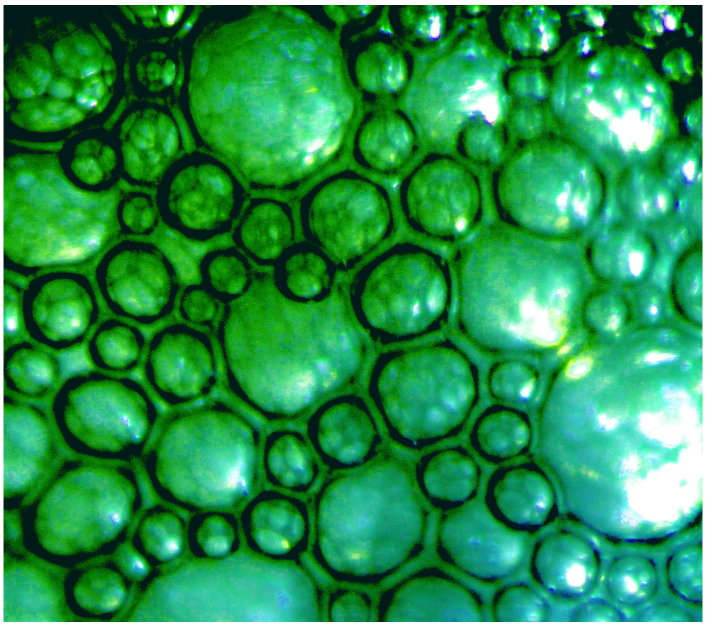
Only Hollow

Group 2 Image Report



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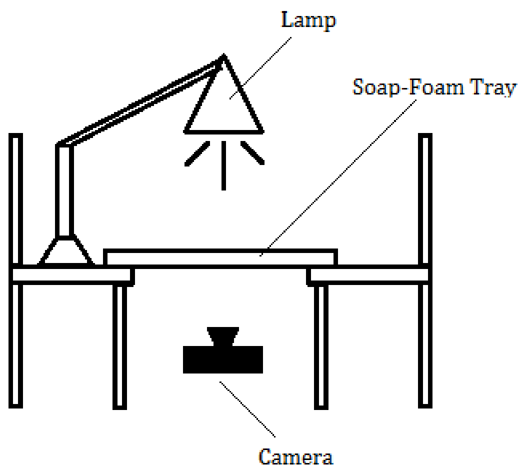

Figure 1: Schematic of experimental setup

This report lists and describes the techniques performed to capture the photo *Only Hollow* as part of the second Team Flow Visualization assignment. The intent of this assignment was to capture an image that effectively displays the complexity and beauty of fluid flow phenomena. Relevant pysics will be discussed and and used to analyze the image quantitatively. The final image was one of several captured during the project period, and it underwent severall steps of post-image processing to achieve the aesthetic intended.

In capturing this image, a relatively simple experimental setup was utilized. A glass cooking tray was filled with dish soap. Water from a faucet was added to the tray until a foam formed. The tray was held on two sides by chairs so the image could be captured from below the tray. A desk lamp was positioned directly over the setup, in attempt to capture iridescent colors from light impinging on the soap film. A schematic of the experimental setup is shown in Figure 1.

The image displays the dynamics of soap film on the surface of water. Soap films form a film when disturbed in water because soap is a surfactant, meaning its molecules are bipolar. The soap molecule has both a hydrophilic and hydrophobic end, thus they seek the surface of water. The hydrophobic tails stick out of the water, and the hydrophilic ends orient toward twater. This formation creates an interface on the water surface, which reduces the surface tension of the water. The soap forms approximately spherical bubbles with shared walls in attempt to minimize surface area and tension.

The Young-Laplace equation, shown in equation 1, describes the pressure balance across a gas-liquid interface.

$$\Delta p = \frac{2\gamma}{r} \tag{1}$$

where γ is the surface tension, and r is the local radius of curvature of the surface. This is illustrated in Figure 2.

