Login + Set Up

Username: **.\wiseguest**

Pasword: **2025guest@CEAS**

Go to:

https://github.com/ianpajohnsonSBU/WISE_computing_heavens

Or for short: github.com/ianpajohnsonSBU/

And download today’s file: 3_3_gw_fft.ipynb

Waves and Gravity

Ian Johnson
For SBU HS WISE

How Do We Think of Waves?

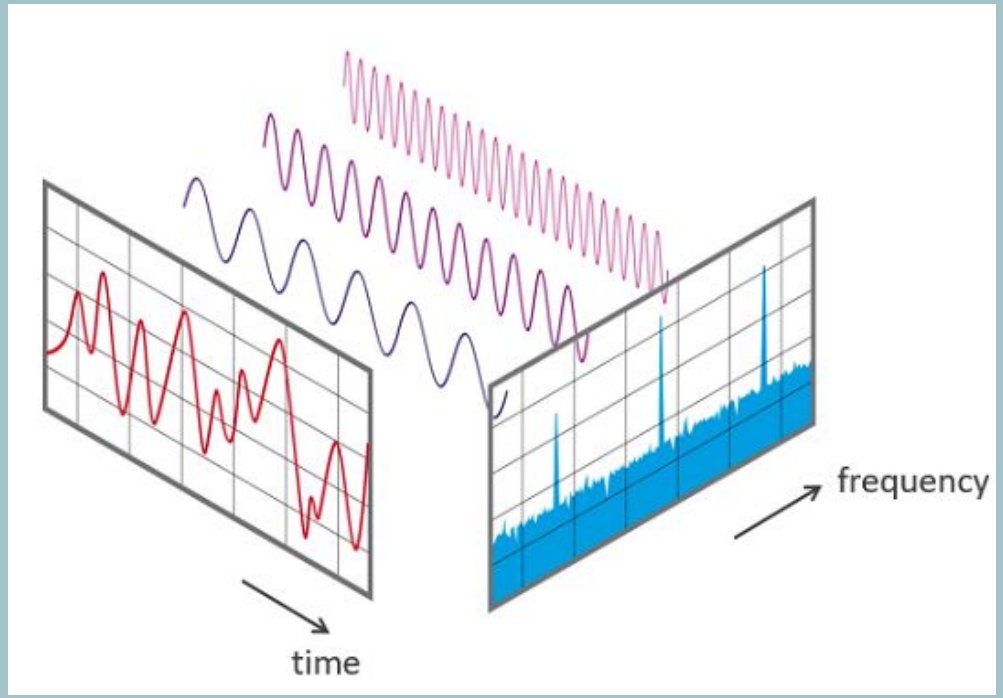
Fourier transform of a signal

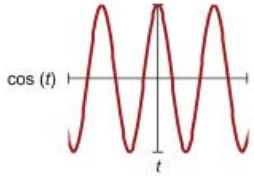
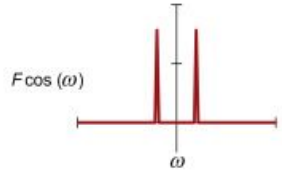
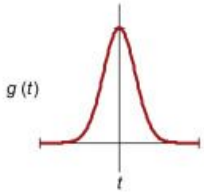
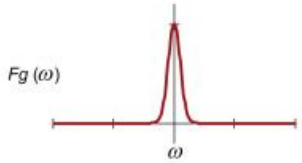
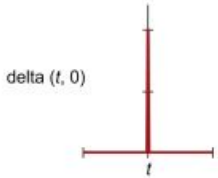
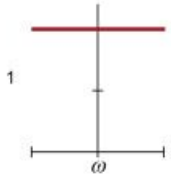
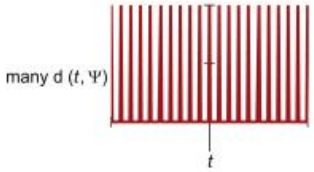
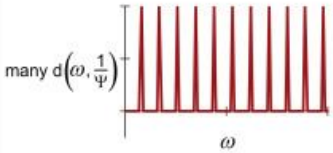
$$f(t) = F[\omega] = [\int_{-\infty}^{\infty} f(t)e^{-j\omega t}dt]$$

Inverse Fourier Transform is

$$f(t) = \int_{-\infty}^{\infty} F[\omega]e^{j\omega t}d\omega$$

The Fast Fourier Transform (FFT):



