# Soap Film with Light Interference Patterns: Team Third Report 2018

MCEN 4151

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Our team third experiment developed from the desire to capture a soap film of varying thickness. We used a formula presented in a prior flow vis report by Dennis Can in 2015 [1]. We set out to experiment with flow formations developed from a soap film with direct lighting. Initially we used lamp lighting and later switched to a large TV set to all white as our lighting source. Joe mixed the soap, sugar solution, and Ziwei held the film container while I took the photos. The experimental setup for this photo is demonstrated in *Fig 1* below:

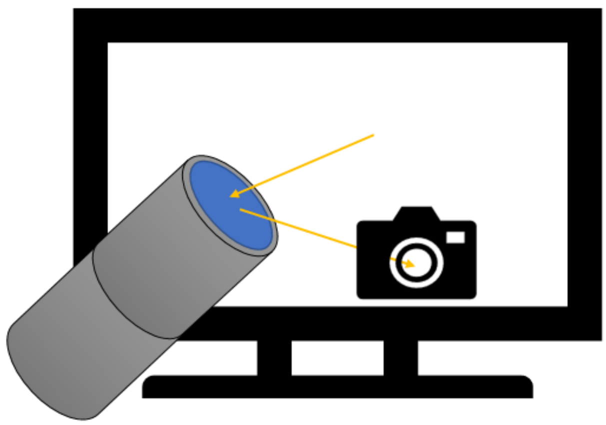

*Figure 1: Soap Film Visualization Setup Diagram*

To begin our process, we mixed a cup of water with 5 tablespoons of sugar and 2 tablespoons of dish soap [1]. We poured the solution into a wide-mount bowl and dipped the rim of a thermos into the solution, creating a film across the surface of the container. As seen in the diagram above, a TV monitor was used as the primary light source and all other lights in the room were turned off. The shot was taken at an angle to capture the reflected colors from the film. The camera was situated between the TV and thermos about 5 inches from the film.

The visual effect of multi-colored drops and bands are developed through light interference and gravity-driven draining [2]. Light interference occurs in soap films as the two reflecting surfaces of the film are microns apart and so cause incoming light to travel slightly different distances while reflecting and therefore interfere [2]. This interference patterns provides colors of different wavelength depending on the angle between the film surfaces and the thickness of the film [2]. Gravitational draining, due to the film’s normal vector being horizontal, causes bands of colors to form based on the varying thickness in the film [2]. In the image, it is evident that the thicker part of the film is at the bottom as it is oriented vertically. Therefore, the upper section of brown and blue represent the thinner portion of the film. Sugar crystals in the solution provide amplified saturation of colors as well as slower movement of the film [3].

The physics of light reflection and refraction is governed by Snell's Law [3]:

$$\frac{sin\theta_2}{sin\theta_1} = \frac{n_1}{n_2}$$

This law helps determine the effect of index of refraction on reflected and refracted light. Here, $\theta_1$ is the angle from the normal of incoming light, and $\theta_2$ is the refracted angle within the medium [3]. The index of refraction for the two materials, the ambient air (1.00), and soap-sugar solution (1.40), are represented by $n_1$ and $n_2$ respectively [3]. Thus, in a soap film, the angle of incoming light as well as the index of refraction in the soap film solution all contribute to the constructive interference of light that is visualized through this process. The physics of the proximity and interference of these light rays is shown in the *Fig 2* below [3]:

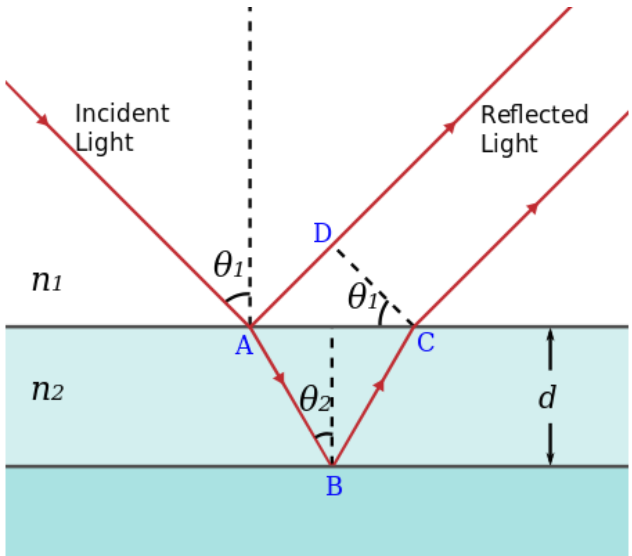


*Figure 2: The Effect of Index of Refraction and Angle of Incidence on Reflected Rays [3]*

I used a Canon T6i DSLR to achieve this shoot. The lens was held at about five inches from the film and the focal length of the lens was $f = 35mm$ which is the maximum zoom for the kit lens used. I used an aperture of f/5.6 which gave a narrow depth of field and made the center of the image pop. The fast shutter speed of 1/80 sec gave a crisp shot with low motion blur. An ISO of 400 was utilized to allow for proper exposure with moderate lighting provided by the TV monitor. I used Digital Photo Professional to edit the image by adjusting the tone curve and cropping. The tone curve was utilized to saturate the colors in the image and provide more contrast. I tried to keep the editing minimal to enhance the natural beauty of the fluid flow physics. The editing process is shown below in *Fig 3* and *Fig 4*.

