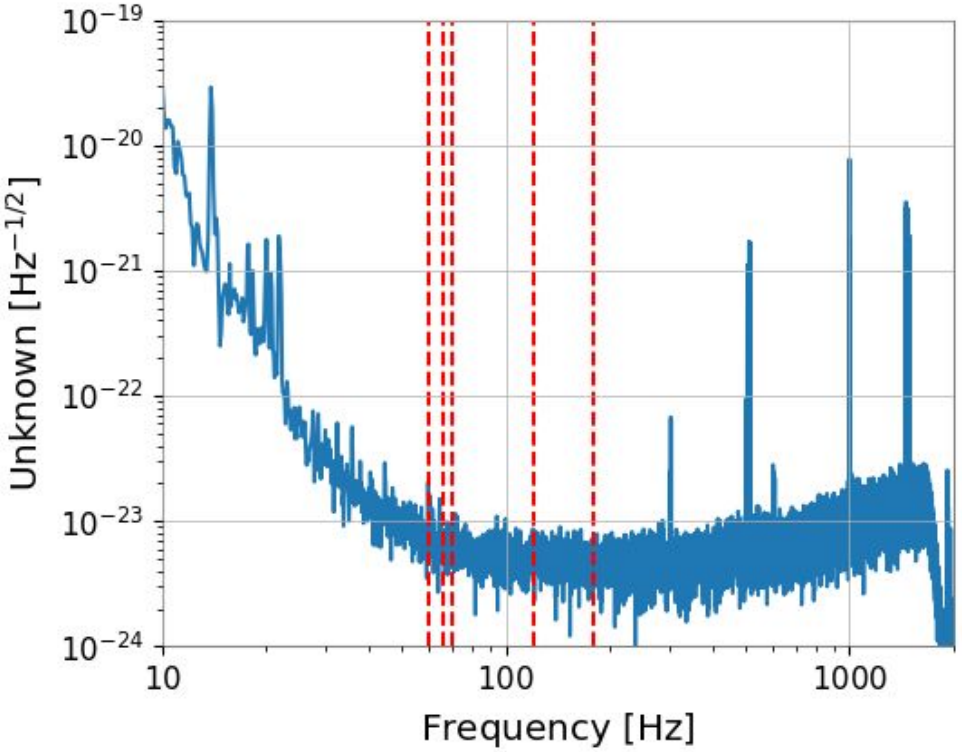
Sonification of Gravitational Wave GW200129_065458

