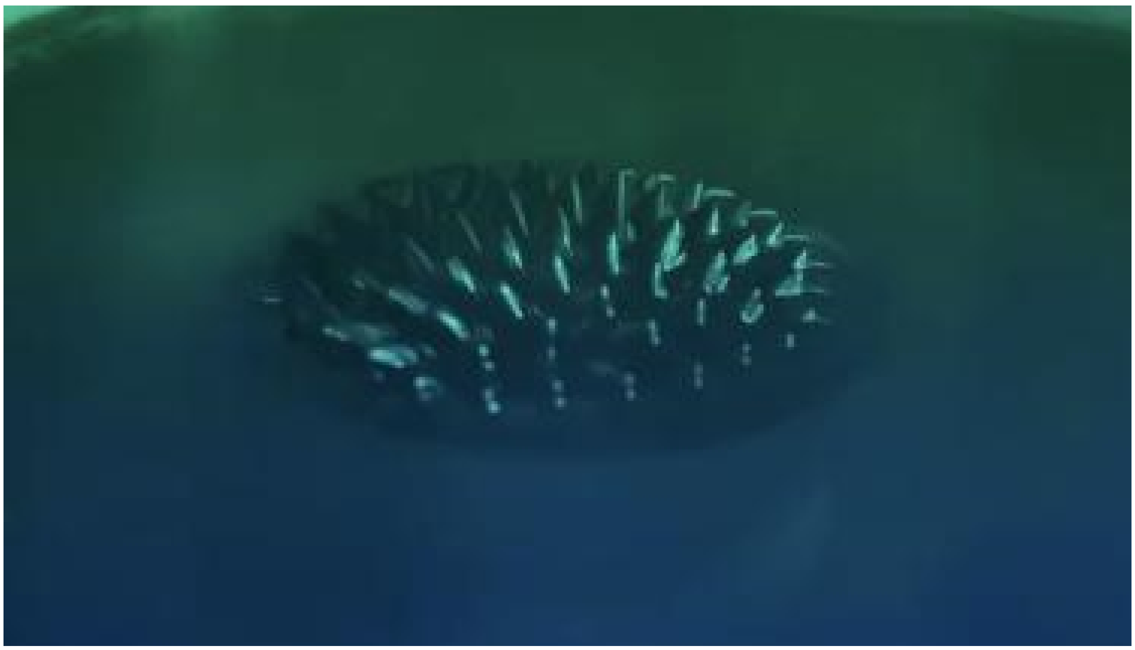
Vibrant Dance



Screenshot from video

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I Introduction

Normal field instability is depicted in this video using ferrofluid and a magnet. Light reflection is shown using colored led lights. Likewise, the photographic and visualization techniques are used to capture the science behind the flow. This video was taken for the Team Third assignment for the Flow Visualization course at the University of Colorado Boulder. The experiment was conducted alongside Jonathon Gruener and Ari Matrajt Frid.

The video shows the resulting flow that occurs when light reflects off of ferrofluid that is reacting with a magnet. When the magnet is placed below the ferrofluid it creates the spikes seen in the video. The reflective properties of the ferrofluid are shown by the led lights.

II Flow Apparatus

This experiment was conducted using ferrofluid, a magnet, and led lights. About a tablespoon of ferrofluid was placed on a circular mirror. Below the mirror a magnet was used to create the instability and move the fluid around. The only lighting used was the flashing led lights. The light strip was placed next to the camera. The experiment setup to capture the video is shown in **Figure 1**.

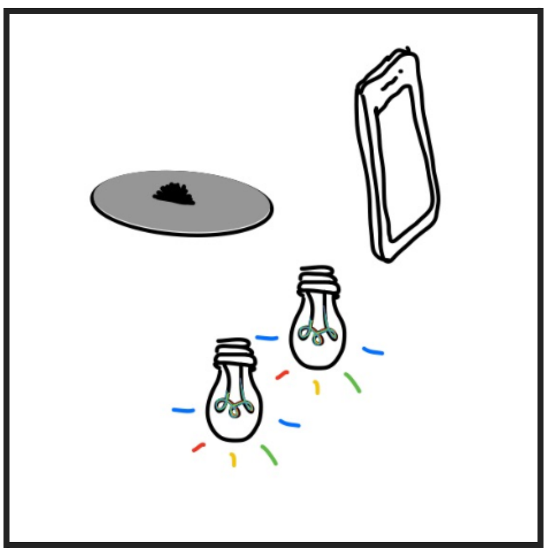

Figure 1: Diagram of experiment setup

The video depicts both fluid dynamics and light interaction. Ferrofluid is a colloidal fluid, which means it is a crystalloid electrolyte solution with an added macromolecule[1]. It is composed of nanoscale ferromagnetic particles that are suspended in a carrier fluid and coated with a surfactant[2]. It becomes highly magnetized in the presence of a magnetic field creating normal field instability. Normal field instability is the need to minimize the total energy of the system by converting to the most stable shape. Basically, the fluid is drawn out along the magnetic field lines resulting in the formation of the spikes[2]. This is shown in **Figure 2.**

