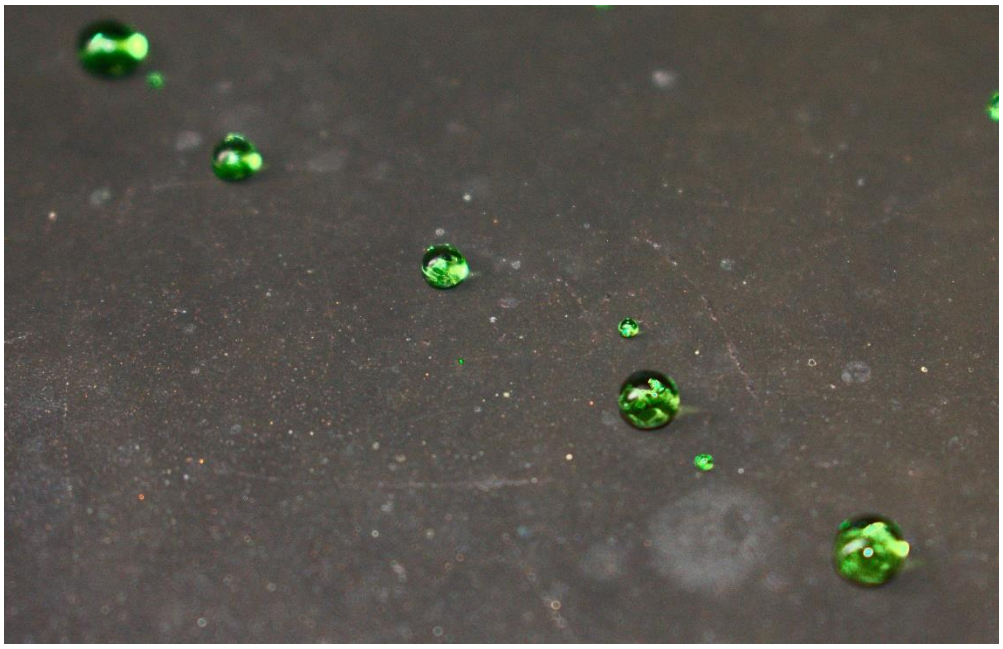

Get Wet Image Report

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This image was for the Get Wet assignment. I set out to capture the Leidenfrost effect. This is a fluid phenomenon that has to do with the boiling of liquids when they are in contact with a surface that is significantly hotter than the fluid's boiling point. I decided to try to incite this effect in water on a hot pan and try to capture the fast moving droplets that occur during the effect. I really wanted to try and capture not only the movement of the droplets but also the sphere like shape the droplets take on.

The effect was created with water droplets on a hot non-stick cooking pan on an electric stove. A desk lamp was propped up over the pan to illuminate the image. Below in Figure 1, the apparatus is shown with dimensions to show scale. The scale of the actual image is shown below in Figure 2 as well, the droplets in the image were around 1 mm in diameter. The burner was turned all the way up to high and the pan was allowed to heat up until drops began to experience the Leidenfrost effect when dropped on the pan. It usually is pretty clear when the effect starts to happen. Droplets will zip all over the pan and stay as smaller spherical droplets instead of hissing and more violently boiling off as they normally would at lower temperatures.

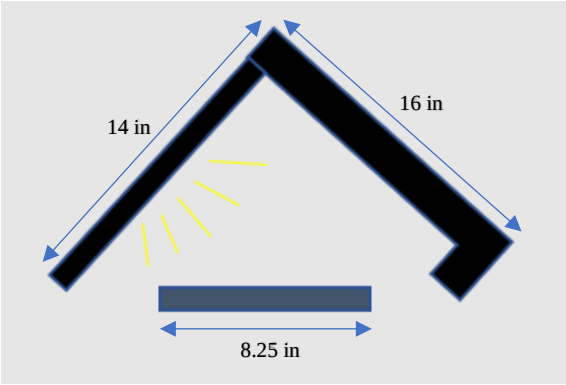

Figure 1: Apparatus Sketch

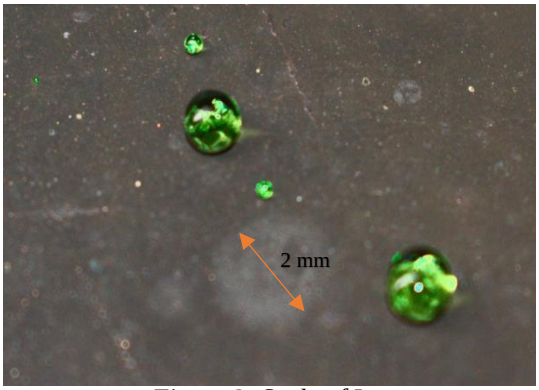

Figure 2: Scale of Image

The Leidenfrost effect is a symptom of the way in which fluids transition between different types of boiling. There are four types of boiling, single phase, nucleate, transition and film boiling. The Leidenfrost effect is just when a fluid undergoes film boiling (Bernardin,1). Which type of boiling a fluid undergoes is dependent on how far above the saturation temperature of the fluid the surface is at. Film boiling is defined as beginning at the Leidenfrost point (Bernardin, 2). This point is defined as the temperature of the surface when the heat flux of the droplet is at a minimum or in other words when the droplet takes the longest time to evaporate. This is shown below in Figures 3 and 4 (Bernardin, 2).

