Flow Visualization Team Project #2

Giant Soap Films

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The purpose of this project was to capture the fluid phenomenon of giant soap films. The point of experimenting with large bubbles was to investigate unique shapes and features that are present in large bubbles that typically don't exist when viewing small bubbles. It was necessary to have a group in order to do this project because several roles needed to be filled. The group members who assisted me in this project are: Daniel Allen, Jeremy Parsons and Anna Gilgur. The photo was taken by one member of the group as another member created the bubble from a homemade wand. Simultaneously, a third member of the group attempted to give a white background to the image by holding a poster board behind the film. Communication and group effort was used efficiently to allow all members to capture a more complex fluid phenomenon than what could have been achieved individually. This image submitted was created for Flow Visualization in spring 2013 taught by Professor Jean Hertzberg.

This report will explain the process followed to create the bubbles in addition to the physics behind what is happening and the camera techniques used to capture the image.

The solution used to create the bubbles was Bubble Fun soap, made primarily of soap and water. Research from our group suggested adding glycerin to the solution would allow the bubbles to last longer and the group could achieve bigger soap films. In general, a three-layered film is what creates bubbles. A thin layer of water is spread between two layers of soap molecules. Each soap molecule is oriented so that its polar (hydrophilic) head faces the water, while its hydrophobic tail extends away from the water layer[1]. This can be seen in the figure below where the blue circles represent the water molecules and red circles represent the hydrophilic heads of the soap molecules with their corresponding hydrophobic tails pointing away:

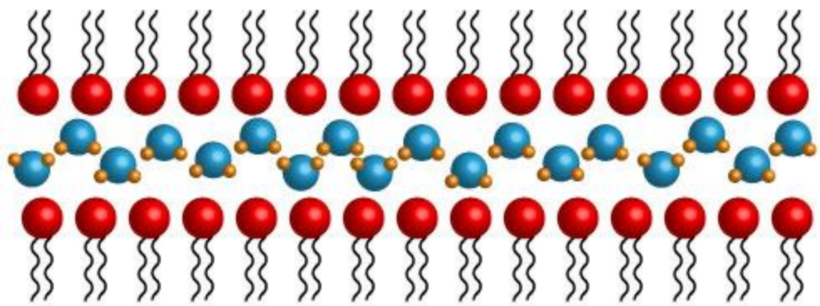

Figure 1 - Three-layer film of soap and water

An interesting observation to note is bubbles always become spherical because the shape of a sphere minimizes the surface area of the structure more than any other shape. This requires the least amount of energy to achieve. The picture in this report has a very unique shape because it was captured immediately after formation. Shortly after capturing the image, the bubble took on a spherical shape. This spherical shape results in a large surface tension which allows the bubbles to form and last for a period of time. The expression relating the size of a bubble to the surface tension is Laplace's equation and has the following form[2]:

$$T = \frac{PR}{2}$$

where:

T = surface tension

R = radius of bubble (assuming it is a sphere)

P = internal pressure

If examined closely, the bubble in the picture shows the reflection of some trees and clouds in the sky. Additionally, there are several colors that appear on the soap films and you can see through the bubble which appears to almost magnify the image. This is because light incident upon a surface will in general be partially reflected and partially transmitted as a refracted ray. Refraction is the bending of a wave when it enters a medium where its speed is different. The refraction of light when it passes from a fast medium to a slow medium bends the light ray toward the normal to the boundary between the two media[3]. The amount of bending depends on the indices of refraction of the media and can be represented by Snell's law:

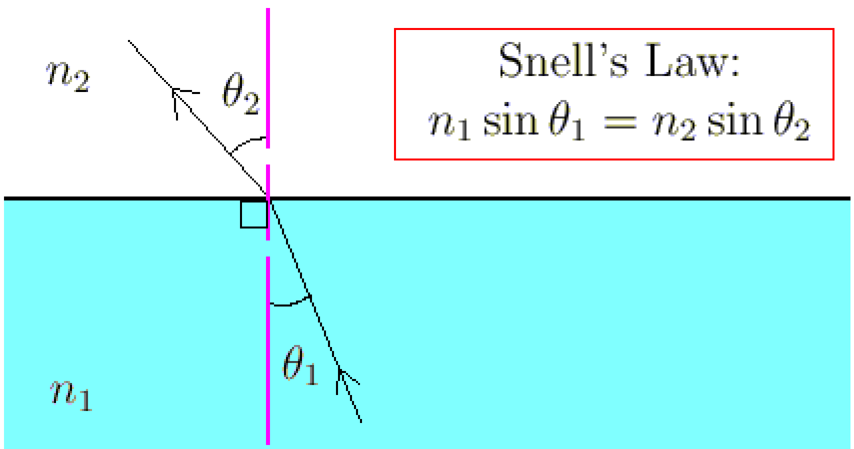

Figure 2 - Diagram showing Snell's Law

This explains the magnification of looking through the bubble. The colors of the visible spectrum seen in the bubble are a result from interferences. The soap films are as thin as the visible light wavelength. This creates iridescence. Each color is the result of varying thicknesses of a soap bubble film. As time goes by after the bubble is formed, the films move around as the liquid begins to evaporate. As the films move, colors change everywhere on the bubble and appear as different colors when viewed from different angles.

The visualization technique used as discussed before is a three-layer film under direct sunlight. The materials used to capture this visualization technique were: a piece of yarn (about 4-5 feet in length), two wooden dowels (about 2 feet in length), duct tape, a washer/nut, and bubble solution (Bubble Fun brand) with the addition of a couple ounces of glycerin. The wand was easily constructed from these materials. The long piece of yarn was taped to the top of each wooden dowel to form a circular shape. A nut was placed on the yarn between each dowel to give weight to the yarn ensuring it would maintain the circular shape. A diagram of the final product can be seen in figure 3 below. To make the giant bubbles, the wooden dowels were held closely together in each hand and the yarn fully submerged in a container holding the bubble solution. The dowels were then separated and the subject slowly moved to create the bubbles.

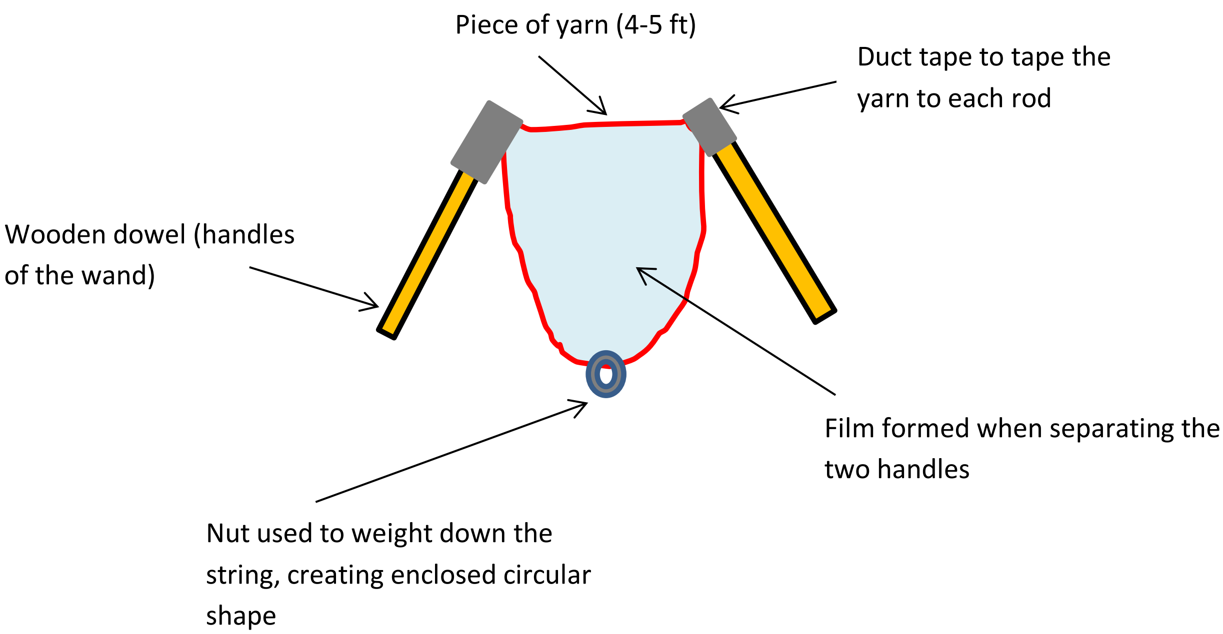

Figure 3 - Diagram of apparatus used

There were no flash used on the camera or any additional lighting techniques used besides direct sunlight. The bubble shows several clouds in the sky that may have passed over during this picture, although it was an extremely bright day for the most part.

