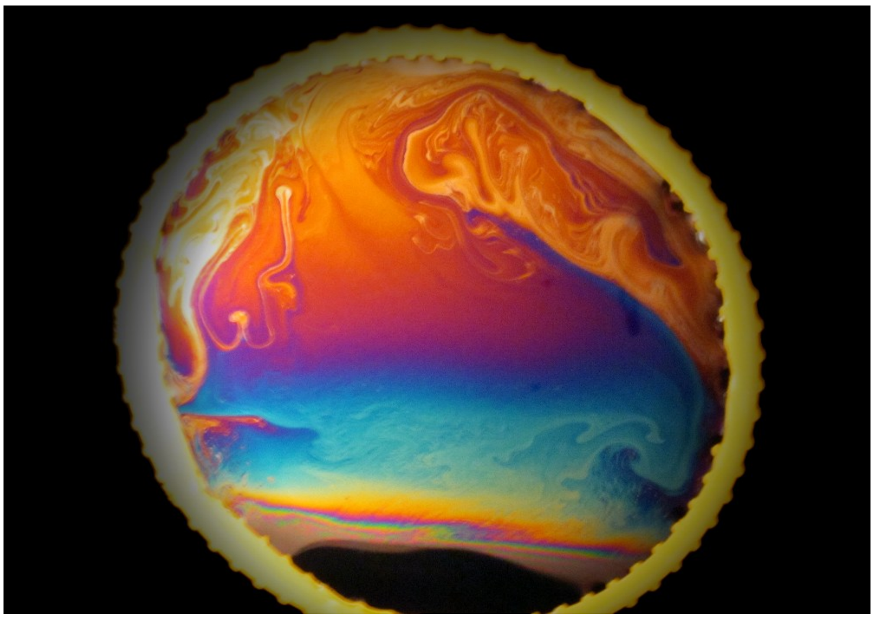
Team Assignment #1

George Seese



Team Members: Nicholas Travers, Doug Schwichtenberg, Ryan Kelley, Andrew Fish

George Seese

MCEN 4151/ ARTF5200

Team Assignment 1

Purpose

The image was taken to satisfy the requirements for the first team photo assignment for the Flow Visualization class at CU-Boulder. The image was selected based on two criteria: artistic value and adequate display of fluid physics. After considering several options, the team chose to use a thin film of soap as the subject of the image. Originally the team had intended to capture a phenomena known as critical fall in the image. However, it proved to be difficult to capture critical fall, and the team elected to use images of the soap film without critical fall, as it was determined that they were significantly more aesthetically pleasing, and they still displayed adequate fluid flow properties.

Image Setup

Several different setups were used before the desired effect was achieved. The team used several different soap mixtures, several different lighting methods, and a number of different objects to form the soap film. The selected soap mixture included water, dish soap, and glycerin. The mix was 1 part water, 2 parts dish soap, and 9 parts glycerin. The mix provided the longest lasting film of any mixtures that were tried. The object used to hold the film in the selected image was a commercially available bubble ring that was 4 inches in diameter. Others objects that were used in several pictures included a small metal lamp shade and a 5 inch diameter PVC pipe. The ring was initially held inverted. Once the team began to observe the colors of the film become visible the ring was rotated 180 degrees and placed into a metal base that was a set distance from the light source and camera. The rotation of the ring created the patterns that were visible in the image. In films that had not been rotated the colors formed uniform layers at first, then quickly broke down into random, non repeating patterns. The rotation is what created the “drops” that appeared in the selected image. Further the rotation was also important in the selected image because during the process of critical fall the top of the film turns black, however in this image the bottom is black; this is because it was originally at the top.

The physics in the image are due to gravity, diffraction and reflection from the thin film, and flows of varying densities interacting. The differences in color each show an area where the film is of a different density. The thickness determines the amount of the light that is reflected back to viewers eyes, as well as the angle that it is reflected at. Further, the waves can be bounced back out of phase, altering the visible color and the brightness of the films appearance. Figure 1 and equation 1 below show how the effect occurs.

