Get Wet Report

MCEN 5151: Flow Visualisation
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Introduction

The Get Wet assignment was to experiment with different flows to develop a visualization that demonstrates flow phenomena. In the image air was blown into a small bowl with soapy water to create small bubbles. The image captured for this report depicts thin film effects of the contact points between soap bubbles in a small bowl.

Setup

Shown in Figure 1 is the test setup consisting of a shallow bowl and LED ring light. In order to diffuse the light and avoid harsh glares on the flow, the light was pointed up and away from the bowl at the white wall behind the counter. The lighting setup could probably be replaced with a proper diffused lighting setup to achieve the same results. To capture the image, the camera was approximately 12 inches away from the bowl and 40∘ above the bowl. The bowl itself has a 3.5 inch diameter with a 2.5 inch depth.

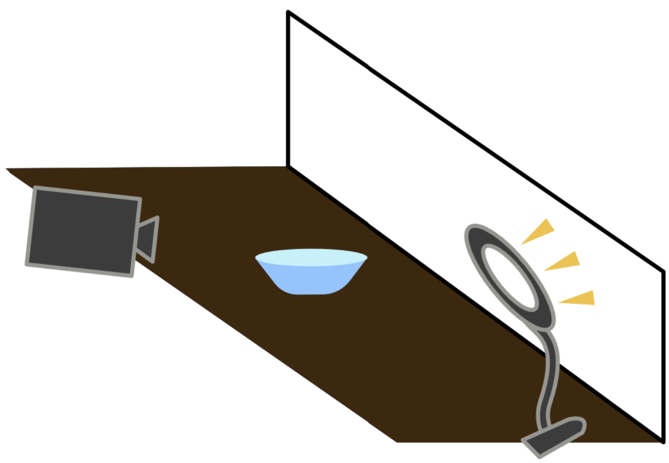

Figure 1: Test apparatus setup showing light placement, bowl and camera

Fluid Dynamics

Thin-Film Interference

The rainbow colors in the image are due to the thin film interference and the index of refraction (IOR) of the soap solution. When incident light hits the surface, part of it reflects directly to the observer (ray 1). The rest of the light travels through the film (n_2) and is reflected back through the film. However, as the light leaves the film, it refracted back to the observer. In the case of the soapy water solution used in the experiment, n_1= air, n_2= soap molecules, n_3= air.

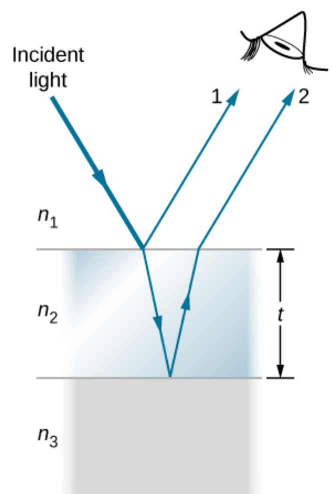

Figure 2: Directions of light refraction for thin film effects (LibreTexts, 2025)

To connect the rainbow colors to the thin film effects, let's introduce the index of refraction (IOR). The IOR of a material is a dimensionless number that indicates how much the material slows down and bends light. A key rule to remember is the higher the IOR the slower light moves and the more it bends. This bending of light is what causes colors to shift to human observers. Thus when the light bends through the soap film (n_2) and bends back when the light exits the film, the colors shift. How much the light bends and shifts depends on the wavelength the light reaches in the medium in the equation:

$$\lambda_n = \frac{\lambda}{n}$$

Where λ_n is the wavelength in the medium, λ is the wavelength in a vacuum, and n is the IOR (LibreTexts, 2025). Using this equation and more we can develop a relation between the color and the thickness of the film (Istenberg, 1992).

Color	**Film Thickness (nm)**
Bright green	700
Bright Blue/Indigo	600
Magenta	500
Yellow	450

Light blue/dusty indigo	300-250
Dusty yellow	150 nm

Marangoni Effect

Another key fluid dynamic concept to examine in the image is the Marangoni effect which takes place in a gradient of surface tension. Liquids with high surface tension pull on surrounding liquid with low surface tension, creating a gradient and causing the fluid to naturally flow from low to high surface tension (Sternling, 1959). Recalling Isenberg's color to thickness relations, light green, bright indigo, and pink colors on the film correspond to thicker films. Not surprisingly on the captured image, particles can be seen flowing from the areas with thicker films to areas with thinner film colors (dusty indigo and yellow).

