Team Image 1: Soap Film Bubble

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MCEN 4151: Flow Visualiation

3/12/2014

Introduction

Soap films display a variety of colors when white light is bounced off of different thicknesses. For the first group image project in the Flow Visualization course at the University of Colorado at Boulder, soap films on bubbles made of glycerin and dish soap were photographed in order to observe these different colors.

Visualization and Photographic Technique

The following materials were used to create the soap film image: glycerin, dish soap, dish, straw, matte black paper, matte black poster board, white poster board, soft box with incandescent bulb and a Nikon DSLR camera. The soap bubbles were created inside of a small clear dish (cut off of cup) by blowing air through a straw into a glycerin/dish soap solution in the dish. The glycerin is added to allow the bubbles to last long enough to be photographed. This dish was resting on a piece of matte black paper and had a matte black poster board behind it as a cohesive background. The image was lit using an incandescent bulb in a soft box. The light was bounced off of a white poster board in order to further diffuse it and prevent reflections from showing up on the bubble. The setup is shown below in Figure 1.

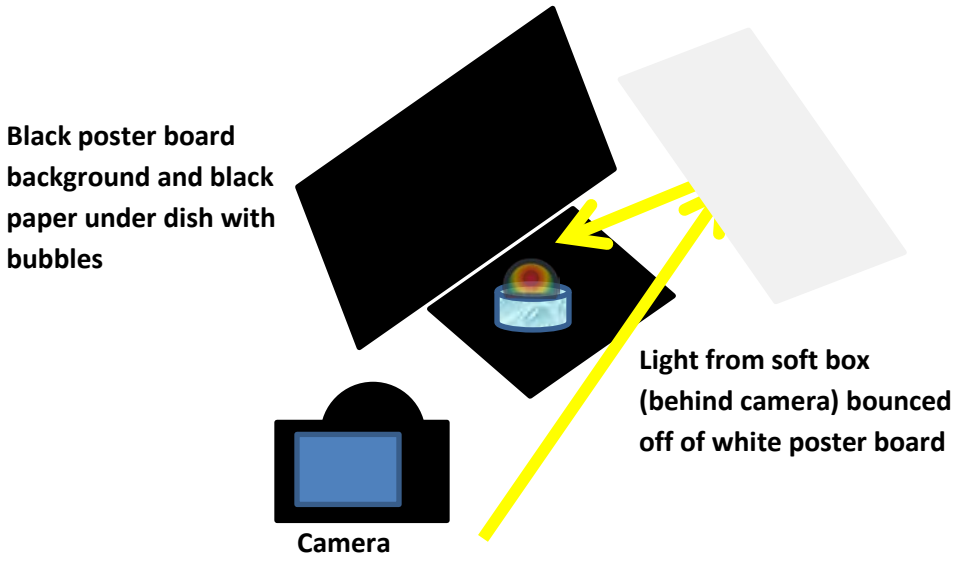

Figure 1: Setup

The camera used to take this photo was a Nikon D5200 DSLR using an f-stop of 5.6, exposure time of 1/20 s, focal length of 55 mm and an ISO of 252. The photo was taken in manual mode in order to be able to precisely adjust the settings. The unedited image is shown below in Figure 2. It is underexposed, so if this photograph were to be replicated, a higher ISO would be recommended.

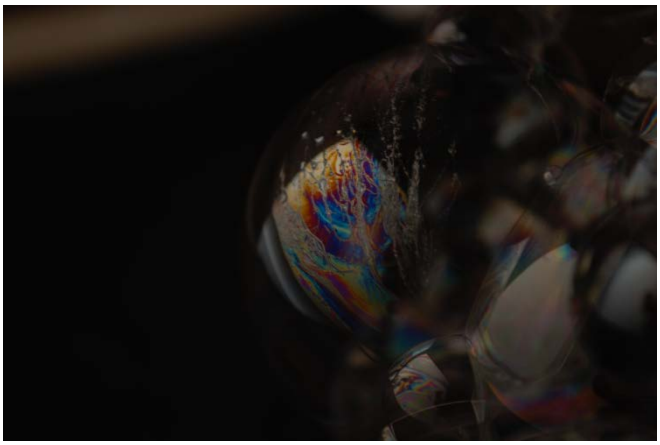

Figure 2: Original Image

The image was cropped in post-processing using the rule of thirds such that the largest bubble was more prominent. The colors were adjusted using Curves to correct for the underexposure. Unsharp Mask was also used in order to bring out the borders of the colors and highlight the dried glycerin on the top of the bubble.

Description of Fluid Phenomenon

The different colors on the soap bubble are caused by destructive interference of reflected light. When there is a soap film, there are two waves that are reflected off of the film, one off the top of the film and one off of the bottom of the film. This small difference in distance caused by the thickness of the film and the speed with which the light travels through the soap compared to air caused the waves to be out of phase when they recombine. When they are out of phase, destructive interference occurs and different colors are seen. Constructive interference, which reflects white light, and destructive interference are shown in the figure below.