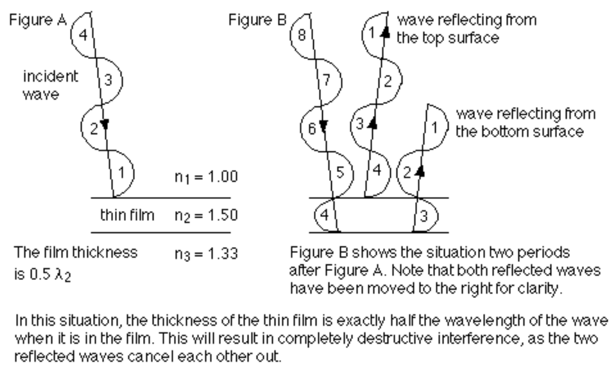


Figure 1 [1]

For constructive interference : $\Delta = m\lambda$ (m = an integer)

For destructive interference: $\Delta = (m + 1/2)\ \lambda$

Equation 1 [1]

The resultant phase shifts from this interaction an cause the wavelength to appear varied, providing different colors, or if the film is of the correct thickness to cause the waves to be completely out of phase, the result will be a black image, as seen at the bottom of the image. The interference wavelengths listed in the equations above can be found using the equation $\lambda_{film} = \lambda_{vacuum}/n_{film}$.[2]

Photographic Technique

The flow did not have any dyes added to it, as all of the colors were achieved due to the physics described above. The setup to capture the image proved to be slightly complicated and required trial and error to acquire the desired results. The lighting that was used was diffuse lighting. The desired light level was achieved by placing a 40 watt desk lamp behind a thin sheet of white plastic. The light was placed at an angle, and the camera was placed at approximately the same angle on the opposite side of the soap film. A black sheet of paper was placed behind the film ring to ensure that there was a flat black background with no distracting elements. A diagram of the setup is visible below in Figure 2.

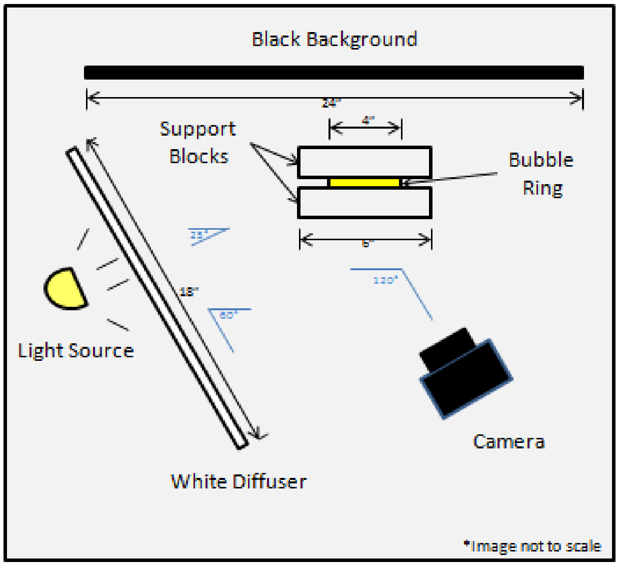


Figure 2

The camera that was used to capture the image was Canon SD1300. It is capable of taking 12 megapixel images. The ring in the image is 4 inches in diameter, meaning that the field of view of the image is around 5 inches across. The distane from the subject to the camera is approximately 16 inches, although the optical zoom was activated. The zoom was used both due to space constraints that limited where the camera could be setup and because it allowed a longer focal length if it was necessary. The focal length that was used was 20mm. The f value was 5.9. The ISO setting that was used was 800 due to the low light conditions. The high ISO allowed a slightly lower shutter time of 1/8 seconds. The ISO could not be decreased because the film was still moving when the images were captured and slight motion blur became apparent when using the longer shutter times that were required. In addition, the image did not suffer from significant noise at the ISO used. The camera aperture was 5.125.

Conclusion

The image shows both the result of flows of different densities interacting and the physics of light interacting with a thin film. Though it did not capture the originally intended effect, the physics that it did not capture were adequate, and the photo turned out to be highly aesthetically pleasing and artistic. In future images, it would be beneficial to spend more time adjusting lighting and angles to avoid areas that were over exposed, although editing was able to eliminate the issue in the selected image. Prior to editing, the ring was too bright and dominated the picture, in future images it would be advisable to use a darker colored ring if the intent was include the entire ring. In images that were shot that only focused on the flow in the middle the ring color is not an issue. Overall, the image accomplished the desired goals.

References

1. "Diffraction and Thin Film Interference." *Boston University Physics Department*. http://physics.bu.edu/~duffy/py106/Diffraction.html
2. "Thin Films." *Wikipedia*. http://en.wikipedia.org/wiki/Thin-film_interference