Topology and mechanics in foam-fibers systems

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The creation of architected structures with new topologies associated with innovative properties is an active research field that triggers numerous important questions in fundamental physics. Already widely spread in the industry, polymer foams allow for self-assembled mass production of aerated materials with interesting mechanical and acoustics properties [1]. Despite recent progress on "liquid foam templating" techniques to generate solid foams with controlled polydispersity from liquid precursors [2], we still lack methods to explicitly control and customize the exact geometry and topology of foams, whose structure is prescribed by capillarity. To overcome those constraints and reach customizable architectures and properties of foams, we want to explore both theoretically and experimentally the idea of adding elastic fibers inside a liquid foam to modify its topology/geometry in a controlled manner before solidification.

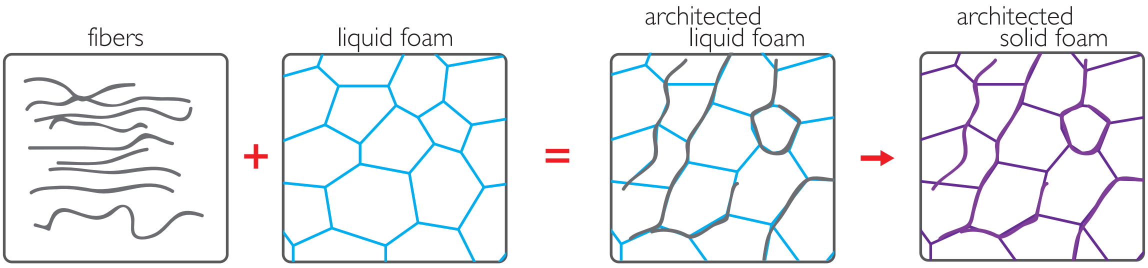

Figure 1 : General overview of the approach: a better understanding of foam-fibers interactions in a liquid foam that can solidify will provide the basis for self-assembled solid foams with novel structures and mechanical properties, obtained upon solidification of such systems.

Very little work has been done in the literature on foam-fiber composites in the elasto-capillary range of interest to us. Most studies focus either on reinforcement of bulk materials with fibers [3], or on the use of foam as a template for aerated network of cellulose fibers [4]. The interplay between elasticity and capillarity in systems involving elastic objects and liquid interfaces is attracting a growing interest [5], as well as the obtention of advanced functionalities through geometry and controlled deformations through programmable materials [6]. In this context, the PhD project will combine experiments and modeling to understand topological and geometrical modifications of liquid foam structures due to the presence of fibers, as well as resulting changes in mechanical properties of the solidified foams. This work will be implemented at Institut Charles Sadron, under the supervision of Jean Farago (Theory and Simulation of Polymers group), in strong interaction with researchers from the Mechanics of Interfaces and Multiphase systems group (Aurélie Hourlier-Fargette and Thierry Roland). Especially, the PhD student will benefit from unique tools (mechanical testing, X-ray tomography) and expertise (physics of 2D and 3D cellular materials, microfluidics, mechanics of solids) present at ICS.

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