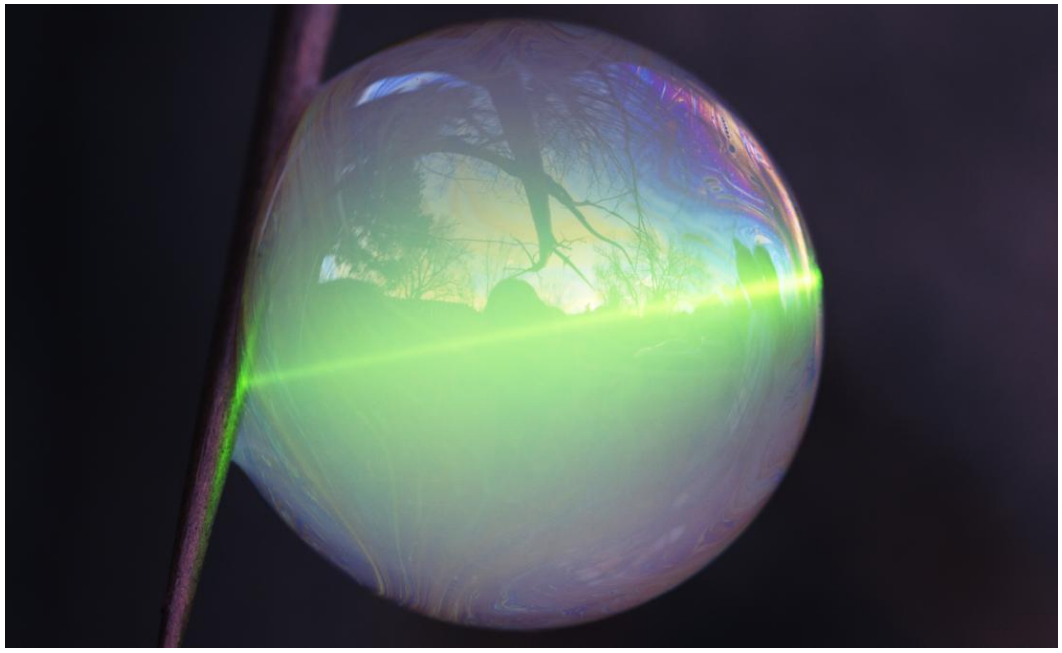
Steven Hendricks **2-5-2011**

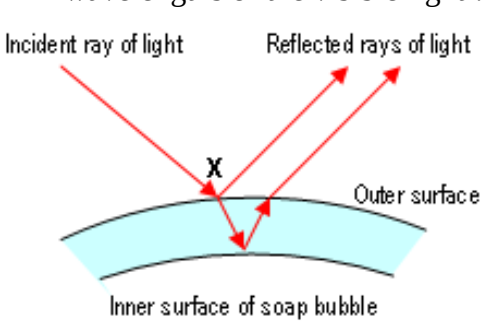
Get Wet Report **Flow Visualization**

Laser Bubble World



The 'Get Wet' project was the first assignment for the spring 2011 Flow Visualization class at the University of Colorado, Boulder. The goal of this project was to capture a detailed and quality image of any range of fluid phenomena occurring. Initial ideas revolved around capturing surface tension in paint, but initial testing proved very difficult. After brainstorming with my lab partner Mr. Kim, we decided to try a new experiment with a combination bubble/fog machine and a laser pointer. The machine was set up outside at dusk on January 30th 2011 and various methods of capturing the bubbles and fog were attempted with a digital camera.

