

Pressure-imposed flows of model granular suspensions

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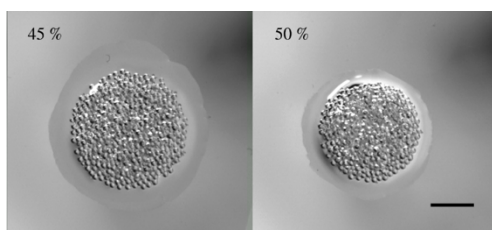
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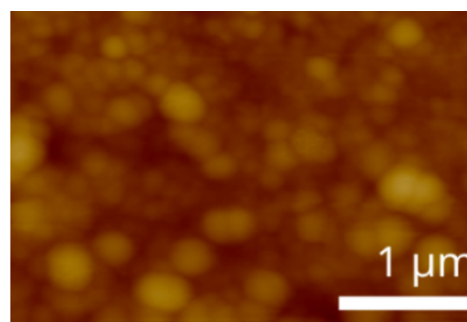
Keywords: granular matter, non-Brownian suspensions, contact physics, fluid mechanics, experiments, instrumentation.



MSC's pressure-imposed rheology tool



Two examples of suspension heap formation well below the critical particle volume fraction $\phi_c \approx 58\%$



Adhesion-inducing polymer phase separation at the surface of a MSC-SIMM particle viewed with AFM.

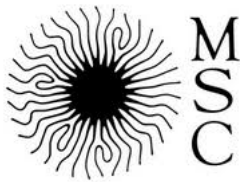
Scientific description: Non-Brownian suspensions such as concrete or mud are common materials in our daily life. Despite a long history, the physics of these complex fluids is still not completely understood, in particular in the high-particle-volume-fraction regime, where interparticle contacts play a significant role. This is in part due to the lack of model suspensions offering extensive control over these interactions and to the difficulty of measuring accurately the mechanical properties of these materials up to the critical particle volume fraction ϕ_c at which jamming occurs.

In collaboration with Nicolas Sanson at SIMM (ESPCI), our group at MSC has set up a simple process to obtain stimuli-sensitive non-Brownian particles in large quantities that can be then dispersed in a variety of solvents [1,2]. The resulting suspensions display frictionless properties in the rotating drum, a device designed to measure friction coefficients. Further investigation demonstrated that the apparent friction coefficient, as well as the adhesive interaction, can be adjusted finely by changing the physico-chemical properties of the suspending liquid, turning suspensions into increasingly more frictional materials.

The goal of this Master 2 internship is to start investigating the pressure-imposed rheology (PIR) of suspensions [3,4], a state-of-the-art method to characterize quantitatively suspensions up to ϕ_c (left image), with the PIR tool currently developed at MSC. Work will revolve around the characterization of the mechanical response of model suspensions developed between MSC and SIMM under imposed pressure. In particular we will focus on frictionless suspensions, as their response to flow is still essentially unknown. Theoretical propositions exist in the literature to which the data will be compared.

This project will be carried out in collaboration with Nicolas Sanson, Jean Comtet and Bruno Bresson at SIMM (ESPCI) who will synthesize the particles and characterize their surfaces with atomic force microscopy (right image), a technique the candidate will become familiar with.

We are looking for an excellent student with a strong interest in experiments and instrumentation and an excellent background in physics; a background in chemistry is appreciated



but not required. The topic offers opportunities for theoretical modelling with the prospect of establishing rigorously a constitutive law for concentrated non-Brownian suspensions accounting for interparticle interactions. As the project is supported by an ANR grant, we offer an opportunity to pursue a PhD, subject to the smooth progress of the internship. The MSC and SIMM groups have been collaborating for the past five years and already supervised together a PhD [1,2].

Techniques and methods: pressure-imposed rheology, rotating drum, fluorescence microscopy, AFM, modeling

Funding: yes

References

- [1] L. Blaiset, Model Suspensions of Functionalized Particles: An Experimental Study on the Impact of Microscopic Properties on Macroscopic Rheological Properties, Université Paris Cité, 2023.
- [2] L. Blaiset, B. Bresson, L. Olanier, É. Guazzelli, M. Roché, and N. Sanson, *Soft Matter* **20**, 5447 (2024).
- [3] F. Boyer, É. Guazzelli, and O. Pouliquen, *Phys. Rev. Lett.* **107**, 188301 (2011).
- [4] F. Tapia, O. Pouliquen, and É. Guazzelli, *Phys. Rev. Fluids* **4**, 104302 (2019).