High Frequency GW Bounds from Galactic Neutron Stars

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Based on Arxiv [2402.14092]

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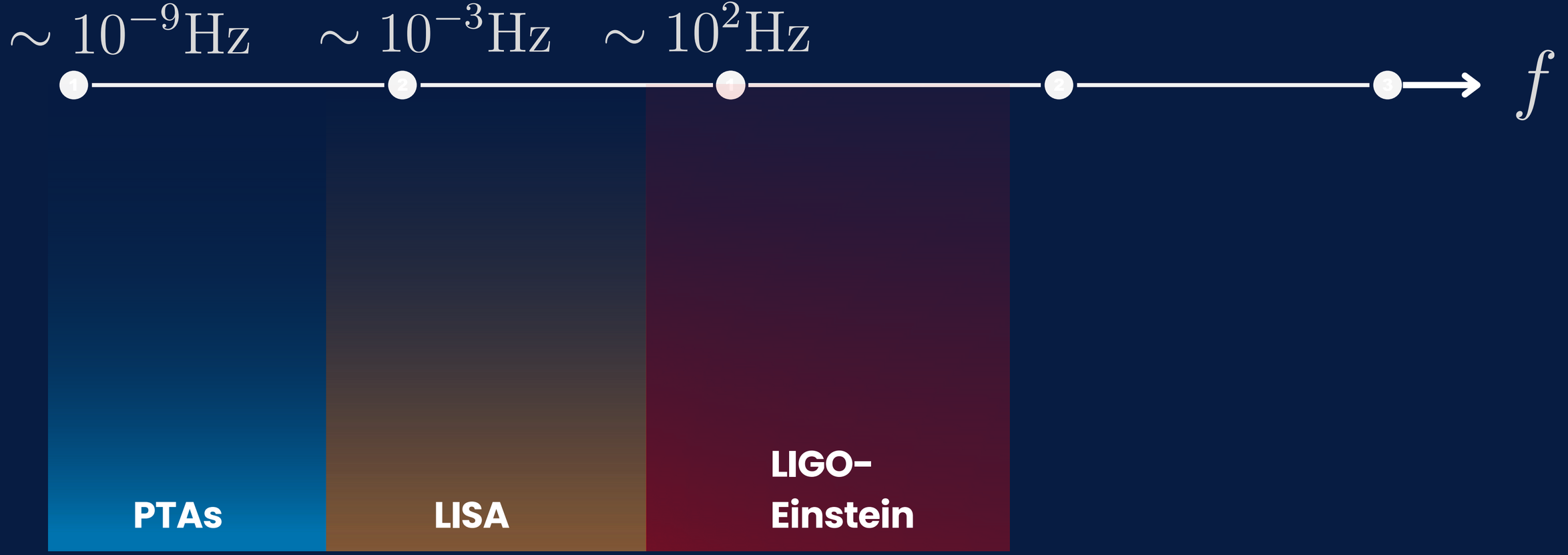
The Situation

What do we know about the GW spectrum ?