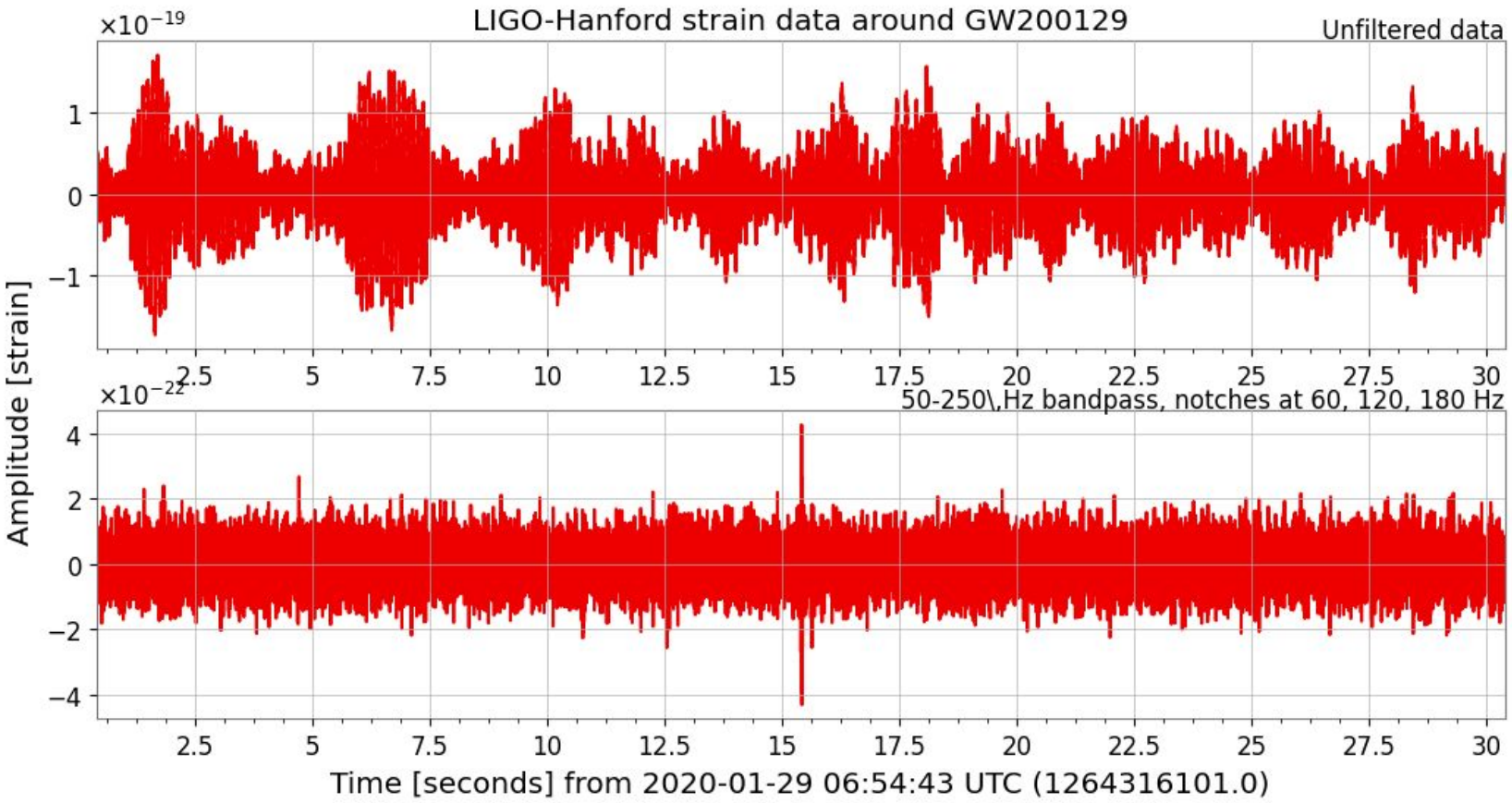
Deeti Patel

Motivation:

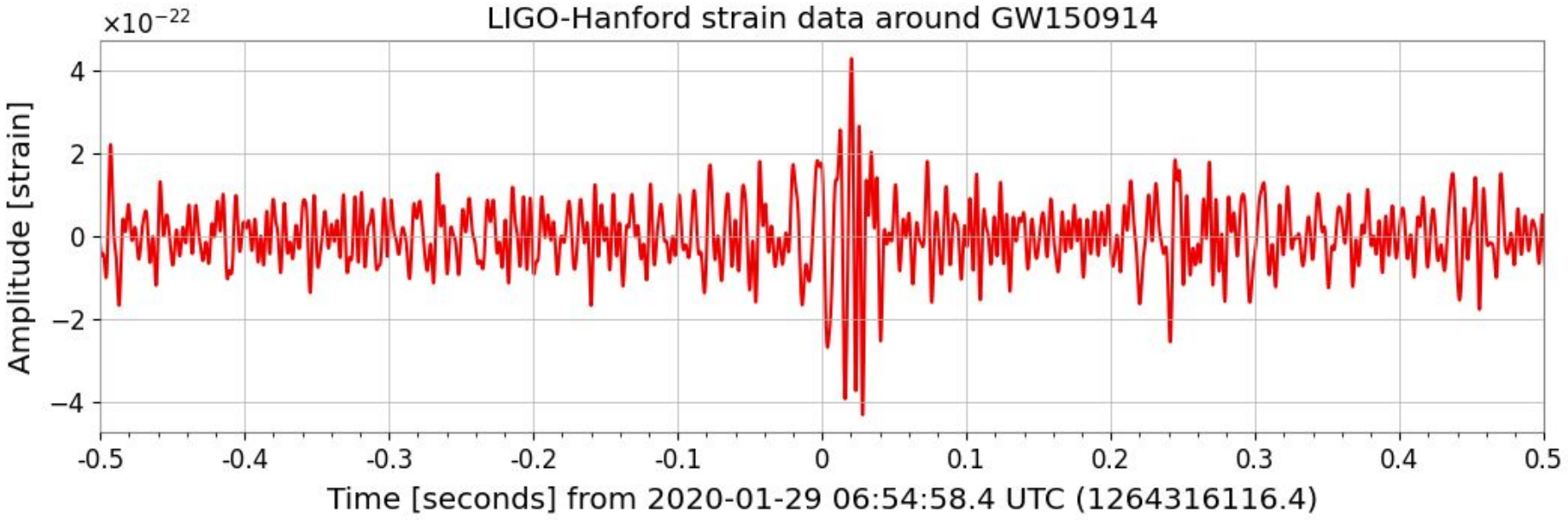
Create the sound of two black holes merging using gravitational waves.

