# MCEN 4151 – Flow Visualisation

# Team Third Report

Author: Kenneth Olavarria

6 December 2023

Collaborators: Hannah DelGuercio, Peter Jakubczak, Sam Lippincott

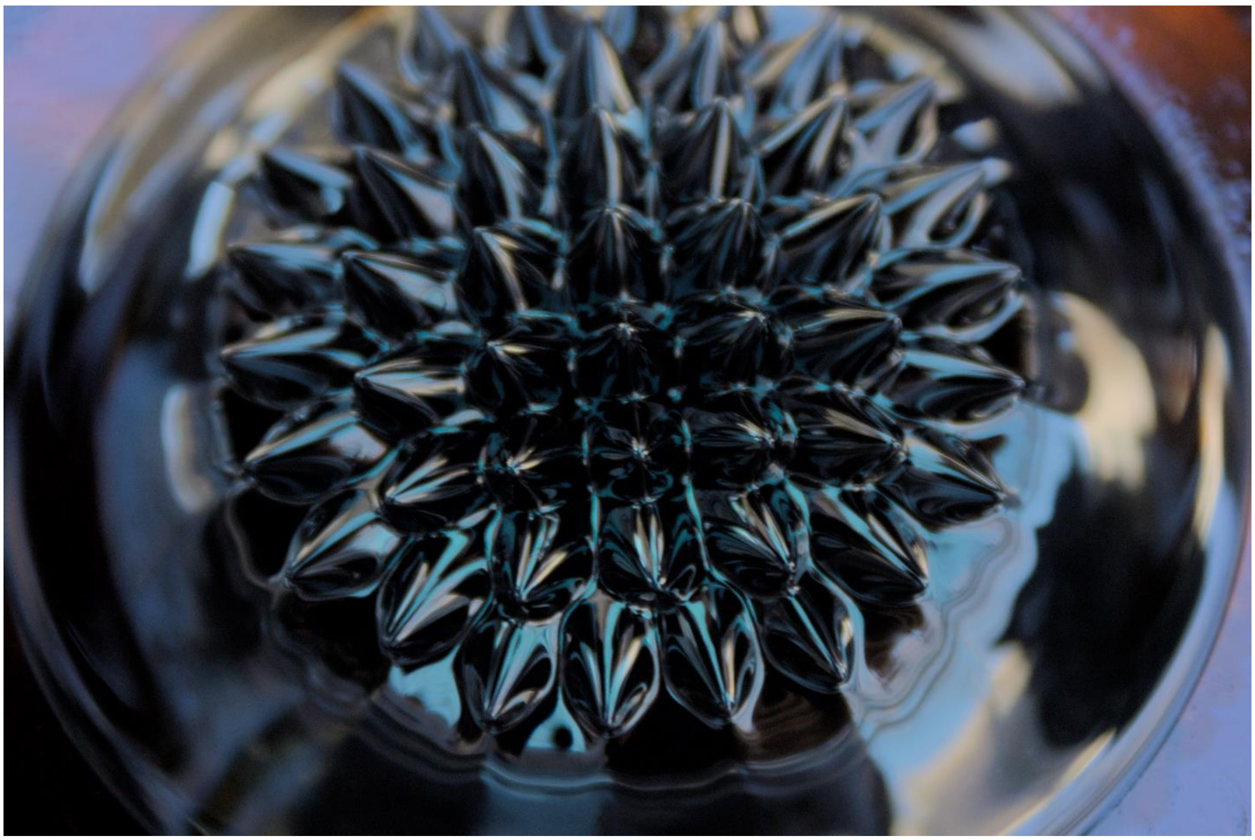

*Figure 1: Final, edited photo*

MCEN 4151 – Flow Visualisation
Kenneth Olavarria
Team Third Report

## Background

The motivation behind this experiment was to recreate the Normal-Field instability on a sample of ferrofluid. The intent was to generate an aesthetically pleasing phenomena for a photograph.

## Setup

The experimental set-up was quite simple. It involved the use of the following: A glass Tupperware, a bottle of ferrofluid, and a neodymium magnet.

