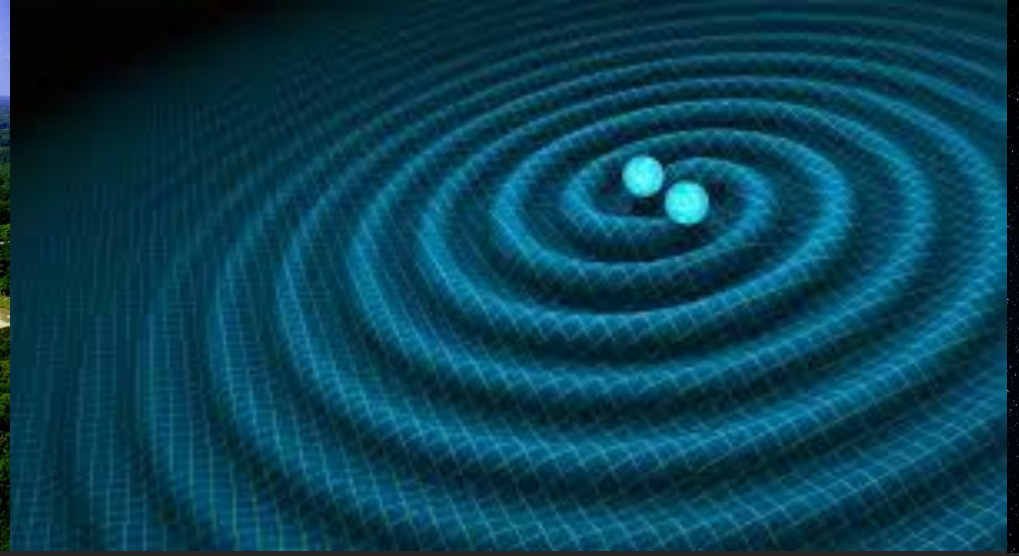
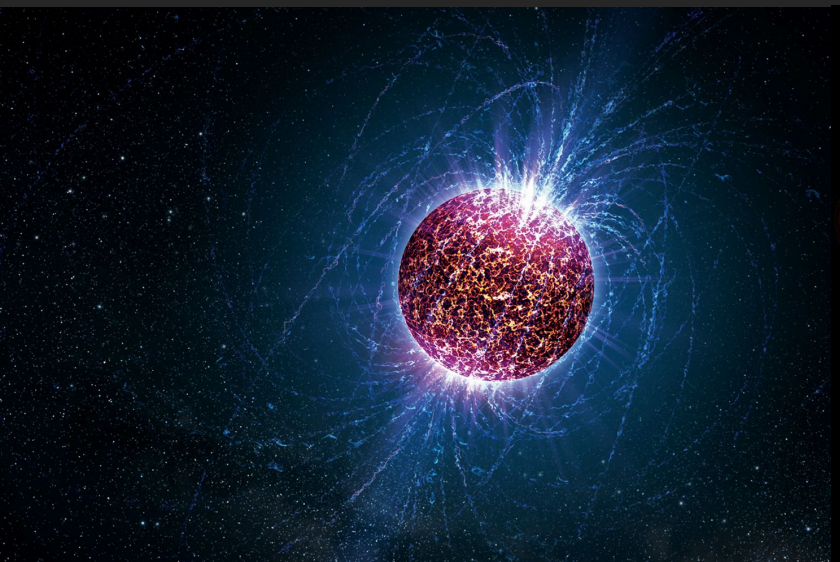
