

Team Second: Spooky Spirals

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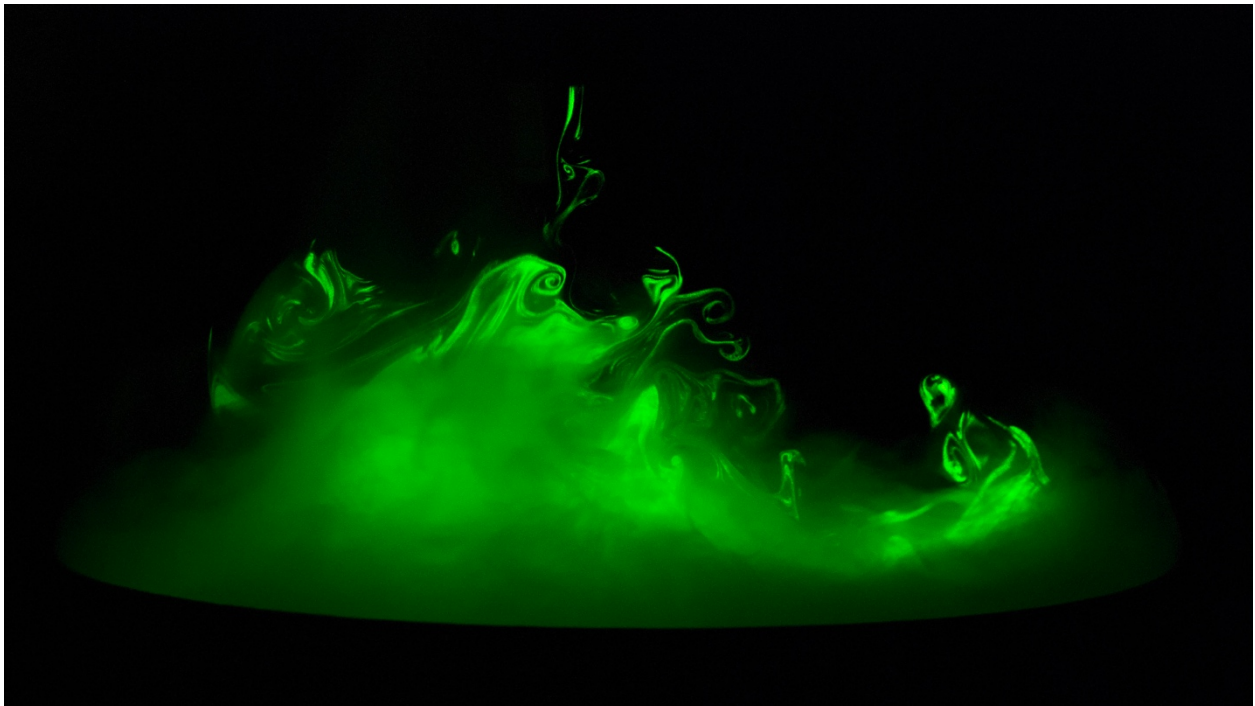


Image 1: Final Edited Image

Intro/Background

The image pictured above was a result of the 2nd team assignment for my flow visualization course at CU Boulder. The assignment was simply to create and capture a unique and interesting flow phenomena. To accomplish this the team decided we wanted to capture the cross section of a vortex using a LASER sheet in a dark room. We initially intended to use a high power pulse laser with a sheet forming lens, along with a vortex generating apparatus to generate our phenomena. However, due to complications with set up and access to the apparatus, we decided to resort to much simpler methods, which are described in detail below.

Flow Set-Up/Description

The set up for this image was relatively simplistic, using only everyday household items. As can be seen in Figure 1 below, a plastic bowl, with a matte white interior surface, was placed on a flat surface with a black backdrop (not pictured). This bowl was then filled with lukewarm water and two medium sized chunks of dry ice were dropped in. As steam started to collect in the space above the water, a small window fan was held roughly a foot above the bowl (pointed upwards) and turned on. This caused air currents to begin to flow from around the bowl, up through the fan, disturbing the collecting steam and pulling it upwards from the surface of the bowl. A laser pointer was then rapidly shook up and down creating a laser sheet which “sliced” through the rising steam, resulting in the above image. The diagram is shown from the perspective of the camera, indicating camera position.