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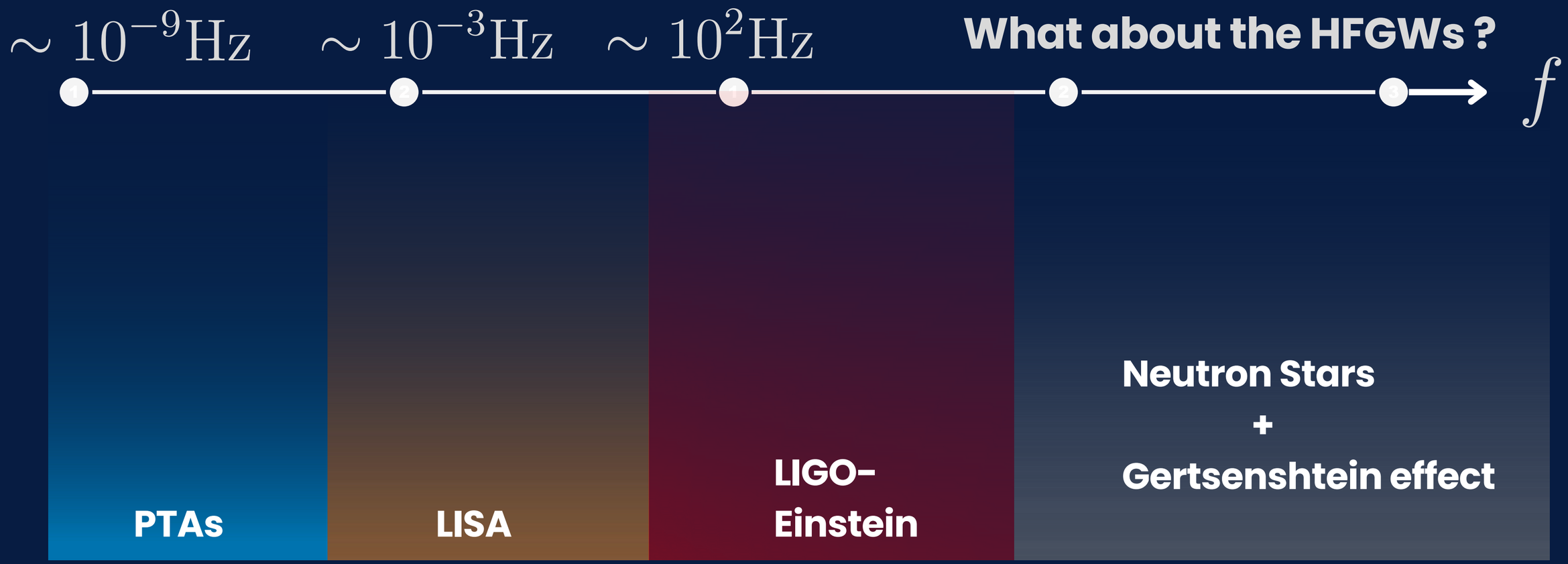
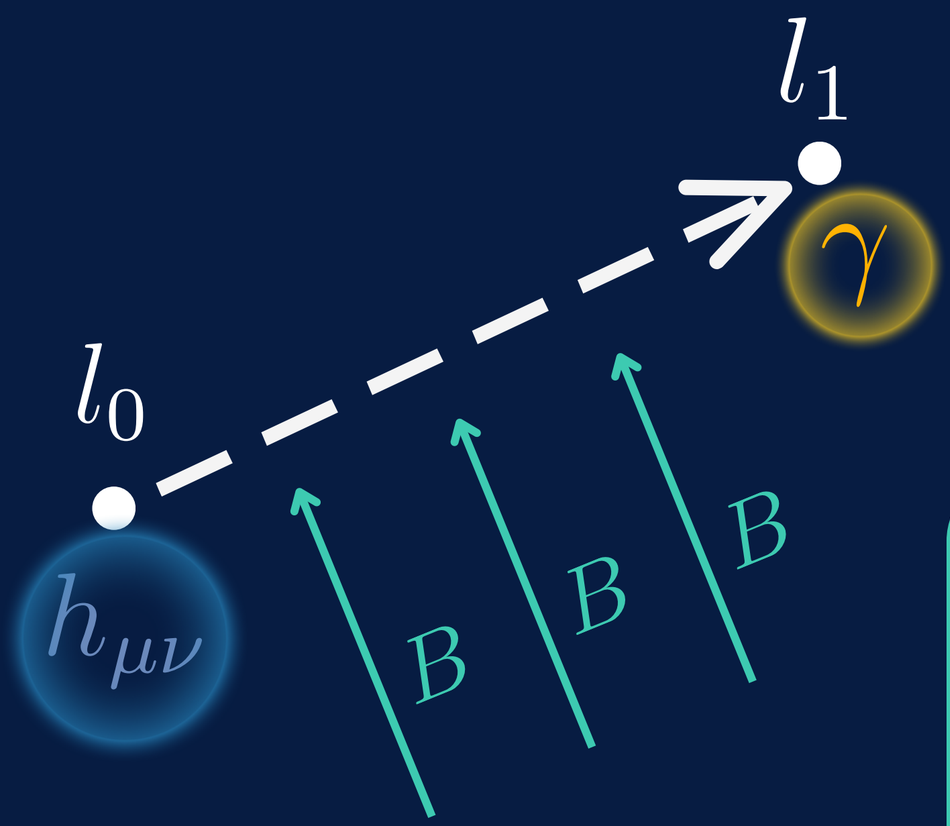


