Team Second 2016

MCEN 4151: Flow Visualization

University of Colorado Boulder

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11/2/16

I remember on hot days during the summer growing up having water balloon fights with my friends. Little did I know there was an interesting effect happening as the water balloon popped. Having the chance to see this happen in extremely slow motion was something I could not pass up. For our second team project we captured the burst of a water balloon using Professor Tadd Truscott's Phantom v2511 high speed camera. Sean Harrison, Hunter Miller, and Ryan Walker were my team members that helped setup and capture the burst.

The slow motion video highlights the physics that happen when popping a water balloon. Everything happens so quickly that you would never be able to break down what all is going on without the use of a high speed camera. Immediately after the initial tear caused by the nail, the latex membrane of the balloon begins to recede. This causes a shear instability to form as the balloon goes back to its initial, unfilled state. The instability is known as the Richtmyer-Meshkov instability that occurs when two fluids, in this case air and water, of different density are impulsively accelerated. As the interface between both fluids become more distorted a region of mixing and turbulence form. This all occurs in a fraction of a second. The initial tear to the end of the video is happening in approximately 0.003 seconds. You can see a boundary layer of water that is acted on by the force of the retracting membrane causes a spray that propagates outward in turbulent flow. The mass of water in the center of the balloon stays in laminar flow because the only force acting on it is gravity.

For the project we used traditional water balloons that you can purchase at Target or Walmart. We filled them up outside the ITLL at the University of Colorado Boulder and then transported them to lab where Professor Tadd Truscott had his high speed camera setup. He had four 250 W dome lights that were offset at an angle of 45 degrees. They shined toward the center where we stood with the water balloon. He also had two LED work lights that we placed in the center to provide some additional lighting. There was a nice black backdrop that was placed behind where we stood to create a clean black background for our videos. Refer to Figure 1 to see a diagram of how the apparatus was set up.

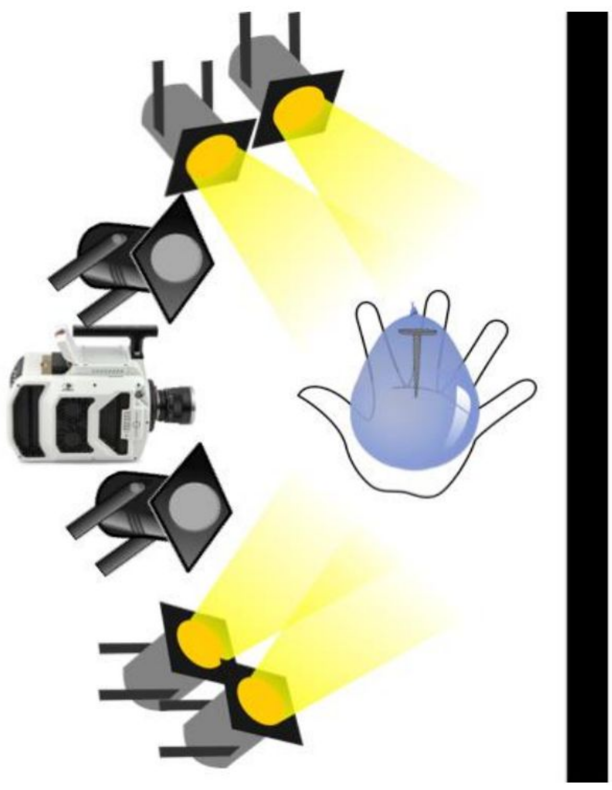

Figure 1: Apparatus Setup

The balloon was laying on my hand and then popped using a small nail. We placed a large fish tank on the floor underneath the balloon to catch the water that came out of the balloon.

To capture the slow motion video we used Professor Tadd Truscott's Phantom v2511 high speed camera. The camera is able to capture 677,000 frames per second at lower quality.   For my video we captured at a frame rate of 70,000 fps with a quality of 640 x 480. The field of view was approximately 5 inches wide by 4 inches tall and the camera was about one foot away. There is only 14.29 microseconds per frame which means the camera is able to capture movement we cannot see with the naked eye. Since the video quality was good I did not want to make a lot of changes in the post processing. I reduced the time down to 15 seconds to capture just the initial tear and spray caused by the burst.

I really enjoyed the opportunity to capture a water balloon exploding in slow motion. The video shows some interesting qualities of fluid flow when a water balloon is popped. I really like how the water sparkles as it sprays outward when the balloon is popped. Also, the initial tear of the balloon changes depending on how you are holding the balloon, orientation of nail on balloon, and whether or not the balloon has air pockets. I would like to see how the water reacts when the water balloon is thrown against a flat surface compared to being popped. Seeing if the initial tear is similar when thrown against different types of surfaces.