PhD offer

Foams with a new edge:
Structure-property relations of dense balloon assemblies

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At: Institut Charles Sadron, Strasbourg, France
Starting date: 01/10/2019
Duration: 3 years

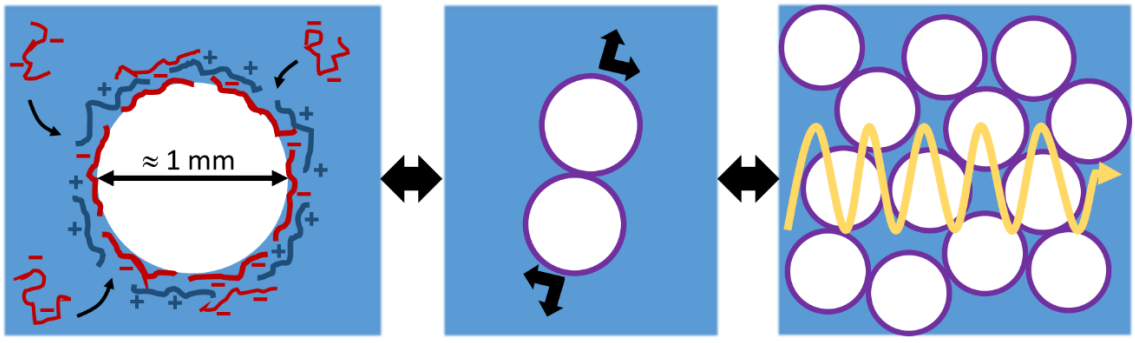
Liquid foams consist of gas bubbles which are tightly packed within a liquid carrier phase. The way the bubbles deform against each other in these packings is controlled by the energy associated with the gas/liquid interfaces, leading to very tight constraints on the type of foam structures which can be obtained [1].

An increasing number of modern foam systems relies on formulations which render the gas/liquid interface "skin-like" via the adsorption of proteins, synthetic polymers or nano-particles, giving the bubbles a balloon-like nature. This introduces additional interaction forces between the bubbles, driven by an interfacial elasticity, adhesion or friction. The resulting balloon-bubbles, or "bubbloons", pack very differently within the foam [2], leading to new kind of foam structures and hence to different structure-property relations.

Overall goal of this PhD thesis is to use a model system of "bubbloons" with well-controlled physical properties to establish how exactly the balloon-type properties change the interactions between the bubbles and how in turn this changes the obtained foam structures. In collaboration with the MSC at Paris Diderot, we will explore how these new structures impact the propagation of sound, with the long-term goal of creating acoustic metamaterials that do not allow certain ranges of frequencies to pass.

The creation of the model bubbloons will be based on the deposition of multi-layers of poly-electrolytes on the bubble surfaces [3,4]. We will then characterise the physical properties of the individual bubbloons, along with the interactions between two bubbloons. Final step of the project will be to generate complete foams with these objects using microfluidic techniques, and to analyse their structural properties using high- end X-ray tomography. The structural analysis will be coupled with acoustic characterisation in collaboration with the MSC.

On the one hand, a strong feedback between bubbloon optimisation and the structural analysis of the obtained foams will allow us to advance our understanding of the packing of highly deformable objects whose interactions are entirely driven by interfacial effects. On the other hand, strong feedback with acoustic measurements will enable us to establish and optimise structure-property relations in view of designing new, self-assembled metamaterials.



[1] Drenckhan, W. and S. Hutzler, Structure and energy of liquid foams. ACIS, 2015. 224: p. 1-16.
[2] Giustiniani, A., et al., Skinny emulsions take on granular matter. Soft Matter, 2018. 14(36): p. 7310-7323.
[3] Safouane, M., R. Miller, and H. Möhwald, Surface viscoelastic properties of floating polyelectrolyte multilayers films: A capillary wave study. JCIS, 2005. 292(1): p. 86-92.
[4] Le Tirilly, S., et al., Interplay of Hydrogen Bonding and Hydrophobic Interactions to Control the Mechanical Properties of Polymer Multi layers at the Oil-Water Interface. Acs Macro Letters, 2015. 4(1): p. 25-29.

Professional environment

The PhD student will be part of of ERC project "Metafoam". He/she will become member of the PMTP team which unites 7 permanent researchers, 2 permanent engineers and 10 non-permanent staff (postdocs, PhD students and engineers).

Collaborations within the ICS:

- Leandro Jacomine (engineer PMTP, characterisation of skin properties and bubbloon interactions)
- Damien Favier (engineer PMTP, X-ray tomography)
- Fouzia Boulmedais (researcher PECMAT team, polyelectrolyte multi-layers)

(Inter)national collaborations:

- Valentin Leroy (MSC Parid Diderot, foam acoustics & acoustic metamaterials)
- Matthias Schröter (MPI Goettingen, physics of soft granular assemblies)

Main activities

The thesis is largely experimental. The PhD student will

- use a range of commercial devices (interfacial tension mesurements, interfacial rheology, X-ray tomography, etc.)
- develop experimental set-ups (microfluidics, imaging, etc.)
- work with engineers who are developing dedicated devices (characterisation of bubbloon skin & bubbloon interaction)
- work with the technical platforms of the Institute (characterisation of polymers, electron microscopy)

Furthermore, the PhD student will

- analyse and interpret results (using analytical and computational tools)
- communicate results (in writing and oral form)
- work as part of a team (English and French spoken)
- collaborate with researchers and engineers in the institute and in France/Germany

Required competences

- Background in physics or physical chemistry
- Taste for experimental work
- Independence
- Capacity and desire to work as part of a project team
- Good level of English

Required diploma

M2 or equivalent in physics or physical chemistry

Salary

2135 € brutto

Application procedure

Applications before the **15/6/2019** through the CNRS portal: **http://bit.ly/2JjSfnM** , accompanied by a detailed CV, motivation lettre and at least one recommendation letter of a former supervisor.