Research Topic for the ParisTech/CSC PhD Program

Subfield: Mechanical Engineering, polymer science

ParisTech School: ESPCI Paris

Title: Poroelasticity and non-linearities in the wetting of gels

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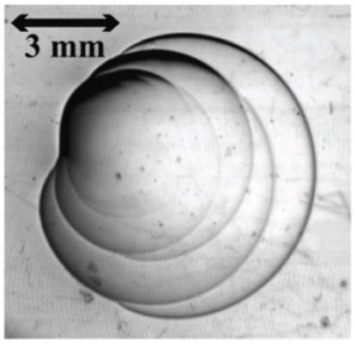
Short description of possible research topics for a PhD:
Crosslinked polymer networks, including rubbers, elastomers, hydrogels swollen in water, are important soft matters which attract industrial and academic interests. These gels find many uses in fluid handling applications (heterogeneous nucleation, inkjet printing...) thanks to the broad range of their mechanical and physico-chemical properties. The wetting of gels is still not well understood, as it is very complex phenomenon due to the deformability of the gels: not only the surface tensions but also viscoelasticity of the gels can play a role in the force balance at the contact line. Recently, we rationalized thickness effects on both elastowetting statics and dynamics by coupling experiments and theory. Nonetheless, important findings of these studies such as long-lived ridges after contact line motion (see figure) still elude our understanding; they are likely signatures of non-viscoelastic mechanics, such as poroelasticity (migration of the solvent at the deformed region of the gels).



We have a collection of reliable experimental techniques (high-speed microscopy, surface profilometry...), material design protocols (silicone elastomers and dissipative dynamic hydrogels) and proven theoretical tools (dual integral equations, Green functions) available. We want to extend our understanding of elastowetting to include the rheological complexity of soft materials by using model solid/liquid systems that we will discuss with our theoretical tools. *During this PhD, the candidate will explore the relation between poroelasticity, ridge growth and relaxation, test how the timescales associated with various rheological responses affect wetting dynamics and investigate wetting when gel displacements are much larger than sample thickness.*

Required background of the student: The proposed thesis will be supervised in a close collaboration of the two laboratories. The “soft matter science and engineering” laboratory in ESPCI for polymer physical chemistry and physics, and the laboratory for “complex matter and system” in Paris Diderot Universty for hydrodynamics and theoretical physics. A candidate from any of these fields is appreciated.

A list of 5 (max.) representative publications of the group:

1. Kajiya, T. *et al.* Dynamics of the contact line in wetting and diffusing processes of water droplets on hydrogel (PAMPS-PAAM) substrates. *Soft Matter* **7,** 11425 (2011).
2. Kajiya, T. *et al.* Advancing liquid contact line on visco-elastic gel substrates: stick-slip vs. continuous motions. *Soft Matter* 454–461 (2013).
3. Dervaux, J. & Limat, L. Contact lines on soft solids with uniform surface tension : analytical solutions and double transition for increasing deformability. *Proc. R. Soc. A* **471,** 20140813 (2015).
4. M. Zhao *et al.*, Geometrical control of dissipation during the spreading of liquids on soft solids, under review
5. M. Zhao *et al.*, Growth and relaxation of a ridge on a soft poroelastic substrate, under review