The Structural Adaptation of Two-Dimensional Air-Liquid Foam to Cyclic Inflation and Deflation

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ABSTRACT

Using an experimental platform, we investigate locally-driven 2D foam and characterize its topological adaptation to cyclic inflation and deflation. The foam is constrained to a single layer of bubbles in a Hele-Shaw cell, and is strongly polydisperse, disordered and unjammed. The timescale of inflation and deflation is slow enough to avoid inertial effects in our system, but fast enough to avoid coarsening and T2 transitions. This reduces the system to a "packing problem", where network adaptation to the stimulus can only be achieved through neighbor-swapping (T1) events and avalanches.

The spatial topological region of influence (ROI) of this specific kind of activity is seen as approximately 5-10 nearest neighbors at injection amplitudes on the order of the bubble size, above a critical threshold. After a critical number of successive cycles, the foam adapts its structure from a higher-energy metastable state to a lower energy state. We identify signatures of this transition in the analysis of vertex trajectories, statistics of T1 events and the analysis of foam energy. Finally, we used this type of canonical perturbation at multiple spatial points in the material, to drive the material in a specific path between states.

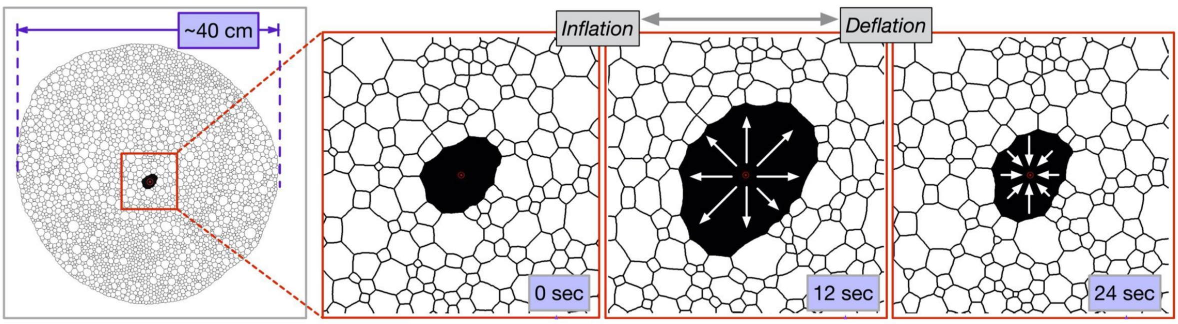

Figure 1: Example of segmented experimental data of 2D foam at different times in an inflation-deflation cycle. Repeated inflation and deflation of an "active" bubble causes structural adaptation of the surrounding foam.