2020 Fall Image-Video 1

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I. Introduction

The purpose of this picture was to explore a concept in flow visualization of our choosing to understand more about fluid photography and its challenges. I choose to research the concept of the Rayleigh-Taylor instability affect. Rayleigh-Taylor instability is when two fluid of different densities interface and the lighter fluid pushes on the lighter fluid. This concept can be seen in a variety of combinations of fluids including water and oil combinations as well as water and ink. To create the photo that will later be analyzed in this report, I used the help of my friend and classmate Colton Oglesbee. I was fortunate enough to use be able to use the professional photography set up at Colton's workplace that included a white backdrop and lighting. Colton was also a huge help in holding one of the three ultra-violet lights directly above my set up. He was also the extra pair of hands to drop the highlighter ink into the water. The following report shows the experimental set-up, the physics behind the phenomenon, and the techniques used to achieve the image.

II. Set-up and Materials

The materials used in this photograph was tap water, yellow highlighter ink, and a stemless wine glass. The set up was in a dry room of a warehouse with no natural light and with the florescent lights off. The only source of lighting was three handheld ultraviolet lights with a rating of 398 nanometers. There was one light on each of the two sides of the wineglass perpendicular to the view of the camera, and with the third light directly above the bowl parallel to the water as seen in Figure 1 below.

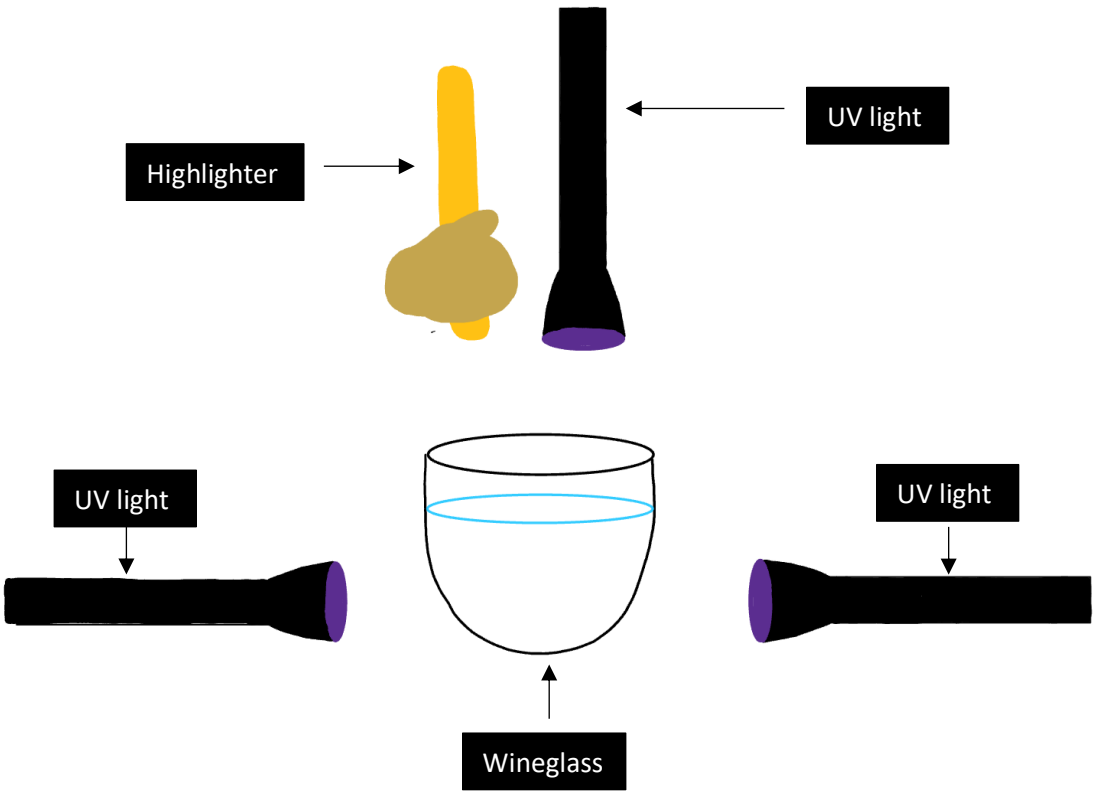

Figure 1: Experiment Set-up

The type of highlighter used in this experiment was a fluorescent yellow Sharpie brand highlighter. The active ingredient in Sharpie highlighters is fluoresceine which causes highlighter ink to show in black light [1]. To extract the fluorescent ink from the highlighter all you need to do is to remove the end cap and take out the tube located inside. The tube was pinched on one end to squeeze out the ink two three inches directly above the water filled glass. To achieve this photo three to four drops of ink where dropped into the glass in thirty second intervals.

III. Flow Phenomenon

This photograph is a prime example of Rayleigh-Taylor instability and shows the phenomenon of vortexes. Rayleigh-Taylor instability created in the photo occurred when a drop of one fluid, highlighter ink, settled in a fluid of a lower density, water. Gravity is the main reason behind this affect, it causes the higher density fluid to sink to the bottom of the glass. As the ink falls its velocity increases causing the Reynolds number to increase until it becomes unstable and chandeliers form. Equation 1 can be used to find this number and then used to suggest the type of flow seen.

$$(\mathbf{1})\ Re\ = \frac{U * D}{v}$$

Where U represents velocity, D is the diameter of the stream of flow, and v is kinematic viscosity. Using estimations for speed and the diameter of flow while looking up kinematic viscosity Equation 1 is used to find Re of the experiment[1].

$$Re\ = \frac{9.81\frac{m}{s} * .035m}{5.0x10^{-4}\frac{m^2}{s}}$$

$$Re\ = 686.7$$

The Reynolds number suggests laminar flow. This makes calculation does not make sense in the photo due to the turbulent plumes seen in the bottom of the picture. This would be due to the error in my estimations for velocity and the diameter of the stream of flow.

