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Cycling experiments and numerical simulations of avalanche precursors

Quasi-periodic collective displacements of grains at the free surface of a tilted grain packing constitute precursors of granular avalanches. Laboratory experiments are commonly performed by slowly tilting the packing from 0° to the maximal stability angle. In these conditions, the number of precursors is too small for reproducible and robust statistical analyses. To go beyond this limitation, we have developed a specific experimental protocol consisting of tilting the packing with successive inclination cycles with an amplitude below the maximum stability angle. We use a high-resolution optical camera and process the images of the packing free surface to identify precursors during many consecutive cycles of a single experiment, detecting an average of 1800 events per experiment. Beside these experiments, we present a two-dimensional numerical model that robustly produces quasi-periodic compaction events. This model shows that distinguishing between the static and dynamic friction coefficients is necessary to produce these events.