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CLUSTERING SPECTRAL NOISE IN THE SEARCH FOR GRAVITATIONAL WAVES

NOISE AND NARROW SPECTRAL ARTIFACTS

Noise : non-gravitational wave data inputs (usually from earth).
Narrow Spectral Artifact : An extremely thin spike at a specific frequency, indicating noise or a signal.
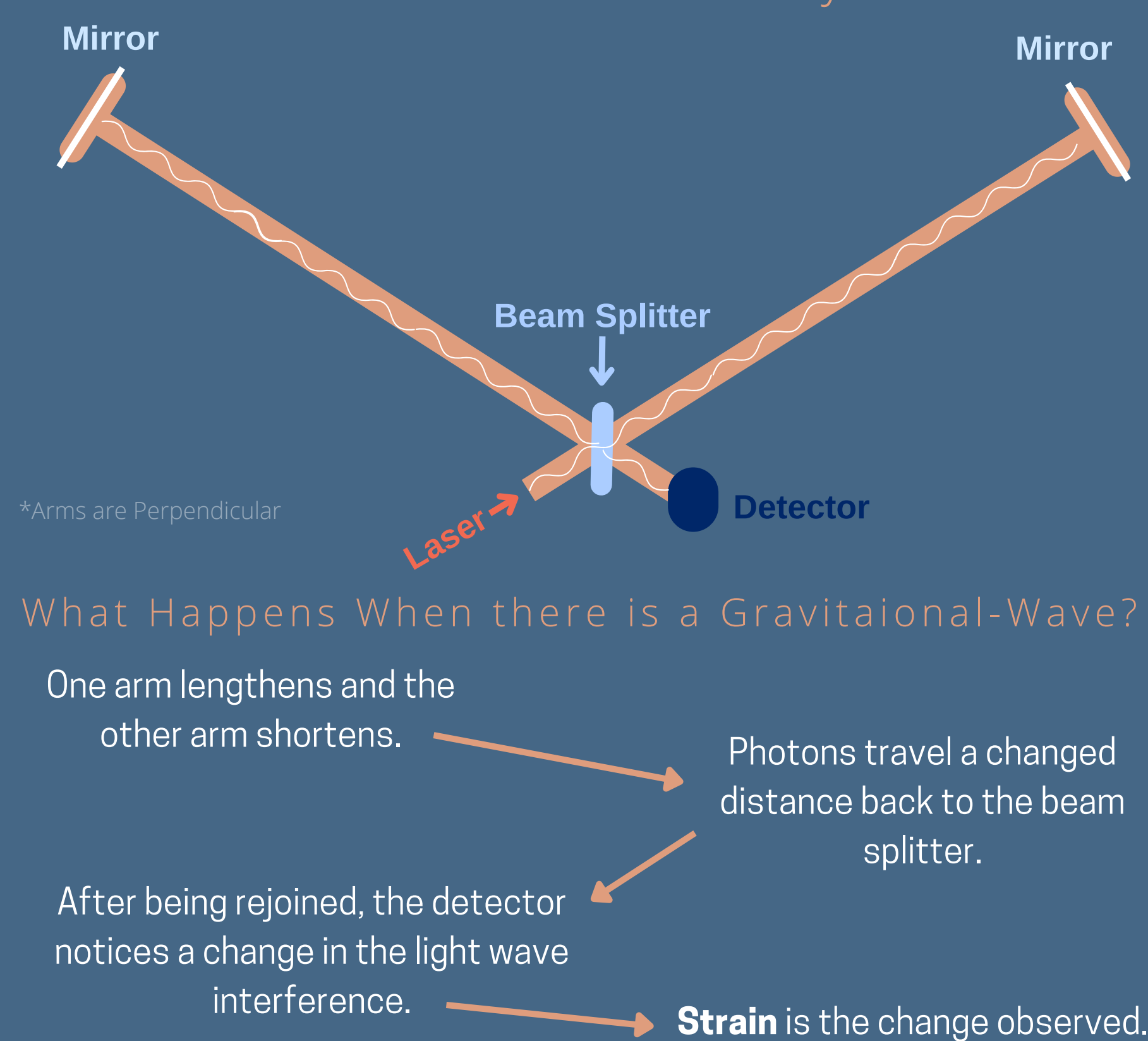
IMPORTANCE

Narrow spectral artifact **noise can mimic the signal of a continuous gravitational wave** from a non-axisymmetric neutron star. So in being able to cluster the noise and determine it is from Earth, helps **prevent false detection**.

