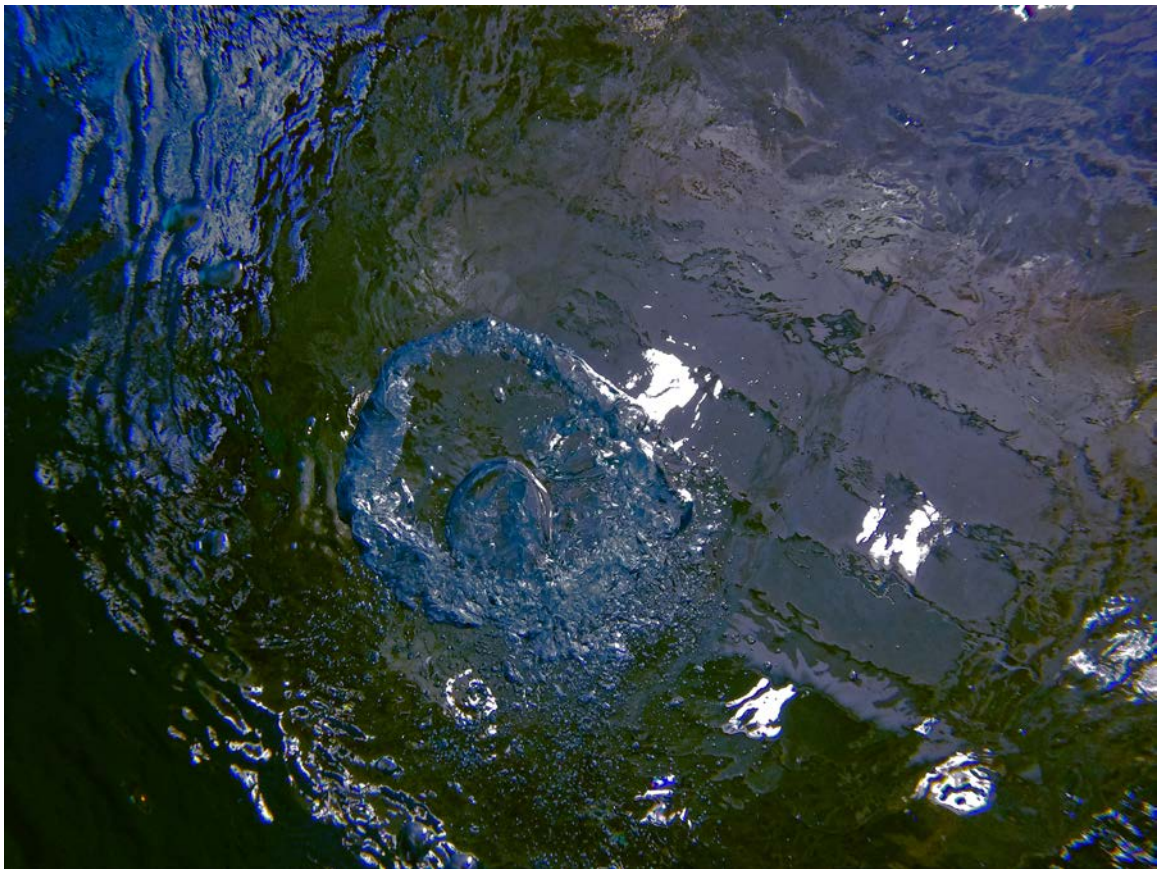
CU Boulder

Flow Visualization

Group 1 Report



Ian Durkin

Purpose

The purpose of this image is to explore the phenomena of toroidal vorticies. The group originally planned to capture the effects of these bubbles interacting with one another. That is to say, capture one toroidal bubble passing through another. Visually, this is a rather stunning phenomena to witness, let alone, recreate. The group, Ian Durkin, Andriy Wybaczynsky, and William Vennard, met at the dive well at the Recreation Center on the CU Boulder campus. The well is a fourteen foot deep pool used by high dive athletes of the school. The group quickly found that forming one of these bubbles is extremely difficult and requires a great deal of skill. [1] Andriy was able to form these bubbles, but no one else. Capturing two of these bubbles in a sequence became out of the question due the pressure at the bottom of the pool and Andriy's lack of oxygen, all of which is expelled to form a bubble.

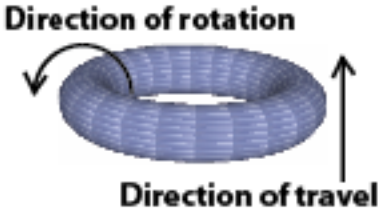
Description of Flow Physics

The image displayed on the front cover of this report is one of many pictures captured. This particular image is captured in an attempt to form a second toroidal bubble passing through the first.

Toroidal bubbles are a phenomena still under active research in fluid dynamic fields. They are seen naturally in nature, most notably while watching dolphin behavior, and can be formed in a variety of fluids. The most common example of this to a lay individual would be blowing smoke rings.

