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Flow Visualization
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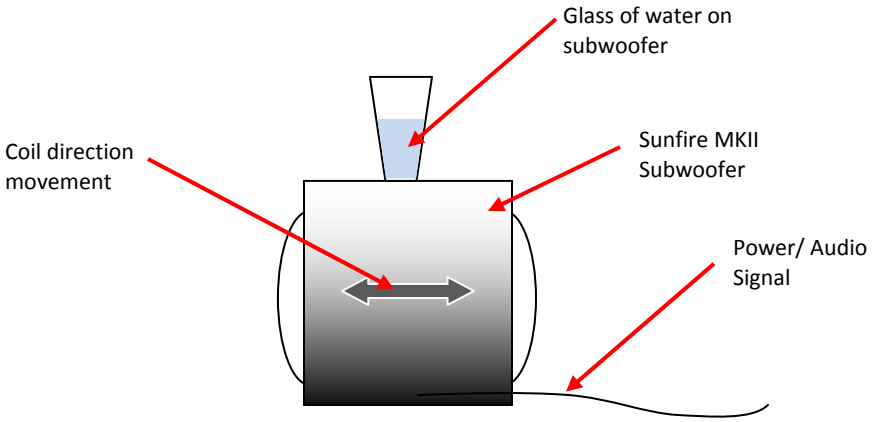
f/5.6 : f-stop
1/80 sec :exposure
ISO-400 : iso speed
32mm : focal length
Canon EOS REBEL T1i: camera
8 inches: distance
1993 x 3270 : dimensions
yes : flash

Get Wet: Water on a Speaker

I have noticed in the past that sometimes in my apartment when the bass gets turned up on my subwoofer that you are able to see ripples in the glass you are drinking due to the quite powerful bass. This vibration can be felt on most surfaces', but visually this cannot be seen. While I am quite impressed with the acoustic capabilities of my subwoofer it was very interesting to see the tangible effects of this vibration. In this image I was trying to capture this vibration by placing a glass on top of the subwoofer, inducing a frequency, and seeing the result. Most ripples seen in water are as a result of gravity waves[1] generated by falling objects impacting.

Common materials like a countertop or couch are so viscous (a soild) that the vibrations are damped into the material and it becomes very difficult to visual see the material in motion. Water, on the other hand has lower viscosity, and reacts to vibrations very visibility. The experiment was setup as shown in the figure below:



In the figure you can see that the movement of the dual subwoofer cones moved perpendicular to the normal of the water surface. To hold the glass down to the surface of the subwoofer, my hand was used, trying to reduce the damping as little as possible. After the glass was about 90% full, I inputted sine waves from 120-15Hz into the subwoofer. Steps of 5 Hz increments were observed. At certain frequencies the result became very sporadic but repeatable, but since I was trying to emulate concentric vibration waves, the 25 Hz input provided the best results. The physics that is causing this phenomenon, is a result of the momentum of the

1. http://www.newton.dep.anl.gov/askasci/phy00/phy00881.htm "Ripples in Water"

water colliding with the walls of the of the glass. As it bounces off the surface of the glass this amplifies the height of the water and concentric rings move in a radial direction on the surface.[2]

The visualization technique used was pain tap water in a clear glass, with a large amount of reflection off the glass and water. The final image was rotated 90 degrees to bring emphasis to the method that caused the flow movement induced by a speaker. As speakers are commonly mounted on walls or vertical surfaces, rotating the image to mimic this, brings enforcement to the method for causing the unique ripples. The lighting that was used in the photo consisted of a light that was at a 45 degree angle from the surface of the water, for direct lighting, and ambient auxiliary lights used for reflection on the glass.

For the image, I tried to get as close to the water as possible, but didn't want a large field of view. The glass used has a three-inch top diameter and the camera was approximately 8 inches away from the glass. The image was taken with an f/stop of 5.6, and a shutter speed of 1/80, and a ISO of 400. The camera used to take this picture was a Canon EOS REBEL T1i taken at 4752x3168. The image was imported into my computer and rotated 90 degrees. After some post processing in Photoshop to increase the contrast and saturate the light the final image was 1993x3270.

I hope that the image reveals ripples in water that were created in a unique and interesting way. While taking the picture I was trying to achieve a small field of view, but as I look back at the image now, I wish that I would have taken the photo with a much larger field of view to encompass the entire water surface. Because of this narrow field of view, the focus doesn't get shifted to the water but rather the round glass that is holding the water. When taking the image, I experimented with several shapes of containers for the water to be in, and found that the round glass with high curvature was produced the best visual ripples.

It would be very interesting to redo the experiment with a larger viscous substance like hot fudge or honey. The higher viscosity might lead to different wavelengths of ripples in the substance.

2. "Sand ripples in an oscillating annular sand--water cell"
M. A. Scherer, F. Melo, and M. Marder, Phys. Fluids 11, 58 (1999), DOI:10.1063/1.869902