Spinning Egg

Jon Severns
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1 Introduction

For the final photo project for Flow Visualization, I had the goal of achieving a very interesting result using a simple process and everyday materials. I also wanted to attempt something I hadn't seen in the class before. While developing ideas, I came across a CNN video I had bookmarked a while back[1]. This video had a number of cool slow motion videos in it, but the one that caught my eye featured a hard-boiled egg spinning in a puddle of milk. I was amazed how interesting an effect was created by such a simple setup. This is the concept I chose to base my photo on.

2 Flow Apparatus

The apparatus used to capture this image was extremely simple. All that is needed is a hard-boiled egg, and a shallow puddle of milk (approximately $1/8^{th}$ inch, I used skim). I chose to pour the milk into a high-sided baking pan to control the splatter. It was also necessary to inspect the eggs and select one without any sharp protrusions that may interrupt the flow.

To achieve the flow, the fatter side of the egg was placed in the milk, and then spun quickly by hand. It was important to spin the egg in a controlled fashion so it would spin mostly in place and not move to one side or another. The flow pattern was the same, but due to the limited depth of focus on the camera, the egg had to stay approximately centered in the pan.

3 Flow Analysis

After reading about some of the research conducted by the BYU students who originally attempted this effect, I was able to understand some of the properties

that cause this to happen. When the egg starts spinning, the fluid around it is pulled along as well. This is caused by the no-slip-condition on the boundary layer[2]. This is evidenced in my photo by the small wave patterns the milk creates. The milk begins to rise up the egg as the result of a difference in the velocity at the bottom of the egg and the top. Near the bottom of the egg, the milk is moving slower than at the top due to the size difference. By Bernoulli's principle[3], that means that the pressure decreases as you move up the egg. Thus, the milk is pulled up the sides because there is less pressure there. When it reaches the widest part of the egg, this pressure difference no longer holds true, and the milk is flung off in small ligaments.

It is important to note that this photo was taken in the earlier portion of the process, before the milk has reached the middle and caused fingering. I selected this image because I found it interesting how much the egg could actually displace the milk. There is a large cavity in the milk puddle where the fluid has been pulled away quickly enough to leave a gap.

4 Photographic Technique

To capture this image, a digital Canon Rebel EOS camera was used. I chose to take the photo with a macro lens (Canon EFS, f/2.8, 60mm) because it had the ability to capture more detail in the close up point of view. The egg, hand, and pan in the photo can be used to understand the size and scale of the setup. The camera was approximately 2 feet from the egg at the time of the photo, on a tripod. The original unedited and final edited and cropped images can be seen below:

Figure 1: Original Image (2048x3072)

Figure 2: Edited Image (1792x1412)

To capture this image, a lot of direct lighting was required. I placed a large CFL bulb directly above the pan, right out of the image. Additionally, there were two fluorescent tube lights on the right and left sides of the pan. To capture the detail in the flow, I had to chose the settings of the camera carefully, particularly the shutter speed The resulting settings were: ISO200, f/2.8, 1/1000.

Some editing was done to produce the final image, although not much. First, the photo was cropped. I removed unnecessary information to bring focus to the egg. Although it was a difficult decision, I ended up leaving the bottom portion of my hand in the frame. I believe by doing so, I was able to help the viewer understand what was happening, as well as provide spatial perspective. Additionally, when the hand was cropped out, the resulting image was very unbalanced.

5 Conclusion

I am very satisfied with the image I achieved. I believe I met my goal of capturing a very interesting fluid phenomenon utilizing common materials. I am also happy that I was able to end up with an image that differs from those featured in the video I watched. My only complaint with the image is the off-balance color. I would have liked to incorporate dyes or other colored elements, as well as change the lighting. Regardless, the physics demonstrated in this image are very compelling, so I like the way the photo turned out.

Appendix

[1] http://www.cnn.com/video/?hpt=hp_c3#/video/us/2013/03/30/pkg-byu-splash-lab-goes-viral.ksl

[2] http://en.wikipedia.org/wiki/No-slip_condition

[3] http://en.wikipedia.org/wiki/Bernoulli's_principle

[4] http://www.youtube.com/watch?v=s5XVqWA1mj4