Team Second: Galactic Glitter

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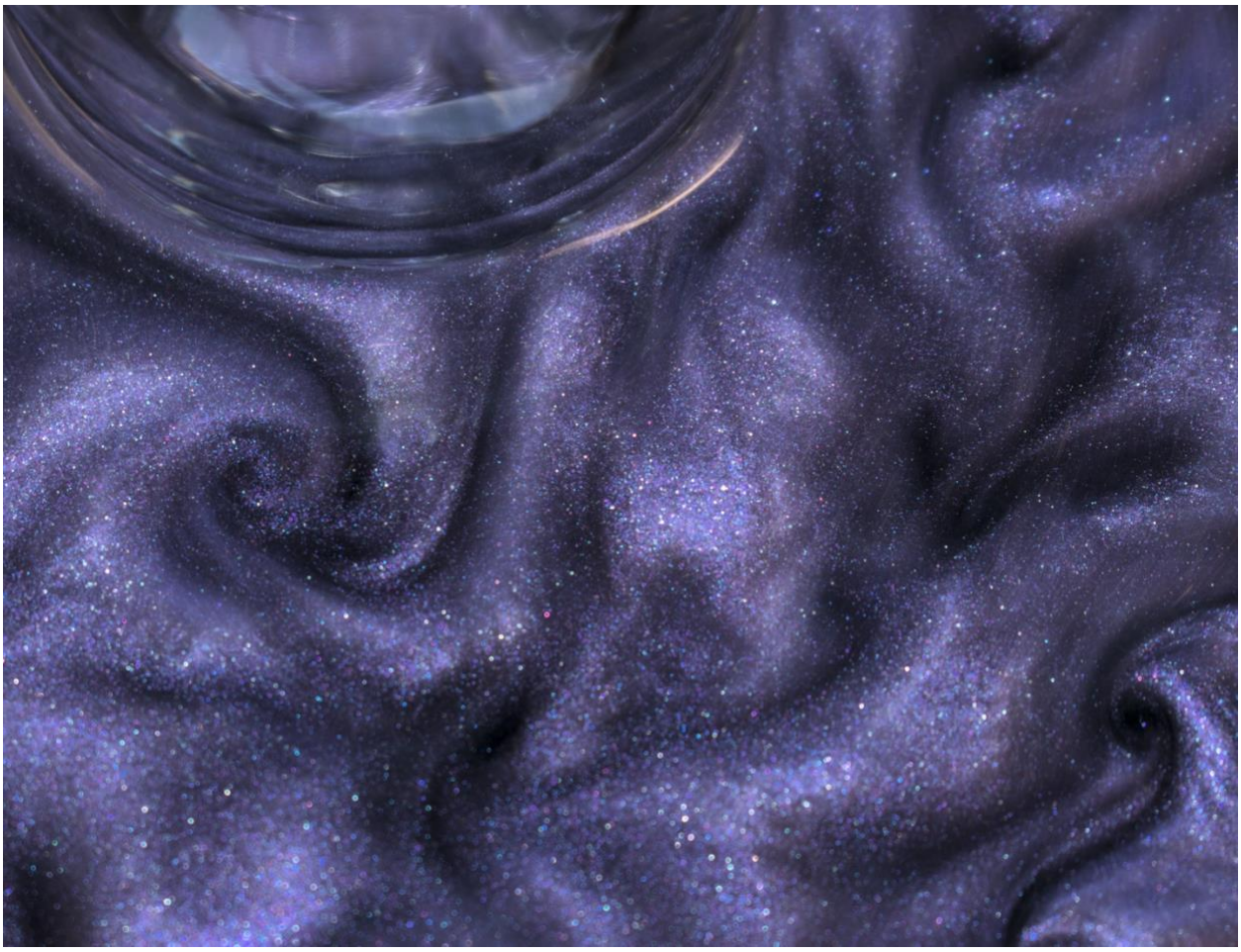

1 BACKGROUND

This image is representative of part of a video that was taken on October 22, 2023. The intention was to capture interesting flow with rheoscopic fluid, in this case edible glitter mixed with fluid. The goal was to capture interesting eddies and turbulent flow from the backside of an obstruction in a fluid flowing field. The experiment was done in collaboration with Avery Fails, Sarah Hartin, and Monica Luebke. Many different flows were captured with the rheoscopic fluid, this report will describe the eddies created and the fluid physics behind the image.

