PARAMETER ESTIMATION FOR INFLATIONARY GRAVITATIONAL WAVE STOCHASTIC BACKGROUNDS

MATTEO BRAGLIA,

10TH LISA COSWG MEETING 06/06/2023

BASED ON PROJECT 15 OF THE COSWG

NYU

TEMPLATE PARAMETER ESTIMATION

Derive analytical templates $h^2\,\Omega^i_{\mathrm{GW}}(f,\vec{\theta}^i)$

TEMPLATE PARAMETER ESTIMATION

Derive analytical templates $h^2\,\Omega^i_{\rm GW}(f,\vec{\theta}^i)$

For each template forecast constraints on the parameters $\vec{\theta}^i$

TEMPLATE PARAMETER ESTIMATION

Derive analytical templates $h^2\,\Omega^i_{\mathrm{GW}}(f, \vec{\theta}^i)$

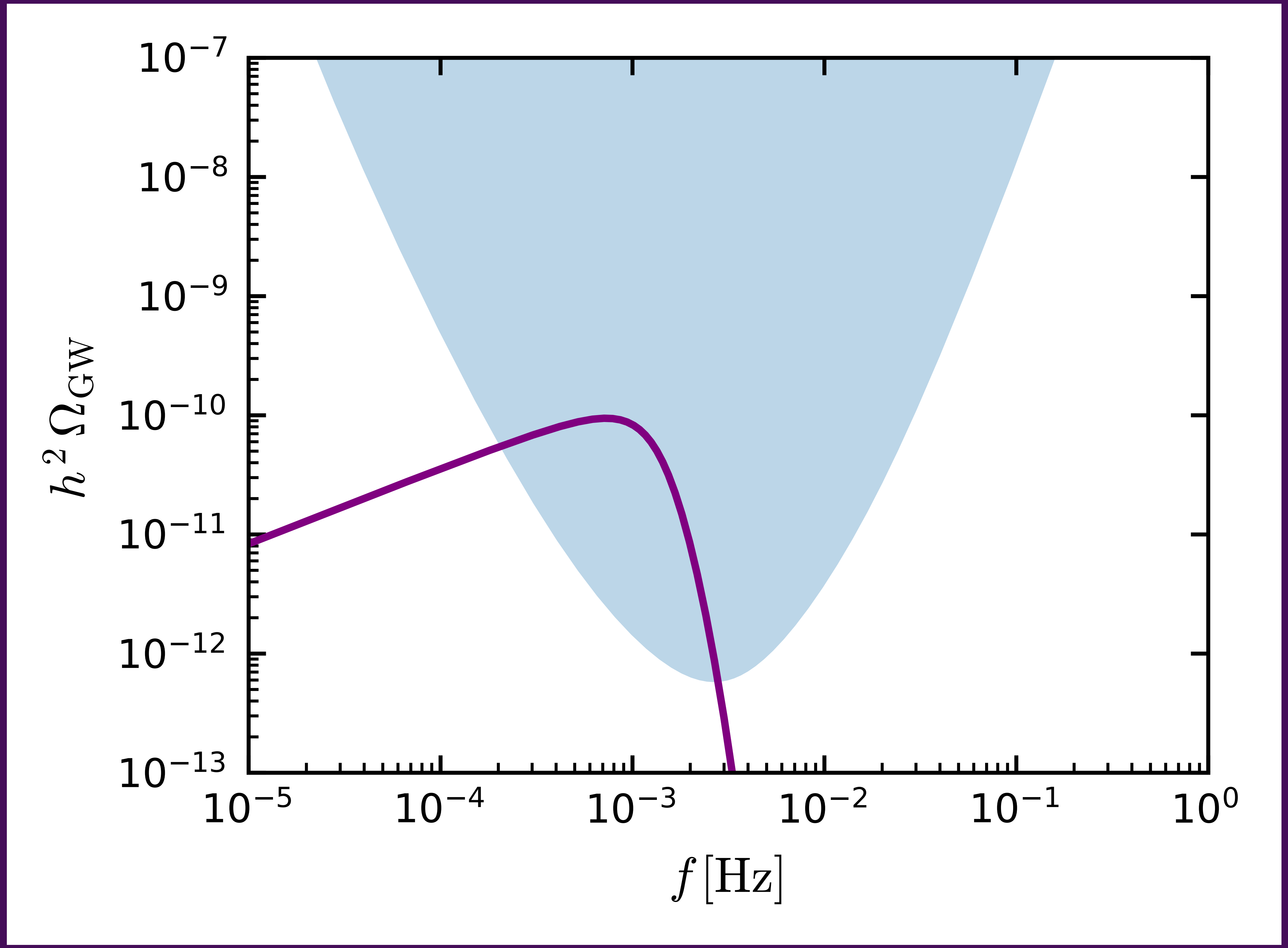
For each template forecast constraints on the parameters $\vec{\theta}^i$

Perform a model selection analysis to identify the 'best' Ω^i_{GW}

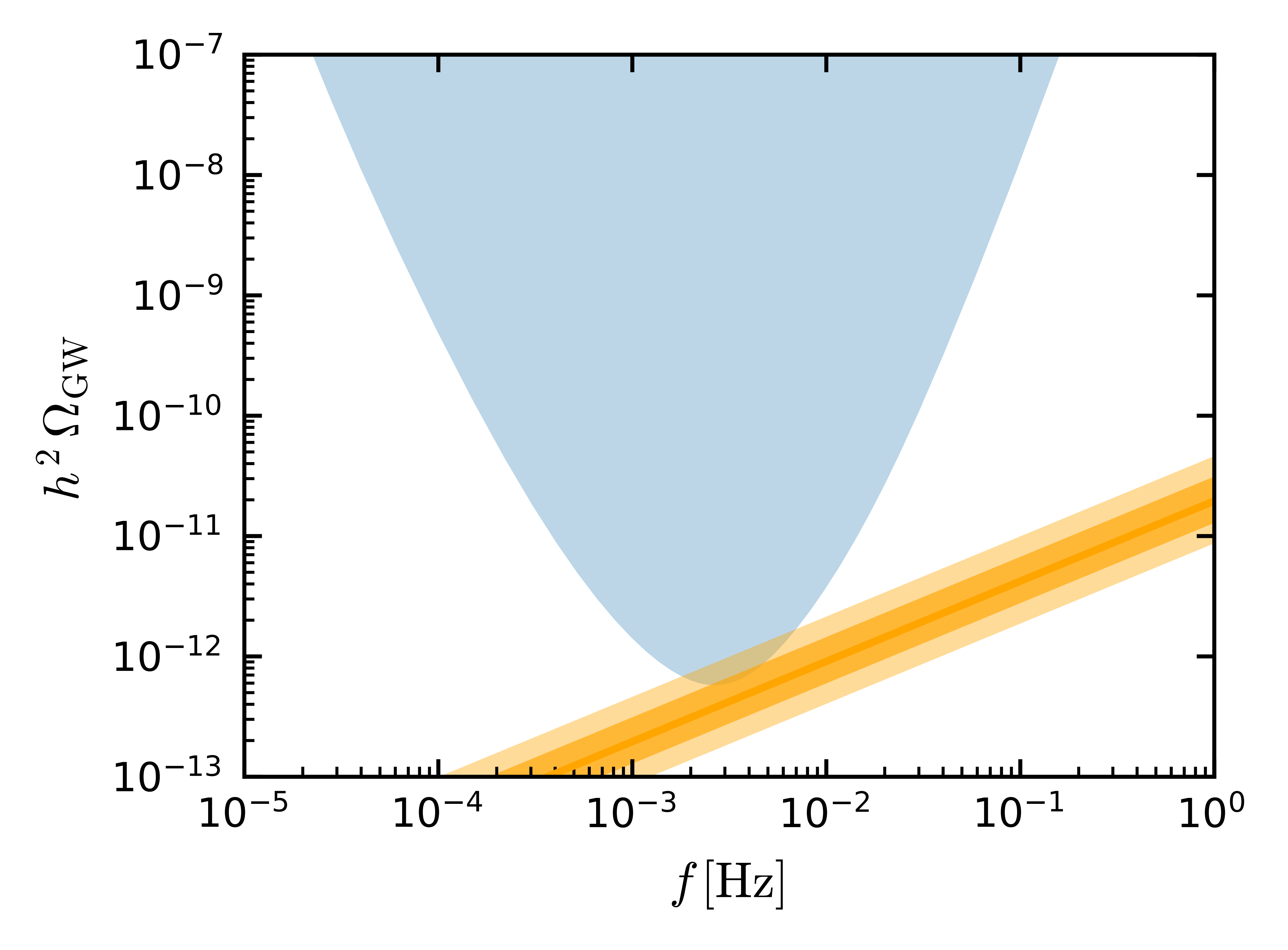
FOREGROUNDS

$$h^2\,\Omega_{\rm gal} = \bar{\Omega}_{\rm gal} \times g(f)$$

$$h^2\,\Omega_{\rm ext} = \bar{\Omega}_{\rm ext}\left(\frac{f}{f_*}\right)^{2/3}$$



