Image- Video I - Smoke photography

Olivia Ward
ARTF 5200- Flow Visualization, Fall 2020
University of Colorado at Boulder

---

1. Introduction

This report will go through the purpose, setup, and capturing of the above image displaying movement of smoke particles through the air as well as describe the physics behind the phenomena shown in the photo. The purpose of the Image- Video 1 assignment was to allow students to play with different flow phenomena and capture their best images to try and explain the physics behind the action. I chose to capture images of smoke from a blown-out candle. This image intended to capture a photo that was not only aesthetic but also could help in visualizing flow phenomena.

2. Flow Phenomena

To set up for my photo, I lit a Yankee candle and used several flashlights to light the smoke from underneath. An open window behind the photo setup sucked the smoke out by equalizing the pressure between the inside and outside of the house. The smoke in this photo starts from the bottom in a smooth laminar flow. As the smoke gets higher, the flow is interrupted and becomes more turbulent and irregular. The irregularity in the smoke originates from a high air velocity from the open window convecting the smoke particles. This movement can be described by a convection-diffusion equation. [1]

$$\frac{\partial C}{\partial t} + \vec{u} \cdot \nabla C = D\nabla^2 C$$

In this equation, C is the concentration of smoke, and D is the diffusion coefficient of smoke. The air will move to create a velocity ($\vec{u}$) which intensifies the spread of the smoke. Because the smoke came from a candle, it has a higher temperature and lower density than the surrounding air, causing the smoke to rise.

3. Flow Visualization Technique

My setup included a Yankee candle that I placed just below my camera. When I blew the candle out, it produced a stream of smoke, of which I was able to take photos. To capture the smoke in the image, I used several flashlights underneath the smoke to illuminate it. My backdrop was a black binder, which had a smooth and dark effect to help contrast with the color of the smoke. The black background and the illuminated smoke created a contrast between light and dark that I was able to capture in the image.

4. Photographic Techniques

I used a Canon EOS Rebel T3i with an 18-55 mm lens to capture this image. The aperture was set to f/8 with an exposure time of 1/100 of a second to help freeze the smoke. The ISO was 100, and the focal length was 40mm. My camera was within a foot of the candle and smoke setup to get the clearest image possible. The edits made on this photo were minimal to keep the image simple. I cropped the picture and enhanced the white colors to create a little more contrast in the image.

Figure 1: Original image

Figure 2: Edited image

5. Results

Overall, I like how my image turned out. I would like to have gotten a clearer photo, and I hope to improve my photography skills of objects that are close to the camera. I am happy with the fluid physics I was able to capture with the smoke and the open window. In the future, I would like to be able to capture more complex smoke phenomena such as smoke rings.

6. References

[1] Markowich, Peter A, and Peter Szmolyan. “A System of Convection-Diffusion Equations with Small Diffusion Coefficient Arising in Semiconductor Physics.” *Journal of Differential Equations*, Academic Press, 30 June 2004, www.sciencedirect.com/science/article/pii/0022039689901228.