

Discussion

GW Sources



**Realism
of SGWB
detection
program**



GW Sources

Inflation

B-modes @ CMB

extra ingredients: shift symm (U1, SU2,), ...

O(Φ^2) induced GWs: PBH, NG

Ema

David

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(p)Reheating

High Freq: unlikely observable, spectroscopy

Violation of relativistic bounds (CMB)

Eq. Of State

Dani

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1stO-PhT

EW @ BSM: Potentially observable @ LISA
BSM/Dark Sectors: observable @ any freq

Chiara ?

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Cosmic Strings

BSM/GUT: Observable multi-freq
NG I vs NG II vs Fld Th

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Realism of SGWB detection program

Computation

Accuracy
Fine-tuning

Detectability

Spectrum Reconstruction \rightarrow param \rightarrow physics
Signal separation / astrophysical SGWB
Other observables: NG, Chirality, Polarisation

**Realism
of SGWB
detection
program**

Computation

Accuracy: G vs nonG, Gauge-dep, Lattice vs Analytics,

Fine-tuning: Param. Choice

Detectability

Spectrum Reconstruction —> param —> physics

Signal separation / astrophysical SGWB

Other observables: NG, Chirality, Polarisation

Preheating

INFLATIONARY PREHEATING

Parameter Dependence (Peak amplitude)

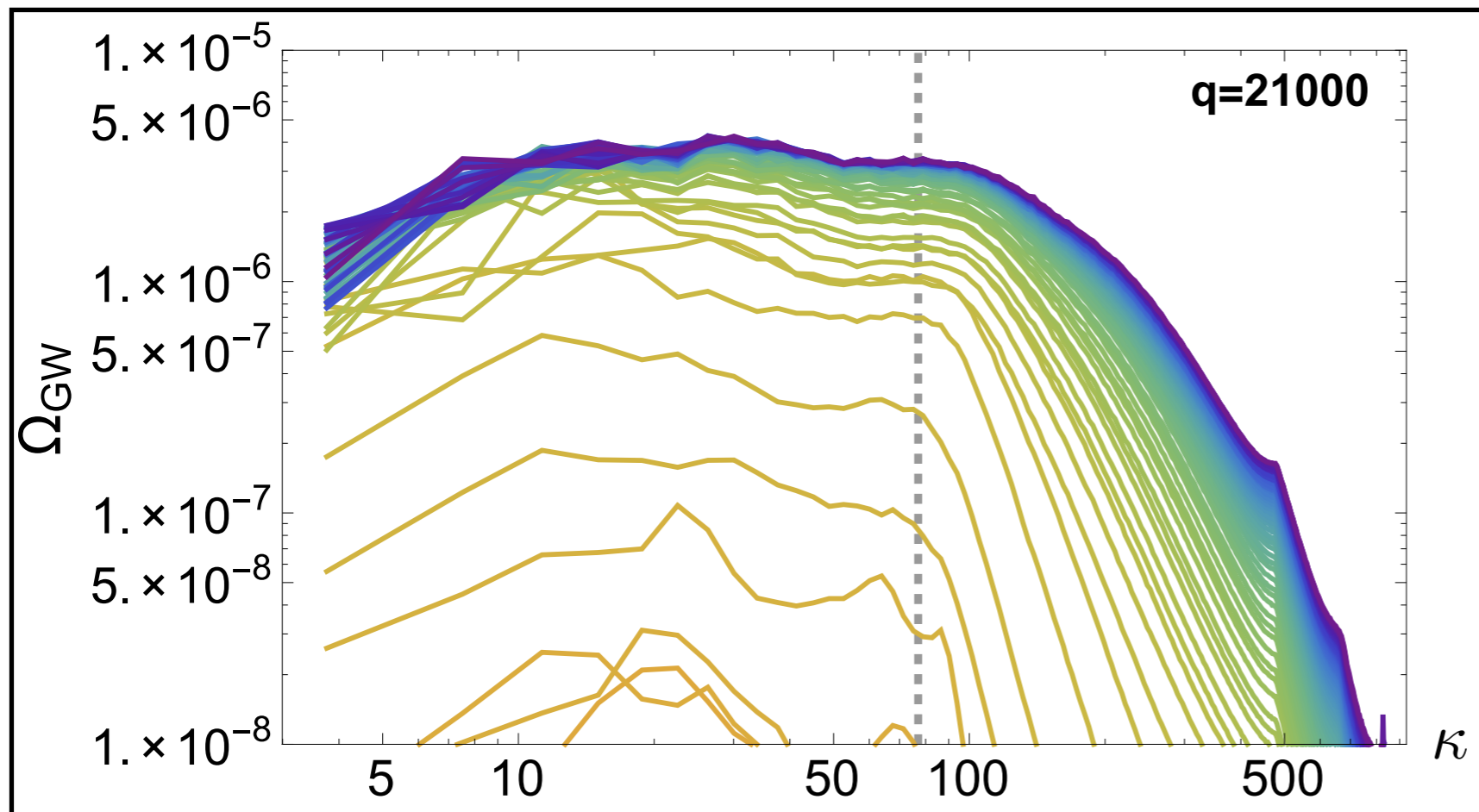
Chaotic Models:

$$\Omega_{\text{GW}}^{(o)} \sim A^2 \frac{\omega^6}{\rho m_p^2} q^{-1/2}$$

$$\omega^2 \equiv V''(\Phi_I)$$

$$q \equiv \frac{g^2 \Phi_i^2}{\omega^2}$$

Resonance
Param.



(DGF, Torrentí, PRD 2017)

INFLATIONARY PREHEATING

Parameter Dependence (Peak amplitude)

Chaotic Models: $\Omega_{\text{GW}}^{(o)} \sim 10^{-11}$, @ $f_o \sim 10^8 - 10^9$ Hz
Large amplitude! ... **at high Frequency!**

INFLATIONARY PREHEATING

Parameter Dependence (Peak amplitude)

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Large amplitude! ... **at high Frequency!**

Very unfortunate... no detectors there!

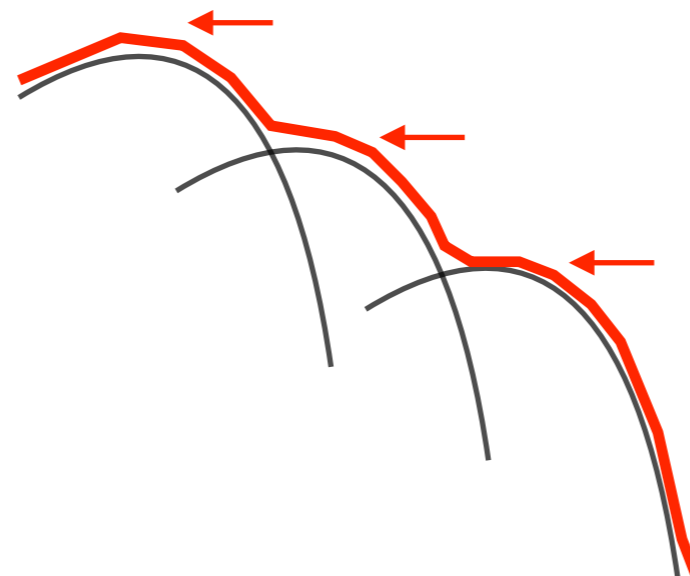


INFLATIONARY PREHEATING

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Large amplitude! ... **at high Frequency!**

$\Omega_{\text{GW}} \propto q^{-1/2}$ \longrightarrow **Spectroscopy of particle couplings?**



**different couplings
... different peaks?**

INFLATIONARY PREHEATING

Parameter Dependence (Peak amplitude)

Hybrid Models: $\Omega_{\text{GW}}^{(o)} \propto \left(\frac{v}{m_p}\right)^2 \times f(\lambda, g^2)$, $f_o \sim \lambda^{1/4} \times 10^9 \text{ Hz}$

$\Omega_{\text{GW}}^{(o)} \sim 10^{-11}$, @ $\begin{cases} f_o \sim 10^8 - 10^9 \text{ Hz} \\ f_o \sim 10^2 \text{ Hz} \end{cases}$

Large amplitude !
(for $v \simeq 10^{16} \text{ GeV}$)

$\lambda \sim 0.1$
(natural)

$\lambda \sim 10^{-28}$
(fine-tuning)

realistically speaking ...



