Internship / thesis offer

Bubble fronts in tree-like structures

Keywords. Condensed & soft matter physics, biophysics, plant physiology, nucleation, metastability, micro/nano-fluidics, porous media, thermodynamics, optics, environment, water.

CONTEXT

When plant tissues are subjected to **dry conditions**, bubbles can spontaneously form in the **complex vascular network of trees** (xylem) conducting water, resulting in the embolism of these tissues (Fig. a-b). With **climate change**, it is thought that such events will occur more frequently and threaten the survival of forests and crops. However, the **physics of the appearance, growth, and propagation of the bubbles in xylem** (which combines microscale vessels, variations in wettability, and random, nanoscale membranes) is still poorly understood. With a combination of numerical simulations and experiments, we aim at establishing the general features of bubble propagation in xylem-like structures, and how the nonlinear coupling between several mechanisms (stochastic bubble nucleation, diffusion-limited growth, capillary breakthrough, poroelastic relaxations, osmotic phenomena, etc.) dictate the dynamics and patterns of gas invasion in disordered structures.

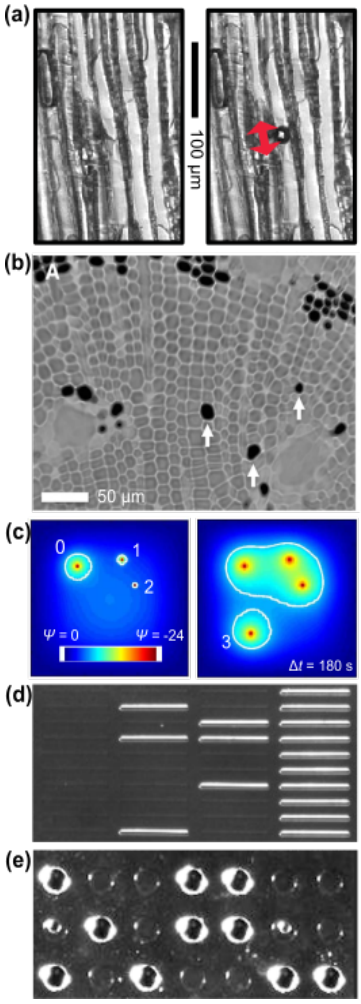
PROJECT

We pursue two complementary parallel directions (modelling and experiments) and are looking for a motivated student to contribute in one or both aspects.

1) **Modeling.** With an in-house code, we will model vascular network as interconnected cells with random connections, and investigate front propagation with various physical mechanisms. The bubble kinetics will be coupled to global poroelastic fluctuations in the pressure / water potential field (Fig. c).

2) **Experiments.** We have platforms to fabricate xylem-like structures (combining micro and nano scales) with precise designs and optical access (Fig. d-e). We will conduct experiments by filling and drying these structures, and compare the results to numerical simulations and to real-world data obtained in the field.

These studies can be extended to look at the effect of solute concentration and/or freezing/thawing, which are processes relevant to plant physiology applications. In addition, the experimental biomimetic devices have potential applications as actuators, sensors or as energy conversion platforms, and the project will investigate these applications in the longer term.



(a-b) Nucleation of bubbles in plant tissue, (c) Simulation of nucleation and interaction of bubbles, (d-e) Bubbles in artificial trees of different geometries

ENVIRONMENT

The internship will take place in the *Liquids and Interfaces* team of the Institut Lumière Matière (ILM), a joint laboratory of CNRS and the University of Lyon 1 (Lyon, France). The group has international recognition in the domain of the physics of liquids, soft matter and their interaction with surfaces, from macro to nano scales. For this project, we will also collaborate with plant physiologists in France, Finland and Germany, among others. Continuation into PhD program is possible and welcome.

CONTACT

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