Flauger et al. 2009.11845

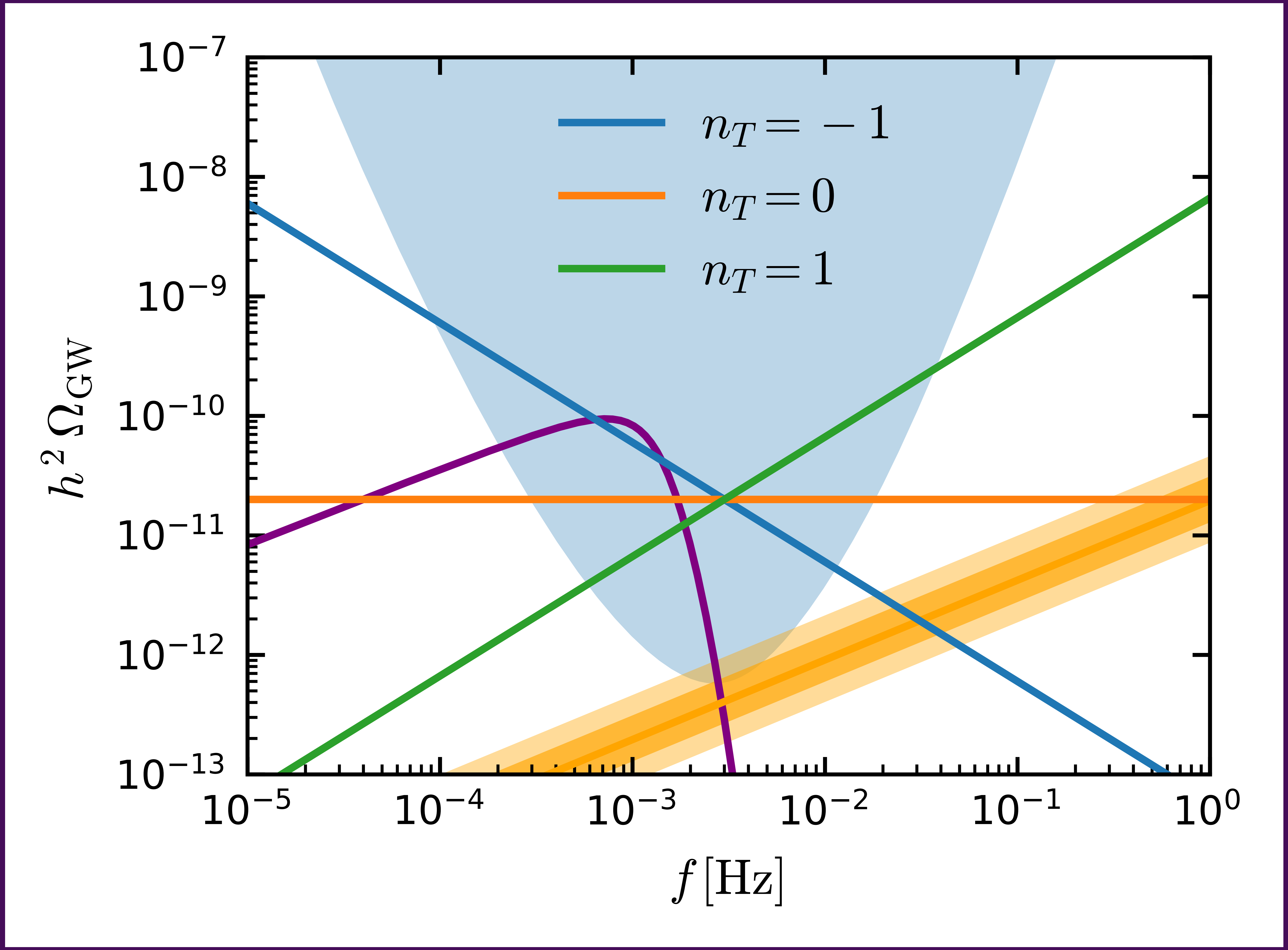


LVK O3

POWER LAW

$$h^2\,\Omega_{\rm GW} = \bar{\Omega}_{\rm GW}\left(\frac{f}{f_*}\right)^{n_T}$$

2 parameters



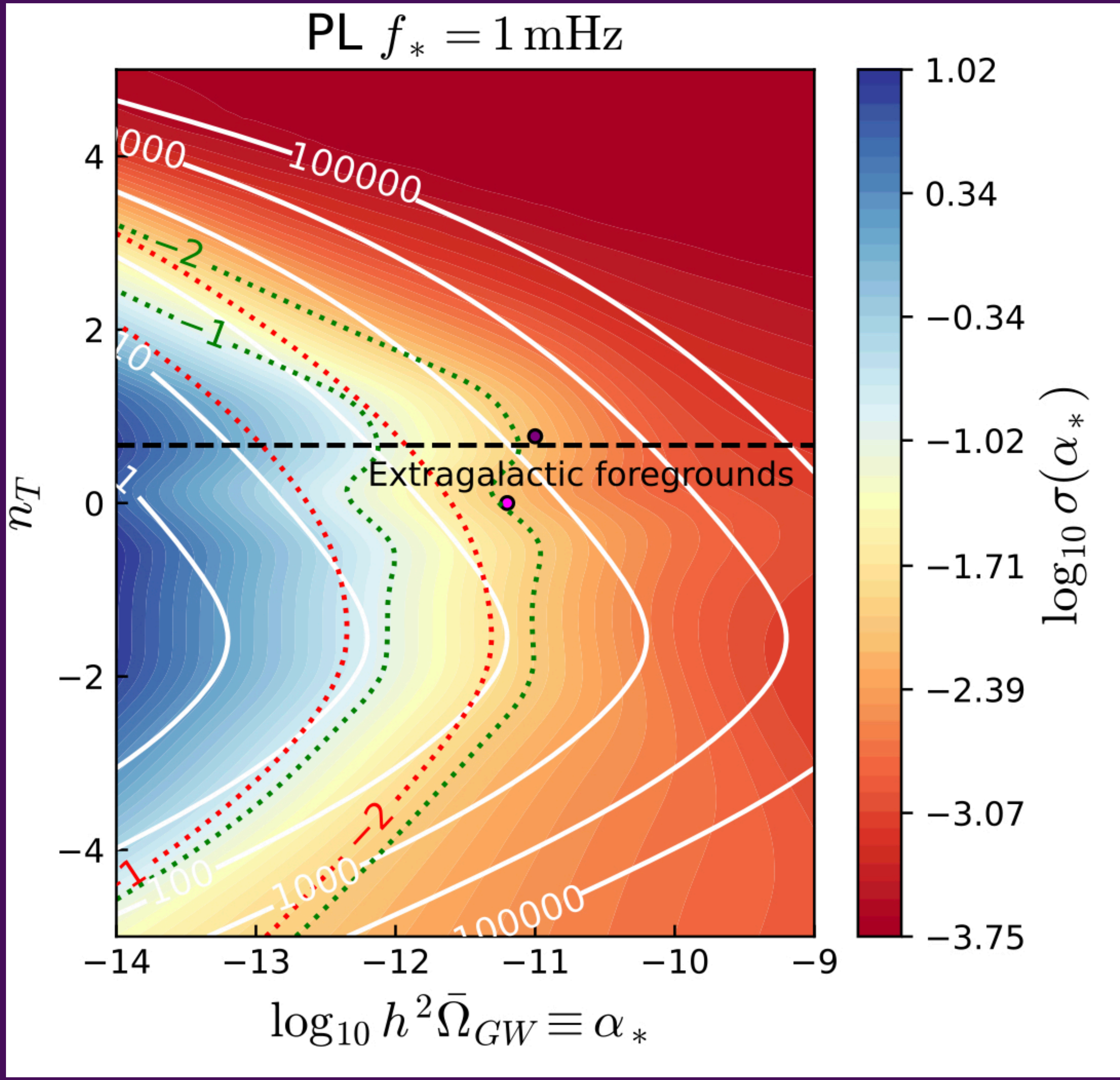
POWER LAW

$$h^2\,\Omega_{\rm GW} = \bar{\Omega}_{\rm GW}\left(\frac{f}{f_*}\right)^{n_T}$$

SNR

$\sigma(\alpha_*) = 0.1, 0.01$

$\sigma(\alpha_*) = 0.1, 0.01$
no fgs



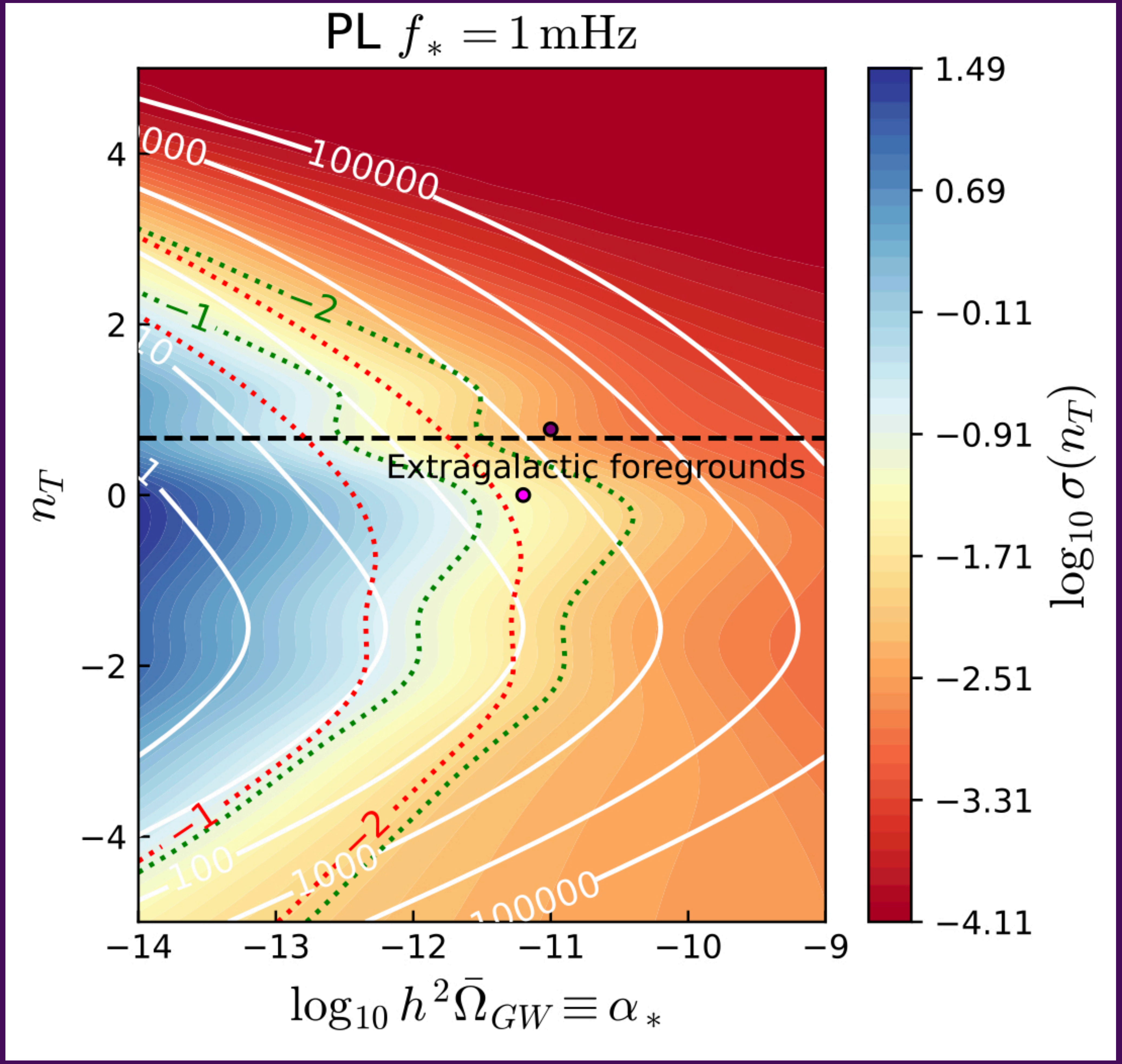
POWER LAW

$$h^2\,\Omega_{\rm GW} = \bar{\Omega}_{\rm GW}\left(\frac{f}{f_*}\right)^{n_T}$$

SNR

$\sigma(n_T) = 0.1, 0.01$

$\sigma(n_T) = 0.1, 0.01$
no fgs

