

# Coherent and Coincident Analyses of LIGO-Virgo Data from the Third Observing Run

**Tesi di laurea magistrale in Fisica**



**SAPIENZA**  
UNIVERSITÀ DI ROMA

Relatore:  
Dr. Francesco Pannarale Greco

Laureanda:  
Giada Caneva Santoro

Anno Accademico 2020/2021

# Gravity: from apples to ripples

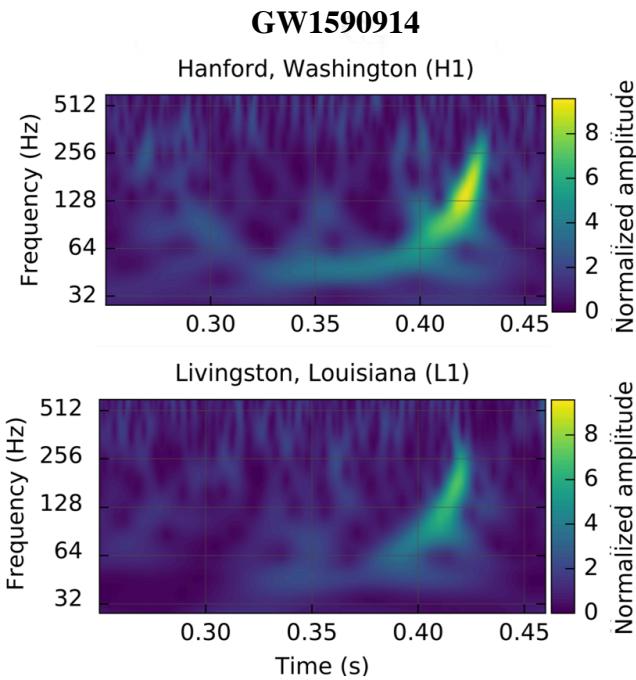
Einstein Field Equations

$$G_{\mu\nu} = \frac{8\pi G_N}{c^4} T_{\mu\nu}$$

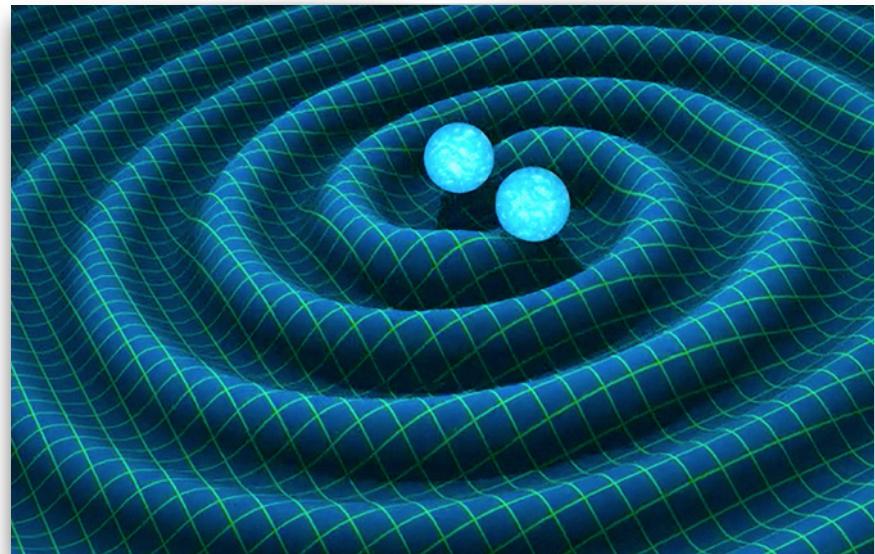


Linearised Field Equations

$$\square \bar{h}_{\mu\nu} = 0$$



## Gravitational Waves

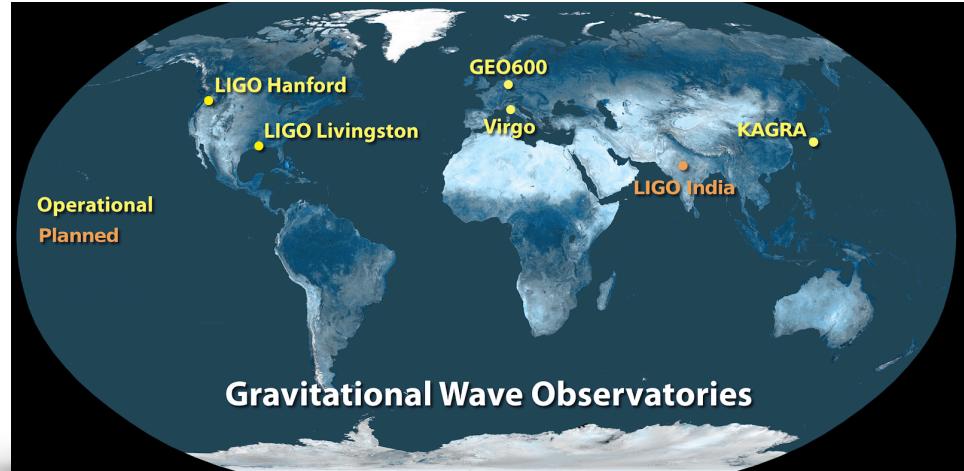


Abbott et al. (2016) Phys. Rev. Lett. 116, 061102

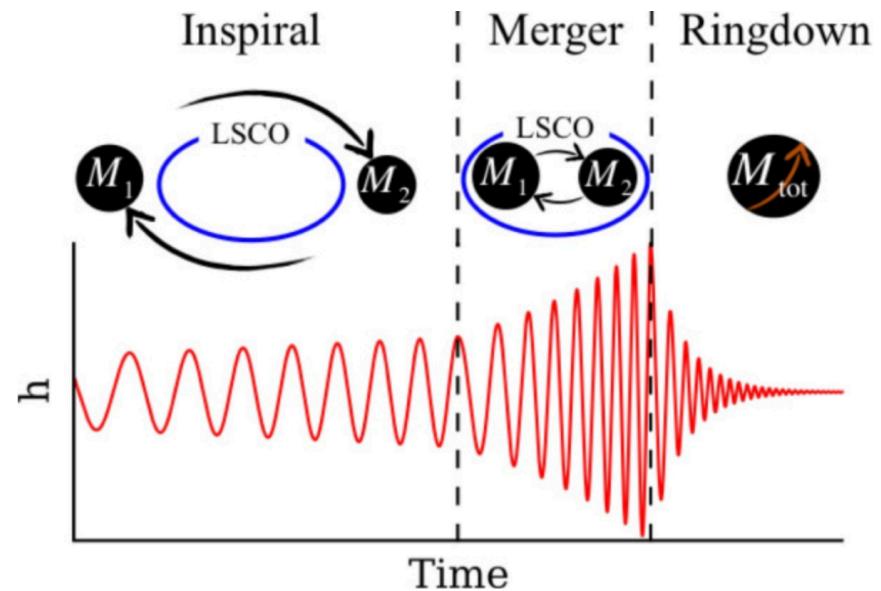
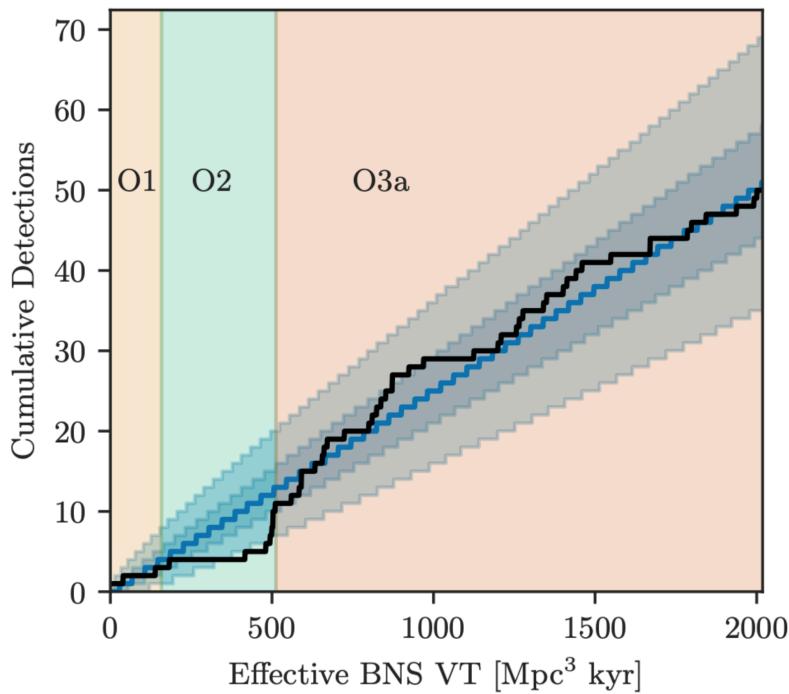
# Gravitational Wave Detection

Network of detector required.

- COINCIDENCE OF DETECTIONS: confidence that signal is from extraterrestrial sources, rather than from noise.
- SKY LOCALISATION: triangulation techniques based on the time delay in more than two detectors.
  - **Multi Messenger Astronomy:** given an accurate sky location, a corresponding EM transient
    - identified in a list of events obtained with the all-sky telescope surveys,
    - guide EM instruments to take images of a small area in the sky.
  - Smaller sky localisation, larger signal-to-noise ratio.



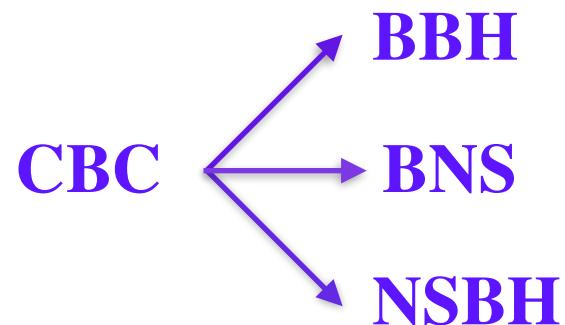
# Compact Binary Coalescence (CBC)



**O1:** September 12, 2015 - January 19, 2016

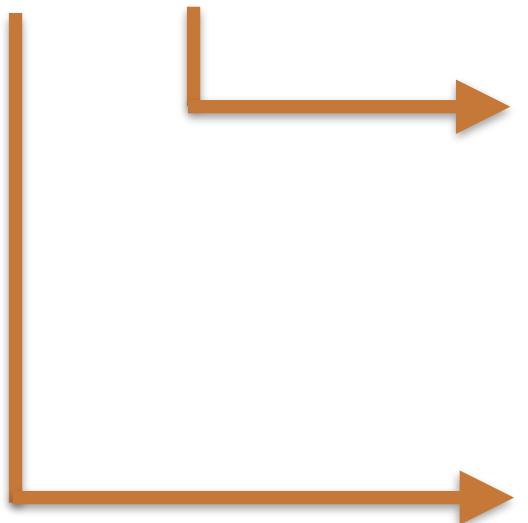
**O2:** November 30, 2016 - August 25, 2017

**O3a:** April 1, 2019 - 30 September, 2019



# CBC searches

- **ONLINE:** detect and report events with sub-minute latencies.
- **OFFLINE:** data calibration and data quality to produce a more sensitive search.



## PyGRB

- Targeted coherent search
- Follow-up to EM transient (GRBs)
- Analysis of three GRBs in O3a data published in [arXiv:2010.14550](https://arxiv.org/abs/2010.14550)

## PyCBC

- All-sky coincident search
- Targets all kind of CBC
- Background analysis of a chunk of O3b data  
(yet to be published by LVC)

# Gamma Ray Bursts

Farthest and brightest explosions in the Universe (1 keV–10 MeV).

## Gamma Ray Bursts

## Gamma Ray Bursts

