Water Jets Colliding

Third Team Image

By: Emily Howard

Image created with the help of:
Preston Wheeler

May 3rd, 2012

The sixth assignment for the Flow Visualization course is the third team image. For this assignment, each student is expected to work in groups to take a photo of a fluids phenomenon that both demonstrates the situation and is artistically sound. This is similar to the initial "Get Wet" assignment except that by working in groups, the students are expected to put their resources and expertise together to create even more brilliant images than were done initially. For this image, I worked with one other teammate to demonstrate the patterns of water which are created when water jets collide. This normally cannot be seen with the naked eye, as the water is moving too quickly and simply looks like a stream, but with flash lighting, the water becomes frozen in space and these patterns become visible.

This experiment uses two small plastic fuel pipes connected to the end of a garden hose to create two small streams of water. A water hose connector, plumbers tape and scotch tape were used to make this connection. This caused a limitation on the speed of the water as it came out of the tubes, because when the water was at too great a pressure, too much water would leak out of the connection point rather the end of the tubes, so the water speed had to be kept below this point. A bucket was placed below the water tubes to catch the water. The scene was lit with ambient light and a detachable flash attached to the top of the camera. While one person took pictures with the camera, the other person held the two small pipes at an angle to each other to cause the streams to interact. The angle at which the streams were pointed and the speed of the water were adjusted throughout the process in an attempt to find and capture the most interesting patterns. Two sized tubes, one 2.5 mm in diameter and one 4 mm in diameter, were used. This set-up can be seen in Figure 1.

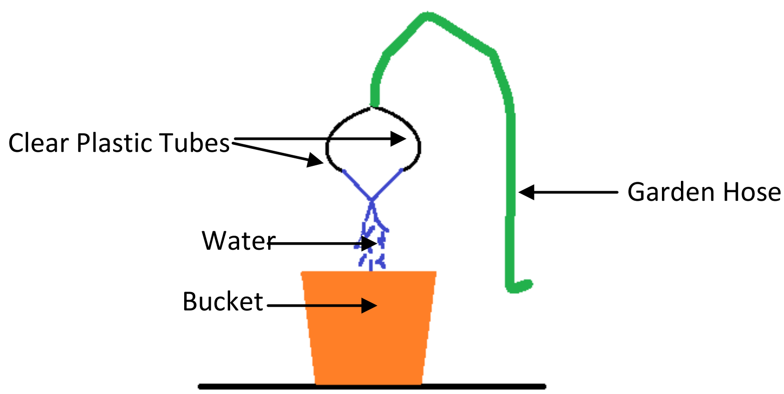

Figure 1: Set-Up

The final image used the larger 4 mm diameter tubes, as more of a pattern was captured with this tube size. The water was turned up as high as it would go without breaking the connection between the garden hose and the clear plastic tubes.

The fingers of water shown in the image show the instability of flow. Although these are in somewhat of a pattern, they are largely unpredictable which demonstrates the instability. As the flow rate is increased, the flow becomes more unstable and these fingers become more apparent.[1] The general shape of the flow is determined by the incoming angle of the water. As the two streams hit each other, they apply a force against the opposing flow and push the water out in an arced shape. It can be seen in the final image that the resulting flow is at the same angle as the input flow, both about 45 degrees.

Water has a very high surface tension due to hydrogen bonding, which causes the water to want to stick together.[2] This is shown in the top part of the picture where the water is in one continuous piece. The frequency of the fingers of the shown fluid has been shown to increase with increase fluid velocity.[3] When this set up is more controlled, the size of the fingers is dependent on the velocity of the liquid. The fingers become detached from the flow as the flow is further from the source.

Unfortunately, as the set up was rather fundamental, there is no way to measure the flow rate of the fluid. Also, as the fluid was frozen with the flash, motion blur could not be used to find the fluid flow rate.

This picture is spatially resolved, which can be seen by comparing the magnitude of the flow to the magnitude of the photo. The smallest point of interest in the photo is the small drops of water. These are estimated to be around 2 mm. The largest part of the flow is all that is included in the frame. This is estimated to be approximately 170 mm. Comparing these two figures, there is a separation of 2 decades. The picture is approximately 2500 pixels in size, which is equivalent to 3 decades. As the flow requires 2 decades to be spatially resolved, and the picture has 3 decades of information, the photo is spatially resolved. This means that all parts of the photo impertinent to understanding the flow in the picture can be seen.

The visualization technique used here is the water frozen in time by the use of flash. The flash was attached to the camera. A black poster board was placed behind the water to bring the detail to the water. The camera settings were defined by the shutter speed and ISO, which were set in such a way as to freeze the motion of the water. The camera specifications and settings are shown in Table 1.

Table 1: Camera Specs and Settings

Camera Body	Canon Rebel T2i
Camera Lens	29mm
Aperture	4.5
Shutter Speed	1/200
ISO	200

The photo was digitally altered in Photoshop. Small spots which appeared on the poster when the poster got when were removed. The background was blurred and the stream was sharpened. The initial pixel size of the photo was 5184 x 3456, and the final pixel size of the photo after cropping is 1702 x 2551.

I feel that this image captures a unique moment which cannot be seen by the naked eye. This pattern is not something that you would know is there without flash to freeze the flow. To improve this image, I would use a darker background, and try to capture more of the flow further along while it was falling. I would also try using different fluids.

References

[1]Bush, John. "Fluid Chains and Fishbones." *Applied Mathematics*. Massachusetts Institute of Technology, 2008. Web. 01 May 2012. <http://www-math.mit.edu/~bush/bones.html>.

[2]"StickyWater." *Sticky Water: Surface Tension*. Exploratorium. Web. 01 May 2012. <http://www.exploratorium.edu/ronh/bubbles/sticky_water.html>.

[3] Bush, John W. M., and Alexander E. Hasha. "On the Collision of Laminar Jets: Fluid Chains and Fishbones." *Journal of Fluid Mechanics* 511 (1999): 285-310. Print.