Get Wet: Suds and Serenity

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MCEN 4151: Flow Visualization

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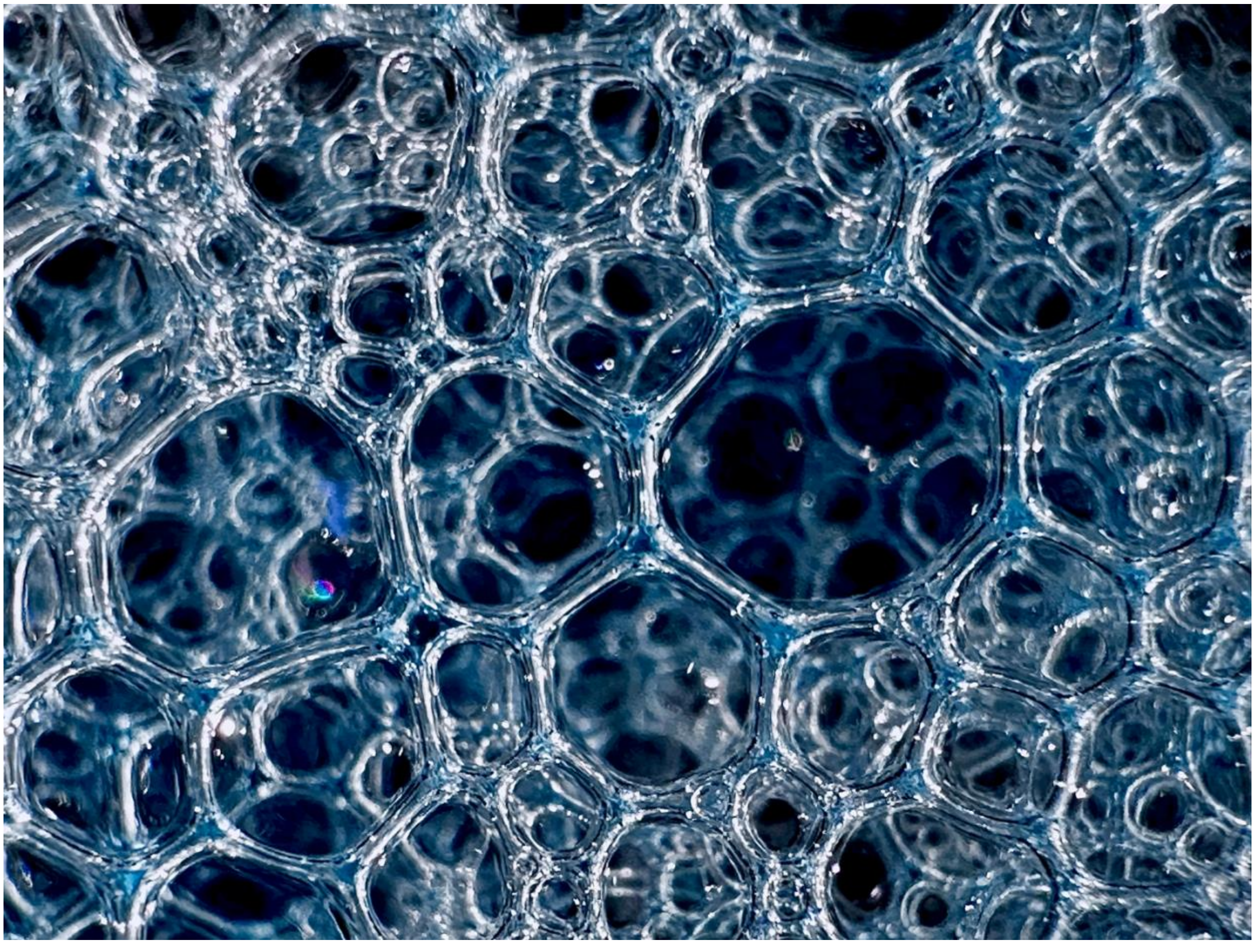

1 BACKGROUND

This image was taken on September 11, 2023, with the aim of capturing the surface tension created by bubbles using simple household ingredients of water and dish soap. The intention was to display a beautiful image that captures a common phenomenon in everyday activities such as washing the dishes. After experimenting with many materials of different viscosities, I discovered the best images were captured with just soap and water. I tried nail polish, watercolor paint, and different soaps to create many images. I found that the two fluids of water and soap prevailed and composed gorgeous combinations. I discovered that there is surface tension between each bubble and over the top of the surface of the container holding the bubbles which will be explained more in the physics section.

2 EXPERIMENTAL SETUP

This experiment was set up using Dawn dish soap and warm tap water from the faucet of my apartment. I used a recycled McDonalds cup to hold the fluids. The materials are shown in figure 1.

Figure 1: Materials used to create Get Wet image including Dawn Ultra dish soap and a clear plastic cup with a tapered edge.

First, a tablespoon of Dawn was added to the empty cup. Directly on top of the soap, high pressured, warm tap water was then dispensed to fill the cup. Soapy bubbles were formed immediately and stretched across the surface of the cup. After taking some photos, I realized I wanted more color in the photo. To achieve this goal, I drizzled more soap over the top of the bubbles which created more blue coloration and a film layer across the bubbles. With the additional soap, an excellent image was captured. Figure 2 displays the final setup when the image was captures.

