A Search for Intermittent Gravitational-Wave Backgrounds (GWB)

Kevin Turbang*, Jessica Lawrence, Andrew Matas, Nick van Remortel, Arianna Renzini, Joseph Romano

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Superposition of unresolved binary black hole (BBH) mergers leads to a BBH GWB

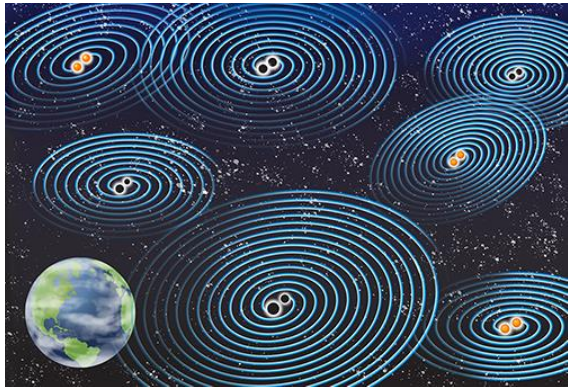


Figure: APS, Carin Cain

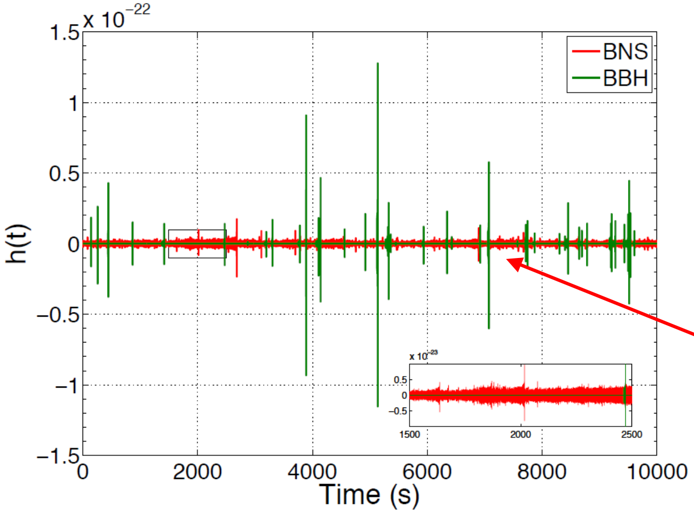
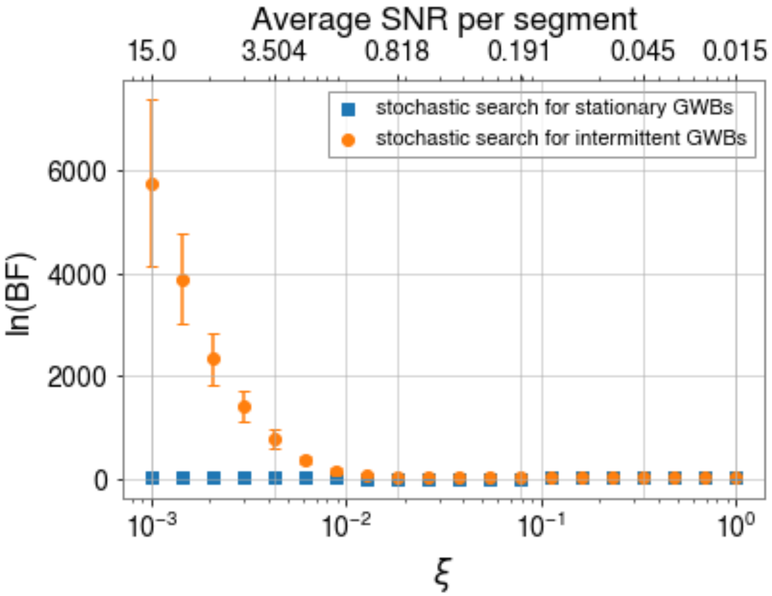


Figure: B.P. Abbott *et al.* Phys. Rev. Lett. **120**, 091101

- BBH merger occurring every few minutes
- In band only for a few seconds

GWB from BBH is **intermittent** ("popcorn-like")



