SCIENCES SORBONNE UNIVERSITÉ

2024-2025

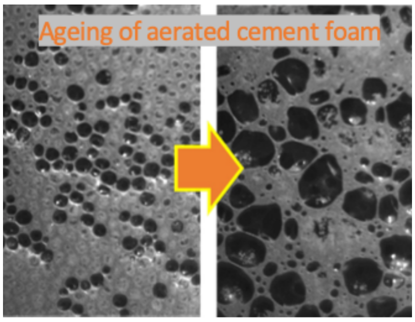
Master thesis proposal

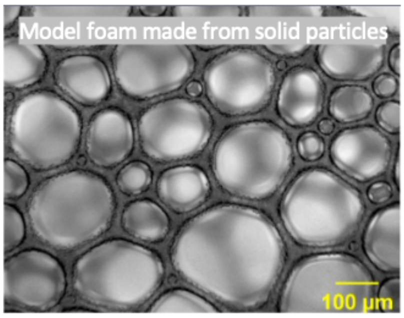
Campus Pierre et Marie Curie
Tower 23 – 3rd floor – 23-22
Director: Massimiliano Marangolo

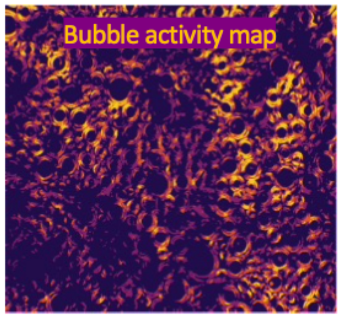
Title: **Coarsening of liquid foam made from solid particles**

Keywords: Experiments, Soft condensed matter physics, Fluid mechanics, Microfluidics

Scientific description: Liquid foams play a crucial role in the ecological and energy transition. With their excellent thermal insulation properties, they enhance the energy efficiency of buildings and infrastructures (see left image below). In the field of flotation, foams enable the separation of finely divided materials, a process particularly used for treating contaminated soils. Additionally, new processes are emerging, leveraging the properties of foams for extracting precious metal particles from recycled electronic devices (urban mining), thus promoting a more sustainable management of resources and urban waste. The presence of solid particles within liquid foams, possibly in high concentration, raises several fundamental questions, the most general one being: can a liquid foam be stabilized using the particles it contains? Indeed, it is well known that simple liquid foam ages[1] through various processes, with coarsening being particularly difficult to counteract: can this be achieved by incorporating particles of a specific concentration and size? This fundamental question forms the main focus of the internship we are offering. It will be addressed by investigations of the ageing of highly model systems made of surfactant foams laden with solid spherical particles packed between the bubbles (see central image below). A possible outcome to this research lies in its application to the stabilization of liquid foams precursor of aerated materials, whose microstructures are directly altered by coarsening before material solidification.







The experimental study will be based on the foaming of a particle suspension thanks to micro- or milli-fluidic devices using technics already tested in our labs. Coarsening will be investigated using videomicroscopy of the sample surface. The image in the right shows an example of a so-called activity map determined by image processing using segmentation and tracking machine learning tools. The map highlights bubble rearrangements that accompany coarsening and occur on relatively short time scales. It is particularly expected that their frequency will decrease and eventually cease when coarsening is being arrested by the particles. Other methods, based on multiple light scattering, will provide additional information on these aspects. The results obtained for various particles sizes and concentrations will be interpreted in terms of rheology of the particle suspension confined between the bubbles.

[1] "Foam: Structure and Dynamics", Cantat, Cohen-Addad, Pitois, et al., Oxford University Press (2013)

Techniques/methods in use: Microfluidic, videomicroscopy, light scattering. Data and image analysis.

Applicant skills: Background in condensed matter physics, or material science (physics/chemistry) or fluid mechanics. A taste in experimental work is expected.

Learning outcomes: Scientific and lab work management. Physics of soft condensed matter. Modelling. Light scattering spectroscopy techniques. Data and image analysis tools.

Internship supervisor(s): sylvie.cohen-addad@insp.upmc.fr, olivier.pitois@univ-eiffel.fr

Internship location: Institut des NanoSciences de Paris, Sorbonne Université, 4 place Jussieu, 75005 Paris
https://w3.insp.upmc.fr/recherche-2/equipes-de-recherche/physico-chimie-et-dynamique-des-surfaces/mousses-bulles-et-films-de-savon/

Possibility for a Doctoral thesis: Yes, French Space Agency (CNES) funding