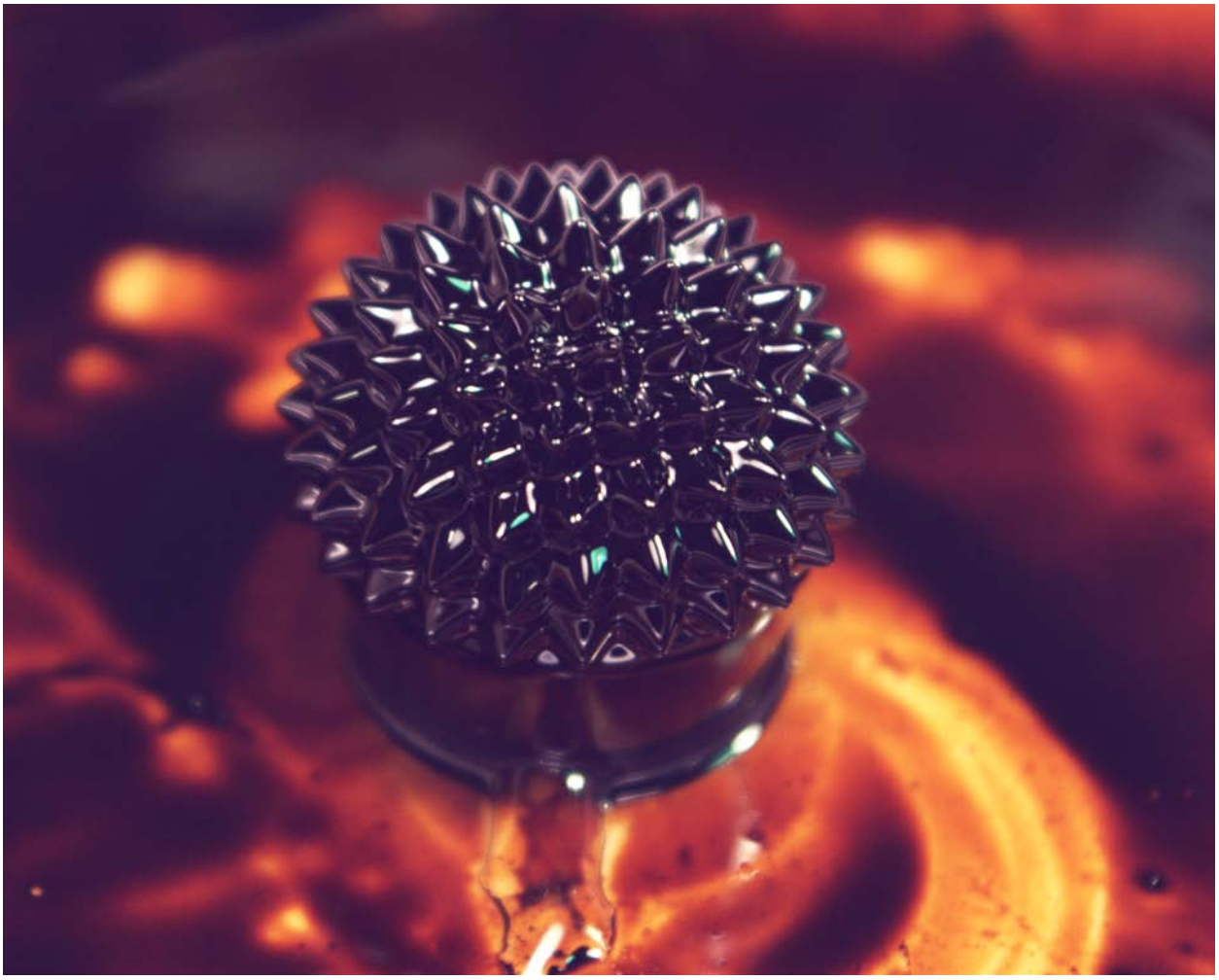

Ian Macfarlane
Group Project #3
Flow Visualization
11 DEC 2015

Purpose and Intent

The purpose of this photo is to show and capture the awesome phenomena of how ferrofluid reacts when presented with a magnetic field. Working on this photo and report in collaboration with my team: Chris O'Brien, William Olson and Gamal Elbialy we were able to produce images that well depict this phenomena. It is an uncommon shape for a fluid to take an almost seems unnatural. But with an easy explanation of the physics taking pictures of fluid will better help people understand how they act and the beauty of that action. The intent of this photo is to give a clear image of the spikes formed in ferrofluid in an artistic and dramatic manor, I believe this photo has well accomplished those goals.

