Soap Bubble Rainbows in Diffused Light:

The intended purpose of the video was to create a soap film on some form of loop that could create a rainbow when a diffused white LED was pointed towards it. Originally, the rim of different jars and bowls were used to create this film, but the rainbow effect proved hard to achieve since the jar or bowl had to be rotated after it was dipped into a soapy-water mix, and that rotation typically caused the formed bubble to pop. Eventually, a bowl filled with soapy water was placed in front of a telephoto lens. A straw was placed inside the mixture, and air was blown into the straw which created a mosaic of bubbles above the liquid mixture. The LED light was placed closely above the mixture pointing downwards, which achieved the rainbow film effects seen in the final video. The video was produced independently.

The apparatus consisted of a cooking bowl approximately 6 inches (0.15 m) in diameter and 4 inches (0.10 m) in height, filled with the mixture to a depth of approximately 2 inches (0.05 m). Water from a kitchen faucet was mixed with approximately 2 fluid ounces of Dawn Platinum dish soap. No other ingredients were added. A straw was placed near the bottom of the bowl, and air was blown through it to produce the bubbles. Blowing stopped before recording. A diffused white LUXLI LED was supported by a mug on top of a box and angled downward toward the bubbles, as shown in the apparatus sketch.

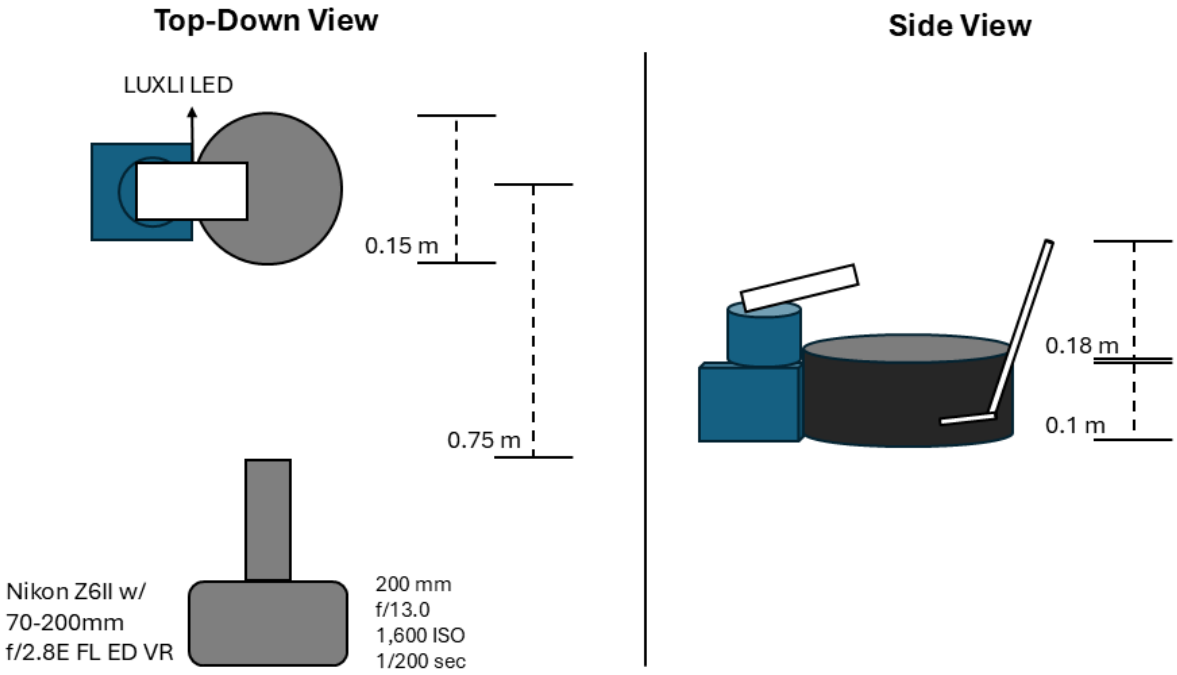


Figure 1. Schematic of Apparatus Setup. The camera settings shown are for the first clip.

