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MCEN 5151 - Flow Vis

Prof. Jean Hertzberg

Team First

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Team Third Report

This is our third and final team picture capturing the ferrofluid with magnet and how the fluid reacts to different distances between fluid itself and magnet. The intent of the image was to capture the shape of ferrofluid with a magnet underneath, we were trying to capture the most unique and symmetric shape of the fluid. At first, I tried to take the picture using my camera for

higher resolution and better adjustability, however, I only have a 24-70mm f4 lens with me without any adaptors that let me take pictures from a short distance and fill the frame. Rather than cropping a lot of images and zooming in from the camera, I took the picture with the phone. Michael and Bradly helped with the picture for setting up the fluid and cleaning up is no easy task.

This phenomenon captured with ferrofluid is called Normal-Field Instability. First, ferrofluid is made from ferromagnetic particles suspended in a carrier fluid like water. Ferromagnetic particles consist of atoms with opposing magnetic moments which makes them attractive to magnets. This is why when the fluid is in the magnet field, they react in this way. This Normal-Field Instability is driven by the magnet field. There are a series of forces acting on the ferrofluid when it is in the magnetic field, the magnetic field is concentrated in the peaks, since fluid is easier to magnetize than air. There is also surface tension and gravity acting on the fluid that contribute to how it looks with peaks and valleys. Surface tension and gravity are acting opposite to the magnetic field. We did place an additional magnet on top of the ferrofluid, it broke the surface tension and gravity easily and fluid started to move upwards towards the second magnet. Time does not play a big part in the ferrofluid, they look the same as time goes by, as the determining factor is the magnetic field, they don’t increase or decrease in time.

There are no specific visualization techniques used, but more of modifying the light source for the picture. In order to get the most contrast for the picture, I moved around the container with ferrofluid up and down trying to see the difference between fluid and magnet. The picture shows the most spikes I can get with a set distance. We put a plastic item under the container to set the distance when taking the picture. For the lighting, we used a flash light

directly from the top of the fluid and a lamp from the left side as two main light sources. There are no flash from the phone, the light source is controlled,

We tried to fill the frame with the ferrofluid as much as possible and also showing the symmetric pattern of the spikes and valleys, with the light in the right direction, the reflections came out great.

- Size of field of view: 56 Degree
- Distance from object to lens: 50mm
- Focal length: 4.76mm
- Type of camera: OnePlus 7 Phone
- Original pixels: 3264x2448
- Final image pixels: 3264x2448
- Exposure Specs: f/1.65; 1/100 s; ISO 160

There are no cropping of the image, since it's already limited by taking the image from the cell phone instead of a camera. There are only some editing regarding, clarity, exposure, brightness, contrast, saturation and hue adjustments. The original image is below:

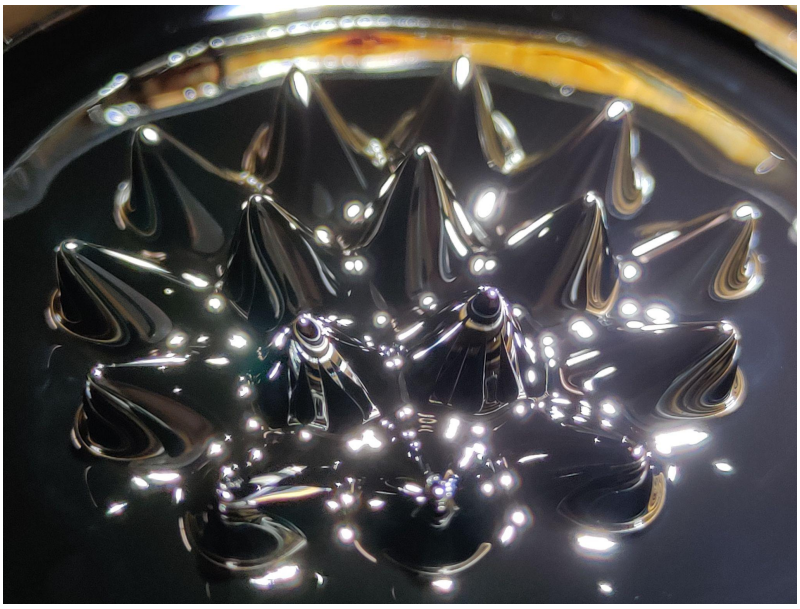

Image reveles the peaks and valleys of ferrofluid under magnetic field. I wish I could take a good picture from my camera with higher resolution. I would have to look more into the lens adapter or different macro lens. I think the fluid physics are shown well here with very clear and clean spikes, the lighting seems to be liked by our peers, so that's an additional bonus compared to when I took the picture in the first place. The intent was to capture the spikes of ferrofluid, and it has been accomplished. To develop the idea farther and things to improve would be a better lens for my camera for a more clear picture with less noise and blurriness.

References

S.Dalvi, “Numerical evaluation of the ferrofluid behavior under the influence of three-dimensional non-uniform magnetic field,” International Journal of Heat and Fluid Flow. Vol. 94 (2022)

H.Bennett, “The rise of ferrofluid,” Chemistry world. (2021)