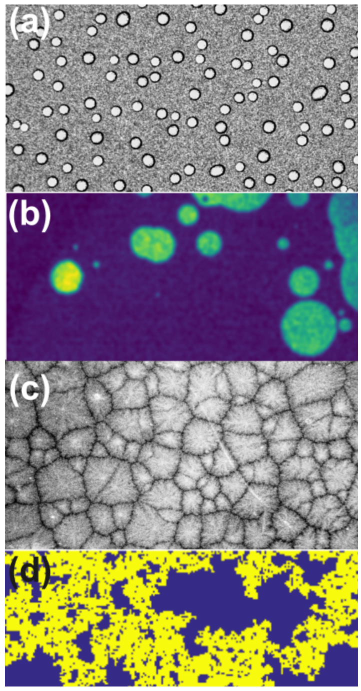
Research Internships (M1-M2)

How salt-infused nanosponges respond to humidity changes

Keywords. Condensed & soft matter, surface and capillary phenomena, micro/nano-fluidics, droplets, crystals, nucleation, percolation, porous media, optics, environment, salt, water.

CONTEXT

We are interested in **fundamental physics** problems that are relevant in various **important societal and engineering contexts**. In particular, we study how evaporation and condensation of salty water happens in complex systems, triggered by variations in external humidity. These phenomena are crucial for e.g. **water harvesting** in dry climates, **cloud formation** in the atmosphere, new strategies for **energy production/conversion**, smart optical/mechanical **metamaterials**, sustainable architecture and **heritage conservation**, etc. but raise basic, unexplored question with rich physics. Recently, we have successfully characterized and described how the interaction between condensation/evaporation and capillary/osmotic phenomena dictate the equilibrium states of salt solutions confined in single nanopores. Now we are investigating **larger scale phenomena** in extended systems formed of many interacting pores (formation of arrays of microdroplets, stochastic nucleation patterns) and are trying to understand how they **emerge from the behavior in single nanopores**.



(a) Spontaneous microdroplet formation *[scale ~1mm]*. **(b)** Nucleation and growth of crystals *[~1mm]*. **(c)** Final crystallization pattern *[~1mm]*. **(d)** Monte Carlo simulations of phase percolation in random networks *[~100nm]*.

PROJECTS

We are pursuing several investigations that combine **experiments and modeling**. We are looking for a motivated student to contribute within our team making progress in one (or several) of these directions:

1) *[Experiments]* **Spontaneous formation of microdroplet arrays** at the surface of nanoporous media (high humidity, Fig. (a)): what dictates the typical size and spacing of these patterns?

2) *[Experiments]* Characterize the **stochastic nucleation, growth dynamics, and final patterns** of salt deposits that appear from the supersaturated solution at low humidity (Fig. (b-c)).

3) *[Simulations]* **Invasion/percolation patterns** induced by the evaporation/condensation of water with continuously evolving salt content in disordered pore networks (Fig. (d)).

These investigations will use a combination of **optical techniques** (microscopy, image analysis, interferometry etc.), homemade high-precision **environmentally controlled cells**, **numerical simulations** (Monte Carlo), and theoretical **(analytical/scaling) approaches**. Knowledge of Python and proficiency in English will be appreciated.

ENVIRONMENT & SUPPORT

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, at scales spanning macro to nano. The project is supported by grants from Agence Nationale de la Recherche (ANR) and the European Union (FET-Open), and by various international collaborations. Continuation into PhD program is possible and welcome.

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