Probing modified cosmology through gravitational wave signals from a first-order phase transition

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in collaboration with M. Lewicki and B. Świeżewska,
arXiv: 2502.18436, accepted in JHEP

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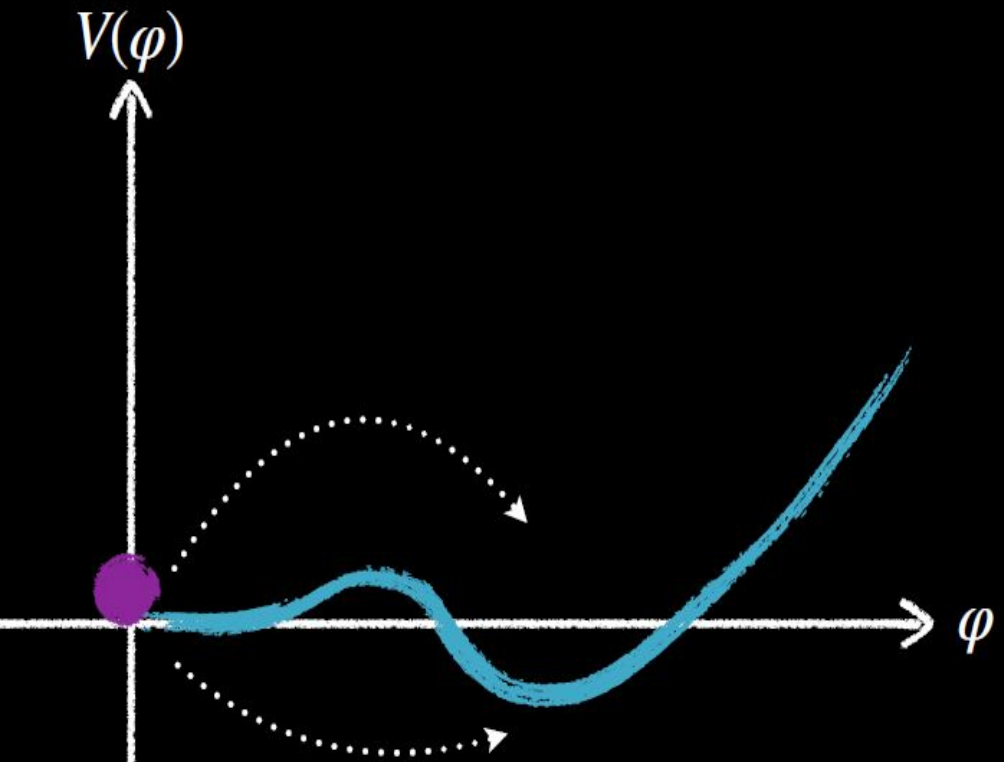
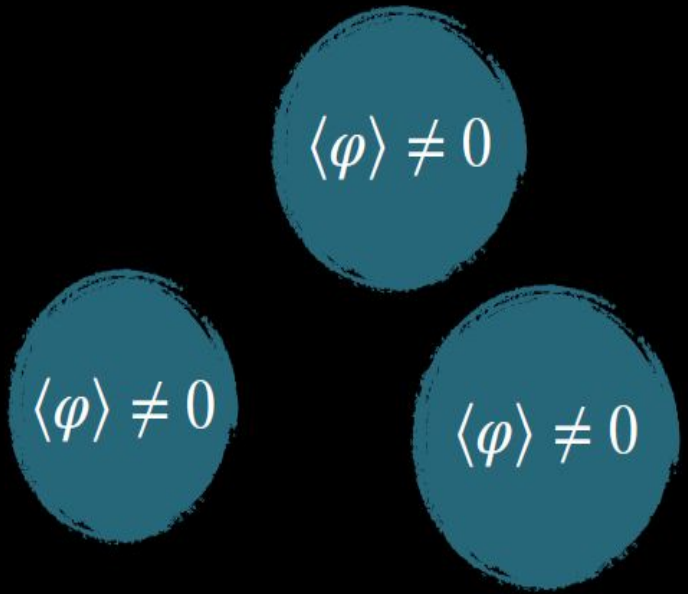
Outline of the talk.

1. Introduction.
2. The key idea. Evolution of the Universe after FOPT.
3. GW signal coming coming from FOPT?
4. Quick introduction to the Fisher Matrix.
5. Results of Fisher Estimation for LISA and ET
6. Conclusions.

FIRST-ORDER PHASE TRANSITION





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The key idea

For GW signal from supercooled phase transition how to:

- Differentiate between models?
- Get information about fundamental interactions?

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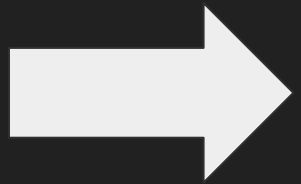

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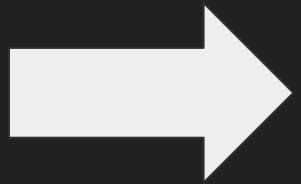

Our answer:

- Measurement of scalar field decay rate Γ/H, from the gravional wave spectra.