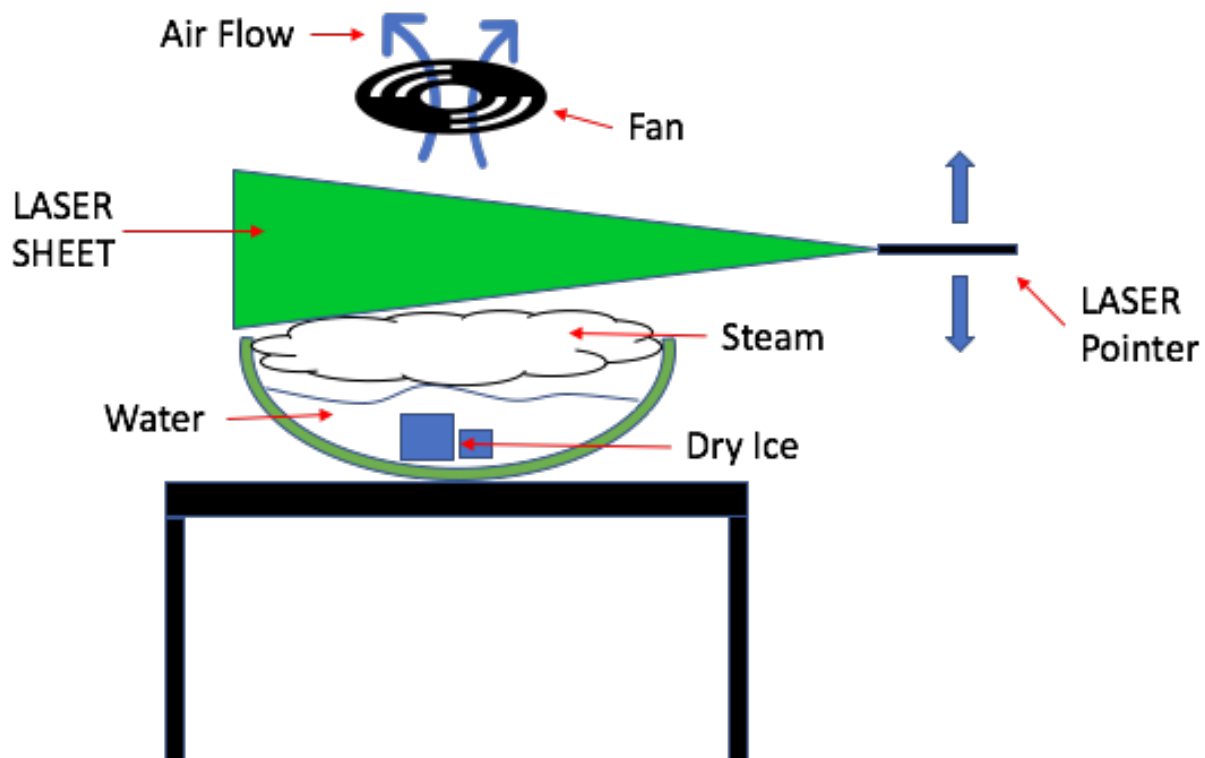


Figure 1: Flow Visualization Set-up

The resulting phenomena, seen in the finalized image, are described in detail by teammate Chet Roe below:

“In the photo, we can see the side profile of some vortex rings. For a vortex ring to occur, a uniform jet of fluid moving upwards (in our case) is the instigator of the curling flow. When this jet reaches a surface, the outside edge catches with the no slip condition at the interface. This means that the fluid nearer to the edge will move slowly, while the center is moving quickly, causing a spinning motion to form. As this spinning fluid with the jet at the center moves through the air, the air at the outside is still relative to the moving fluid, causing the fluid at the edges to slow, similar to how it did at the surface interface. This interaction continues the spinning of vortex.

For our fluid, we have a miniscule amount, about one drop, of dish soap in the mix bowl of water and dry ice. As a dry ice bubble forms and rises quickly to the top of the water it has a very uniform speed. When it reaches the water surface, the bubble bursts and some of the vapor catches on the water surface, as if it were a hole in a can as shown below [1]. This creates a vortex as described earlier.

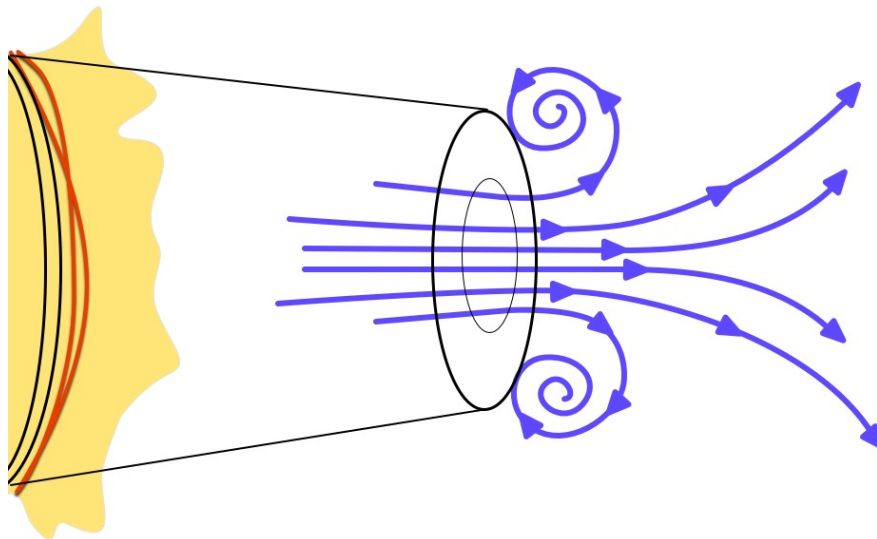


Figure 2: Vortex ring being pushed out of a small opening in a soft bottle [1]

Another phenomenon we see is that the CO₂ gas is staying very low and just above the bowl. This is a simple hot air rises situation, where the gas is still much colder than the surrounding air. The only upwards plumes are caused by exploding bubbles or by the fan sucking the air upwards.