- GPS: 1264316116.4
- Filtered at 60, 65.8, 69.8, 120, and 180 (spikes within 50-250 Hz)





Unfiltered data on bottom with a clear spike that shows it is the “chirp”



Further zoom into the peak, between x-axis t0-.5 and t0+.5

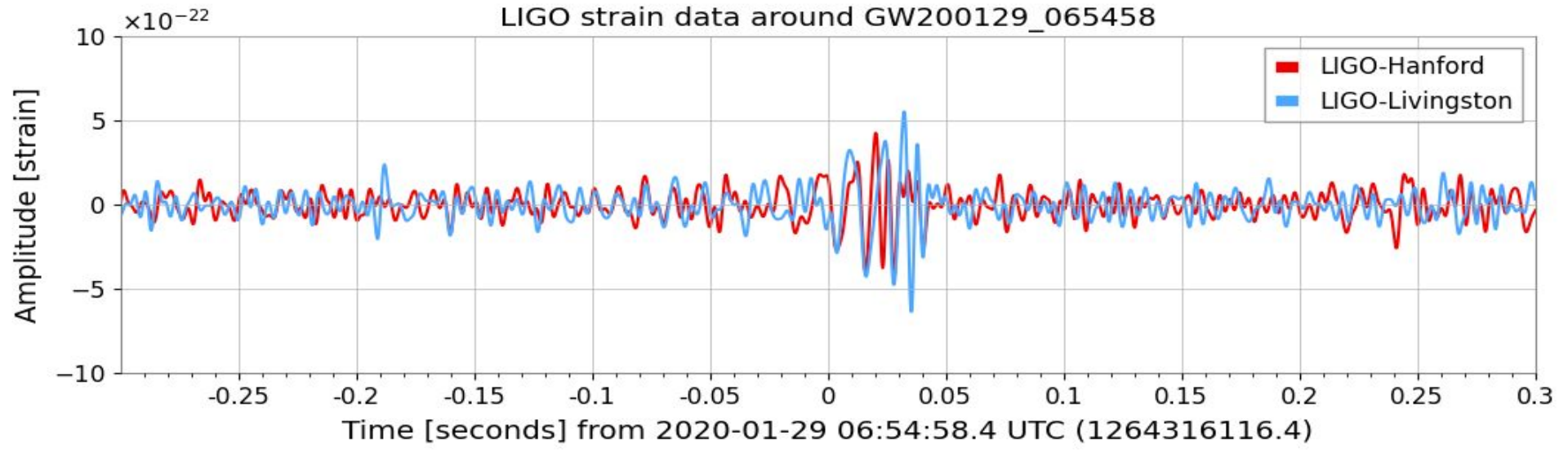
Livingston data

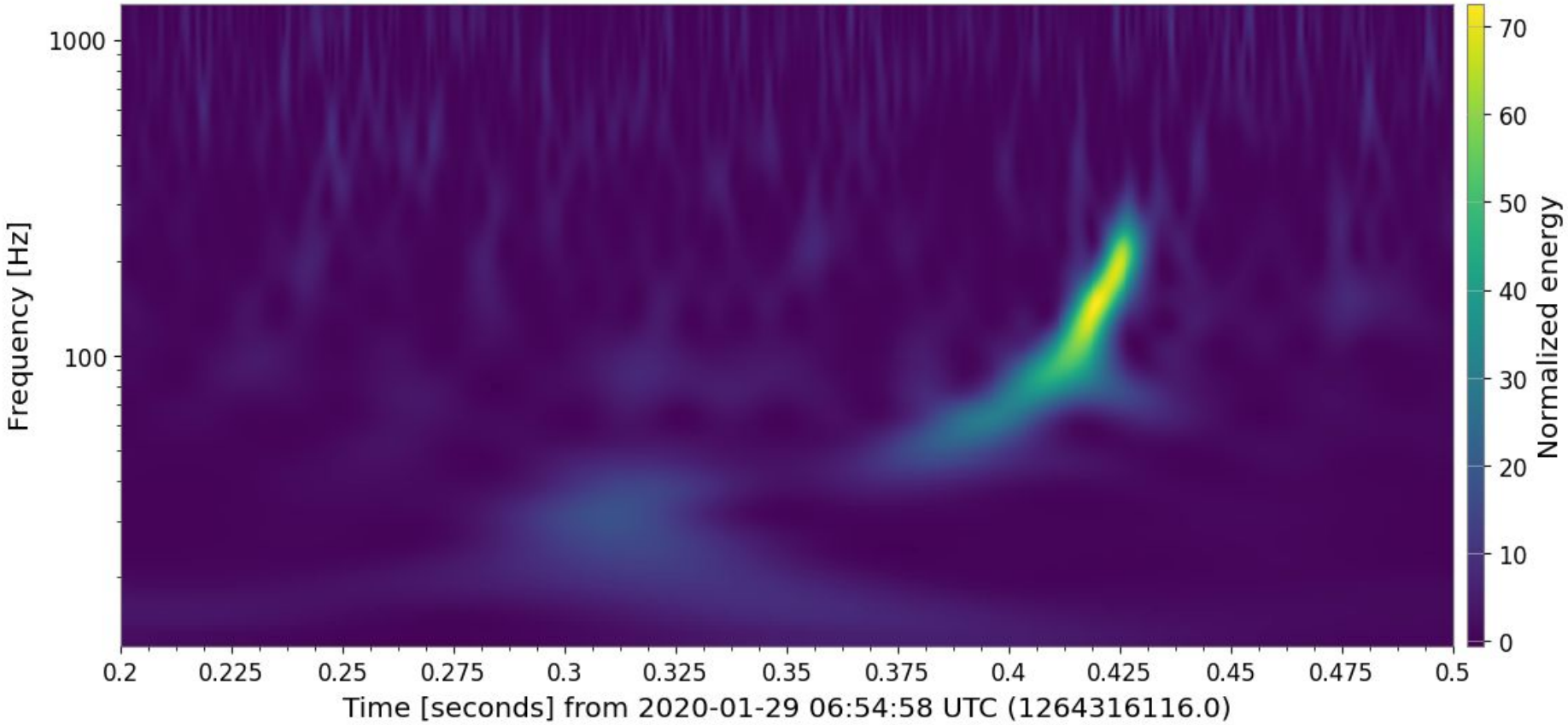
(factor in the time delay between locations for wave to travel)

```
[8]  ldata = TimeSeries.fetch_open_data('L1', t0 - 16, t0 + 16)
     lfilt = ldata.filter(zpk, filtfilt=True)

