Smoke Ring Vortices
Group Project 1

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For this project, our group decided to investigate the vortex rings produced from ejecting smoke from a round orifice. It was desired to see the circulation caused by the vorticity, as well as the trailing smoke pattern left behind the vortex ring. Below is the final image that was achieved, after a little bit of tweaking in Photoshop.

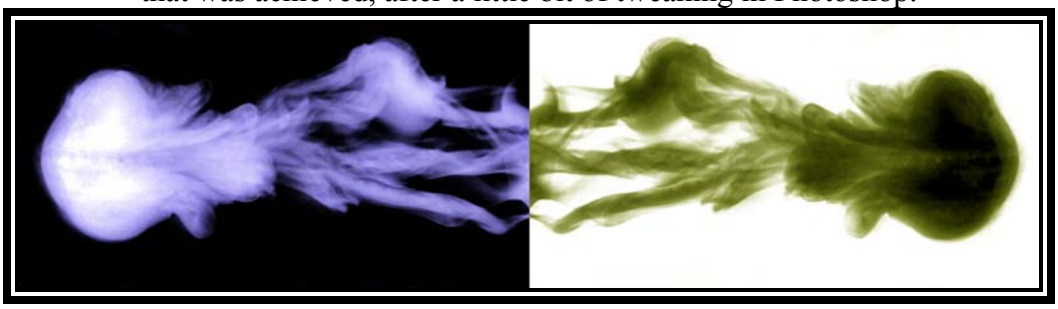

Figure 1: Final Smoke Ring Image

After hundreds of smoke rings, and hundreds of pictures, a few good photographs were found. The above image was chosen due to it portraying fairly well what the smoke ring was doing, as well as the trailing smoke. The smoke rings were somewhat hard to visualize as they were traveling fairly fast across the field of view and the lighting was difficult, however the end result seems pleasing both visually and scientifically.

The apparatus used for this picture was fairly simple. A small cylindrical chamber was filled with smoke generated from a fog machine. A plastic membrane on the back on the chamber was hit to force the smoke out of the circular opening in the other side, creating a smoke ring. The ring was then photographed from the side as it passed by, using a black velvet cloth as a background. The setup can be seen below.

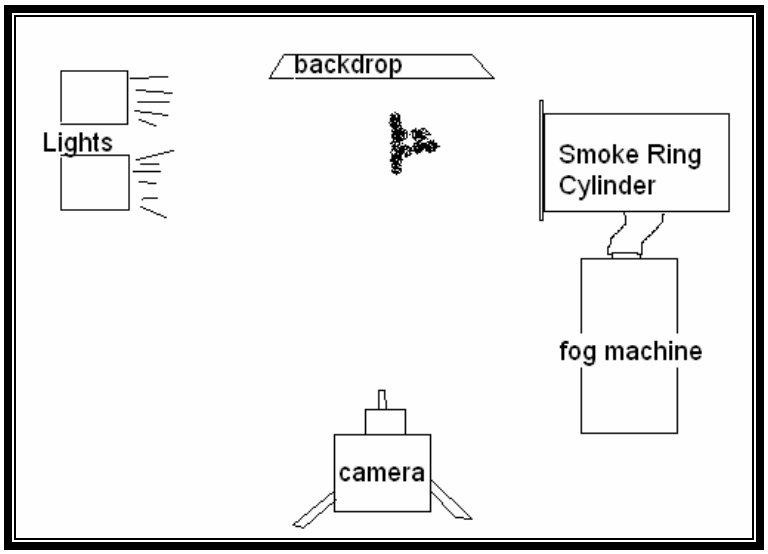

Figure 2: Apparatus

The smoke ring is formed as the smoke is forced out the orifice. The outer part of the ring goes slower than the inner part, causing a circulation of the smoke. This constant circulation causes the vortices to form. If the hole is irregular in shape, the curvature of the ring affects the speed it travels. Thus if the smoke ring is oval, the major and minor axis switch as the curvature changes.

The camera used for this picture was a Pentak film SLR camera, with Ilford HP5+ 400 black and white film, using a wide angle lens, zoomed into 50mm. The aperture was set to the largest possible to allow the most light possible into the lens. Shop lighting was used for lighting from below, as well as using a flash, to ensure a very fast shutter speed (TV = 1000). The fast shutter speed ensured that there would be no motion blur. Also, a tripod was used to ensure that the camera would not shake at all and ruin the picture. The film was developed in the University of Colorado's art building's dark room. The film was then scanned into Photoshop at 3200dpi. Increasing the contrast and fixing the level

of the picture allowed for a threshold to be used, so as to remove the undesirable background. The hue was then modified to better exhibit the streamlines. The image was then copied, inverted and mirrored, thus creating the image seen in figure 1.

This image is desirable both for its aesthetic look as well as its scientific appeal. It reveals the smoke ring in the front, with the turbulent smoke trailing along behind it, caused by vortex not being able to recirculate all the smoke. If I could, I would like to improve the image by fixing the lighting so as to better accentuate the streamlines of the vortex. The flash from straight on somewhat caused the vortex to be washed out into one big white mass. Possibly if a laser sheet could be used to cut through the center of the vortex, the streamlines of the vortex could be seen much better.

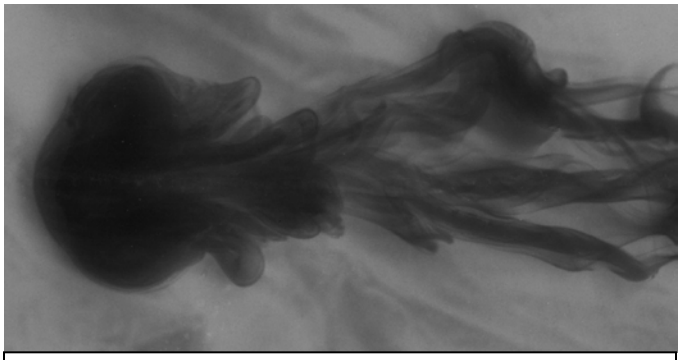

Figure 3: Original Image

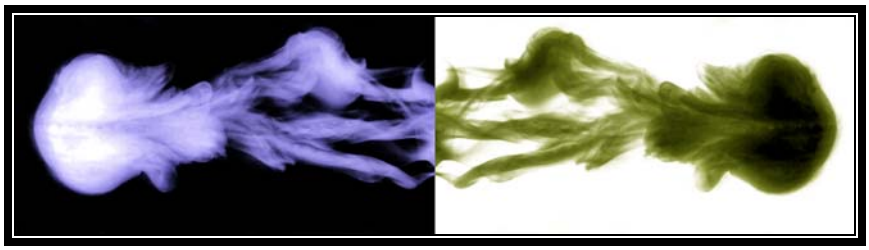

Figure 4: Final Image