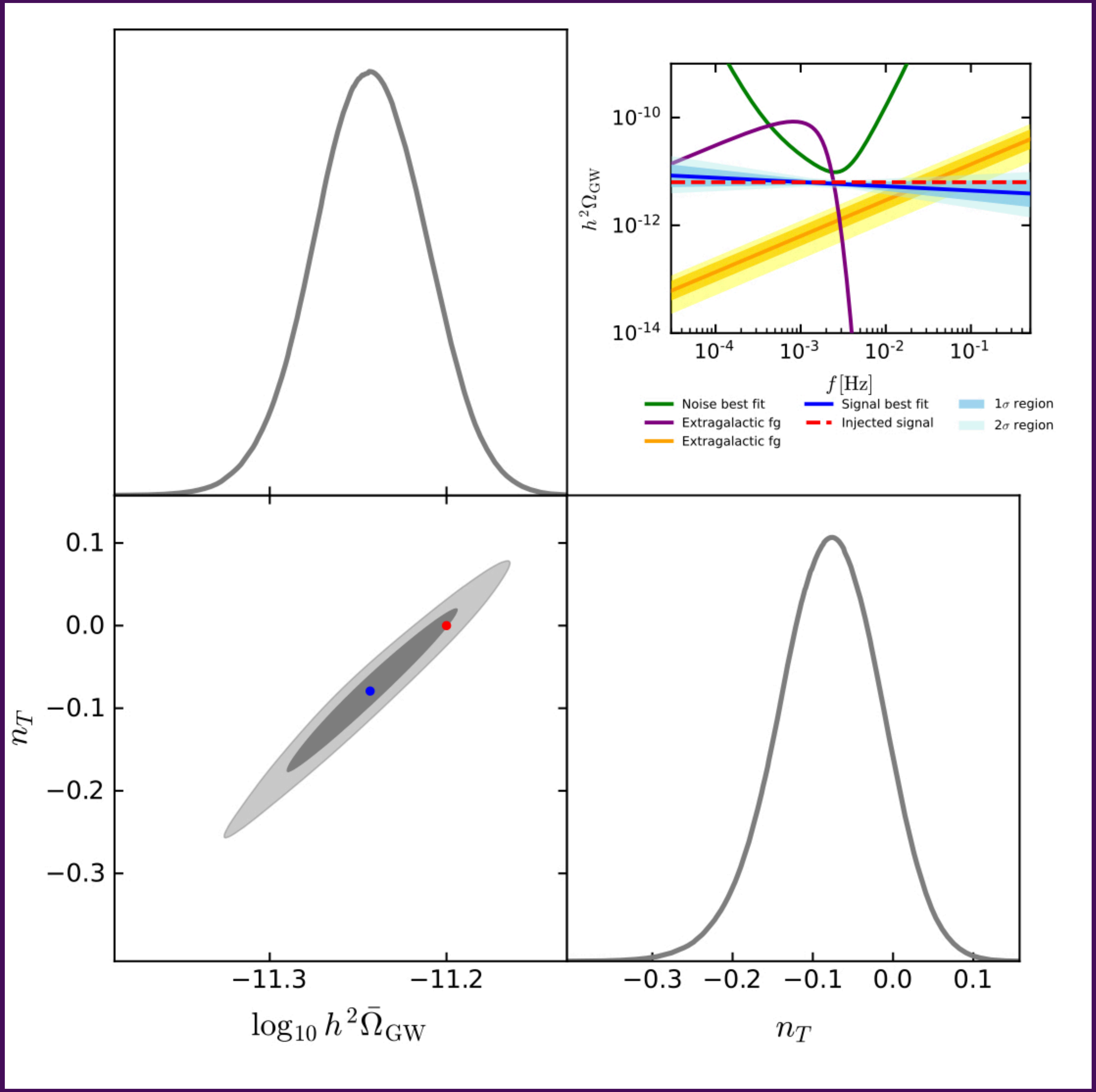


EX: FLAT SPECTRUM

$f_* = 1\text{mHz}$

$\log_{10} \bar{\Omega}_{\rm GW} = -11.2 \in [-30, 5]$

$n_T = 0 \in [-10, 10]$



EX: AXION INFLATION

Barnaby & Peloso 1011.1500

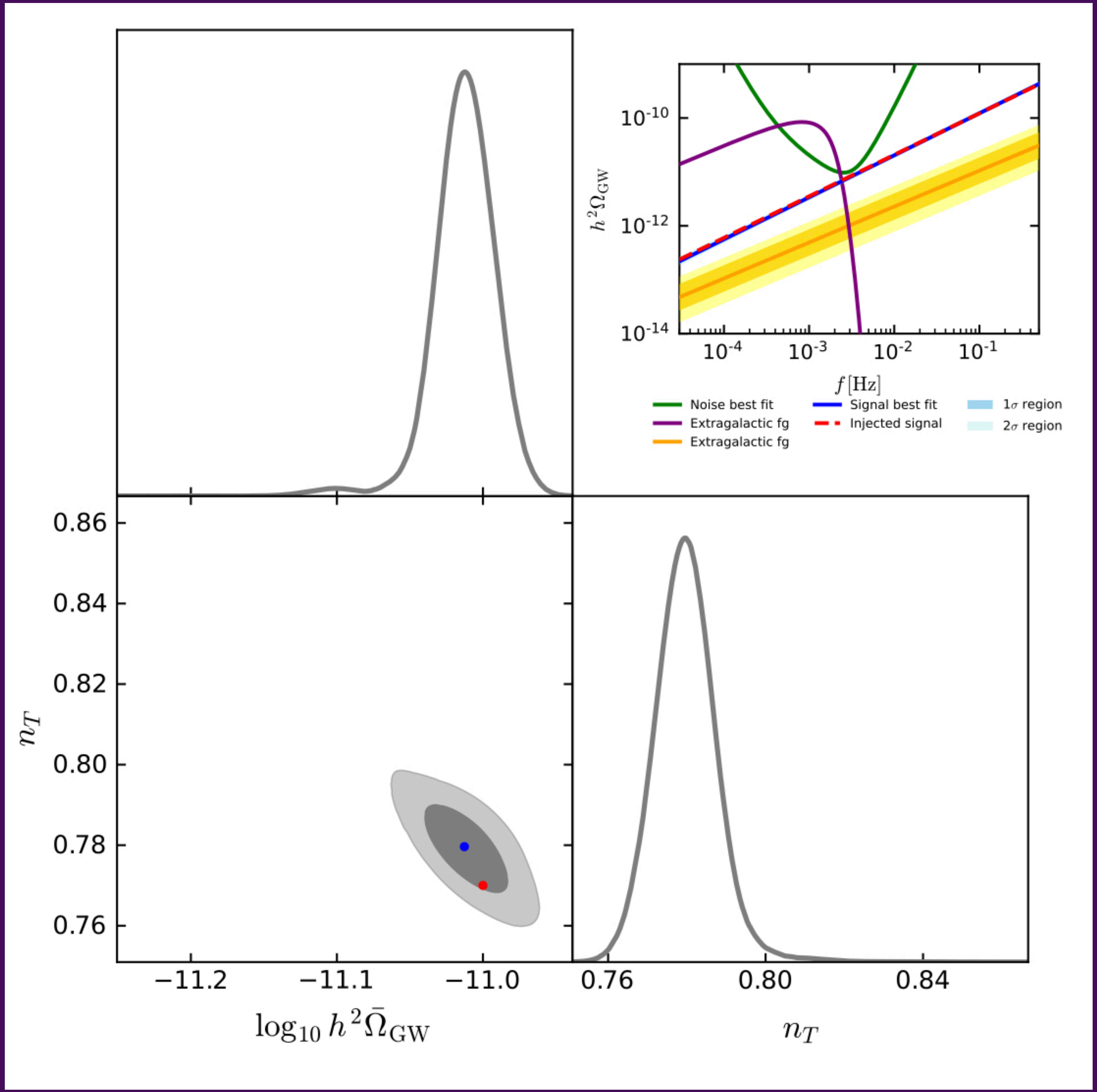
Sorbo 1101.1525

Bartolo et al. 1610.06481

$$f_* = 1\text{mHz}$$

$$\log_{10}\bar{\Omega}_{\rm GW} = -11$$

$$n_T = 0.77$$



EX: AXION INFLATION

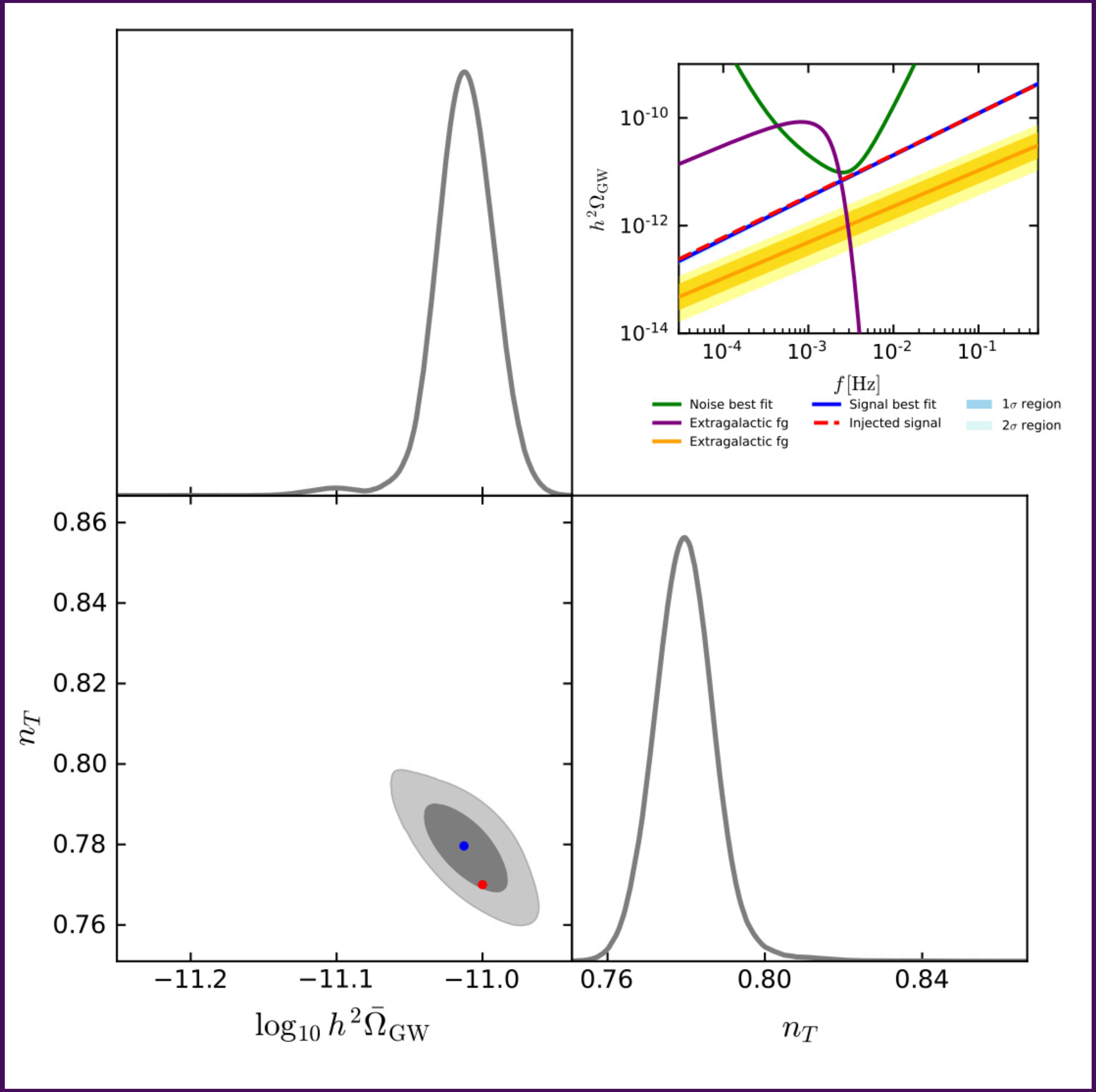
Barnaby & Peloso 1011.1500

Sorbo 1101.1525

Bartolo et al. 1610.06481

$$\bar{\Omega}_{\rm GW} = 1.5 \times 10^{-13} \frac{H_*^4}{M_{\rm pl}^4} \frac{e^{4\pi\xi_*}}{\xi_*^6}$$

