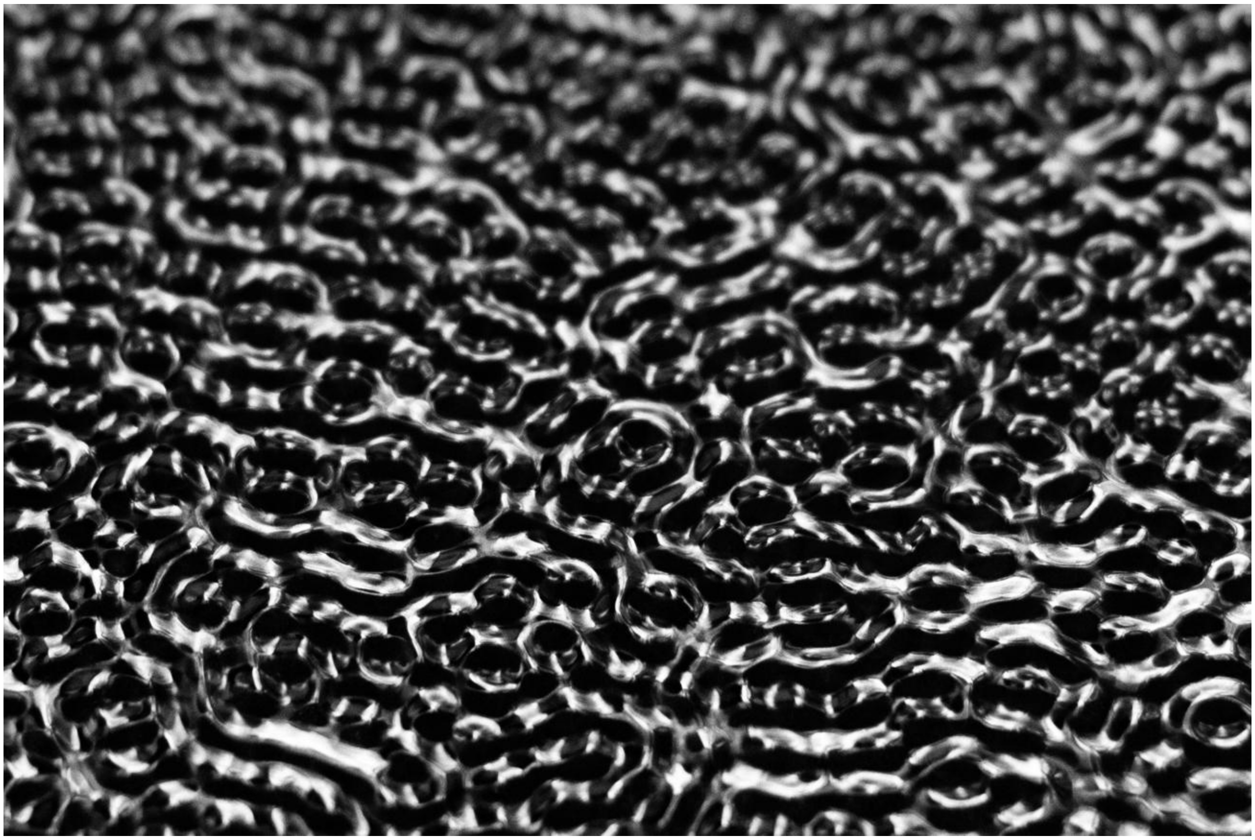

Simple Cymatics

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September 13, 2023

Flow Visualization: The Physics and Art of Fluid Flow

Project 1: Get Wet

Introduction

Cymatics is the study of visualizing sound waves in vibrating matter; in this case, water. It's well known that sound moves through the air in waves, but it's rare that we can visualize sound waves. This experiment aimed to visualize the wave dynamics of sound in a simple cymatic setup. I have not attempted a cymatics experiment, nor had my collaborator Curran Collier, prior to this experiment, so much of the process was experimentation to investigate how to create the best effect.

I worked with Curran Collier on this assignment, utilizing his camera expertise in purely an assistance capacity. Curran is an experienced photographer, and as I am reasonably new to photography as an artistic medium, I felt it would be useful to have him present in order to offer basic assistance when it comes to setting up a shot's settings for the best quality. The concept of the project, all materials and tools, and direction of photography are my own.

Physics Discussion

For waves driven by a sinusoidal force, such as sound waves, across a fixed length waves will travel across the medium and rebound off the far side and return to the point of origin. For a given wave, there are specific frequencies that divide the length of oscillating medium by the wavelengths evenly. At these frequencies, the rebounding waves will build on the approaching waves, increasing the amplitude. The waves in this situation would lose any sense of transverse movement and would appear as standing waves (Moebs). The maximized amplitude is an example of resonance.

