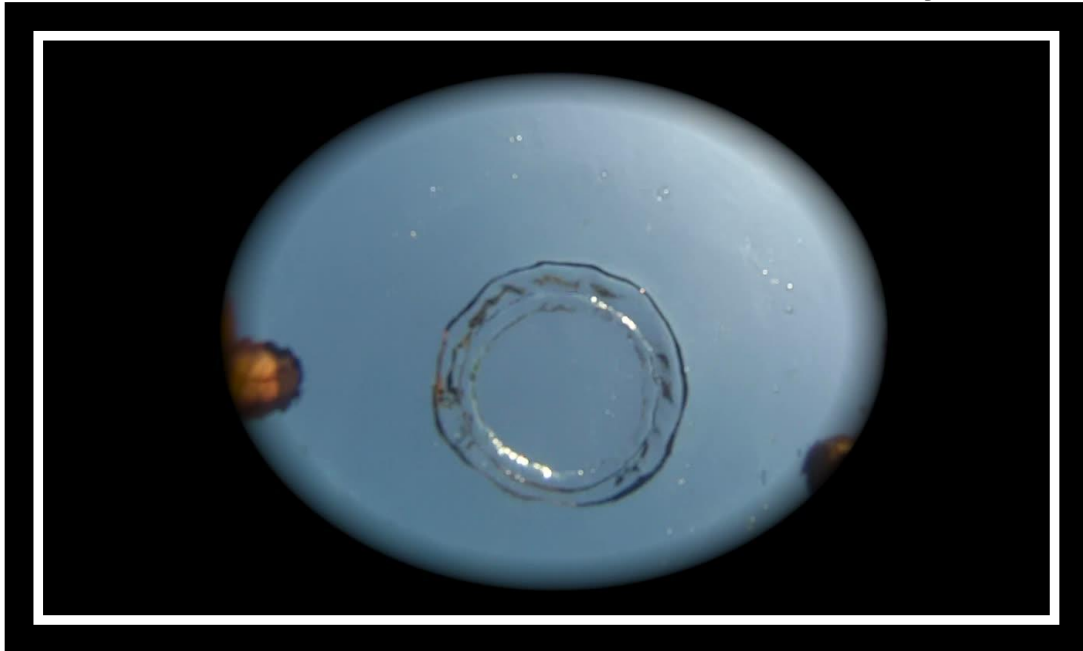


Scotty Hamilton



Introduction:

The goal of this video was to show the effects of blowing bubble rings in a static water pool. These “bubble rings” are commonly known as toroidal vortices. There is a lot of evidence of underwater mammals creating these toroidal vortices as seen in by the dolphin in figure 1. Taking the knowledge that marine mammals can create these unique vortices, an experiment was set up to create our own vortices.



Figure 1 Dolphin blowing toroidal ring.¹

Video:

The video was taken in a friend's hot tub in Southern California. The bubble ring had to be created in a hot tub because of the very static water. It was first attempted in a pool but the water had too much movement to create a consistent bubble ring. An accurate image of the setup can be seen below in Figure 2.

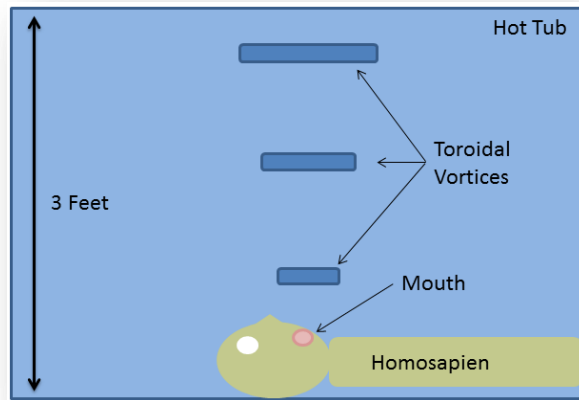


Figure 2 Initial setup for image

Physics of Phenomenon:

The physics of bubble rings has been researched more extensively in a very similar phenomena, the smoke ring. While both of these are vortex rings, they pass through different mediums, one water and one air.³ As mentioned earlier, dolphins commonly produce bubble rings for entertainment. Research on this dolphin behavior led to an understanding that any spherical bubble larger than 2 centimeters will become a bubble ring due to the difference in pressures above and below the bubble.⁴ As the surface tension of the spherical bubble collapses the rushing water through the center of the ring causes poloidal rotation. A poloidal rotation is a type of turning around a donut shape. This rotation can be seen by the in Figure 3.