Our proposed search for an intermittent stochastic gravitational-wave background recovers the averaged power of the bursts for simple toy models and **outperforms** the standard stationary search for low duty cycles

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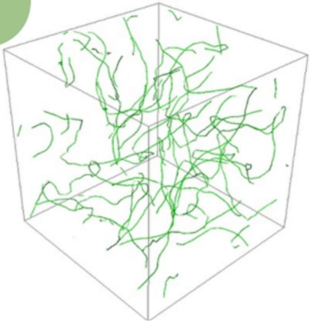
fwo

Stochastic gravitational waves from long cosmic strings

arXiv:2205.04349,arXiv:2104.14231

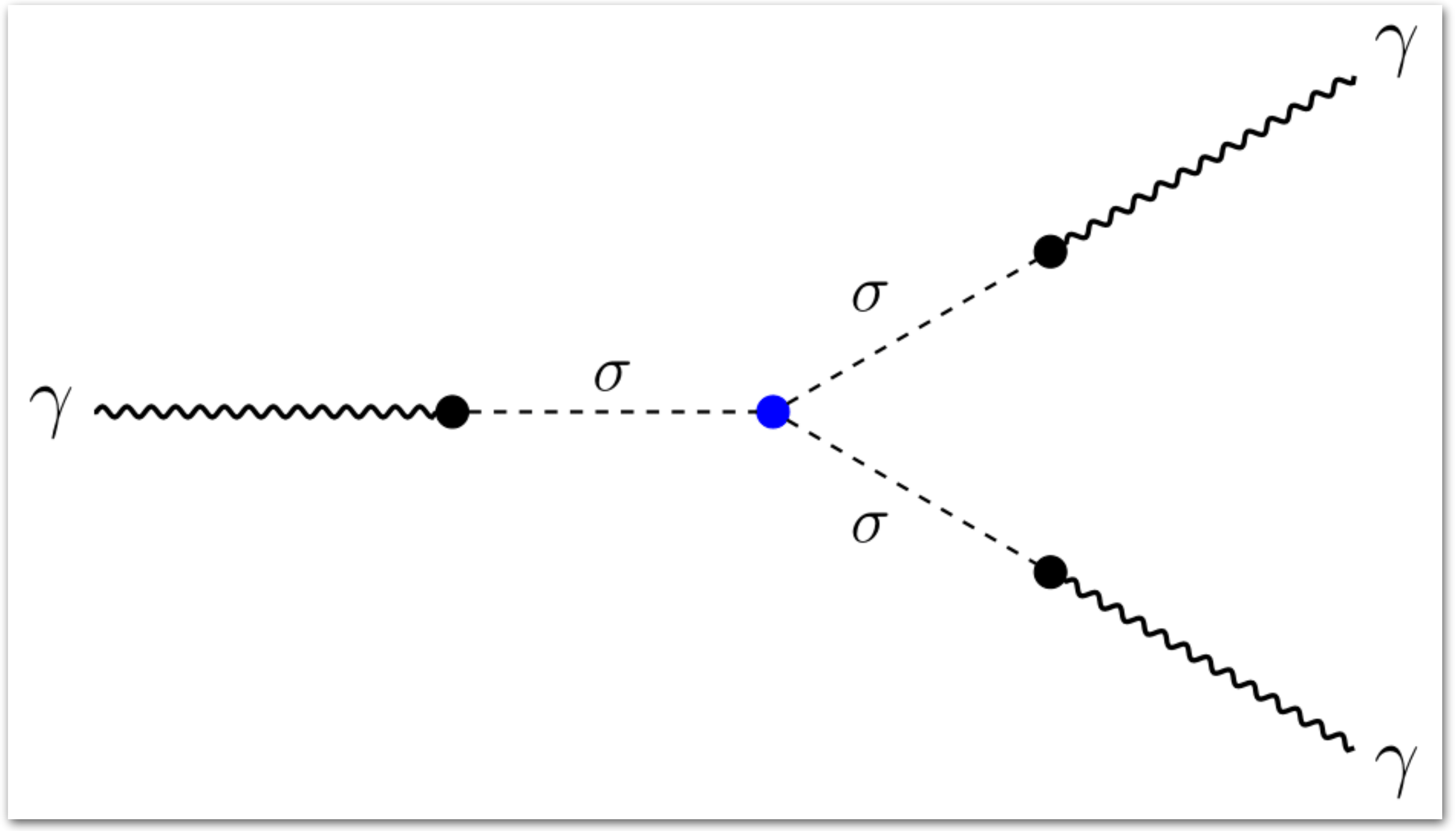


Probing Inflation with SGWB

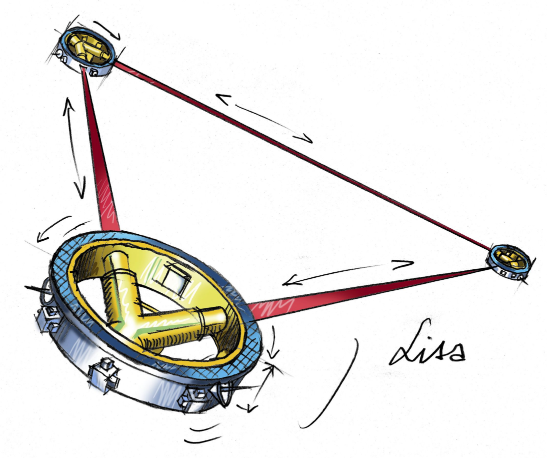
Ameek Malhotra, GWO 2022

Single field vs Multi-field signatures

non-Gaussianity

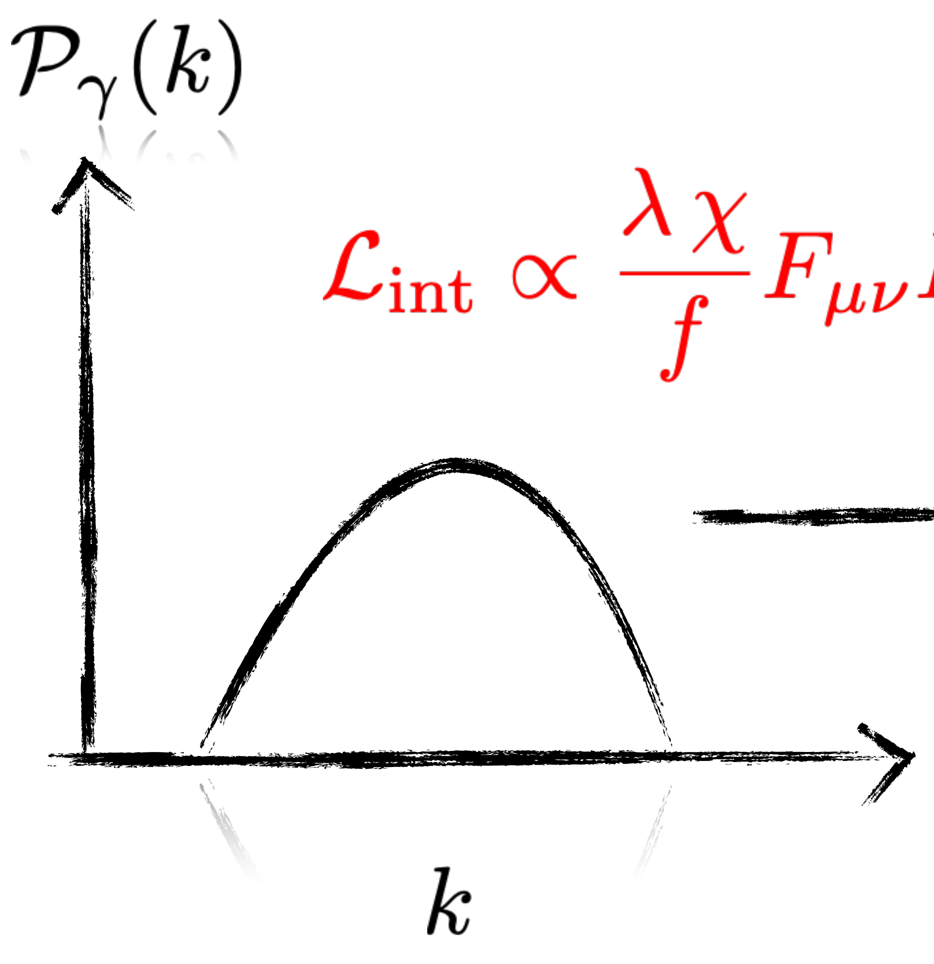


What can we learn about σ?

