Cooperation between two objects moving side-by-side in a granular medium

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Various practical situations involve the movement of several objects in a granular medium, such as animal locomotion or civil engineering applications. Interactions between objects moving close to each other in grains have been the topic of several studies. In the case where the objects move freely, it has been shown that they repel each other at short distances and attract each other at intermediate distances [1]. These observations have motivated the study of the side force experienced by two threaded objects placed side-by-side into grains [2]. Numerical simulations have also shown that the interaction between objects has an impact on the drag they experience [3]. However, experimental confirmation of this effect on drag force has yet to be established.

Figure 1. Two spheres (20 mm in diameter) moving side-by-side close to the surface of a granular medium.

In order to fill this gap, we investigate experimentally the drag experienced by a pair of spherical intruders moving side-by-side into grains at constant depth and constant velocity (Fig. 1). We quantify the influence of the separation distance between the spheres and their depth below the granular surface. When the intruders are sufficiently far apart, they do not interact and the average drag felt by each of them corresponds to that of a single intruder. However, for a small separation between the intruders, the mean drag is reduced, confirming the existence of a cooperative effect that facilitates motion. In addition, the relative drag reduction is observed to increase with burial depth. We propose a model for the drag reduction of a pair of intruders based on the breakup of contact chains caused by the shear generated by the neighbouring intruder. These results provide new insights into the interaction between solid objects that move together in grains, as in the case of animal locomotion in sand or the growth of plant roots in soil.

Références

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