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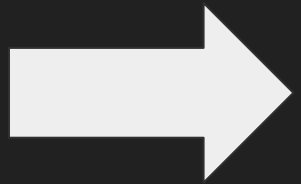

Our answer:

- Measurement of scalar field decay rate Γ/H, from the gravional wave spectra.
- Precise measurement of Γ/H, would serve as messenger about fundamental interactions.

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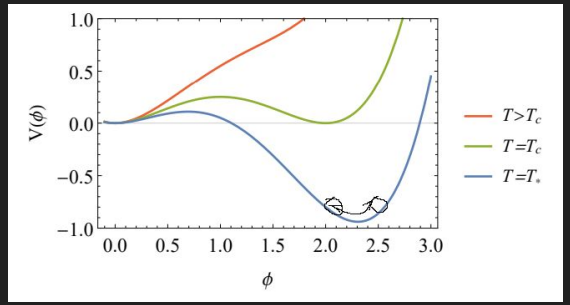
What is evolution after FOPT?

- Assume reheating is not instantaneous. Then we have period of Universe behaving like Matter Domination, due to oscillations of the field.



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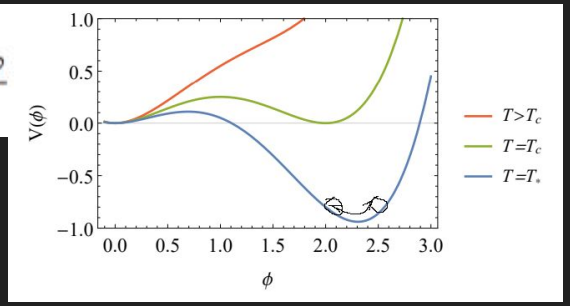
$$\dot{\rho}_R + 4H\rho_R = \Gamma_\varphi \rho_\varphi, \quad \dot{\rho}_\varphi + 3H\rho_\varphi = -\Gamma_\varphi \rho_\varphi, \quad H^2 = \frac{\rho_R + \rho_\varphi}{3M_P^2}$$



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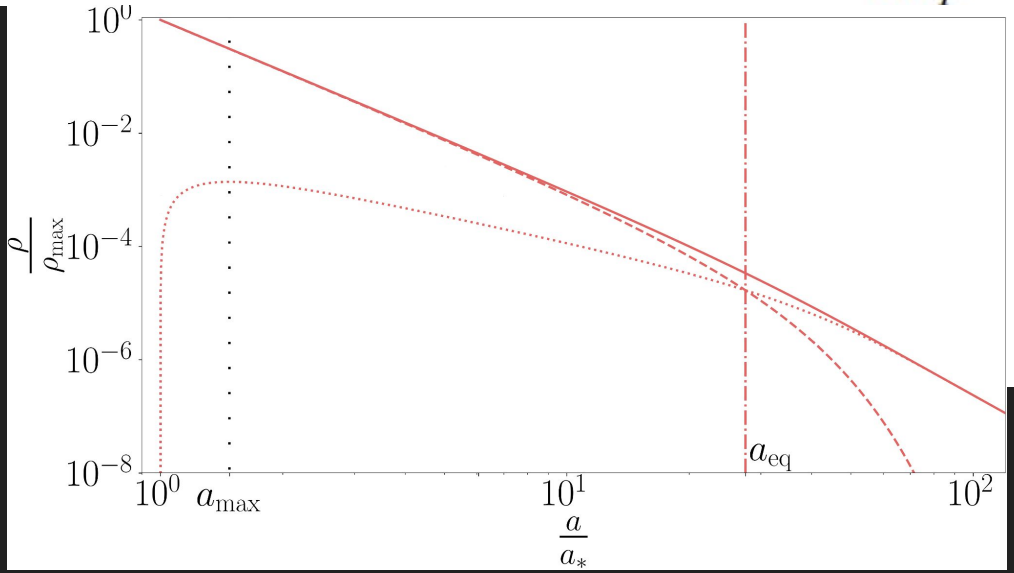
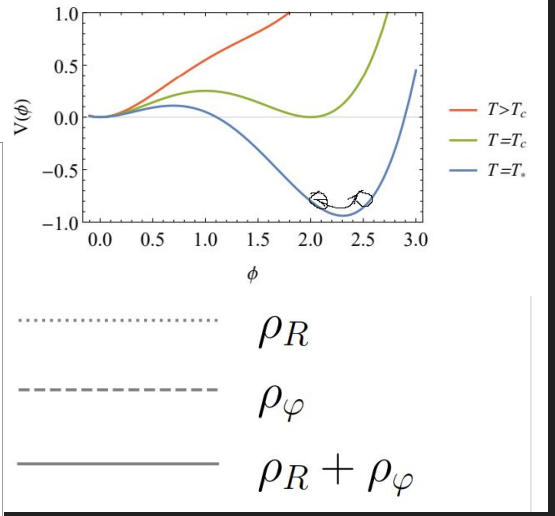
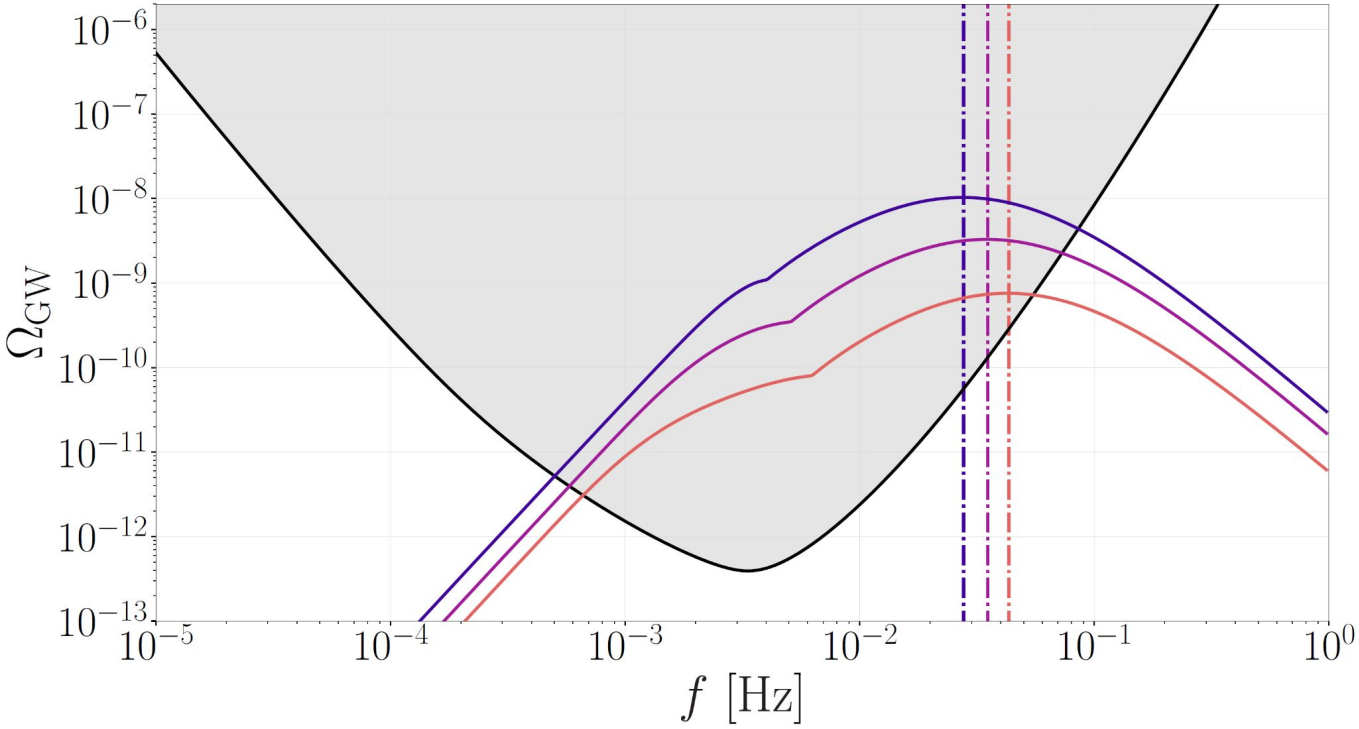