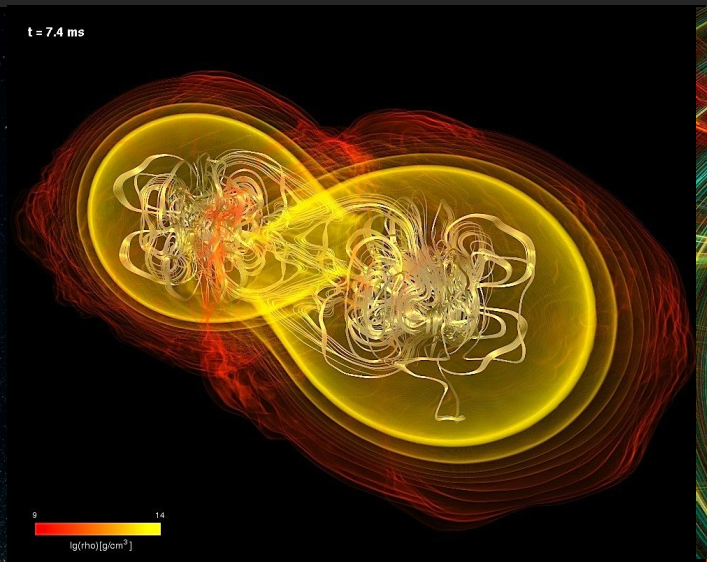
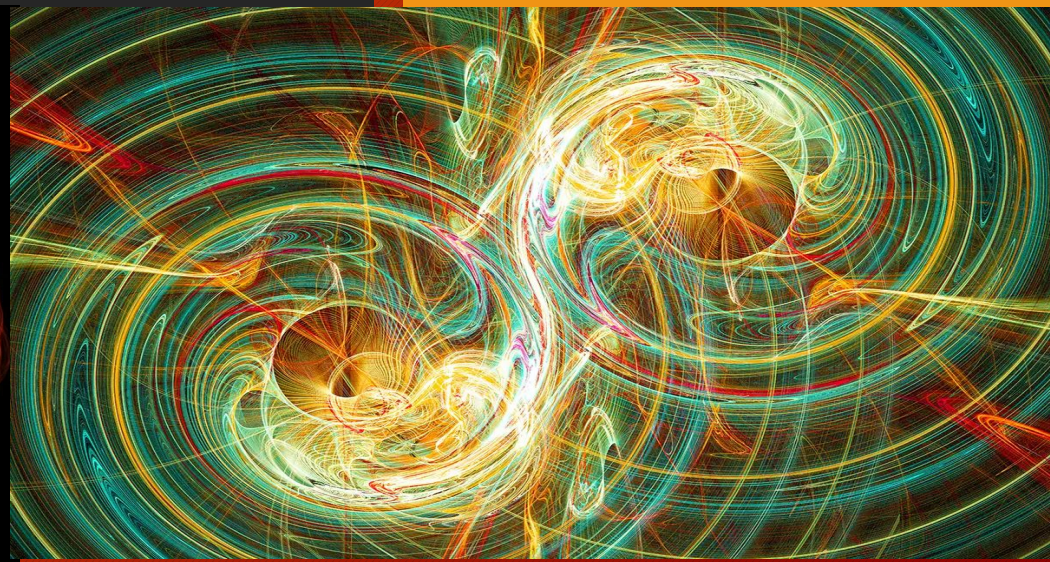