Taylor explains this in terms of driving frequencies and natural frequencies, where in this situation the natural frequency would be the frequency at which the waves return. When the natural frequency approaches the driving frequency, the combined amplitude is maximized through the following equation where A is the resulting amplitude, ω is the driving frequency, ω_0 is the natural frequency, f_0 is the amplitude of the driving force, and β is the damping constant:

$$A^2 = \frac{f_0^{\,2}}{(\omega_0^{\,2} - \omega^2)^2 + 4\beta^2\omega^2}$$

In cymatics, resonance is not only influenced by the frequency of driving force or vibration, but also by the shape of the wave container. For circular containers, resonance is easier to visualize due to the symmetry, as the waves will combine in resonance at the center of the container. Containers of other shapes such as squares, you will see more complex patterns, but the amplitudes are likely to be lesser as the waves do not have a central point of constructive interference, but rather a region. Waves driven from each side will collide in an ‘X’ formation.

Experimental Setup

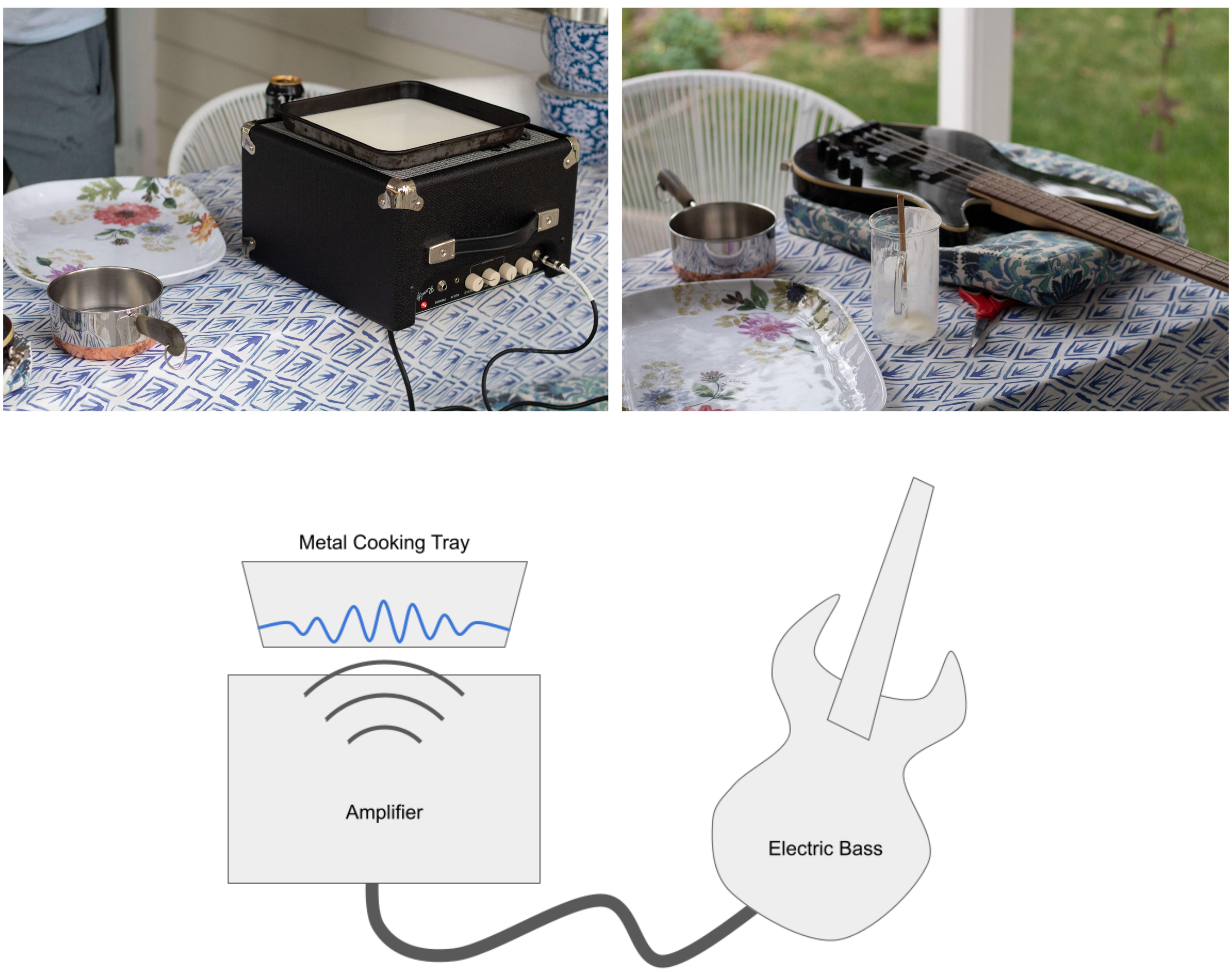

Fig. 1

My setup was like so: A square metal cooking tray, about 30 centimeters long on each side, with curved corners filled with a couple centimeters of water, placed on top of an amplifier with an electric bass feeding into it (See Figure 1). Then, I would pluck the strings on the bass to generate the vibrations through the amp into the tray. I tested to see which strings, and where on the bass' neck, caused the most noticeable patterns and found the lower the note, the better. More specifically, the 'E' string plucked at or below the bridge pickup. The bass was placed on a seat pillow to reduce feedback between the bass and the amplifier.

