Team First / IV 2 Report

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Special Thanks to:
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I. Purpose and Acknowledgment

This report details the setup and final image of the first team project working with ferro-fluids. The purpose of this image was to observe the amazing patterns that ferrofluids exhibit when interacting with a magnetic field. The team members on this project helped acquire all the required resources for the setup including: ferrofluid, lamps, magnets, and backdrop. Each of us also took turns holding the testing apparatus at different angles to create individual shots for us to upload our own unique photos to flowvis.org. A big thank you to Abdullah Alkhaldi for also letting me use his camera and lens to capture my final image.

II. Experimental Setup

The experimental setup for this experiment was quite simple. A small amount (~2-3mL) of ferrofluid was carefully poured onto a white paper plate, and a small ring magnet was placed underneath the plate. One team member would hold the magnet and plate in place, one would adjust lighting as fit, and the other would capture the image.

Figure 1. Original unedited image

As we were experimenting with the ferrofluid, we noticed that the white surface against the dark fluid created an orange color with floral patterns. I decided to have my image be focused around this characteristic, and moved the ring magnet in arbitrary swirl patterns, using the trail as a paint brush guided by the magnet to create a life-like pattern.

III. Background

A ferrofluid consists of tiny ferromagnetic particles that are suspended in a carrier fluid. Ferrofluids are characterized by a colloidal suspension, where the larger unstable magnetic particles exhibit different behavior from the fluid it is suspended in. This means that when a ferrofluid is in the presence of a magnetic field, the unstable magnetic particles will become magnetized and create a normal field instability. The pattern of this normal field instability is typically a repeating pattern of peaks and valleys, which is the result of the system minimizing its own energy. The fluid reaches its peaks, where surface tension and gravity then overwhelm the magnetic force, and the fluid drops. Unique to this experimental setup, a weak ring magnet was used in conjunction with a very small volume of ferrofluid, which meant that the valleys and peaks were much more uniform, and less spikey (figure 2).

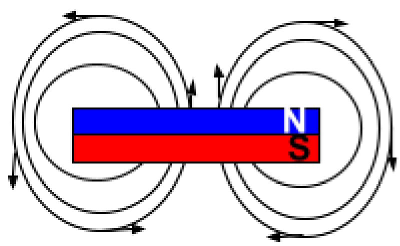

Figure 2. Magnetic field lines of a ring magnet.

You can see in the image that the ferrofluid follows these magnetic field lines. Ferrofluid behavior is governed by the equations of static equilibria which include: the Laplace equation for the magnetostatic potential Φ in the fluids above and below the interface, the magnetically augmented Young-Laplace equation for the force balance at the interface, and the equation of volume conservation of each incompressible fluid. These equations involve nonlinear analysis, and calculations are beyond the scope of this class.

IV. Visualization Techniques

No dyes or other visualization techniques were used in this experiment. The dark ferrofluid against the white background provided enough contrast to create a clear image. It may be worth experimenting with dyes to get different colors in the fluid, but these may alter the properties of ferrofluids described above. Lighting was achieved using two lamps sourced from the Integrated Teaching and Learning Laboratory (ITLL). One of the lamps was manually held by a teammate that shone directly on the ferrofluid at different angles, depending on the angle the image was being captured.

V. Photographic Techniques

Distance from Object to Lens	~2 in
Camera Type	Nikon D7000 DSLR
Lens Type	Nikon AF-S DX VR Zoom-Nikkor 18-200, f/3.5-5.6G
Aperture	f/5.6
Shutter speed	N/A
ISO	100

Table 1. Image, Camera, and Lens specifications

Figure 3. Final edited image

One of the main techniques used for this image is bokeh, where the background of the image is blurred, while the subject of the image is in focus. To accentuate this effect, I used an ovular vignette in darktable during post processing. Further editing included a red color correction to create a more intense color. The contrast and shadows were changed to make the white plate glow in the absence of the ferrofluid. The RGB curve was also slightly changed to have an s-curve, bringing out the lights and darks of the image. Finally, the image was cropped to remove the unwanted view of the blue design on the rim of the paper plate that is present in the original image.

VI. Conclusions

I am very happy with how the overall image turned out. I believe that I successfully captured the form of the image that I envisioned, and used post-processing to further improve the final image. I wish that the focus was better on the normal field instability that was occurring with the ferrofluid, which could easily be improved if I were to repeat this process. I struggled with planning a unique experiment with ferrofluid besides simply observing the normal field instability, but in the future I would love to somehow create a changing magnetic field that was in sync with music to create a cool video.

VII. References

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