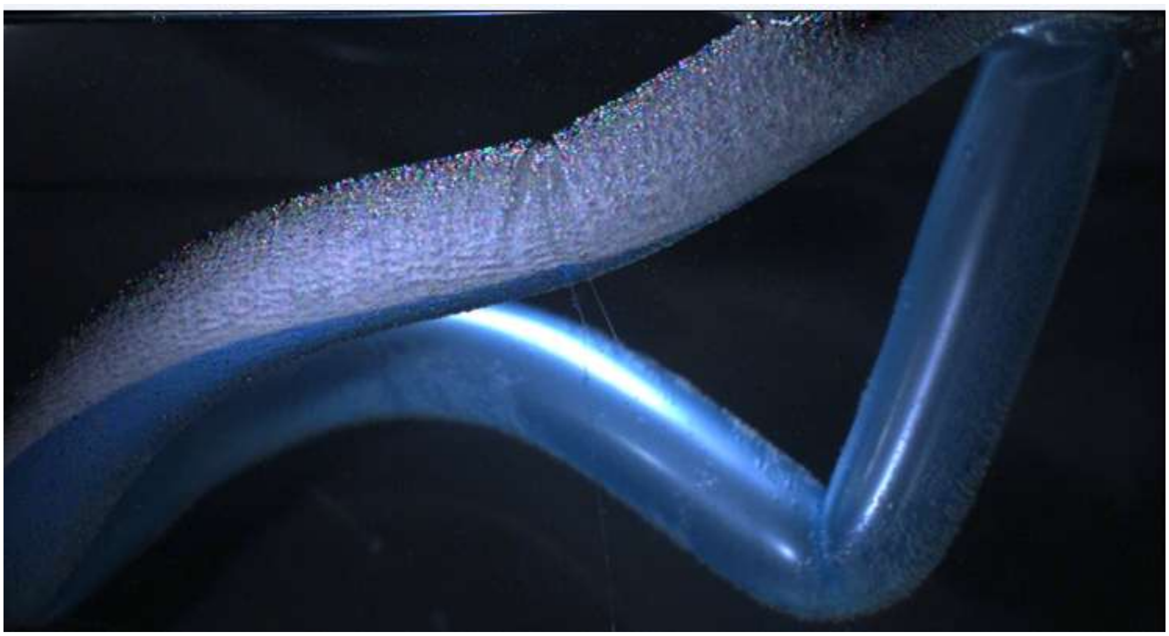
High Speed Image of a Balloon Popping Under Water



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Flow Visualization, Team Image #1

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The goal of this flow visualization was to capture high speed video of a balloon filled with air popping under water. The image shown above is a single frame taken from the video which shows the balloon as it is popping and releasing air into the water. Scott from our group is credited with developing this idea.

The schematic in Figure 1 shows the setup of the fluid visualization. A 10 gal. fish tank was filled with water so that it was about 90% full. A party-style balloon was filled with air until it reached about three feet in length. This balloon was twisted into a horseshoe shape and was held under water using fishing line and steel weights. A small part of the balloon was left above the surface of the water. The balloon was popped by pressing a needle into the part of the balloon that was left above the surface of the water. This was done so that the person popping the balloon would not disturb the water with his hand.

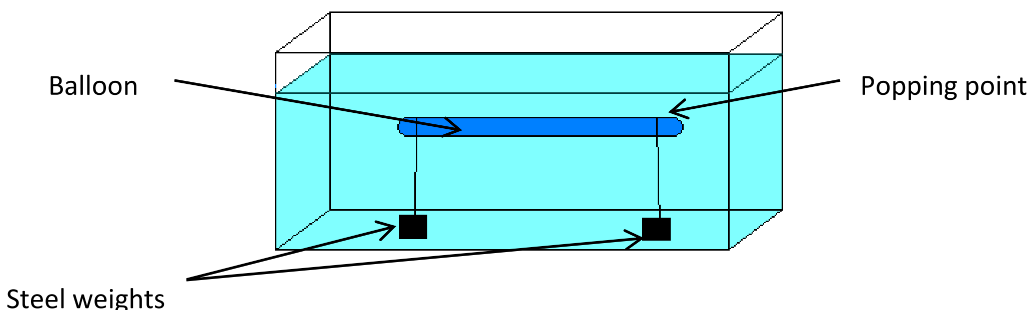

Figure 1: Image Setup

So what's going on? Once the surface of the balloon is punctured by the needle the elastic properties of the balloon cause it to tear apart and shrink to release the stress caused by the air stretching the balloon. As the balloon unwraps around the air it creates a small amount of surface tension on the air and the water. This tension does not deform the air much at all. As the air is released from the balloon the buoyant force causes it to rise through the water. The buoyant force results from the difference in density between the air and water. The magnitude of the buoyant force is equal to weight of the water that the air displaces. Given enough room to rise, the bubble would have eventually reached a terminal velocity. Since our bubbles only rose roughly 8in. they did not reach the terminal velocity. A force diagram is shown below in Figure 2.

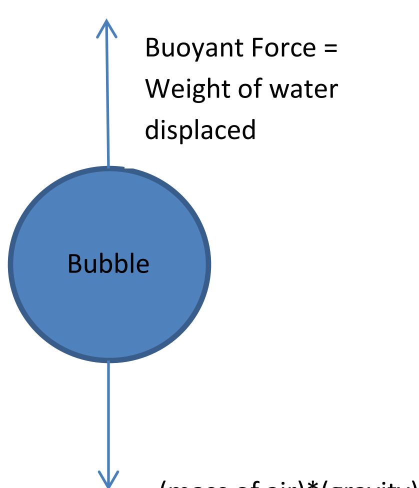

Figure 2: Force Diagram

When the air moves through the water drag from the water causes the air to form into bubbles. The bubble shape occurs because the spherical shape has the smallest surface area to volume ratio.

The following table lists the materials used to create this image with the exception of the camera. Material properties are not included since air and water have commonly known properties. My last reference represents one a of few pages I looked at to try and help me figure out what the Reynolds number of our flow might be. I did not attempt to calculate the Reynolds number since I do not think I could accurately estimate the speed of the flow, however, from the articles I read I would guess that the Reynolds number is in the range of 4000 – 6000.

Table 1: Materials

Materials
Air
Water
10 Gal. Fish Tank
Party-Style Balloons
Needle
Fishing Line
Weights

All photos shown were taken on Mar 3rd, 2011 in the Durning Lab at the University of Colorado during a camera demo offered by Vision Research. The camera used was a Phantom V710. The only preparation the group prefromed was to wipe bubbles off of the surface of the tank before popping the balloon.

- 20000 fps
- Distance from lens to object: 3 ft.
- Image dimensions: 1000 X 1000 pixels

The image was cropped but no other adjustments were made to the original image.

This image is a great example of the capabilities and value of high speed cameras. In real time the balloon popped so fast it was difficult to even see where the balloon remnants went. However, when you watch the video at a slow frame rate the popping sequence is much more interesting and artistic. The way the balloon slowly unwraps around the fluid is strange and impressive. My favorite part about this video is watching the air as the surface texture changes and bubbles begin to form. For future images I would attempt to better understand the camera provided by Vision Research and I would attempt to set the lighting so that there is not such a glare off the balloon.

References

Woodrow Shew, Sebastien Poncet, Jean-Francois Pinton Laboratoire de Physique, Lyon, France
http://woodrowshew.com/bubjfm.pdf

Physics Forums, Air bubble in water at 50m
http://www.physicsforums.com/showthread.php?t=314443