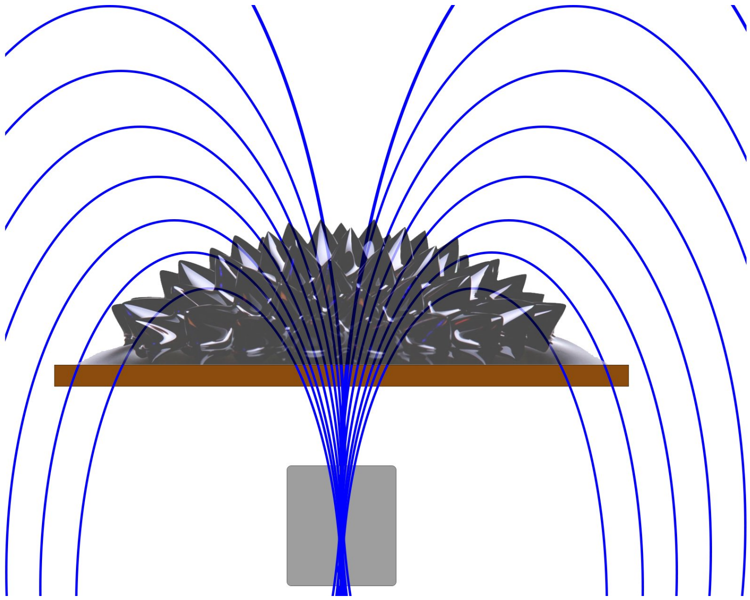

Figure 2: Ferrofluid Magnetic Field Lines[3]

The formation of the uniform and smooth corrugations is caused in the presence of low magnetic field strength. When the strength of the magnetic field increases, it leads to imbalance between the interparticle and magnetic forces. This is because the creation of these corrugations lowers the magnetic energy of the entire system but raises the gravitational and surface free energy[2]. Without this balance, the minimum energy configuration cannot be achieved.

III Visualization Technique

The visualization of this experiment was achieved using a 3-inch circular mirror to create more dimension. The ferrofluid was placed on the mirror towards the center to avoid as much background as possible. A magnet was then placed directly underneath the mirror to create the spikes, and then moved around to generate different shapes and sizes.

To attain the desired reflective lighting, this experiment had a led light strip pointed towards the ferrofluid right next to the camera. The light shining from next to the camera helped to avoid a shadow casted from the camera itself. The white light was shut off to make the colored lights shone brighter.

IV Photographic Technique

The video was captured on an iPhone 12 with a wide camera lens. The distance from the camera to the object was about 3 inches in length and had a field view of about 1.5 inches. The exposure was 1/50 seconds, the focal length was 22 mm, aperture *f*/1.6, and the ISO was 3000. The video had 4k resolution and a frame rate of 30.00 fps. The original video has a width of 1200 px and a height of 720px. The final edited video has a width of _ px and a height of _ px. The screenshots from the original and edited videos are shown in **Figure 3** and **Figure 4** below, respectively.

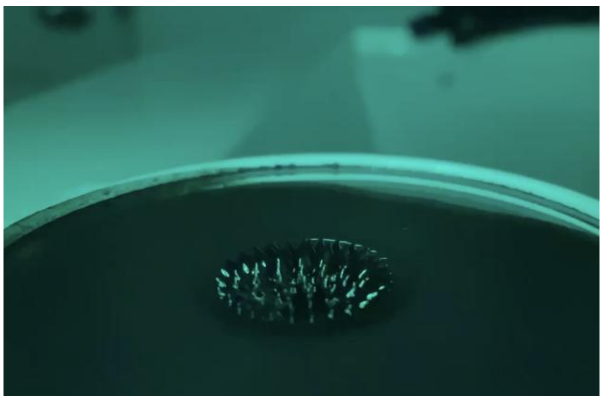

Figure 3: Screenshot from Original Video

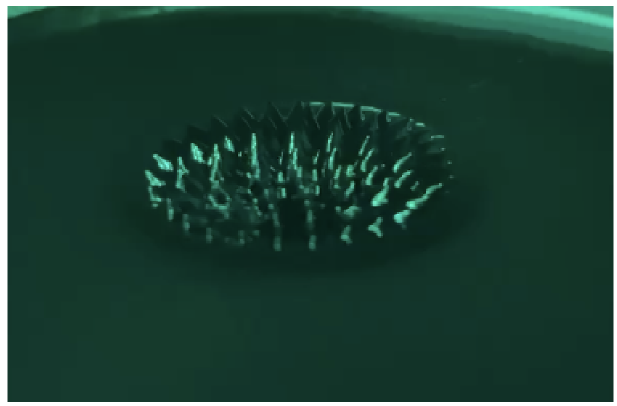

Figure 4: Screenshot from Edited Video

The editing software used to get the final video was iMovie. The video was cropped down from four minutes to 14 seconds. The video was cropped down to create focus on only the ferrofluid. The music added to the video is Scream & Shout by will.i.am feat. Britney Spears. These edits were made to capture the most focused parts of the video, and to increase the overall aesthetic.

V Video Analysis

The video provides an example of normal field instability. I really like the vibrancy of the colors in the final edited video. I believe that the lighting for the video could have been edited better to reduce the overall flashiness of the video. I also believe that this issue could've been solved by slowing down the frames per second or moving the light further from the camera. I feel as though the focus could have been a bit more sharp to make the flow more visually appealing. To further develop this experiment, I would try and add some dye or more reflective material to increase the vibrancy. I think the video has a unique appeal that is high-energy and fun to experience.

VI References

[1] Hahn, R. (2016). Colloid fluids. In R. Hahn (Ed.), *Clinical Fluid Therapy in the Perioperative Setting* (pp. 10-19). Cambridge: Cambridge University Press. doi:10.1017/CBO9781316401972.005

[2] Magcraft. (2015, January 31). *What is a ferrofluid?*. MAGCRAFT Brand Rare Earth Magnets. https://www.magcraft.com/blog/what-is-a-ferrofluid

[3] *Smart materials : Ferrofluids & Magnetic Levitation*. PhysicsOpenLab. (2017, April 3). https://physicsopenlab.org/2017/04/03/smart-materials-ferrofluids-magnetic-levitation/