Team First

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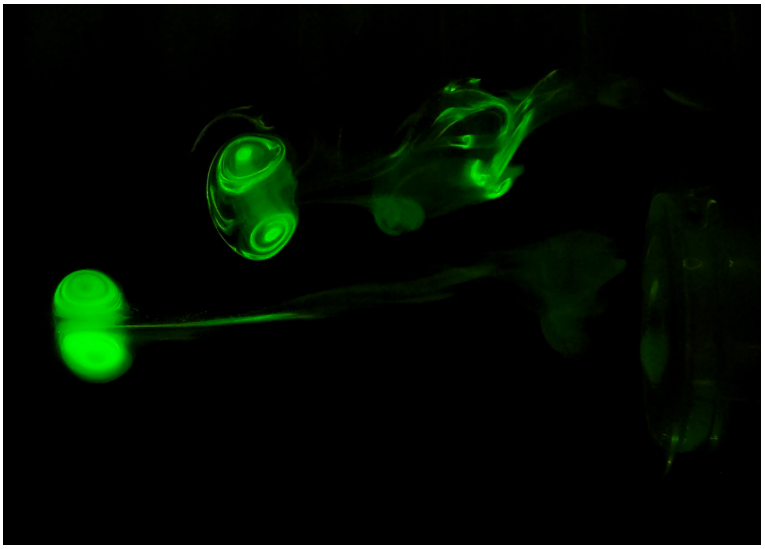

1 Introduction

This image is the cross section of a vapor vortex ring that is being created by a device called a Zero Blaster. The ring itself is being illuminated by an elliptical cone of laser light created by a separate office desk toy. This photo was taken in a dark room completely absent of other light sources as well as any external air flows. The main goal of the image is to show a cross section of the fluid flow to better understand vortex rings.

2 Experimental Setup

The set up of this experiment has three main parts. The first is the laser desk toy. This toy creates an elliptical cone of laser light by rotating a mirror in which a laser is constantly shining on. The next main part is the Zero Blaster. This device is positioned above the entirety of the laser desk toy. The Zero Blaster creates a visible vapor in the air by heating up a fog machine mix consisting of propylene glycol, triethylene glycol, and glycerin. This vapor is then pushed out of the circular opening using quick impacts on a diagram in the back of the toy. This is what creates the vortex ring that is to be pictured. The last major piece is the setting. In order to get this image, there has to be very little air movement outside of the vortex ring, and very little light in the background. This is why this was done indoors in a blacked out room.

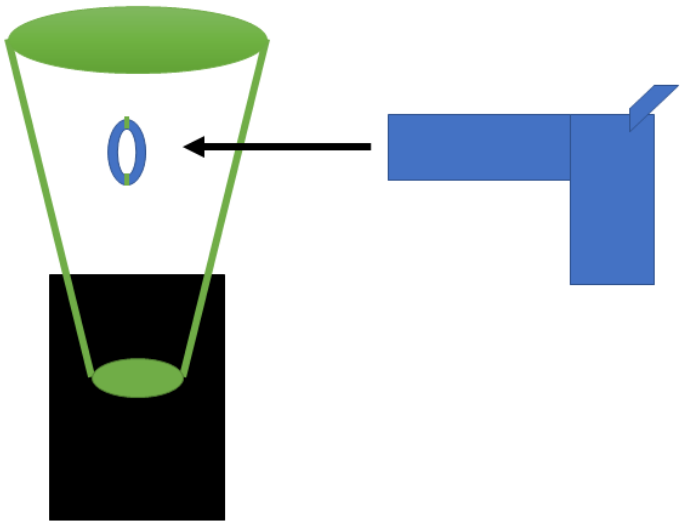

Figure 1: Experimental set up diagram

This diagram shows the basic set up of the experiment. The large blue object represents the Zero Blaster, while the small ring represents vapor. The green is the conical laser surface, while the black box is the laser desk toy.

3 Fluid Physics

The physics behind this picture is based on vortex rings. A vortex ring is exactly what is sounds like, a vortex in the shape of a ring. More specifically, a vortex is a flow of a fluid that is revolving around an axis. A good example of a vortex is a tornado, as all of the gas rotates around an axis going upward. In the case of a vortex ring, the gas all still rotates around an axis, but the axis in which the fluid rotates around is a ring. This

creates a torus shape. In a vortex ring all of the fluid moves in the same direction around the ring. This, in effect, creates a flow of fluid moving inward on one side of the ring and outward and around on the other side.

In the cross sectional image of this effect, rings moving in the direction of the vortex are clearly visible. On the outside of the vortex ring you can also see some of the vapor being pushed off the ring because of it's motion through the surrounding air. When a vortex ring is moving though a fluid, the relative motion of the vortex ring makes the inside travel faster than the outside. In this respect, the sear force of the outside air does less to slow down the vortex ring. This gives this ring the ability to travel further than other types of air flow, similar to how a rolling ball will go further than one being dragged on the floor.

Another interesting phenomenon that is show is the density of the vapor. The vapor coming from the zero blaster must be heated to be created and, because of this, tends to be less dense then the surrounding air. The photo captures two separate blasts from the Zero Blaster. The first one is on the right. It is clear that this is higher up. This is because it was shot slightly earlier and had time to rise in the heavier air ambient air. There are many aspects that make the fluid dynamics in this image rather unique.

4 Visualization Techniques

The main technique in capturing this image is the lighting. No backdrop was used other than a dark room, and the flow was simply coming from a device that creates vapor vortex rings. The lighting was done with a rotating laser as mentioned above. It created the illusion of surface of light, and with the right shutter speed, it was possible to see this surface of light illuminated all at once. This is what creates the beautiful green color that lights up a perfect cross section of the vortex ring's movement.

5 Photography Techniques

For this photo, there was a lot of guess and check when taking the photos. I was using an Olympus OM-D mirror-less camera with a 14-42mm zoom lens. The camera was in full manual mode so I could make sure the settings matched what I was trying to capture. After some guess and check I found that a shutter speed of 1/200 of a second would give time for the rotating laser beam to fully show the surface I wanted to see. It was also a compromise between catching enough time resolution and having enough light go to the sensor. I chose and aperture of F3.5 to allow as much light in as possible since this photo was in such a dark environment. Given also that everything being pictured in the image would be nearly the same distance from the camera, I had no problems with spacial resolution. From these two settings I started at a low ISO and moved up until the images had the right amount of light. The exposure sensor was useless in this effort, as I was not going for a middle gray image. The ISO in the final image was 4000. When I took this photo it was done using no zoom, as zoom would not allow for as much light to be recorded. The focal distance was 14mm and it was taken from about 1.5 ft away. The last thing that had to be set was focus. This was set manually by adding lots of vapor near the laser beam before taking the shot, focusing, and keeping the camera fixed at this distance. After hundreds of shots, the image you see turned out exactly as I was hoping. The photograph had little post processing other than darkening the background slightly and cropping the image.

Figure 2: Original Unedited Photo

6 Comments

I'm very proud of the job I did on this photo. The extreme contrast of the bright green and dark black really help make the viewer focus on the flow. I also really enjoy how you can see specific lines of flow in the image.