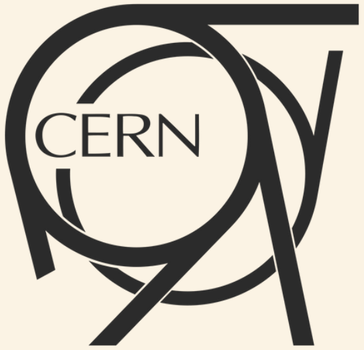


SEARCH FOR SCALAR INDUCED GRAVITATIONAL WAVES IN PTAS

V.DANDOY, V.DOMCKE, F.ROMPINEVE

Based on: 2302.07901

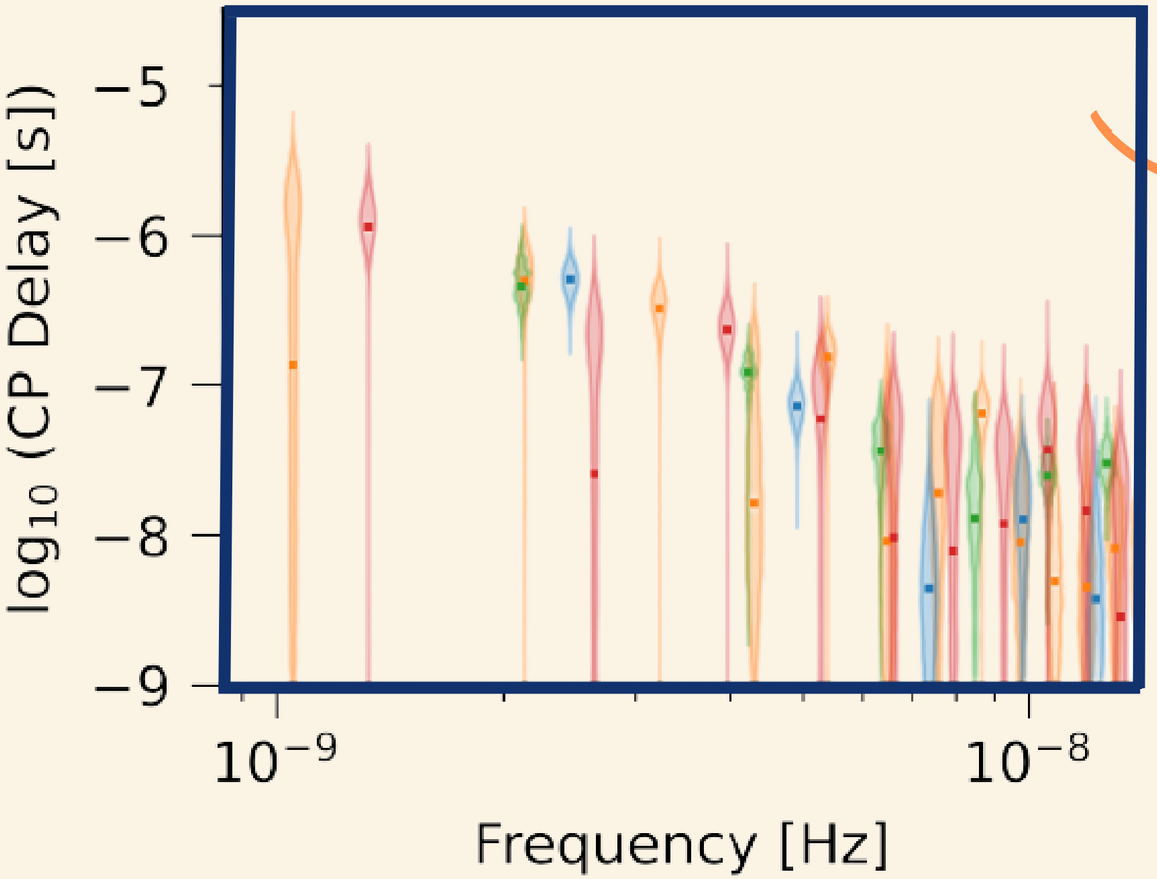
Goettigen 2023
Invisible Workshop

28th August 2023

MOTIVATION

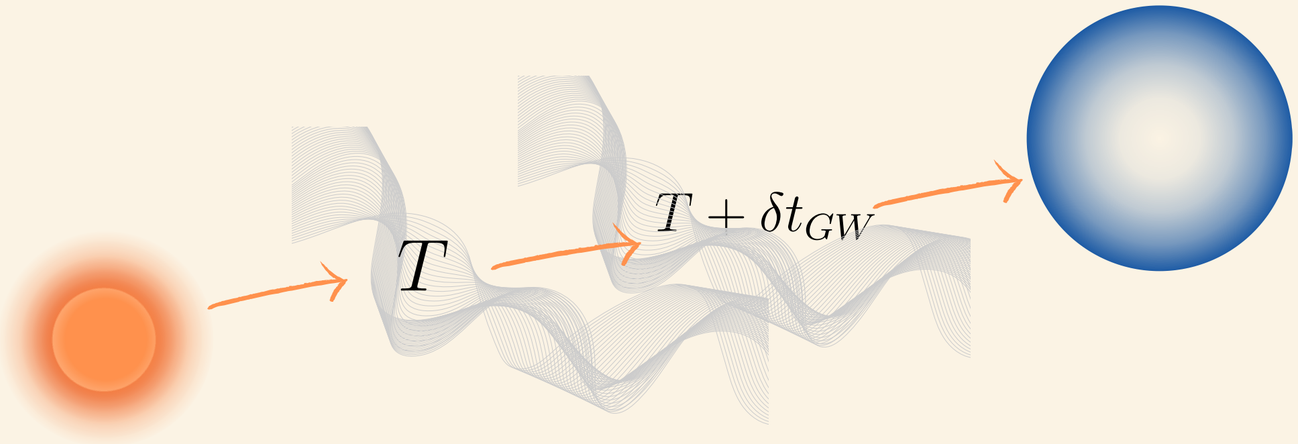
POTENTIAL GW SIGNAL IN PTA

Delays observed in PTAs



Potential signal from a nHZ frequency GW background observed in all PTAs

[2201.03980]