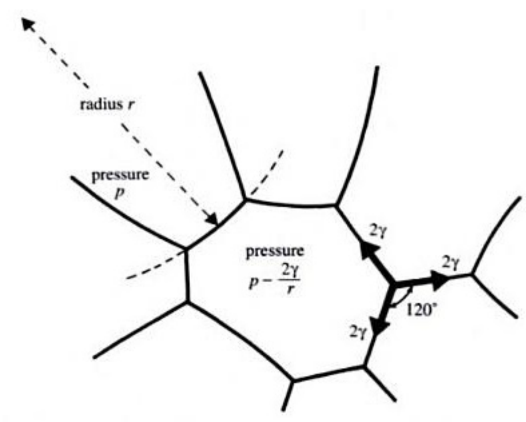

Figure 2: Two-dimensional foam consists of circular arcs [1]

Equation 1 is true for spherical bubbles; however, it is not sufficient in describing soap foams, since the bubbles in foam are generally not perfectly spherical. For a foam within a soap film, equation 1 is adjusted to [1]:

$$\Delta p = \frac{4\gamma}{r} \tag{2}$$

A two-dimensional foam consists of circular arcs, with curvature consistent with the pressure gradient between walls. Foam structure is described by the Aboav-Weaire Law, shown in equation 3. This empirical law offers an accurate fit for various cellular foam patterns:

$$m(n) = 6 - a + \frac{6a + \mu_2(n)}{n} \tag{3}$$

where m is the average number of sides of cells with n-sided neighbors, and a is a parameter based on the particular soap pattern. For a disordered soap foam, $a \simeq 1.2$. μ is the second moment of the two-dimensional foam probability distribution. These equations are extremely involved and beyond the scope of this course. They do, however, offer a brief explanation of the physics behind this fluid phenomena. For further explanation, see [1].

The image was captured on March 20, 2013 with a Nikon D5000 SLR 12.3 megapixel camera. The image specifications are shown in Table 1. The area of field of view is approximated to be 22.6mm x 15.2mm. The distance from the lens to the water surface was approximately 150mm. The image was post-processed in Photoshop after initial capture. The hues and saturation were adjusted to make the bubbles green, and the curves and exposure were adjusted to enhance overall image quality.

The image is somewhat grainy, much more than would be expected from a DSLR camera. This is due to the fact that the image was compressed in a jpeg format rather than RAW. Also, the image was cropped significantly. Despite this, I am satisfied with the final image. I particularly like the varying film thickness from between bubbles; some exhibit much

Specification	Value
F-number	4.2
Exposure time	1/10
Focal length	26
ISO	1000

Table 1: Image specifications

darker rings than others. I attempted to research this further but could find no substantial explanation other than the physics described above. The original final images are shown in Figures and , respectively. The image is titled *Only Hollow* as an homage to the Irish rock band *My Bloody Valentine* and their song, "Only Shallow". Special thanks is given to fellow student, Shea Zmerzlikar, who aided in principal photography.

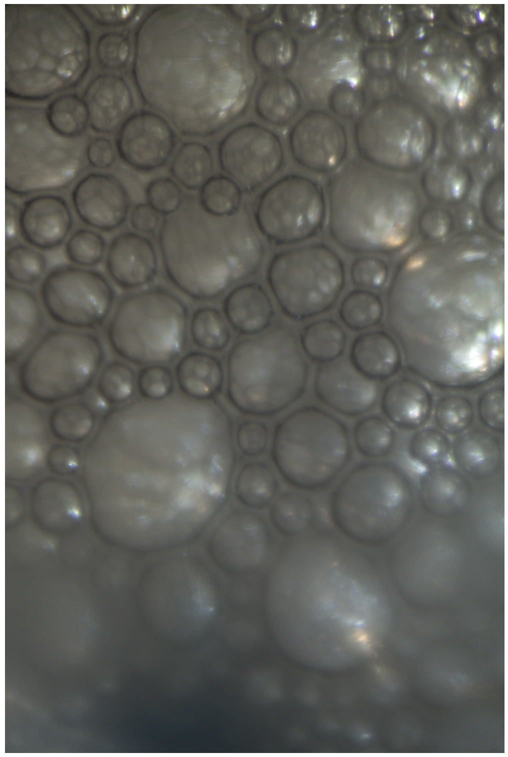

Figure 3: Original image

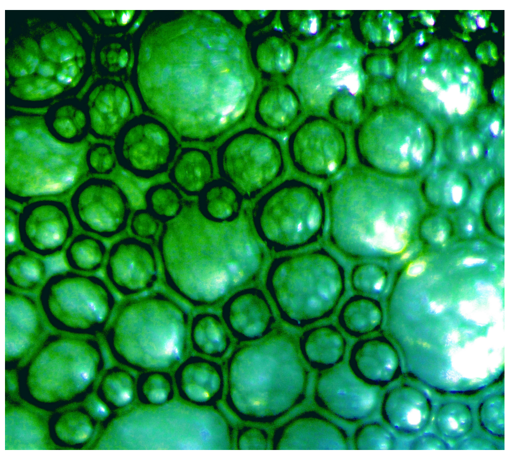

Figure 4: Final image

References

[1] Denis L. Weaire, Stefan Hutzler. *The Physics of Foams*. 1999. Oxford University Press