MCEN 5151: Get Wet Image Report

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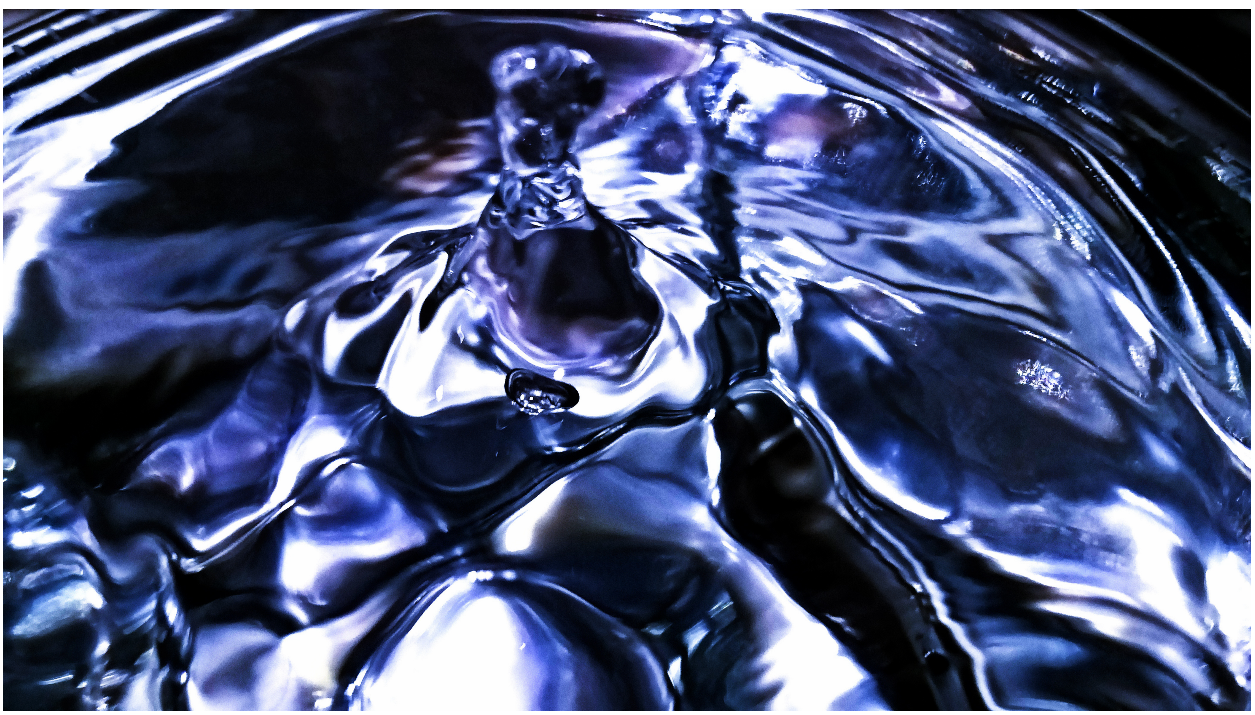

This image was my first attempt to capture the beauty of the flow. The first photo-taking assignment of the class Flow Visualization really gave me a good opportunity to capture something I truly like. I like water, especially the illuminated ripples in the running water. That actually inspired me to create a scenario in which those elements were involved and take an image that visualized the glamor of water. A very fast shutter speed has been used to freeze the moment when a water droplet fell from the faucet and impinged upon the water surface.

Flow Apparatus:

- An old fashion glass with a square cross section.
- iPhone 6s Plus(as a light source).
- Lumia 640 XL(as an imaging device).

I took the image in my apartment and thus I used whatever I had in hand. The flow apparatus involved was quite simple. The old fashion glass is actually a good water container because the transparent glass allows much light in, reveals more details and thus makes those ripples much more visible to viewers. The iPhone 6s Plus has a true tone flash. It not only produces a more natural flashing but also serves as a good light source because of its greater luminosity. The Lumia 640 XL has a stock feature that most smartphones don't have——settings such as white balance, ISO, focal length, shutter speed and exposure can be customized manually within the mechanical limit. And its 13MP camera also produces high resolution images that are convenient for post-editing.

