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FILM4200-001
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Team First: Exoplanet

For our second image, my team assembled and utilized the “DropSplash Apparatus”. The DropSplash allows for fine control of camera, flash, and droplet timing. We wanted to capture something with high contrast, and an interesting color profile. This was done using food coloring, milk, water, and colored films. Over the course of several days of setup and photography with my teammates: Wes Caruso, JT Balling, J. Lanier and Julian Quick, we captured droplets in a variety of stages ranging from droplet impact to satellite droplet collisions. While there were many interesting candidate photos, I decided to pull my image out of context a bit, and try to cast it as something that it wasn’t.

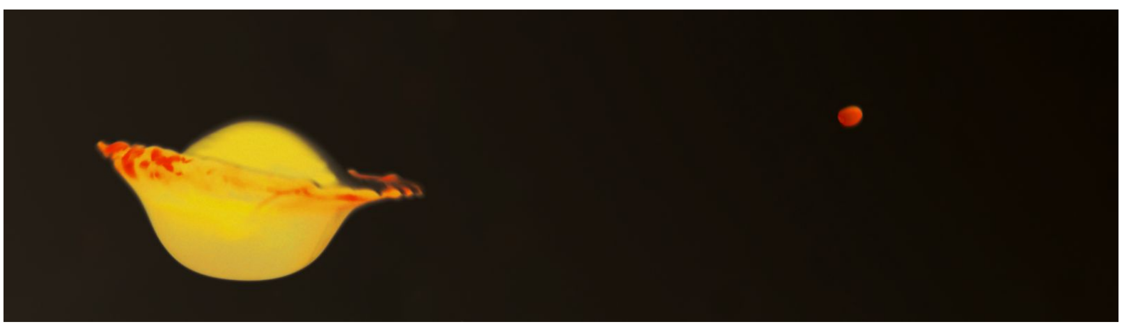

Figure 1. Final Image

The DropSplash was assembled as pictured in Figure 2 (this was not the final layout) in the ITLL 3D-scanning room, as it allowed us to block out almost all ambient light.
The camera was attached to a mini-tripod, placed approx. 1.5’ away from the impact site, angled slightly downward. The valve was approx. 9.5” above the fluid surface, with the reservoirs mounted on the top bar (not drawn) in Figure 3.

Figure 2. Preliminary Setup.

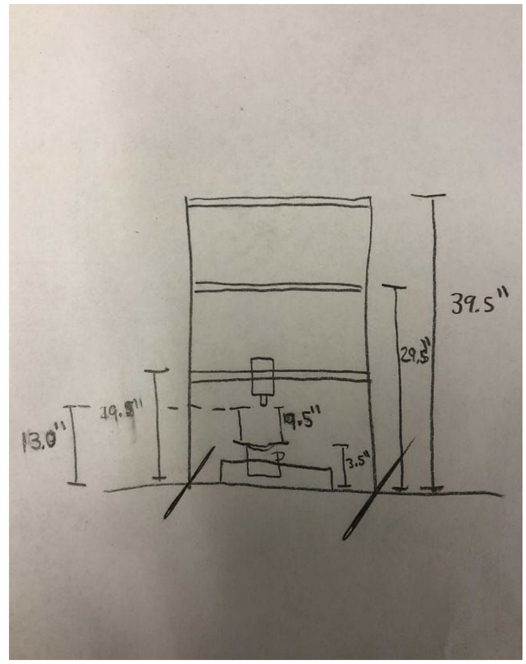

Figure 3. DropSplash Dimensions

Behind the sample was an opaque, white plastic sheet, partially submerged in the bin. Behind which, we placed colored films to change the hue of the image. The droplets captured were of mostly the same relevant parameters, being volume (drop size setting 40 ms) and drop velocity (same valve height). To determine the volume of the droplets, the radius can be estimated from the size of the cup, which comes out to approx. 0.35-0.45 cm, depending on the valve timing. The water has a density of 1 g/cm3, and can be assumed spherical with negligible linear drag. This gives average mass $\bar{m} = 0.67\ g$, thus the impact force and velocity can be determined:

$$x = \frac{1}{2}at^2$$

$$t = \sqrt{\frac{2x}{a}} = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2(0.24\ m)}{9.81\ m/s^2}} = 0.22\ s$$

$$v = gt = 2.2\ m/s$$

$$T = \frac{1}{2}mv^2 = \frac{1}{2}(6.7e^{-}4\ kg)(2.2\ m/s)^2 = 0.0016\ N$$

Additionally, the Reynolds Number for a droplet impacting a fluid can be defined as[1]:

$$Re \equiv \frac{v_0 D}{\nu}$$

Where $v_0 =$ mean velocity, $D =$ diameter, and $\nu =$ kinematic viscosity[2], yielding:

$$Re = \frac{(2.2\ m/s)(8e^{-}4\ m)}{8.9e^{-}4\ m^2 s^{-1}} = 1.9$$

This very low reynolds number is to be expected for such a small-scale encounter, but showcases why there are so many coherent shapes and structures visible in droplet impacts. Additionally, the calculated fall time of 200 ms is in agreement with our timing offset, which was set to 190 ms. The timing and settings are attached.

