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Spatiotemporal stick-slip phenomena in a coupled continuum-granular system

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In sheared granular media, stick-slip behavior is ubiquitous, especially at very small shear rates and weak drive coupling. The resulting slips are characteristic of natural phenomena such as earthquakes and well as being a delicate probe of the collective dynamics of the granular system. In that spirit, we developed a laboratory experiment consisting of sheared elastic plates separated by a narrow gap filled with quasi-two-dimensional granular material (bi-dispersed nylon rods) . We directly determine the spatial and temporal distributions of strain displacements of the elastic continuum over 200 spatial points located adjacent to the gap. Slip events can be divided into large system-spanning events and spatially distributed smaller events. The small events have a probability distribution of event moment consistent with an $M^{-3/2}$ power law scaling and a Poisson distributed recurrence time distribution. Large events have a broad, log-normal moment distribution and a mean repetition time. As the applied normal force increases, there are fractionally more (less) large (small) events, and the large-event moment distribution broadens. The magnitude of the slip motion of the plates is well correlated with the root-mean-square displacements of the granular matter. Our results are consistent with mean field descriptions of statistical models of earthquakes and avalanches. We further explore the high-speed dynamics of system events and also discuss the effective granular friction of the sheared layer. We find that large events result from stored elastic energy in the plates in this coupled granular-continuum system.