Time domain signals	Frequency domain spectra
 (A) Cosine wave	 (B) Fourier transform of cosine wave
 (C) Gaussian function	 (D) Spectrum of Gaussian function
 (E) Delta function	 (F) Frequency content of delta function
 (G) Sampling function in time domain	 (H) Transform of sampling function

Uses Are Wide

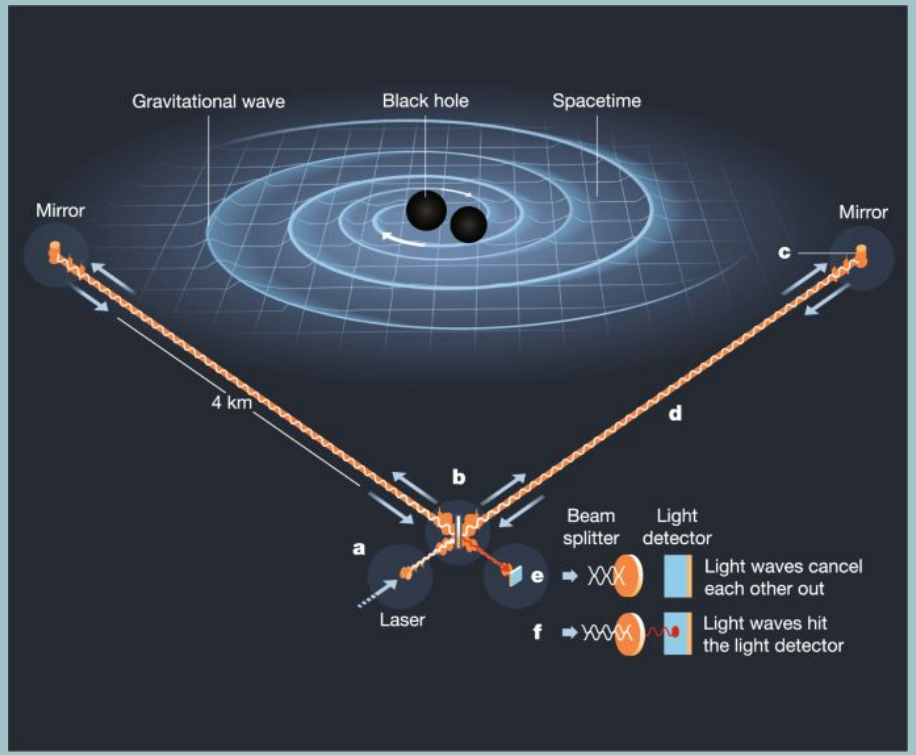
- Compression (like .jpg files)
- Telecommunication
- Signal detection
- Noise filtering
- Sometimes makes math much, much easier

