Lecture day GFR 2024 at IUSTI Laboratory

3 lectures to sum-up the progresses made over the last 10 years in the description of dense granular suspensions. Particular focus will be made on the role of microscopic interactions between particles (friction, adhesion, repulsive forces, …), underlining their primary importance in determining the macroscopic rheological behavior of these systems.

Tuesday 22th (at IUSTI Laboratory)

11:00

Jean Comtet (CNRS, ESPCI Paris)

Dense suspensions at the microscopic scale: characterizing and controlling interparticle interactions

In their concentrated regime, dense suspensions of particles can show a range of fascinating and exotic rheological behaviors. Inter-particle interactions at the microscopic scale - associated to friction, adhesion, rolling resistance... - are expected to play a predominant role on these peculiar macroscopic rheological properties. These microscopic interactions remain however poorly characterized at the nanoscale, as well as their precise relations with macroscopic rheology. In this lecture, I will present and discuss recent experimental efforts aiming at both characterizing and controlling these local interactions at the particle scale. I will show how these novel microscopic approaches build upon the development of advanced instrumentation for the measurement of nanoscale interactions at the particle scale combined with creative physico-chemical surface engineering, and will discuss their recent success, limitations and prospects.

12:30

Lunch Break

2:00

Francisco Melo da Rocha (IUSTI, Marseille)

Rheology of dense granular suspensions from microscopic considerations

Granular suspensions are widely observed in various geophysical and industrial processes. In the dense regime, contact dynamics play a crucial role in the macroscopic rheology, yielding a variety of complex behaviours. Over the past two decades, significant progress has been made in connecting microscopic interactions to macroscopic emergent phenomena, primarily by studying model granular suspensions with tunable interparticle properties. This lecture will summarise some of these recent advances, focusing on approaches that treat the suspension as a single effective fluid. To set the scene, we will first discuss the simplest case of non-Brownian granular suspensions, for which the effective viscosity is a function only of the particle volume fraction ϕ, which diverges at the jamming fraction ϕc. We will discuss the difference between volume- and pressure-imposed methods for measuring the suspension viscosity and how these approaches give equivalent constitutive laws. In the second part, we will see how introducing more complex interparticle interactions may induce a stress dependence on ϕc, dramatically impacting the macroscopic rheology. Here, we will focus on two specific macroscopic phenomena: shear thinning and thickening. First, we will discuss how particle roughness and adhesion may increase ϕc with increasing pressure to generate shear-thinning behaviour. Then, we will turn to shear-thickening suspensions, discussing the frictional transition model, new methods to probe their constitutive laws, and how these peculiar flow rules can explain the emergence of new hydrodynamic instabilities.

3:30

4:00

François Peters (InPhyNi, Nice)

What simulations tell us about granular suspension rheology?

Much progress has been made in the understanding of non-Brownian particulate suspension rheology in creeping flow since the 1980s, especially in the high concentration range. This has been made possible by considerable experimental and theoretical effort, but also due to the development of effective numerical simulation methods, which allow to probe the influence of specific mechanisms and make available relevant quantities, some of which are difficult or impossible to obtain from experiments, thereby clarifying some experimental measurement or theoretical concepts. The present course provides an overview of the rheology of granular suspensions as seen through the prism of numerical simulations. The main relevant physical mechanisms at play, mainly hydrodynamic interactions and contact forces, will be reviewed, as well as the various numerical methods allowing to account for them in the simulations. Some important issues will be addressed. How to extract rheological quantities from the simulations, such as the different contributions to the suspension stress? How to validate a numerical method, considering for instance very dilute suspensions (meaning a few particles). Then the journey will take us over a wide range of volume fraction and particle interactions, in various homogeneous and non-homogeneous flows.

5:30

Visit of the SOFT group experiments at IUSTI Laboratory

(https://iusti.cnrs.fr/research/axe-mdfc/)

6:30

Access:
-count 35 minutes from Vieux port
-Take Metro 1 until terminus La Rose,
-Take bus B3B until the third stop Polytech Marseille.
-The laboratory IUSTI is across the street from the bus stop
-follow the signs.

Organizing Committee:
B. Metzger, L. Bergougnoux, O. Pouliquen, F. M. da Rocha, L. Tiran (IUSTI Marseille), S. Tlili (IBDM Marseille), S. Gsell (IRPHE Marseille), R. Castellani (Mines Paris).

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