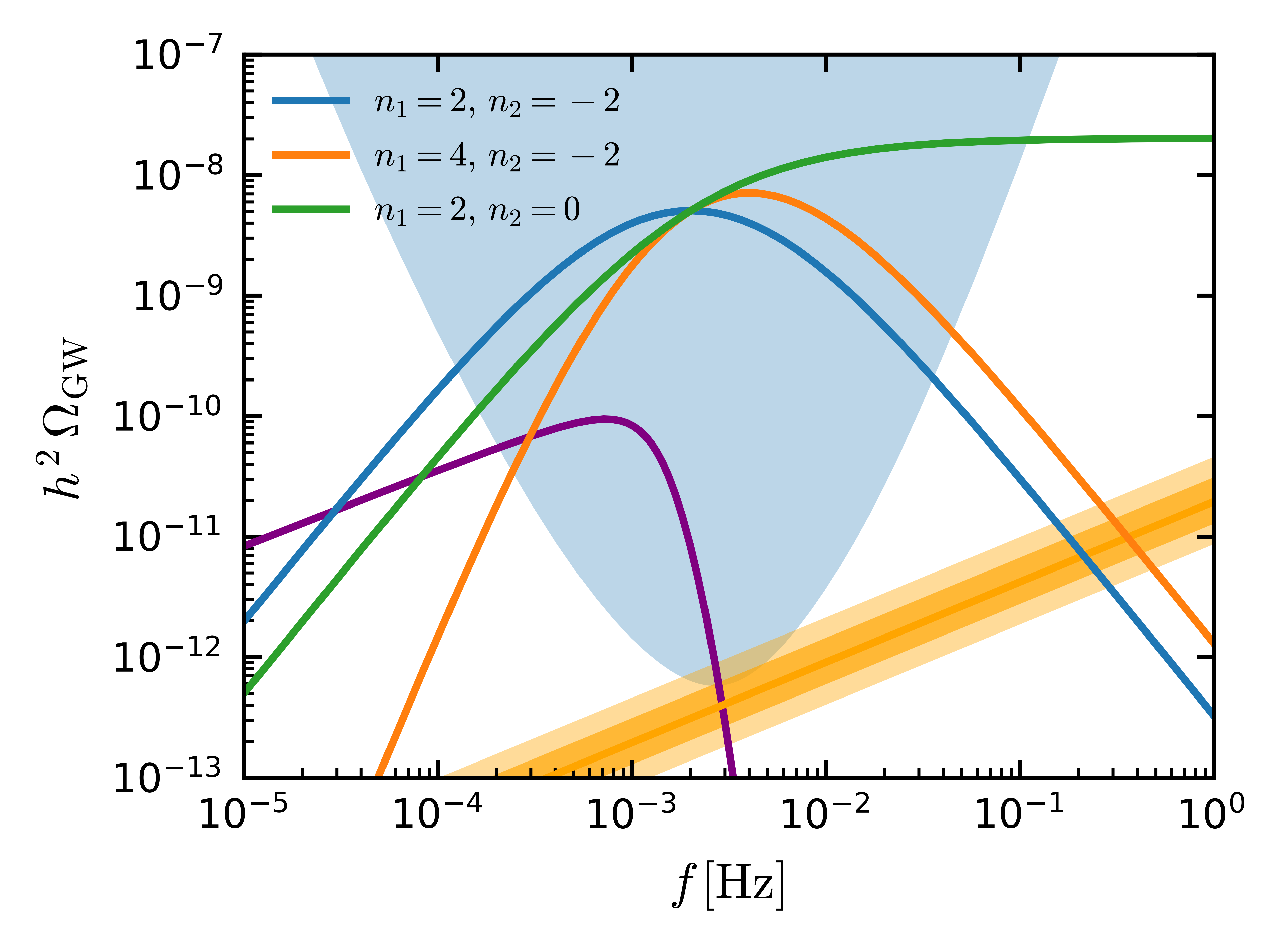
$$n_T = -4\xi_* + (4\pi\xi_* - 6)(\epsilon_* - \eta_*)$$



BROKEN POWER LAW

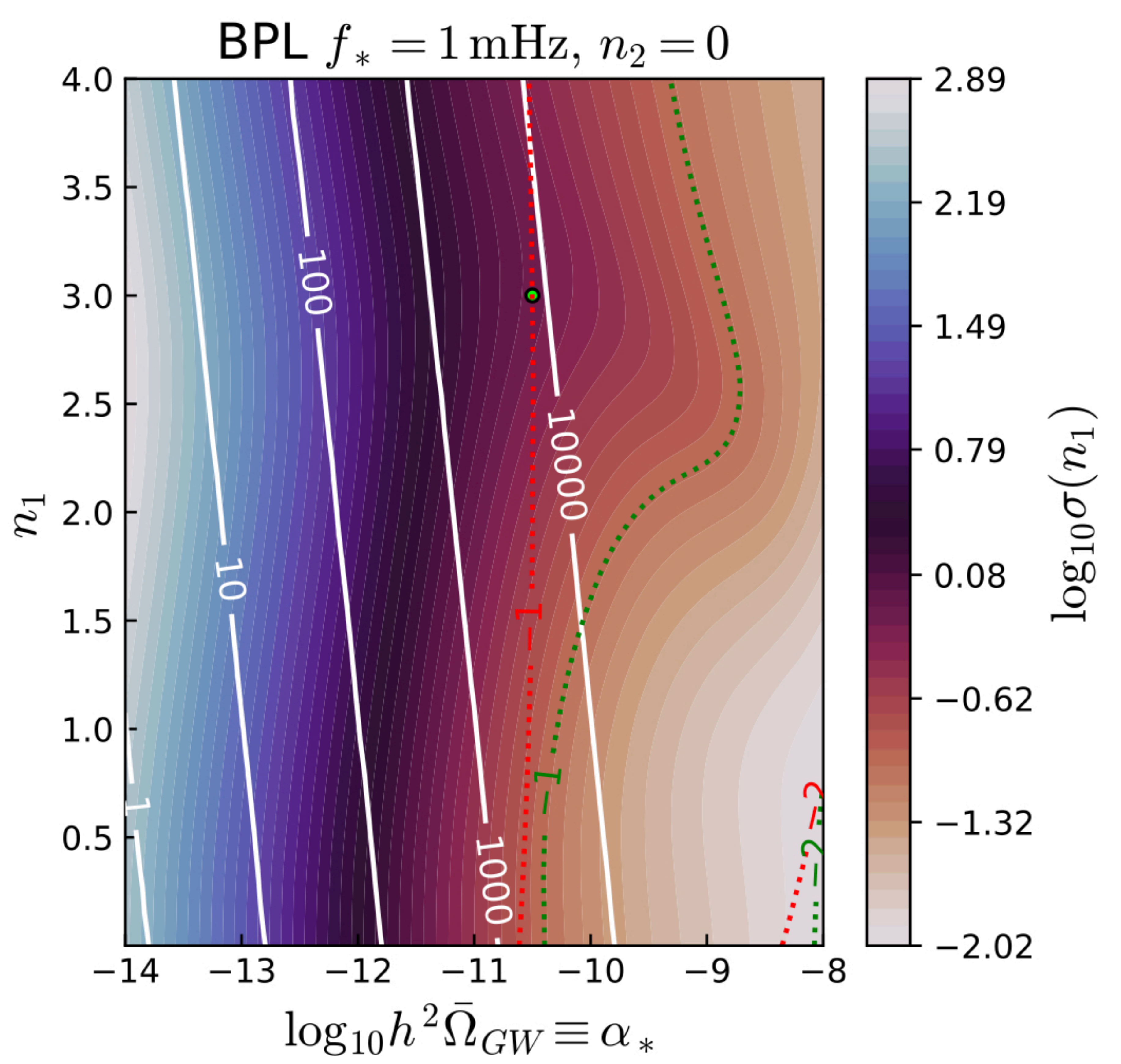
$$h^2\,\Omega_{\rm GW} = \bar{\Omega}_{\rm GW} \frac{\left(\frac{f}{f_*}\right)^{n_{T,1}}}{\left[\frac{1}{2}\left(1+\frac{f}{f_*}\right)\right]^{n_{T,1}-n_{T,2}}}$$

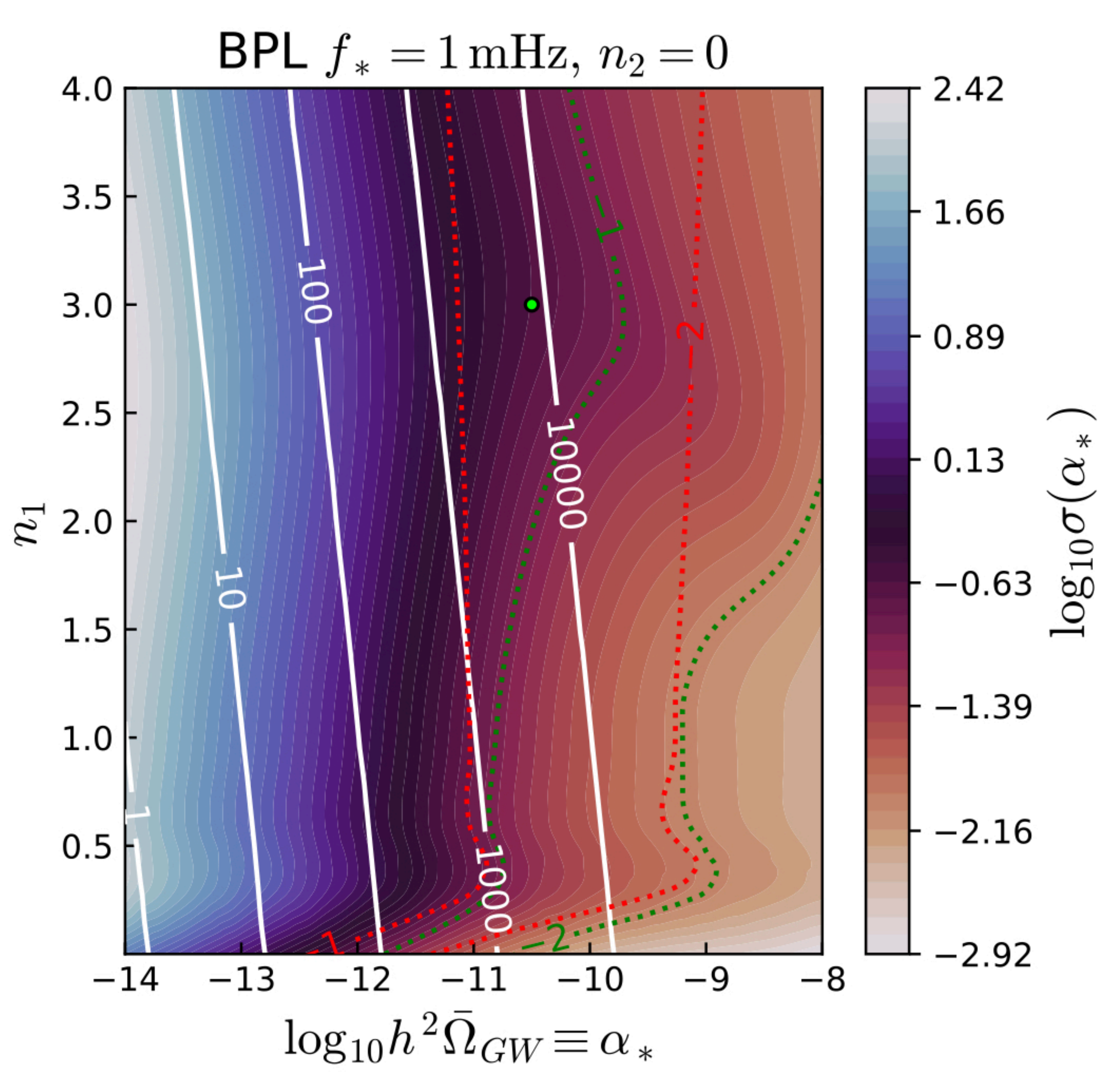
4 parameters



BROKEN POWER LAW

$$h^2\,\Omega_{\rm GW} = \bar{\Omega}_{\rm GW}\frac{\left(\frac{f}{f_*}\right)^{n_{T,1}}}{\left[\frac{1}{2}\left(1+\frac{f}{f_*}\right)\right]^{n_{T,1}-n_{T,2}}}$$