Flow Set Up

For the setup of this image a ceramic bowl, disk magnets, ferrofluid, and a few lights were used. Approximately one teaspoon of ferrofluid was added to the 6 in. diameter bowl before any magnetic forces were applied. Once the ferrofluid had settled in the bowl, two disk magnets attached together were dropped into the bowl with the fluid. The bowl was placed underneath two lamplights to help illuminate the fluid and give it a crisper appearance. These two magnets stood vertically at the bottom of the bowl in the fluid with a second chain of magnets that were held underneath the bowl (not touching the fluid). Using this setup, which can be seen in the diagram below, I was able to create my final image which had a set of spikes formed around the top of the magnets caused by the ferrofluid.

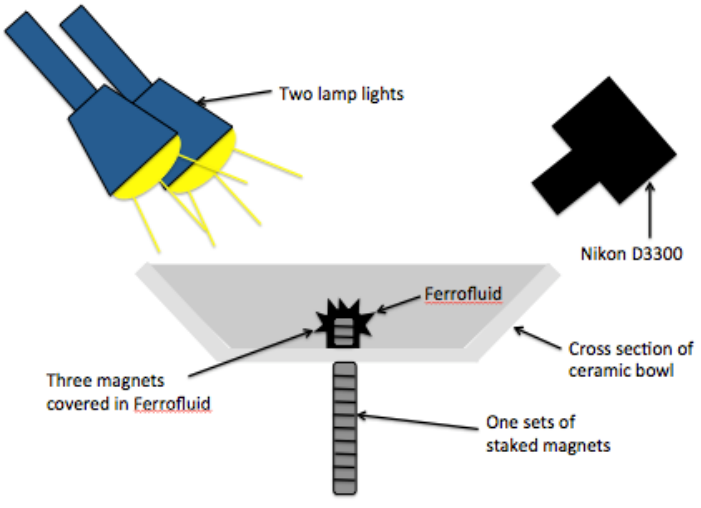

Figure 1: Photo Setup

Visualization Technique

With using ferrofluid we were able to visualize the physics involved in magnetic fluid. Ferrofluid is a liquid that becomes magnetized in the presence of a magnetic field. It is made up of many tiny insoluble particles within a carrier fluid. [1] The fluid we used was EFH1, made by FerroTec. It uses light mineral oil as the carrier fluid and the nominal particle diameter is 10 nm. More info about the fluid can be found on the flow visualization website.[3] As seen in the images within the ferrofluid there are spikes formed throughout the liquid at some of the edges. The Normal-Field Instability can describe these peaks and valleys that are created.[2] The magnetic field concentrates at certain points then due to the fact that the fluid is more easily magnetized then the air the fluid gets pulled out creating the spikes. This occurs until there is a force balance between the forces of the magnetic field and the forces of gravity and surface tension. [1] It takes energy to suspend the fluid against gravity as well as increase the surface tension so the stronger the magnetic field lines the greater the spikes will be. By placing magnets within the fluid along with underneath the fluid, being separated by a ceramic layer the fluid, the ferrofluid gathered at the top of the magnets within the fluid and created spikes around this pole.

Photographic Technique

Due to the small size of the magnets it was fairly difficult to capture the image in a manor of which did it justice. Using a Nikon 3300 camera at its macro setting we were able to get very close to the fluid and capture the image. With the cameral only being a few inches from the subject all the detail can be seen without loosing any focus. The final image captures an area of only approximately 3 inches wide and 2 inches vertically with a similar depth of field that only consists of a few inches. The image is 3319 x 2659 pixels. After obtaining the photo it was realized that the camera had been saving the

images as .NEF it was necessary to convert to a PNG file as the program available to me was unable to open the original image. During the conversion some of the image data was lost. The F-Number was 5.6, the exposure time was 1/80 and the Focal length was 55. As stated the macro setting on the camera allowed us to capture the small image in focus and little was needed to be done in Photoshop for post processing. In post processing the image was slightly cropped and the curves were very slightly adjusted.

Sources

[1] https://en.wikipedia.org/wiki/Ferrofluid

[2] http://www.physicscentral.com/explore/action/ferrofluids.cfm

[3] http://www.colorado.edu/MCEN/flowvis/course/FerrofluidTechData.pdf'

Original image