The following photographic techniques were used:

Size of the field of view	About 4 feet across by 3 feet tall
Distance from object to lens	Approximately 3 feet
Lens focal length	45.0 mm
Type of camera	Canon EOS Rebel T3
Aperture/Shutter Speed/ISO setting	F 5.0 - 1/500 sec - 100
Final image Width x Height	1024 x 682 pixels
Photoshop editing	• Cropping to remove distractions • Use of “curves” tool to increase contrast

The contrast was increased to really bring out the iridescence of the image. The reflections of the clouds and trees can still be seen on the image, but the purple, green and red colors really pop from the image. I believe I almost increased the contrast a little too much because it takes away from the crisp resolved edges of the bubble. The image was cropped to obviously remove the group member's body and other distracting features that draw attention away from the bubble. The original image and final image can be seen in the pictures below:

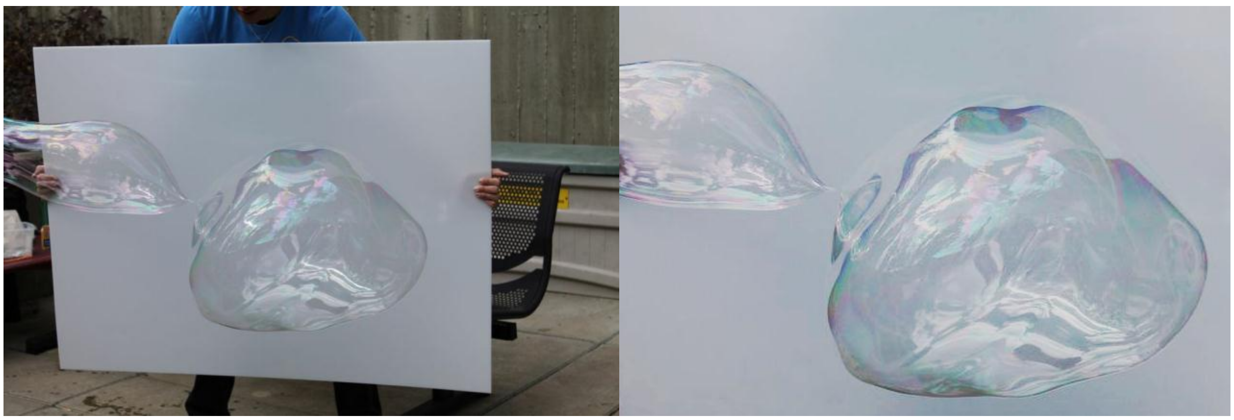

Figure 4 - Before and after editing image

The image reveals several different effects of light as well as interesting fluid phenomena. The bubble shows reflection and refraction of sunlight as well as interferences that contribute to iridescence and show colors of the visible spectrum. What was very interesting to see is that the colors changed over time as the thickness varied in different parts of the bubble. It is often mistaken that soap increases the surface tension of water which allows bubbles to be made where in fact the soap decreases the surface tension[3] and molecules spread out evenly. This also helps explain why bubbles make a spherical shape to reduce the surface area as much as possible while enclosing a volume of gas. Extremely interesting shapes and other unique features could be achieved in this experiment and every image submitted by the group is original and different. I would be interested in trying to capture a close up image of a bubble that shows the film and iridescence even more. If I were to repeat this experiment, I would use an object that would help scale the image and show how large the bubbles were. Alternatively, I think some great pictures could be taken if smaller bubbles were created in a controlled environment with proper lighting. The scene could be set a lot better and background set as opposed to attempting to run alongside of the big bubbles with a poster board.

References

1. "Bubble Science." About.com Chemistry. Web. 4 Apr. 2013. http://chemistry.about.com/od/bubbles/a/bubblescience.htm>.

2. Rankin, Ryan C. "The Physics of Bubbles." N.p., n.d. Web. 04 Apr. 2013. http://ffden-2.phys.uaf.edu/311_fall2004.web.dir/Ryan_Rankin/titlepage.htm

3. "Surface Tension and Bubbles." *HyperPhysics*. Department of Physics and Astronomy, n.d. Web. 04 Apr. 2013. <http://hyperphysics.phy-astr.gsu.edu/hbase/surten2.html>.