The Gertsenshtein Effect



- GWs convert into photons in a strong magnetic field

Conversion probability for gravitons travelling from l_0 to l_1 :

$$P_{g\to\gamma}(f) = \left| \int_{\ell_0}^{\ell_1} \mathrm{d}\ell\, \Delta_{\mathrm{M}}(\ell) \exp\left\{ -i \int_{\ell_0}^{\ell} \mathrm{d}\ell'\, \Delta_{\gamma}\left(\ell'\right) \right\} \right|^2$$

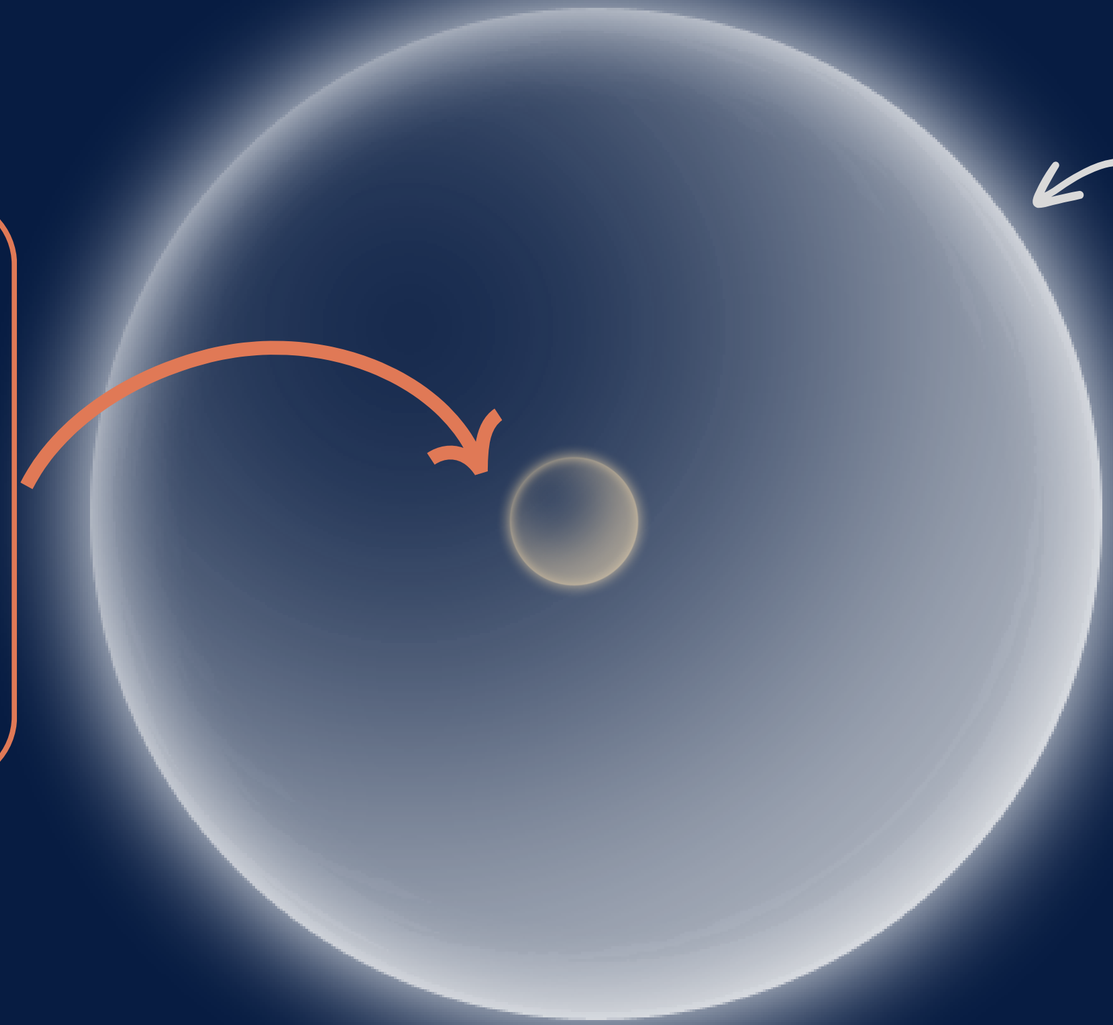
- The mixing term is $\Delta_M \sim B$
- Effective photon mass Δ_γ

