The Manifold Rheology of Agitated Granular Media
Part I

Olfa D'Angelo
Friedrich Alexander Universitat (Germany)

Agitated granular media have a rich rheology: they exhibit Newtonian behavior at low shear rate and density, develop a yield stress at high density, and cross over to Bagnoldian shear thickening when sheared rapidly--making them challenging to encompass in one theoretical framework. We measure the rheology of air-fluidized glass particles, spanning five orders of magnitude in shear rate. We show that all rheological regimes can be delineated by two dimensionless numbers: the Peclet number, Pe, and the ratio of shear-to-fluidization-power, Π. By comparing fluidization-induced to Brownian agitation, we propose a constitutive relation based on Mode Coupling Theory (MCT). The Granular Integration Through Transient (GITT) model qualitatively predicts the rheological regimes observed; when taking into account shear banding, GITT also quantitatively captures our results over seven orders of magnitude in shear rate, encompassing all flow behaviors in one unified framework.

References
O. D'Angelo, M. Sperl, W.T. Kranz, Rheological Regimes in Agitated Granular Media under Shear, PRL (2025) In print

W.T. Kranz, F. Frahsa, A. Zippelius, M. Fuchs, M. Sperl, Rheology of inelastic hard spheres at finite density and shear rate, PRL 121, 148002 (2018).

O. D'Angelo, A. Shetty, D. Schütz, M. Sperl, W.T. Kranz, The manifold rheology of fluidized granular media (2025). Preprint available [arXiv: 2309.00413].