EX: HYBRID INFLATION

Clesse & Garcia-Bellido 1501.07565

Clesse, Garcia-Bellido, Orani 1812.11011

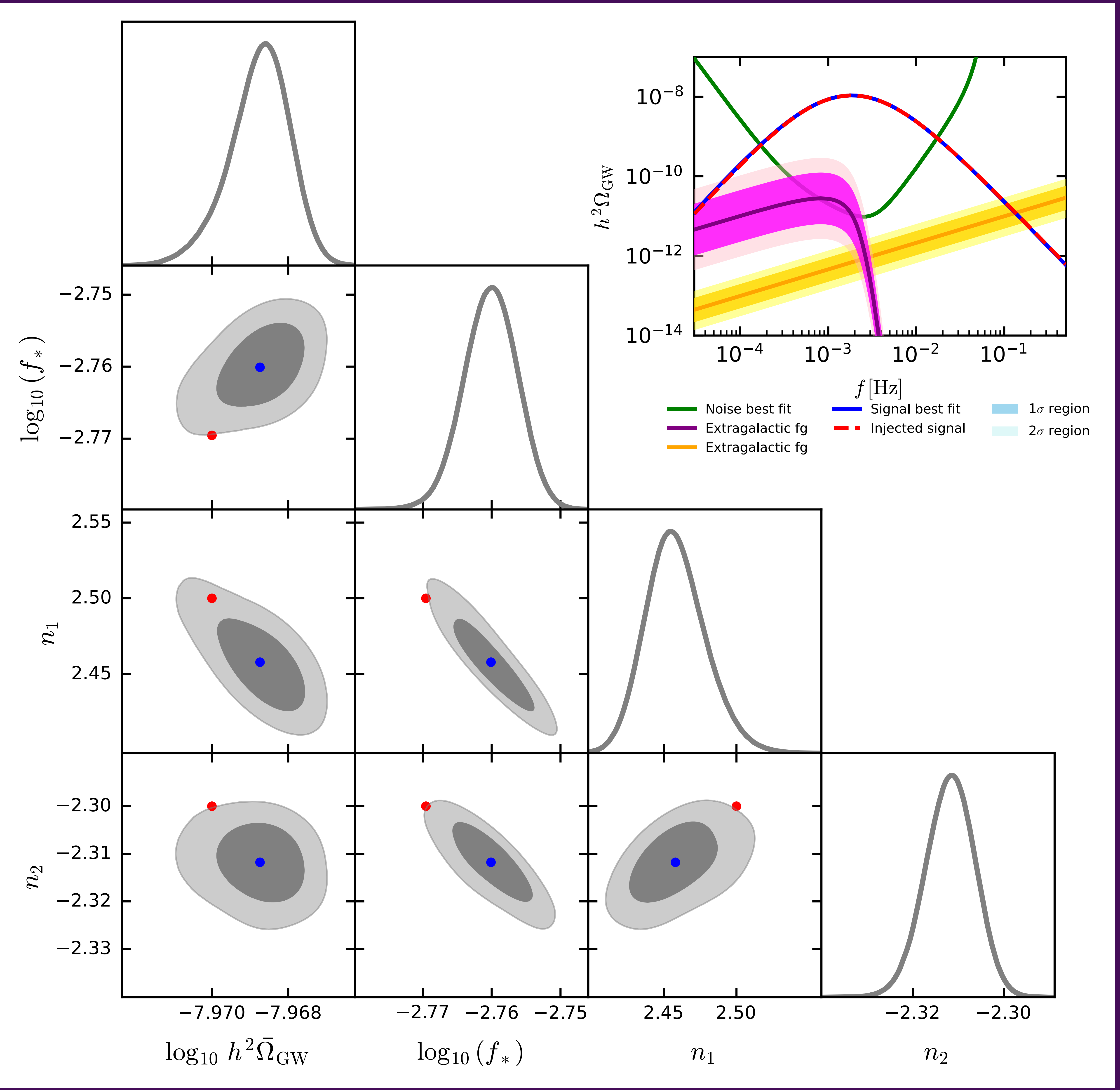
Braglia et al. 2211.14263

$$f_* = 1\text{mHz}$$

$$\log_{10} \bar{\Omega}_{\rm GW} = -8$$

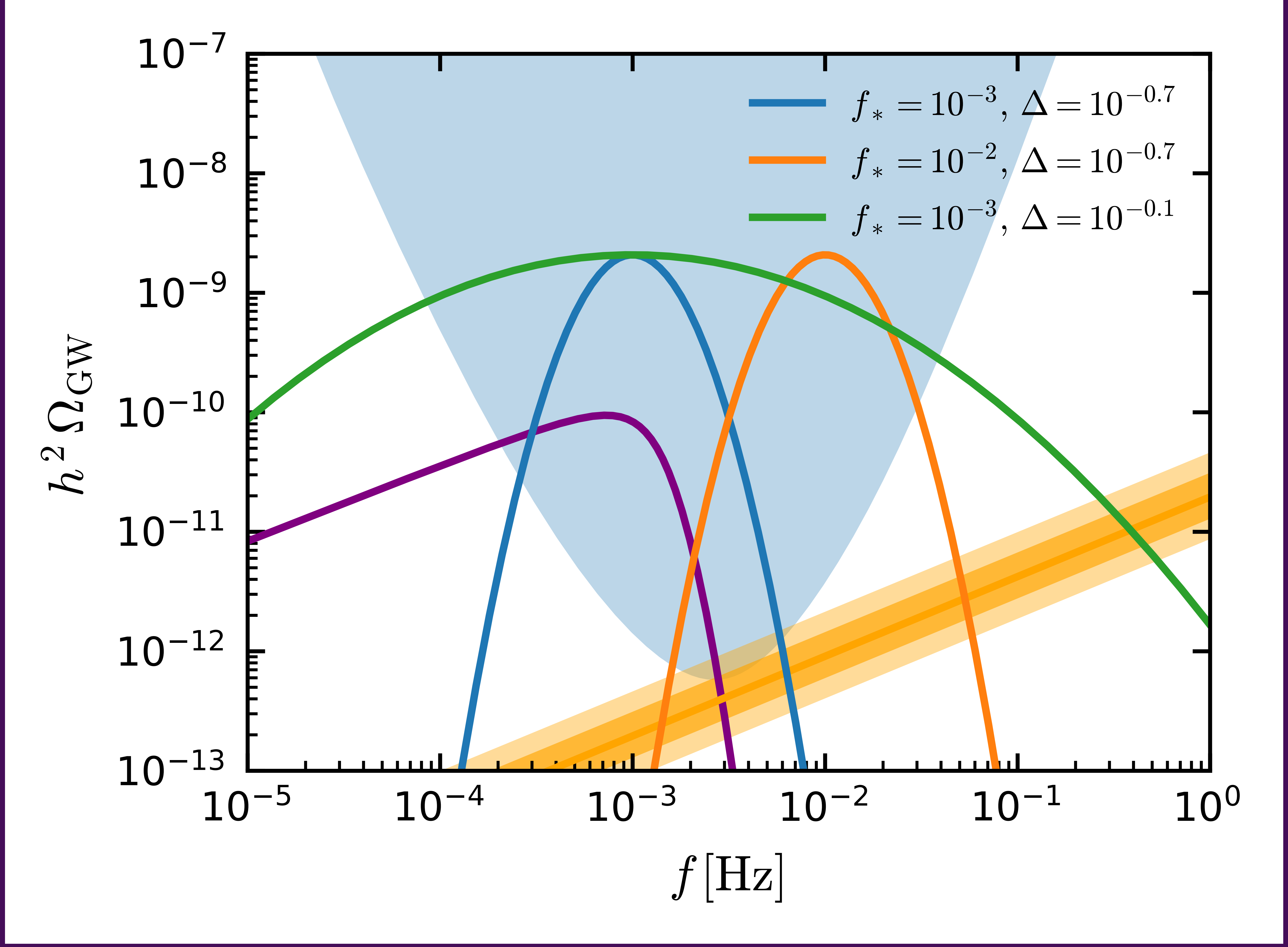
$$n_1 = 2.5$$

$$n_2 = -2.3$$



GAUSSIAN BUMP

$$h^2\,\Omega_{\rm GW} = \bar{\Omega}_{\rm GW}\exp\left\{-\frac{\log_{10}^2 f/f_*}{2\times 10^{2\Delta}}\right\}$$