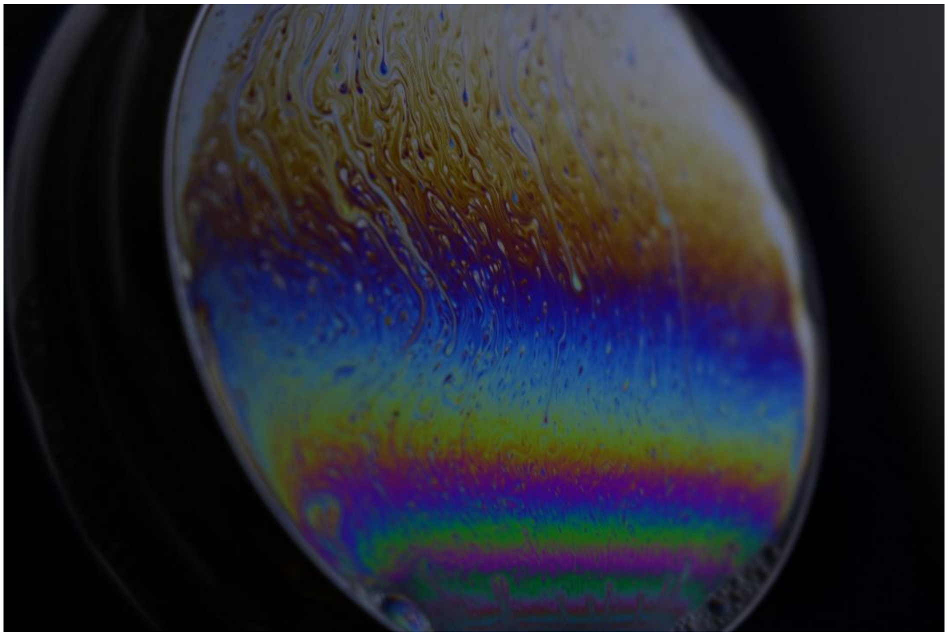

*Figure 3: Unedited Image*

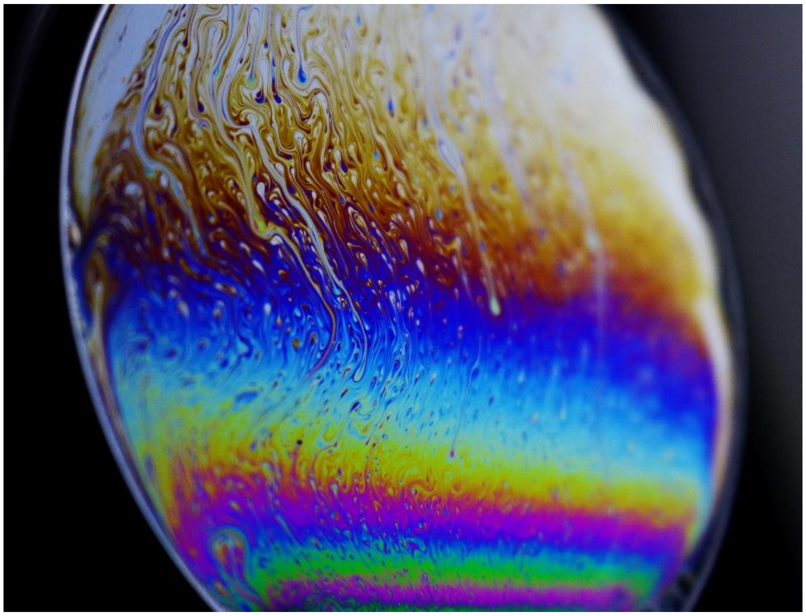

*Figure 4: Final Edited Image*

Creating this photo was an educational experience that taught me and my teammates about thin film interference and its beauty in draining soap solutions. The patterns formed by the thin film were spectacular to see unfurl and provided introspection into the world of light physics. If I were to recreate this photo I would try using the sun as the primary light source, thus allowing me to use a narrower aperture and capture more of the shot fully in focus. I would also like to experiment with different orientations of the soap film to achieve different draining patterns. Overall, I am satisfied with the photo that we achieved through our exploration of soap films and am interested in doing further work with soap films in the future.

References

[1] "A Horizontal Soap Bubble Film Drains towards Its Center, While Nonuniformities from Undissolved Sugar Crystals Create Colored Patterns as the Film Thickness Varies." *Flow Visualization*, www.flowvis.org/2015/05/21/a-horizontal-soap-bubble-film-drains-towards-its-center-while-nonuniformities-from-undissolved-sugar-crystals-create-colored-patterns-as-the-film-thickness-varies/.

[2] *Inferior Mirages (Water)*, www.weatherscapes.com/techniques.php?cat=miscellaneous&page=soap_films.

[3] "Snell's Law." *Wikipedia*, Wikimedia Foundation, 6 Oct. 2018, en.wikipedia.org/wiki/Snell's_law.