Cosmic Strings

Cosmic Strings Network: Loop configurations

Cosmic string loop (length l) oscillates under tension μ

➔ emits GWs in a series of harmonic modes

Extra emission of GWs ! (Vilenkin '81)

and many others !

$$\frac{d\rho^{(o)}}{df} \equiv \Gamma G\mu^2 \int_{t_*}^{t_o} dt \left(\frac{a(t)}{a_o} \right)^3 \int_0^{\alpha/H(t)} dl l n(l, t) \mathcal{P}((a_o/a(t)) fl)$$

expansion history

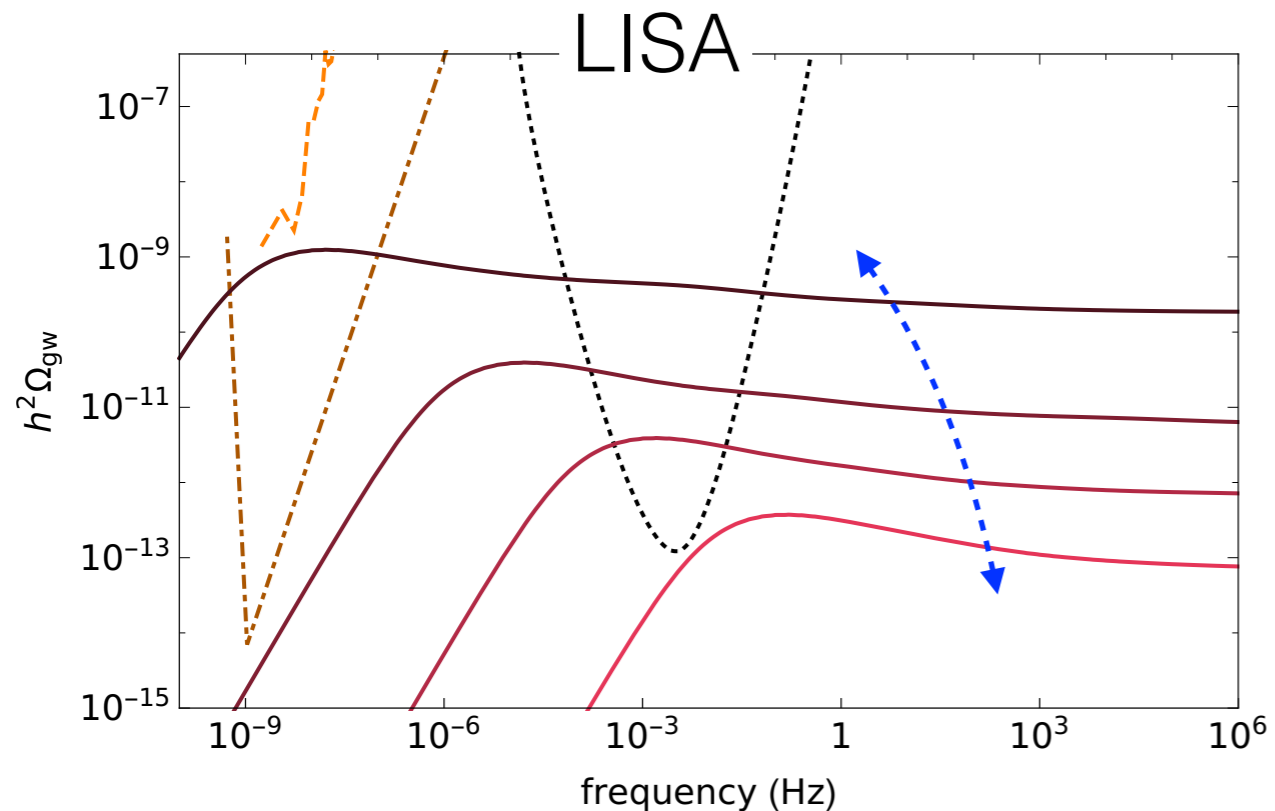
length

number density

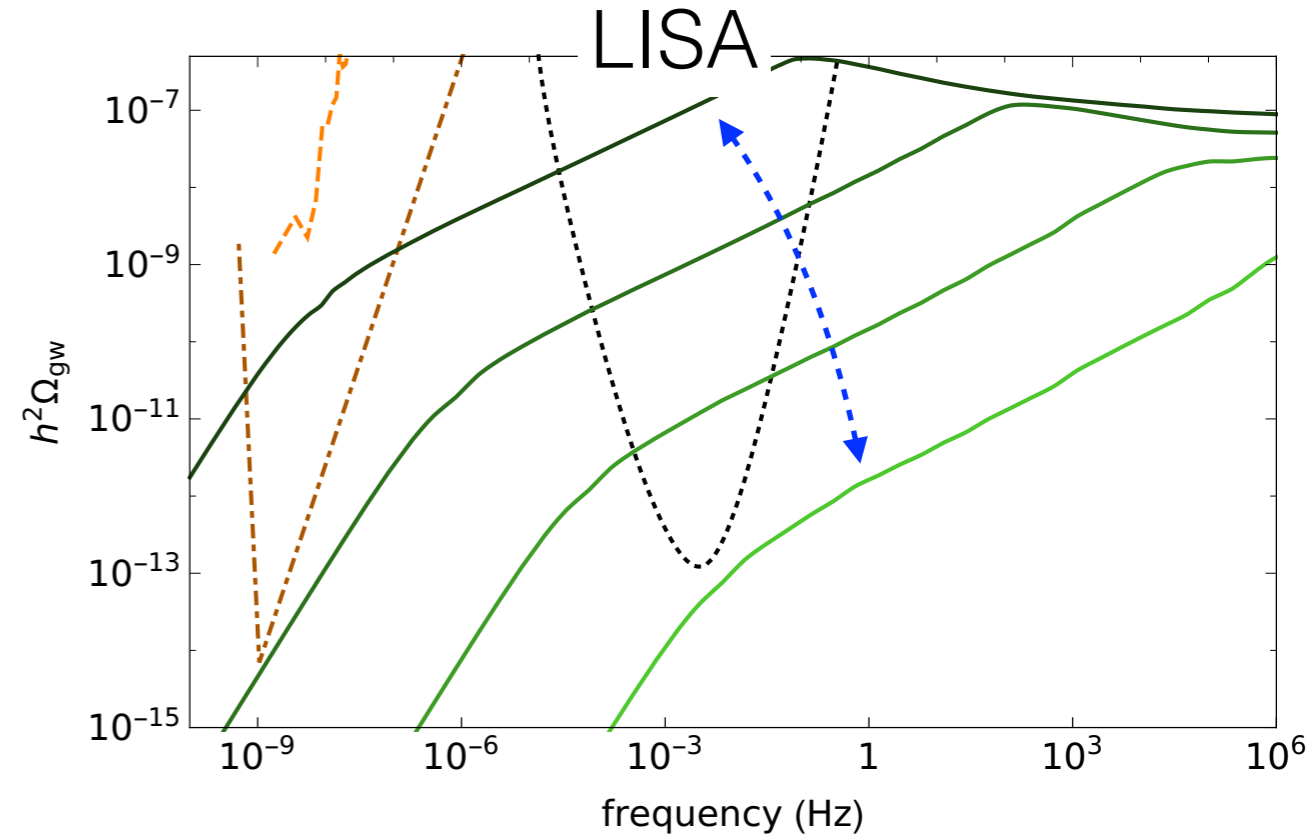
GW power emission
 $\propto 1/(fl)^{q+1}$
features
(kinks, cusps, ...)