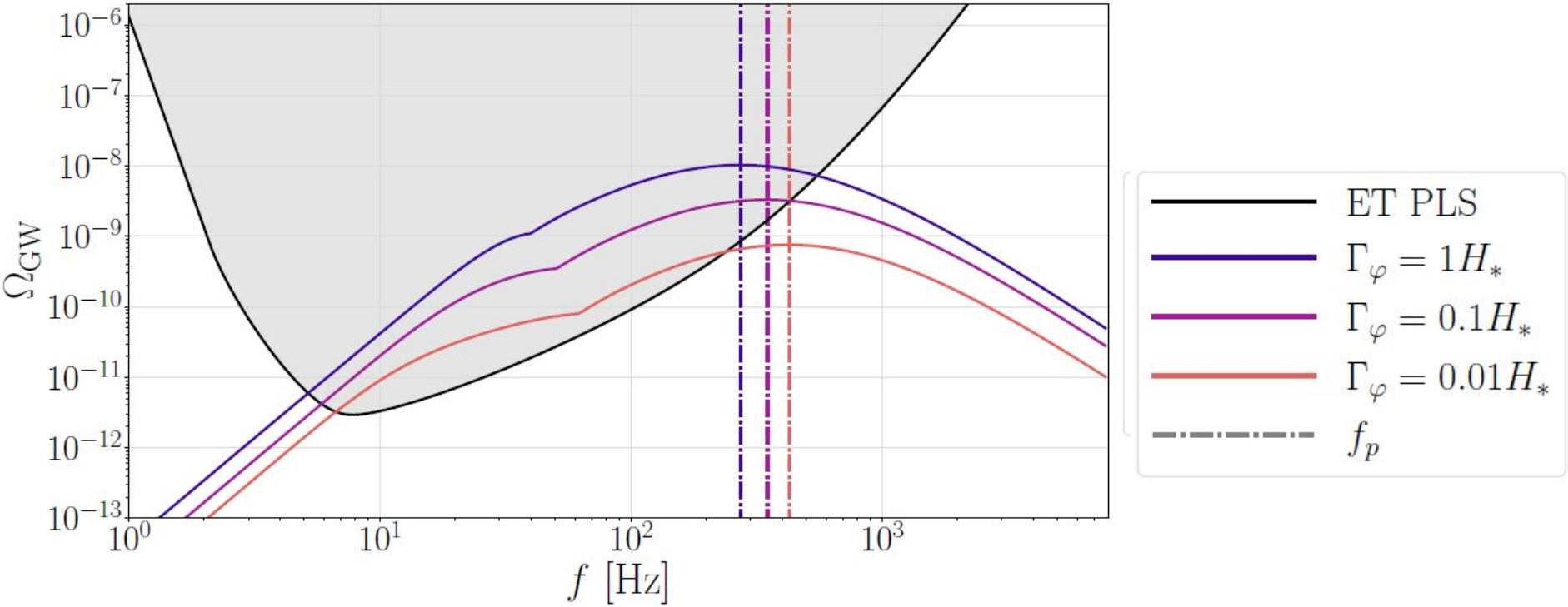


On the picture, energy density Γ/H=0.01.

Gravitational waves from supercooled phase transition in LISA.



Gravitational waves from supercooled phase transition in ET.



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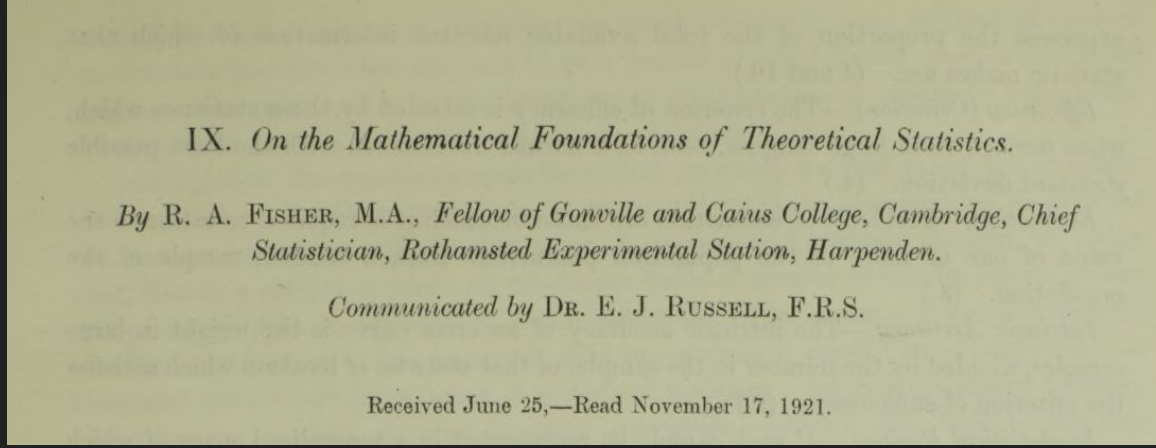
Quick Introduction to Fisher Estimation



IX. *On the Mathematical Foundations of Theoretical Statistics.*

By R. A. Fisher, M.A., *Fellow of Gonville and Caius College, Cambridge, Chief Statistician, Rothamsted Experimental Station, Harpenden.*

Communicated by Dr. E. J. Russell, F.R.S.

Received June 25,—Read November 17, 1921.

arXiv:2108.01167

$$F_{\alpha\beta} = T_{\rm obs} \int_{f_{\rm min}}^{f_{\rm max}} {\rm d}f \, \frac{\frac{\partial \Omega_{\rm GW}}{\partial \theta_\alpha} \frac{\partial \Omega_{\rm GW}}{\partial \theta_\beta}}{\left(\Omega_{\rm noise} + \Omega_{\rm GW}\right)^2}$$

The inverse of the Fisher matrix gives the squared covariance matrix

$$\sigma^2 = F^{-1} \, .$$

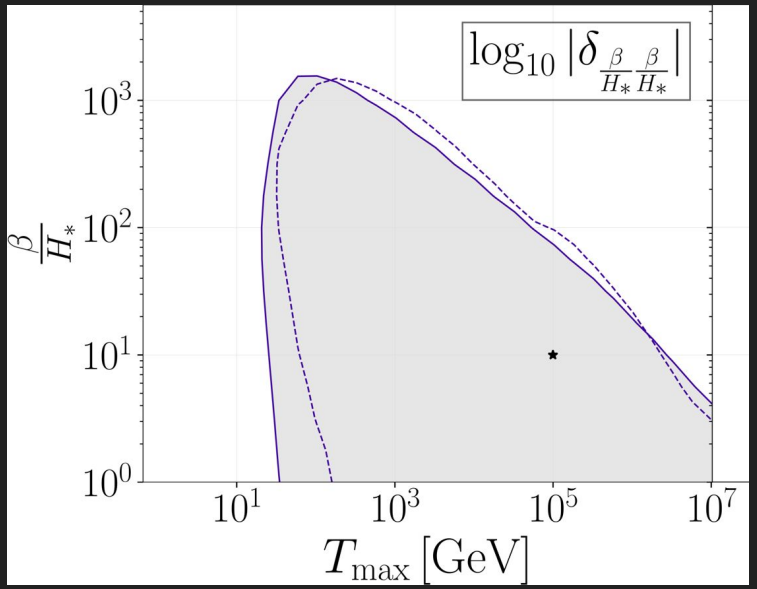
LISA CONSORTIUM Laser Interferometer Space Antenna

