Fast Radio Burst Signals

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Goal of the Experiment

What does the CHIME Telescope's detected Fast Radio Burst (FRB) signal sound like?

CHIME Radio Telescope

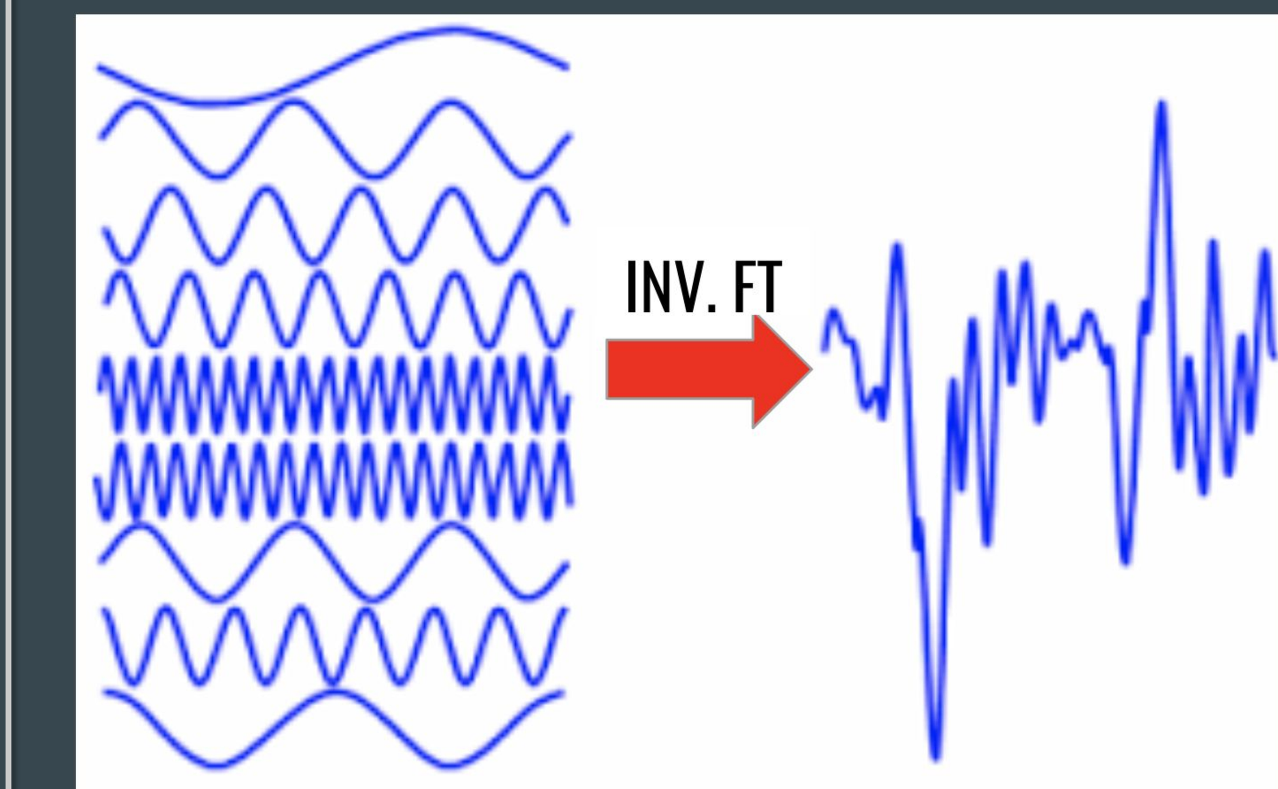
CHIME and FRBs

The Canadian Hydrogen Intensity Mapping Experiment, otherwise known as CHIME, built a radio telescope to create a map of hydrogen to measure the expansion history of the universe. This telescope can also be used to measure and discover fast radio bursts, which is the data we worked with.

The fast radio burst data is usually electromagnetic data shot from pulsars or black holes. The data is broken down into frequencies and intensities, and when an inverse Fourier transform is applied, we get the resulting sound wave.

What Is an Inverse Fourier Transform?

The CHIME Telescope takes measurements across thousands of frequencies along the electromagnetic spectrum. The Inverse Fourier Transform allows us to take all of those frequencies and superimpose them into a single sound wave. This is how we achieved our final sound file.



Listen to our audio file using this QR code!

