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Predicting dense granular flows: continuum modeling with a length-scale DAVID HENANN, KEN KAMRIN, MIT — Dense granular materials display a complicated set of flow properties, which differentiate them from ordinary fluids. In particular, slowly-flowing granular media form clear, experimentally-robust features; most notably, shear bands, which can have a variety of possible widths and which decay non-trivially into the surrounding quasi-rigid material. Despite the ubiquity of granular flows, no model has been developed that captures or predicts these complexities, posing an obstacle in industrial and geophysical applications. We present a three-dimensional constitutive model for well-developed, dense granular flows aimed at filling this need. The key ingredient of the theory is a grain-size-dependent nonlocal rheology – inspired by efforts for emulsions – in which flow at a point is affected by both the local stress as well as the flow in neighboring material. With a single new material parameter, we show that the model is able to quantitatively describe dense granular flows in an array of different geometries. Of particular importance, it is the first model to pass the stringent test of capturing all aspects of the highly-nontrivial flows observed in split-bottom cells – a geometry that has resisted modeling efforts for nearly a decade.

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