[9]  lfilt.shift('6.9ms')
     lfilt *= -1
```

Livingston and Hanford LIGO data during event





Visualization of the “chirp”, Frequency vs Time

Code to download the wave into a sound file labeled “example.wave”

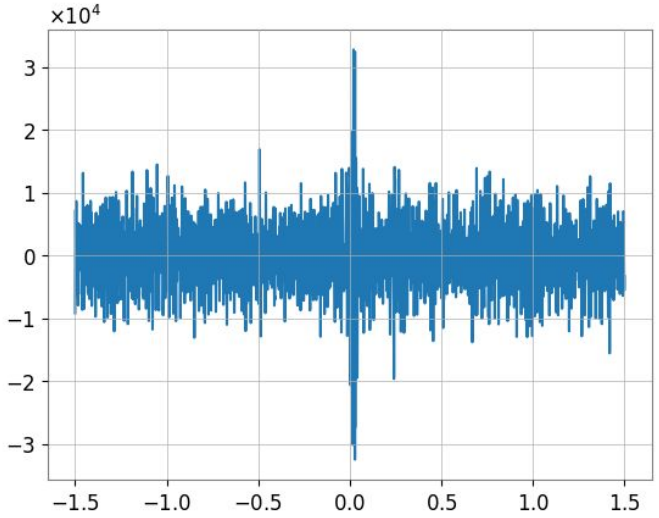
```
from scipy.io.wavfile import write
import numpy as np


amplitude = np.iinfo(np.int16).max

ind = np.where((x_val < (t0+1.5)) & (x_val > (t0-1.5)))
y = y_val[ind]
# y = y**3
y = y / np.max(y)
plt.plot(x_val[ind] - t0, (np.array(y) * amplitude).astype(np.int16))
```

