Grain dispersion in smooth granular flows

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Mixing plays a crucial role in various industrial processes, such as glass and concrete manufacturing, where inadequate homogenization of raw materials can significantly impact product quality. Chaotic flows are known to enhance the mixing at low Reynolds number through advection and diffusion [1]. Quantitative analysis of the homogenization processes can be made following the concentration field [2].

While numerous studies have explored mixing in different fluids, the description of granular mixing in smooth flows remains limited [3]. Differences between fluids and grains, such as the discrete nature, the lack of thermal agitation and the shear-related diffusion, contribute to a poorly understanding of the interplay between advection and diffusion, while the Peclet number is low compared to classical fluid experiments.

We developed a 2D dry granular experiment in a closed configuration to study their dispersion using a figure-eight protocol to stir the grains (Fig. 1a). Following each grains, we quantify the separation of Lagrangian trajectories and the evolution of a initially tagged particles toward a homogeneous state, focusing on the role of a global rotation of the system. Our results underscore the potential for refining dispersion models in smooth granular flows through further analysis of variance decay.

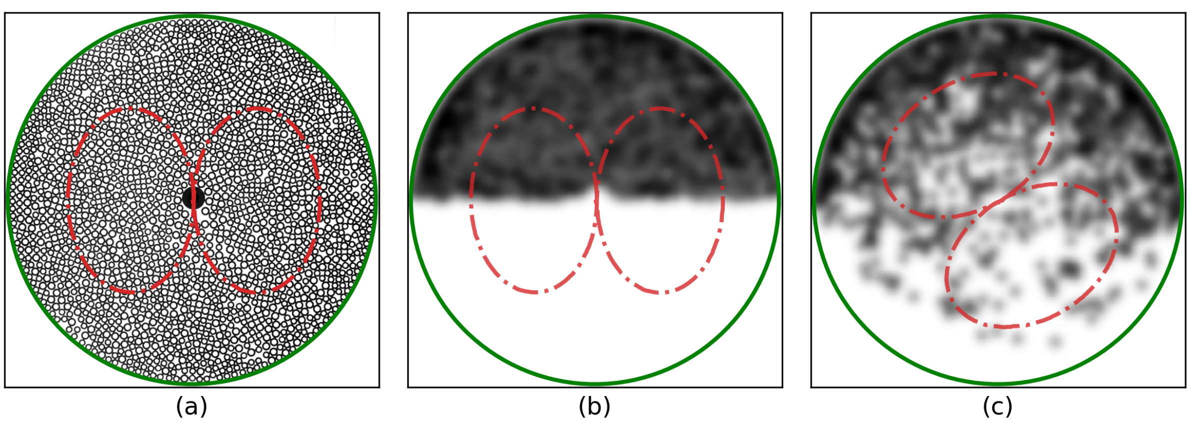

Figure 1. (a) 2D granular experiment confined in a circular closed configuration (green line), where the grains are stirred by moving the rod using a figure-eight protocol (red line). (b) Tagged particles at the initial state of the system. (c) Dispersion of the tagged particles after 40 cycles of the rotated protocol.

Références

1. AREF, H, Stirring by chaotic advection. *Hamiltonian Dynamical Systems*. pp. 725-745 (2020).
2. VILLERMAUX, E., Mixing versus stirring. *Annual Review Of Fluid Mechanics*. **51** pp. 245-273 (2019).
3. OTTINO, J. & KHAKHAR, D., Mixing and segregation of granular materials. ANNUAL REVIEW OF FLUID MECHANICS. **32**, 55-91 (2000).