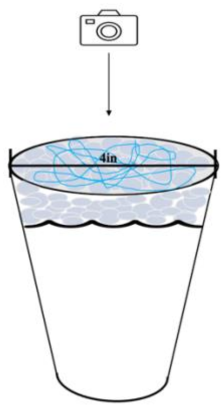

Figure 2. Final setup with all bubbles and extra soap added. Camera view was from directly above the fluid.

3 PHYSICS OF THE FLOW

The key physics that this photo displays is surface tension. Surface tension holds the bubbles and prevents them from popping. The thin layer of soap liquid encases air while surface tension minimizes surface area, creating a sphere. Additionally, there is a pressure difference between the inside and outside of the globule of air; the inside has a higher pressure than along the spherical curve of liquid [2]. The Marangoni effect can describe the films of soap being created and the bubbles rising to the top of the cup. According to the Marangoni effect, fluid flows from areas of low surface tension to high surface tension, demonstrated by these bubbles.

Within the conglomeration of bubbles, there is a liquid layer at each interface, creating a bilayer of air, liquid, air meeting each other. Inertial cavitation also occurred, the liquid draining consistently [4]. This describes why all the liquid eventually disappears, creating a constantly shifting set of bubbles that do not stay the same for any one instant.

To create the bubbles in the first place, there had to be an infinite stream of liquid, which in my case was from my sink into the cup. According to Yurong Wang in an article titled "Cavitation bubbles with a tunable-surface-tension thermal lattice Boltzmann model" from 2022, "The maximum cavitation bubble radius in an infinite liquid is nearly linearly proportional to the input initial energy. An increase in the surface energy reduces the maximum radius of the cavitation bubbles, while increasing the pressure energy and thermal energy promotes the maximum radius of the cavitation bubbles" [5]. The flow of the faucet was the initial energy and created the cavitation bubbles which then used surface tension to stay across the surface of the cup. These bubbles then remained before they drained so I could capture the photo.

4 VISUALIZATION AND PHOTOGRAPHY TECHNIQUES

This photo was taken using marked boundary techniques [1]. The glycerin of the soap creates a boundary between the water and the air inside the bubble. There is a clear boundary highlighted by the lighter white parts that are the mixture of water and soap in comparison to the darker sections of air trapped inside a bubble.

One of the key factors in capturing this photo was lighting. In order to make the bubbles really stand out on the page, I focused on directing bright light straight on to the experimental setup. Instead of using flash from the camera, I opted for an external light source. I positioned my experiment in a completely dark room and then pointed an artificial bright lighting from a flashlight onto my conglomeration of bubbles. The continuous flash was pointed at the flow itself from underneath to illuminate the globules. The light was about fifty lumens [3].

Another key photography technique that I used and adjusted between each photo was zoom. I ensured to take the photos very close to the setup. Instead of using the zoom built into my camera, I physically moved the lens closer to my bubble setup to capture a clearer image. I think this helped keep a higher resolution. In the final image, I the lens was about a half an inch away from the surface of the fluid.

The photo was taken with a 48mm lens of a digital iPhone 14 Pro camera. The ISO was set to 160, the F-Stop as f/2.2, and the exposure as 1/67. The image is 4032x3024 pixels. The photo was edited to bring more color to it and highlight some of the brighter portions. The before and after can be seen in Figure 3.

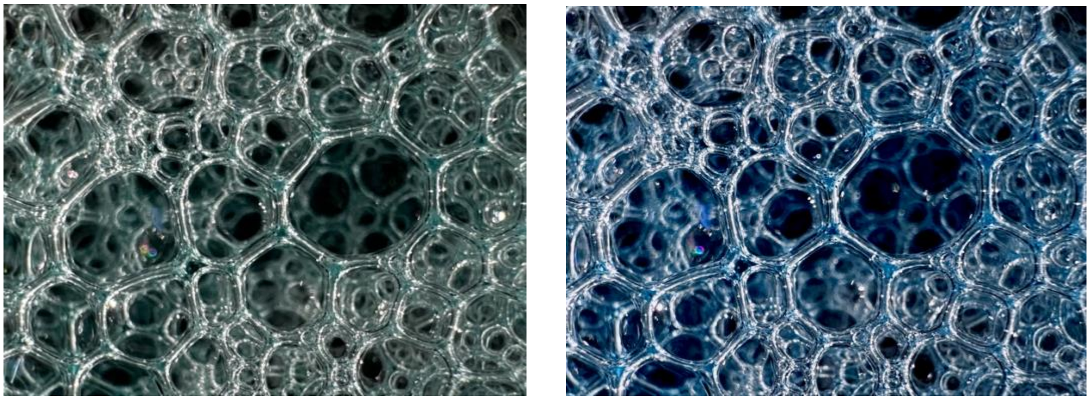

Figure 3. The unedited, raw image is displayed on the left. The image on the right is after post-processing.

5 CONCLUSION

Using boundary techniques and a constant light, a lovely composition was captured. Surface tension describes the fluid physics of the bubbles produced in my photo. Additionally, there is a liquid layer at each interface of the bubbles. I really love this image and think it displays physics in a unique way. It is stunning how a common set of bubbles using dish soap can reveal a lot about physics in a beautiful way. I would love to see this on a much larger scale with even more bubbles, or alternatively on a macro, focusing on a single bubble.

6 REFERENCES

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