Cosmic strings loops: GW background

Blanco-Pillado, Olum, Shlaer



Lorenz, Ringeval, Sakellariadou



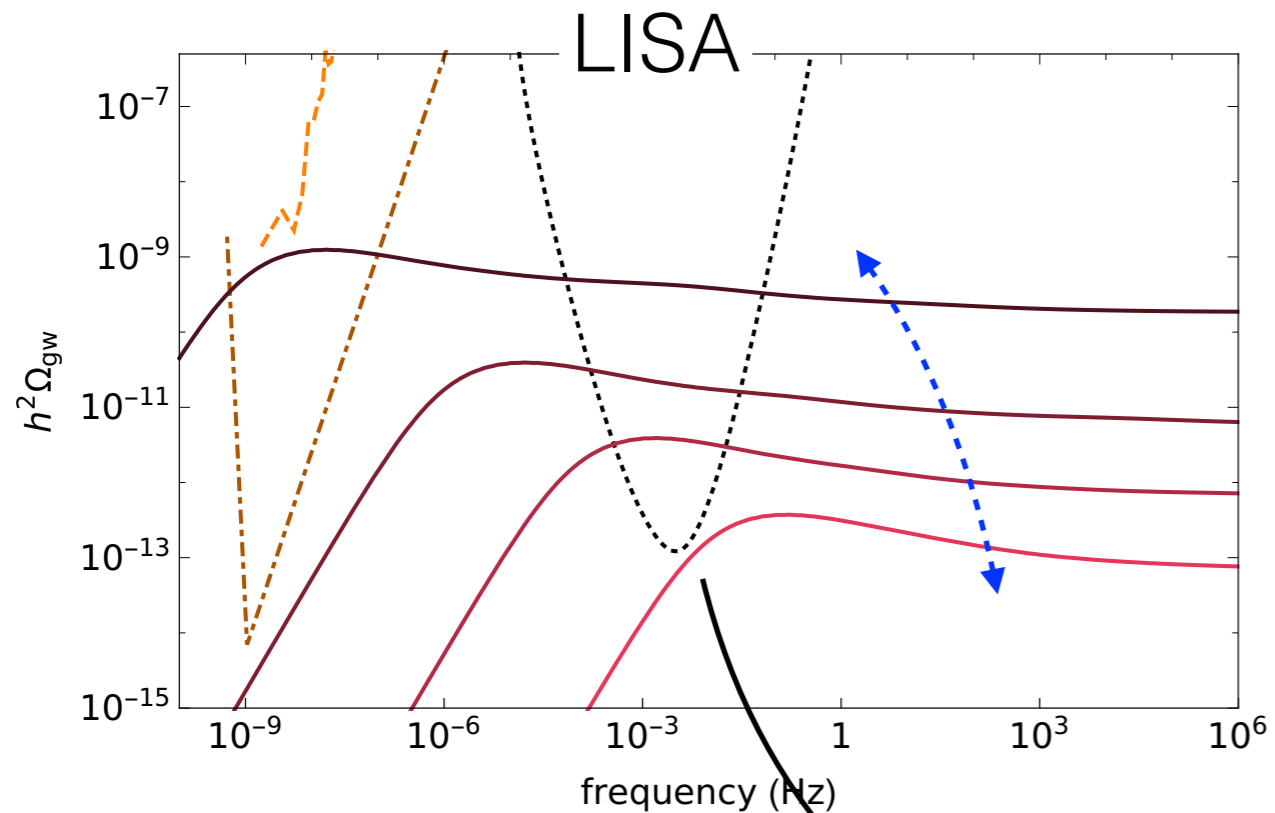
$$G\mu \sim 10^{-11} - 10^{-17}$$

Very large parameter space !