Time frequency analysis
Non stationary noise

DSP Project 2021 EE386
By: P.Ramyashri
Link to codes and project log:
https://github.com/rum1887/TimeFreq-Analysis



Topics

1. Abstract
2. The dataset
3. Noise model
4. Time Frequency Analysis
5. Future plan

Abstract

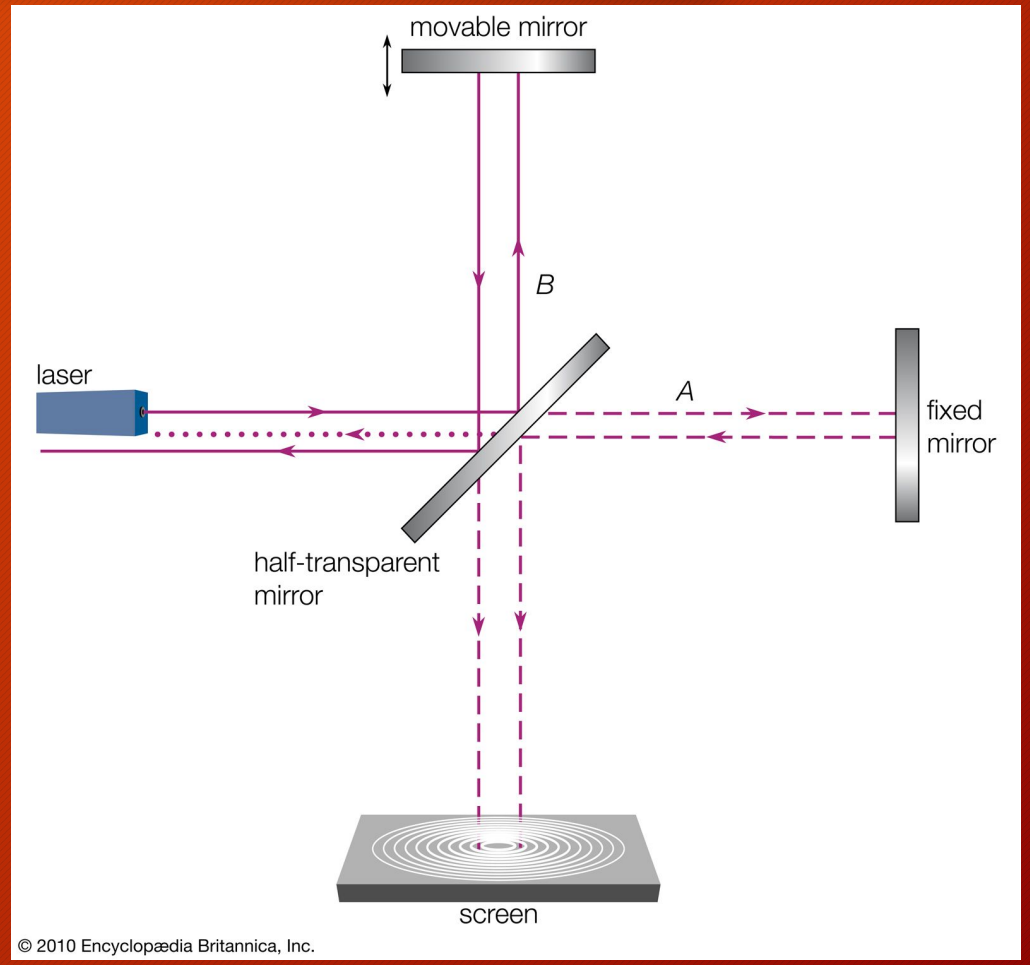
Using wavelet domain to detect non stationary portions of the gravitational wave data.