IV. Photographic Technique

The camera used for this image was a DSLR Cannon Rebel T7, which comes with a 0 to 55 mm zoom lens. The camera was placed about 4 inches away from the wine glass using the 55 mm zoom which gave the field of view of the camera to be 3x3 inches. The settings where set to the following specifications, F5.61 aperture value, 1/160 shutter speed, a ISO speed of 640, and using manual focus. These settings where used to compensate for the low lighting in the room. The original photograph can be seen in Figure 2 below which has 6020 x 4015 pixels.

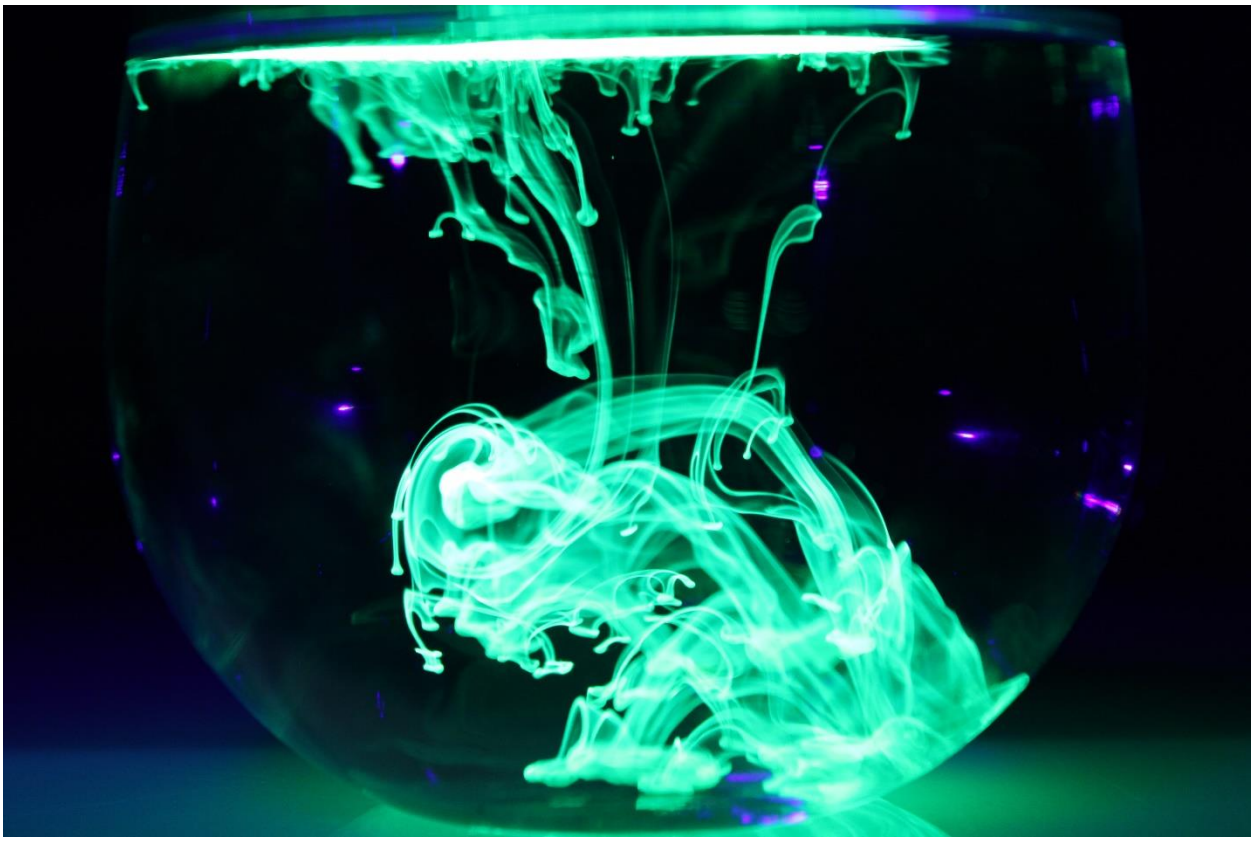

Figure 2: Original Photo of Highlighter Ink in Water

Post processing on this photo was done in Digital Photo Professional 4 by Cannon. The top of the glass was cropped out to remove the hot pixels from distracting from the fluid movement. To increase the contrast and to make the ink pop the highlighting in the photo was increased, the color tone was decreased, and then fine tuned the colors to make the green pop more. Finally, the photograph was inverted to make the fluid flow look like an artistic tree rising from the ground seen in Figure 3.

Figure 3: Post Processed Photo

V. Conclusion

This photo shows the phenomenon of Rayleigh – Taylor instability in both its laminar stage as well as the developed unstable region that creates the beautiful chandeliers shapes. The biggest challenge in achieving this photo was the need for more than two hands. Once a helper is acquired the hardest thing is making sure the camera is in focus. To improve upon this experiment, I would suggest using something solid to put in the glass to first set the focus. To further develop this experiment, I would suggest using multiple types of ink and maybe even different colors to see how they interact.

References

[1] "Highlighter Data Sheet." (n.d.): n. pag. Dokumental. 27 July 2011. Web. 26 Sept. 2020.