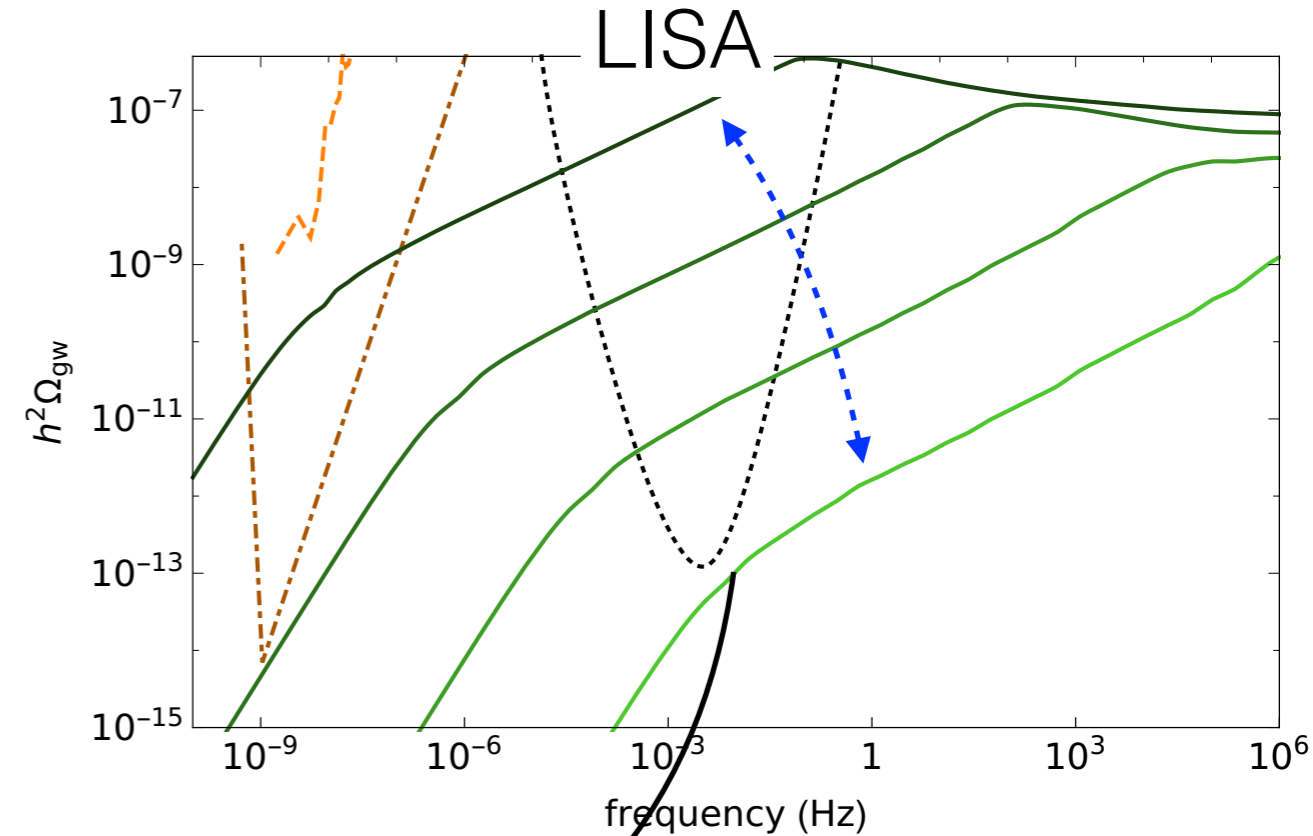
**LISA paper
1909.00819**

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$$G\mu \gtrsim 10^{-17}$$

Very large parameter space !