The image was lit from the rear by two DSLR flashes, at an oblique angle to the impact site, with diffusion hoods (mirrored behind the setup in Figure 2). To soften the lighting, and remove some over-saturation and glare issues we were experiencing. Using a Nikon D700, we were able to use a long exposure, with a brief flash in a dark room, to capture the process with very little motion blur, as the flash illuminates the sensor much more briefly than even the shortest shutter speed. Here, we used a ½ second exposure at a low ISO of 200 and f-stop 1/16. Since the flash is very bright for the instant the image is captured, a low ISO helps to balance the image with the dark period to avoid overexposure, and the small aperture was used to add depth to the relatively short focal distance, 105mm. In post processing, I cropped the image to show only the impacting droplets, and a distant satellite or auxiliary droplet, which was likely cast away by the initial impact, or decohered from the second droplet when it was released from the valve. The colors were inverted to give the black background, and the blue droplets became orange planets.

The direction I took in post processing loses a lot of the relevant details of the encounter, such as the water column and impact site, as well as all of the geometry. That said, taking the drops out of context, I believe it is still clear that an impact between droplets is occurring, and I like the way that the image contrasts between the two shapes, whereas the small droplet was entirely lost in the original image. I dislike that some of the sharpness and color depth are lost to the color inversion, and the physics isn't clearly displayed. It would be nice to merge this concept with the broader context.

Appendix

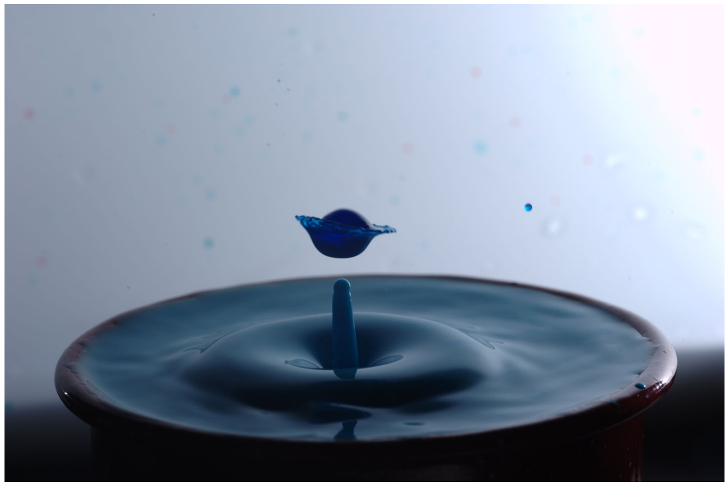

Figure 4. Original Image

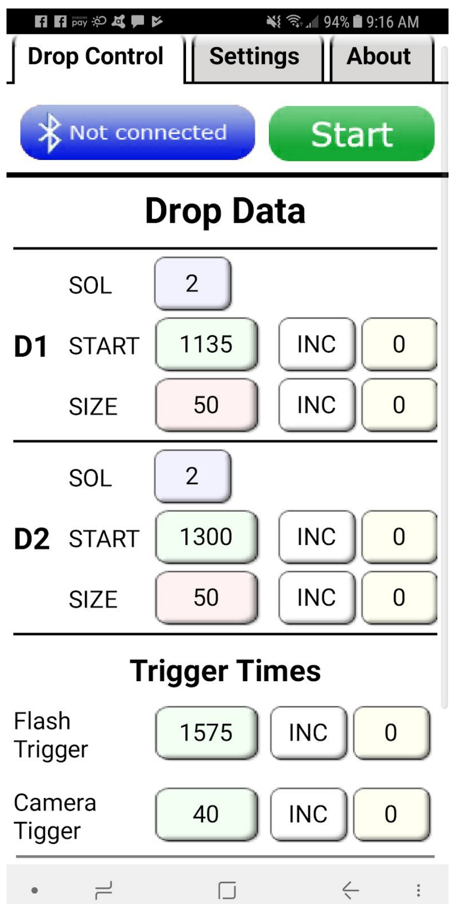

Figure 5. DropSplash App Settings

Citations

[1] Gu, Yongan, and Dongqing Li. “Liquid Drop Spreading on Solid Surfaces at Low Impact Speeds.” Colloids and Surfaces A: Physicochemical and Engineering Aspects, vol. 163, no. 2-3, 2000, pp. 239–245., doi:10.1016/s0927-7757(99)00295-2.

[2] “Water – Viscosity Table and Viscosity Chart.” – Viscosity Table and Viscosity Chart, 2 May 2014, www.viscopedia.com/viscosity-tables/substances/water/.