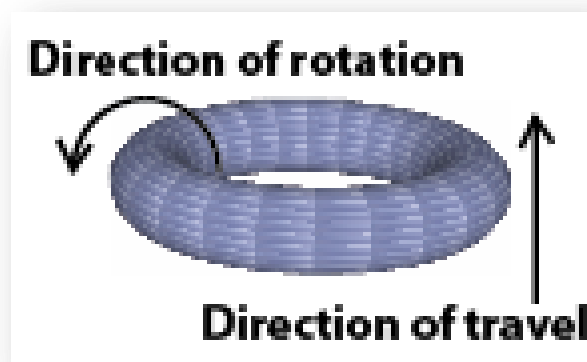


Figure 3 Poloidal rotation shown by the direction of rotation arrow

In the experiment conducted in the hot tub, it was noticed that a larger than 2 cm diameter bubble was difficult to make. Therefore blowing out in a ring shaped

pattern allowed a quicker bubble ring to form. See Figure B and C in appendix for a better view of the bubble generator.

Divers commonly create bubble rings as well. Some research into how divers create these bubbles has produced some awesome images. Figure 4 shows the progression of a large bubble as it is released through a small orifice.



Figure 4 Creation of bubble sequence⁵

The sequential bubble creation image shows the quick collapse of the bubble into the toroidal shape. This is a result of the pressure differential between the top and the bottom of the bubble.

Looking at the footage closely it can be inferred that the bubble took 46 frames to reach the surface of the hot tub. Knowing the camera was shot at 30 frames per second, a time can be determined.

$$\text{Time to reach surface} = \frac{46 \text{ frames}}{30 \text{ frames/second}} = 1.53 \text{ seconds}$$

Knowing the time the bubble took to reach the surface and the distance it traveled, a speed can be determined.

$$\text{Velocity of bubble ring} = \frac{3 \text{ feet}}{1.53 \text{ seconds}} = 1.96 \text{ ft/sec} = .597 \text{ meters/sec}$$

Photographic Technique:

The following is a list of the camera settings used to take the photo.

- Size of the field of view: 24 x 24 inches
- Distance from object to lens: 30 inches
- View Angle: 170 degrees
- Type of camera: Go Pro Hero (1280 x 960)

- Frame Rate: 30 fps

The video was edited in Final Cut Pro X. Most of the editing comprised of adjusting the speed of the flow and cropping out unnecessary sections of the surrounding water. This allowed for a clearer view of the bubble rings and ultimately led to a better understanding on how they flowed.

Commentary:

The bubble rings created in the hot tub showed an important phenomena in fluid dynamics and also proved to be very beautiful. Further work could include creating a device that produces consistent bubble rings every time. Some devices already exist and can be found on bubblerrings.com, a picture of such a device can be seen in Figure A in the appendix.

References:

1. (Dolphin creating toroidal vortices) <http://wn.com/dolphin_smoke_rings>
2. (Poloidal rotation)
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5. van der Velde, Jorgen. "The Physics of Bubble Rings." *Deep Ocean Diving's Diving Science*. Deep Ocean, 13 Mar 2005. Web. 7 May 2012.
<<http://www.deepocean.net/deepocean/index.php?science09.php>>.
6. (Bubble ring generator)
<http://bubblerrings.com/bubblerrings/products_pool.cfm>

Appendix:



Figure A. Bubble ring generator⁶



Figure B. Bubble creator making quick succession of bubble rings



Figure C. Snapshot of bubble generator with bubble ring