Riley Kenyon
MCEN 4151
March 1, 2018

Team First – Spring 2018

Figure 1: Screenshot from video

Context:

The team first assignment was the first group project of the semester, where we could make use of having multiple sets of hands and perform more elaborate setups to demonstrate flow phenomenon. Observed in Figure 1 is a screenshot from the video, where supercooled water is disturbed abruptly and the process of freezing progresses from the cap of the water bottle downwards. Many trials occurred while attempting to capture this tricky phenomenon, approximately 30 bottles of water were frozen before successfully getting one to remain liquid while beneath the freezing temperature. This image did not require a lot of hands, but rather a lot of time. For the purposes of taking a video, my sibling helped me by slamming the water bottle down to begin the "snap freeze".

Apparatus:

The phenomenon being observed in figure 1 is known under a general term of supercooling, a process where liquid changes to a solid under further cooling at the glass-transition point. This is a difficult area to study because the liquids that undergo a glass transition are disordered in structure, meaning it is difficult to observe how the structure changes [2]. Water is one such material that displays a similar property. What is known is that it is a liquid crossing its freezing point will crystalize in the presence of a nucleation point, such as a seed crystal. At this point, the crystal structure will grow forming a solid. It is possible to do this at lower and lower temperatures, until the liquid reaches its glass transition temperature, where an amorphous solid will form if crystal homogeneous nucleation occurs. For water, this temperature is ~-54°C [1]. For the purposes of this project, it was not necessary for water to be

cooled to such an extent to see crystallization occur. Cooling the purified water down below the freezing temperature of water by a couple of degrees (~30°F) suffices, and therefore a regular household freezer was used to lower the temperature of the liquid. A frame from the video is shown below from, where the nucleation sites for crystallization and initial crystal growth are visible.

Figure 2: Nucleation sites for crystallization

Note it is important to use distilled or purified water because particles in the water are impurities that can be a site for nucleation to occur at the freezing temperature, and the instantaneous freeze will not occur. The shooting setup was not too complicated, but the most difficult part was lighting. After trial and error, the tungsten video light was placed in the background, behind and to the right of the water bottle. This effect resulted in a clear lighting of the subject, without any major lens flares. The background is a black felt cloth placed over a box, and because of the texture of the felt, it appears to have a dull black appearance which emphasizes focus on the crystallization. For the shot, I did not want to see the bottle on the bottom surface because of a difference in texture. To crop that out, the water bottle was placed on a clear upside-down shot glass. In the video, the base is not visible. See the schematic below for an image representation of the setup.

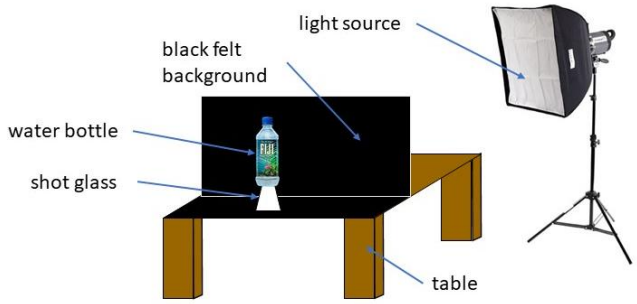

Figure 3: Setup Schematic

Visualization technique:

To get the effect visualized in Figure 1 I used a six-pack of FIJI water bottles (16.9oz) with their labels removed. The water was let sit for approximately 5 minutes before gently being placed in the freezer. Horizontally. To get the water below the freezing temperature and become a supercooled liquid, the bottle was undisturbed in my specific freezer for approximately 78 minutes. The freezer was held at 0°F. If done successfully, the water could be seen to still be liquid and clear when removed carefully from the freezer. The second hardest part about the setup was getting the lighting in the right area. I played around with a tungsten video light in my dining room until I couldn't see any of the light source spots in the reflection of the water bottle. The success was shown in the video, where the ice would immediately be illuminated white as the shards progressed throughout the bottle. You can see one side of the bottle is brighter than the other, which is where the light was most focused.

Photographic Technique:

The original video shown was shot in 1920 pixels x 1080 pixels at 24 frames per second. The camera used is a Canon PowerShot SX50 HS. The camera was placed on a tripod, about 5ft away from the water bottle, and facing horizontally, perpendicular from the side of the bottle. The field of view is approximately 8", with the bottle being about 3" across. The video was edited in post processing using Davinci resolve 12. This was to add the title page, fade in and out, as well as the music: Tabletop Moon by Tapes & Tubes, freemusicarchive.org. The reason I decided to put music to the video was because there was talking in the initial audio. However, I think that the ethereal music adds a soothing component to the overall quality. I chose to use specific parts of the music to flow well with the slow lattice progression.

Critique:

The video reveals the main phenomenon I wanted to catch, snap freezing. Because of how difficult this was to record, I was not able to successfully control all the variables involved. If repeated, I would more thoroughly remove the adhesive that attached the Fiji label to the bottle. This is a bit of a deterrent throughout the video, and would have liked to have a smooth surface. I would also adjust the auto-white balance to be turned off. I find the overexposure at the beginning to be distracting, and there is a lot of information lost because of this. However, once the quality resolves and the shards of the ice are visualized, I think the resulting effect is beautiful. Overall, I fulfilled the intent of the project and captured the freezing flow I wanted to see from this video. If more could be added to it, I would like to play around with food coloring in the water. That may cause impurities to be added to the purified water, result in an easier nucleation point for freezing, but it might be worth investigating.

References:

[1] Subcooling. (2018, February 8). Accessed March 2, 2018, from https://en.wikipedia.org/wiki/Subcooling

[2] “Assessing the role of static length scales behind glassy dynamics in polydisperse hard disks." Accessed March 2, 2018. https://doi.org/10.1073/pnas.1501911112