2 EXPERIMENTAL SETUP

This experiment was set up at the ITLL at the University of Colorado Boulder. The image was setup on a table in the ITLL. A mixture of fluid was poured and mixed into a Pyrex square container. The fluid was a mixture of Rosé Bubbles Underwood and water. The water was obtained from a tap in the ITLL. The Rosé Bubbles used can be seen in Figure 1. The fluid concoction was mostly water with about two ounces of Rosé Bubbles.

Figure 1: Rosé Bubbles Underwood used to create the fluid mixture for the image.

The mixture was poured into a square, clear Pyrex container shown in Figure 2.

Figure 2: Square Pyrex container that held the fluid.

Finally, three large pinches of edible glitter were added to the mixture to make it rheoscopic fluid that would be able to best display flow. The glitter used can be seen in Figure 3. This image used the violet color.

Figure 3: Edible glitter used to create rheoscopic fluid.

To create the flow, the fluid was stirred in a circular motion. A clear 1.5-ounce glass was then placed into the fluid to produce eddies. We wanted to mimic turbulent flow from the backside of an obstruction in a fluid flowing field. This image was taken from above. Figure 4 shows a diagram of how this image was captured.

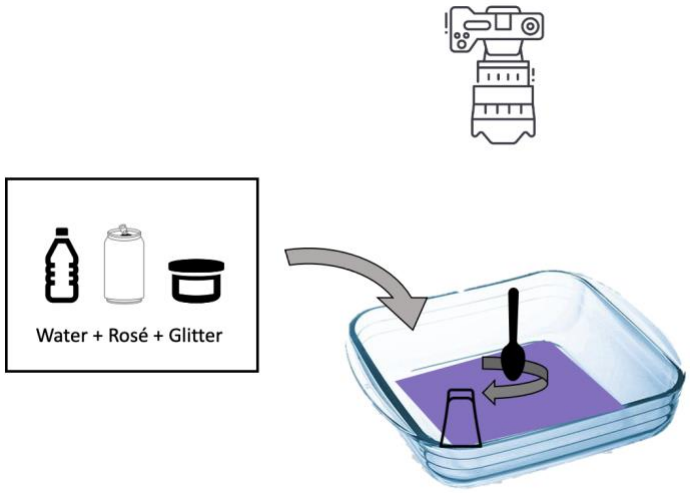

Figure 4: Diagram of the setup for this image. The rheoscopic fluid is mixed in its container and then the glass added.

3 PHYSICS OF THE FLOW

This photo shows chaotic eddies as well as vortices created by stirring the rheoscopic fluid. The turbulent flow produces flow instabilities in the fluid.

To calculate the Reynolds number of the stirred fluid, the diameter of the flow was utilized. The equation for Reynolds number is in equation 1.

$$Re = \frac{\rho V D}{\mu} \qquad \text{[Equation 1]}$$

The density in this instance is 998 kg/m^3. The viscosity is 0.001 Pa-s [2]. The diameter of the fluid pour was 0.229m and the velocity was 0.719 m/s. Once these values are plugged into Equation 1, we find that Reynolds number is 164,000. Since this is significantly above the boundary for less laminar versus turbulent flow, the flow can be categorized as turbulent flow.

The stirring of the fluid generated this turbulence in a single vortex in the middle of the Pyrex dish. Once the glass was added to the turbulent flow, the glass diverted the flow in the center of the dish toward the outside. This obstruction then created eddies and other flow instabilities within the fluid [3].