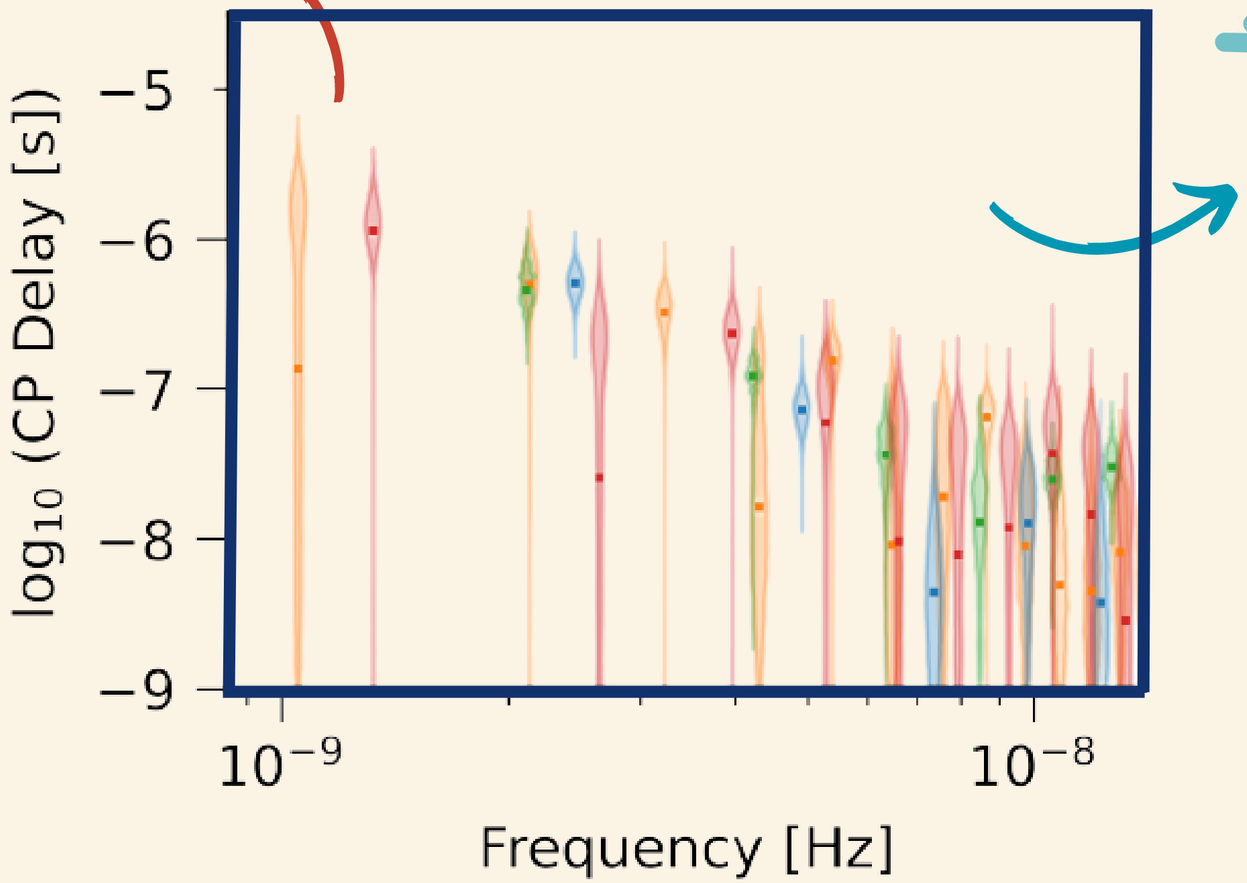


ORIGIN OF THE SIGNAL

Astrophysical source:

- Super massive black holes

Delays observed in PTAs



Cosmological sources:

- Phase transition
- Inflation
- cosmic strings
- Scalar induced GWs

ORIGIN OF THE SIGNAL

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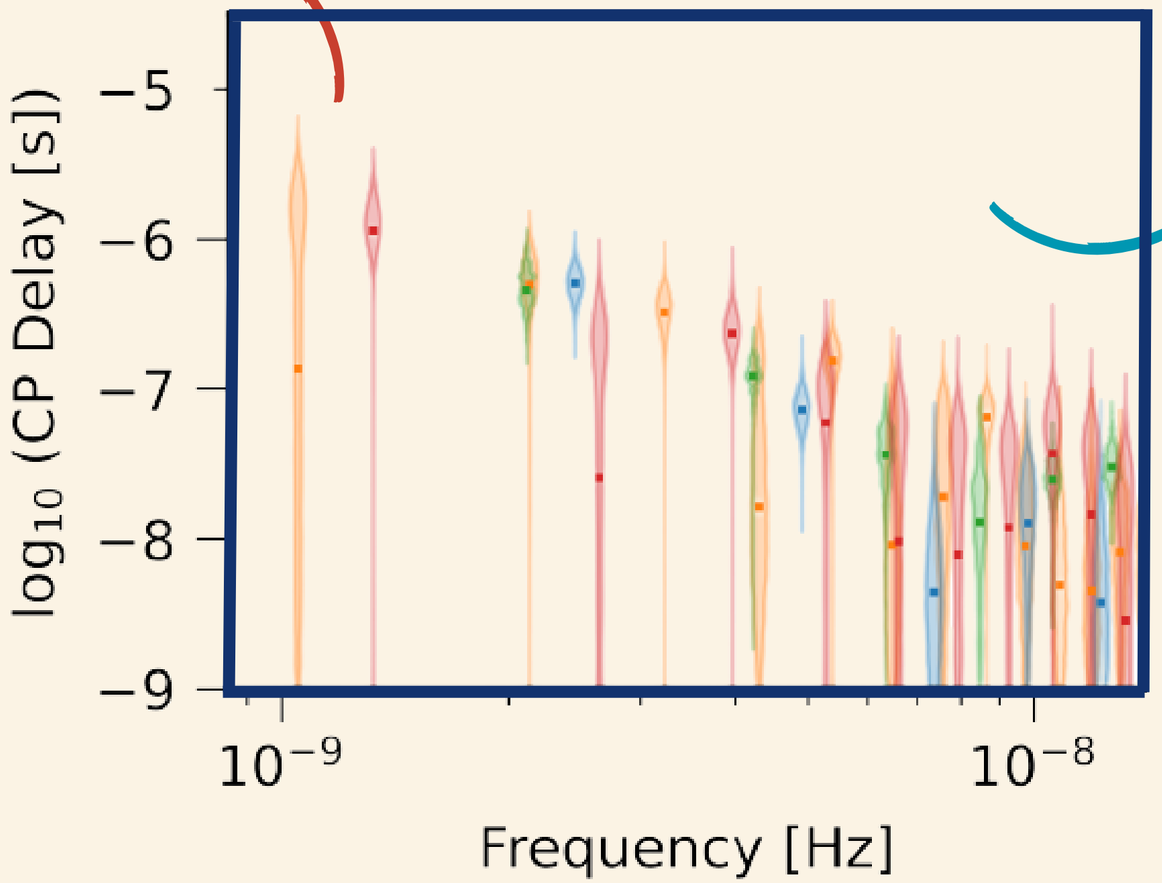

Cosmological sources:

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WHAT ARE THE SIGWS?