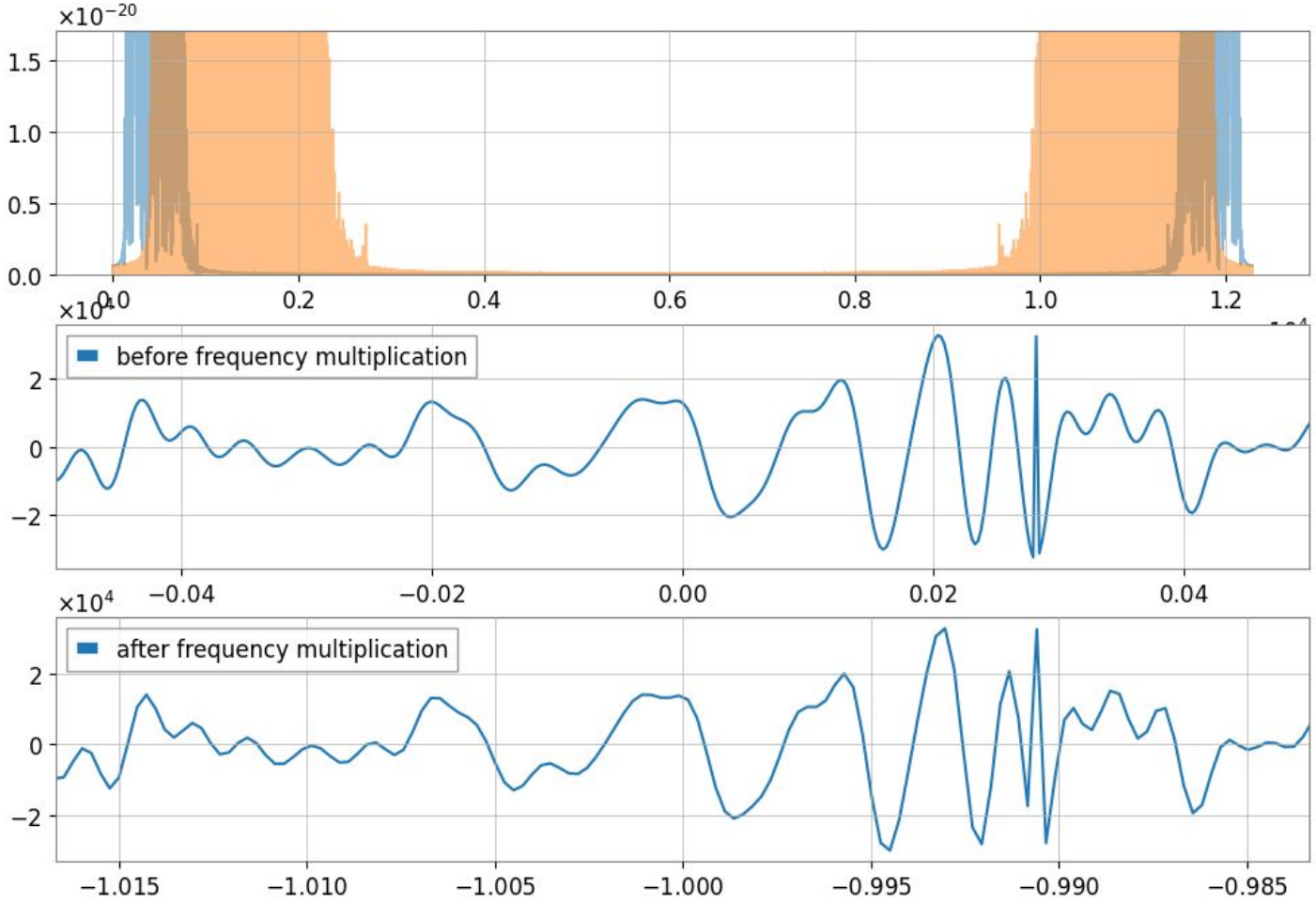
```
from google.colab import files
files.download("example.wav")
```

Visual representation of sound wave



Beautify the sound

- Make clip 1.5 sec
- Increase the frequency of sample wave by 3
- Make signal more distinct from the noise
- Makes sound wave of merger more audible



Code for slowed down version of the of the merging

```
!pip install pydub
from pydub import AudioSegment
```

```
Collecting pydub
  Downloading pydub-0.25.1-py2.py3-none-any.whl (32 kB)
Installing collected packages: pydub
Successfully installed pydub-0.25.1
```

```
[ ]  sound = AudioSegment.from_file("example.wav")
     print(sound.frame_rate)
     # sound.frame_rate = 1024
     print(sound.frame_rate)
     sound = sound.set_frame_rate(4096 * 4)
     sound.frame_rate = 4096 * 2
     sound.export("example_slow.wav")
     files.download("example_slow.wav")
```