Mount Etna releases a smoke ring [2]

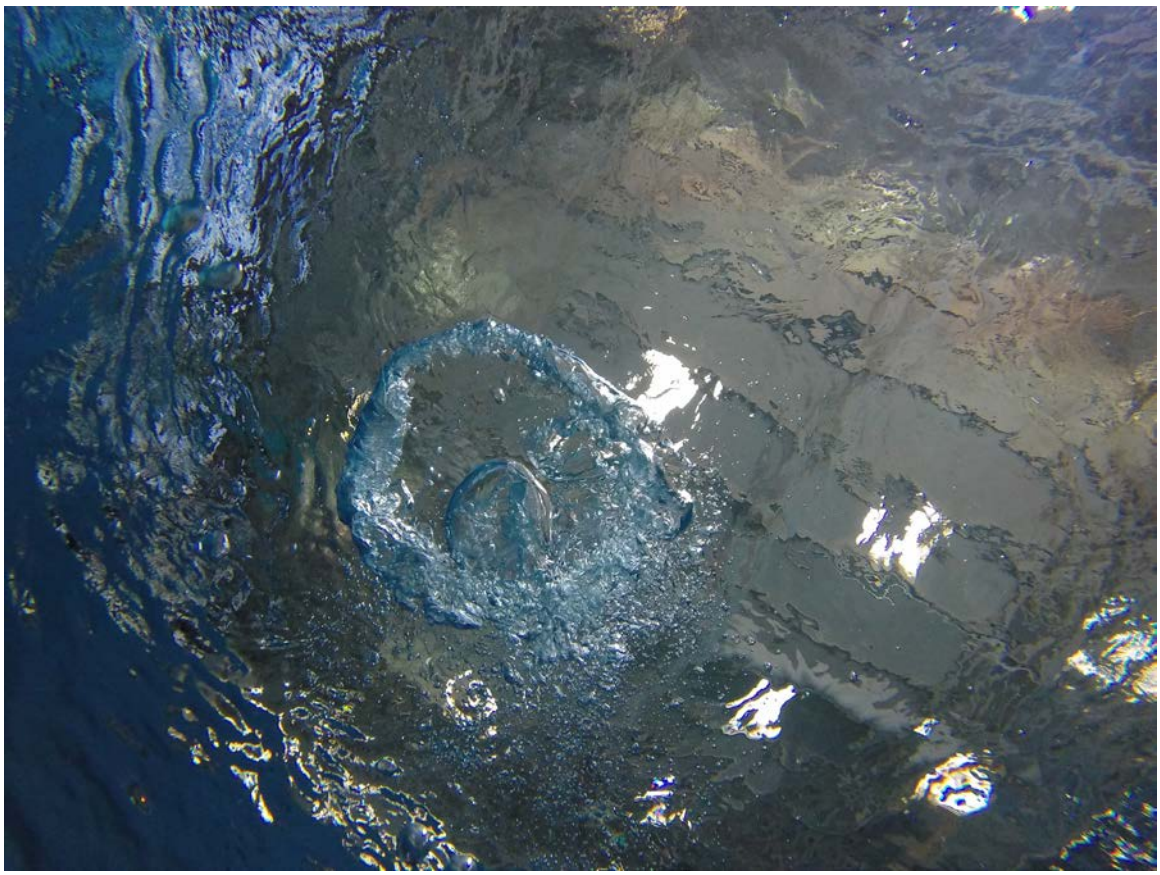
The bubble forms when air is captured in the center of a vortex in a ring shape. As this air rises up, a downward drag force is applied from the fluid to the air, resulting in a spin in the ring fluid. This causes the vortexing effect that provides stability to the toroidal ring. Thus, the faster the velocity of the ring, the more stable it becomes. [3]