(Gertsenshtein, 1962)
(Raffelt, Stodolsky 1987)

Conversion in NS magnetosphere

Typical Neutron Star

$$T \approx \mathcal{O}(1)\,\mathrm{s}$$
$$R \approx 10\,\mathrm{km}$$



Magnetosphere

$$B(r) = B_0 (r/R)^{-3}$$
$$B_0 \approx 10^{13}\,\mathrm{Gauss}$$

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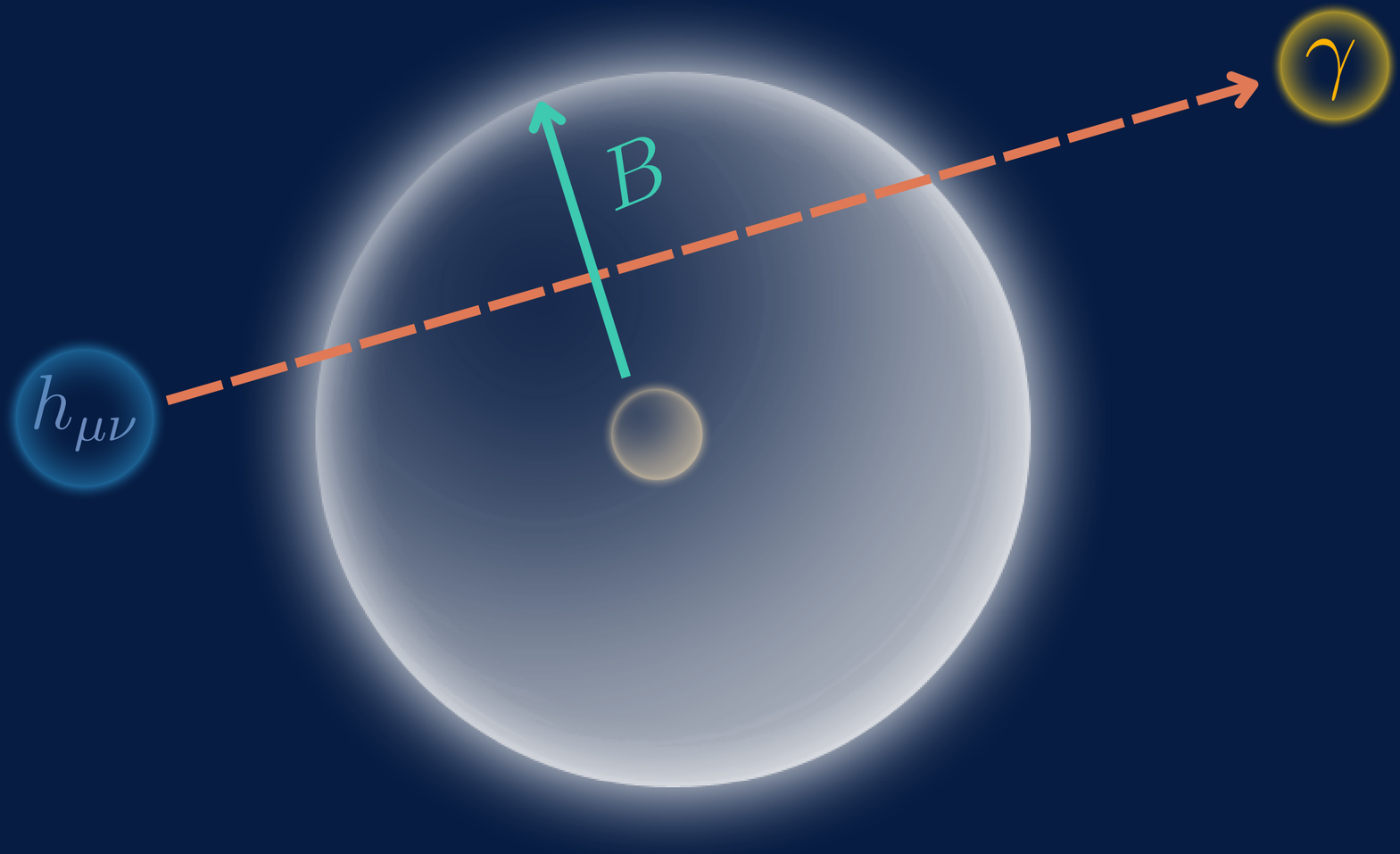

