M2+PhD position

Physics of shear-thickening suspensions: from rheology to flow instabilities

Supervision: Bloen Metzger (CR1 CNRS) and Yoel Forterre (DR2 CNRS).
Location: Laboratory IUSTI-CNRS UMR 7343 Marseille, France.
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Collaborations: M Wyart (EPFL Switzerland), R. Mari (LiPhy Grenoble).

Shear-thickenning is one of the most spectacular phenomenon observed in complex fluids. It occurs in suspensions whose viscosity dramatically increases when the imposed shear-rate exceeds a critical value. The archetype of such suspensions is grains of cornstarch immersed in water, which exhibit fascinating behavior as illustrated by many youtube movies [1]. Understanding and modeling the flow of shear thickening suspensions is crucial for a very broad range of applications, ranging from modern concrete to smart dampers that rigidify under an impact for sport and medical protections.

For long considered as a puzzle, the physical origin of shear-thickening only starts to be understood. Recent theoretical and experimental studies suggest that shear-thickening arises from the activation of microscopic friction between particles, above a critical stress needed to overcome short-range repulsive forces [2-4]. Yet, testing this scenario and probing the rheology of shear thickening suspension is very challenging since standard approaches do not give access to the frictional behavior of the suspension, which is the key quantity.

Recently, we have started to develop new approaches inspired by the physics of granular flows to characterize the flow of shear-thickening suspensions [3]. The goal of this PhD is to go beyond this work and develop a new concept of rheometer: the Capilarytron (Figure 1b). By imposing the pressure acting on the grains using the capillary interface (instead of imposing the volume fraction as in standard rheology), we should be able to access the frictional property of the suspension and establish for the first time the full constitutive laws of shear-thickening fluids. The results will then be used to tackle the flow instabilities observed in more complex configurations, like flow down inclined planes (figure 1 c).

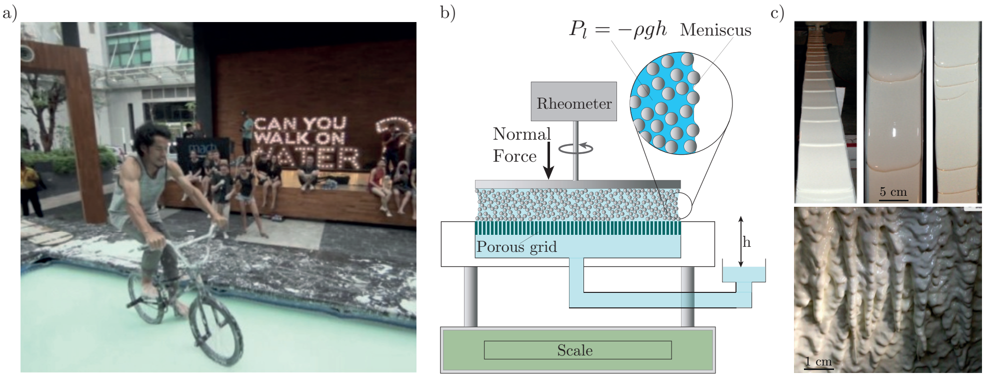

Figure 1: a) Pool filled with cornstarch, b) Capilarytron. c) Surface instabilities with cornstarch.

The work will be mostly experimental involving advanced rheological (pressure imposed) and imaging (index matching, laser induced fluorescence, PIV) technics. It will be performed at IUSTI in the Particulate Flow Group with Yoel Forterre and Bloen Metzger. This PhD is funded by the ANR project ScienceFriction which also comprises theoretical and numerical approaches in collaboration with M. Wyart at EPFL, Switzerland, and with R. Mari at LiPhy, Grenoble. Two other post-docs will be hired within the same project to work on flow instabilities and to perform numerical simulations. We thus expect strong interactions and constructive collaborations with also travel possibilities in the other groups. Candidates with a background in Physics are welcome to send us a CV.

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Refs: [**1**] http://www.youtube.com/watch?v=BleCJJAKkgw. [**2**] M. Wyart and M. E. Cates. Phys. Rev. Lett., 112, 098302, (2014). [**3**] C. Clavaud, A. Bérut, B. Metzger, and Y. Forterre. Proc. Nat. Acad. Sci., 114, (2017). [**4**] R. Mari, R. Seto, J. F. Morris, and M. M. Denn. Journal of Rheology, 58, (2014).