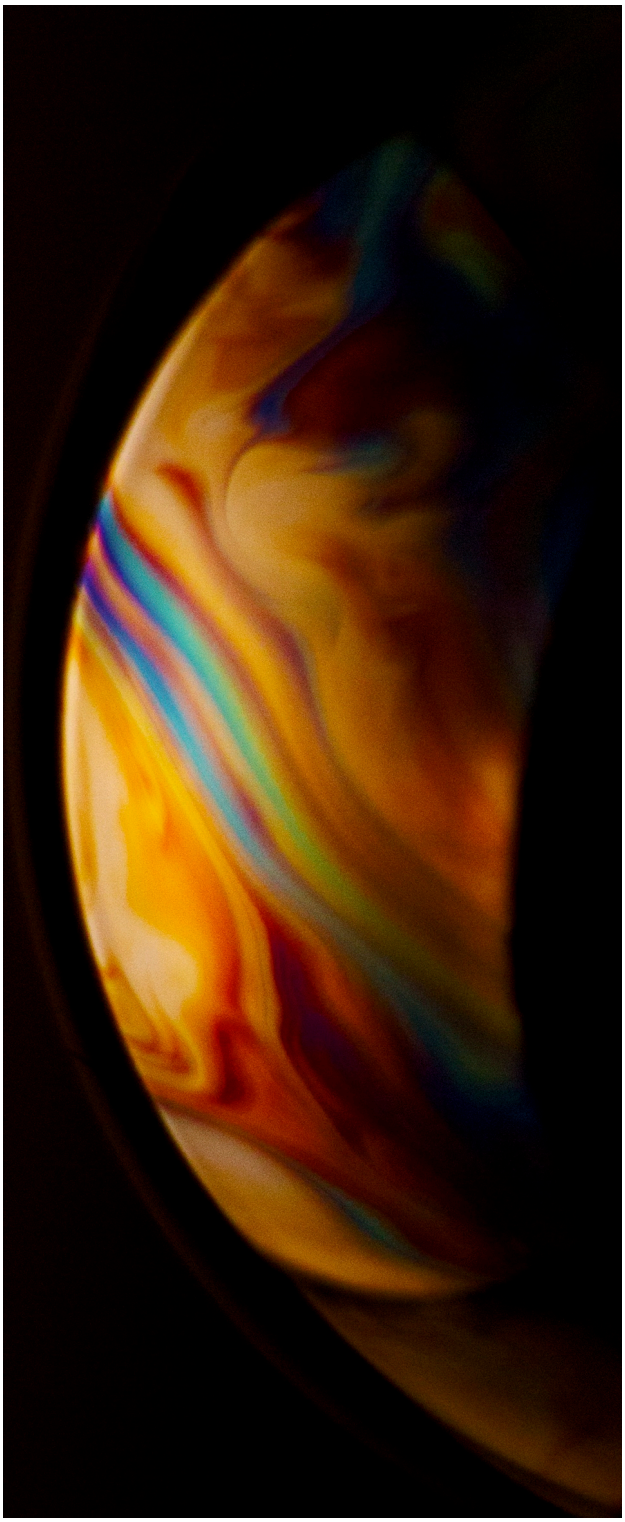

Figure 1: Final Image

Team Second Report

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MCEN-4151
Flow Visualization: The Physics and Art of Fluid Flow

Background

This image that resembles a planetary atmosphere is of a soap bubble. The bubble was illuminated from above, and the image is rotated 90 degrees. The light source is from above the bubble, which is formed around the rim of a glass. The rainbow appearance of the bubble is due to varying thicknesses of the bubble film. This is a thin film phenomena and the colors are caused by an interference of the reflected light.

Experimental Setup and Process

The experimental setup needed to capture this image was rather elaborate, fig. 2. A light dome with a diffuser was placed above where the bubble would be blown. A black backdrop cloth was wrapped completely around the light dome blocking all external light. The surface on which the glass used to the blow the bubble rested was a black fabric covered chair. The camera was setup on a tripod approximately 1.5 ft from the bubble. It was found that turning off the room lights increased the quality of the images. The rim of the glass used to blow the bubble was 2 in in diameter. A whole was cut in the bottom of the glass and a straw connected, with tape sealing the interface to prevent air leakage. The straw was approximately 2.5 ft in length to allow the team member blowing the bubble to be outside of the camera frame and not affect the lighting on the bubble.