Figure 1: Flow Apparatus

The phenomenon captured in the image is call a Worthington jet or Rayleigh jet. A new dimensionless number, Weber number(We) needs to be introduced to further explain this phenomenon. In fluid mechanics, the Weber number serves as a useful tool in analyzing fluid flows, especially thin film flows and the formation of droplets and bubbles. It can be considered as a measure of the relative importance of the fluid's inertia compared to its surface tension.
For the water droplet in this image:

$$\mathrm{We} = \frac{\rho v^2 l}{\sigma} = \frac{1000 \times 0.171^2 \times 5 \times 10^{-3}}{71.62 \times 10^{-3}} = 2.041$$

where:

ρ is the density of the fluid($\mathrm{kg/m^3}$), for water ρ=1000$\mathrm{kg/m^3}$

v is its velocity(m/s), v=0.171m/s

l is its characteristic length, typically the droplet diameter(m), l = 5mm

σ is the surface tension(N/m), σ=71.62mN/m, for water(25°C)

The higher the Weber number, the greater the energy a drop has. When such a drop impacts the water surface, it creates splashing and a crater in the fluid surface. And a Worthington jet protruding from the center of the crater may follow up if the impact energy is high enough.

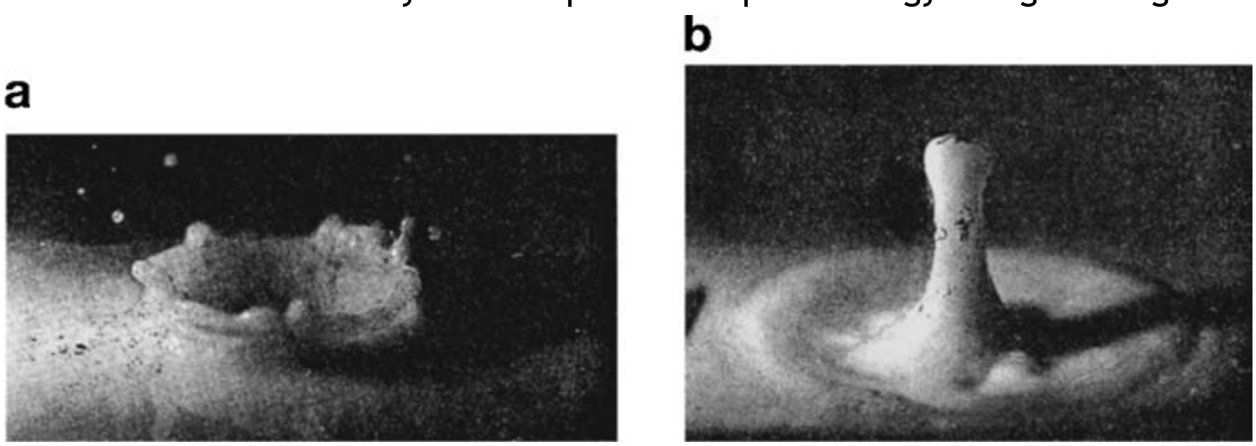

Figure 2: (a) Crater surrounded by a crown-like ejecta (b) Worthington jet rising from the collapsing crater. From Worthington (1908).

In fact, the only visualization technique that has been used in the process of photographing is the flashlight illumination. This image was taken in my bathroom. Before getting started, I turned off all the lights to remove unnecessary and distracting illuminations. Then I grabbed a wood phone stand from the room and mounted my iPhone on it at an inclination of 120 degrees. The flashlight was just 6 or 7 inches away from the fluid surface, which made the sink bright enough yet not so bright as to cause detail losses. In this process, the flashlight on the photo-taking camera should remain disabled at all times, otherwise it would yield lousy images.

Figure 3: The original image

Very few advanced maneuvers have been used in making this image. The old fashion glass I used here was about 4 inches in height and 3 inches in diameter. The aperture of the camera is fixed at f/2.0, which is a standard configuration on a smartphone. To make this image, I set the focal length at 3.78mm, which is the shortest value that can be achieved on this phone. The Worthington jet usually lasts less than half a second, which necessitates a fast shutter speed. Therefore, I set the shutter speed at 1/1600, which was even faster than the value most people would set when taking an image of the Worthington jet. The ISO setting remained automatic. Thanks to the good lighting condition and the short distance between the lens and the water droplet, the quality of the image was still not bad in spite of a high ISO(1250) and a fast shutter speed. Finally, it yielded an image of 4208×2368 resolution. I used the Polarr Photo Editor on my Mac to edit the photo. With a few tweaks, the image was sharpened and ended up in a blue-purple tone.

Personally, I think this image does reveal what a Worthington jet is. For an image made by just a smartphone, the resolution, the aperture and the shutter speed are satisfactory. However, the focal length, I believe, is the key issue of this image. One can easily find that the Worthington jet itself is kinda blurry and grainy. If I had moved the lens a little bit closer to the Worthington jet instead of focusing on the lower part of it, the Worthington jet itself would've been more crisp on the image. Capturing a wonderful moment of water is just fascinating. I'll keep on making more images of water and displaying the versatility of water fluids. To begin with, it is necessary to strengthen my photography background and learn from those good images taken by trained photographers.

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