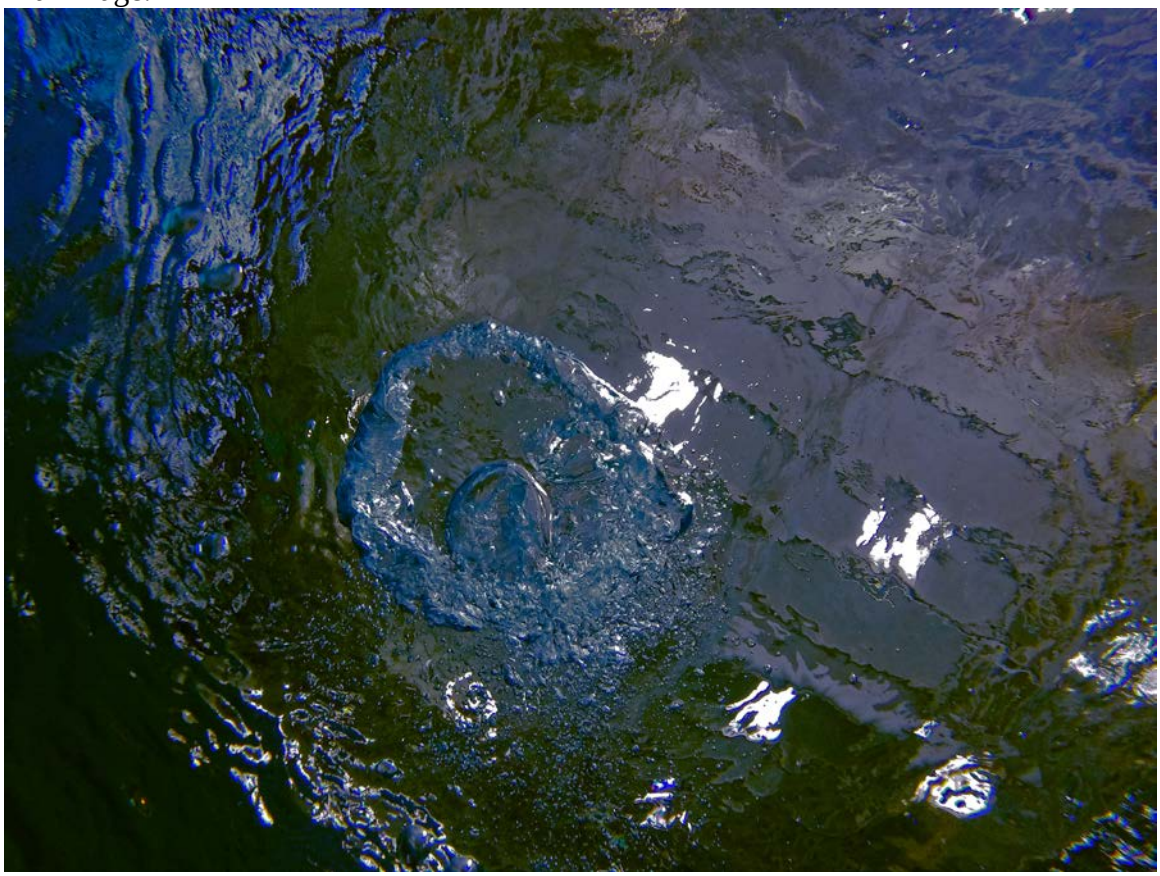
David Whiteis. Used under Creative Commons

Photographic Technique

The photograph is taken on a GoPro Hero 3 camera, in an underwater case, using the photo burst function. Most settings were left automatic due to the varying light during the tracking of the bubble underwater. The specific image measures 2592 x 1944 pixels in size, taken at a focal length of 5mm, f-number of 2.8, and a shutter speed of 1/213 seconds. The ISO data is unavailable from the camera. Below is the original image.



Mild post processing of this image is applied using the Photoshop Elements 10 software package. No cropping was applied to preserve the framing of the original image with regards to the bubble and the line of the room ceiling, seen through the surface of the water. Blue levels were increase, to detract from the greening effect of the chlorinated water. A slight increase in contrast was applied to sharpen out the image. Below is the final image.



Conclusion

The goal of the experiment was to capture the effects of multiple toroidal bubbles propagating through a fluid, in that this image demonstrates an attempt at capturing this. What was found, however, that this phenomena takes a great deal of skill to form. The particular image shown represents a toroidal bubble dissipating while a failed attempt passes through the center of the ring. Performing this experiment again, I would wish to have some sort of mechanism that would reliably replicate a toroidal bubble every time, with the hopes of capturing two at once. Underwater capabilities aside, the GoPro may not have been the best choice of camera given its notoriously wide lens. This lens produces a fish eye effect on most images the camera captures, unless the subject is extremely close to the lens. Tracking this phenomena would not be possible at a close distance, as the turbulence caused by the swimmer was found to disturb the bubble.

Reference:

[1] "Blow Underwater Bubble Rings." › *Tricks (ABC Science)*. N.p., n.d. Web. 05 Nov. 2015.
http://www.abc.net.au/science/articles/2014/04/11/3978532.htm

[2] Tomlinson, Simon. "Meet the Gandalf of Volcanoes: Incredible Moment Mount Etna Puffs out Perfectly Formed 50-METRE Smoke Rings." *Mail Online*. Associated Newspapers, 24 Feb. 2014. Web. 05 Nov. 2015.
http://www.dailymail.co.uk/news/article-2566812/Incredible-moment-Mount-Etna-puffs-perfectly-formed-50-METRE-smoke-rings-blue-sky-coast-Sicily.html

[3] Ruban, V. P., and J. Juul Rasmussen. "Toroidal Bubbles with Circulation in Ideal Hydrodynamics: A Variational Approach." *Physical Review E Phys. Rev. E* 68.5 (2003): n. pag. Web.
http://arxiv.org/pdf/physics/0306029.pdf