Foggy Night

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I. **INTRODUCTION**

This image captures fog wisps after a fog machine has been turned off. My intent for capturing this image was to highlight the swirling and temporary nature of fog in a room, and I accomplished this. For the first team photo, we were inspired by capturing the ambiance of a concert, where lights highlight sections of fog in a dark room. Originally we planned to use lasers, but we didn't have access to any lasers so we settled on headlamps.

II. **PHENOMENON**

a. **Setup**

A fog machine was the most important element of our setup, as we needed a medium to illuminate the flow of the room. We opened the upper latch of the machine so the fog came out in a geyser pattern instead of falling immediately to the floor. Then, we used 2 headlamps on maximum power to light the fog at 110-degree angles from the photographer, as shown in Figure 1. The camera was approximately 6 inches away from the fog to capture as much in-focus lit-up fog as possible.

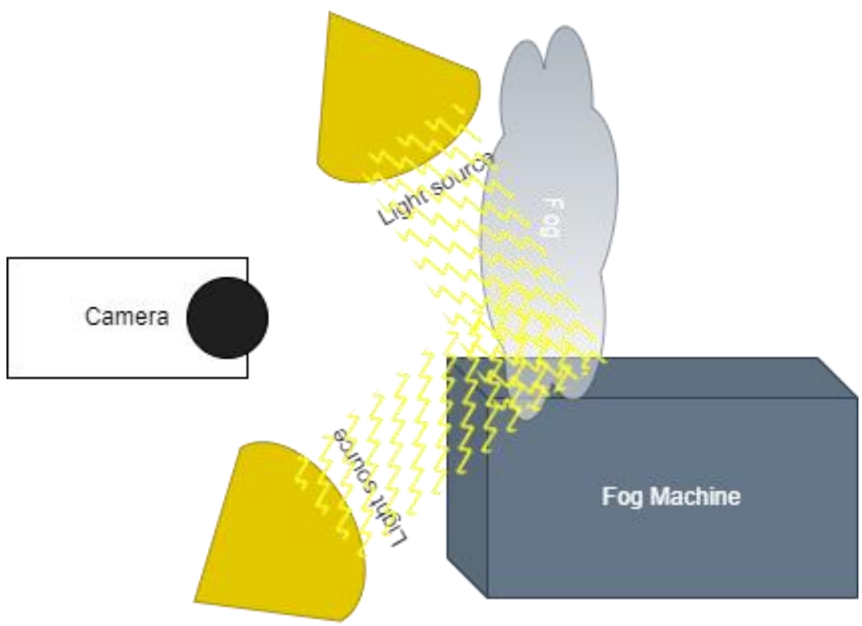

Figure 1. An image showing the general setup of the fog machine, fog, camera, and light sources in respect from one another.

b. **Flow**

The fog is warm when it comes out of the fog machine, so the fog initially rises, and as it begins to cool, it falls back to the floor and dissipates. Since the windows and doors were open to the east and west side of the room, fog flow as in a cross flow. According to Cao et al., "For cross-flow velocities higher than the critical velocities, all the plume generated from the source would be forced downstream and the location of the backlayering front would move downstream," which shows that since the plume is not moving downstream rapidly and instead dissipates, the cross-flow of the room is not higher than the critical velocity of the fog (Cao et al. 2022). This can be further explored using the Reynolds number:

$$Re = \frac{\rho \upsilon L}{\mu}$$

Equation 1. ρ represent the density of the fluid ($\frac{kg}{m^3}$), υ represents the velocity of the fluid ($\frac{m}{s}$), L represents the height of the room as the characteristic length (m), and μ represents the dynamic viscosity ($\frac{kg}{m*s}$).

Shavlov et al. states that at a high shear rate, such as when moving at a higher velocity than the surrounding air, the fog viscosity is similar to that of air (Shavlov et al. 2022). As such, the dynamic viscosity of air (μ=1.81 x 10e-5 kg/(m*s)) is used to calculate the Reynolds number. The density of the fog is similar to air (5kg/m^3), and the velocity of the fluid is estimated at 2 m/s using the height of the room (L) as a reference. The calculated Reynolds number is approximately 1,000,000 which is large. As soon as the fog leaves the fog machine, it starts turbulent mixing with the surrounding air, hence a large Reynolds number. Additionally, this image was taken as the fog was heavily fading, at approximately 10 seconds after fog initiation, meaning that significant mixing with the room air had already occurred.

III. VISUALIZATION TECHNIQUES

The fog machine lit up with another light source shows a marked boundary flow visualization technique. Fog from the machine mixes with the general air of the room and is a similar fluid to the air of the room in terms of density and viscosity.

IV. PHOTOGRAPHIC TECHNIQUE

Capturing individual whisps of fog in a dark room was challenging. The scenario required a fast shutter speed -- 1/2000 -- to maintain an unblurred image, and the room was dark besides the light of the flashlight, so the ISO was very high as well at 3200. The only thing left to change was the aperture, which had a large opening -- f/6.3 -- so enough light could get in. The image was shot with a Canon EF-M 15-45mm f/3.5-6.3 IS STM lens and a Canon EOS M50 camera. The image is 6000px x 4000px and captures an image area of approximately 8in x 6in. The camera was about 6in away from the fog pictured. Some post-processing occurred, with an emphasis on adjusting the brightness of the fog on the right side of the image and making the image less grainy.

Figure 2. Pre-processed image.

V. IMAGE

The image reveals the wispy nature of fog in a room with airflow. It is a beautiful and haunting image because of the strong curves present throughout. The fluid physics is shown well in the image, but it is challenging to understand the scale of the image from just the photograph and no outside information. In the future, I would like to make my image less grainy while conserving the fluid flow.

VI. APPENDIX

a. Calculations

$$Re = \frac{\rho v L}{\mu}$$

$$Re = \frac{5 * 2 * 4}{1.81 * 10^{-5}} \ (see\ units\ above)$$

$$Re \sim 1{,}000{,}000$$

b. **Bibliography**

Cao, Yicheng, et al. “Characteristics of a Buoyant Plume in a Channel with Cross-Flow.” *International Journal of Heat and Fluid Flow*, vol. 93, Feb. 2022, p. 108899. *ScienceDirect*, https://doi.org/10.1016/j.ijheatfluidflow.2021.108899.

Shavlov, A. V., et al. “Non-Newtonian Viscosity of Water Fog.” *Physics Letters A*, vol. 450, Oct. 2022, p. 128394. *ScienceDirect*, https://doi.org/10.1016/j.physleta.2022.128394.