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Continuum modeling of secondary rheology in slow granular flows

DAVID HENANN, DAREN LIU, Brown Univ, KEN KAMRIN, MIT — Recent dense granular flow experiments have shown that shear deformation in one region of a granular medium fluidizes its entirety, including regions far from the sheared zone, effectively erasing the yield condition everywhere. This enables slow creep deformation to occur when an external force is applied to a probe in the nominally static regions of the material. The apparent change in rheology induced by far-away primary motion is termed the "secondary rheology" - a curious phenomenon that arises due to the cooperativity of slow granular flows. Recently, the new nonlocal granular fluidity (NGF) model was successfully used to predict a wide variety of steady granular flow fields. In this talk, we show that the NGF model is also capable of capturing secondary rheology. Specifically, we will demonstrate (i) the vanishing of the yield condition in the presence of primary flow, (ii) the rate-independent nature of secondary rheology for sufficiently slow primary flow rates, (iii) an exponential-type relationship between the force applied to the intruder and the consequent creep rate, and (iv) the anisotropy of secondary rheology, in which the observed phenomenology changes depending on whether the intruder is forced along with or counter to the primary flow.

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