In the uncropped photo (Fig. 2), we can see that the most highly defined patterns are in the center of the tray, with the amplitude tapering off as it nears the edge. The shape of the cooking tray was a significant factor in the shape of the waves. We can see more circular, rounded shapes, as well as more straight, longitudinal shapes. The more circular antinodes are certainly due to the rounded corners of the tray, whereas the straight sides create the linear forms. We can also see 'arms' of the waves reaching out from the central, highly defined pattern, once again, due to the straight edges of the tray. The irregularity is also likely due to the shape. If I had chosen a perfectly circular or square vessel, the patterns would have been much more predictable and constant.

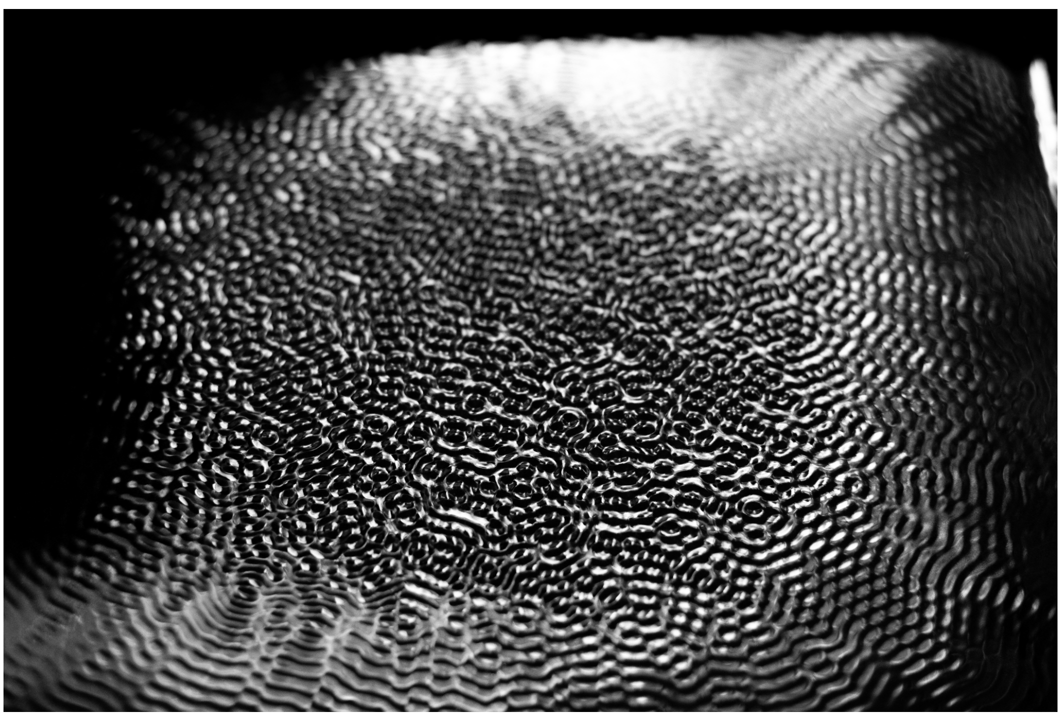

Fig. 2

I also ran the experiment with a mixture of cornstarch and water to investigate how the consistency of the fluid would affect the patterns observed. The cornstarch-water produced very consistent patterns but were not as visually interesting as the patterns in water. For that reason I chose to use the photos of the water

Photography

The photo was taken on an overcast day, outside on a covered patio. Thus, the lighting conditions were pretty ideal. There was a nice soft natural light so no extra lighting or flash was necessary. When it came to intent when taking the picture, all I was really considering was to have the prominent waves in focus. I feel this was accomplished, while also giving the image some flavor with a small depth of field. The depth of field was not an intentional choice, but I'm pleased with the result. The photo was taken from about half a meter away from the subject.

The specific settings of the camera are as follows:

Camera Make and Model	Canon EOS Rebel T6
F-Stop	F/2.8
Exposure Time	1/500s
ISO	400
Focal Length	50mm
Maximum Aperture	1.75

Conclusion

I'm very pleased with my image and feel that I adequately fulfilled my intent with this project. I feel it captures cymatics and the physics behind resonances well, while offering patterns that are complex and appealing to look at. If I were to continue this study I would certainly try varying shapes of containers. I think a circle would be interesting to see, even if the pattern would be very simple. It would also be interesting to try to simulate the patterns digitally through density plots to try to visualize the pattern, before even undertaking the experiment. On the photography side of things, I think it could be interesting to involve lights; to try to use the waves to draw patterns on the walls or ceiling, as there are so many interesting patterns you can create with cymatics.

Works Cited

Moebs, William, et al. "16.7: Standing Waves and Resonance." *University Physics Volume 1*, OpenStax, 2016. Accessed 21 September 2023.

Taylor, John Robert. *Classical Mechanics*. University Science Books, 2005.