SCALAR INDUCED GWS

- Primordial metric perturbations are decomposed into scalar and tensor perturbations

$$ds^2 = a^2(\eta)\left[-(1+2\Psi)d\eta^2 + ((1+2\Phi)\delta_{ij} + h_{ij})\,dx^i dx^j\right]$$

Scalar perturbations

Negligible at linear order

→ No GWs produced at linear order in perturbation theory/for small perturbations

SCALAR INDUCED GWS

- Metric perturbations are decomposed into scalar and tensor perturbations

$$ds^2 = a^2(\eta)\left[-(1+2\Psi)d\eta^2 + ((1+2\Phi)\delta_{ij} + h_{ij})\,dx^i dx^j\right]$$

Sourced by the scalar perturbations at non-linear order

Negligible at linear order

→ Gravitational waves produced if large primordial perturbations!

CAN THE SIGWS EXPLAIN THE PTA SIGNAL ?

SCALAR INDUCED GWS

- CMB constrains the amplitude of the scalar perturbations at large scales

$P_\zeta \approx \mathcal{O}(10^{-9})$ at scales $k \approx \mathcal{O}(1\mathrm{Mpc}^{-1})$ [1807.06211]

Too small to induce any detectable GWs...

Almost no constraints on the perturbation amplitude at small scales !

