Zack Herzer
Flow Vis IV2
MCEN 4151-001
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Chilled Vodka Cymatics

This was the second project that I completed for Flow Visualization Fall 2022, and it was our first group project. Heider Iacometti and I decided to experiment with fluids on speaker cones, which is a study on cymatics. Cymatics is the study of nodal vibration, especially on fluids (What is Cymatics?). Nodes are the areas of a sine wave that remain stationary while the peaks and troughs move in the transverse direction. Nodal vibration in this sense means that the surface of the liquid becomes a regular, evenly spaced series of peaks and troughs. The simplest way to think about them in an acoustic way is plucking a guitar string: the ends of the string are the stationary nodes, and the middle part oscillates at a frequency that determines it's pitch. Robert Hooke experimented with nodal vibrations in 1680 with flour atop a glass plate, and nodal vibrations themselves were experimented with thousands of years ago with musical instruments. Heider and I made a video of the phenomenon, which was chilled vodka in a hemispherical bowl tested atop a speaker playing 60hz and 120hz tones. I will be focusing on one of the still images that we took, which was during the 60hz frequency. My aim with this project was to experience cymatics for myself; I had seen youtube videos of oobleck but never with a more attainable fluid.

The apparatus used was quite simple: a bookshelf speaker was placed with the ~6 inch driver facing up, and a 10 inch diameter hemispherical Pyrex glass bowl was placed directly on top of the cone. Chilled (0 degree celsius) vodka filled the bowl up to about 2 inches below the surface, so about 3 cups were used.

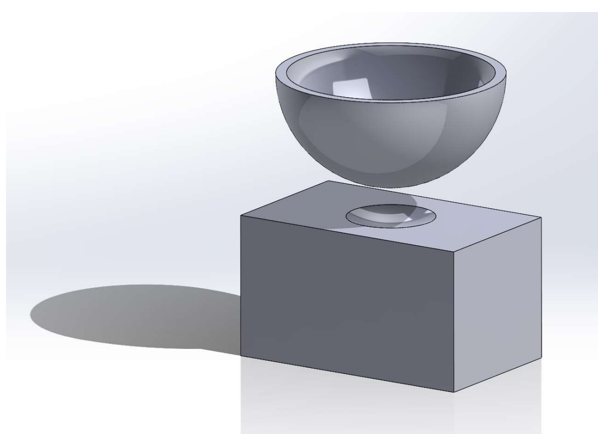

Fig 1: Bowl is simply placed on top of speaker cone

Chilled vodka was used because it is more viscous than room temperature vodka or water, and could display cymatics differently than the latters. Speakers can be simplified to mass-spring-damper systems, and the driving force can be thought of as an electrical motor. To achieve a desired frequency, in this case 60 cycles per second, the mass, spring, damper, and driving forces must all be balanced properly. The mass is the mass of the cone of the speaker, and the spring and damper are properties of the speaker cone itself (rubber gaiters and springs). The driver (motor) is told by the computer to oscillate at a set frequency, and assuming that the speaker has been engineered properly, the driver translates its frequency to the larger cone, allowing more air to be displaced, meaning your ears perceive a louder sound. Audio purposes aside, the driver functions as a physical oscillator in our system, meaning that the speaker driver is transferring translational energy through the speaker cone into the bowl, and then into the vodka. Because the mass and damping coefficients were most certainly altered by placing the filled bowl directly on the speaker cone, it is possible that the actual frequency of the vodka was not 60hz. Depending on the software that the speaker driver uses, the speaker might be able to account for the changes in the physical system and could respond with a different frequency to match the target of 60hz.

60hz was chosen because it produced the clearest and highest amplitude surface bumps; faster than this created excessive splashing that made the surface difficult to focus the camera on. One perplexing thought I had was whether the shape of the containment vessel altered the shape of the bumps. This is because some of the surface bumps appeared to be hemispherical in shape, just like our bowl. After researching the topic and zooming into our pictures, the bumps appeared to be 3d sinusoids, and during the process of being excited by the speaker, became standing waves after a fraction of a second from when the speaker was turned on. These standing waves weren't quite stationary, they jigged and moved about, which was an effect that gives the viewer the impression that the fluid is gelatinous. Because of this, I came to the conclusion that the shape of the containment vessel is correlated to the locations of the bumps, but not the individual shapes, because they are all sinusoids. The locations of the bumps/nodes is determined by the viscosity of the fluid, shape and material properties of the containment vessel, and the frequency of the driver.

The visualization technique was simple: use the speaker (generic brand), bowl (Pyrex), and chilled vodka (generic brand) to visualize the cymatics. It was performed inside, approximately 72 degrees fahrenheit, and the lighting was standard house lighting. I was not able to collect the type of light bulbs and distances of Heider's lighting.

We used Heider's sister's Canon EOS Rebel SL1 DSLR camera, fitted with a Canon EF-S 18-55mm f/3.5-5.6 IS STM lens. The aperture was set at f/6.3, exposure time at 1/100 seconds, and ISO 3200. The focal length was 34mm and the focus distance was 0.39 meters. The photo is 5280x3528 pixels, and the size of the field of view was approximately 16x11". My main goal when editing the image was to increase the contrast on the surface of the vodka, showcase the shadows on the yellow speaker cone, and to darken the image because I felt like it was slightly overexposed. I think that a darker image would fit the theme of the project better too. I altered the rgb curve quite heavily, and also modified the velvia strength and midtones bias, as well as minutely increasing the blue-yellow contrast to make the yellow cone more vibrant while making the speaker enclosure less noticable.

