# Team First Fall 2025

# Vorext Illuminated by Blue LED

**Nathaniel Wheaton Flow Visualization 5151-001, 9/23/2025**

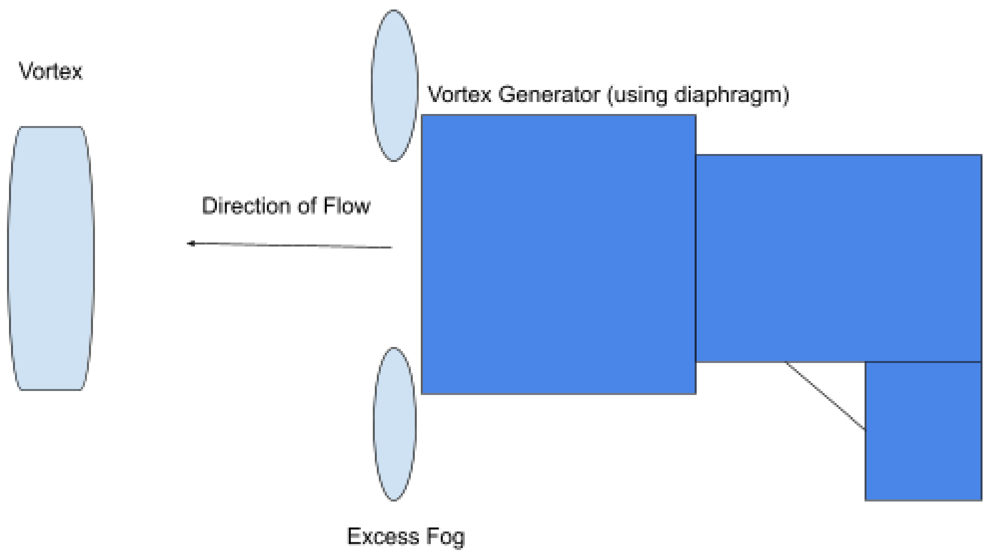
**Collaborators: Kanon Page, Friderik Mcmahan**

## Intent

The scientific intent of this experiment is to explore the formation and development of vortex rings generated by a ZeroBlaster vortex generator. The stage fog and LED help to visualise the air currents which make up the vortex, and show the incredible efficiency of vortexes. I chose to visualise vortexes because I have always been fascinated by the fine details in their motion. The blue light from the LED illuminates the fog just enough such that the contrast between the fog and the background helps to highlight the details of the flow.

## Experimental Setup

The vortex was generated using a ZeroBlaster vortex generator which uses a diaphragm to create vortexes. This vortex generator utilises an LED and stage fog to illuminate the phenomenon, at the moment of the photo being taken the LED was ~2.5 ft from the visible vortex. The exit of the chamber was ~1.5 in wide and the fog chamber was cylindrical ~3 in diameter and ~3 in depth. A simple diagram is shown below:




# Flow Analysis

The initial vortex created begins as a disturbance within the smoke cavity in the vortex cannon, this disturbance is caused by a hammer impact with a diaphragm causing some air to exit the nozzle at a relatively high velocity creating a current which rolls up into a vortex ring conserving energy and momentum [1]. Assuming a small velocity (U = 0.5 m/s) and a ring diameter ($L$ ) of 0.05 m, using v = 1.5 x 10^-5 m^2/s (kinematic viscosity of air) we can estimate the Reynolds number:

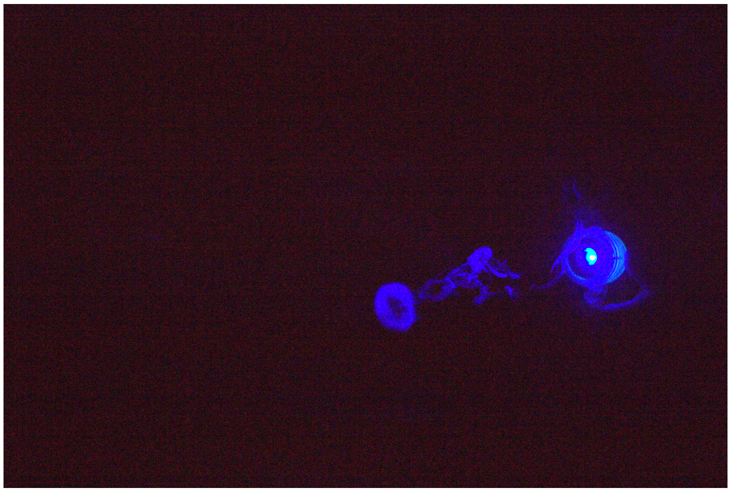
$$Re = \frac{UL_C}{v} = \frac{(0.05*0.5)}{1.5*10^{-5}} = 1666$$

A Reynolds number of 1666 would suggest that the flow on the exterior of the vortex is laminar, repeating a similar calculation for the interior would provide a smaller Reynolds number due to the smaller characteristic length, so we can assume that the vortex was operating in a laminar manner, but dissipated somewhat quickly after being launched, this agrees with Hernández [2] who determined that given Re>600 a Vortex ring will be less stable and will develop instabilities in the flow pattern, though they used much slower and much smaller vortexes than I did. Despite these instabilities I am still surprised at the efficiency of vortexes, and the surprising amount of time that they can persist.

# Photographic Technique

The image captures a complete vortex, including the nozzle of the vortex cannon. The nozzle is pointed at an angle towards the camera of ~45 degrees. The focus on the vortex itself is lacking, however the focus on the residual effects, and the cannon is adequate. In the future, this could be solved by decreasing the aperture which would increase the depth of field.

The unedited photo has a field of view of about 3 ft x 5 ft. The distance to the lens is about 4 ft. I used a DSLR camera, specifically the Canon Eos Rebel T3i. The original dimensions of the image are 5202 x 3464. The F-stop used was f/3.5, the exposure time was 1/200 sec, the ISO was 6400, the focal length was 18mm. The original image is shown below:



As can be seen in the unaltered image, there is quite a bit of graininess due to the high ISO used. Additionally the high ISO also caused some blow-out in the nozzle of the cannon due to the LED. I reduced the effect of the blow-out in post, primarily by applying a tone curve, and I fixed the large amount of graininess by using denoise in Darktable. Additionally I cropped the image to highlight the phenomenon, the final image has a resolution of 2307 x 1098.

## References

[1] Saffman P. G., (1975), On the Formation of Vortex Rings, Studies in Applied Mathematics, 54, doi: 10.1002/sapm1975543261.

[2] R. H. Hernández, B. Cibert, and C. Béchet, “Experiments with vortex rings in air,” Europhys. Lett., vol. 75, no. 5, p. 743, Jul. 2006, doi: 10.1209/epl/i2006-10171-0.