Abstract Submitted
for the DFD13 Meeting of
The American Physical Society

Granular Impact: Predicting Dynamics with a Collisional Model[1]

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Granular impact, where a high-speed intruder strikes a granular material, occurs frequently in industrial and natural processes. Due in part to difficulty in obtaining sufficiently fast data at the grain scale, a complete description, which connects grain-scale processes to macroscopic dynamics of the intruder, is still lacking. Using photoelastic particles and a high speed camera, we perform experiments which allow us to capture the intruder dynamics and local granular force response at very fast time scales. This allows us to approach the problem both macroscopically, fitting the intruder dynamics to a fluid-like force law which is dominated by a velocity-squared drag force, and microscopically, where we observe large force fluctuations at small space and time scales. Thus, the intruder deceleration is not smooth and steady, but dominated by intermittent collisions with clusters of grains. Based on this, we present a simple collisional model which yields a shape-dependent velocity-squared drag force. Using experimental data, we show that this model captures the shape-dependence of the intruder deceleration and o-axis rotation well. This confirms the microscopic assumptions of this model, and may provide insight into other dense, driven granular flows.

[1]Supported by DTRA, grant HDTRA1- 10-0021

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Date submitted: 01 Aug 2013 Electronic form version 1.4