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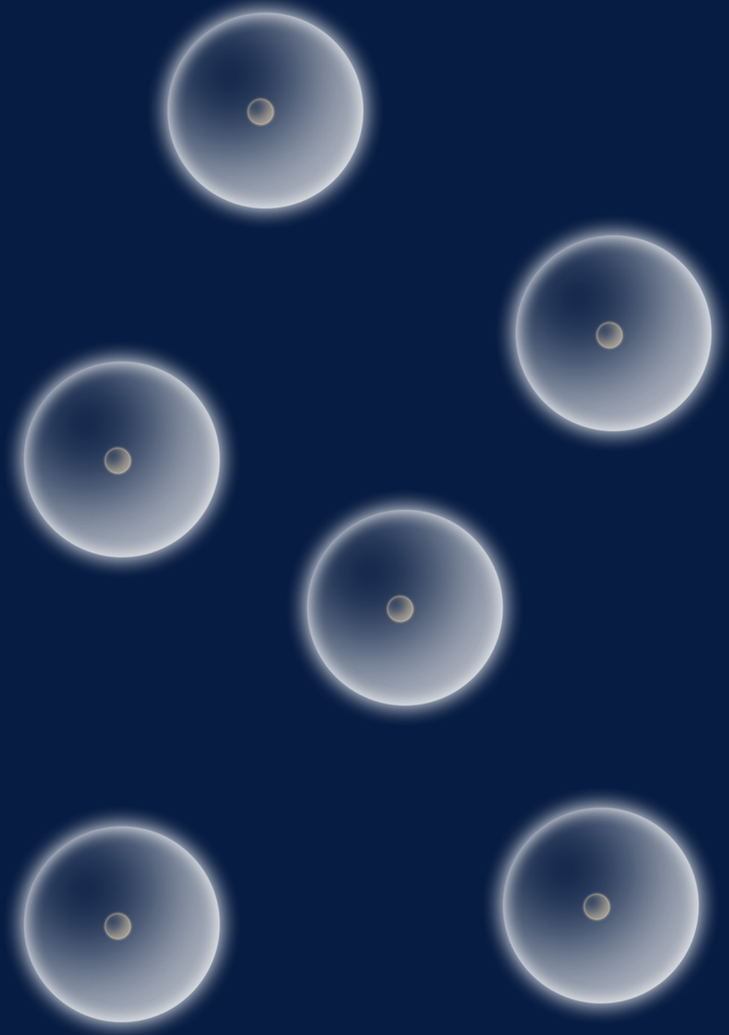


(Kaspi et al 2006)

