

Master 2 internship proposal

Physique et Mécanique des Milieux Hétérogènes

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When liquids stiffen solids

Composite materials combining architected soft solids and complex fluids offer a versatile platform to engineer mechanical properties through fluid-structure coupling. In such materials, a complex fluid is infused within a porous or cellular soft solid, whose geometry can be tailored to control the overall mechanical response. These composites can exhibit enhanced stiffness, energy absorption and impact resistance while retaining the tunability of architected materials [1]. This interplay is particularly rich under dynamic loading, as deformation of the architecture modifies local flow conditions and, in turn, the mechanical response of the fluid. Shear-thickening suspensions are a striking example, exhibiting a rapid and reversible increase in viscosity under shear [2] (Fig. 1a) due to the formation of frictional contacts between particles, enabling spectacular phenomena such as running across a bath of cornstarch suspension (Fig. 1b). When infused into 3D-printed soft solid foams (Fig. 1c), these suspensions couple shear-induced solidification with the architecture, strongly reinforcing the composite upon impact. By varying the fluid rheology and solid geometry, we aim to design adaptive materials with tunable stiffness and energy absorption, while elucidating the transient mechanisms governing their mechanical response.

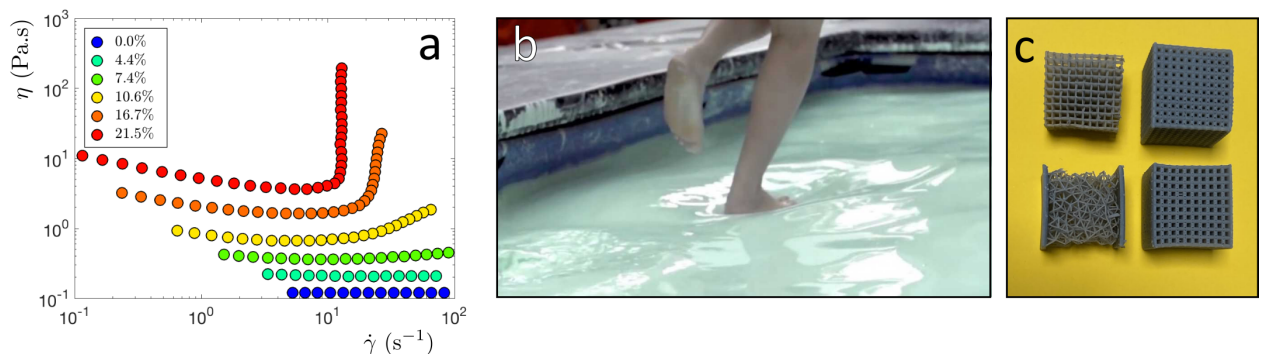


Figure 1: (a) Shear-thickening denotes a rapid increase of viscosity η as function of shear-rate $\dot{\gamma}$ (from [2]). (b) A person can run over a bath of cornstarch and water mixtures exhibiting shear-thickening. (c) 3D-printed solid foams of different architectures.

References:

- [1] S.M. Livermore, **A. Pelosse**, M. van der Naald, H. Kim, S. Atis and H.M. Jaeger, Shear thickening inside elastic open-cell foams under dynamic compression. *Soft Matter* (2025).
- [2] **P. Bourrianne**, V. Niggel, G. Polly, T. Divoux and G.H. McKinley, Tuning the shear thickening of suspensions through surface roughness and physico-chemical interactions. *Physical Review Research* (2022).

The applicant should have interests in fluid/solid mechanics and soft matter.
Possibility to pursue in PhD on the topic.