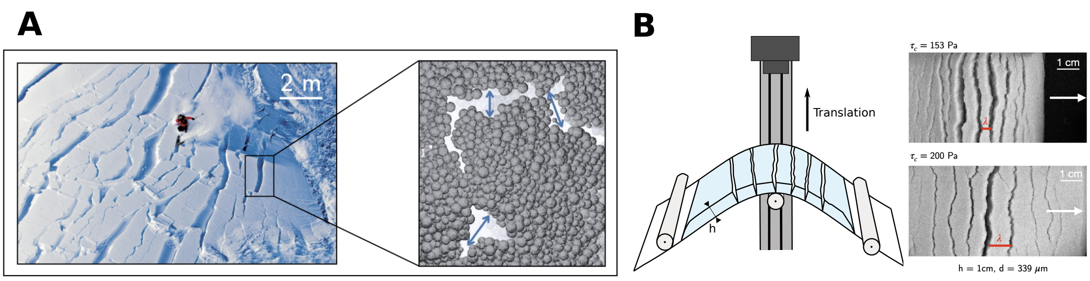

Figure 1: A. Exemple of fractured flows: Slab avalanche triggered by a skier Mt Cook National Park, New Zealand. Mark Gollub, New Zealand Geographic, issue 117 (sep-oct 2012). B. Experimental results in the quasistatic regime.