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Continuum modeling of diffusion and dispersion in dense granular flows[1] IVAN C. CHRISTOV, Theoretical Division & Center for Nonlinear Studies, Los Alamos National Laboratory, HOWARD A. STONE, Mechanical & Aerospace Engineering, Princeton University — Continuum modeling of granular flows remains a challenge of modern statistical physics. Granular materials do not perform Brownian motion, yet diffusion and shear dispersion can be observed in such systems when agitation causes inelastic collisions between particles. In a number of canonical flow regimes (e.g., in a rotating container or down an incline), granular materials can behave like fluids. We formulate and solve the granular counterparts to two basic fluid mechanics problems: diffusion of a pulse and shear dispersion of a pulse for dense granular materials in rapid flow. We provide a theory to account for the concentration-dependent diffusivity of bidisperse granular mixtures, and we give an asymptotic argument for the self-similar behavior of such a diffusion process for which an exact self-similar analytical solution does not exist. For shear dispersion, we show that the effective dispersivity of the depth-averaged concentration of the dispersing powder varies as the Péclet number squared, as in classical Taylor–Aris dispersion of molecular solutes. The calculation is extended to generic shear profiles, showing a significant enhancement for convex profiles due to the shear-rate dependence of the diffusivity of granular materials.

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