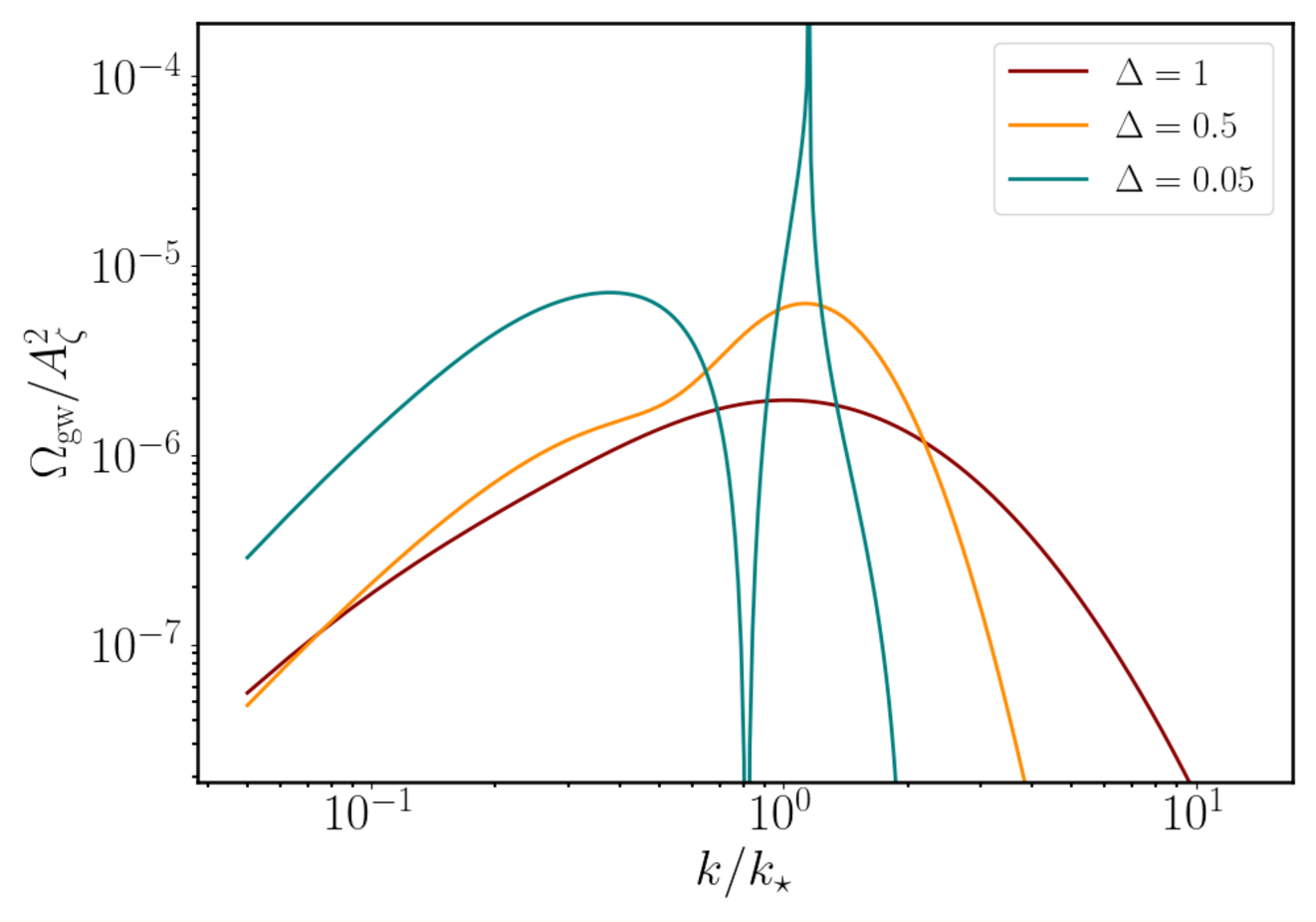
SCALAR INDUCED GWS

- CMB constrains the amplitude of the scalar perturbations at large scales

$P_\zeta \approx \mathcal{O}(10^{-9})$ at scales $k \approx \mathcal{O}(1\mathrm{Mpc}^{-1})$

- Parametrize the power spectrum at small scales with a log-normal shape