4 VISUALIZATION AND PHOTOGRAPHY TECHNIQUES

This photo was taken using marked boundary techniques [1]. The glitter is iridescent and when mixed with the fluid creates a marked boundary where the glitter is not. The separation is very pretty, and I think represents the physics well. The lighting to capture this photo was natural lighting created from the windows in the room as well as the flash from the digital camera that took the photo.

There was quite a bit of post processing done to this image to better highlight the flow without deterring from any of the fluid physics. I changed the color quite a bit to make it a darker purple. See Figure 5 for the final colors captured from Darktable.

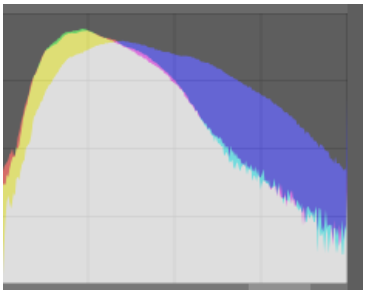

Figure 5: The final color arrays of my edited image after being post processed in Darktable.

In addition to altering the colors, I also increased the contrast to define the purple from the shadows of the black without glitter. I also cropped the image as to only capture the main eddie

in the center as well as the one in the bottom right of the image. I decided to keep the glass in the image to show what was creating the eddies and provide helpful context. The biggest change I made was to do some spot removal of the glare created by the glass that is in the center of the image. Figure 6 shows the edited and unedited images.

Figure 6: The image on the top is the unedited picture and the bottom is the edited photograph.

The unedited image is 5,980 x 3,980 pixels. The edited image is 1,531 x 1,166 pixels. The spatial resolution of this image on the order of two because the ratio is about $1{:}10^2$, therefore is two decades. When this image was captured, the fluid was stirred, creating a motion blur. Due to the blur, this image is not time resolved, it instead has time averaging creating some of the blur [1].

The Camera used was a digital Nikon D5500 camera on a Nikkor 18-55mm lens with a focal length of 55mm. The ISO was set to 200 and the f stop at f/5.6 and the shutter speed of 1/16s. The focus was manual focus.

The camera was less than a foot away from the surface of the liquid and the field of view was 8 inches.

5 CONCLUSION

Using marked boundary techniques, this image is able to reveal some beautiful eddies. Turbulence of flow around an object is represented using the rheoscopic fluid made with edible glitter, water, and canned Rosé. I am proud of how this image turned out, especially due to the post processing that eliminates the imperfections. I like how the image looks like a galaxy and overall, quite nebulous. The one thing I dislike is that I wish there were even more eddies because that would show even more fluid physics. I think the fluid physics are shown very well. I am curious how much impact the glass had on the flow, or if it was just the mixing of the fluid that generated the eddies. I would improve by repeating the experiment even more times to capture even more variations of this flow. All in all, this image fulfilled my intent well by using glitter to highlight physics in a glamorous way.

6 ACKNOWLEDGEMENTS

This photo was captured with assistance from Avery Fails, Sarah Hartin, and Monica Luebke.

7 REFERENCES

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[2] Edge, Engineers. “Water - Density Viscosity Specific Weight.” *Engineers Edge - Engineering, Design and Manufacturing Solutions*, www.engineersedge.com/physics/water__density_viscosity_specific_weight_13146.htm#:~:text=Water%20has%20a%20viscosity%20of,centipoise%20at%2020%20%C2%B0C.&text=where%20A%3D2.414%20%C3%97%2010,boiling%20point%20is%20listed%20below.&text=Pure%20water%20has%20it’s%20highest,%3D%201000%20kg%2Fm3. Accessed 10 Nov. 2023.

[3] M.M. Zdravkovich, Conceptual overview of laminar and turbulent flows past smooth and rough circular cylinders, Journal of Wind Engineering and Industrial Aerodynamics, Volume 33, Issues 1–2, 1990, Pages 53-62, ISSN 0167-6105, https://doi.org/10.1016/0167-6105(90)90020-D. Accessed 10 Nov. 2023.