TREES DRYING FROM THE INSIDE: PHYSICS OF BUBBLE PROPAGATION

LABORATORY : Institut Lumière Matière

TEAM(S) : LIQ@INT

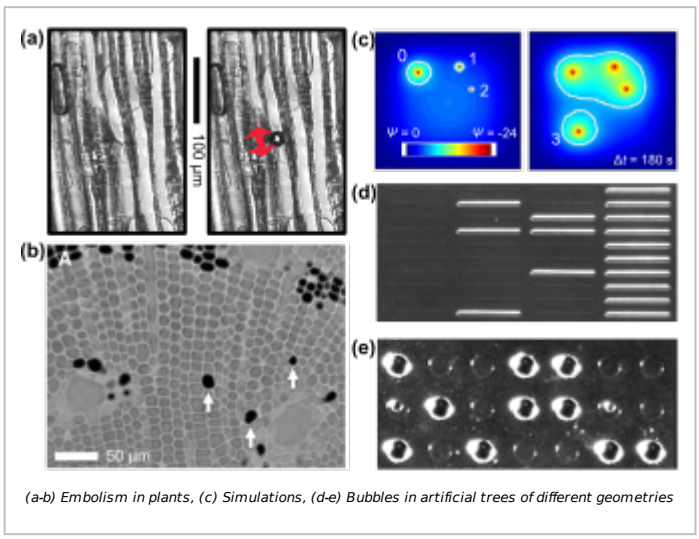
CONTACT(S) : VINCENT Olivier

CONTACT(S) DETAILS: olivier.vincent[at]univ-lyon1.fr / Tel. 0472448070

KEYWORD(S) : Water / Plants / Nucleation

SCIENTIFIC 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, and poroelastic relaxations, among others) dictate the dynamics and patterns of gas invasion.



(a-b) Embolism in plants, (c) Simulations, (d-e) Bubbles in artificial trees of different geometries

MISSIONS :

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 the difference between front propagation due to nucleation or to bubble breakthrough. The nucleation/breakthrough kinetics will be coupled to global 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.

For this project, we will also **collaborate with plant physiologists** in France, Finland and Germany, among others.

OUTLOOKS :

Continuation into PhD program is possible and welcome.

published on 19/10/2023