$$P_\zeta(k) = \frac{A_\zeta}{\sqrt{2\pi}\Delta}\mathrm{Exp}\left(-\frac{\log^2(k/k_*)}{2\Delta^2}\right)$$



BAYESIAN SEARCH IN PTA DATA

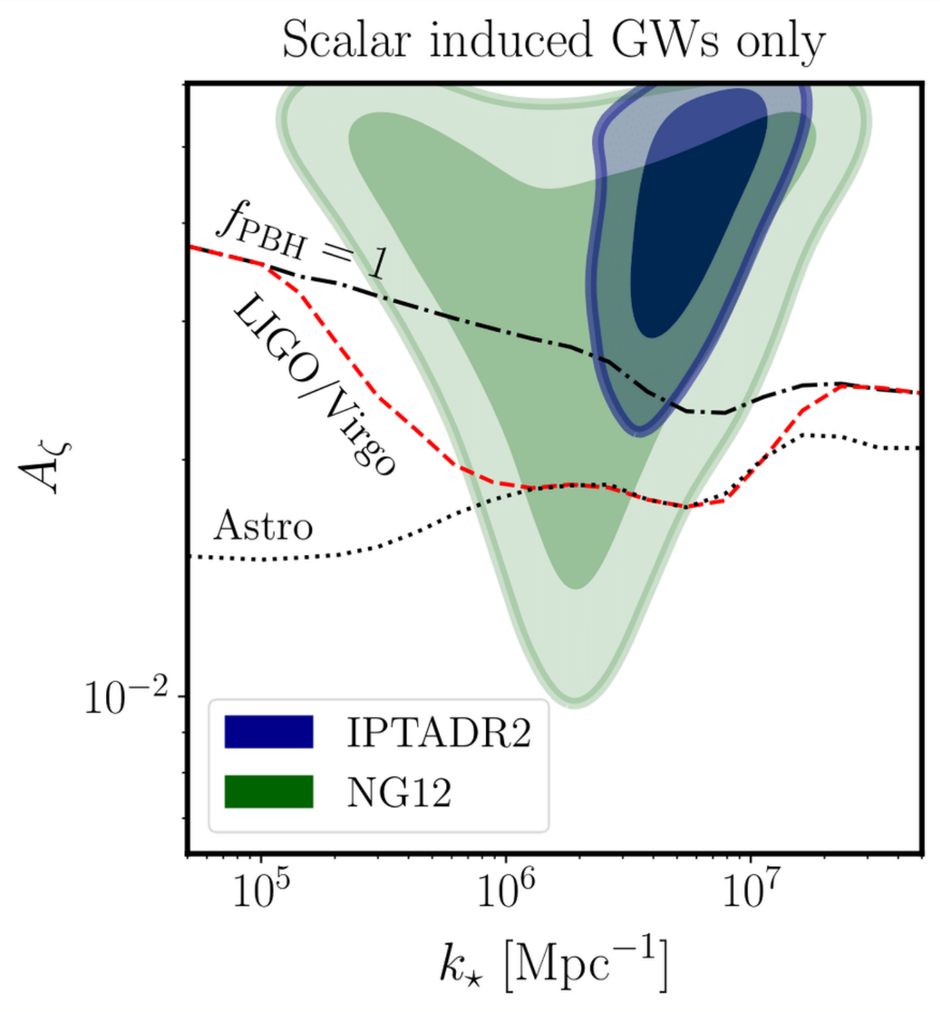
- Parametrize the power spectrum at small scales with a log-normal function