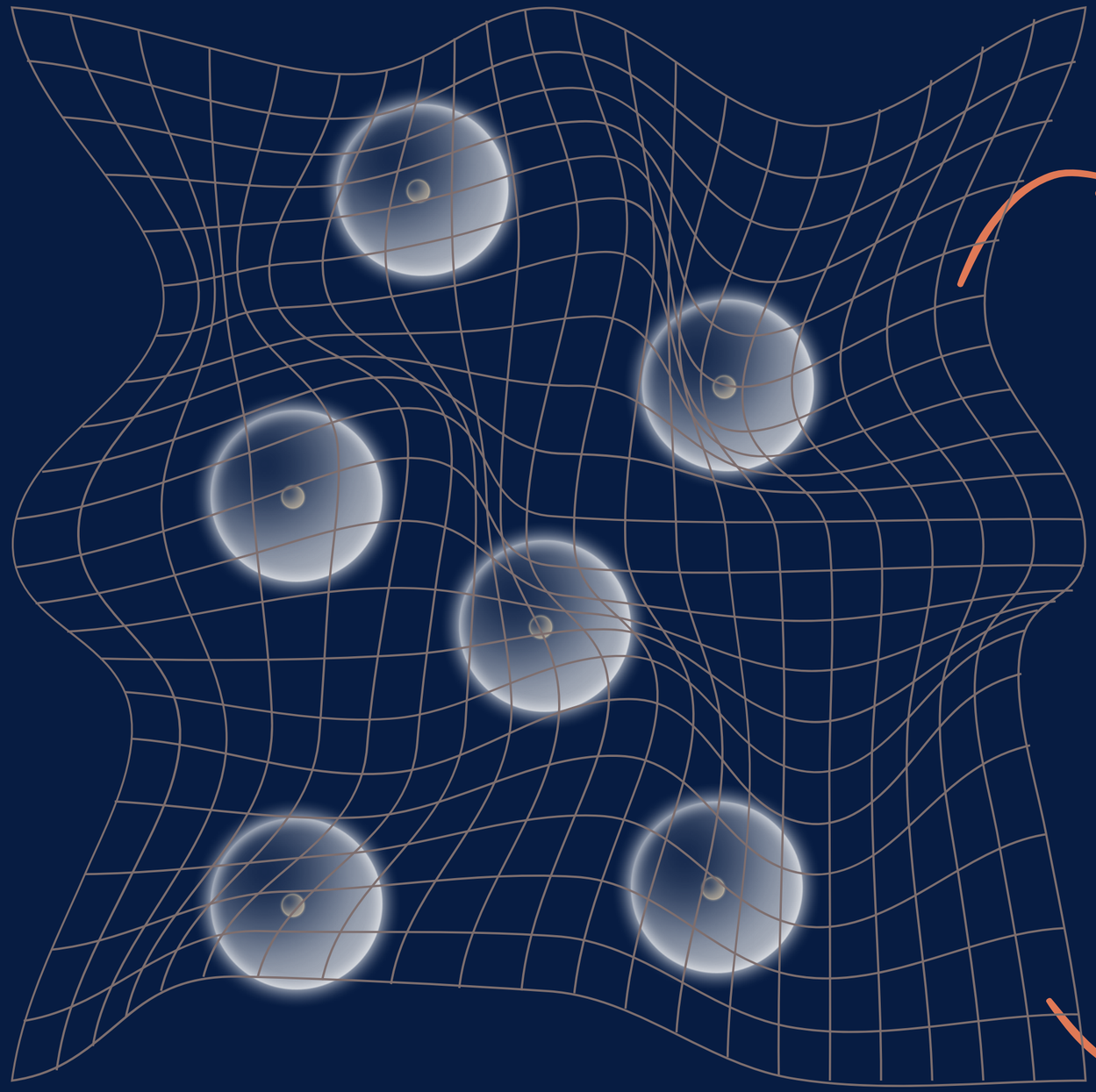
(Popov et al 2010)

$$n_{\mathrm{NS}}(\boldsymbol{r})\ P(T)\ P(B_0)$$

Assuming a model for the galactic neutron stars

The Idea

Conversion in NS magnetosphere



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$$n_{\rm NS}(\boldsymbol{r})\ \ P(T)\ \ P(B_0)$$

