Internship & PhD proposal

Capillary effects in armored bubbles

Host laboratory

Location : Institut de Physique de Rennes – UMR 6251 (Soft Matter Department)

Funding M2 and PhD: yes (ANR MicroRheoFilm)

Supervision

PhD advisors : Anaïs Gauthier **Mail** : anais.gauthier@univ-rennes.fr

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Sujet

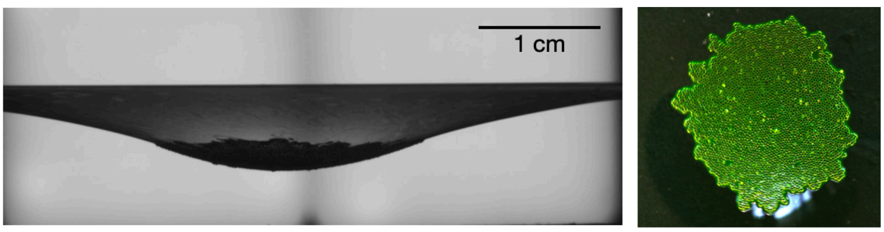
Capillary effects in armored bubbles

Controlling the mechanical properties and stability of foams is both an everyday and an industrially important problem. While in some cases one wants to destroy the foam (for example in wastewater treatment), in many situations, the goal is instead to make it as stable as possible — as in the food industry (ice cream, chocolate mousse) or cosmetics (shaving foam). A simple and remarkably effective technique for increasing foam stability consists in adding small solid particles. When the foam is created, these grains become trapped in the thin liquid films separating the bubbles, which gives the foam remarkable properties. Such particle-laden films drain more slowly (greater resistance to thinning), are less permeable to gases (which slows down their aging), and withstand mechanical stresses much better.

The macroscopic properties of these particle-stabilized films are now well understood, but many open questions remain at the scale of individual particles. In particular, particles tend to suck the liquid around them, which profoundly modifies the distribution of liquid within the film over time. Capillary forces could even reverse the usual drainage process, leading instead to a *thickening* of the film with time — the opposite of what occurs for a clean, particle-free film. This is the central point of interest in this project.

We will focus here on the properties of granular rafts — composite objects formed by a large number of particles trapped at the surface of an horizontal bubble. To analyze how these rafts absorb and redistribute liquid within the film, we will monitor how their shape (as seen from the side) evolves with time. The rafts will also be brought into contact with a liquid reservoir, in order to study the process of two-dimensional capillary imbibition. We will then relate these observations to the interfacial rheology of armored bubbles, using triaxial Helmholtz coil system capable of generating strong magnetic fields (up to about 250 G). This setup will allow us to measure the local rheology of the bubble by rotating a small needle made of two glued magnetic particles. These measurements will be complemented by optical analyses (interferometric measurements and high-speed imaging).

The project will be primarily experimental, with complementary theoretical modeling. The joint supervision of this internship will provide the student with the combined expertise of Anaïs Gauthier, for the study of particles at interfaces and capillary interactions, and Isabelle Cantat, for the physics of flows within bubbles.



Side (left) and top views (right) of a granular raft held by a soap film. The beads diameter is 300 µm.