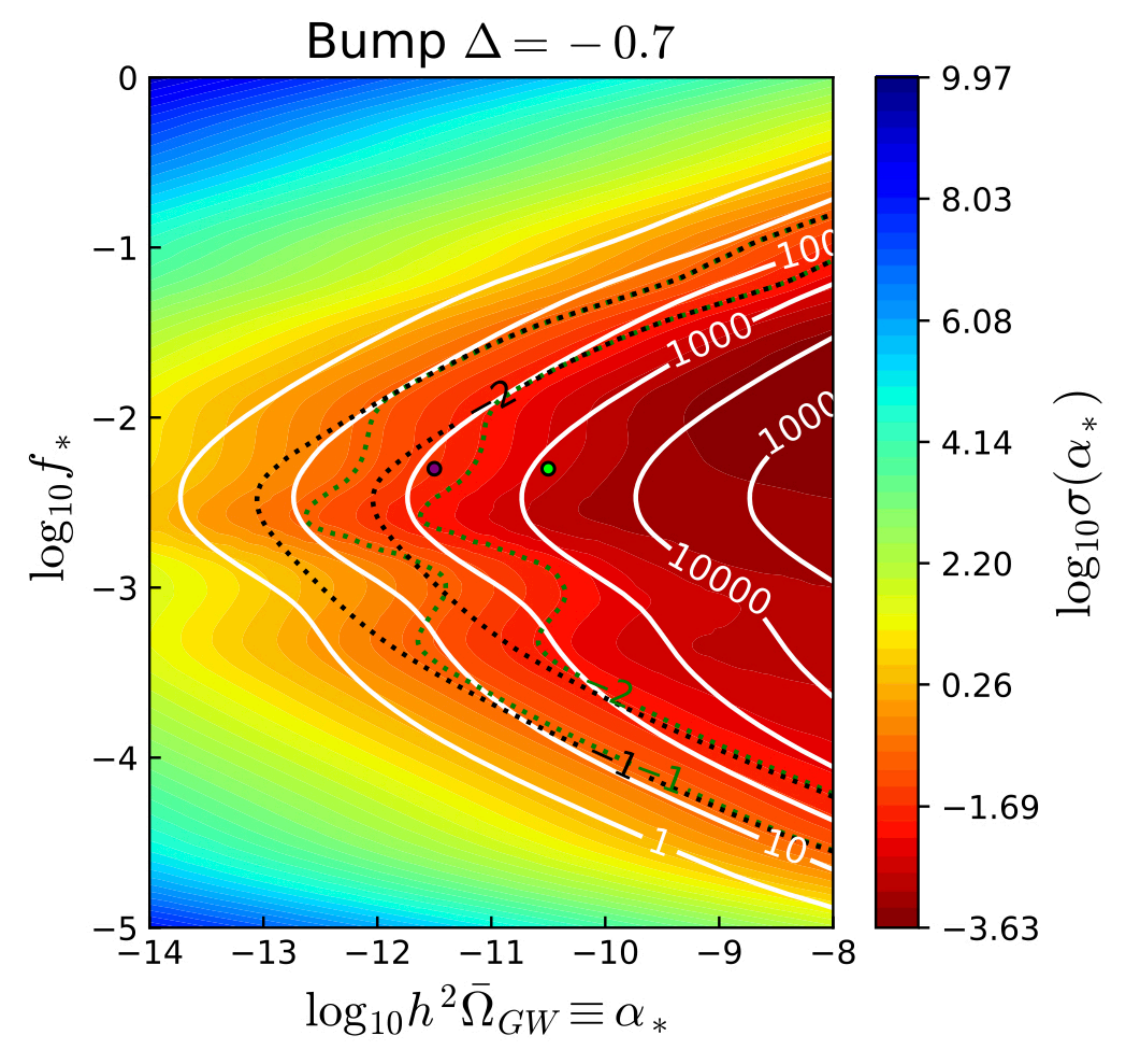


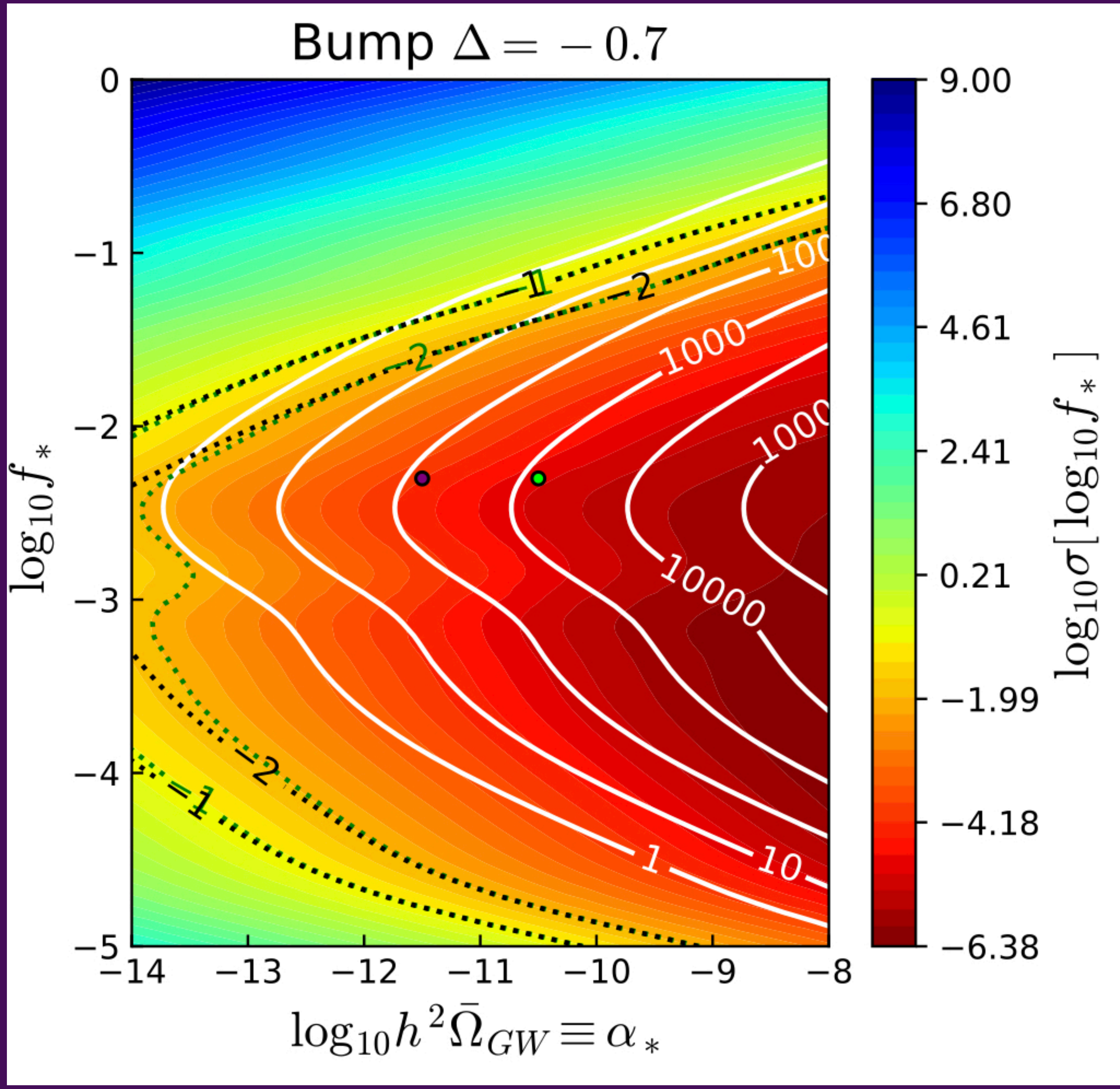
3 parameters

GAUSSIAN BUMP

Fixed width Δ

$$h^2\,\Omega_{\rm GW} = \bar{\Omega}_{\rm GW}\exp\left\{-\frac{\log_{10}^2 f/f_*}{2\times 10^{2\Delta}}\right\}$$

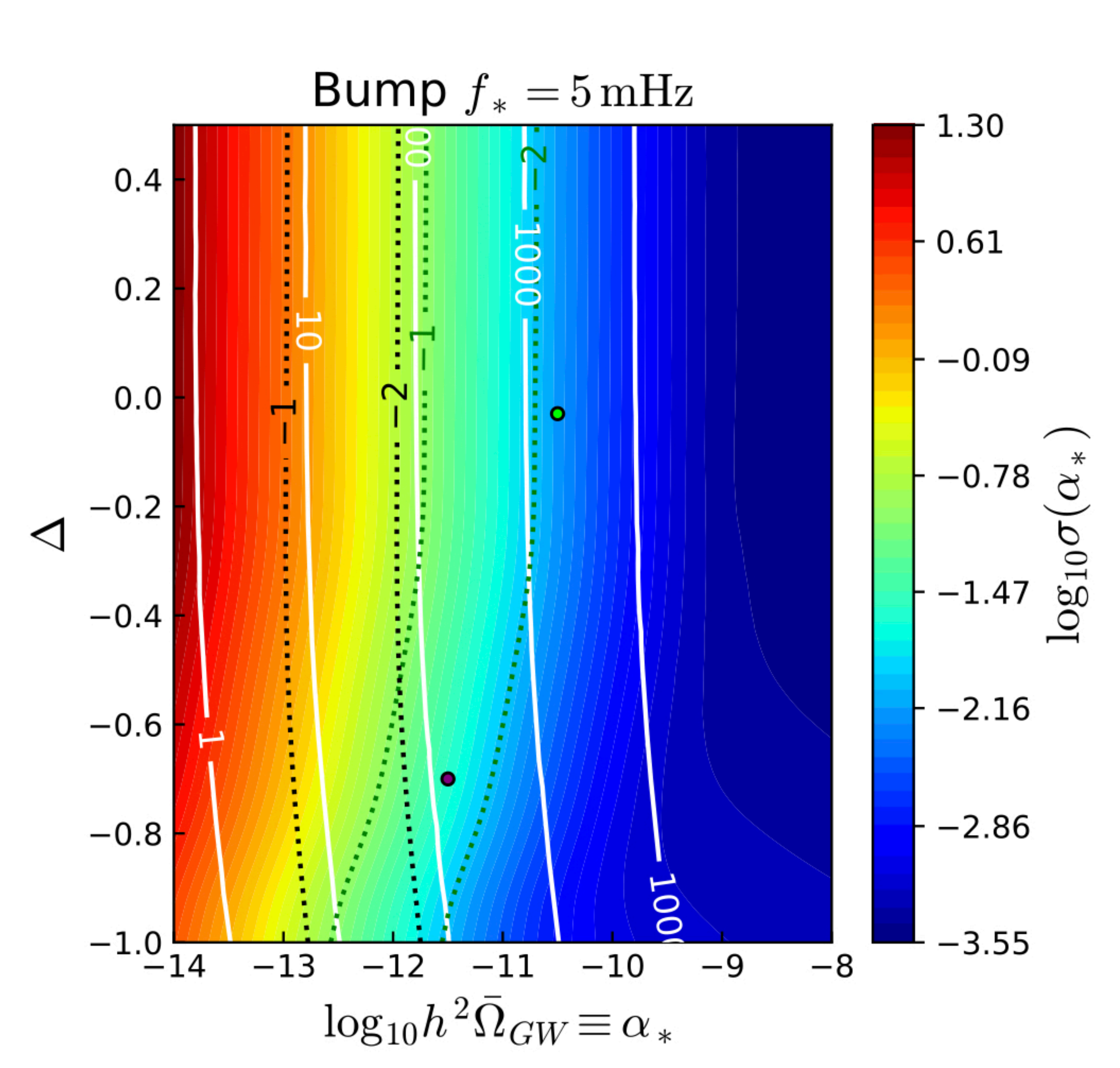


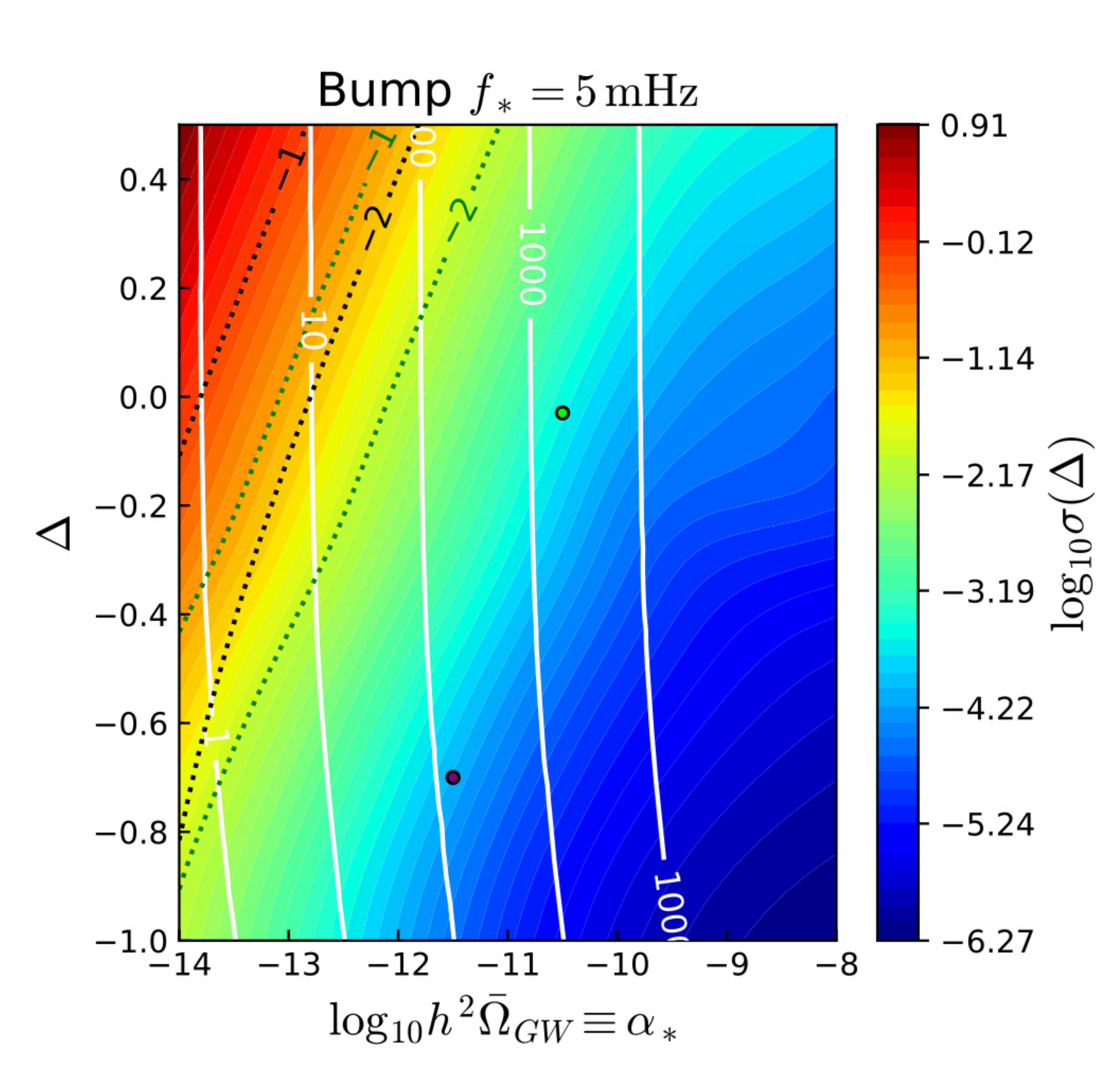


GAUSSIAN BUMP

Fixed pivot f_*

$$h^2\,\Omega_{\rm GW} = \bar{\Omega}_{\rm GW}\exp\left\{-\frac{\log^2_{10} f/f_*}{2\times 10^{2\Delta}}\right\}$$