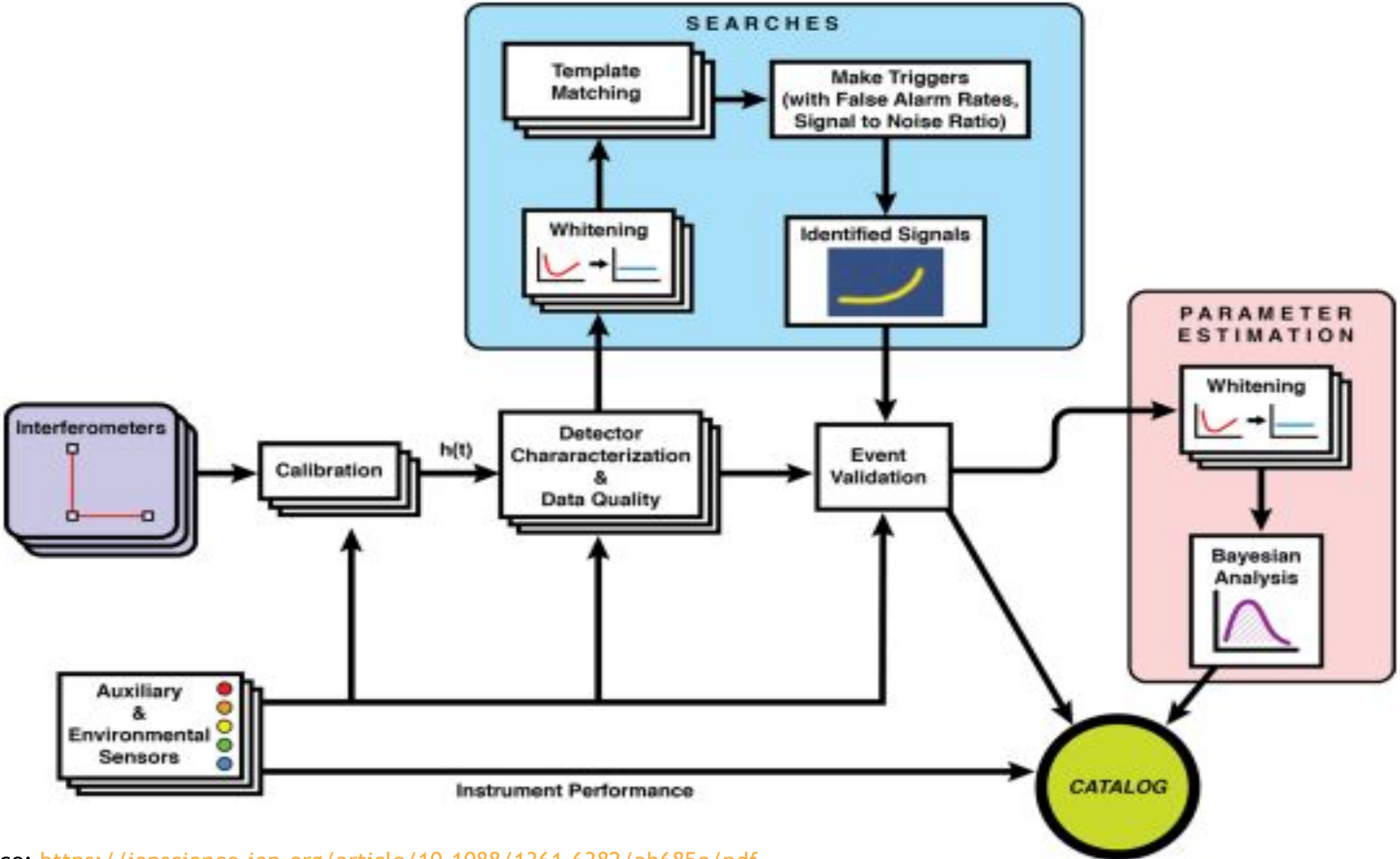
Gravitational wave dataset

1. Gravitational waves causes stain in space time which is detected by the michelson interferometers.
2. DATA: Change in the relative lengths of the detector arms is reflected as power variations(captured by photodiodes) , which is the gravitational wave data.
3. Gravitational-wave strain data is a time series, sampled at 16384 Hz for LIGO data and 20kHz for Virgo data.

Dataset : GWOSC

Signal recycling , Power recycling employed





Source: https://iopscience.iop.org/article/10.1088/1361-6382/ab685e/pdf

Noise

1. The data recorded by the Advanced LIGO and Advanced Virgo instruments are impacted by many sources of noise.
   Quantum sensing noise, seismic noise, suspension thermal noise, mirror coating thermal noise,gravity gradient , transient noise events of unknown origin.
2. The noise is described as a stochastic process with statistical properties given by the joint probability distribution p(n).

1. Stationary and gaussian noise.
2. Stationary noises
   Mathematically: Covariance matrix depends only on |i-j|
   Characterised by correlation function, fourier transform=power spectral density.
   In fourier domain, stationary noise has a diagonal covariance matrix. White noise
3. Non stationary noises

Time frequency analysis

1. Non stationary behavior.
   1) Transients (Glitches)
   2) Adiabatic drifts in power spectrum

2. Identifying non stationarity
   1) Observing correlations on F amplitudes.
   2) Time-frequency methods

PIPELINE TO TEST IF THE DATA CHUNK IS NON STATIONARY

1. Data whitened using amplitude spectral density estimate
2. Whitened data transformed using discrete wave packets from meyer wavelets , del t=1s and del f= 1Hz
3. Avg power computed by summing the squared of each wavelet amplitude and dividing by normalisation factor.
4. Perform this on a stationary and gaussian noise and use this distribution as the reference distribution.
5. Perform Anderson darling test on the distribution of the average power to the reference distribution. (statistical test to check of a given sample data is drawn from a given probability distribution).
6. Generates p value indicating the stationarity of the chunk. For small p value, we can assume the signal is non stationary for that period.

Future Plan

1) Implementation
2) Signal Detection
3) Inferring physical parameters from source

THANK YOU