IV2: Fog in Lasers

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MCEN 4151

Professor Hertzberg

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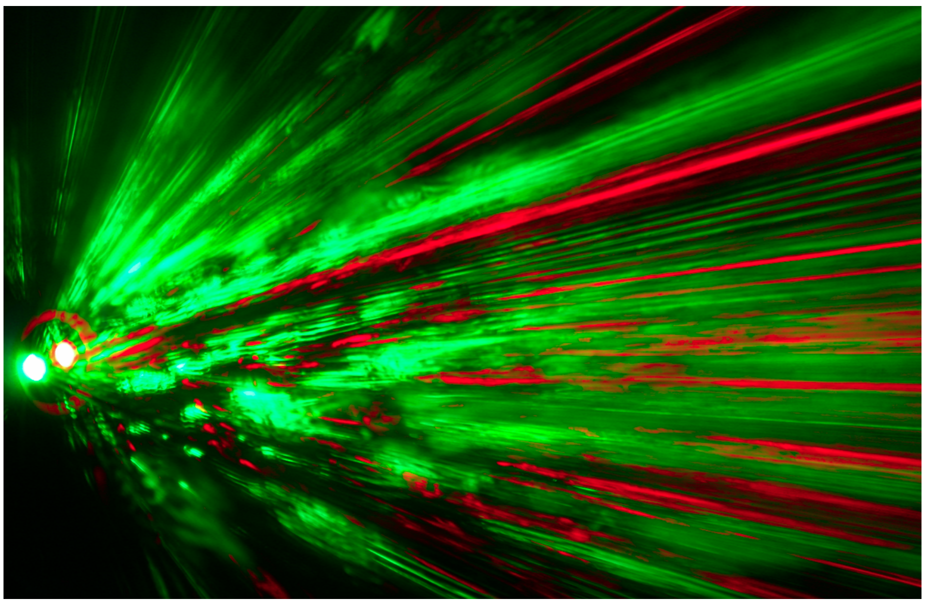

Introduction and Background

The purpose of this photograph is for the “IV 2” assignment which was assigned by Professor Jean Hertzberg for the course Flow Visualization at the University of Colorado at Boulder. The objective of this assignment was to capture a visualization the physics behind the fluid flow of fog shown by the fog’s interactions with lasers in a way that is aesthetically pleasing. Our team decided to capture a photograph of this phenomenon because of the memorizing visualization of lasers in addition to the visibility of the fog fluid flow in the lasers. We thought that this would allow us to not only capture a beautiful visual of not only the lasers but the turbulent flow of the fog as well.

Team

This assignment was completed with the following team members:

1.) Bryce Dickson
2.) Tobin Price
3.) William Watkins
4.) John Whiteman

Procedure

Our team began this experiment by setting up a black backdrop that was positioned to the left of the lasers so that we would be able to get the best photograph of the fog interacting with the lasers (refer to Table 1. below for a list of materials that were used during this experiment). Then, we positioned the laser machine on the floor at an angle of -25 degrees from the backdrop (the line parallel to the surface of the backdrop). We then positioned the camera at an angle of 170 degrees from the normal vector of the laser machines face (refer to Figure 1. below for the experimental setup) at a distance of approximately 1 ft from the laser machine.

Commented [WMW1]: Needs work also maybe mention red and green lasers.

Table 1: *Required materials for the assignment*

Required Material	*Description*
Black Backdrop	Any solid black backdrop
Laser Machine	Christmas Lights Outdoor Projector
Fog Machine	Rockville R720L Fog/Smoke Machine
Camera	Cannon Rebel T7 DSLR Camera

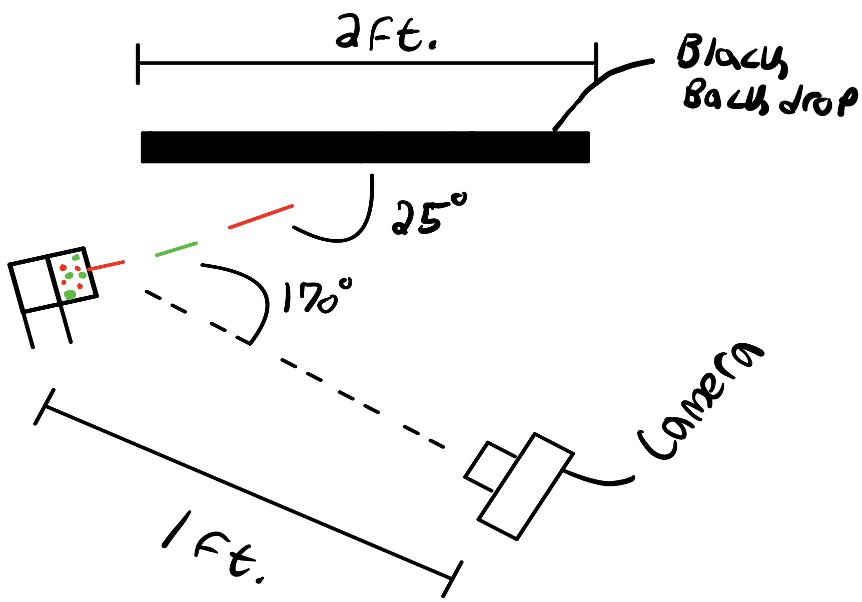

Figure 1: *Illustration of Experimental Setup*

Our team decided to perform this experiment in Tobin's garage which allowed for us to ensure that there was no natural lighting once the door was shut. We had one team member hold the fog machine in the air behind the laser machine. We had another member take photos while one member turned on the fog machine. Initially, our team realized that the fog machine was pushing the fog into the lasers at a velocity that was too fast for us to accurately visualize the flow. Thus, we attempted to let the fog settle in the lasers so we would turn the fog machine off roughly 5 seconds before taking the photograph. This helped us to better visualize the form of the fog while in the light of the lasers. The laser machine had a setting that allowed for the lasers to be static because all of the other settings on the laser machine required the lasers to be moving (flashing). The lasers were green and red which provided a captivating image when interacting with the fog.

