First Team Report

Rob Drevno

MCEN 4151-001: Flow Visualization

Mechanical Engineering

University of Colorado, Boulder

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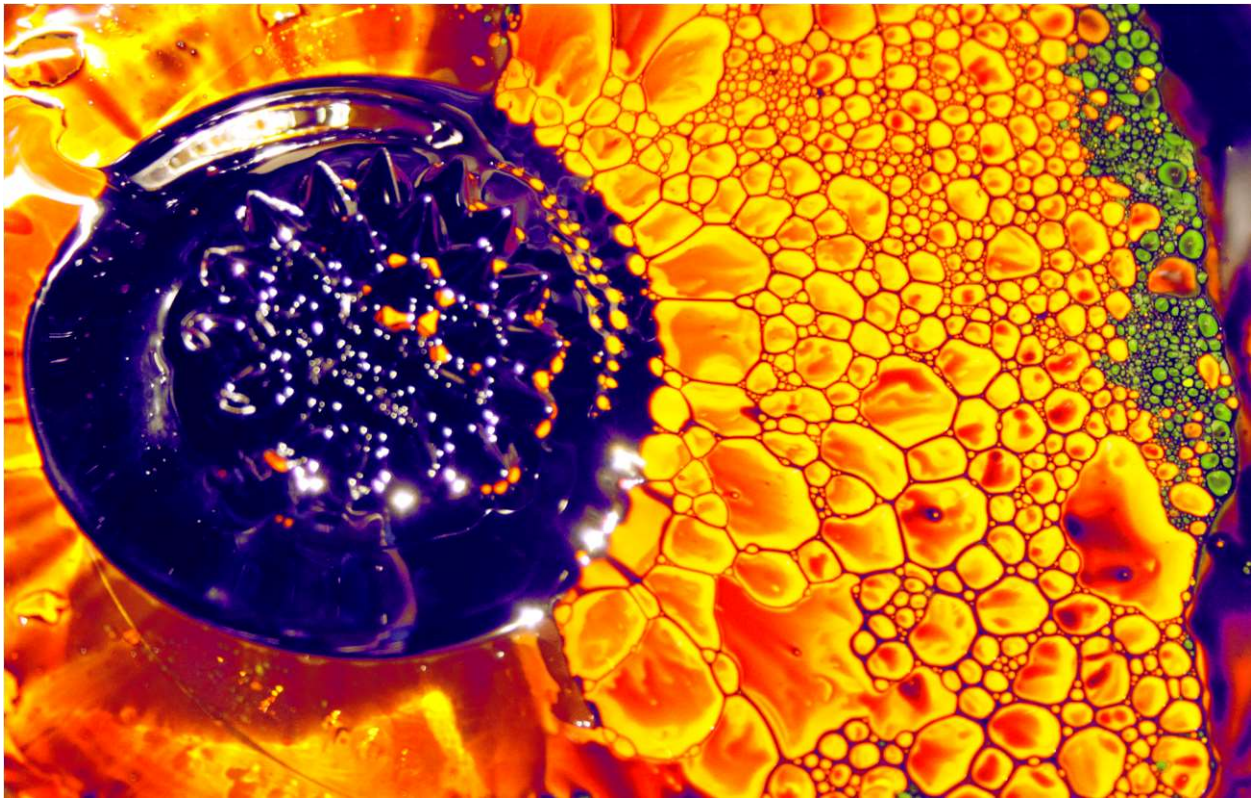

Contributors: Faisal Alsumairi, Blake Chin, Matthew Knickerbocker, and Abhishek Kumar

Introduction

The objective of this assignment is to create an experiment and photograph a fluid's flow. The image will uncover the physics of the flow and result in an aesthetically engaging photo. This experiment uses Ferrofluid's interaction with magnetic fields and India Ink to create a striking image.

Experiment setup

Ferrofluid is a black-brown fluid comprised of three main components: magnetic solids, surfactant, and a carrier. Typically, nanoscale ferromagnetic materials on the scale of 10 nanometers containing iron make up the magnetic solid. This solid is then mixed with a surfactant to decrease clumping when magnetized. The surfactant counteracts the van der Waals forces that would normally draw the particles together. This fluid is mixed with a carrier to allow it to flow like a common fluid. Most ferrofluids use light mineral oil as a carrier.

When ferrofluid is subjected to a strong magnetic field, the surface will bulge and form reoccurring peaks and valleys. This effect is known as the normal-field instability. The ferromagnetic materials line up with the magnetic field and form the typical peaks and valleys.

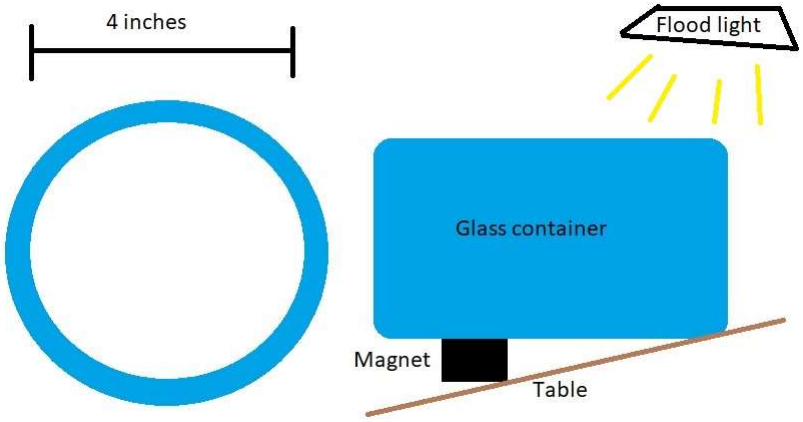

Figure 1: Scale and sketch of setup

A 4-inch Pyrex glass bowl was used to contain the ferrofluid for this experiment. The bowl was then tilted on a table with a strong magnet underneath to rotate the container. A flood light was placed above the container to add extra lighting to the experiment. Our team used India Ink and multiple magnets of various strengths to alter the shape of the ferrofluid. The team dropped vibrant colors on the activated ferrofluid to counteract the darkness of the solution. The India ink reacted strangely with the ferrofluid and created "cells" within the mixture. Ideally, the mineral oil of the ferrofluid and India ink had some effects to be immiscible.

