Adhesive bubbles and drops between circular frames : Shape, force and stability analysis

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We exploit the theory of axisymmetric constant mean curvature surfaces (Delauney surfaces [1]) to describe the mechanical interactions between drops, bubbles or capillary bridges [2,3] held by circular frames with radius R and distance $2h$ (see Figure 1). We complement the theory with experimental and computational approaches (Surface Evolver [4]). The Figure 1 shows our obtained shape diagram, which indicates under which constraints the bubbles remain axisymmetric and in contact. Due to four different instabilities, the bubbles lose contact or lose their axisymmetry. Two of these four instabilities (2 and 3) have been discovered by us. Different contact angles between the bubbles θ are due to different adhesive forces between the bubbles. The shape diagrams of the two limiting cases with $\theta = 0°$ and $\theta = 180°$ have been obtained additionally to the case of $\theta = 60°$ (see Figure 1). Using these diagrams and theory, the stability and mechanical properties of capillary bridges or bubbles in contact under tension or compression can be predicted [5]. The provided analysis holds equally for bubbles, drops or capillary bridges and gives an approach to investigate more complex interfaces with for example elastic skins.

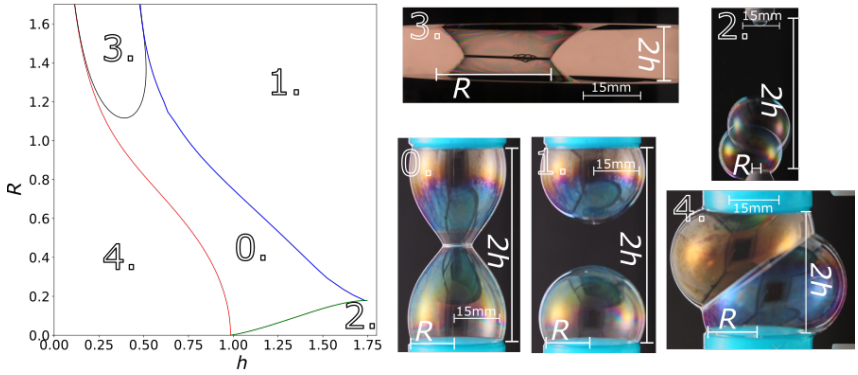

Figure 1. Shape diagram for two bubbles with a contact angle of 60° with 0. Delauney Surfaces 1. Bubble bubble detachment, 2. Bubble frame detachment, 3. Non axisymmetric shifting and 4. Non axisymmetric tilting.

Références

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