Ref : LISA-LCST-SGS-TN-001	
Issue : 1	Revision : 0
Date : 2021/08/04	Page : 1/ 42

LISA Sensitivity and SNR Calculations

N/Ref :	LISA-LCST-SGS-TN-001
Title	**LISA Sensitivity and SNR Calculations**
Abstract	This Technical Note (LISA reference LISA-LCST-SGS-TN-001) describes the computation of the noise power spectral density, the sensitivity curve and the signal-to-noise ratio for LISA (Laser Interferometer Antenna). It is an applicable document for ESA (European Space Agency) and the reference for the LISA Science Requirement Document.

Results: relative error and detectability in LISA



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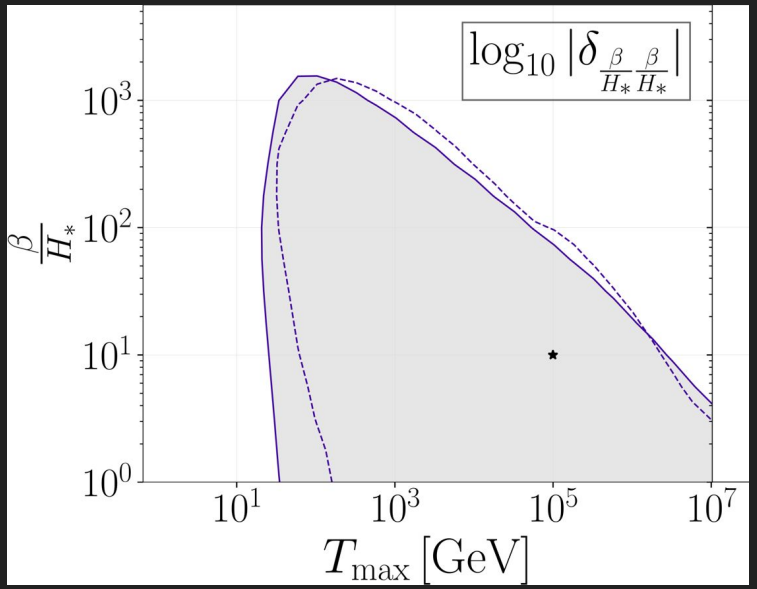
Results: relative error and detectability in LISA

~Amplitude of signal



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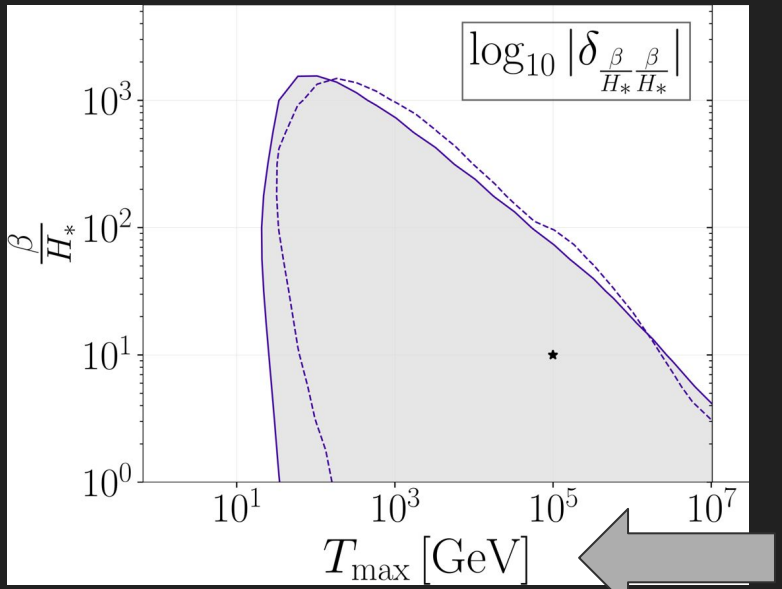

~ Temperature of reheating

~Frequency of the signal

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Results: relative error and detectability in LISA

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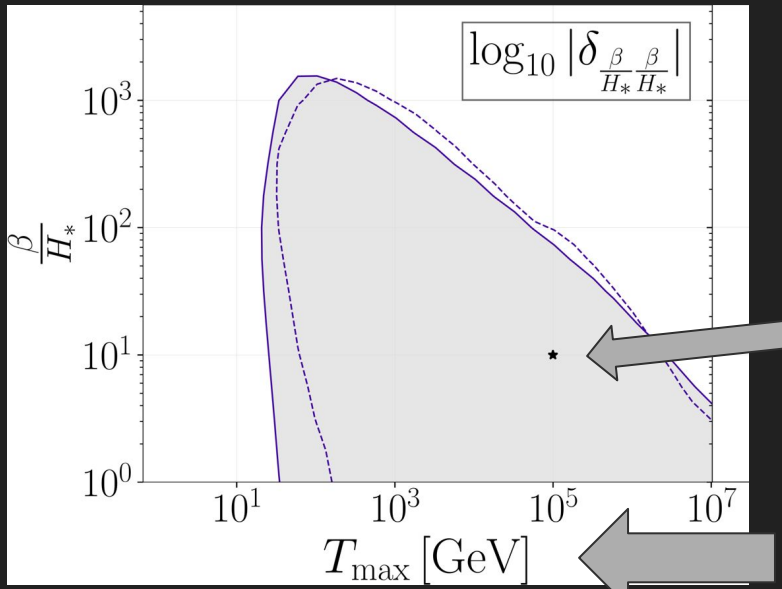