Photo Editing

Figure 2: Original image

The field of view of the original image is 4 ½ x 4 in. with a 3 – 4 in. distance from the bowl to lens. The original image is 4750 x 3150 pixels. The focal length is 55 mm so I could focus on the center of the "cells" within the container. I used a 18-55 mm lens on a digital Canon EOS-50D on aperture priority mode. My exposure specifications are 1/50 second shutter speed, 1600 ISO, and f/5.6 aperture. For editing the image, I used Gimp to crop, edit, and resize the image.

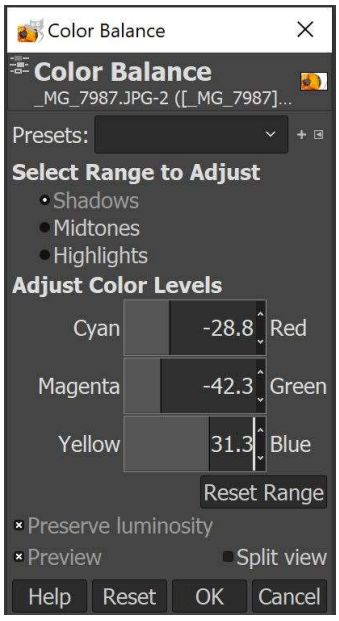

Figure 3: Color Balance settings used to change the image

I applied a color balance edit to the photo during post processing. The editing was done on the shadows so that the darkness of the ferrofluid would be more effected than the bright colors of the India ink. I adjusted the color sliders until the image became visually striking.

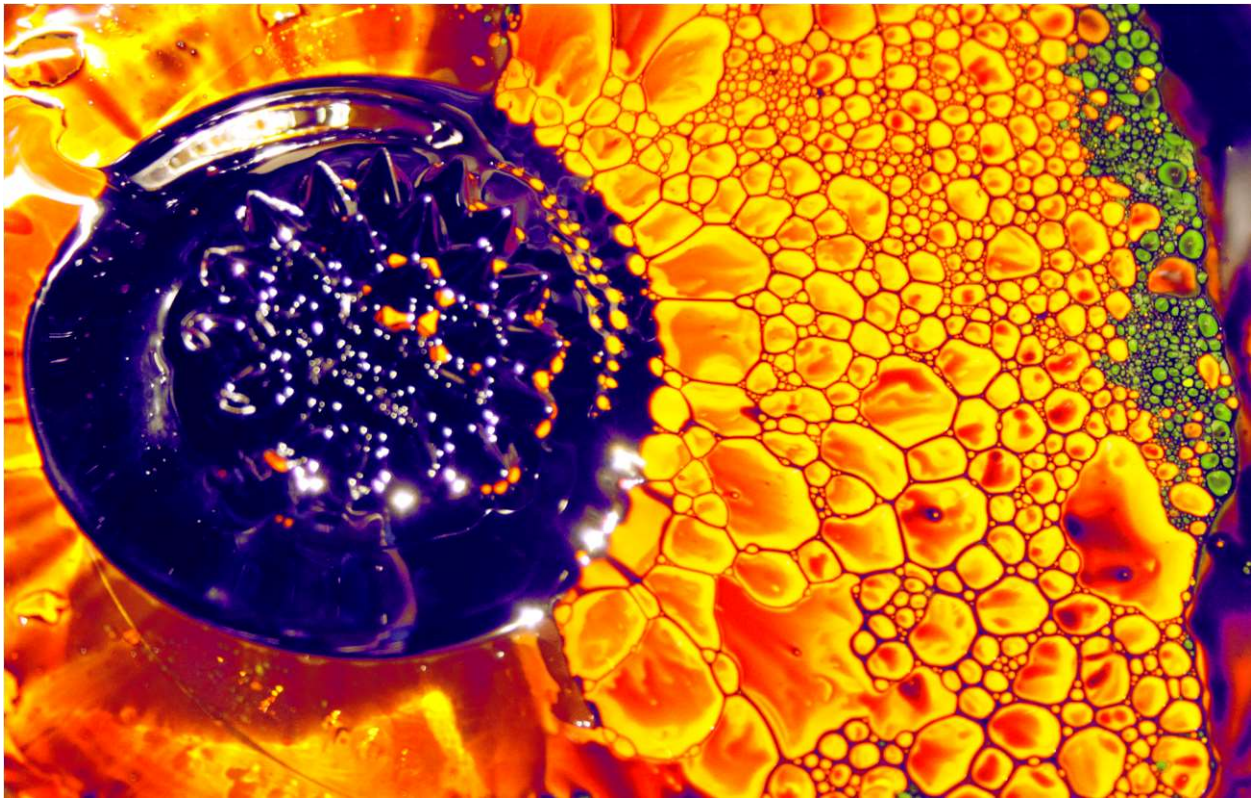

Figure 4: Final image

Conclusion

The normal-field instability can be visualized in the ferrofluid peaks and valleys. Some of the India ink is trapped in the instability zone and clearly defines the ferrofluid's reaction with magnetic fields. The dropped India ink has spread out and mixed with previous colors to achieve a visually pleasing gradient within each cell. The artistic intent and flow visualization of the experiment has clearly been accomplished.

References

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