The interrupted nature of constricted dense suspension flows

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When people, animals, or particles are forced through a constriction, the flow may become intermittent due to the development of clogs that obstruct the constriction. Despite the diverse nature and scale of these systems – including hungry sheep herds [1, 2], pedestrian crowds trying to escape a room in a life-and-death situation [3], discharge of dry granular silos or suspended hydrated particles transported through pipelines, sand hourglass, or mices escaping a water pool – a distinctive phenomenology of particles or bodies flowing in erratic bursts is observed, separated by short period of arrest. The analogy does not seem to be only qualitative: in all cases the number of escapees per burst follow an exponential distribution, and the probability distribution of time lapses separating the passage of consecutive bodies seems to exhibit a power-law tail with characteristic exponents that depend on diverse system parameters.

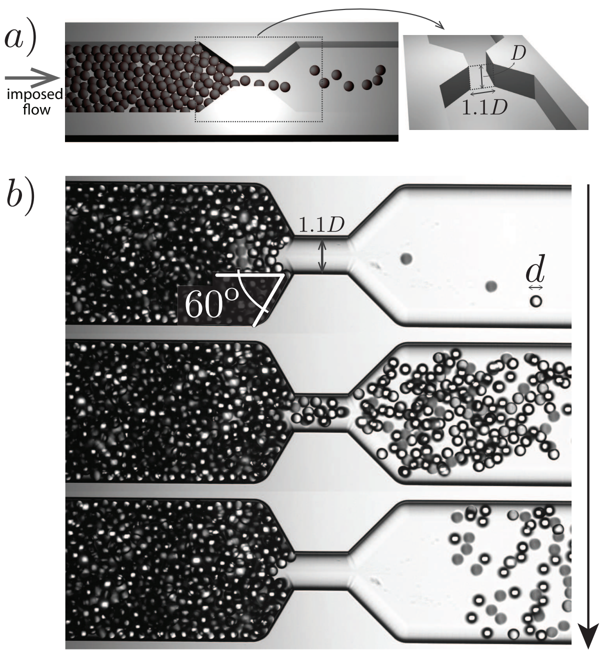

Fig. 1. a) The experimental setup consists on a glass channel with rectangular sections that transitions through a conical section to a constriction with an almost squared cross-section, characterized by the neck-to-particle size ratio D/d, where $D = 100$ μm is the constriction width and d is the particle size diameter (d =33 μm in this case). b) Sequence of events during a burst of particles in an intermittent flow regime.

We follow this statistical approach, which require high time- and space-resolution experiments to obtain probability distributions of arrest times between successive bursts, which display power-law tails with characteristic exponents. We will show that dense non-cohesive particle suspensions going through a constriction exhibit intermittent flow behavior with a striking similarity as in dry granular matter, human crowds, or animal herds [1, 4, 5], both for pressure or volume-controlled driving. Nonetheless different flow drive leads to subtle and non-trivial results that will be discussed in the presentation [6]. Our results will also be compared with approximated computational fluid dynamics simulations and discrete particle simulations [7], illustrating the crucial role of the interparticle liquid flow.

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