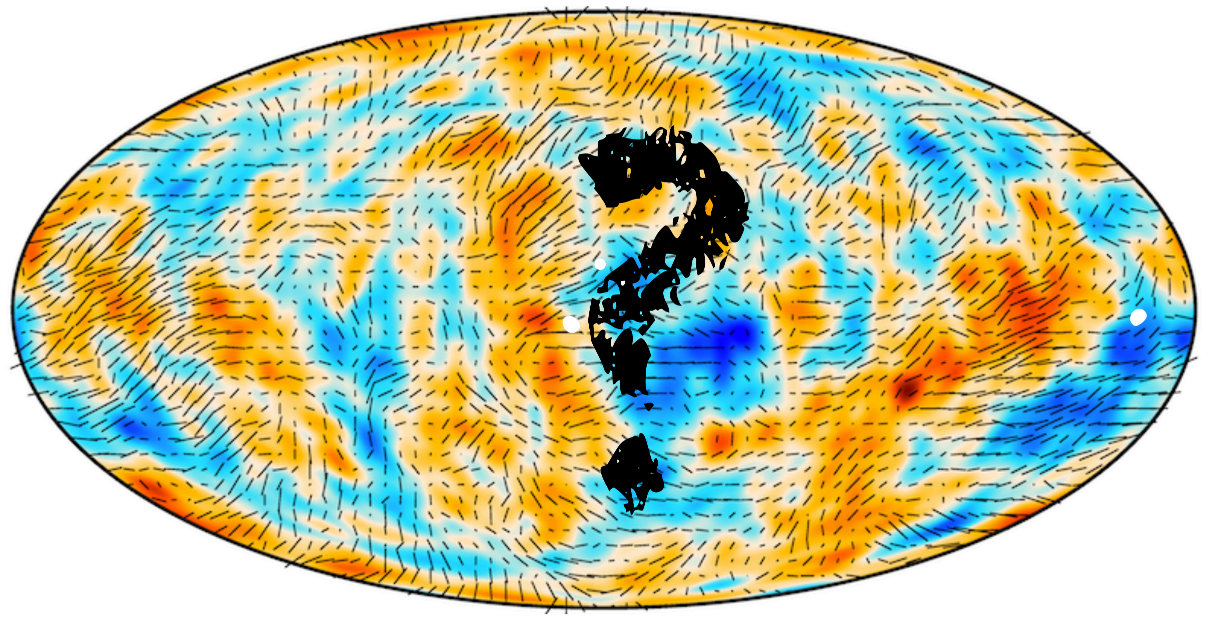


JCAP03(2021)088 and *JCAP02(2022)040*

Spectral Shape



$$\mathcal{L}_{\rm int} \propto \frac{\lambda\chi}{f} F_{\mu\nu}\tilde{F}^{\mu,\nu}$$



arxiv:2209.00827

Bayesian parameter estimation for targeted anisotropic gravitational-wave background

PennState

LIGO DCC : G2201440-v1

Leo Tsukada

Email : lqt5311@psu.edu

- Can we do PE with anisotropic GW background ? ➡ Yes!

