PhD Project

Dynamics of Dense Suspensions

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Suspensions are common materials found in diverse applications from cosmetics (toothpaste), food products (coffee), to construction materials (cement) or even geophysical fluids (sludge). They are known to exhibit a wide variety of rheological behaviors under flow. In particular, at high volume fraction, dense suspensions show a shear-thickening regime, i.e. a reversible increase of the viscosity with the shear rate (Figure 1a). Such rheological properties affect dramatically the ability of complex fluids to flow. The formulation of many industrial suspensions is thus limited by the challenging mixing of dense suspensions due to the emergence of a yield stress and the shear-thickening observed at high volume fraction. In particular, the impossibility to mix a concentrated concrete suspension limits the mechanical performance of construction materials optimized for a maximum concentration of particles. By tracking the local deformation and structure within a dense suspension under shear, the project aims to determine the flowing conditions of complex materials for construction to reduce the energetic cost necessary to make them flow.

The objective of the PhD is to rationalize the dynamical and structural response of dense suspensions under shear and to prototype shear-thickening materials able to flow and/or solidify upon an external stimulus. By coupling PIV measurements and scattering techniques in a transparent suspension of fumed silica particles (Figure 1b), we will relate the local deformation of dense suspensions to its microscopic structure. The expected results will contribute to solve practical questions such as industrial or geophysical complex flows, or even the puzzling run of a person over a bath filled with a shear-thickening fluid (Figure 1c).

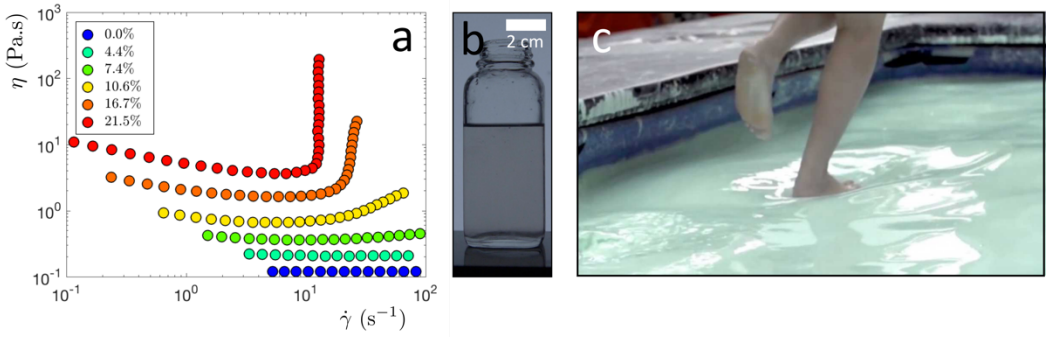

Figure 1: Shear-thickening suspensions. **a)** Flow curves of dense suspensions of fumed silica. At large volume fraction, the viscosity diverges at a finite shear-rate. **b)** Transparent suspension of fumed silica particles. **c)** While a walking person sinks into a liquid-like pool filled by a dense suspension, a faster solicitation transforms the shear-thickening fluid into a solid allowing a person to run on it.

The applicant should be interested in experiments, fluid mechanics and soft matter. The PhD will take place at PMMH (ESPCI Paris) in close collaboration with C3M, and will lead to international collaborations. The funding is provided by the Région Île-de-France (DIM MaTerRE). The PhD will start before December 2024. Feel free to contact Philippe Bourrianne (philippe.bourrianne@espci.fr) for more information.