Antibubble collapse: beyond the Taylor-Culick retraction

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Antibubbles, formed by entrapping a thin air film between a droplet and the liquid medium, represent the structural antithesis of soap bubbles. As the air drains under the action of the hydrostatic pressure difference between the bottom and the top of the antibubble, the film thins down to the point it punctures due to intermolecular forces, initiating the antibubble collapse. Typically, the retraction of a punctured liquid film tends to a constant speed, known as the Taylor-Culick speed. Essentially, the liquid accumulates along a rim that surrounds the growing hole. However, in the case of a punctured air film surrounded by liquid, as in antibubbles, it has been observed that the retraction deviates from the behavior of a liquid film. In fact, the retraction speed diminishes as the rim progresses along the antibubbles while the hole is growing [1]. While antibubble collapses have been explored previously[2,3], the influence of soap concentration remains uninvestigated. In doing so, the local concentration of surfactants can drastically vary during the rapid collapse of the antibubble. We observed that, with certain soap concentrations, the retraction can be interrupted in the middle of the process. Then, fractures appear all over the remaining half-shell, in the form of dendritic fragmentation leading to the generation of a myriad of bubbles (see Figure 1). We believe that this fragmentation mechanism of an air film opens a new pathway for the massive production of microbubbles.

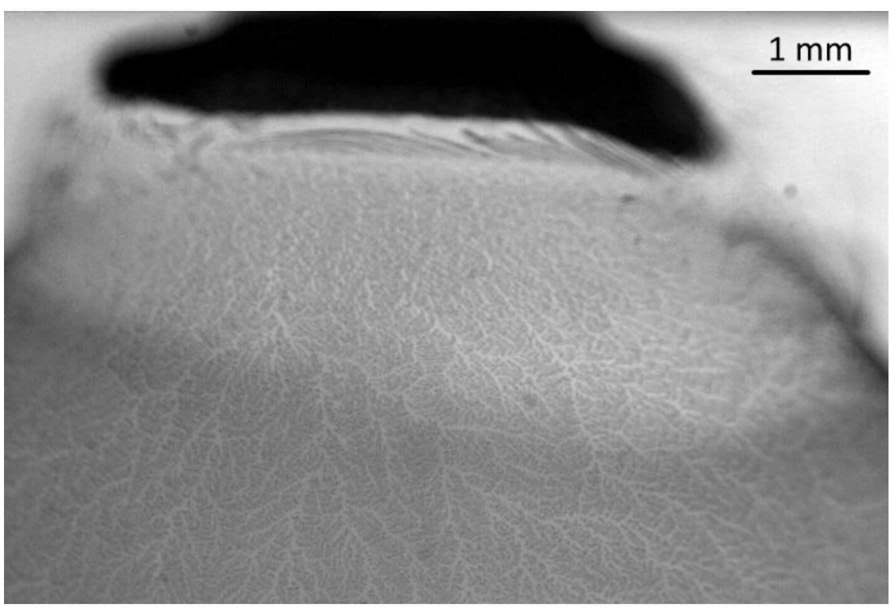

Figure 1: Example of patterns observed during an antibubble collapse. The antibubble and the medium are composed of a low-concentration soapy solution.

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