The turbulence in the film can be explained by hydrodynamic instability or interfacial turbulence (Sternling, 1959). Interfacial turbulence has been found to have high rates of mass transfer which stabilize the bubble to prevent popping (Sternling, 1959).

The Managroni number measures the ratio of surface tension forces to viscous forces. An estimate of the Marangoni number is below.

$$Ma = \frac{\Delta\sigma L}{\mu D}$$

$$Ma = \frac{(\sigma_{water} - \sigma_{soap})L}{\mu D} = \frac{(0.072-0.025)(0.025)}{(10e-3)(5e-10)} \approx 10^{8}$$

The high Managroni number indicates the fluid dynamics are dominated by surface tension forces.

Visualization Technique

The visualization technique involved minimal setup and relied heavily on lighting and positioning of the camera. To achieve the soap solution, 75ml of water, three drops of Dawn dish soap, and a pinch of cornstarch were stirred together in the bowl. When no more soap was at the bottom, the end of a straw was fully submerged in the solution and air was blown in to create bubbles. The straw had a 6mm diameter opening. This technique produced many small bubbles, with the largest being 1.5 inches in diameter.

To light the shot a LED desk lamp was pointed up and away at a white wall to diffuse the light around the test setup. Once the bubbles were set, the camera was angled roughly 40∘ above the bowl.

Photographic Technique

Camera Settings and Reasoning

The main goal when capturing my image was to have a clear focus of the flow phenomena with minimal glare. The AV setting was used for simplicity along with aperture set to f/5.6 to have the flow phenomena be the focus of the shot. Shutter speed and ISO were automatically set for the exposure to be balanced.

Camera	Canon EOS Rebel T7
Lens	Canon EFS 18-55mm
Aperture	f/5.6
Shutter Speed	1/80 sec
ISO	1000
Focal Length	55 mm

Post Processing
The most important post processing on the image was cropping to have the fluid dynamics be the focus of the image. The original photo shown in Figure 3 indicates the cropping of the final image. The original image dimensions were 6020 x 4015 and the final image dimensions are 3520 x 2347.

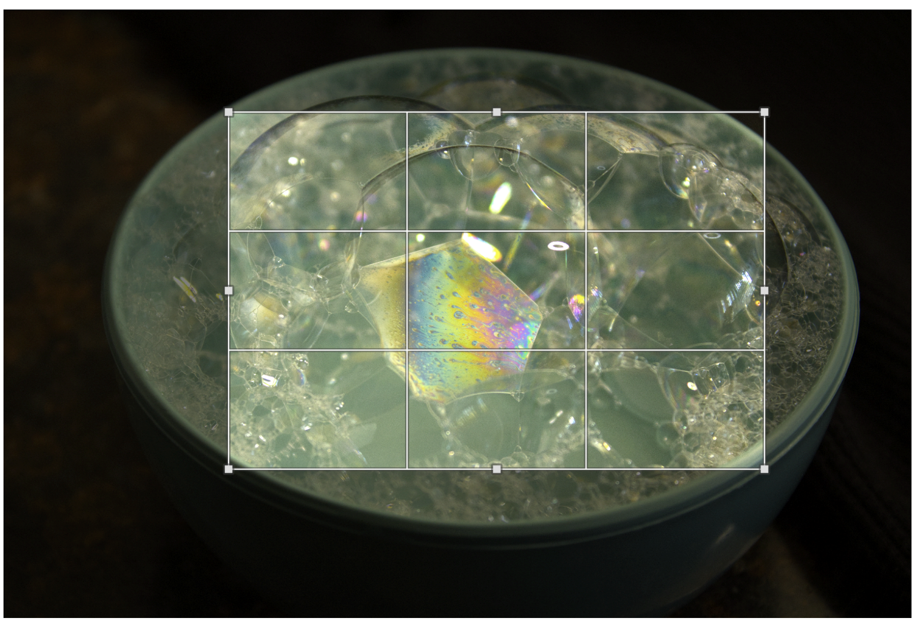

Figure 3: Original uncropped image

Additionally the vibrance and saturation of the fluid dynamics were increased to make the visuals stand out against the background.

Conclusion

This image reveals the wonderful visualisation of the Managroni effect and optical distortion in soap film. My favorite part of the image is the irregular shape that contains the interesting fluid dynamics. With all the contrasting clear bubbles around it, it looks like a portal or fragment of a different planet. One aspect I would like to improve is the resolution of the image. Because the final image is heavily cropped, I would have liked to take a closer picture of the bowl to preserve some resolution. Overall, I'm happy with the final image and its visual impact.

Sources

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