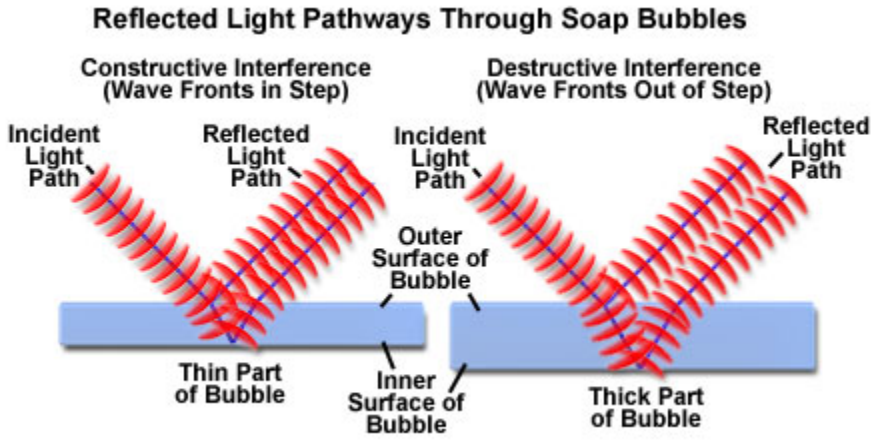

Figure 3: Soap Film Interference Diagram[3]

The following equation relates wavelength to thickness for destructive interference[2].

$$2n_2 d\cos(\theta_2) = m\lambda$$

In this equation, d represents the thickness of the film, m is an integer, λ is the wavelength of the light in the film, and n_2 is the index of refraction, which is a specific number describing how light propagates through a medium. The angle θ_2 is shown in the following diagram.

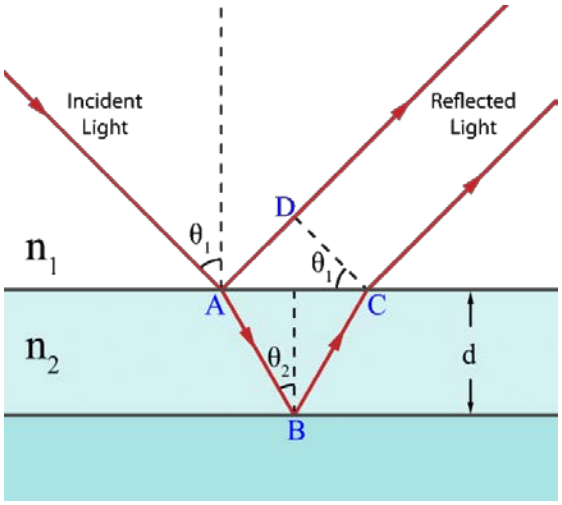

Figure 4: Destructive Interference Schematic[2]

Soap films correspond to wavelength roughly as shown in the figure below. The illuminant D65 is a standardized light source that mimicks daylight. The index of refraction "n" is a number that describes how light propagates through a specific medium. Based on this plot and the image of the bubble, the thicknesses of the bubble photographed were between approximately 190 to 500 nm.

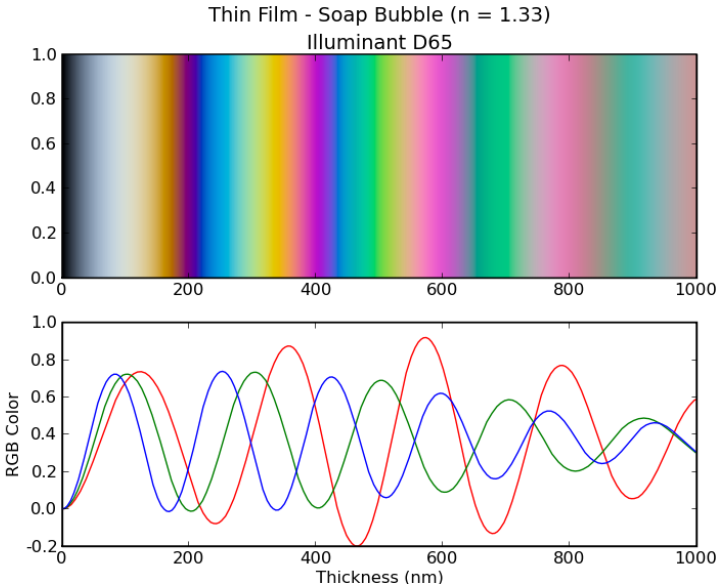

Figure 5: Wavelengths of Light Corresponding with Thickness of Soap Film[3]

Discussion and Reflection

This image fulfilled the intent of viewing different thicknesses on soap films via the different wavelengths of light reflected off of them. Photographically, the image was well-resolved and clearly showcased the soap film colors. If this image were to be replicated, it could be improved by increasing the ISO to prevent it from being underexposed.

References

[3] "Molecular Expressions Microscopy Primer: Light and Color - Interference Phenomena in Soap Bubbles: Interactive Java Tutorial." *Molecular Expressions Microscopy Primer: Light and Color - Interference Phenomena in Soap Bubbles: Interactive Java Tutorial*. N.p., n.d. Web. 10 Mar. 2014.

[2]"Thin-film Interference." *Wikipedia*. Wikimedia Foundation, 28 Feb. 2014. Web. 10 Mar. 2014.

[1] Kness, Mark. "ColorPy." *ColorPy*. N.p., n.d. Web. 10 Mar. 2014.