Constitutive law for dense agitated granular flows: from theoretical description to rheology experiment

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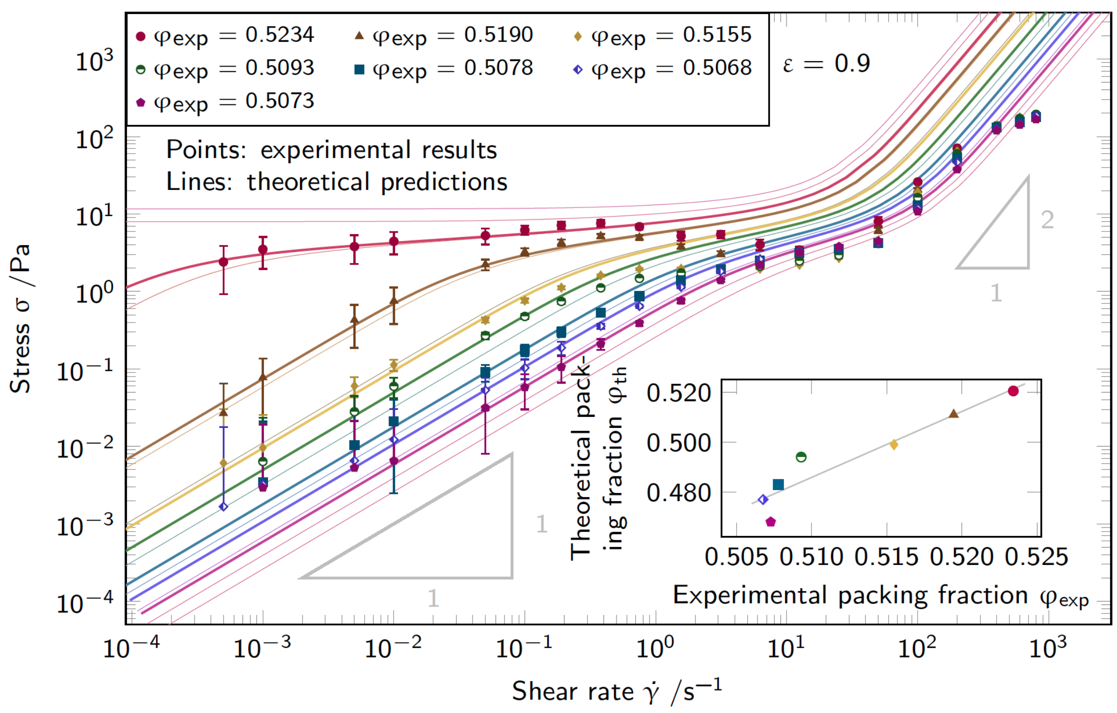
The variety in granular materials’ behaviour makes them a fascinatingly counterintuitive material, but also one that is difficult to encompass into a globalised theory. Recently, Kranz et al. described granular fluids close to the glass transition using mode coupling theory (MCT), and extended this theory towards the non-linear rheology of such granular fluids submitted to shear at finite shear rates [1]. This approach allows to embrace in a single theoretical framework the variety of rheological responses observed in dense granular fluids, as it predicts and delineates rheological regimes comprising Newtonian, shear thinning, and shear thickening (Bagnoldian).

We provide the first experimental validation of this theory [2], through flow curves spanning six orders of magnitude in shear rate, and over a wide range of packing fractions. As we uncover the predicted rheological regimes in an air-fluidised granular bed of glass beads, we explore the areas of uncertainties in comparing our careful measurements to the theory. Experimental results and theory compare very favourably; besides the predicted regimes, experiments reveal an additional regime at high Peclet number where the Bagnold scaling is lost.



[1] W. T. Kranz, F. Frahsa, A. Zippelius, M. Fuchs, and M. Sperl, “Integration through transients for inelastic hard sphere fluids,” Physical Review Fluids, vol. 5, p. 024305, 2020.

[2] O. D’Angelo, A. Shetty, M. Sperl, and W. T. Kranz, “Constitutive law for dense agitated granular flows: from theoretical description to rheology experiment,” 2022, in preparation.