The bubbles pressed against one another, producing polygonal boundaries. Surface tension helps shape the films, while gravity draws liquid downward through the foam. Differences in curvature create pressure differences that move liquid between the films and the thicker channels where they meet, called Plateau borders. Viscosity resists motion. These processes change the thickness of the films after the bubbles have formed [1, 2]. The rainbow colors come from thin-film interference. Light reflects from both surfaces of each liquid film, and the reflected waves combine to strengthen come colors and weaken others. The colors depend on film thickness and viewing angle [3]. As liquid moves and the films thin, the patterns change. The colored surfaces are visible in Figure 2, although the colors alone do not directly measure liquid speed or film thickness.

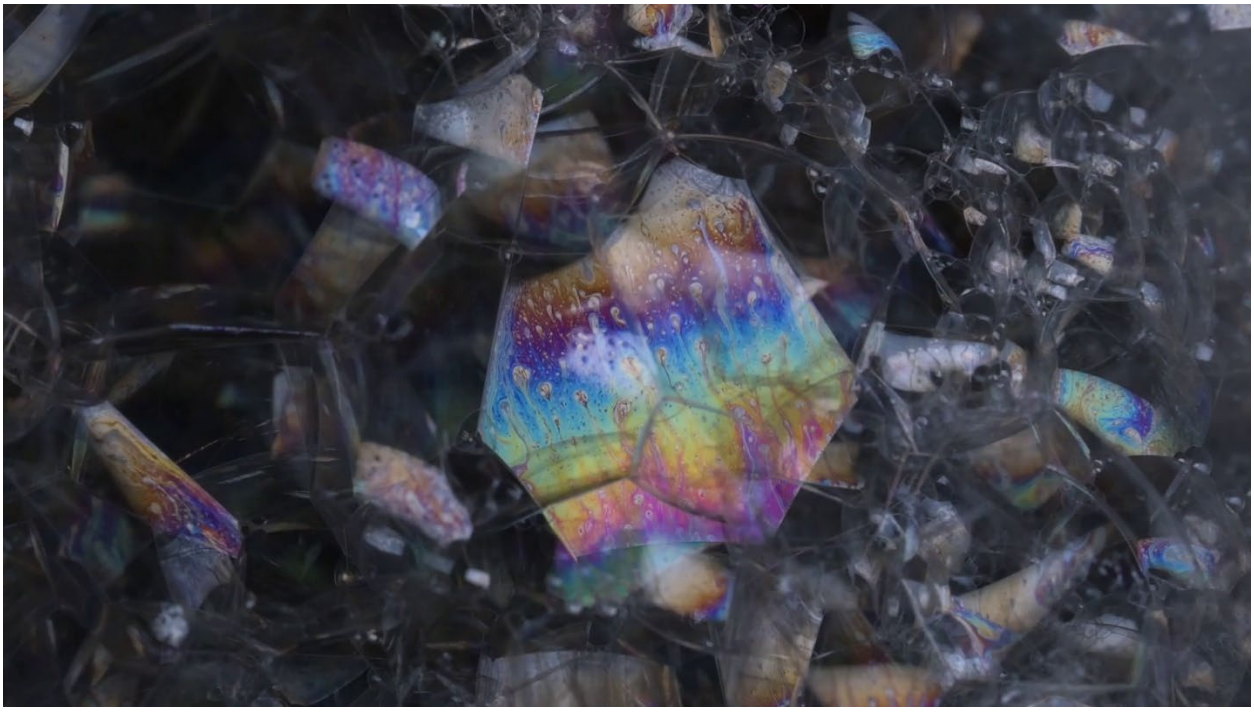


Figure 2. Single Frame from Second Clip at 17s, showing interference colors and polygonal boundaries in the bubble cluster.