Visualization Technique

As is mentioned above, the visualization was captured by using dry ice “smoke” and a green laser to highlight cross-sections of the smoke. We used roughly 1 part dry ice to 4 parts warm

water to get the desired fog density and the laser used was a hand-held *Wicked Lasers*® green laser pointer. The entire set up took place in an absolutely dark room with no natural light, meaning the only light source was the laser pointer. The camera used was a Nikon D80 and the flash was left off for the visualization.

Photographic Technique

Team member Hanna Kieger describes the photographic technique as such: “The size of the field of view was around a foot wide and the distance from the object to the lens was around 6-7 inches. The focal length was 40.00 mm. The image was taken with a digital Nikon D80 camera which resulted in an original image of size 3872 x 2592. The final size of the image uploaded to flowviz.org is 1300 x 866. The exposure specs are as follows: exposure - 1/15 seconds, aperture - f/10, ISO 800.”

Post processing manipulations on the image were kept to a minimum as there was little to improve given the extreme contrast of the green laser to the dark room. In short, the image was cropped slightly to center the phenomena in the image and brightness and levels were adjusted to bring out some of the more subtly highlighted smoke. The original image is included below for reference.

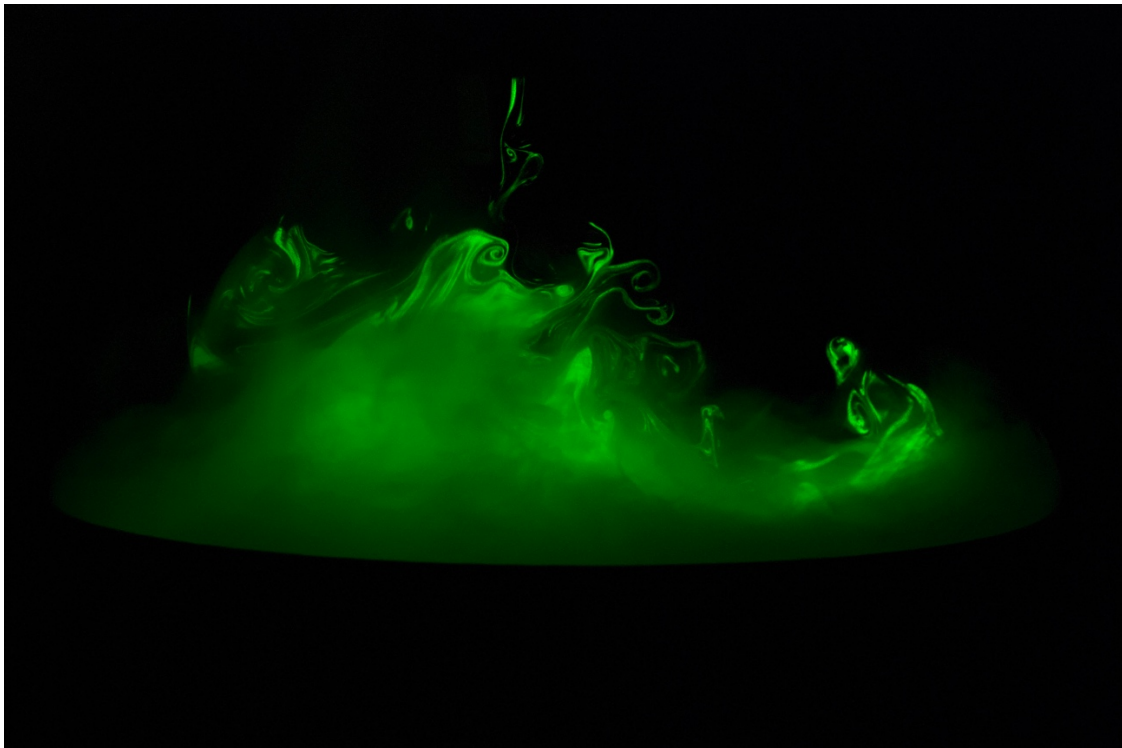


Image 2: Unedited Image

Discussion

Despite being unable to capture the cross section of a perfect vortex, I am quite happy with the way this image turned out. I think the out of focus smoke surrounding the crisp, highlighted

flow phenomena created a very dramatic effect, that was quite fitting for Halloween, when it was taken. I am also fascinated by the perfect spirals we were able to capture throughout the image. However, if given the opportunity to repeat the image I would like to find a way to generate a perfect vortex (smoke tornado), as I am still quite curious what such a cross section would look like.

References

[1] <https://www.sciencefriday.com/educational-resources/design-a-better-vortex-cannon/>