امواج گرانشی به منظور مقیدسازی مدل‌های انرژی‌تاریک جایگزین
GW to constrain alternative dark energy models

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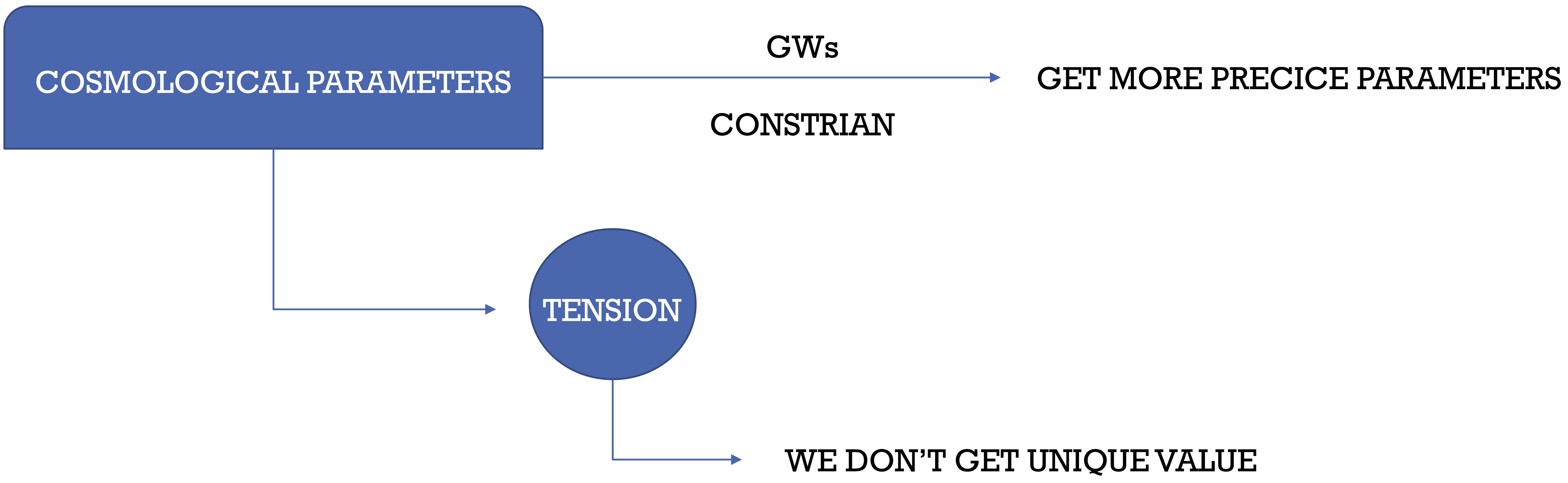
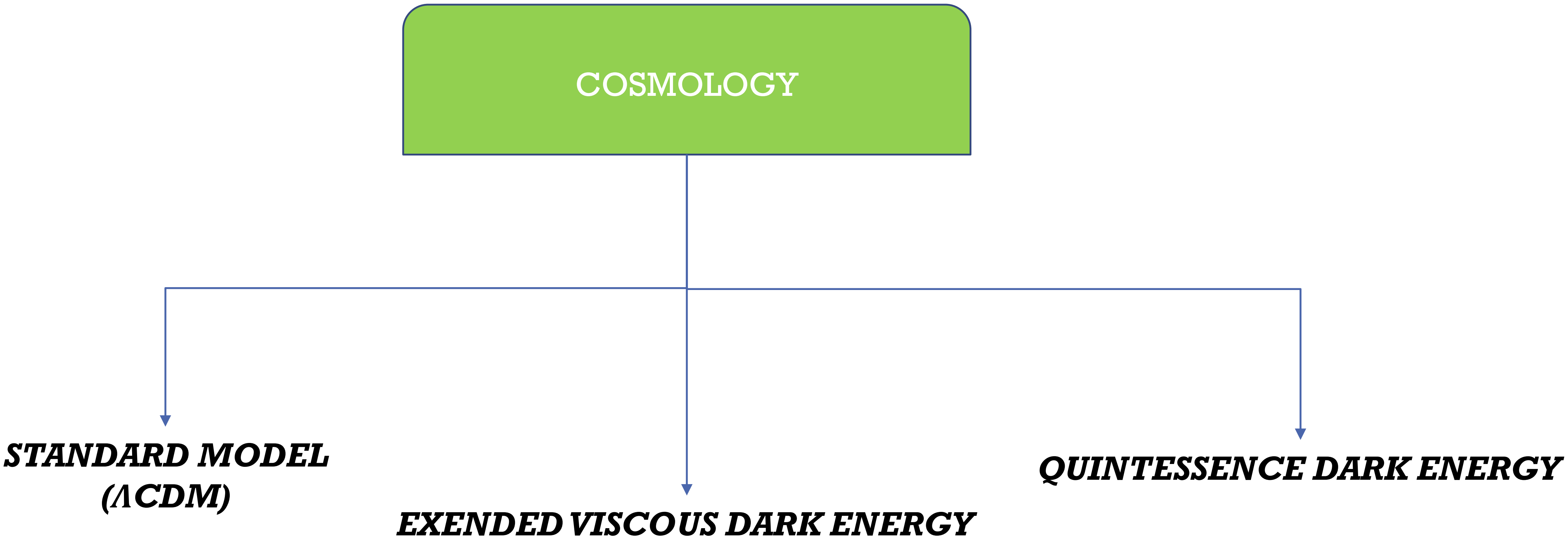
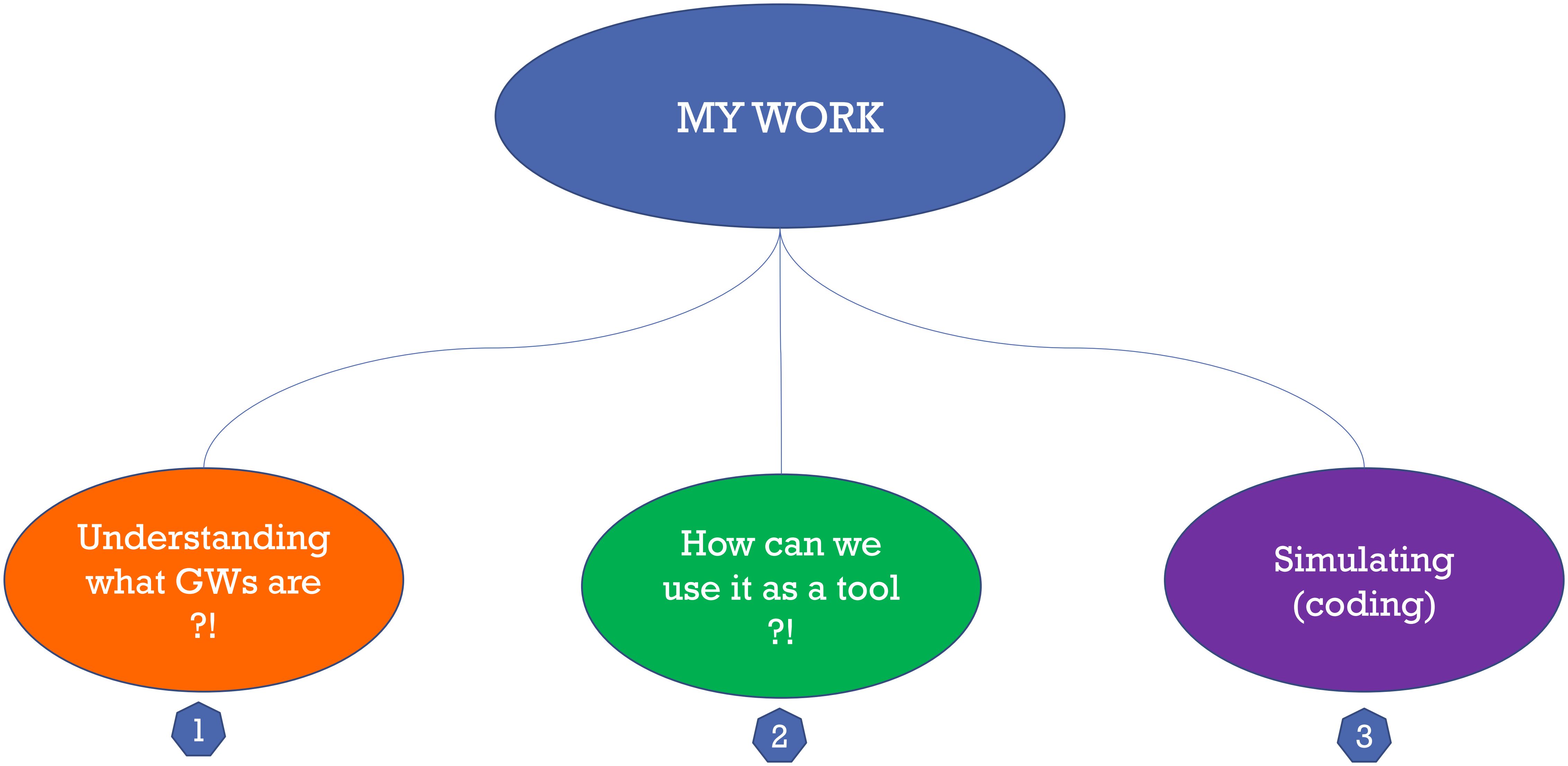

COSMOLOGICAL PARAMETERS
GWs
CONSTRIAN
GET MORE PRECICE PARAMETERS
TENSION
WE DON'T GET UNIQUE VALUE

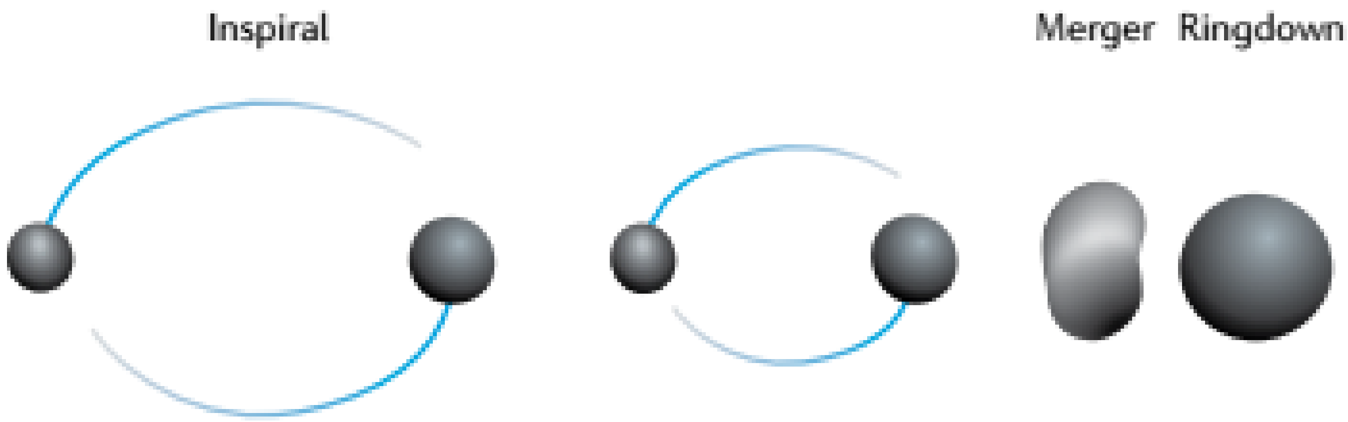

COSMOLOGY
STANDARD MODEL
(ΛCDM)
EXENDED VISCOUS DARK ENERGY
QUINTESSENCE DARK ENERGY


MY WORK
Understanding what GWs are ?!
How can we use it as a tool ?!
Simulating (coding)
1
2
3

1

What is GW ?

inflation



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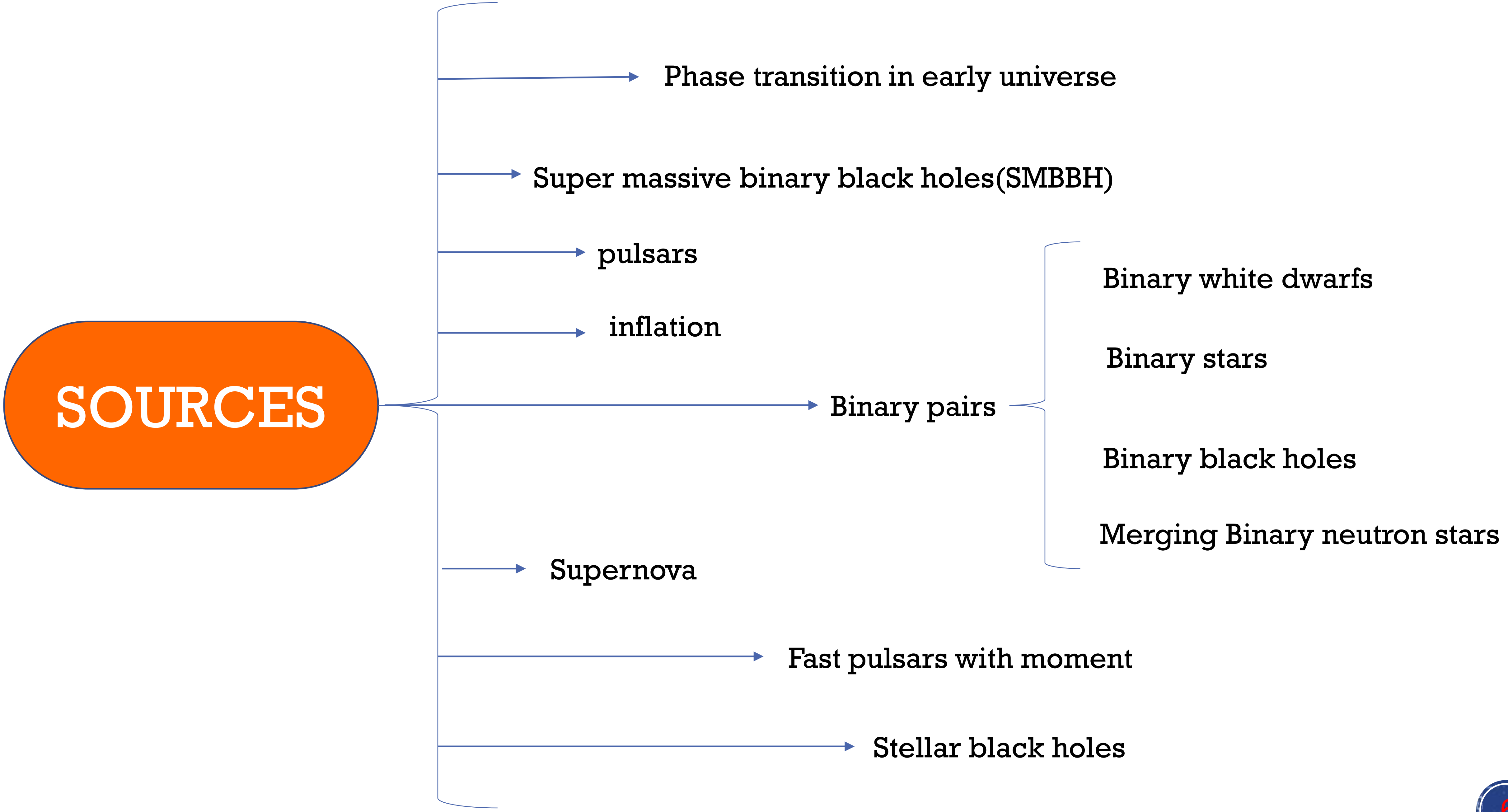
Why GWs are important for us ?

We can understand distance and mass of their sources

We can get more information about EARLY universe


SOURCES
Phase transition in early universe
Super massive binary black holes(SMBBH)
pulsars
inflation
Binary pairs
Binary white dwarfs
Binary stars
Binary black holes
Merging Binary neutron stars
Supernova
Fast pulsars with moment
Stellar black holes

DETECTORS !

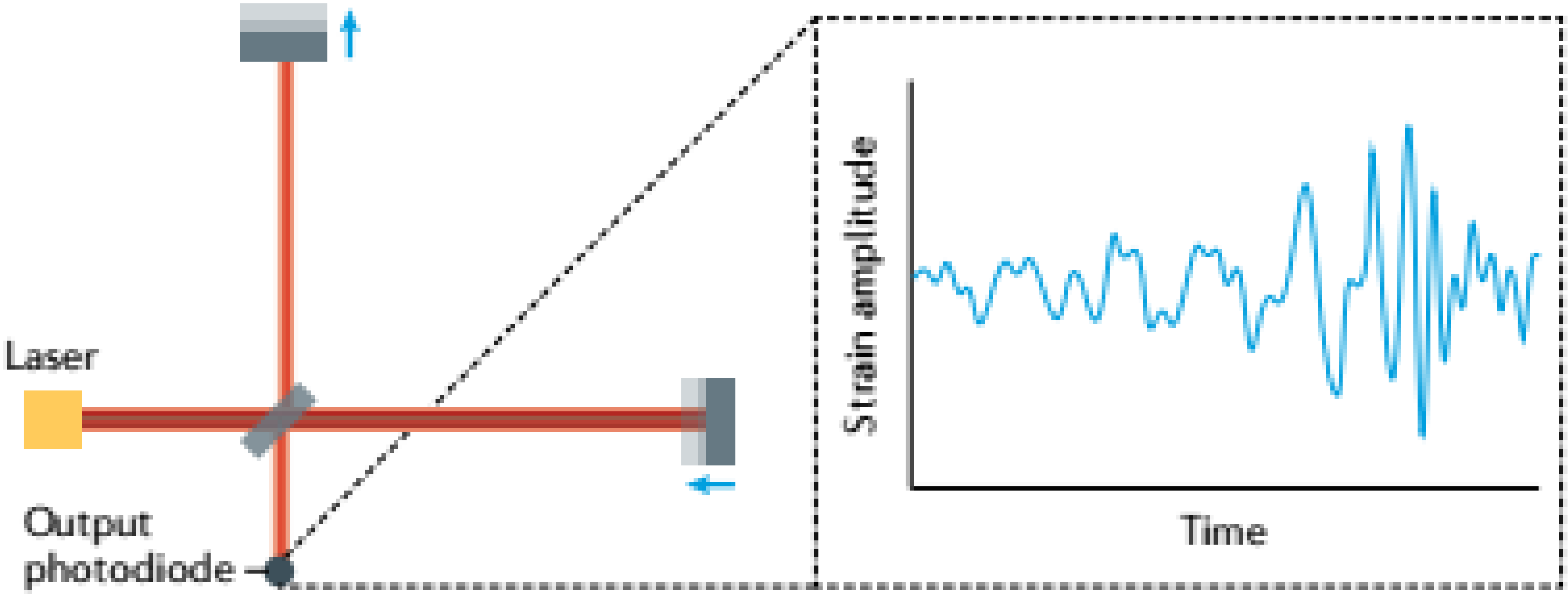
1. *Ground-based detectors*
2. *Space-based detectors*

Michelson–Morley experiment

3. *PTAs* → *TIMING RESEDUL*
4. *Cosmic microwave background polarization*

HOW DO WE DETECT GWs ?

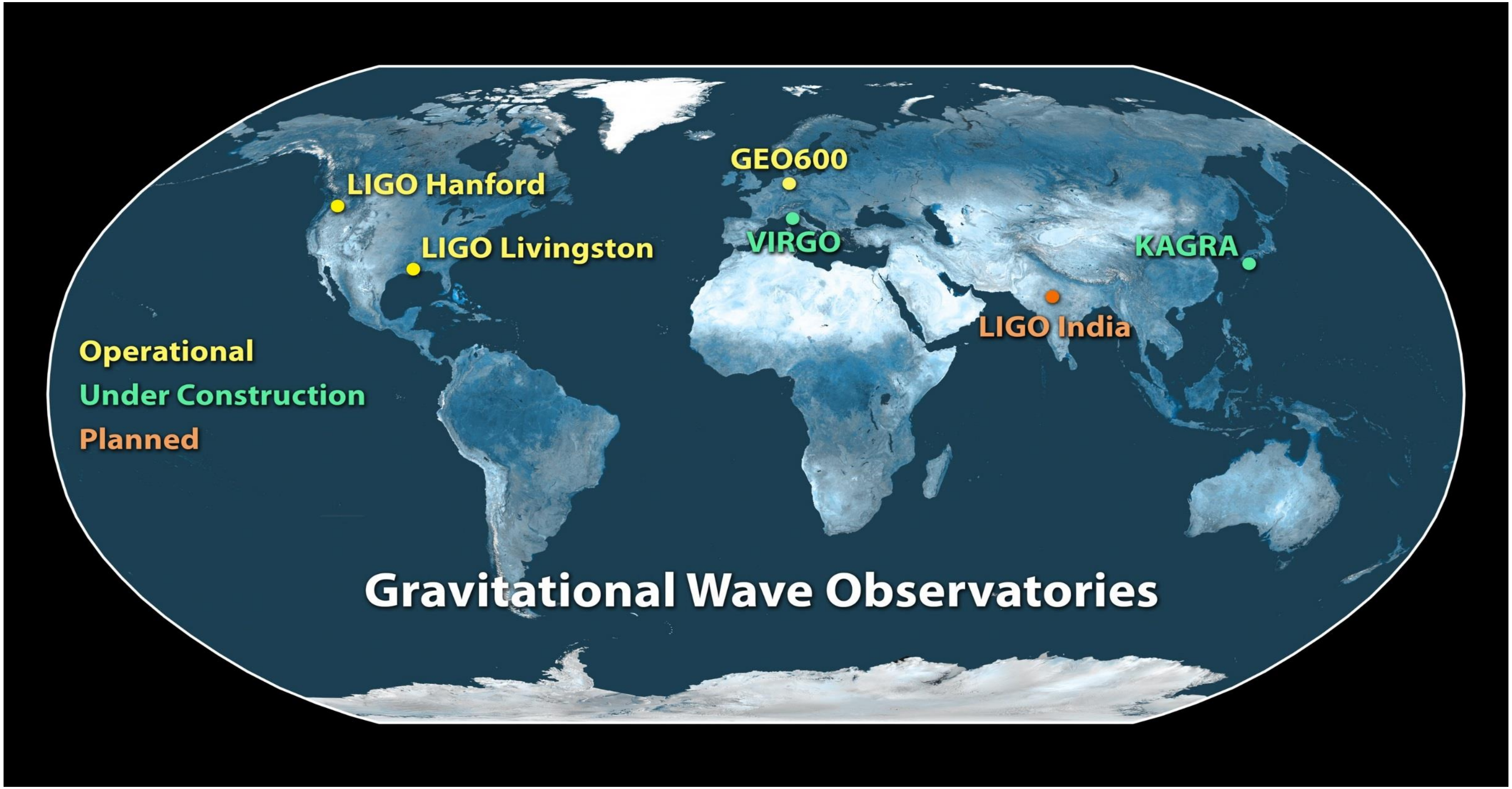
Michelson–Morley experiment



Ground-based detectors

LIGO-VIRGO-KAGRA …

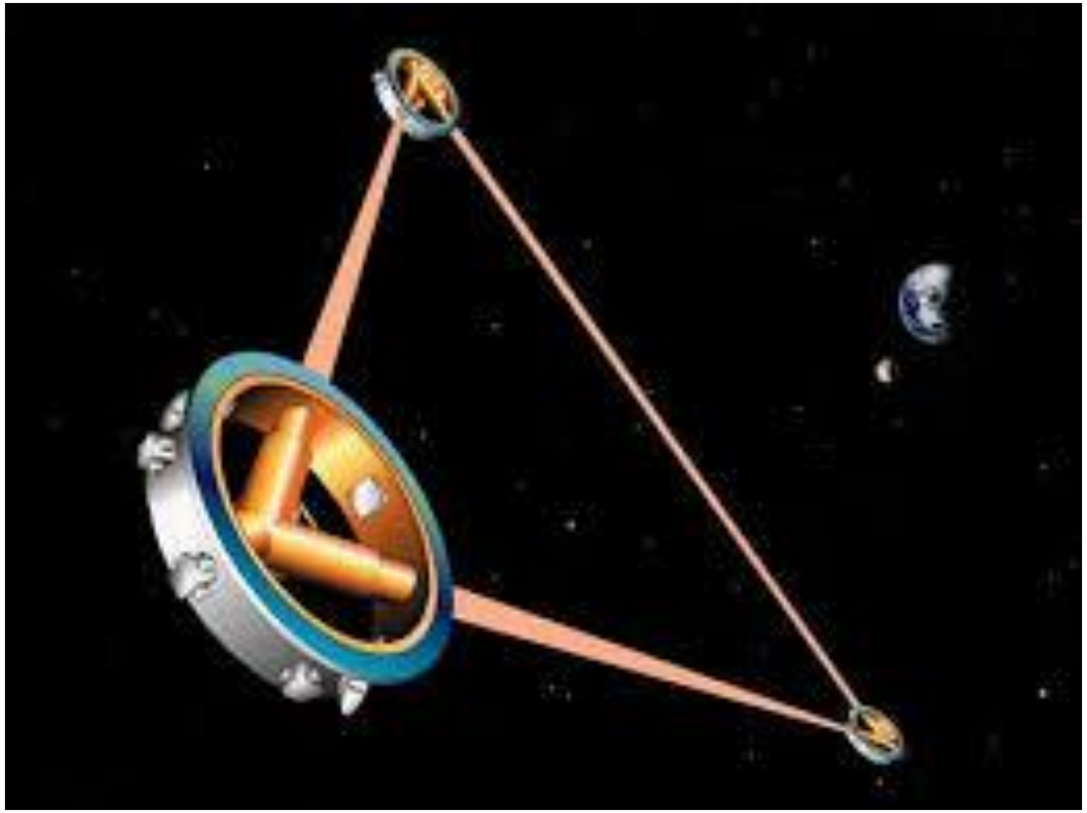
Ground-based detectors



Space based detectors

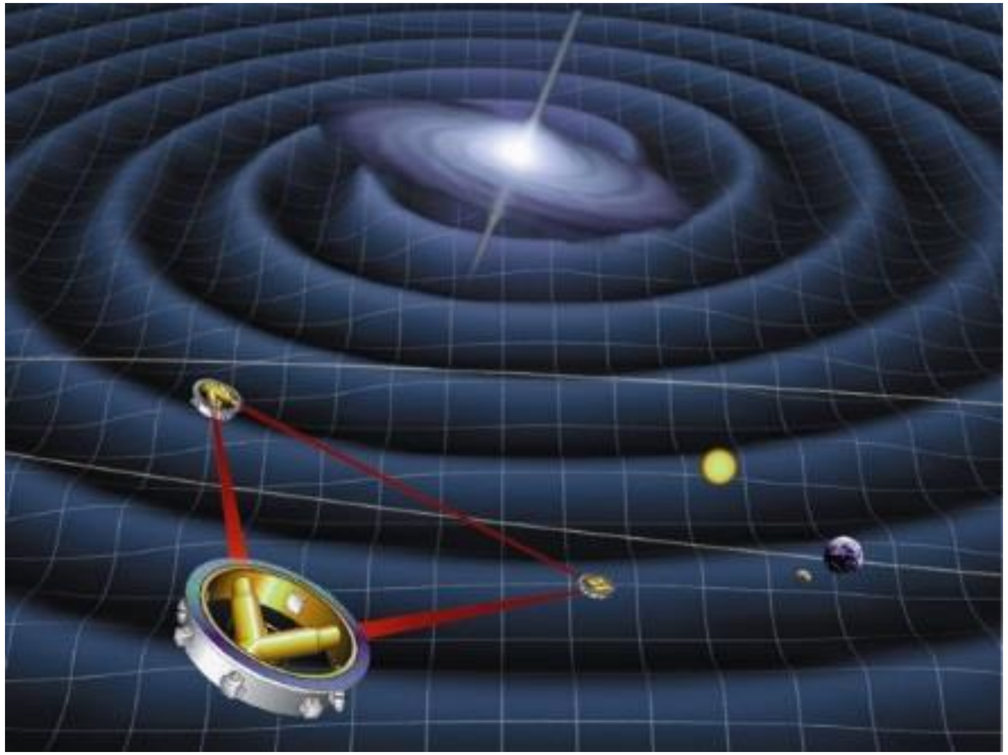
Laser Interferometer Space Antenna(LISA)

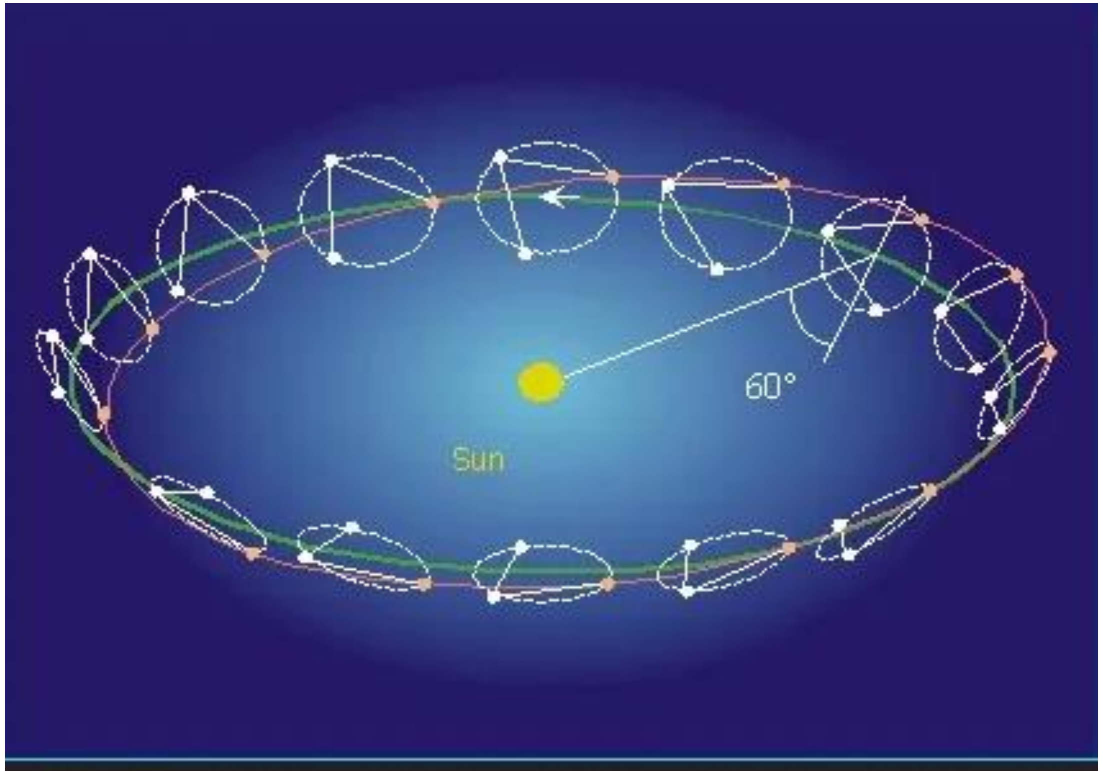
5Gm



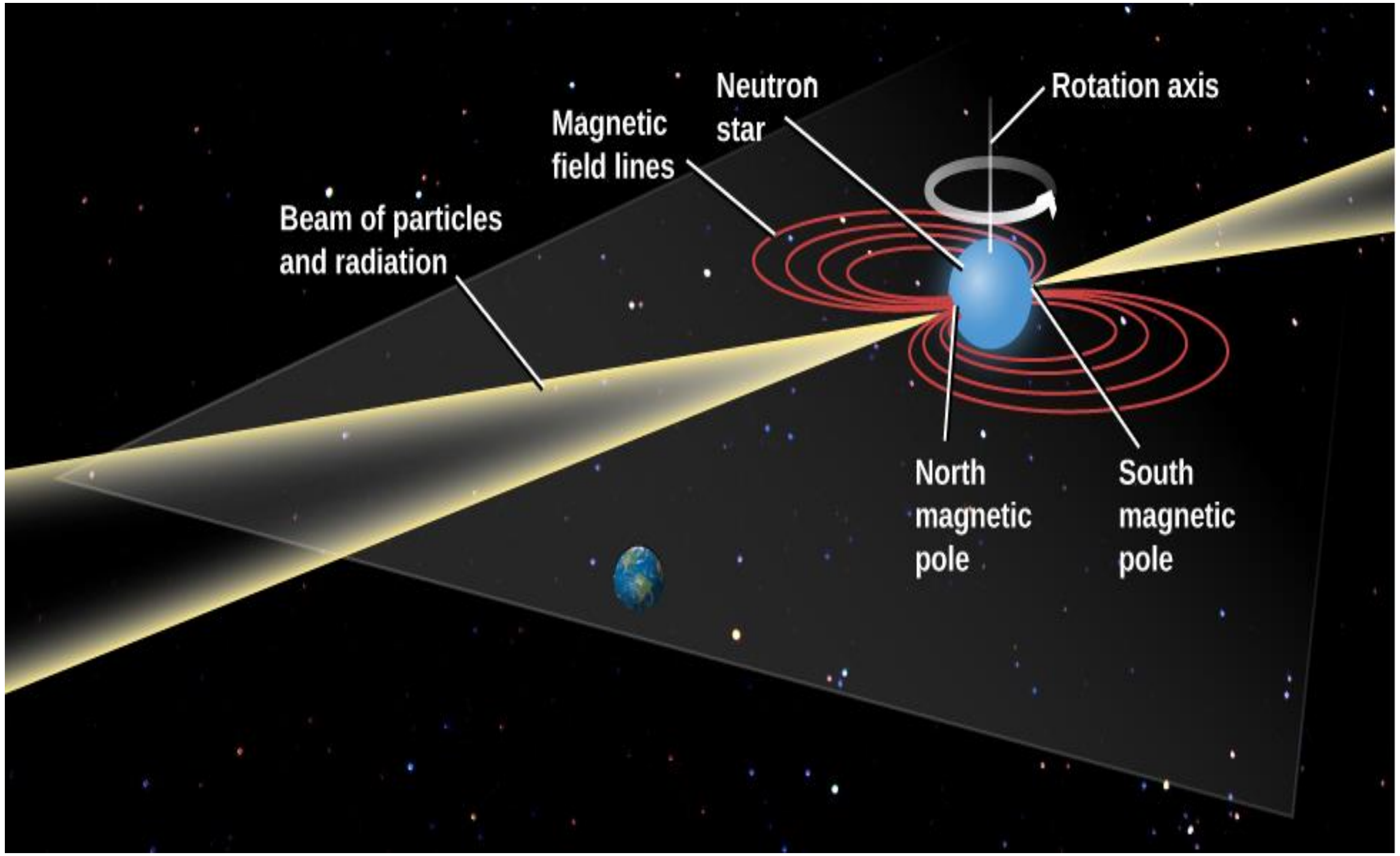
Deci-hertz Interferometer Gravitational wave Observatory (DECIGO)

Space based detectors





Pulsar timing arrays(PTA)



Pulsars are rotating neutron stars that act like cosmic lighthouses, appearing as periodic pulsating radio
sources. Because millisecond pulsars, pulsars with periods between roughly 1.4 and 30 ms, possess rotational
stabilities comparable with the best atomic clocks, they
are ideal timing sources.

variations arising from GW perturbations can be measured. Distortions in the spacetime around Earth or the pulsars will produce systematics
in timing residuals

One example

Detectors of PTAs

Today, there are three major PTAs: the Parkes PTA72
in Australia, the European PTA Consortium65 and the
NANOGrav73 consortium in North America.

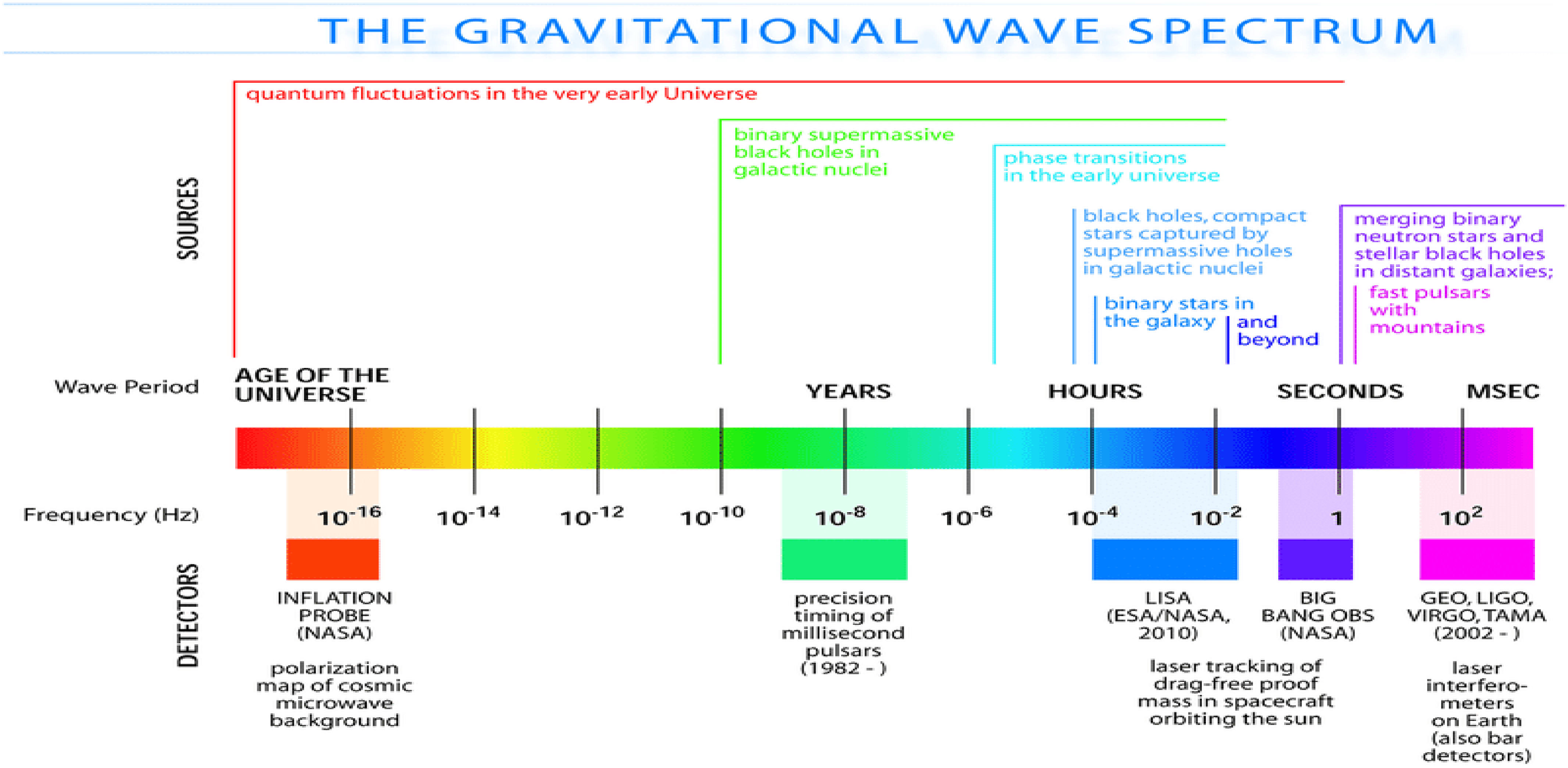
Cosmic microwave background polarization

Laser Interferometer Space Antenna(LISA)

Pulsing timing arrays(PTA)

Degree Angular Scale Interferometer (DASI)

GWs SPECTRUM



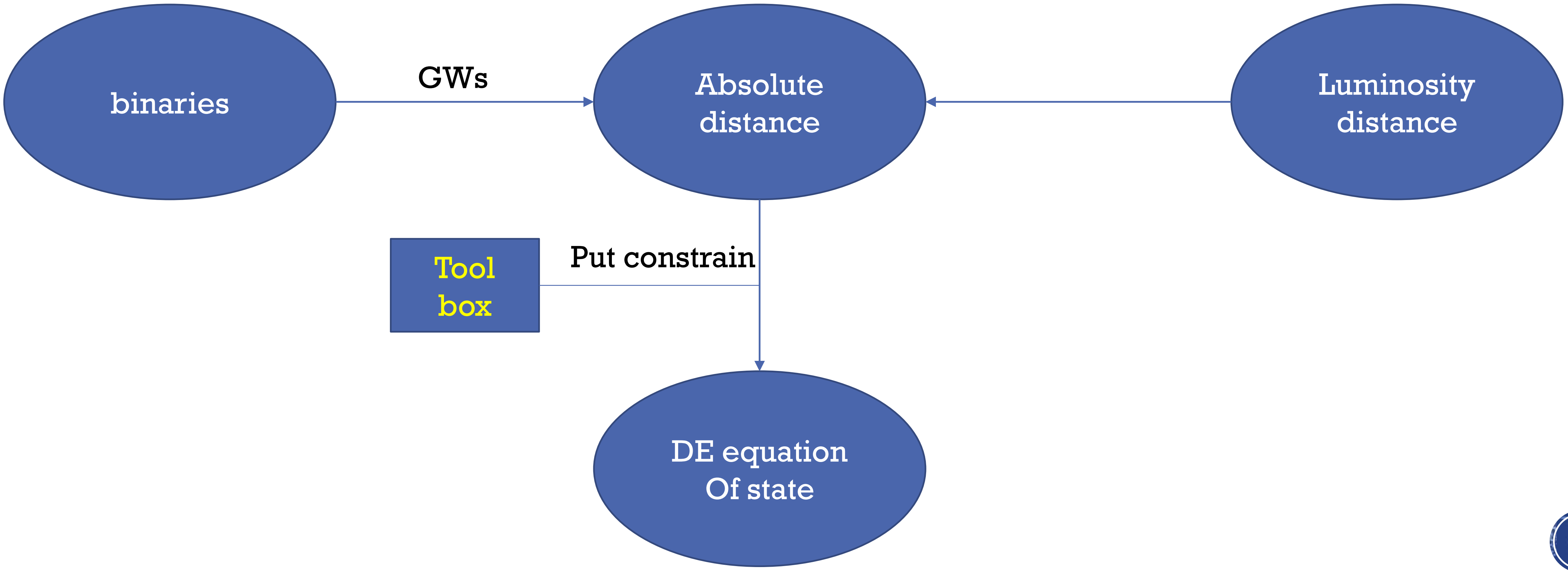
2

What is usage of GWs ?

We can use it to constrain cosmological parameters

- **Identifying EM counter part**
- **Getting redshift of producing source & dL**
- **Gravitational lensing**
- **Using mass distribution of binaries**

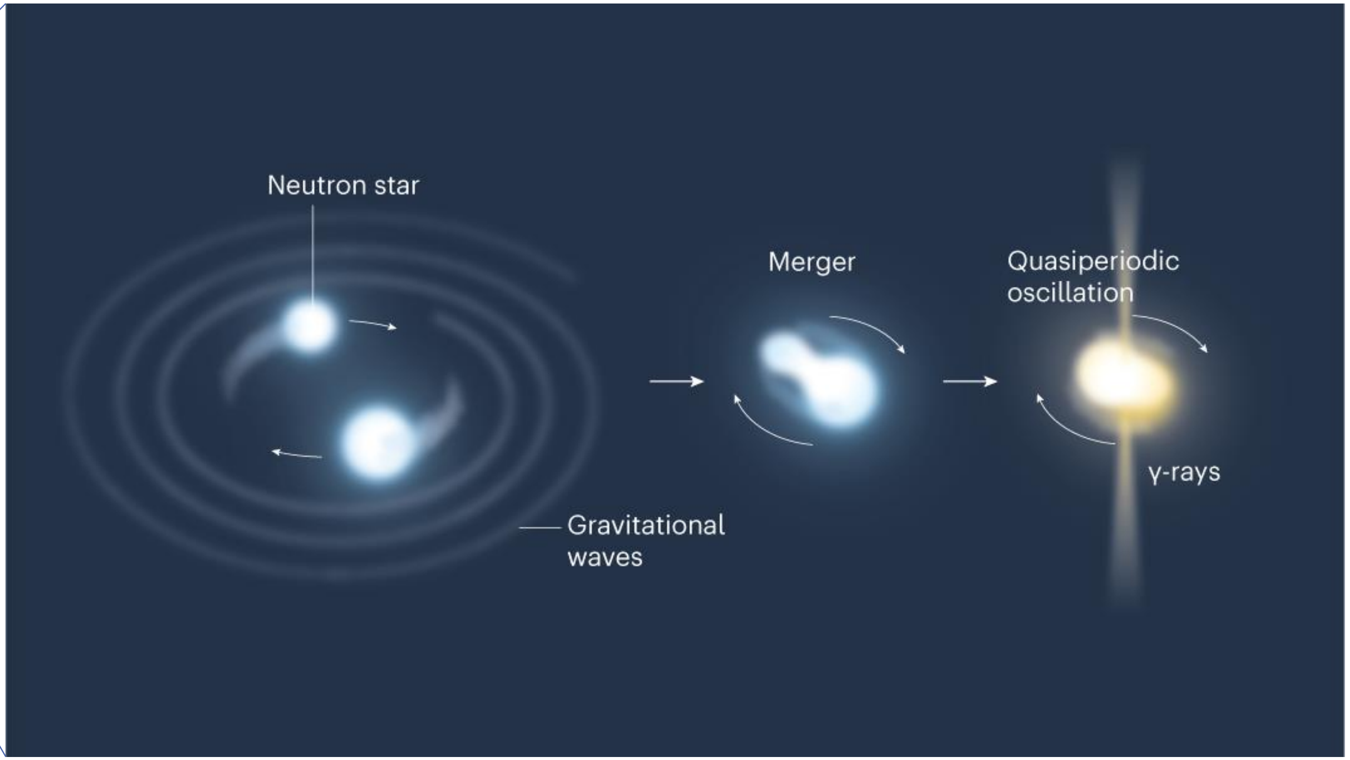
Getting redshift of producing source & dL



Luminosity distance → We need redshift !

- Galaxy catalog
- Neutron star mass distribution
- Tidal deformation of NS
- Binary merger of NS

Tool box



3

Simulating (coding)

likelihood

$$L(D|\Theta) \propto \exp(-\chi^2)$$

$$\chi^2 = \frac{1}{N}(X_{th} - X_{obs})^2$$

minimize

$$\frac{\partial \chi^2}{\partial \Theta} = 0$$

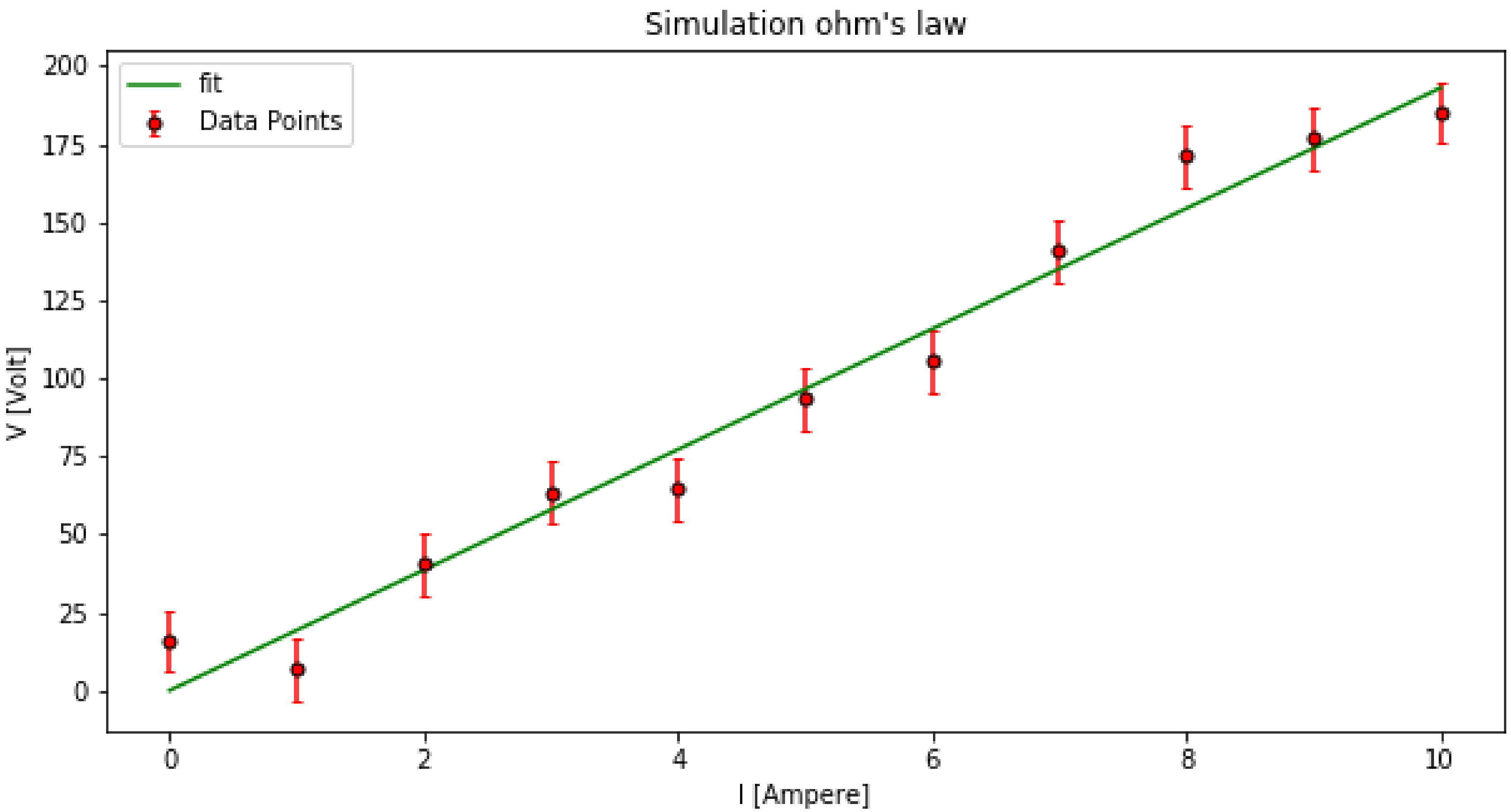
$$V = R * I$$

$$\chi^2 = \frac{1}{N}(RI_I - V_i)^2$$

posterior

$$\frac{L(D|\Theta)\ p(\Theta)}{\int L(D|\Theta)\ p(\Theta)}$$

What is it all about?!




سپاس از شما

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