$$P_\zeta(k) = \frac{A_\zeta}{\sqrt{2\pi}\Delta}\mathrm{Exp}\left(-\frac{\log^2(k/k_*)}{2\Delta^2}\right)$$

- Use IPTA and NANOGrav data to find what parameter space fits the signal

$$A_\zeta \sim 10^{-2}$$

$$k_\star \sim 10^6\,\mathrm{Mpc}^{-1}$$



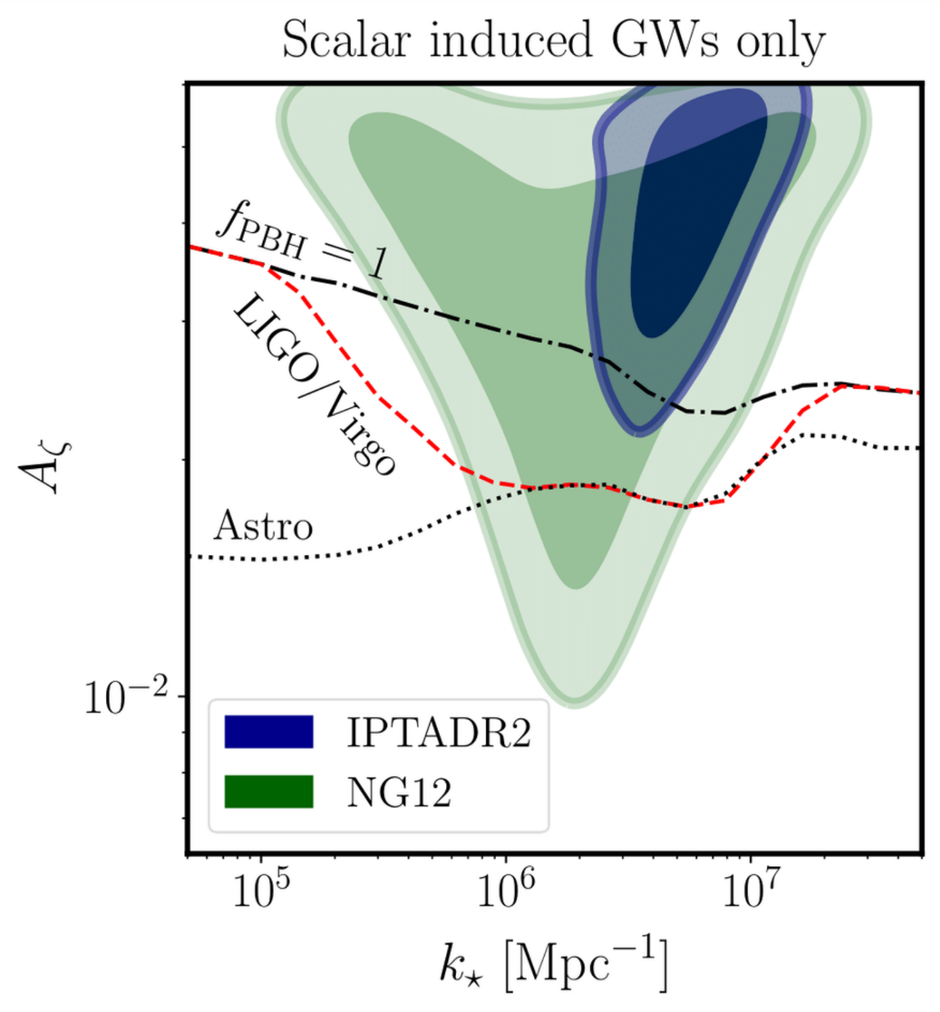
BAYESIAN SEARCH IN PTA DATA

$$A_\zeta \sim 10^{-2}$$

That large amplitudes of fluctuations also produce primordial black holes...

- The PBH abundance is a function of the parameters $(A_\zeta, k_\star, \Delta)$

The parameter space that can explain the signal is also in conflict with PBH overproduction constraints



THANK YOU!