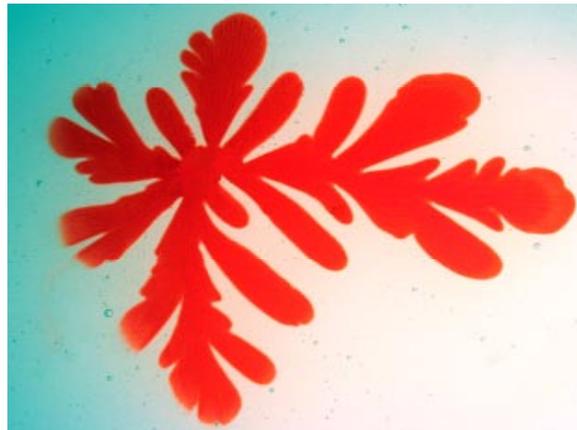


Saffman-Taylor Instability

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Flow Visualization
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Introduction

The purpose of this image was to capture an intriguing and intricate image that demonstrates Saffman-Taylor Instability through a Hele-Shaw flow. The image was created using a Saffman-Taylor Instability Machine, available to students in the ITLL. After several attempts, I was able to capture an image that I enjoyed.

Body

The flow apparatus used in the image was a Saffman-Taylor Instability Machine. This is basically two parallel flat plates with a very small gap between the two. The bottom plate in this case was made from acrylic, and had a small hole in the center to allow fluid to be injected into the gap. The top plate was made of glass to allow for maximum visibility of the Hele-Shaw flow. Hele-Shaw flow is the flow of a fluid between two plates with a very small gap between them, and is typically slow and high in viscous forces. In order to create Saffman-Taylor Instability, a low viscous fluid is injected into a higher viscous fluid, which generally results in "fingering," where the less viscous fluid tends to jet out from the injection point in a way that resembles fingers. The image was approximately 5" by 5". The lower viscous fluid was injected into the higher viscous fluid at an extremely slow rate, so when entering the system, the fluid flow was laminar, and the Reynolds number was very low. The image was taken approximately fifteen seconds after injection. After injection, the less viscous fluid very slowly moved away from the injection point.



Fig. 1 Saffman-Taylor Instability Machine Setup

In order to capture this image, a small mound of Softsoap hand soap was placed on top of the acrylic bottom plate above the injection hole. The glass top plate was then placed on top of the acrylic bottom plate. When the top was placed down, the soap spread out into a circle with an approximate diameter of six inches. Red food coloring mixed with water was then slowly injected into the Softsoap until fingers began to form. The injection was then stopped and pictures were then taken as the fingers slowly spread. The lighting consisted only of one halogen lamp placed below the Saffman-Taylor Instability Machine to backlight the image. There was no flash from the camera.

The field of view was approximately 5" by 5". The distance from the object to lens was approximately one foot. The camera used was a Cannon EOS Digital rebel XT. The original image had a width of 3456 pixels, and a height of 2304 pixels. The final image had a width of 2481 pixels, and a height of 2157 pixels. The focal length was 42mm. The aperture was f/11. The shutter speed: 1/250 of a second. The ISO was 400. The image was edited in Adobe Photoshop where the curves adjustment was used, along with the clone-stamp to remove bubbles, and the cropping tool.

Conclusion

The image reveals Saffman-Taylor Instability. I enjoy the fingers and patterns that arise from this instability. I wish I could have captured more texture in the image. I think that the fluid physics are portrayed very well and are easily visualized. My intent was filled in this image. In order to develop this further, more colors could be injected into the Softsoap to create a more complex image.

References:

http://m.njit.edu/Undergraduate/Capstone/Spring2002_kondic/a/index.html

<http://www.colorado.edu/MCEN/flowvis/course/SaffmanUser.pdf>

http://en.wikipedia.org/wiki/Hele-Shaw_flow