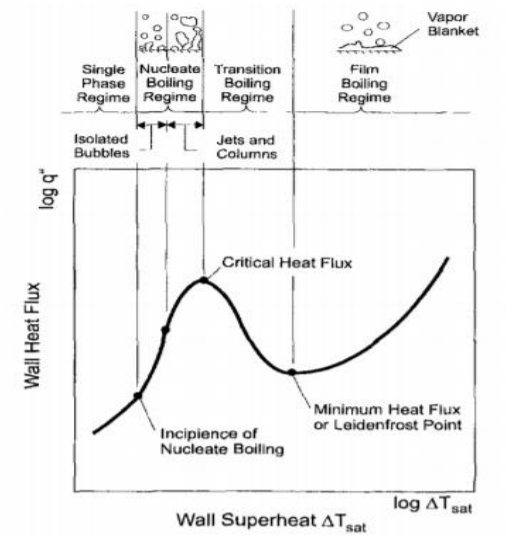

Figure 3: Heat Flux VS ΔT_{sat} (Bernardin,2)

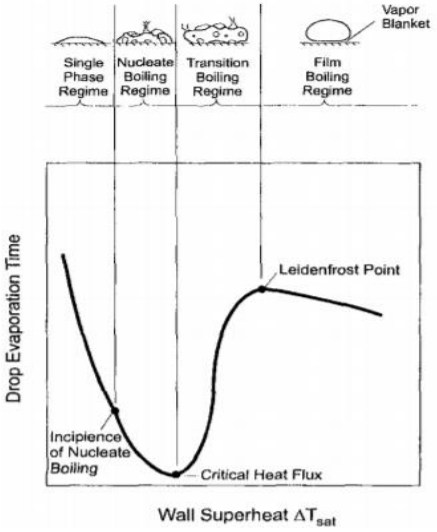

Figure 4: Evaporation Time VS ΔT_{sat} (Bernardin,2)

The reason why the Leidenfrost effect happens is due to a formation of an insulating layer of steam between the droplet and the surface. This layer of vapor has a much lower thermal conductivity and convection coefficient. This causes the heat flux, how fast thermal energy is transferred, to decrease compared to having the surface directly in contact with the droplet. This also causes the drops to be able to 'float' over the surface and move quite quickly. This is due to any slight variations in the shape of the surface causing the pressure from the vapor layer on the

drop to be uneven, resulting in an acceleration in a given direction. To touch on the shape of the droplets, it depends on the surface tension and force of gravity on the droplet. If you can get this to be just right with the right radius the droplets form almost perfect spheres (Hashmi,1). This can be seen in the image; the green droplets are very spherical.

To better visualize the effect, I chose to use a dark colored pan and dyed the water I used. I dyed the water using the dye from the inside of a green BIC highlighter. The dye from one highlighter was diluted in approximately 12 oz of water to achieve the color. I also used well-lit conditions to help illuminate the droplets to help them stand out. I used an LED desk lamp as shown in Figure 1.

I wanted to show off the shape of the droplets and what they looked like close up, so I chose to take the photo very close up. Since the droplets had to be relatively small to take on a spherical shape, using smaller droplets and taking the photo up close made the most sense. The end of the lens was approximately 4 or 5 inches away from the pan. The camera used was a Nikon D3400. The original image dimensions were 6016 x 4016 pixels and the edited image dimensions were 4813 x 3088 pixels. I chose to crop the image a bit to make the droplets more of the focus and in the center. I also like how the droplets being lined up looked in the edited image. An exposure of 1/200 sec was used so that the droplets were not blurry, as they were moving around the pan rather quickly. The ISO used was 360 and the aperture F-stop setting was f/5.6. The focal length of the lens was 55 mm. The ISO and aperture were chosen so that the image was not too dark but also so that the clarity of the drops was captured. I used a very bright desk lamp so I would not have to use too high of an ISO.

I edited the image in darktable. The original image was a bit dark and the colors were dull. To fix this I manipulated the base curve to make the image brighter and have a higher contrast and saturation. Below the unedited image in shown in Figure 5.

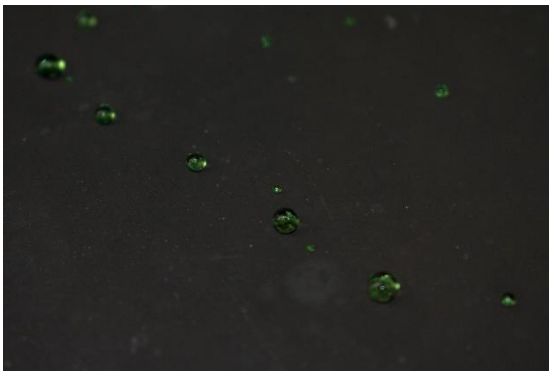

Figure 5: Unedited Image

I think the image shows off the Leidenfrost effect well and highlights the shape the smaller droplets take on. I like how clearly I was able to capture the stationary drops in the middle and how they contrast the drops not in focus that were moving. I really enjoy the strong diagonal line the droplets create across the pan. It makes me think of some far out galaxy and the droplets are like planets in orbit. The texture and color of the pan adds to this effect too. I originally wanted to try and capture the effect from the side and show off the vapor layer, but I like that I went with more of a top down angle. I think it gives the image more depth. If I were to do it again, I would want to try and get more of the droplets in focus. If I were to develop the idea behind this image more, I could use multiple different colors of droplets to really give the effect of them being different planets in space.

Bibliography

Bernardin, J. D., and I. Mudawar. “The Leidenfrost Point: Experimental Study and Assessment of Existing Models.” *Journal of Heat Transfer*, vol. 121, no. 4, Jan. 1999, pp. 894–903., doi:10.1115/1.2826080.

Hashmi, Ali, et al. “Leidenfrost Levitation: beyond Droplets.” Scientific Reports, vol. 2, no. 1, Dec. 2012, doi:10.1038/srep00797.