What are Gravitational Waves

- Distortions in space time.
- Produced by cosmic events like in-spiraling binary systems (of black holes or neutron stars) or non-axisymmetric spinning neutron stars.
- First predicted by Albert Einstein in his theory of general relatively.

In-Spiraling Binary System

Non-Axisymmetric Spinning Neutron Star

LIGO
Laser Interferometer Gravitational-wave Observatory

Mirror

Mirror

Beam Splitter

*Arms are Perpendicular

Laser

Detector

What Happens When there is a Gravitaional-Wave?

One arm lengthens and the other arm shortens.

Photons travel a changed distance back to the beam splitter.

After being rejoined, the detector notices a change in the light wave interference.

Strain is the change observed.

## Clustering Method

Getting the Data Ready

- Strain data is processed into a frequency domain (SFT).
- SFT's combined into an average frequency spectrum.
- Threshold is set and therefore persistence value produced.
- We are then left with cvs and txt files showing the deviation from the set noise value of the data lines over time.

Time Epoch 2

threshold

mean

Time Epoch 1
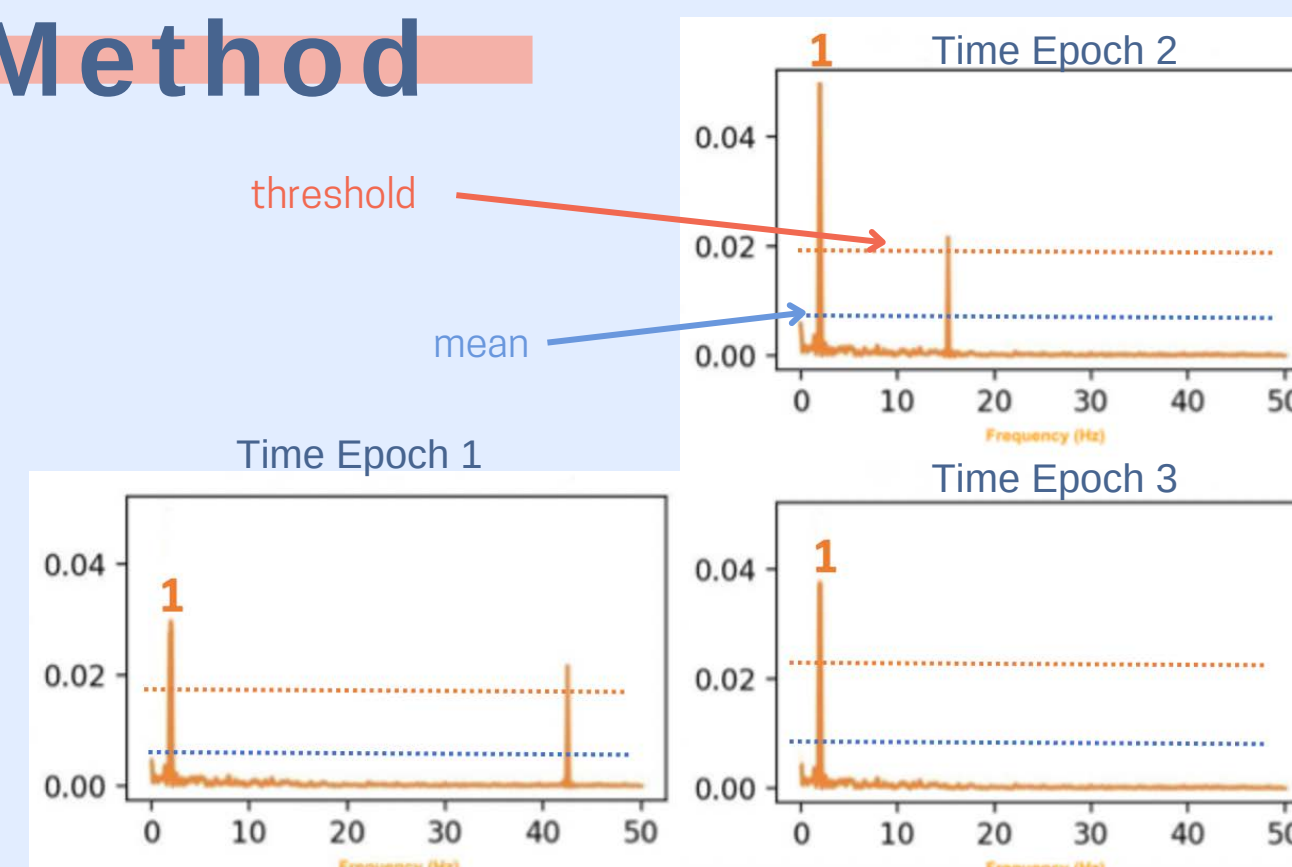
Time Epoch 3

The GPS time lines are then digitized based on if the frequency is above the set threshold value or not.

Above translates to 1 meaning on (noise occuring) and below translates to 0 meaning off (noise not occuring).

	Frequecy 1	Frequency 2	Frequency 3
Time Epoch 1	1	0	1
Time Epoch 2	1	1	0
Time Epoch 3	1	0	0
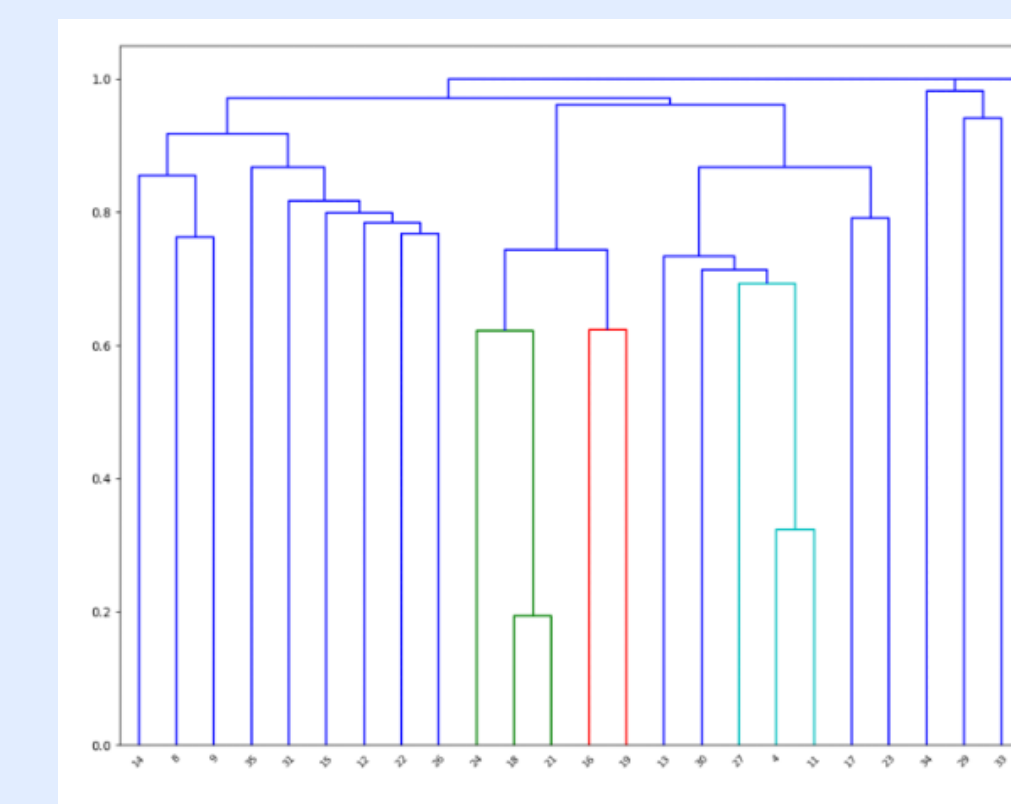
Lines are then compared based on the varying of "on" and "off" over time, and clustered together if deemed similar enough by set parameters.

Results Produced

The program produces two things: the cluster diagram, and cluster line name list

Each cluster has a corresponding diagram and name list produced. If the line has already been identified it will show as a tooth of a comb. If the line has not been previously identified it will show as "unidentified". The ability to cluster these unidentified lines aids in finding the source, and ruling if noises are related.