The relative importance of gravity and surface tension can be estimated using the Bond number,

$$Bo = \frac{\Delta\rho\, g\, L^2}{\sigma}$$

Where $\Delta\rho$ is the liquid-air density difference, g is gravitational acceleration, L is a characteristic length, and σ is the surface tension of one liquid-air interface. For an approximate bubble-scale calculation, a representative diameter of $L = 0.01$ m was selected from the estimated image scale. Bubble sizes varied across the foam. The density

difference was approximated as 1000 kg/m^3, and $\sigma = 0.03$ N/m was assumed. The surface tension is representative of values reported for sufficiently concentrated soap films [4], rather than a measurement of the Dawn Platinum mixture.

$$Bo = \frac{(1000\,\mathrm{kg/m^3})(9.81\,\mathrm{m/s^2})(0.010\,\mathrm{m})^2}{0.030\,\mathrm{N/m}} \approx 33$$

This estimate suggests that gravity matters at the selected centimeter scale, while surface tension remains critical to the films. The result depends on the estimated bubble size and assumed surface tensions; it does not establish if the flow is turbulent.

The clips were captured using a Nikon Z6II digital mirrorless camera with an AF-S NIKKOR 70-200 mm f/2.8E FL ED VR lens at 200 mm. The focus was manually set to its closest focusing position and then the camera was moved until the front bubbles were in focus. The first clip was recorded at f/13, ISO 1600, and a shutter speed of 1/200 s. The second clip was recorded at f/18, ISO 2000, and a shutter speed of 1/200 s. Both clips used a white balance of 5200 Kelvin and were recorded at 25 frames per second. The long focal length concentrated attention to the bubble surfaces. Some surrounding bubbles remained soft because the foam extended through several depths.

The original recordings measured 3840 × 2160 pixels. Each clip was cropped to 1920 × 1080 pixels without resizing, retaining half the original width and height and one-quarter of the original image area. This concentrated attention on the bubble effects while reducing the exported frame dimensions.

The field of view was estimated using the len's maximum magnification of 0.21x [5]. The camera recorded at full frame, the sensor area at 4k/25p is approximately 35.9 x 20.2 mm [6]. Dividing by magnification and applying the crop gives:

$$W = \frac{35.9\,\mathrm{mm}}{0.21}\left(\frac{1920}{3840}\right) \approx 85\,\mathrm{mm}$$

$$H = \frac{20.2\,\mathrm{mm}}{0.21}\left(\frac{1080}{2160}\right) \approx 48\,\mathrm{mm}$$

The estimated final field of view was therefor 8.5 x 4.8 cm. Spatial sampling at the focused bubble plane was:

$$\Delta x = \frac{85\,\mathrm{mm}}{1920\,\mathrm{pixels}} \approx 0.044\,\mathrm{mm/pixel}$$

Cropping preserved the original sampling within the retained region. Focus, diffraction, motion blur, and compression also limit the smallest detail resolved. Both clips were recorded and played back at 25 frames per second. The interval between frames was:

$$\Delta t = \frac{1}{25\,\mathrm{s^{-1}}} = 0.040\,\mathrm{s}$$

The exposure duration was:

$$t_e = \frac{1}{200}\,\mathrm{s} = 0.0050\,\mathrm{s}$$

Adobe Premiere Pro was used to inspect the clips' metadata, combine the two recordings, and add the music. No color or exposure adjustments were applied to either clip. The submitted video is 26.80 seconds long and combines the two clips with a dissolve transition around nine seconds. The soundtrack is "The Subtle Truth" by Ian Post, listed at royalty-free music on Artlist [7].

The final video connects the geometry of a bubble cluster with the changing colors produced by its thin liquid films. I particularly liked the contrast between the bright rainbow regions and the darker surrounding bubbles and out of focus background. It reminds me of the Pillars of Creation photo taken by NASA inside the Eagle Nebula (M16). The second clip provides a stronger subject, while the first shows more of the repeating film structure across the foam. Overlapping reflections sometimes make individual boundaries difficult to follow. In a future attempt, I would measure the mixture proportions, include a scale reference, and record one film for longer under fixed lighting. The video achieved my goal of capturing changing rainbow patters within the bubble cluster.

References:

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