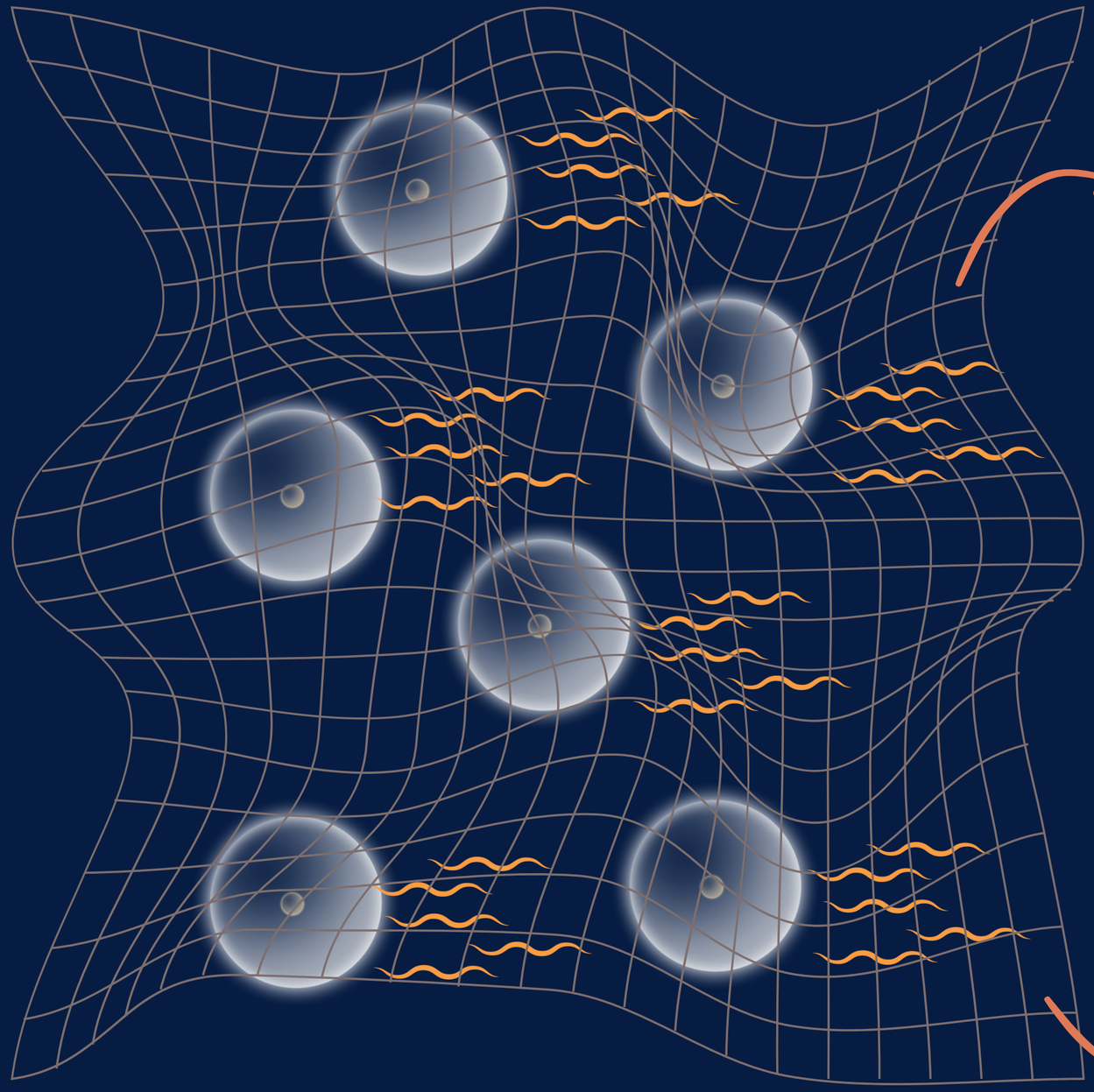
Assuming a model for the galactic neutron stars