Blue is off
Yellow is on

*Each data line is a horizontal row of pixels in the diagram. (each cluster has multiple lines)

Cluster Diagram

Cluster id 26

Cluster id 490

Cluster id 150

Cluster id 479
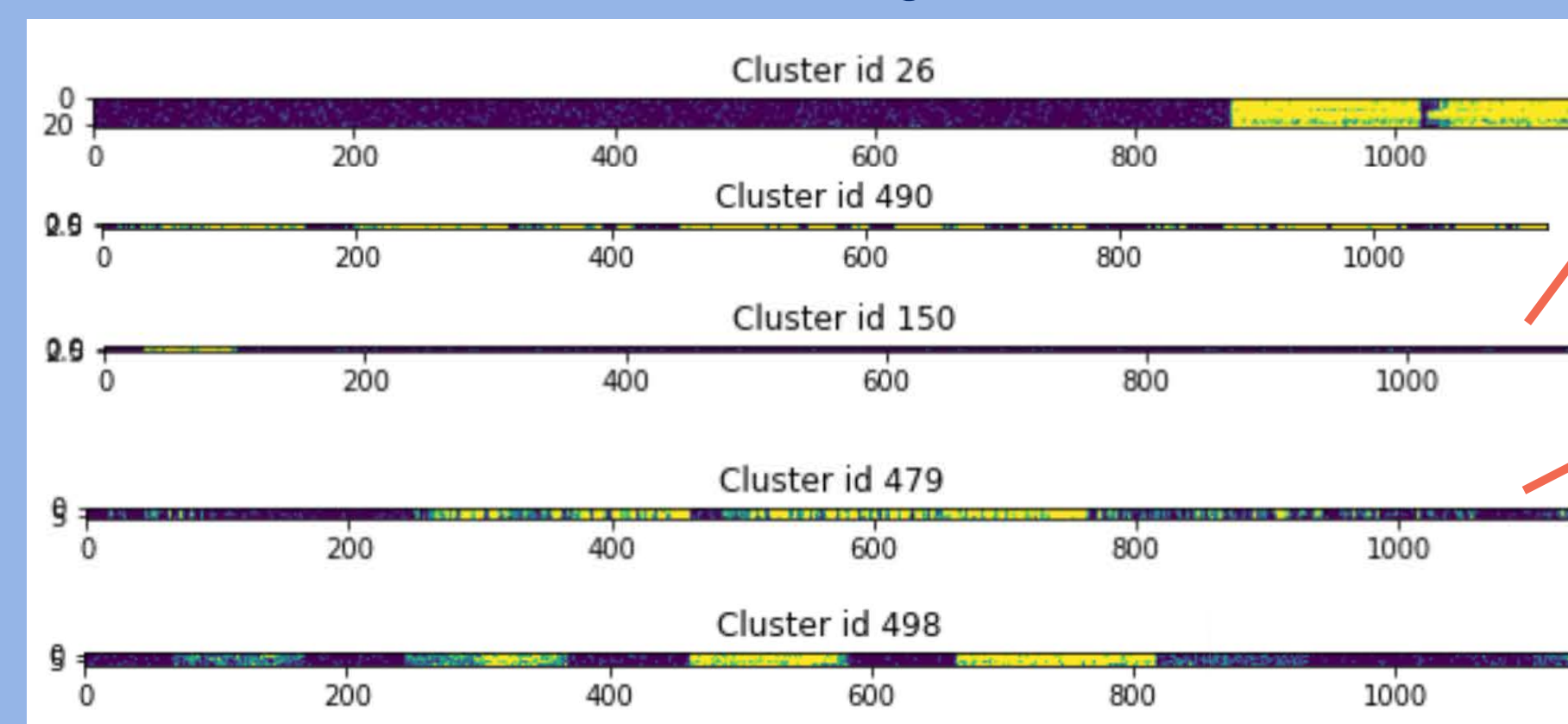
Cluster id 498

Cluster Line Name List

```
Cluster id 150
27.33514        Unidentified line
29.23597        Unidentified line
34.8625         Unidentified line
36.76361        Unidentified line

Cluster id 479
10.08    Tooth of the 0.16;0.0 comb
10.24    Tooth of the 0.16;0.0 comb
10.4     Tooth of the 0.16;0.0 comb
10.56    Tooth of the 0.16;0.0 comb
10.72    Tooth of the 0.16;0.0 comb
10.88    Tooth of the 0.16;0.0 comb
11.04    Tooth of the 0.16;0.0 comb
11.2     Tooth of the 0.16;0.0 comb
11.36    Tooth of the 0.16;0.0 comb
```