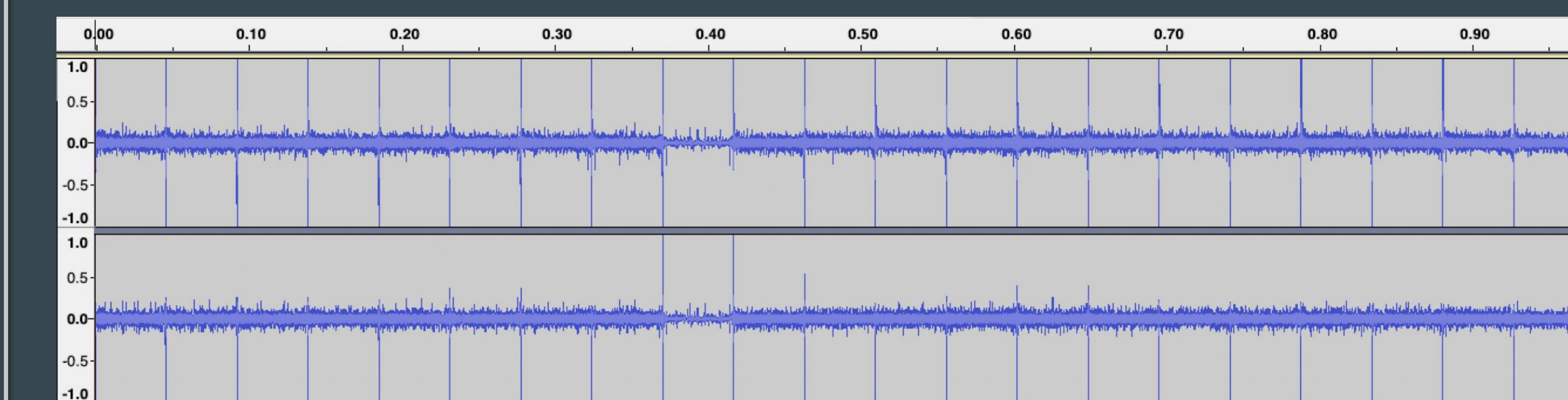
Formulas Used

Inverse Fourier Transform:

$$f(t) = \frac{1}{2\pi}\int_{-\infty}^{\infty}[F(\omega)]e^{jwt}d\omega$$

Results

The CHIME data was packaged as 21 millisecond-long frequency readings. These readings were transformed into a total of 84 sound files in Python and pieced together in Audacity to create a single audio waveform:



This audio essentially sounds like static with occasional "clicks", which is what we would expect from a naturally-occurring FRB signal.

Python Code Used

```python
from cfod import chime_intensity as ci  # CHIME package; pulls frequency array from data file
import numpy as np                      # Allows us to use Inverse Fourier Transform (and more!)
import scipy.io.wavfile                 # Allows us to write sound files using frequency arrays

fn = "test/astro_9386707_20180725175943123139_beam0166_00101519_01.msgpack" # data file
intensity, weights, fpga0, fpgaN, binning, frame0_nano, nrfifreq, rfi_mask = ci.unpack_data(fn)
# data file is unpacked into frequency array using above line

array = np.fft.irfft2(intensity) # Inverse Fourier Transform is performed here
sound_array = np.transpose(array) # Setting up array for use in "wavfile" function

# Our array is too large for the "wavfile" function
# Solution: Break the array into pieces and recompile the sound files in Audacity
s1 = np.empty([2046, 4096])
s2 = np.empty([2046, 4096])
s3 = np.empty([2046, 4096])
s4 = np.empty([2046, 4096])

# Frequency values are added to our smaller arrays here:
for i in range(2046):
    s1[i], s2[i], s3[i], s4[i] = np.array_split(sound_array[i], 4)

# 4 sound files are created, then combined in Audacity
scipy.io.wavfile.write("test/signal1.wav", 44100, s1) # 44100 Hz is a standard audio sampling rate;
scipy.io.wavfile.write("test/signal2.wav", 44100, s2) # This value can be set to any number;
scipy.io.wavfile.write("test/signal3.wav", 44100, s3) # The only difference would be the speed of the audio;
scipy.io.wavfile.write("test/signal4.wav", 44100, s4) # This rate matches our expected length for the final sound file
```