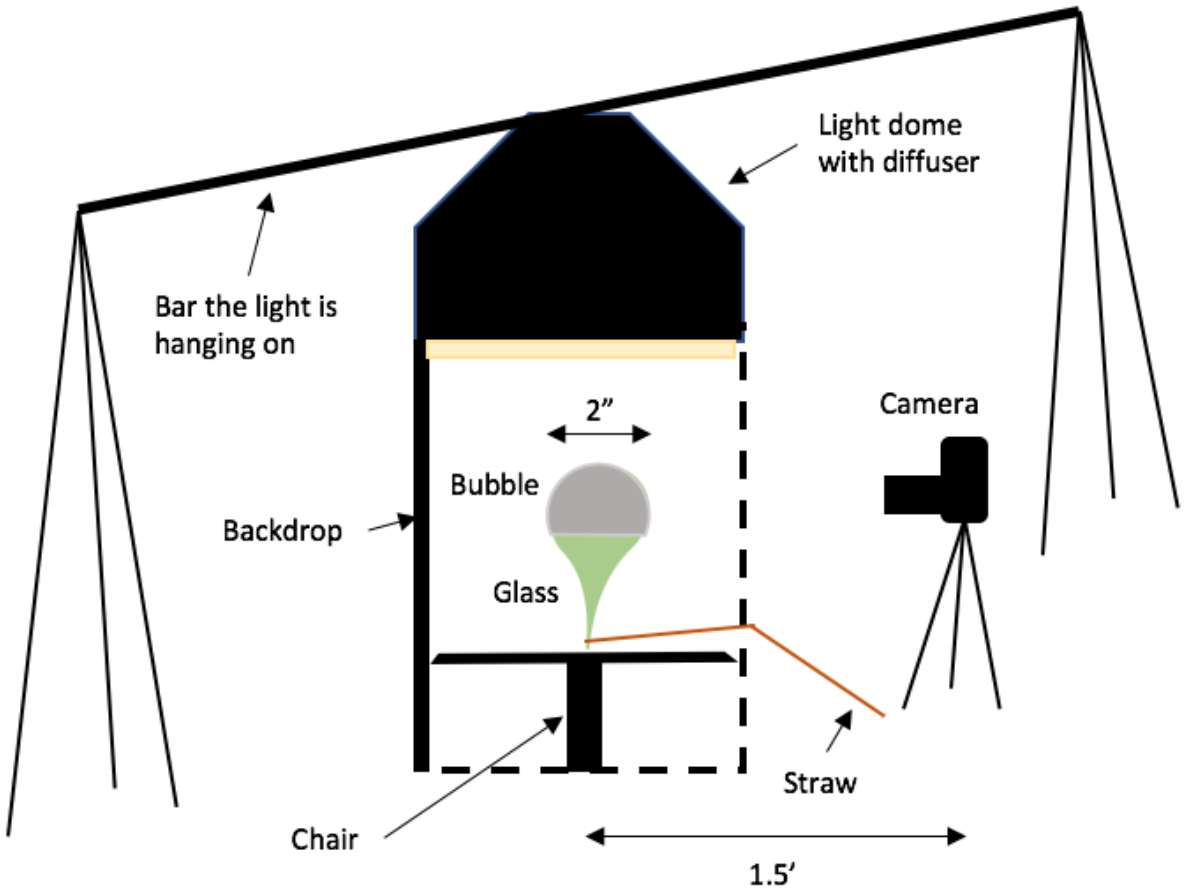

Figure 2: Experimental setup

To blow the bubble, one team member held a shallow dish with dish soap. Another team members were manning the camera and the room lights. The team member blowing the bubble dipped the glass into the shallow dish and positioned it where the camera was focused. The lights were turned off and the bubble blown. The colors in the bubble changed as the bubble began to dry out and the film became thinner. Each bubble lasted at most 20 seconds before popping. This image was taken at about half the bubble lifetime.

The image was taken using a Canon EOS Rebel SL1 with a 50mm fixed lens. The glass was placed on the chair and the camera focused. The glass was returned to the same location with the bubble fluid, so the focus did not need to be readjusted. To capture this image, the exposure was set to 1/250 second, the F-stop set to f/1.4, and the ISO to 100. The image was cropped and rotated 90 degrees in post processing. The saturation increased slightly by +20 and vibrance increased to +70. The color density was changed to 20%. All image editing was done in Adobe Photoshop. The edited image can be seen in fig 1., with the original image in fig. 3. The original and final images have dimensions of 5208x3476 and 961x2348 pixels respectively.