The Physics behind the Phenomenon

Fog Machines use a water and glycol mixture to create fog also known as “Fog Juice” [2] which is made up of glycol, glycerin, distilled water, and mineral oil. The mixture is heated while being pressurized which causes the fog to be pushed into the air [2]. The fog that came from the laser machine was turbulent, so our team ensured that the fog was allowed to settle for roughly 5 seconds before the photo was taken. To calculate the Reynold’s number of the fog as it flows through the air (reference Eqn. 1 below), it can be shown that the fog flowing through the air as it left the nozzle was extremely turbulent from the Reynolds number of 21442 (reference #3 and reference #4). Where p is the density of the air, u is the speed of the fog in the air, L is the diameter of the nozzle of the fog machine, and μ is the dynamic viscosity of air. The nozzle of the fog machine has a diameter of .0508 m, the density of air is 1.199 kilogram/ m^3 (reference #5), the dynamic viscosity of air is .00001818 N s/ m^2 at 70 degrees Fahrenheit (reference #6) and the speed of the fog was calculated to be 6.4 m/s from the area of the nozzle multiplied by the volumetric flow rate (reference #7 and Eqn. 2 below). Where A is the area of the nozzle, and R is the radius of the nozzle.

$$Re = \frac{puL}{\mu} \qquad \text{Eqn. 1}$$

$$A = \Pi * R^2 \qquad \text{Eqn. 2}$$

Photography Technique

I used a Cannon EOS Rebel T7 DSLR camera with an 18-55mm lens to take photos during this experiment. The camera was placed on the ground approximately 1 ft away from the laser machine at an angle of 170 degrees from the normal vector of the laser machine’s face (we had to be sure not to look at the lasers head-on while taking the photograph to ensure that we did not hurt our eyes). There was minimal to no lighting for this photograph (only the light from the lasers). The photo has a width of 6000 pixels and a height of 4000 pixels. We used the camera setting of exposure priority (refer to Table 2. Below for the full list of camera specifications during the experiment). I used the Camera’s RAW setting that develops photos in CR2 file. I transferred these photos into PNG using the software Irfanview. I found a YouTube video (reference #1) which gave me a tutorial for how to download this software. I used DarkTable to edit the photo because of DarkTable’s significant selection of photo editing features. I began to edit the photo by adjusting the “sharpen” feature to allow the details of the photo to show up better. I then adjusted the “rgb” curve feature to allow for the best lighting of the features of the photo. Lastly, I cropped the photo to emphasize the fog in the lasers.

Table 2: *Camera Specifications for Cannon Rebel T7 used during Experiment*

Specification	*Description*
Aperture	f/0.0
Exposure	1/inf
ISO	0
Focal Length	0 mm
Priority	Exposure priority

Conclusion

The objective of this assignment was to capture an aesthetically pleasing visualization of the flow phenomenon behind turbulent fog while visualizing the fog using lasers. My team and I collected photos that depicted the flow phenomenon of turbulent fog while it settled visible in exposure to red and green lasers. The photo was very aesthetically pleasing while still allowing for us to see the form of the fog as it settled. For this experiment in the future, a camera with a higher shutter speed could allow us to capture more precise images of the fog flow as well as having a fog machine which would allow for the fog's velocity to be controlled easier. In addition to this, I would want to photograph the fog using different angles to allow for a different perspective of the fog which could potentially allow for a cleaner photo of the fog. Finally, I would want to take the images in a room that allows for absolutely no light exposure.

Appendix:

1.) "How to Convert RAW Canon CR2 Pictures to JPG PNG or TIF". YouTube. https://www.youtube.com/watch?v=D6viyxBWbnA . Accessed on 09/21/22.
2.) ThoughtCo. "How Smoke Machines Work" ThoughtCo.com, 2019, https://www.thoughtco.com/how-smoke-machines-work-607861
3.) "The Differences between Laminar vs. Turbulent Flow." Resources.system-Analysis.cadence.com, resources.system-analysis.cadence.com/blog/msa2022-the-differences-between-laminar-vs-turbulent-flow.
4.) "Motion of an Object in a Viscous Fluid | Physics." Courses.lumenlearning.com, courses.lumenlearning.com/suny-physics/chapter/12-6-motion-of-an-object-in-a-viscous-fluid/.
5.) Engineering ToolBox. "Air - Density and Specific Weight." Engineeringtoolbox.com, 2019, https://www.engineeringtoolbox.com/air-density-specific-weight-d_600.html
6.) Engineering ToolBox. "Air - Absolute and Dynamic Viscosity ." Engineeringtoolbox.com, 2019, https://www.engineeringtoolbox.com/air-absolute-kinematic-viscosity-d_601.html
7.) Rockville Pro Sound and Lighting. "Rockville R720L Fog/Smoke Machine" Rockvilleaudio.com, 2022, https://www.rockvilleaudio.com/r720l-v2/?gclid=Cj0KCQjw4omaBhDqARIsADXULuXVmmPCgcmZRZksNUol31JHqCit3ELt_nXQECHDwDweIKEzvMDuL_0aArNYEALw_wcB

Original Photo: