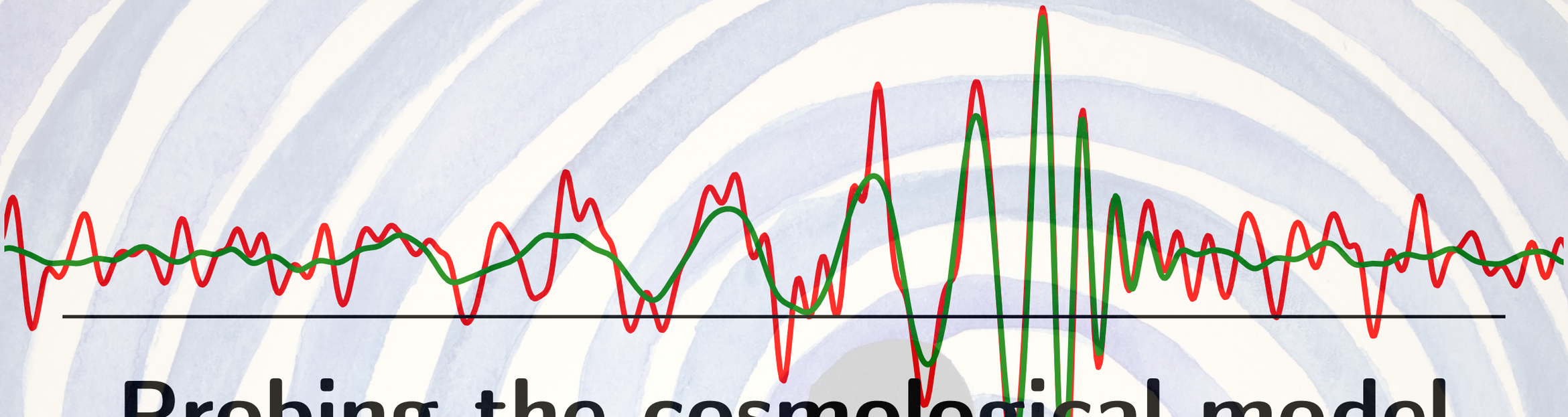


Probing the cosmological model with the population of BBHs

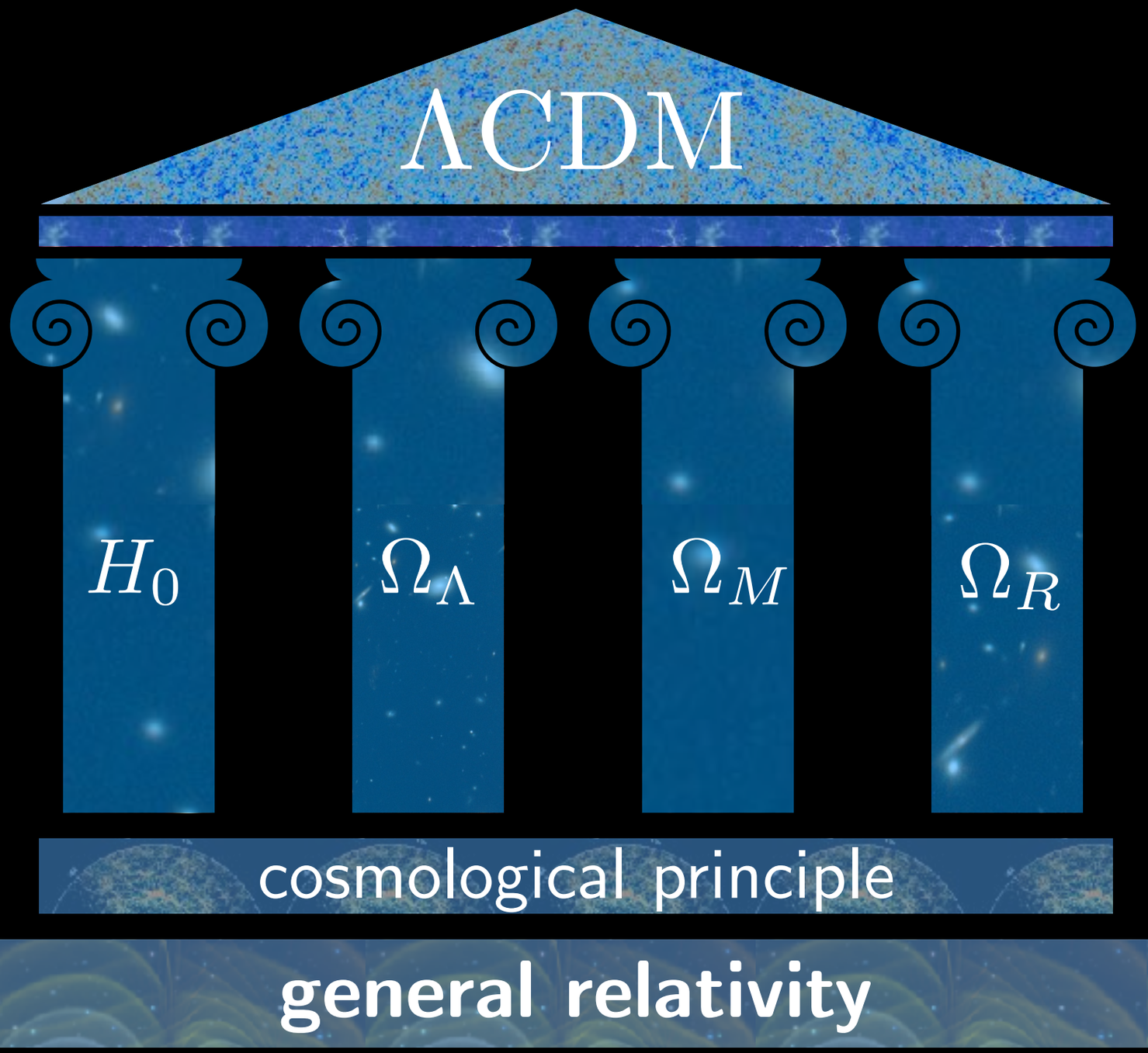
Jose María Ezquiaga

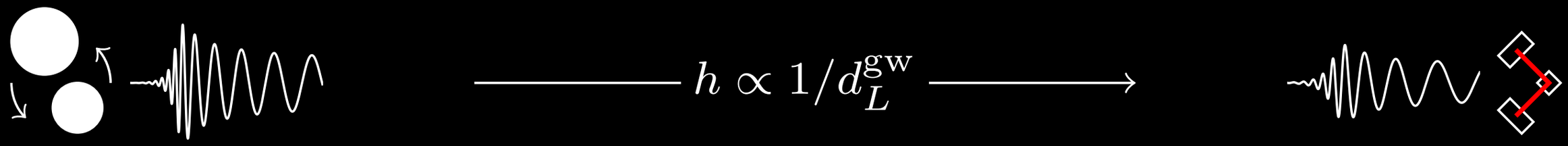
NASA Einstein fellow

ezquiaga@uchicago.edu

arXiv: 2104.05139

THE UNIVERSITY OF CHICAGO


ΛCDM
H_0
Ω_Λ
Ω_M
Ω_R
cosmological principle
general relativity



$$\{d_L^{\rm gw}, m_{1z}, m_{2z}\}$$

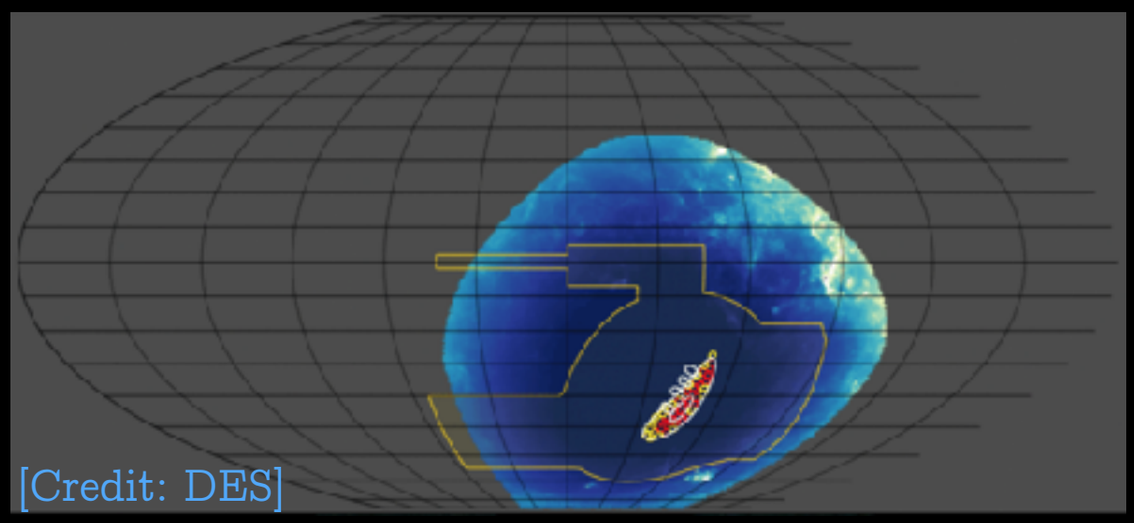
Bright sirens

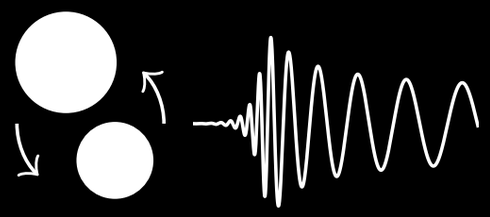
- Redshift from EM counterpart
- E.g. GW170817
- Need **neutron stars**!
- Bright counterpart at high-z?


[Credit: D. Berry]

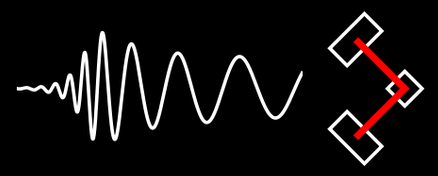
Dark sirens

- Statistically infer z from galaxies in localization volume
- E.g. GW170814
- Need good localization and **complete** galaxy catalogs!

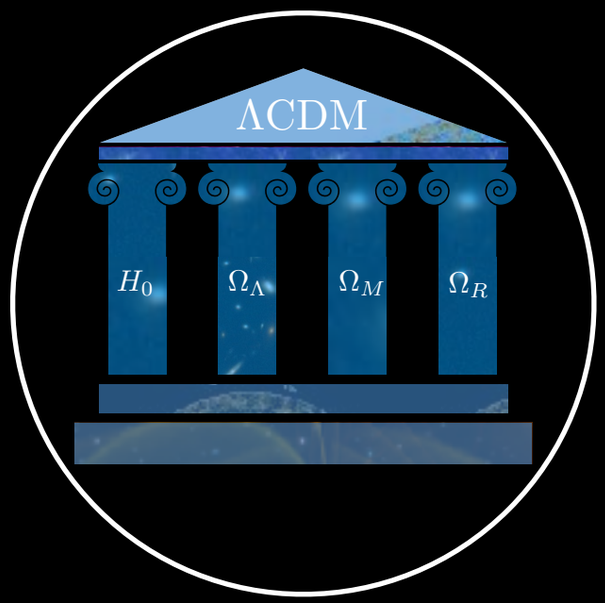

[Credit: DES]



$$h \propto 1/d_L^{\rm gw}$$

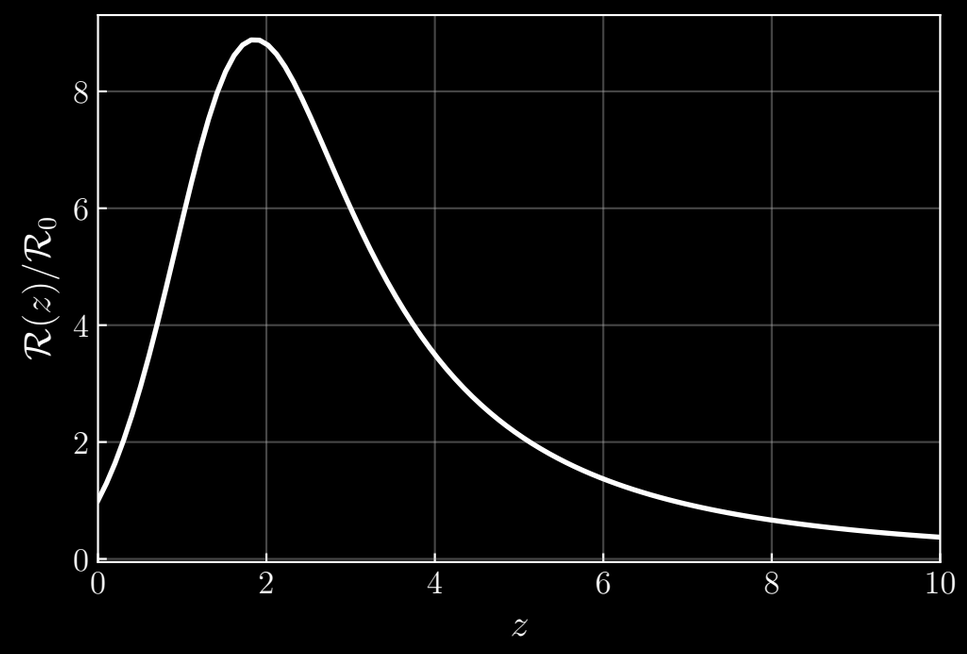


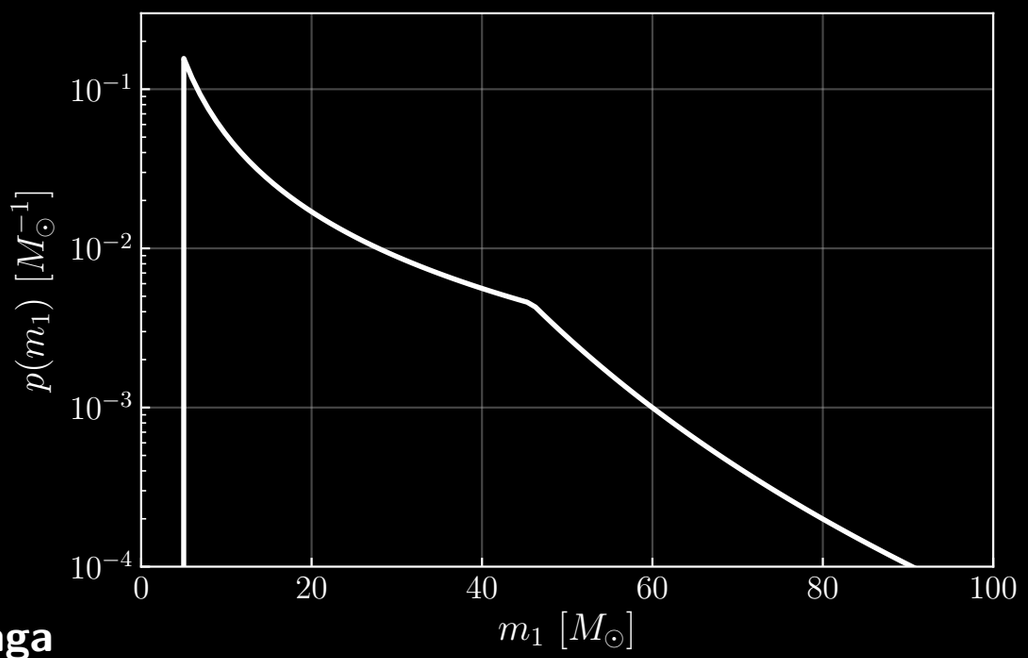
$$\{d_L^{\rm gw}, m_{1z}, m_{2z}\}$$

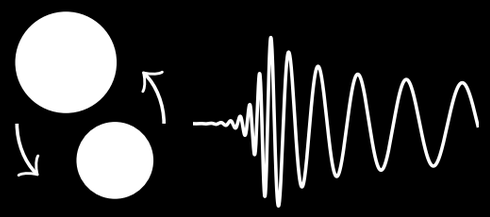


$$\{z, m_1, m_2\}$$

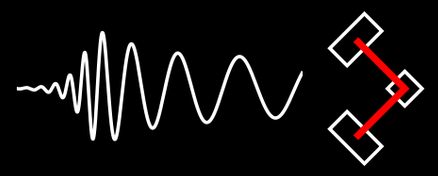
[see GWTC-2 astro pop]



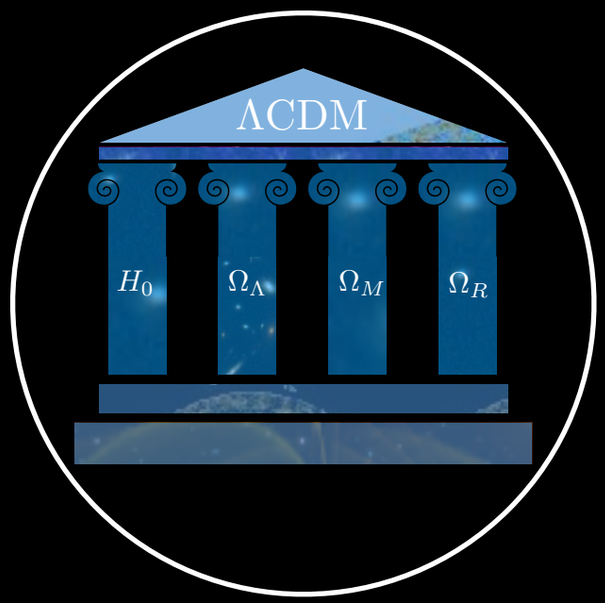




$$h \propto 1/d_L^{\rm gw}$$



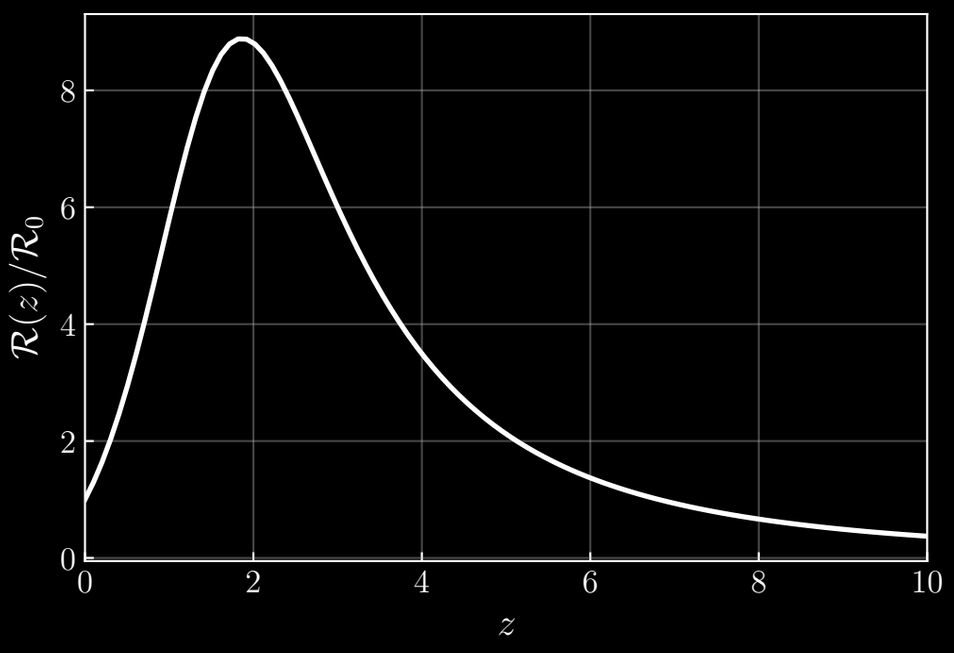
$$\{d_L^{\rm gw}, m_{1z}, m_{2z}\}$$

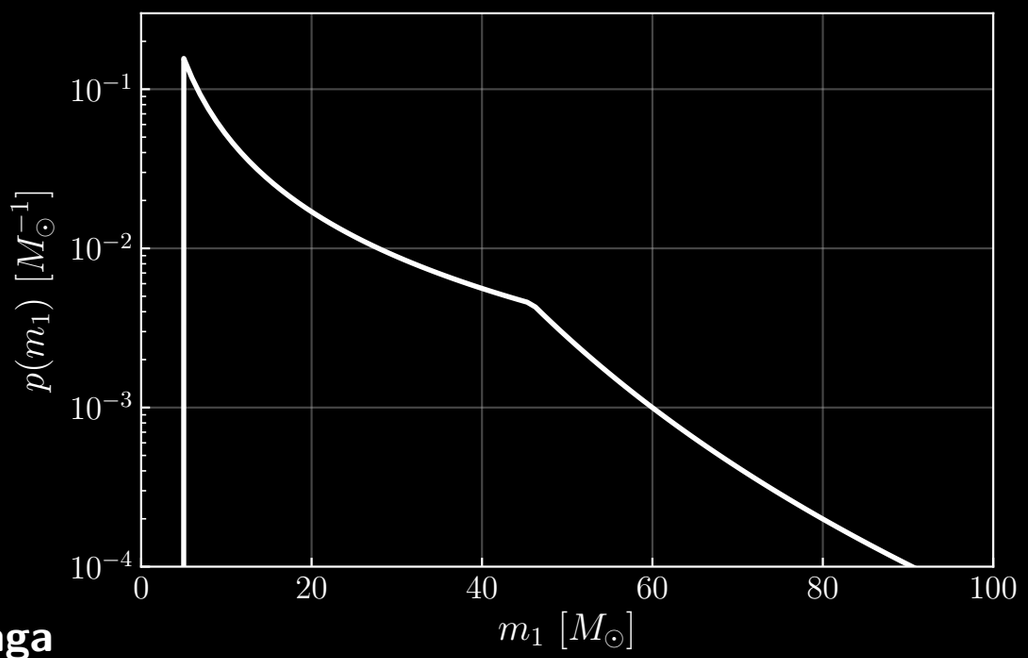


$$\{z, m_1, m_2\}$$

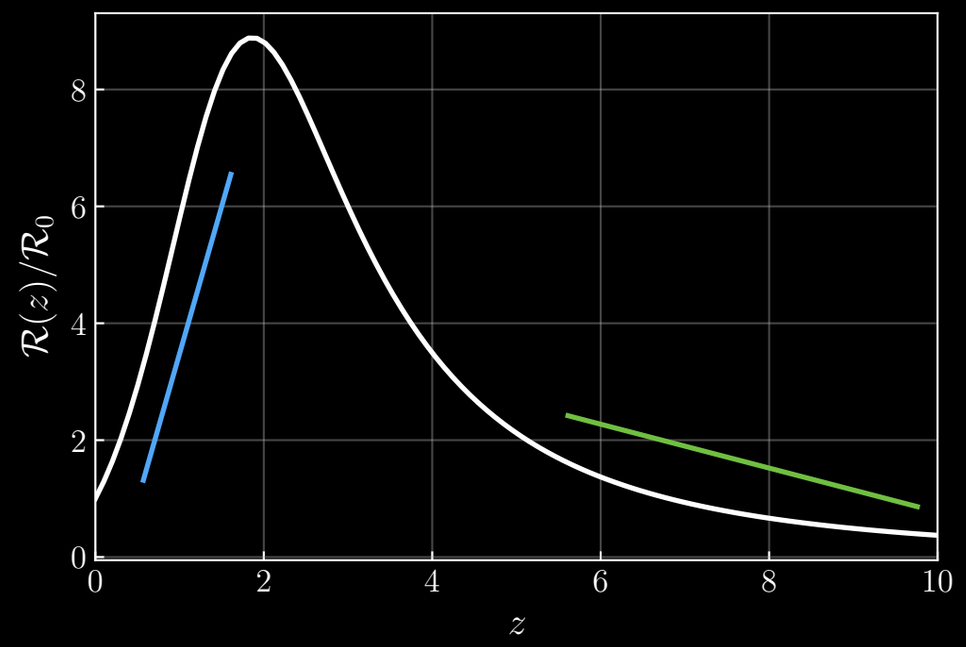
Test gravity!

[see GWTC-2 astro pop]





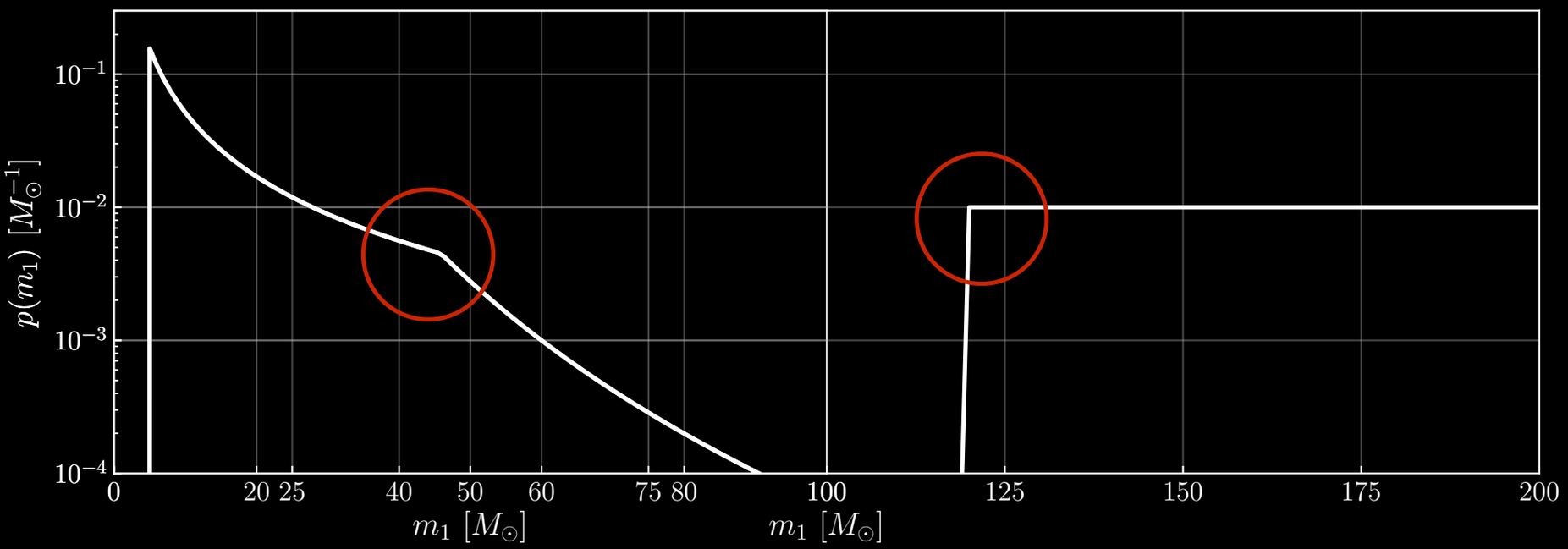
Astrophysical BBH population



$$\mathcal{R}(z) \propto \frac{(1+z)^{\alpha}}{1+\left(\frac{1+z}{1+z_p}\right)^{\alpha+\beta}}$$

[Callister+'20]

Pair Instability SuperNova (PISN)



[Fishbach+'19]

[Mastrogiovanni+'21]

[Ezquiaga&Holz'20]

Modified GW propagation

$$\frac{d_L^{\rm gw}}{d_L^{\rm em}} = \exp\left[\frac{1}{2}\int_0^z \frac{\nu}{1+z'}\mathrm{d}z'\right]$$

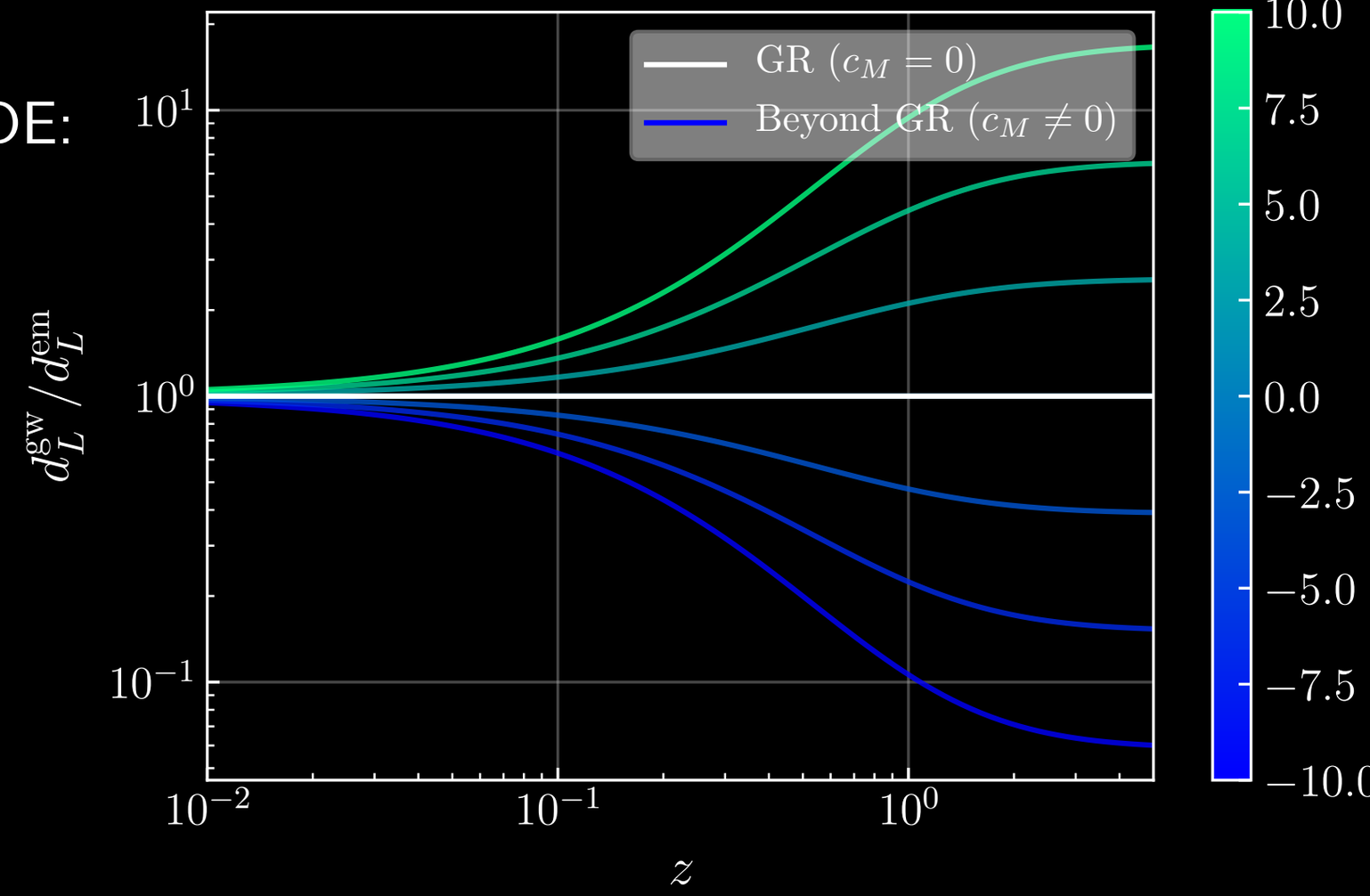
- Parametrizing friction with DE:

$$\nu(z) = c_M \frac{\Omega_{DE}(z)}{\Omega_{DE}(0)}$$

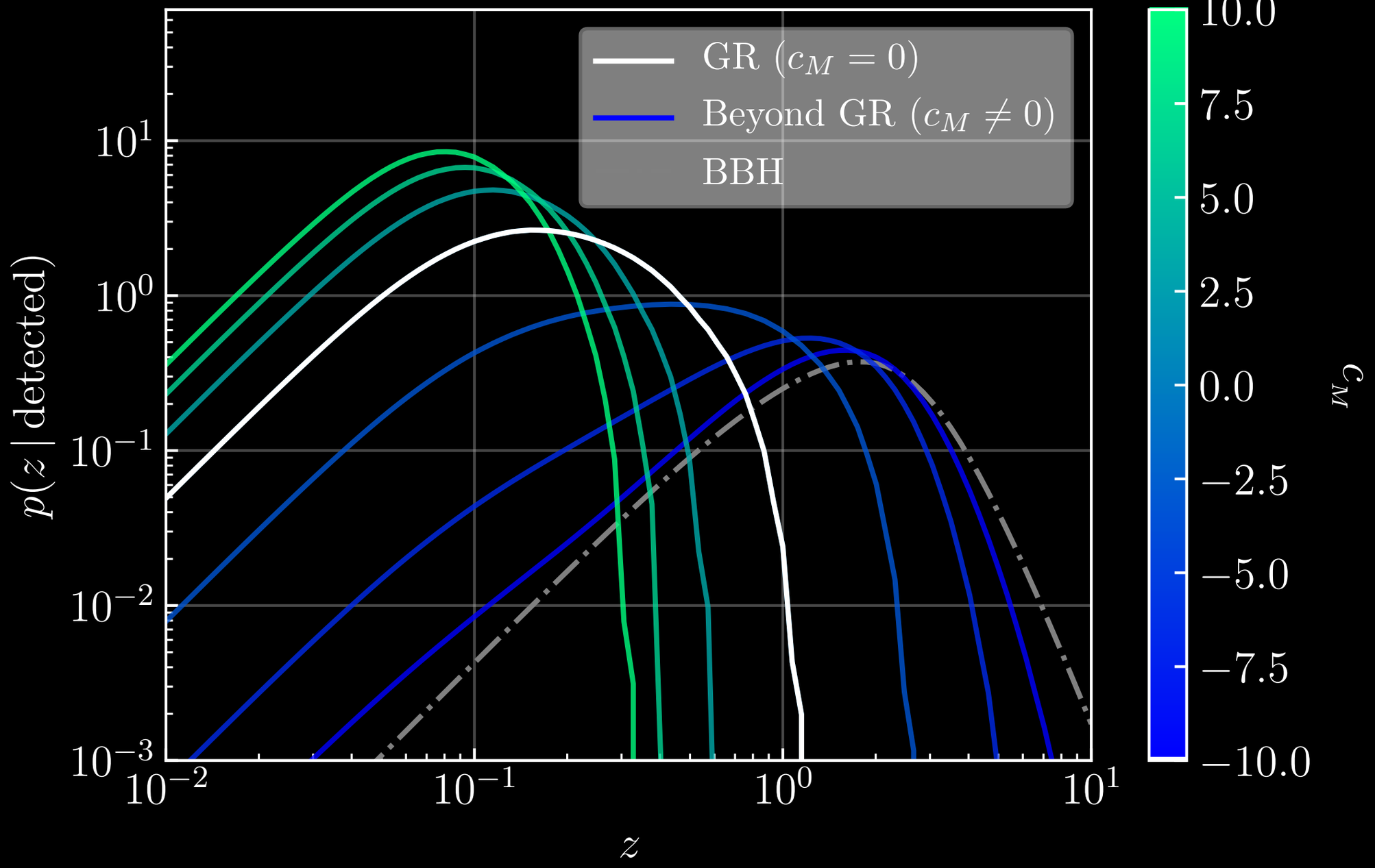
- Bounded by GW170817

$$c_M = -9^{+21}_{-28}$$

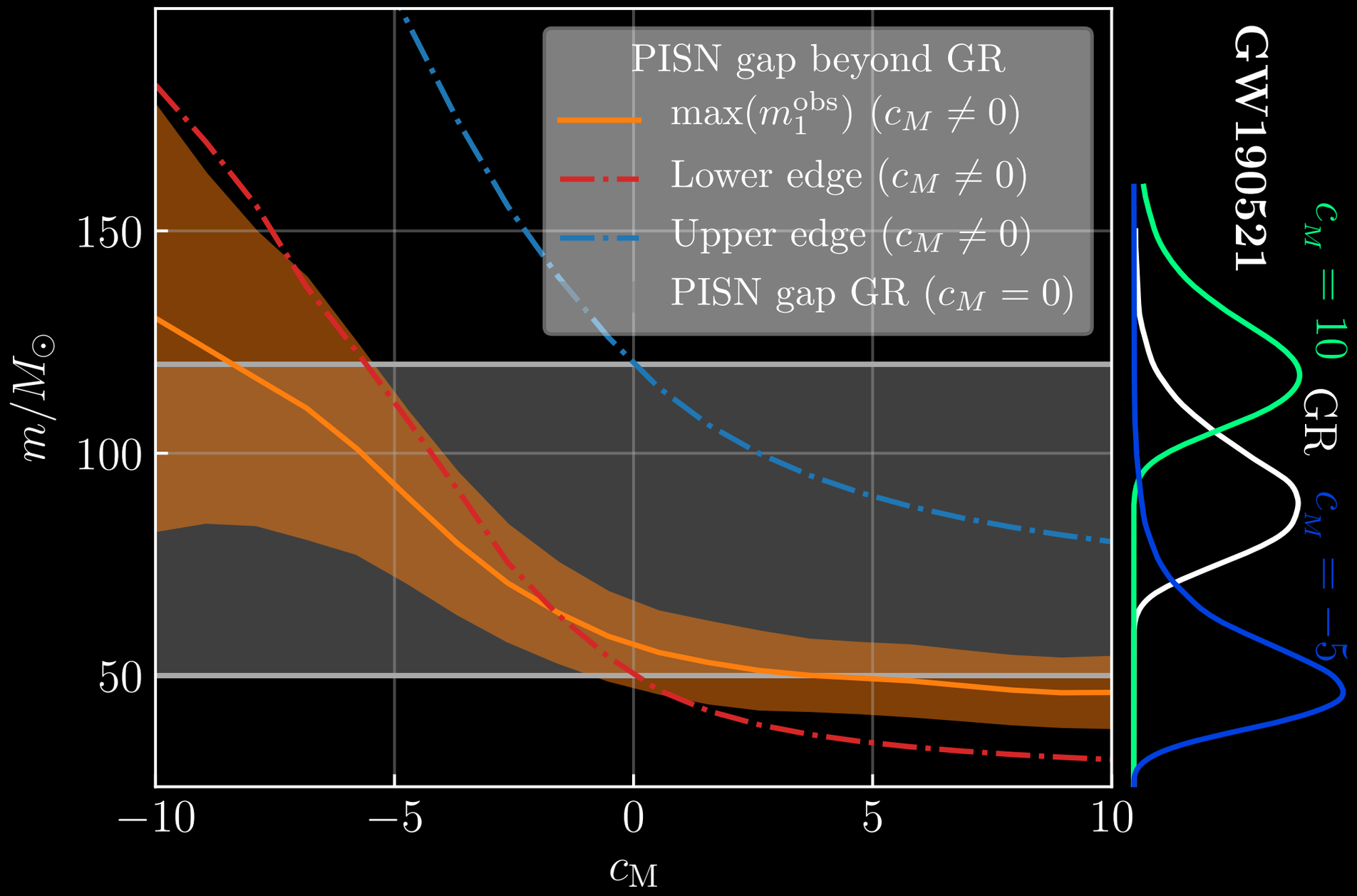
[Lagos+'19]



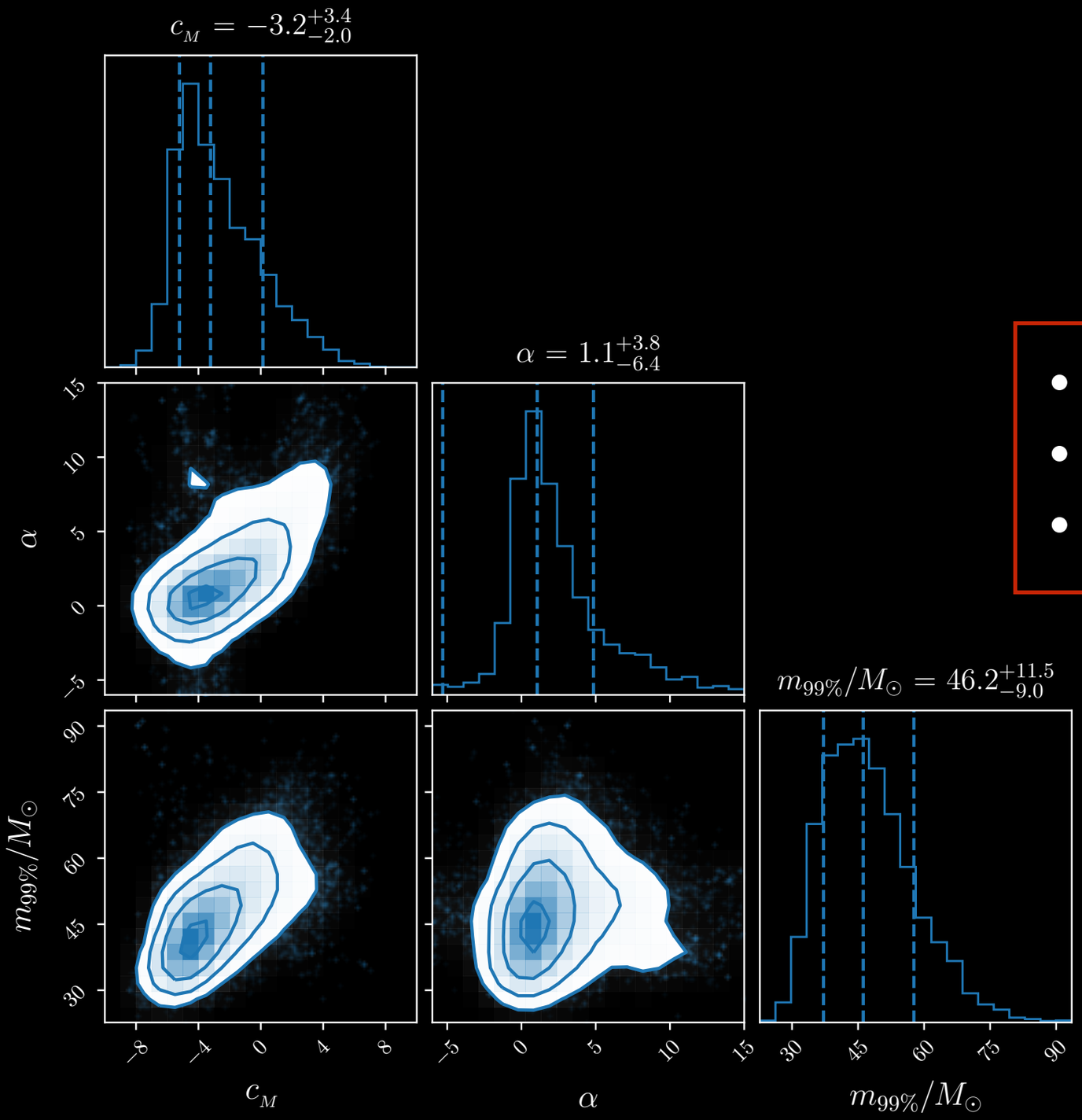
How far can we hear BBHs?



How is the PISN gap affected?



Results from GWTC-2



$$c_M = -3.2^{+3.4}_{-2.0}$$

- More constraining than GW170817
- Shifts $m_{99\%}$ to lower values
- GW data only!

Conclusions

Hearing gravity from the cosmos:
GWTC-2 probes general relativity at cosmological scales

(arXiv 2104.05139)

- Binary black hole mergers alone can probe gravity at cosmological scales
- Hierarchical Bayesian analysis of **GWTC-2** leads to **stronger** constraints than GW170817. Results consistent with GR.
- This is a guaranteed test for any present or future GW catalog!