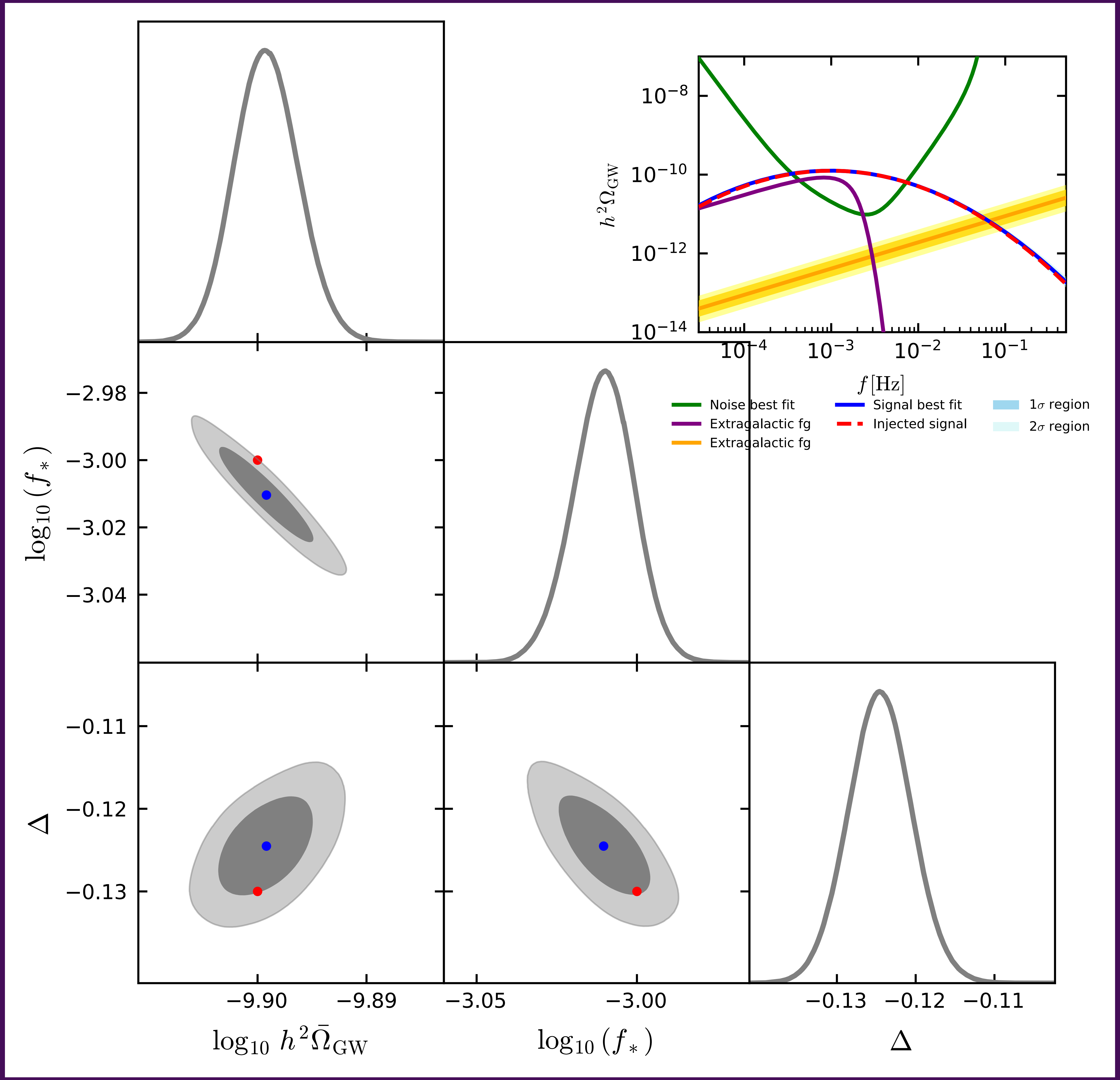
EX 1: AXION INFLATION WITH ROLLING SPECTATOR

Namba et al. 1509.07521

$$f_* = 1\mathrm{mHz}$$

$$\log_{10} \bar{\Omega}_{\mathrm{GW}} = -9.9$$

$$\Delta = -0.13$$



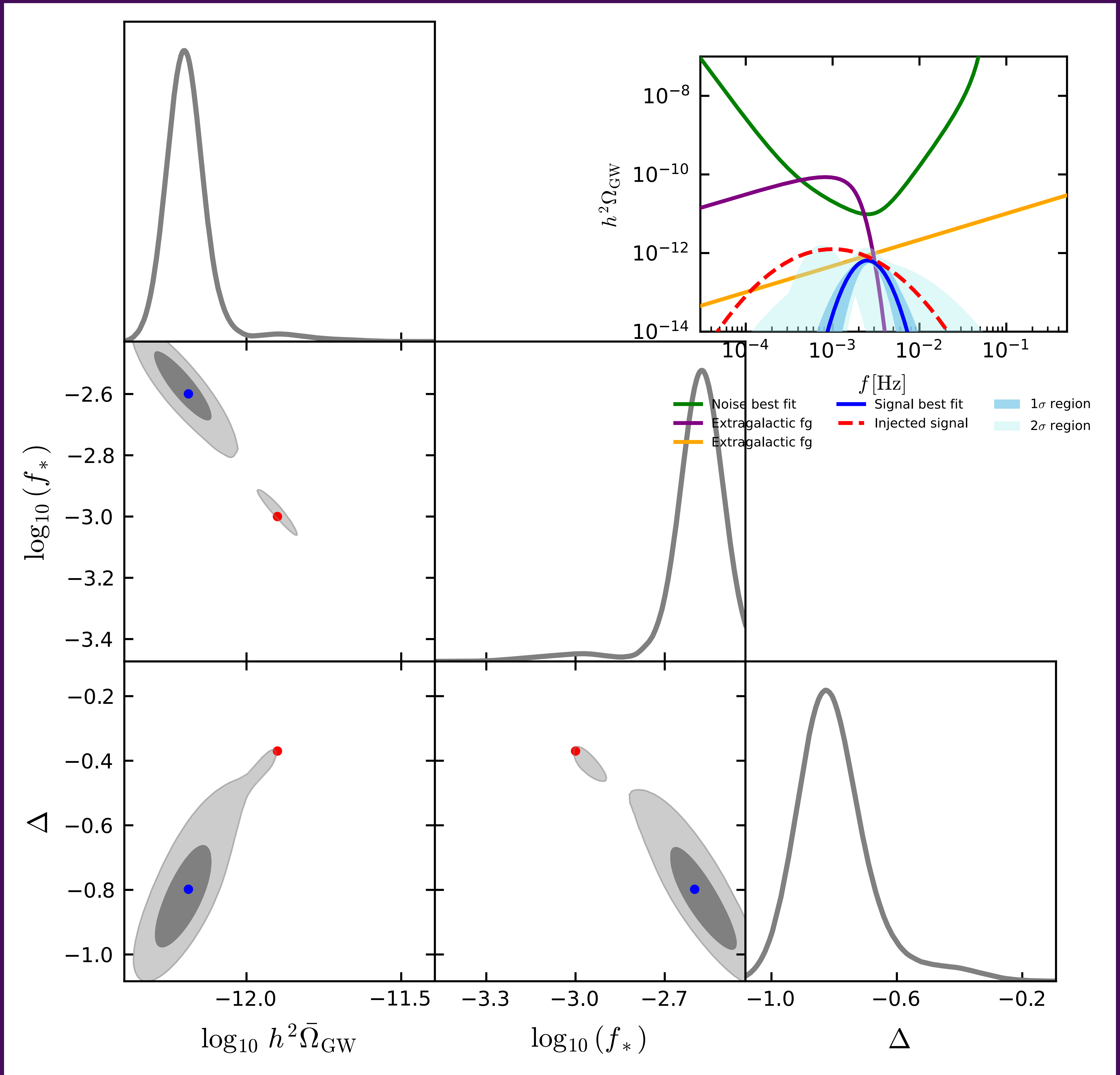
EX 2: AXION INFLATION WITH ROLLING SPECTATOR

Namba et al. 1509.07521

$$f_* = 1\text{mHz}$$

$$\log_{10} \bar{\Omega}_{\rm GW} = -11.9$$

$$\Delta = -0.37$$

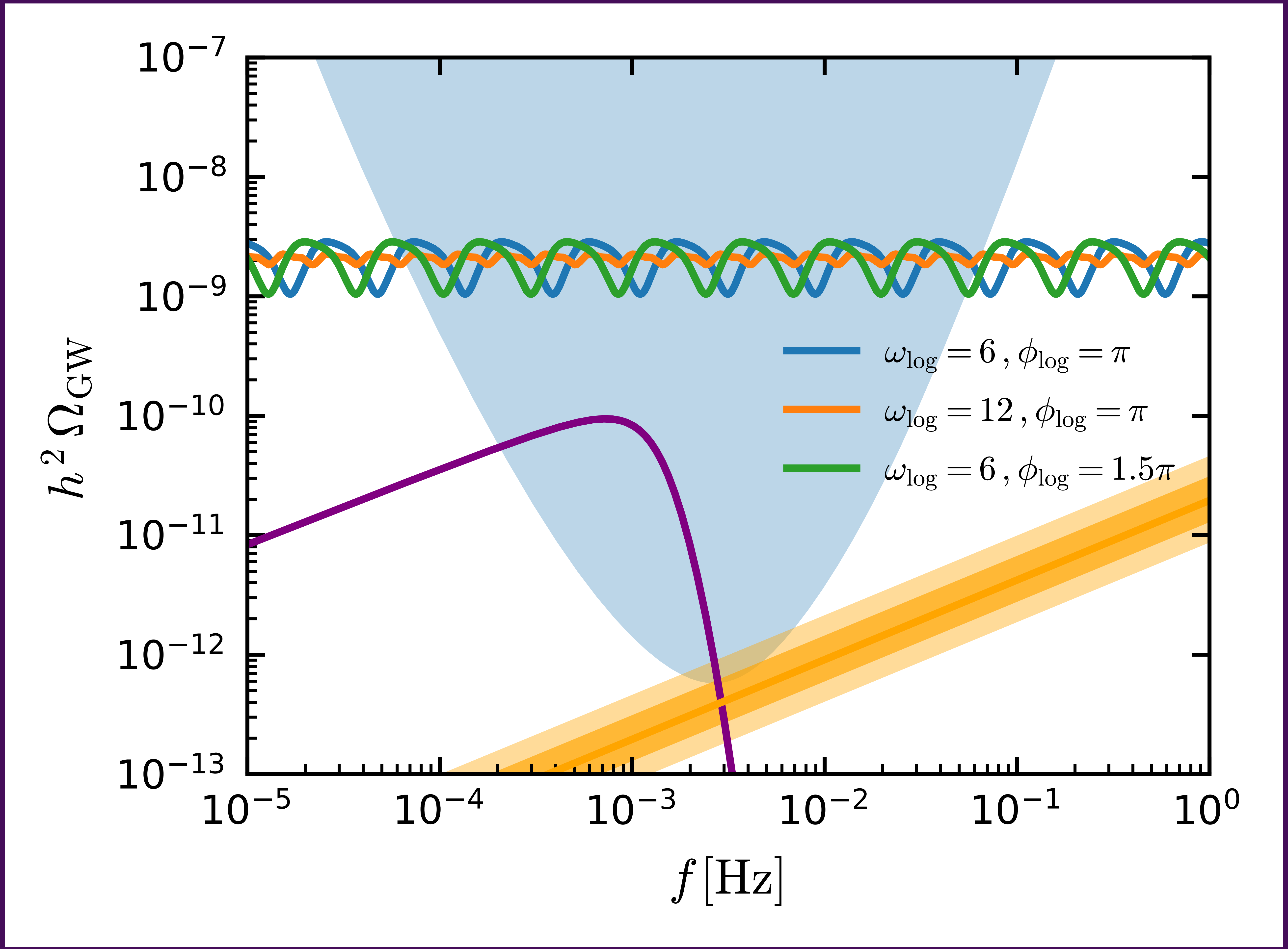


OSCILLATORY FEATURES

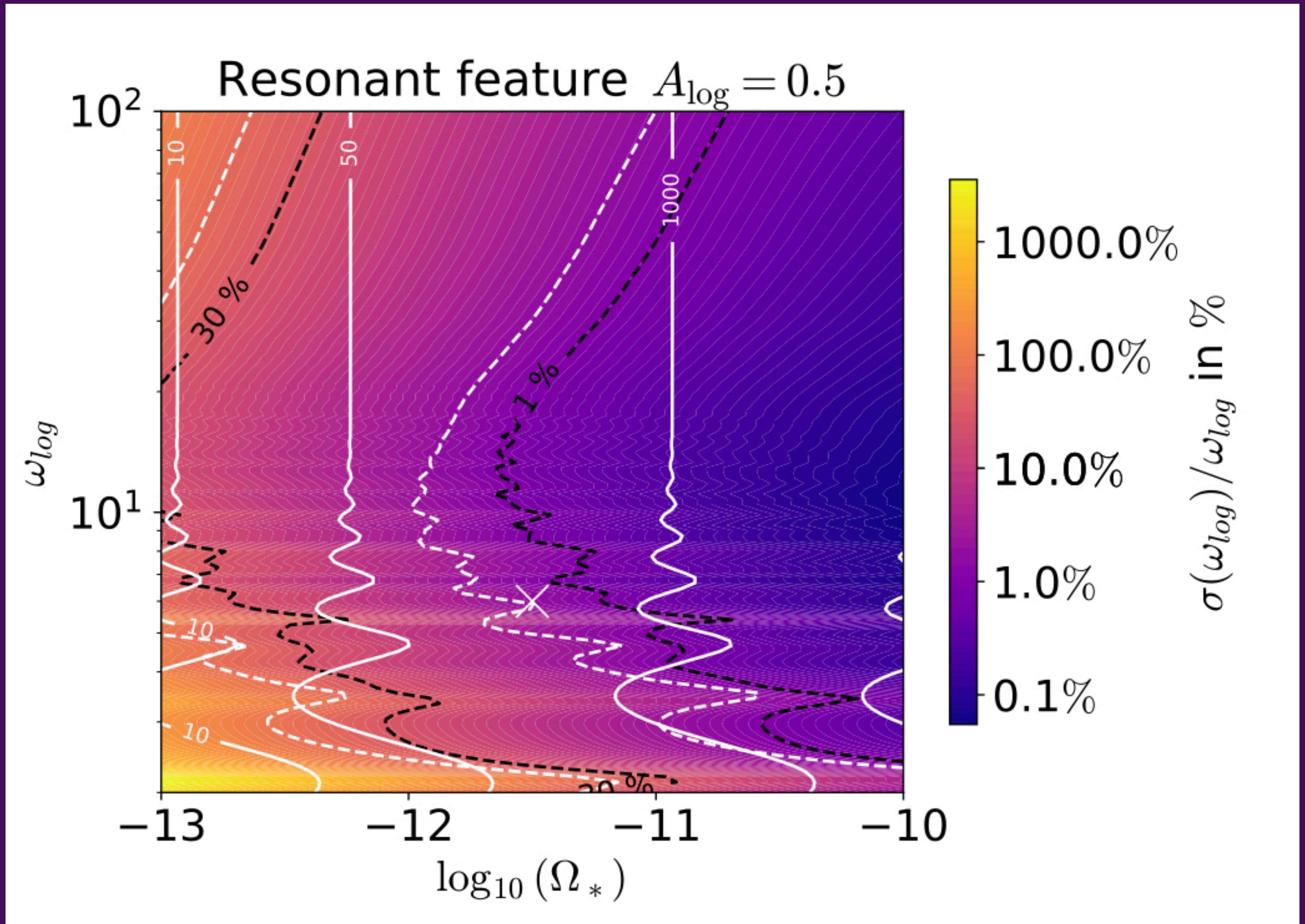
$$h^2\,\Omega_{\rm GW} = \bar{\Omega}_{\rm GW}\Big[1 + \mathscr{A}_{\mathbf{log},1}\cos\big(\omega_{\mathbf{log}}\ln(f/\mathbf{Hz}) + \theta_{\mathbf{log},1}\big)$$

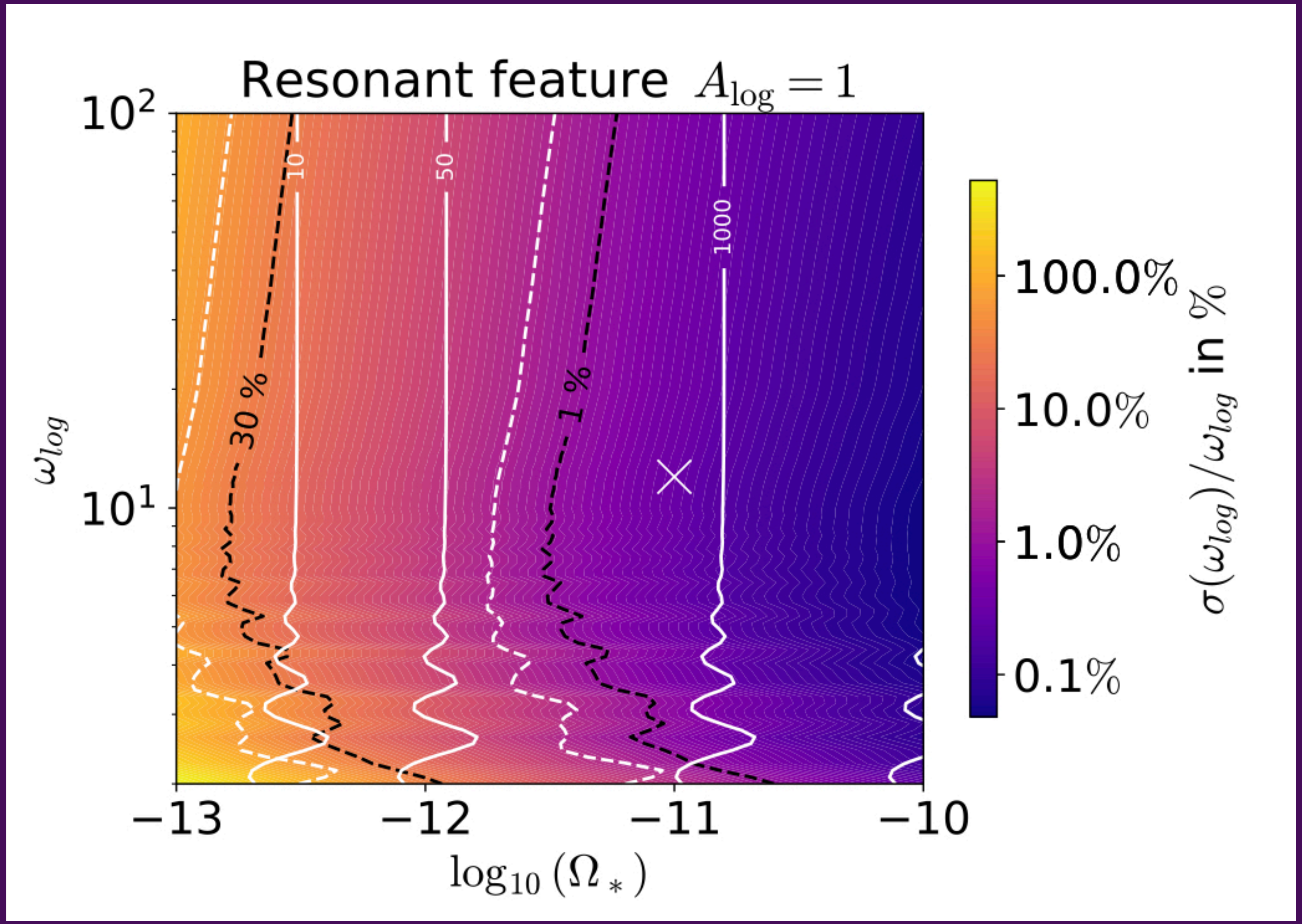