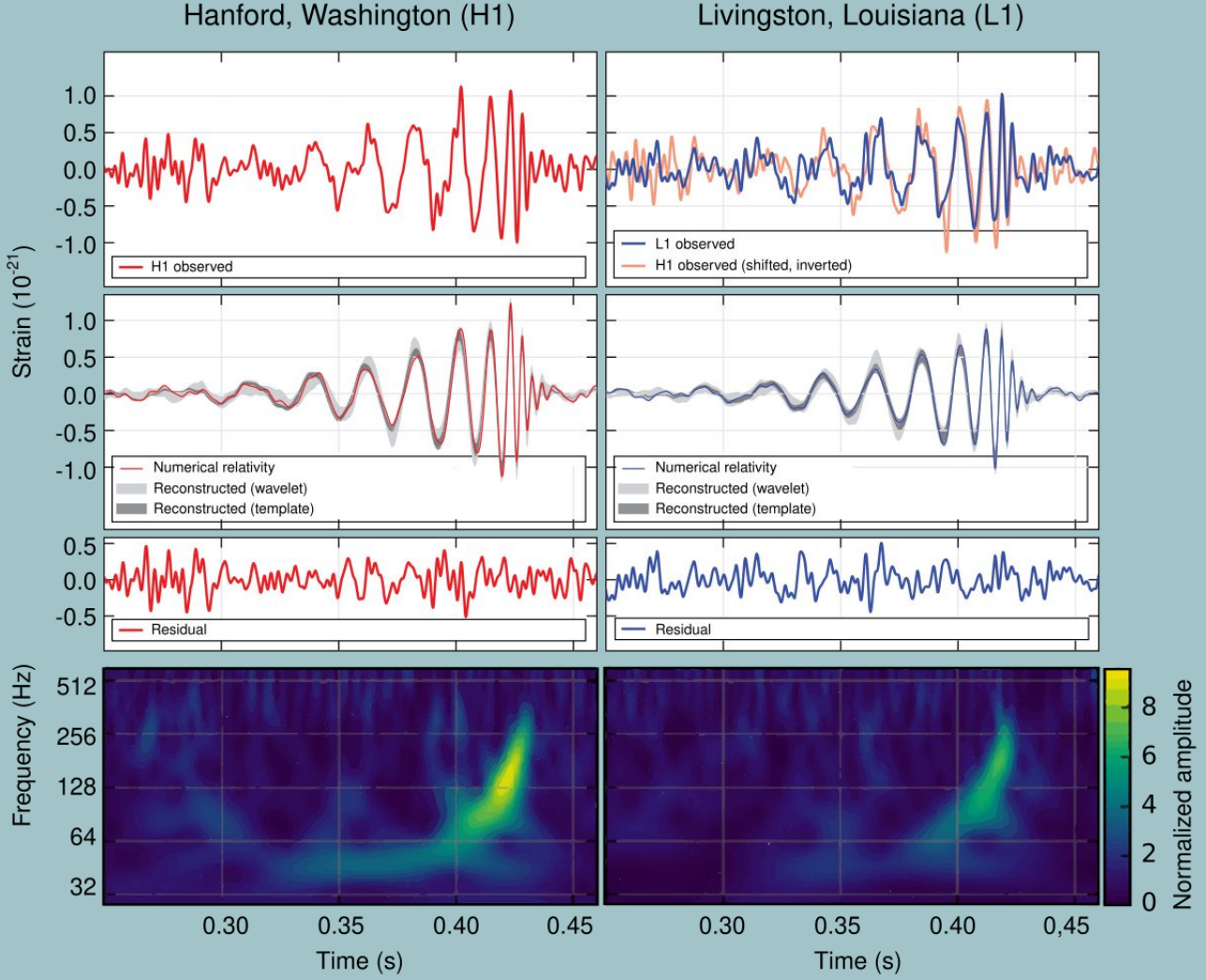
The Fast Fourier Transform (FFT):

Fun drawing with math:

https://medium.com/@vladimirstojoc/drawing-images-with-fourier-series-e7468ecb47b0

Gravitational Waves




Hanford, Washington (H1)
Livingston, Louisiana (L1)
Strain (10^{-21})
H1 observed
L1 observed
H1 observed (shifted, inverted)
Numerical relativity
Reconstructed (wavelet)
Reconstructed (template)
Residual
Frequency (Hz)
512
256
128
64
32
0.30
0.35
0.40
0.45
0,45
Time (s)
Normalized amplitude
8
6
4
2
0

Gravitational Waves

$$G^{\mu\nu} = \frac{8\pi G}{c^4} T^{\mu\nu}$$

linearize

$$g_{\mu\nu} \approx \eta_{\mu\nu} + h_{\mu\nu}$$

flat space metric

metric perturbation

$$\Box h^{\mu\nu} = \left(-\frac{\partial^2}{\partial t^2} + \nabla^2 \right) h^{\mu\nu} = -\frac{16\pi G}{c^4} T^{\mu\nu}$$

inhomogeneous wave equation -> gravitational waves (GWs)

Evaluations!

https://forms.gle/ZDb6nf9XJTr8Dsgx8

High School Women in Science & Engineering (WISE): 2025 Symposium

Join us for **Dinner** to celebrate our High School WISE students' hard work that will be on display at the **Poster Session** and celebrated at the **Awards Ceremony**!

Date: Friday, May 8th, 2025

Time: 5:30 – 7:30 PM EST

Location: Zodiac Lobby, Charles B. Wang Center, Stony Brook University

Address: 100 Circle Rd, Stony Brook, NY 11794

RSVP below by Friday, April 11th, 2025

Fill-in the form via this link or scan the QR code!

SCAN ME

Project!

Detecting a gravitational wave signal from real data!

Group Sizes?

Pick Groups?

Additional steps outside class?

Would you like a template for presentation?