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Prabhu Nott (Indian Institute of Science) ”The mechanics of disordered granular media in statics and flow: biased random walks to jamming-yielding dynamics”

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Disordered granular media, such as sand, mineral ores and food grains, exhibit features that are both solid-like and fluid-like. However, their mechanical response differs substantially from elastic solids and viscous fluids, due to the complexity of inter-grain interactions. In the static state, it is known that the stress depends strongly on how the grain assembly is created. In the flowing state, experiments show two contrasting rheological regimes, namely slow (quasistatic) and rapid (inertial) flow, for which the dependence of the stress on the shear rate are very different. We show that a combination of particle dynamics simulations and experiments throw light on the nature of stress transmission in static and flowing granular media, which lead to the development of closure or constitutive relations for the stress. We show that propagation of contact force in a static grain assembly under gravity can be thought of as a biased random walk. This helps us derive a simple closure relation for the macroscopic stress. For grains flowing in the slow flow regime, we show that deformation occurs via recurrent jamming-yielding dynamics, with the stress being elastic in the jammed phases and yielding occurring in short bursts. This findings lead to explanations for the rate independence of the stress and dilatancy, which are distinctive features of slow granular flow.