Ferrofluid Patterns Under UV Light

Dhairya K Agnihotry

Context and Purpose

This report presents an exploration of ferrofluid behaviour under UV light, conducted as part of a fluid visualization project. The objective was to observe the visual effects produced by the combination of magnetic fields, ferrofluid, and UV light, capturing how the ferrofluid responds and interacts with these elements to create complex patterns. The project initially planned as a dancing ferrofluid experiment shifted to UV light exploration to capture a unique fluid phenomenon.

Experimental Setup and Flow Apparatus

The experiment setup, as shown in the image below, involved positioning a bounty sheet with ferrofluid on a reflective surface (mirror) on a table. A strong neodymium magnet was placed underneath to create a magnetic field. The UV light source was placed adjacent to the setup to illuminate the ferrofluid and the surrounding surface. The ferrofluid formed spiked patterns in response to the magnetic field, highlighting the normal-field instability of the liquid. The surface used was chosen for its reflective properties to enhance the visual effect.

Visualization and Lighting Techniques

A UV tube light was employed to cast a glow over the entire setup, producing a high contrast between the black ferrofluid and the illuminated background. The dim lighting in the room reduced ambient interference, ensuring the focus remained on the fluid's behaviour under the UV light. The reflective surface beneath the ferrofluid added depth and additional visual interest as it mirrored the ferrofluid spikes.

Photographic Technique

The image, as shown in the first photo, was captured using a Canon EOS 600D camera with the following settings:

- ISO speed: ISO-100
- F-stop: f/5.6
- Exposure time: 3.2 seconds
- Exposure bias: 0 step
- Exposure program: Manual
- Metering mode: Spot
- Flash mode: No flash, compulsory
- Focal length: 195 mm
- Image dimensions: 5202 x 3464 pixels

The camera was mounted on a tripod approximately 50 cm from the ferrofluid setup to ensure stability and precision in capturing the intricate details of the ferrofluid spikes and the reflections. The long exposure time allowed for optimal light capture, making the UV-lit spikes appear more vivid and pronounced.

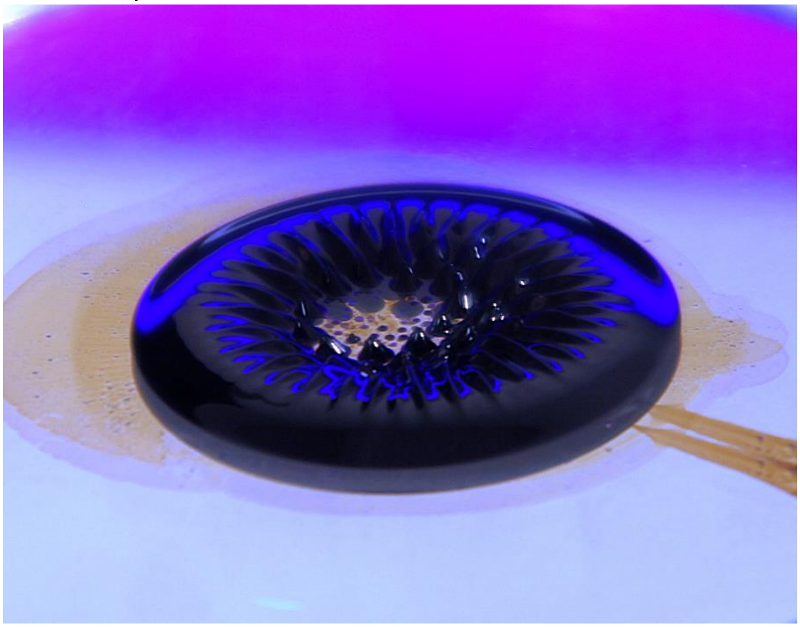

Image Analysis and Observations

The final image of the ferrofluid under UV light reveals an intricate combination of optical and magnetic phenomena. The spiked formations arise due to the normal-field instability, where the magnetic force on the nanoparticles surpasses the stabilizing surface tension, causing the fluid to form sharp peaks. This effect is governed by the balance between magnetic forces, represented by the magnetic Bond number, and surface tension forces. The UV light interaction highlights these spikes due to the ferrofluid's high absorption coefficient [1], making the peaks appear dark and prominent against the illuminated background. The reflective surface beneath the ferrofluid adds depth by reflecting light back through the spikes, creating a halo effect that enhances their three-dimensional appearance [2].

Optical phenomena such as diffraction and edge effects further contribute to the visual impact. The light waves bend slightly around the sharp edges of the spikes, creating a soft, glowing transition at their boundaries. The UV light, being shorter in wavelength, enhances this effect by scattering less and being more sharply absorbed by the ferrofluid. This selective absorption emphasizes the boundaries between light and shadow, lending a glowing outline to the dark peaks. Together, these interactions—magnetic alignment, light absorption, reflection, and edge diffraction—result in a striking image that captures the complex interplay of fluid physics and light behaviour.

Reflections on the Setup

The combination of the magnetic field, UV lighting, and reflective surface successfully highlighted the unique properties of ferrofluid, creating a striking visual effect that met the goals of the project. The image captured the intricate details of the spikes and how they responded dynamically to the magnetic field.

References

1. Rosensweig, R. E. (1985). Ferrohydrodynamics. Cambridge University Press.
2. Born, M., & Wolf, E. (1999). Principles of Optics: Electromagnetic Theory of Propagation, Interference and Diffraction of Light. Cambridge University Press.