

EQUILIBRIUM SHAPES OF THIN ELASTIC RIBBONS IN SIMPLIFIED FOAMS

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ABSTRACT:

Combining soft materials with fluids leads to rich systems in which elasticity and capillarity come into play, in particular in the case of slender elastic structures. Strategies using elastocapillarity to control the architecture of mechanical assemblies have recently highlighted ways to fold, spool or assemble elastic objects [1]. However, those intelligent design approaches remain unexplored in the context of liquids with a hierarchical architecture, such as foams.

In the context of the FoamFibMat project supported by ITI HiFunMat via a Starting grant, we investigated the competition between elasticity and capillarity in a 2D foam column upon introduction of an elastomer ribbon (Fig.1). In the low-density limit, bubble arrangements and foam structures are governed by Plateau's laws, corresponding to the minimisation of interfacial energies [2]. Confining bubbles into tubes leads to periodically ordered structures which are controlled by the ratio of tube width to bubble diameter: as a model system, we consider the so-called staircase structure formed in a square section tube where bubbles of equal volume are rearranged in a staggered pattern [3]. This quasi-2D structure has central soap films connected at 120 degrees angles, in which we introduce elastic ribbons of different bending rigidities. Using X-ray micro-tomography, we quantify the equilibrium shapes of the foam/ribbon systems. We provide a detailed analysis of the ribbon profile, that compares well with theoretical predictions in the whole range of bending rigidities. In addition, our proof-of-concept experiments show that such setup can be used as a method to mold materials with characteristic shapes and curves imprinted by the foam structure. This can be imagined as a first step towards the design of composite materials with new architectures based on solidification of the whole system.



Figure 1: Staircase structure of bubbles in a container with square cross-section without (A) and with (B) an elastomer ribbon inserted inside the central soap film.

References

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