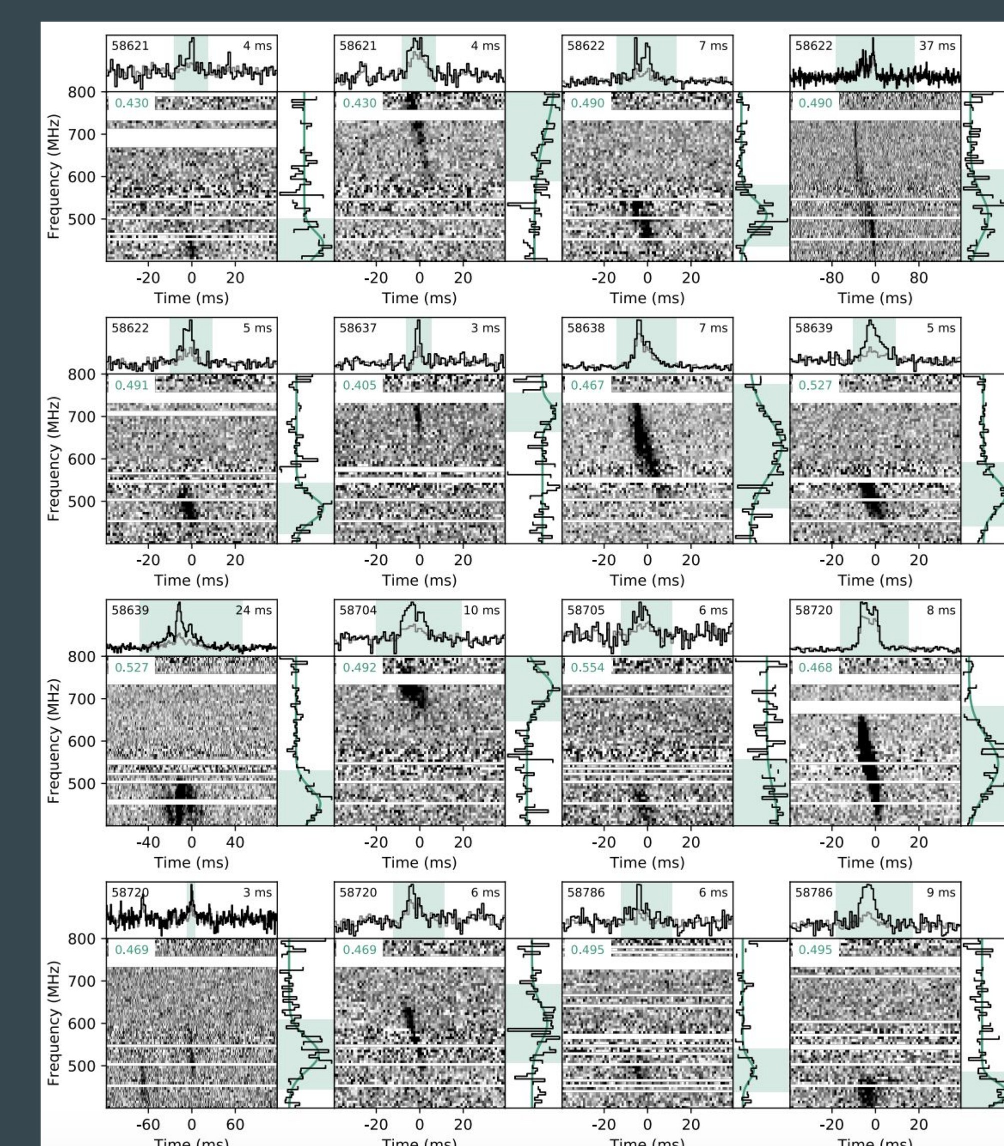
Conclusion

Our final sound file shows behavior that we would expect from a celestial body such as a pulsar, which fires concentrated electromagnetic bursts into space. CHIME approximated that about 14 pulsars fit within the projection of space that fits their calculated origin with 99% certainty. It is likely that one of these pulsars is the source of this electromagnetic pulse.

Interestingly, as we worked on this project, the CHIME Telescope published an article showing evidence of a periodic FRB; this 16-day repeating signal is the first of its kind ever discovered on Earth. CHIME scientists attribute the repeating signal to a massive binary star system, but even they admit that the source is difficult to verify with current technology.

For more information on this repeating signal, visit:

https://cnn.it/2TkMTMK



Repeating Signal Discovered by CHIME

Linn-Benton Community College