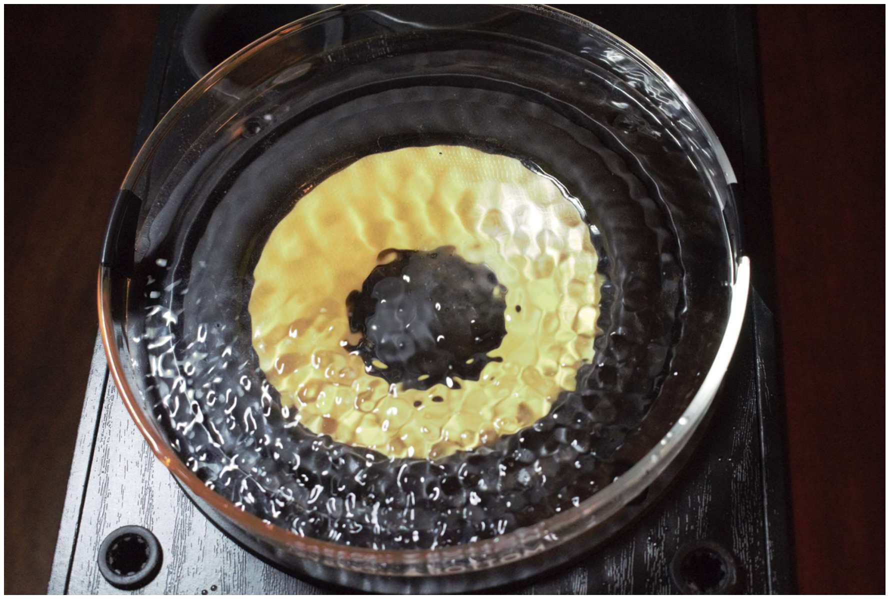

Fig 2: Original, unedited image

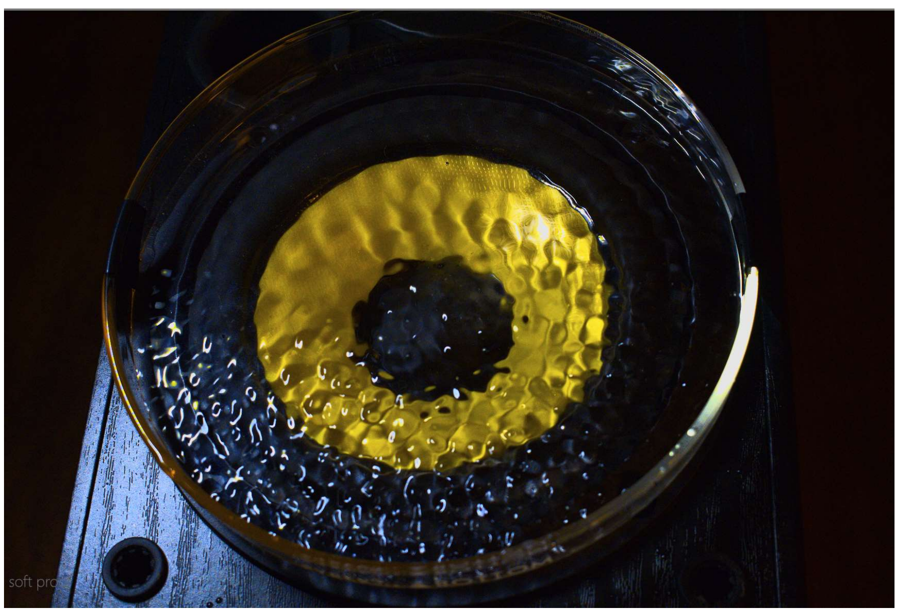

Fig 3: Edited image

The image clearly shows the surface rippling at the bottom, and the shadow of the ripples is projected onto the yellow speaker cone near the top of the image. I like that the image is almost bisected this way, although it does not accurately represent what was happening at the time: the bumps were nearly stationary, jiggling in the horizontal directions, evenly spread across the surface. Due to the lighting, the reflections were not picked up at the top of the image, so we see through the fluid onto the speaker cone where the shadows are. I still do have remaining questions regarding the influence of the containment vessel shape on the bumps, although I believe that this relationship simply needs to be experimentally measured. Through my research, I found that the bumps are sinusoidal, with only the amplitudes and periods being responsive to changes in input. The bumps cannot change their shape, which was what I originally thought was happening. They do not emulate the shape of the container they are in, they are simple sinusoids. What does change, however, is their arrangement. We saw slight movement in these bumps in our setup, and I wish that we had tried additional containers and fluids to try and make a totally stationary modal display.

Reference:

"What Is Cymatics? the Art and Science of Visible Sound Explained." *Journey of Curiosity*, https://journeyofcuriosity.net/pages/what-is-cymatics-how-to-explained.