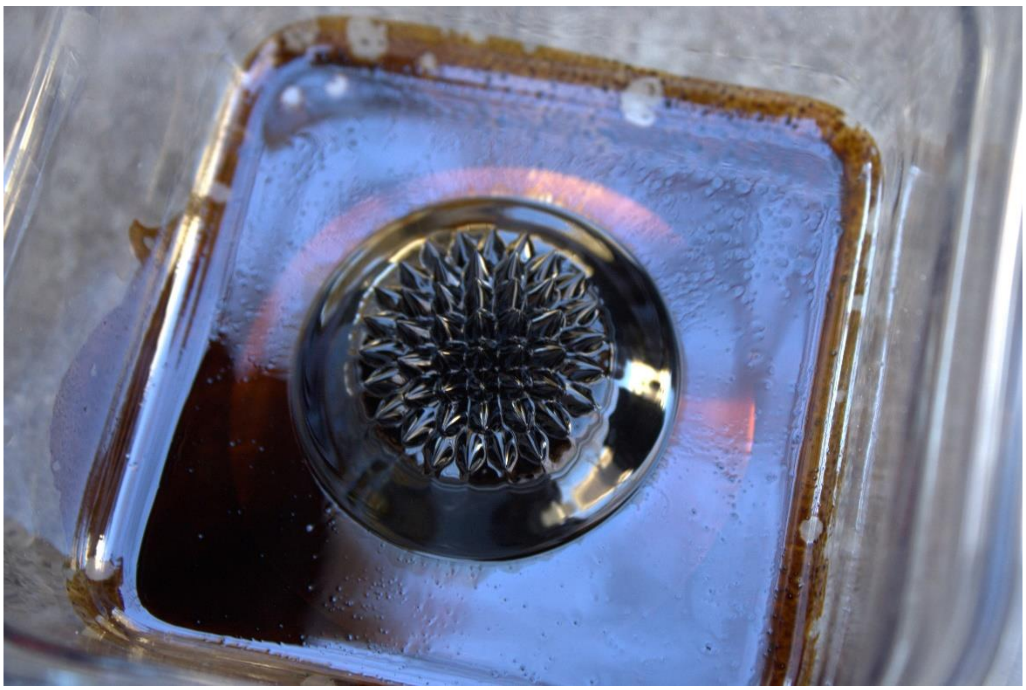

*Figure 2: Experimental Setup*

## Physics Behind the Flow

Unfortunately, the math to quantitatively describe this flow phenomena is rather advanced and outside the scope of this assignment – so I will do my best at explaining the phenomena quantitatively.

The flow phenomena developed in this experiment is called the "Normal-Field Instability". It is essentially the formation of three-dimensional peaks and valleys in a paramagnetic fluid. How does it happen?

This instability is driven by the magnetic field generated by the neodymium magnet underneath the Tupperware. The magnetic field is most concentrated at the peaks, and the formation of these peaks lowers the total magnetic energy in the system [1]. The peaks then terminate when a balance of forces between magnetism and surface tension (and gravity) is established.

**Visualization Technique**

The visualization technique used was simple light impingement on the ferrofluid sample. The photographs were taken on a clear day in Boulder, CO. The lighting used was moderate sunshine.

**Photographic Techniques**

I took the final photo with my own Canon Rebel T7.

| Setting | Value |
|---|---|
| Camera | Canon Rebel T7 |
| Lens | 18-55mm |
| Aperture | f/5.6 |
| Exposure | 1/30 |
| Focal Length | 55mm |
| Focal Distance | 0.26m |
| ISO | 400 |
| Dimensions | 6020px x 4015px |

The final photo was cropped down to 6014px x 4003px and edited using Darktable. I adjusted the RGB curve and color balance to accentuate blues and greens. I also adjusted the brightness of the background and the ferrofluid sample to increase the contrast and shininess of the ferrofluid.