$$+\mathscr{A}_{\mathbf{log},2}\cos\big(2\omega_{\mathbf{log}}\ln(f/\mathbf{Hz}) + \theta_{\mathbf{log},2}\big)\Big]$$

4 parameters



OSCILLATORY FEATURES





FLAT SPECTRUM

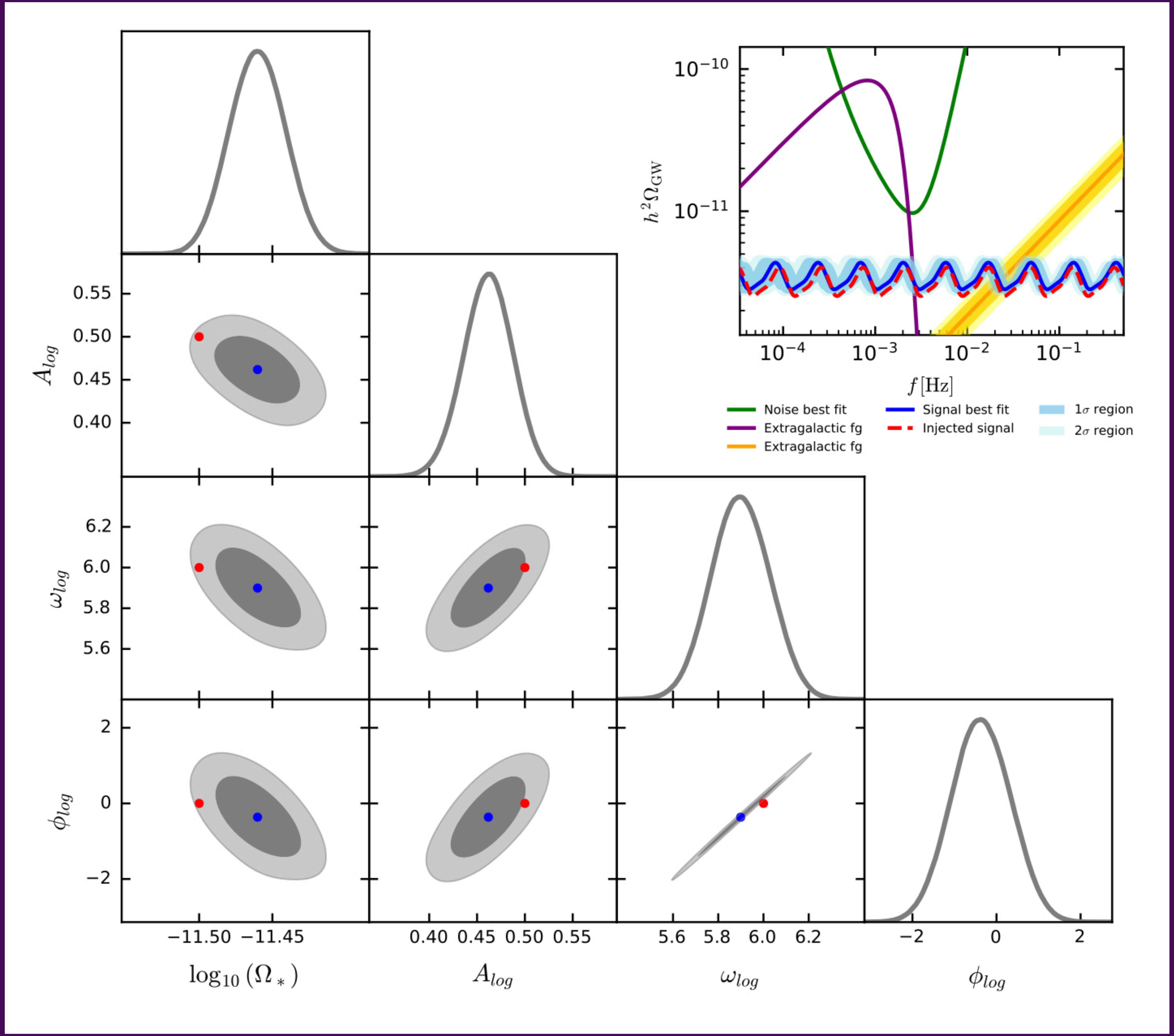
Fumagalli et al. 2105.06481

$$\log_{10}\bar{\Omega}_{\rm GW} = -11.5$$

$$\omega_{\log} = 6$$

$$A_{\log} = 0.5$$

$$\phi_{\log} = 6$$



CONCLUSIONS

- Extreme freedom in model building: conclusions depend on the model considered
- In general, for each model we can test a large portion of the theoretically allowed parameter space
- For some of the models a 1to1 connection between template and theory parameters exists. ‘Pheno’ can be straightforwardly translated into ‘theory’ constraints