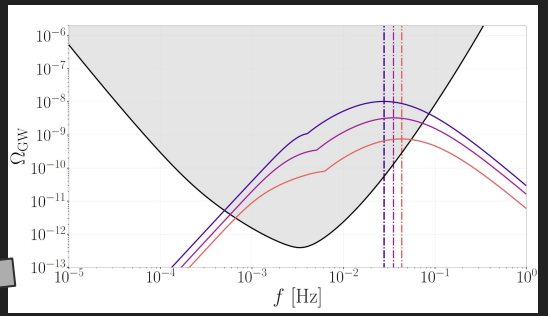

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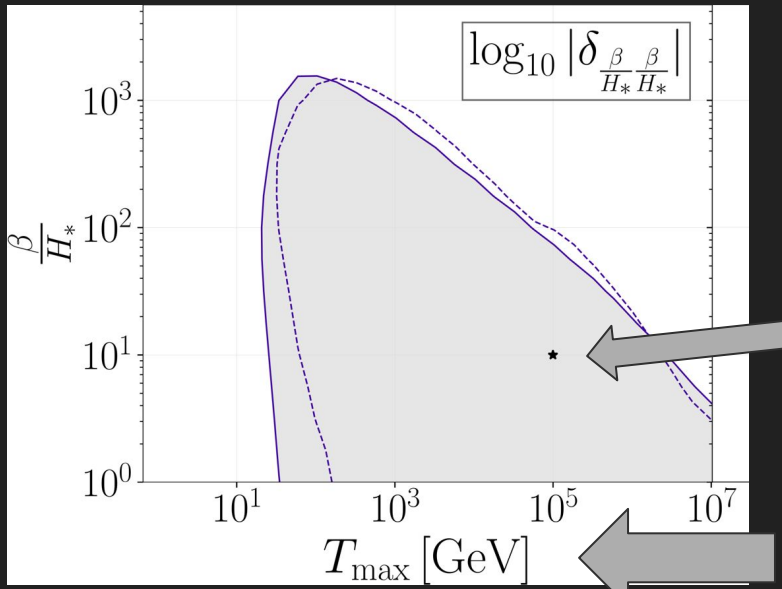