Fog filled bubbles were created using the Bubble Fogger machine pictured to the right[6]. The machine was capable of creating many small bubbles very rapidly, however, the bubbles were ejected quickly and floated throughout the air unpredictably which made them difficult to capture on camera. After noticing that the bubbles could stick to thin objects, the machine was placed at the base of a tree in a small bushy area. This allowed several small bubbles to land on the thorns and branches provided by the tree. Once a bubble landed, it sat there for about 10 seconds as the gravity pulled and thinned the soapy film across its surface which caused an iridescent pattern to swirl and shape itself across the exterior. The iridescence was caused by multiple reflections in the different thicknesses of the semi-transparent bubble wall which caused interference in the wavelengths of the visible light[3]. Upon close inspection of the bubbles, and especially noted when using the macro lens, was the reflection of the environment on the surface of the bubble which was distorted by the spherical shape of the bubble and reduced to shadows. The diagram to the left shows how the light is refracted through the wall of the bubble and also reflected from the inner and outer surfaces of the bubble[4]. As the sun descended over the flatirons the laser pointer was used to provide another light source on the experiment. The photon diffusion provided by the fog on the laser beam within the bubble, combined with the natural lighting in the environment, made for a surreal and



atmospheric effect which seemed ideal for presenting the different interactions of fluids with light. In this case, the particulate matter which made up the fog was scattering and absorbing the light from the laser beam[1-2]. Once the laser pointer was used, the pictures turned out well on the camera, and shortly after, the image for the project was captured.

The Bubble Fogger machine and its liquid components were crucial to the success of this experiment and the capture of the photos. The machine has two separate compartments and mechanisms: In the front is a compartment for a store bought soap/water mixture and a mechanical bubble wand, and in the back of the machine is a tank for a glycol/water mixture which is run through a heat exchanger and then blown through the bubble wand. As the fog fluid was vaporized it turned into a thick white cloud inside the bubbles. Caution and safety must be emphasized when using this device as it contains liquids in close proximity to electrical components and risk of shock or fire is heightened. During my photograph, the bubble fogger was connected to an extension cord set up stably on the patio in the front yard of the house.

Using the macro lens on the Canon EOS Rebel T2i I was limited to photographs without much movement; this is why the bush set up was used. The bubble was between 1 and 1.25 inches in diameter and the thorn seen in the photo was about three inches in length. I held the camera with both hands and once a bubble landed on a thorn I would bend down and try to capture it. The depth of field and focus were difficult to adjust before the surface tension broke and the bubble popped, but some bubbles lasted longer than others. For this photo, I held the lens of the camera within 2 inches of the bubble and the camera data supports this with a focal length of 100mm. According to the camera data file, the shutter speed was set to 1/125 sec, the f-stop and aperture value were set to f/5.6, while the ISO was set to a speed of 400. During a particularly calm moment one bubble allowed Jaewon time to aim the laser pointer down the center as I simultaneously coordinated a photo of all of the events happening at once. Once the photos were taken, Photoshop CS3 was used to view and edit the images. The photo shown below is the original photograph used for the submission of this assignment. I used Photoshop to crop the image to 5492 pixels wide by 3365 pixels high and since the diffusion of the green laser light was dominant in the original photo I used the curves feature to even out the blue and red hues in the image. This provided better contrast with the background and showed more detail in the iridescence on the surface.

This image is dramatic and thought provoking for me for several reasons. At first it reminds me of a distant planet that is floating in space but then I remember it's a bubble and the science and fluid dynamics start to fill my mind. The image shows multiple interactions of fluid phenomena with light simultaneously and cohesively while the spherical shape and fragile nature of the bubble are balanced by the jagged edges and sharp lines from the tree. Overall I'm pleased with the resulting photographs and I really had fun performing the experiment with Jaewon and the bubble machine. Next time I wish to find some fluorescent dye which is sensitive to ultraviolet light and add it to the fog mixture then, if we have some UV lights, we will see many glowing spheres.

Works Cited

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[4]Knott, Theresa. "Soap Bubble." Wikipedia (2011): http://en.wikipedia.org/wiki/Soap_bubble.

[5]Oprea, John. The Mathematics of Soap Films. Chicago: America Methematics Society, 2000.

[6]WooHome. "Bubble Fogger Photo." http://www.woohome.com/wp-content/uploads/2008/09/bubble-fogger-machine-1.jpg 2008.