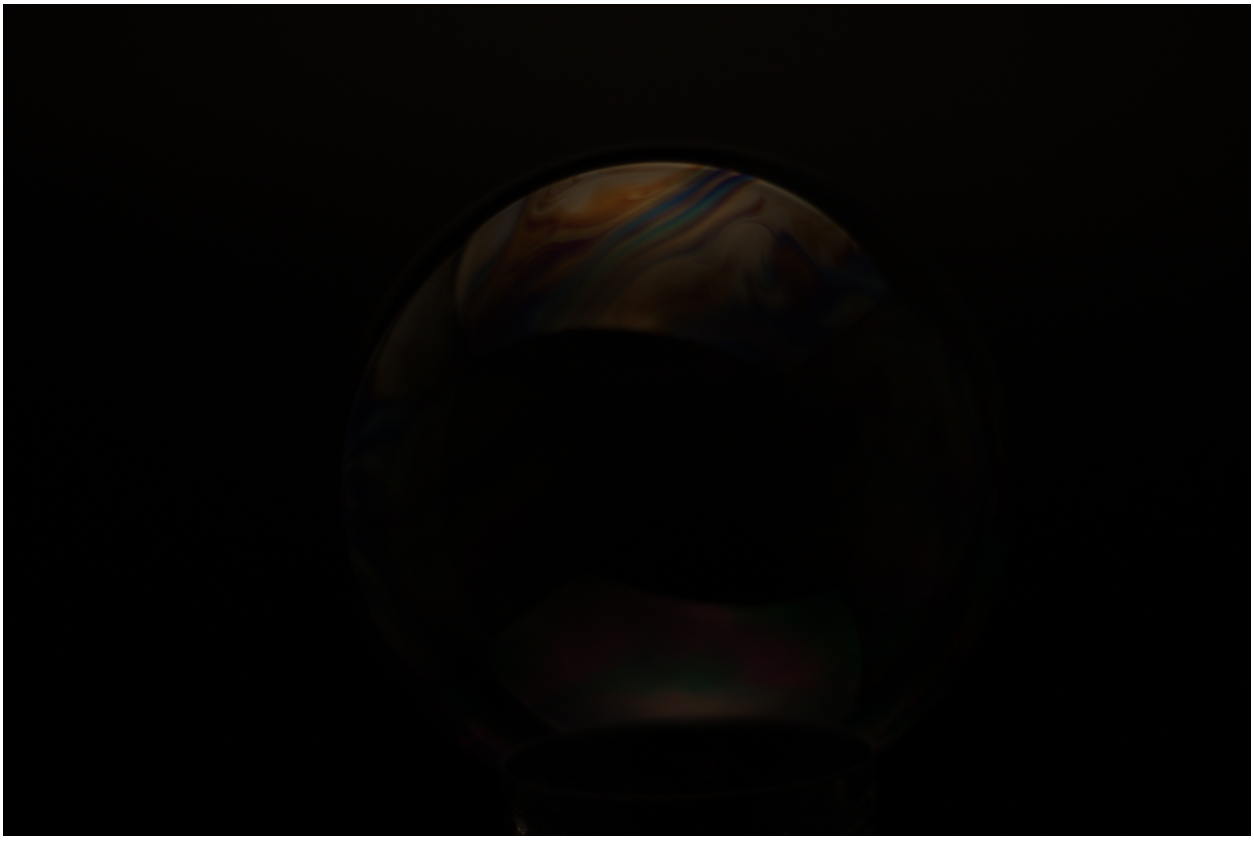

Figure 3: Original unedited image.

Fluid Physics

Bubbles are considered a thin film and usually have a thickness around 2.5 nm immediately prior to popping. Light impacts the surface of the bubble and roughly 8% is reflected and the rest

travels through the bubble fluid[1]. Then 8% of the remaining light reflects off the inner surface back out, and the remaining light travels to the inside of the bubble. When the light hits the surface of the bubble, it is refracted and then reflected at the same angle off of the inner surface of the bubble. The light that reflects off of the outer surface of the bubble is also reflected at the angle of incidence. Light reflected off of the inner surface of the bubble interferes at the outer surface of the bubble with light that is reflected off the outer surface. This interference causes the light to change colors. The colors produced vary with the thickness of the bubble film.

When the bubble is initially blown, the colors cannot be seen. After a few seconds, colors start to appear and are in the blue-green range. As the bubble matures it changes to include purples, pinks, reds, and yellows. As the bubble matures, the color changes to brown, gray, and black. The brown, gray, and black bubble is nearing the end of its life. These colors appear due to differing film thicknesses[1]. Thicker portions of the bubble are often towards the bottom creating a color gradient from top to bottom. Here, the act of blowing the bubble caused the thickness to vary due to airflow, creating the swirling patterns seen on the bubble.

Conclusion

These beautiful colors appear every time a bubble is blown. Often ambient light is very high and prevents them to be seen. For this experiment, the light was limited and oriented perfectly to capture this rainbow phenomenon, giving the bubble a whole new dimension. It makes you wonder how many other everyday objects are hiding rainbows.

References

Wiebe, A. (1990). *Soap Films and Bubbles.* Fresno, CA: AIMS Education Foundation.

[1] Wiebe, A. (1990). *Soap Films and Bubbles.* Fresno, CA: AIMS Education Foundation.