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GW background constrained by LISA

$$G\mu \gtrsim 10^{-17} \quad (v \gtrsim 10^{10} \text{ GeV})$$

CMB

PTA (today)

PTA (future)

$$G\mu \sim 10^{-7}$$

$$G\mu \sim 10^{-11}$$

$$G\mu \sim 10^{-14}$$

LISA improve:

$$\mathcal{O}(10^{10})$$

$$\mathcal{O}(10^6)$$

$$\mathcal{O}(10^3)$$

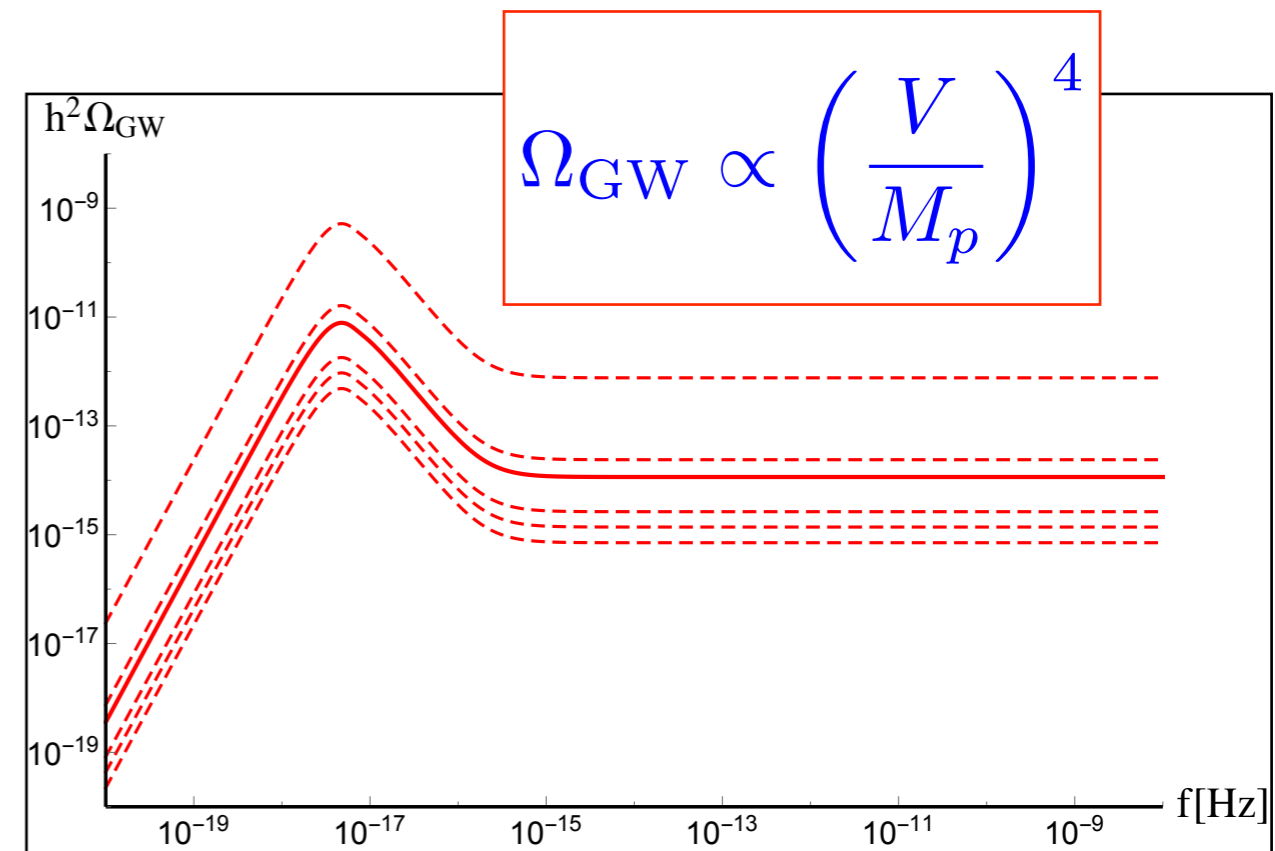
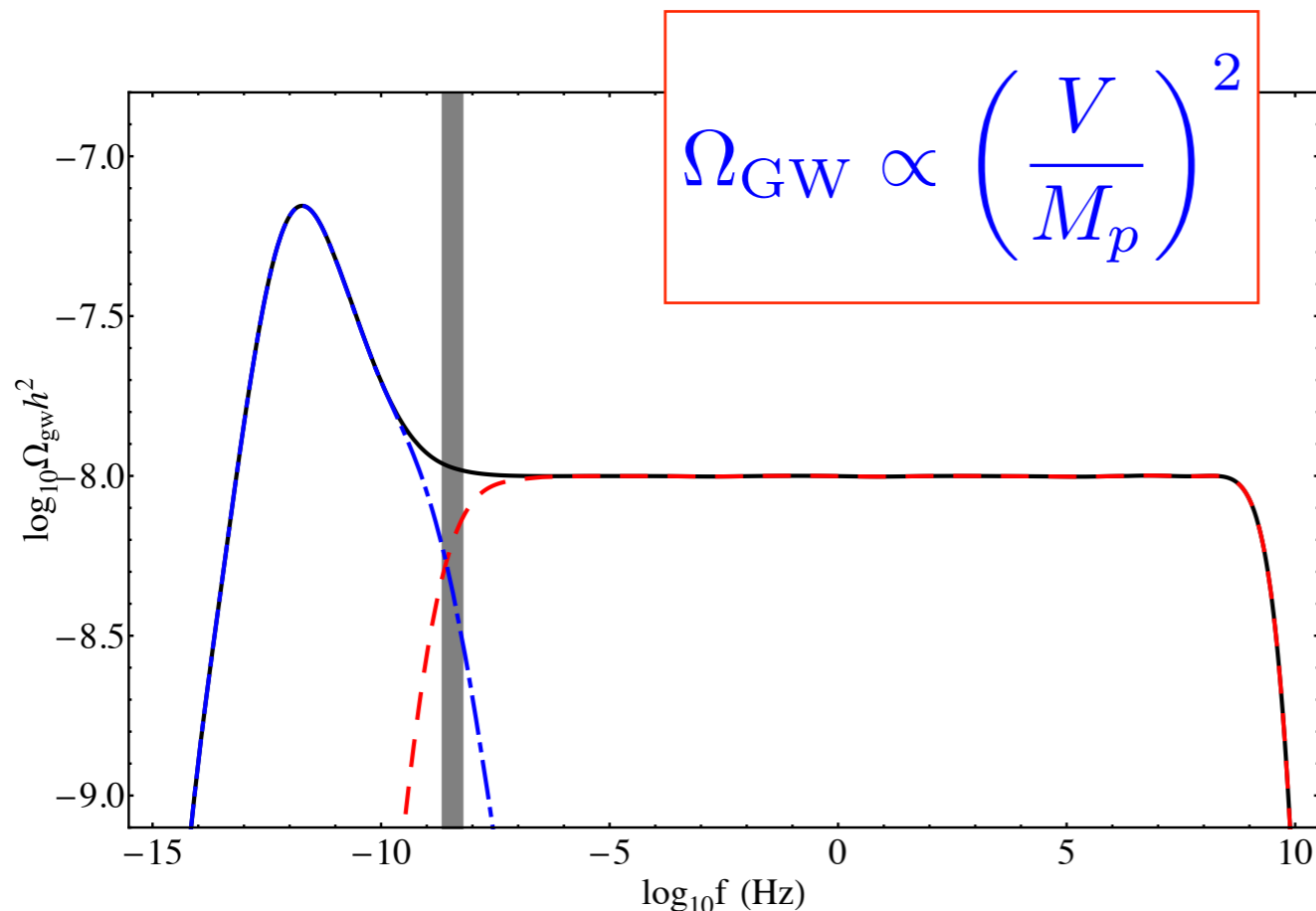
LISA

- * **Best constraints on Cosmic Strings**
- * **(actually only way to obtain them)**
- * **Discovery, or stringent constraints**

**LISA paper
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Cosmic Strings Network: Loop configurations

GW from string loops \neq GW from "Infinite"-Strings
(particular emission) (irreducible emission)



*Vilenkin, Vachaspati, Bouchet, Siemens et al,
Sanidas et al, Blanco-Pillado et al, ... 1981 - 2020*

*DGF, Hindmarsh, Lizarraga, Urrestilla,
work in progress 2013-2020*