GW background

$$f\ ,\ h_c$$

The Idea

Conversion in NS magnetosphere



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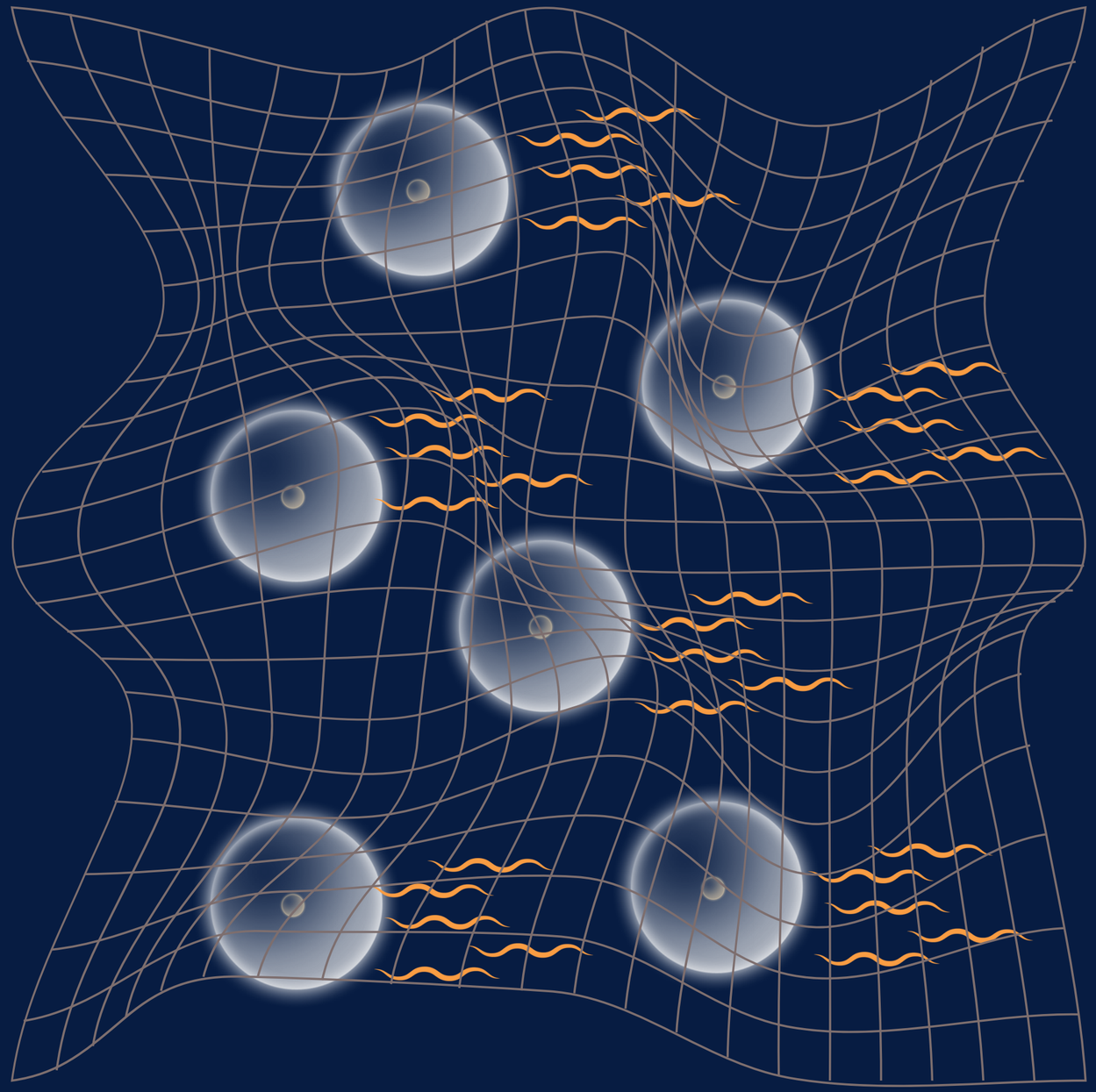
$$n_{\mathrm{NS}}(\boldsymbol{r})\ \ P(T)\ \ P(B_0)$$

Photon flux induced by the Gertsenshtein in each neutron star !

$$f\ ,\ h_c$$

The Idea

Conversion in NS magnetosphere

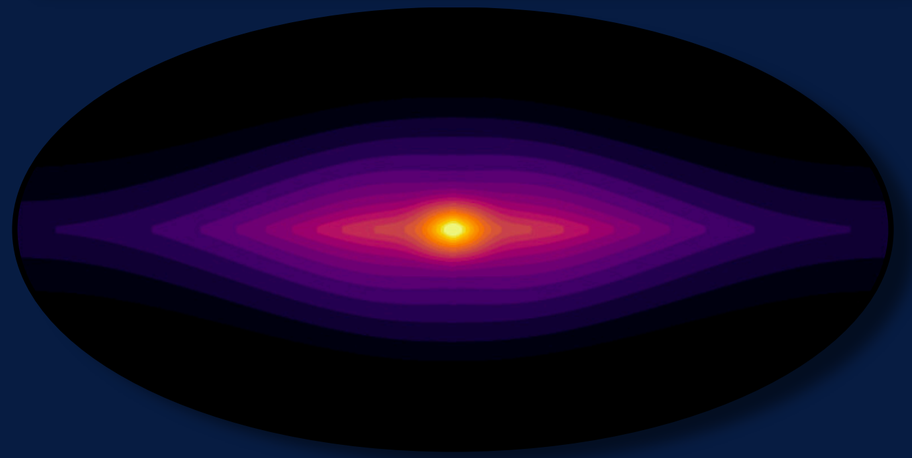


$$f = 10^{15}\,\mathrm{Hz}$$

$$h_c = 10^{-25}$$

$$\log\left(f \times \frac{\partial F_\gamma^{\mathrm{galac.}}}{\partial f}\right)\,[\mathrm{erg}/(\mathrm{cm}^2\,\mathrm{s}\,\mathrm{sr})]$$

$-18.5 \quad -18.0 \quad -17.5 \quad -17.0 \quad -16.5$



The Results

Constraints on the HFGW spectrum