Master 2 internship proposal

Physique et Mécanique des Milieux Hétérogènes

Contact: Virgile Thiévenaz/ @: virgile.thievenaz@espci.fr / Web: **https://www.vthievenaz.fr**
Internship location: barre Cassan A, campus Jussieu, 7 Quai Saint Bernard, 75005 Paris

Stretching and relaxation of polymer solutions

Many natural or industrial fluids contain polymers in solution. In a flow, the solvent will impose stress on these polymers, which may adapt by changing conformation, by stretching, by moving, etc; this evolving microstructure retroacts onto the flow and gives it non-Newtonian properties; the different time scales involved at the microscopic level are key to understanding and modelling the flow. When a drop of polymer solution detaches, the stress acting on the neck that binds the drop to the rest of the liquid increases dramatically. The solution initially behaves like a Newtonian fluid; when the neck is too thin it becomes viscoelastic [1]. The viscoelastic properties appears through the formation of a long thread in which polymer chains are strongly stretched (Fig. 1). The transition between the two regimes has recently been shown to be remarkably universal: it does not depend on solvent viscosity nor polymer concentration nor molar weight [3]. Moreover, the time scale of the transition is quite different from the usual relaxation time of the polymer and follows different power laws. This particular result raises questions regarding which relaxation time is relevant in the modelling of polymer solutions, and how it can be measured.

The internship goal is to explore experimentally the spectrum of relaxation times in original configurations. The experimental work will consist in high-speed imaging of capillary flows and rheological measurements.

Figure 1: Extension, thinning and pinch-off of a droplet of aqueous solution of polyethylene oxide (PEO). The nozzle is 2.75mm-wide.

References

[1] Y. Amarouchene, D. Bonn, J. Meunier & H. Kellay, Phys. Rev. Letters 86, 16, pp3558–3561 (2001)
[2] V. Thiévenaz & A. Sauret, Phys. Rev. Fluids 6, L062301 (2021)
[3] S. Rajesh, V. Thiévenaz & A. Sauret, Soft Matter 18, pp3147-3156 (2022)

Expected skills: The applicant should have interest in physics, fluid mechanics and experimental work. Interest in chemistry and polymer science is appreciable but not essential.