INFLUENCE OF MECHANICAL VIBRATIONS ON GRANULAR FRICTION

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Triggering large-scale motion by imposing vibrations to a system can be encountered in many situations, from daily-life shaking of saltcellar to silo unclogging or dynamic earthquakes triggering [1, 2, 3]. In the well-known situation of solid or granular friction, the acceleration of imposed vibrations has often been proposed as the governing parameter for the transition between stick-slip motion and continuous sliding [4]. The threshold acceleration for the onset of continuous slip motion or system unjamming is usually found of the order of the gravitational acceleration [4, 5]. These conclusions are mostly drawn from numerical studies.

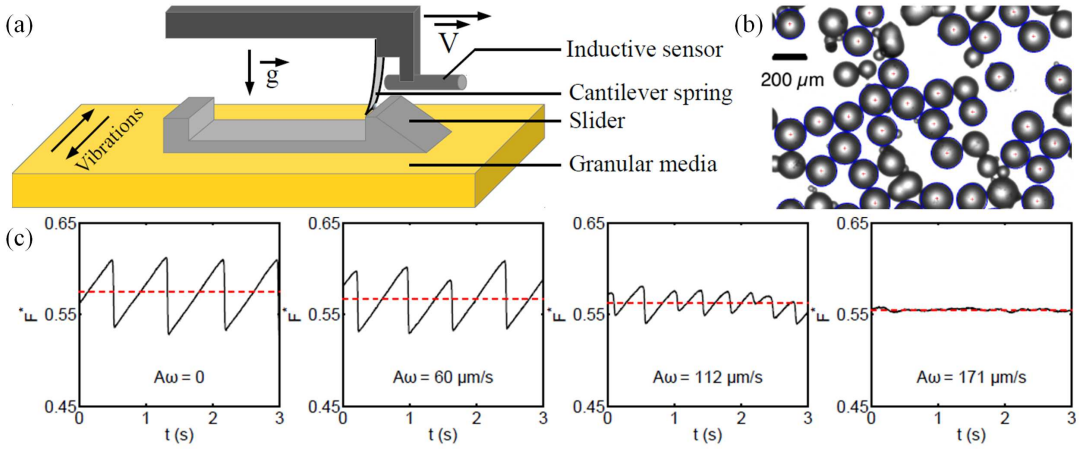

Figure 1. (a) Experimental setup. A slider (mass m) is pulled at constant velocity V, via a cantilever blade, on a granular layer. (b) Typical grains used in the experiments (polydisperse spherical glass beads). (c) Effect of the mechanical vibrations (amplitude A, frequency ω) on the stick-slip motion. F^*=F/mg indicates the normalized force applied on the slider. The stick-slip amplitude (initially without vibration, left panel) decreases (middle panels) until the system undergoes a continuous slip motion.

We investigate, in the laboratory, granular friction by shearing a layer of grains subjected to horizontal vibrations (Fig. 1a,b). When increasing either the amplitude A or frequency ω of the vibrations, the amplitude of the stick-slip motion decreases, until the system exhibits a transition to a continuous slip motion (Fig. 1c). Therefore, under mechanical vibrations, both the static and dynamic friction coefficients decrease. We show that, in contrast to previous results, the quantity that controls the frictional properties is the characteristic velocity $A\omega$, and not the acceleration $A\omega^2$, of the imposed mechanical vibrations [6]. The critical velocity at which the system undergoes the transition to a continuous slip motion is very small, of the order of 100 μm/s. Thus, when the system is statically loaded, the typical acceleration of the vibrations which trigger large slip events is much smaller than the gravitational acceleration. These results may be relevant to understand dynamic earthquake triggering by small ground perturbations [3].

References

[1] A. Janda, D. Maza, A. Garcimartín, E. Kolb, J. Lanuza & E. Clément, *Unjamming a granular hopper by vibration*, Europhysics Lett. **87**, 24002 (2009).
[2] P.A. Johnson & X. Jia, *Nonlinear dynamics, granular media and dynamic earthquake triggering*, Nature **437**, 871–874 (2005).
[3] J. Gomberg, P. Reasenberg, P. Bodin & R. Harris, *Earthquake triggering by seismic waves following the Landers and Hector Mine earthquakes*, Nature **411**, 462–466 (2001).
[4] A.L. Sellerio, D. Mari, G. Gremaud & G. D'Anna, *Glass transition associated with the jamming of vibrated granular matter*, Phys. Rev. E **83**, 021301 (2011).
[5] M. Pica Ciamarra, A. Coniglio, D. De Martino & M. Nicodemi, *Shear-and vibration-induced order-disorder transitions in granular media*, Eur. Phys. J. E **24**, 411–415 (2007).
[6] H. Lastakowski, J.-C. Géminard & V. Vidal, *Granular friction: Triggering large events with small vibrations*, Sci. Rep. **5**, 13455 (2015).