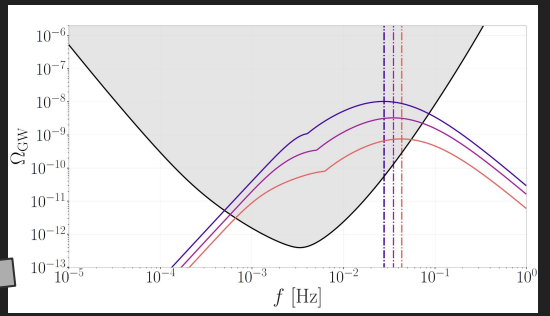

~ Temperature of reheating

~Frequency of the signal

$\Gamma_\varphi = 1H_*$

$\log_{10}\delta_{xy} = -1$

SNR = 10

Relative Error 10%

Border of Detection

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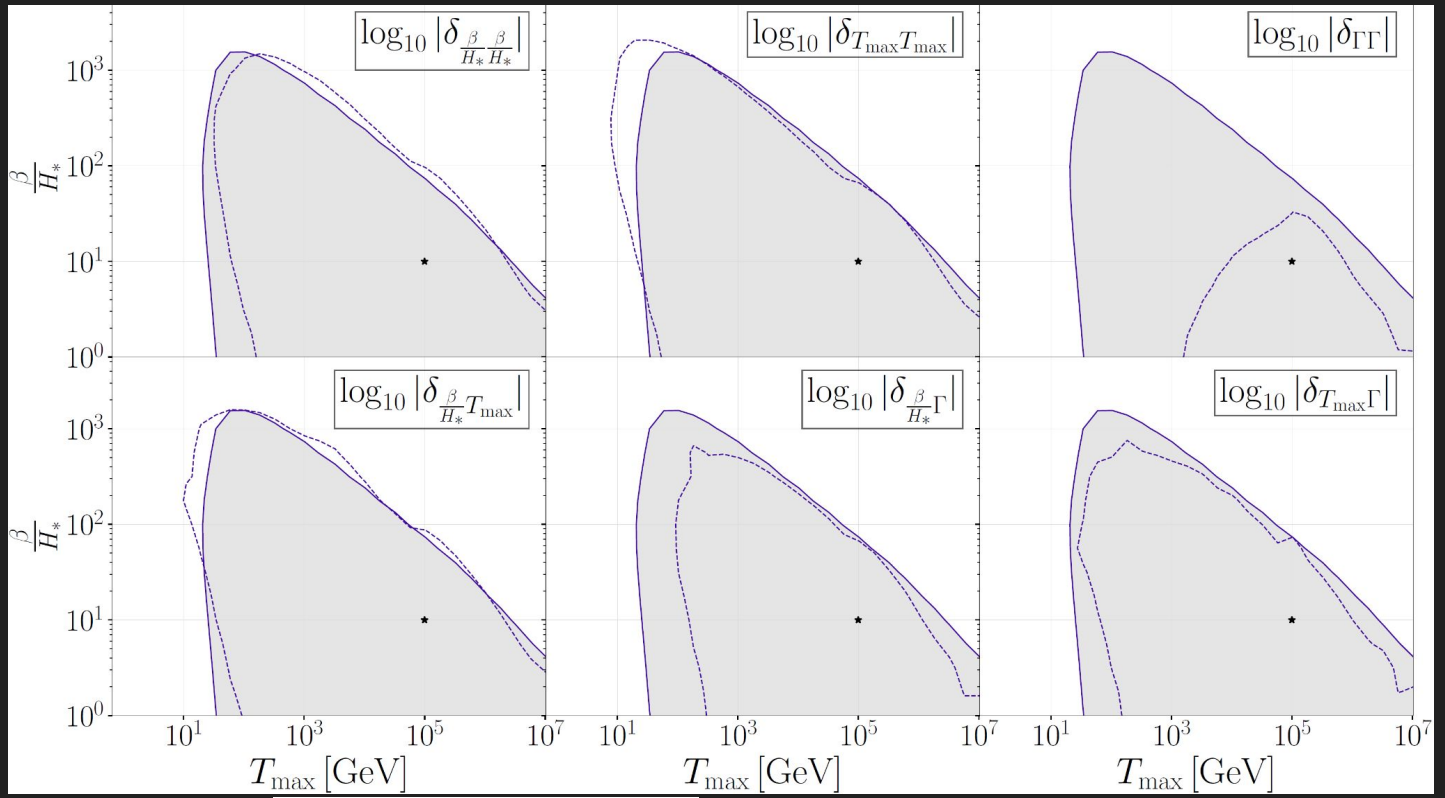
Results: relative error and detectability in LISA



