INTERNSHIP PROPOSAL

Laboratory name: Institut Jean le Rond ∂'Alembert, Jussieu / LadHyX, Ecole Polytechnique
CNRS identification code: UMR 7190 / UMR 7646
Internship director'surname: Suzie PROTIERE, Camille DUPRAT,
e-mail: protiere@ida.upmc.fr, camille.duprat@polytechnique.edu
Thesis possibility after internship: YES

NON-NEWTONIAN AND ELASTO-CAPILLARY EFFECTS IN TEXTILES

The goal of the internship (and thesis) is to understand and characterize the interaction of a model fibrous material (network, torsion, elasticity) and a liquid (imbibition, drying, swelling, complex fluid).

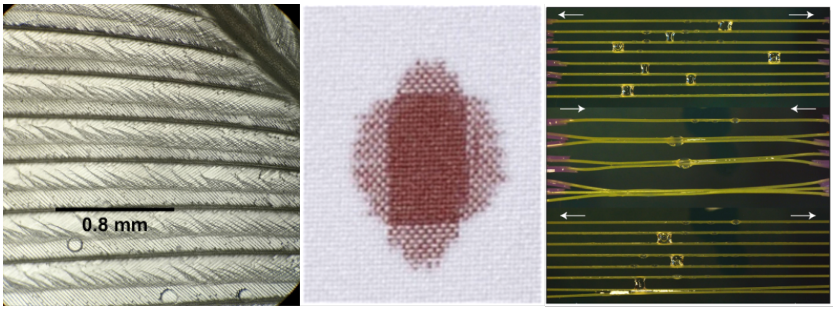

Figure: Oil on a bird feather, blood stain on a fabric, drops on an array of parallel fibers

Textiles, i.e. woven or non-woven assemblies of natural or synthetic fibers, are ubiquitous in various applications (clothing, paper making, construction, energy, filtration, medicine) but also in many natural systems, such as collagen networks, bird feathers or wall plants. There is an increased effort to use new materials, e.g. replace cotton (whose production has large negative environmental impacts) with different cellulosic materials such as viscose, or use local vegetal fibres such as flax or hemp as a replacement for synthetic fibres. Indeed, fibrous materials made from natural fibres, such as wood-fibre, flax or straw, that are locally produced, readily available, biosourced materials, have important advantages regarding biodegradability, recyclability and renewability in comparison to fossil-based plastics. In particular, the interaction of fibrous materials with liquids (through adsorption, wetting, drying, imbibition) is a very common yet complex phenomenon which remains poorly understood. During imbibition, drainage or drying, many liquid-interface appear; the capillary forces associated with these interfaces can locally deform adjacent fibres. These **elasto-capillary** effects play a role in the fibers adhesion or in the wetting dynamics. Moreover many liquids, in industrial or natural systems are non-newtonian (saliva, glue, resin, blood, paint, soap etc.). In particular, many recent studies in forensic science have tried to infer information by looking at blood spatter stains on textiles, which require to understand the complex wicking dynamics of blood within the textile after impact (figure 1 center). In many processes, such as in glass wool manufacturing processes, drops of resin are sprayed on fibres in order to form junctions between the fibres and give mechanical strength. Finally, many of these complex fluids are suspensions or emulsions, i.e. contains two components. The effect of these properties on the elastocapillary phenomena have not yet been studied.
During the internship, we will first focus on the simpler case of a drop placed between two rigid or flexible fibres. In particular, we will investigate the effect of the rheological properties on the dynamics of spreading and retracting of drops, as well as the evaporation dynamics. Depending on the student's interest, different fluids may be investigated: a **suspension** to see how the concentration in particles will affect the wicking dynamics, the adhesion of the fibers or the evaporation rate of the liquid, an **emulsion** (e.g. water/oil) where part of the liquid is volatile/non wetting and the other is non volatile/ wetting, or a model **non-newtonian fluid**, e.g. viscoelastic solutions of polymers.

The work will be mostly experimental. From these results, we will look for simple theoretical models.
The internship is part of a collaboration between LadHyX at École Polytechnique and Institut Jean le Rond ∂'Alembert (Sorbonne Université, Site Jussieu). The internship can be continued with a PhD thesis between Polytechnique and Jussieu.