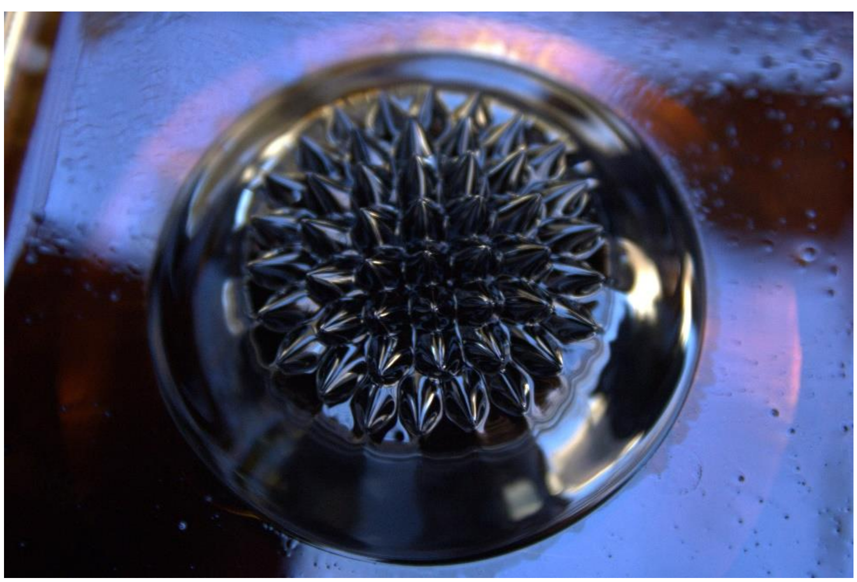

*Figure 3: Raw, unedited photo*

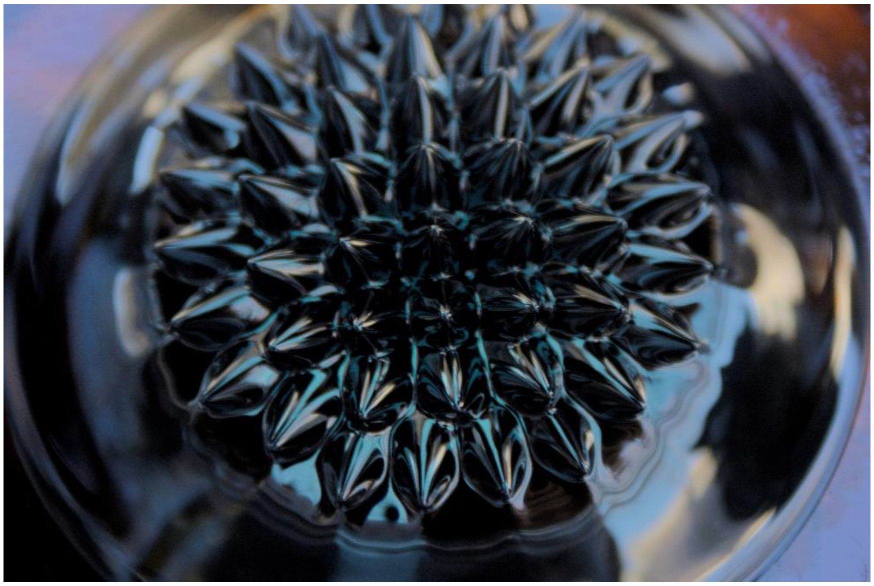

*Figure 4: Final edited photo*

## Conclusion

I find the image above rather aesthetically pleasing – the amount of shine and detail that I could extract using Darktable is quite substantial! The spikes are shiny, and one can also see thin film diffraction on the boundary between the instability and the rest of the ferrofluid. The reflectivity of the ferrofluid also adds another layer of depth to the image. I find the cyan color augmentation to be quite aesthetically pleasing. The fact that the front spikes are more in focus than the rear spikes also adds a layer of depth and complexity to the image.

## References

**[1]** *Andelman, David; Rosensweig, Ronald E. (2009). "The Phenomenology of Modulated Phases: From Magnetic Solids and Fluids to Organic Films and Polymers". In Tsori, Yoav; Steiner, Ullrich (eds.). Polymers, liquids and colloids in electric fields: interfacial instabilities, orientation and phase transitions. pp. 1–56.*