Smoke Ring Cannon

Anthony Landberg*

Physics Department, San Francisco State University

Abstract

A physical treatment of the smoke ring cannon is presented, including the basics of construction and the underlying principles of ringed flight.

*Electronic address: alandber@stars.sfsu.edu; URL: http://physics.sfsu.edu/~alandber

I. PHYSICAL DESCRIPTION

A. Smoke Ring Cannon

The smoke ring cannon is constructed out of a 30 gallon trash container. The container was bought new at a hardware store, whereas any large cylindrical container with at least one sealed end may be utilized. A concentric, circular hole was cut out of the bottom of the container with a compass set with a radius of 3 inches. The hole was cut so as to produce a smooth lip as well as to emphasize circularity. The hole could be made any size as long as the radius is not larger than one half the radius of the container. The original lid of the trash container is used as the impulse membrane. Future considerations include a tarpaulin membrane with a restoring force elastic cord system. This is intended for a replacement for the existing lid.

B. Smoke Machine

The smoke produced is made from an aqueous solution containing traces of Thylene Glycol solutions, brand name Fog Juice. The machine used is a Heshan Lide Fogger, model number FM-400p.

II. VORTICES

A. Toroidal vortices explained

As the membrane pushes the air out of the gun, aerodynamic drag from the edge of the ring that makes the front of the gun and the still air outside of the gun causes the exhausted air to begin rotating as the curling lines show in Figure 1.

This creates the toroidal vortex. Torus is the mathematical description for doughnut-shaped. Because the air ring or toroidal vortex is rotating, the velocity inside the vortex is greater than the velocity of the air outside it. The velocity of the air outside the vortex happens to be zero because it is standing still. Bernoulli's principle states that the faster a flow of air is moving the lower the air pressure drops. Since the air inside the torus is moving and the air outside is not, the air pressure inside the torus is lower than the air pressure

outside. This difference in pressure results in a net inward pressure is the force that holds the smoke ring together. Figure 2 show a cross section view of the smoke ring. The net difference in air pressure is shown by the three arrows on the bottom of Figure 2,

The rotational arrow at the top of Figure 2, is the direction the air in the vortex is moving, backwards on the outer surface of the ring. As this flow rubs against the still air that surrounds the torus, friction causes the torus to move itself forward. Think of a bike wheel sent spinning with the tire pushed suddenly against the ground, friction would tend to pull the bicycle wheel forward. The energy that is used to move the ring forward and keeps the vortex rotating is taken from the momentum of the rotating air inside the vortex. Air has mass and therefore once air is in motion it has momentum that will keep the air ring moving in the original direction it was sent. The spinning of the air in the torus is where the energy that keeps the torus moving is stored. Eventually, air friction eats away all the energy stored in the vortex and the smoke ring puffs to a stop.

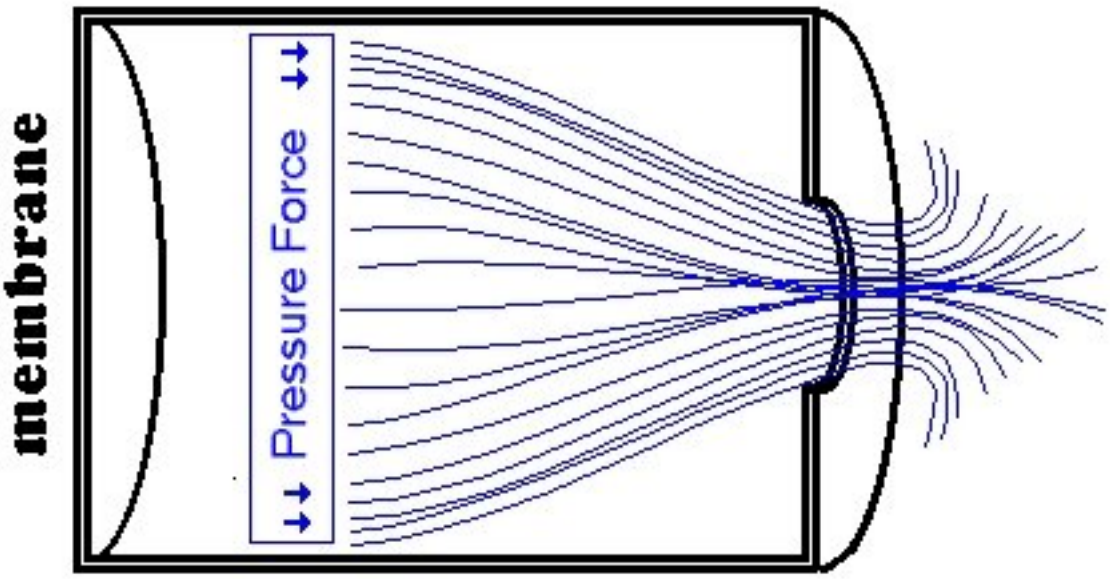

Figure 1: The membrane pushes the air out of the circular opening, creating the toroidal vortex.

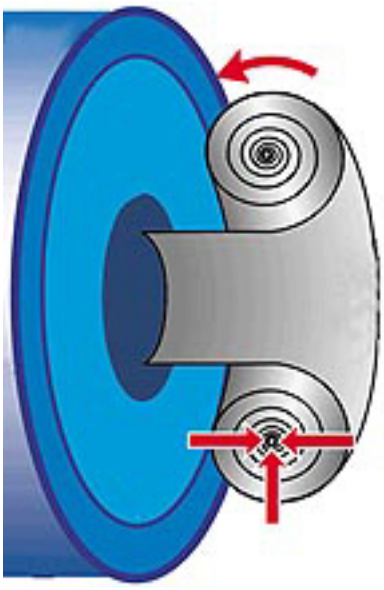

Figure 2: Cross section view of toroidal vortex.