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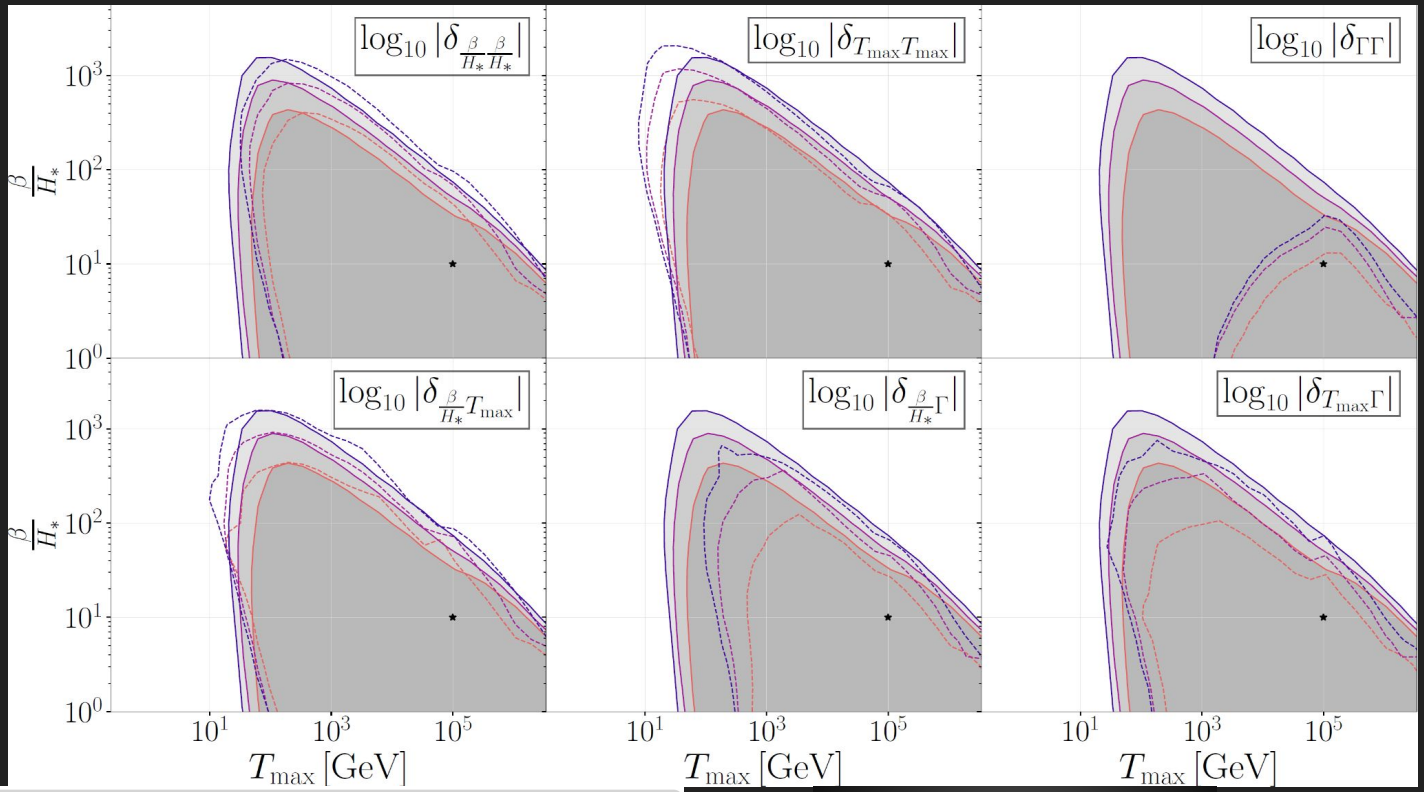
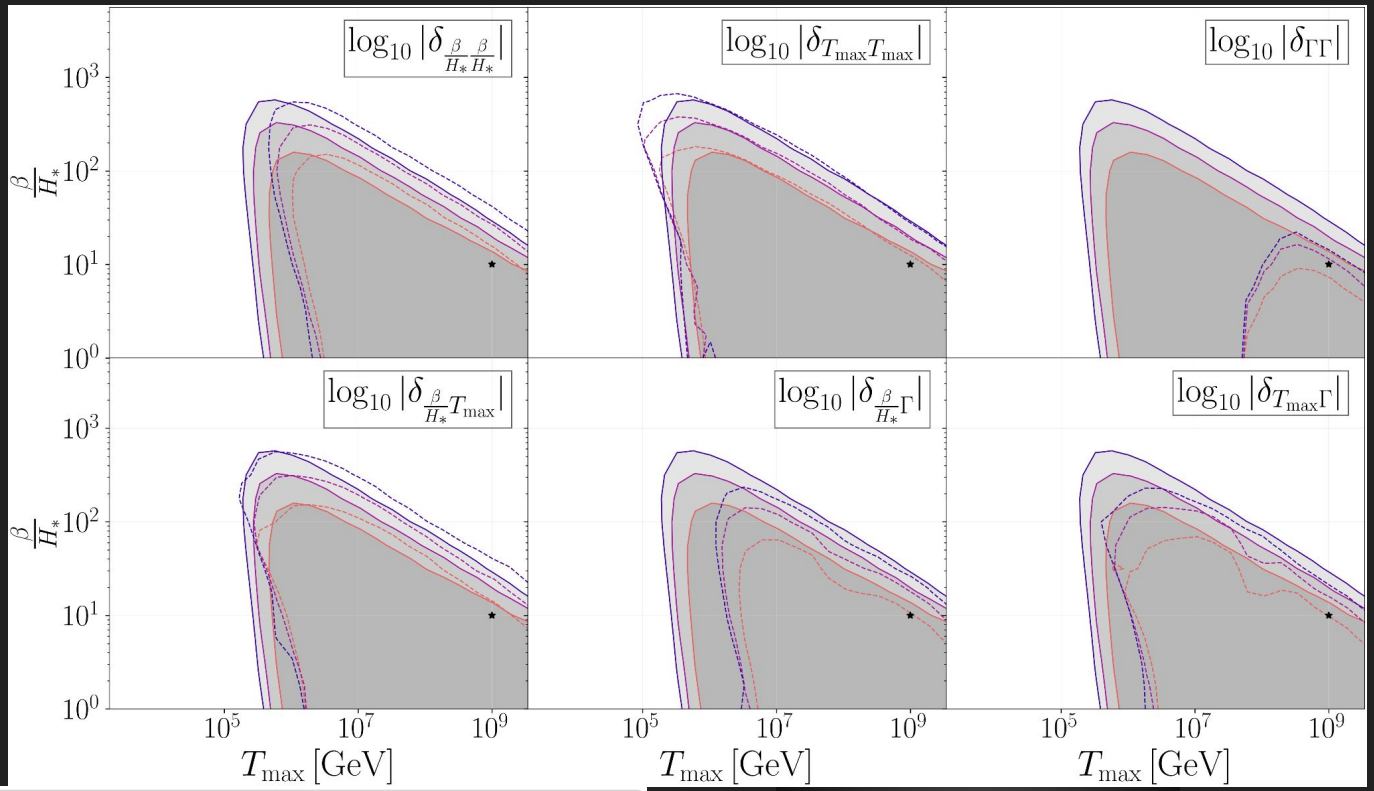


Results: relative error and detectability in ET



Conclusions

- Observation of GW signal in LISA/ET from FOPT

10 % accuracy of temperature of reheating and β/H.

Link to the paper.
Arxiv:2502.18436

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10 % accuracy of temperature of reheating and β/H.

- Determining Γ/H would require a very strong signal, which might be realized in nature. For example the are some, which conformal models predict such signal.
- Gravitational wave may give us information about fundamental physics models.

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