IV3

Sydney Levy

Michael Anthony

MCEN 5151

11/23/20

The purpose of the image was to capture the splash effect of droplets hitting a still surface of liquid. An opaque, milky white fluid was used as the still fluid, which filled a martini glass to the brim. Red dye was dropped into it from a significant height. A crown splash was captured. In order to capture the splash, the camera took many photos is rapid succession. My good friend Michael Anthony (a member of my COVID bubble) triggered the series of photos as I dropped the dye into the fluid.

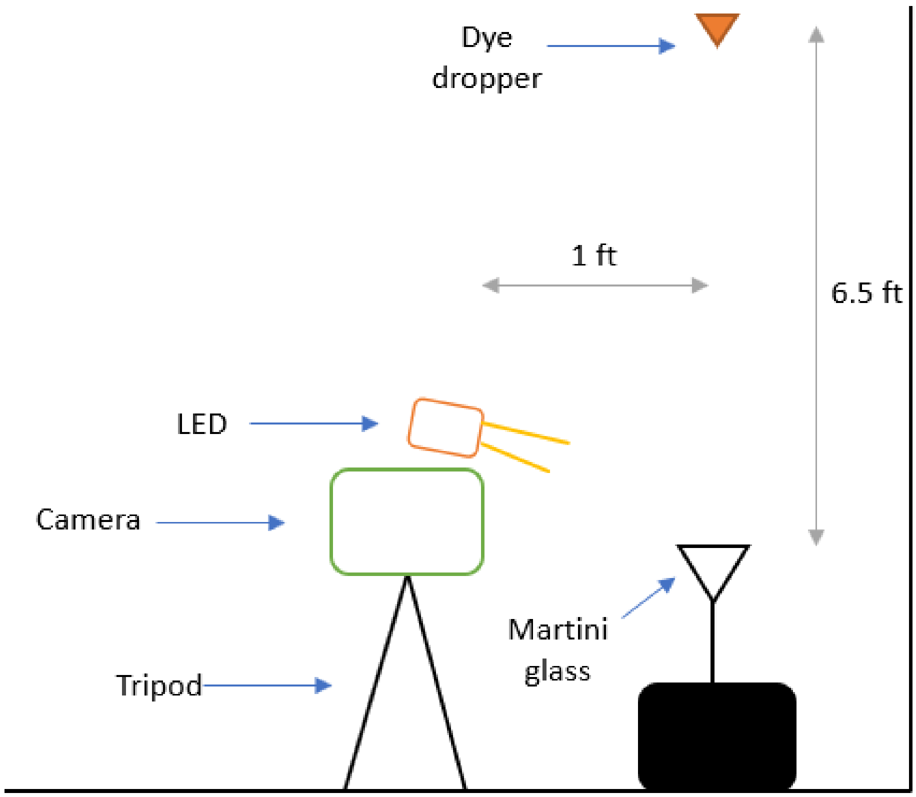

Figure 1: General set-up of apparatus.

Based on the dimensions of the martini glass (9 cm diameter), we estimate that the crown splash had an average diameter of 2.5 cm. Given that the droplets were dropped from a height of 2 meters, we calculate an impact velocity of 6 m/s.

$$v = \sqrt{2gh} = \sqrt{2(9.8)2} = 6 \text{ m/s}$$

Because this is a falling droplet, not a flow, the Reynolds number is not applicable in its typical flow-through-a-tube application. However, it can be applied to the air moving around the droplet as it falls, which we find to be clearly turbulent.

$$Re = \frac{UD}{v} = \frac{(6)(0.05)}{1.81\ x\ 10^{-5}} = 20000$$

Nevertheless, the focus of the image is on the crown splash, which forms in discrete steps. First, a hollow cylindrical sheet rebounds from the water. Once linear stability is broken, the rim of the cylinder starts to oscillate at a particular wavelength. Tips develop on the rim, from which jets emanate. Finally, the drops pinch off from the jets [1]. The submitted image shows the tips just before they form droplets. The droplets are formed by the Rayleigh-Plateau instability, which, driven by the a liquid's surface tension, tend to minimize surface area. The droplets, being spheres, have a smaller surface area to volume ratio than the jets from which they came [2]. Based on similar experiments, we can conclude that Re = 600-1000 for moving fluid to create the crown splash [1]. The submitted image shows the tips just before they form droplets.

To capture the image, red *McCormick Food Color & Egg Dye* was dropped from about 2 meters into a martini glass filled to the brim with *Almond Breeze Unsweetened Original* almond milk. The dropped were released one at a time. The high shutter-speed made the image quite dark, so lighting was important. Two desktop lamps were positioned just out of frame, pointed directly at the martini glass. Most of the light came from a 300 Lumen *Black Diamond* LED headlamp that was positioned on top of the camera and pointed directly at the surface of the almond milk. This was the extent of the light available, but more light would have been preferred if possible. The image could be improved by adding even more light, which would allow a reduction in ISO, and therefore noise. To recreate the image, even more light is recommended.

To capture the splash with as little motion blur as possible, a 1/3200 sec high shutter speed was used. Because this was such a high shutter speed, the picture was exceptionally dark, so the largest aperture possible was used (f/3.5). The focus of the image is small (~3 cm splash), so the camera was positioned as close to the object as possible while keeping the splash zone in focus. This maximized the number of pixels that would capture the splash, while not compromising the shutter speed. Finally, test images were taken to dial in the appropriate ISO of 1600. Any less, and the image would be too dark. More specifics of the camera and image settings are listed in the table below.

Camera	Sony α6000
Lens focal length	35 mm
Size of Field of View	20 cm
Distance from object to lens	30 cm
Original Image Size	6000 x 4000
Final Image Size	4492 x 2877
Shutter speed	1/3200
Aperture	f/3.5

ISO	1600

The image was rotated slightly and cropped in post processing. The color not corrected in any way. The original image is featured below.

Figure 2: Original Image

The image is successful in revealing the shape of a crown splash in a moment of time. I really like the focus and stillness of the image. The splash is perfectly clear, and the shutter speed is high enough that there is no motion blur. I wish, however, that I could have captured a larger splash to take up more pixels in the image. With more pixels dedicated to the splash, we could see more detail in the physics. I wonder what type of lens is necessary to get focus so close to the camera lens. I would like to improve my idea by creating a timing rig that creates a droplet at a certain height and then take a picture with strobes when it impacts the fluid surface. Despite these potential improvements, I believe I fulfilled my intent with the photo, as it is aesthetically pleasing, but still shows the physics of a drop impacting a fluid surface, particularly that of a crown splash.

Works Cited

[1] Deegan, R D, P Brunet, and J Eggers. “Complexities of Splashing.” *Nonlinearity* 21, no. 1 (December 3, 2007): C1–11. https://doi.org/10.1088/0951-7715/21/1/c01.

[2] Zhang, Li V., Philippe Brunet, Jens Eggers, and Robert D. Deegan. “Wavelength Selection in the Crown Splash.” *Physics of Fluids* 22, no. 12 (December 1, 2010): 122105. https://doi.org/10.1063/1.3526743.