  - **Cross spectrum density (CSD)**

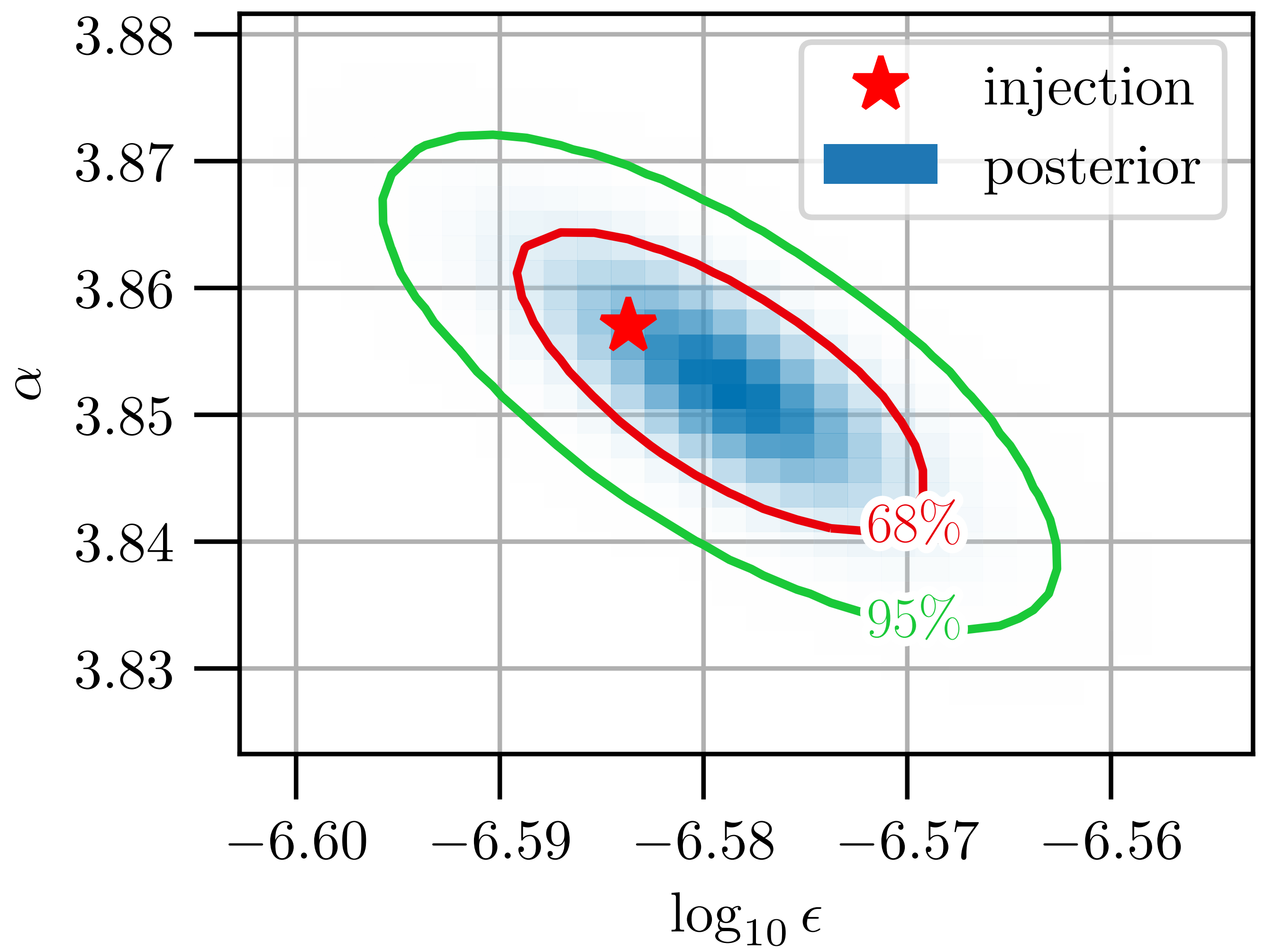
$$C(f,t) \equiv \frac{2}{\tau}\tilde{s}_1(f,t)\tilde{s}_2^*(f,t) \Rightarrow \langle C(f,t)\rangle = \underbrace{\gamma_\mu(f,t)}_{\text{Overlap reduction function}}\underbrace{\mathcal{P}_\mu(f,\{\vec{\theta}\})}_{\text{Anisotropy model}}$$

  - **Likelihood expression**

$$p\left(\{C_{ft}\}\middle|\{\epsilon,\vec{\theta'}\};\ell_{\max},\bar{\mathcal{P}}_{\ell m}\right) \propto \exp\left\{\sum_{f,t}\frac{\left|C(f,t)-\epsilon\bar{H}(f;\{\vec{\theta'}\})\gamma_\mu(f,t)\bar{\mathcal{P}}_\mu\right|^2}{P_1(f,t)P_2(f,t)}\right\}$$

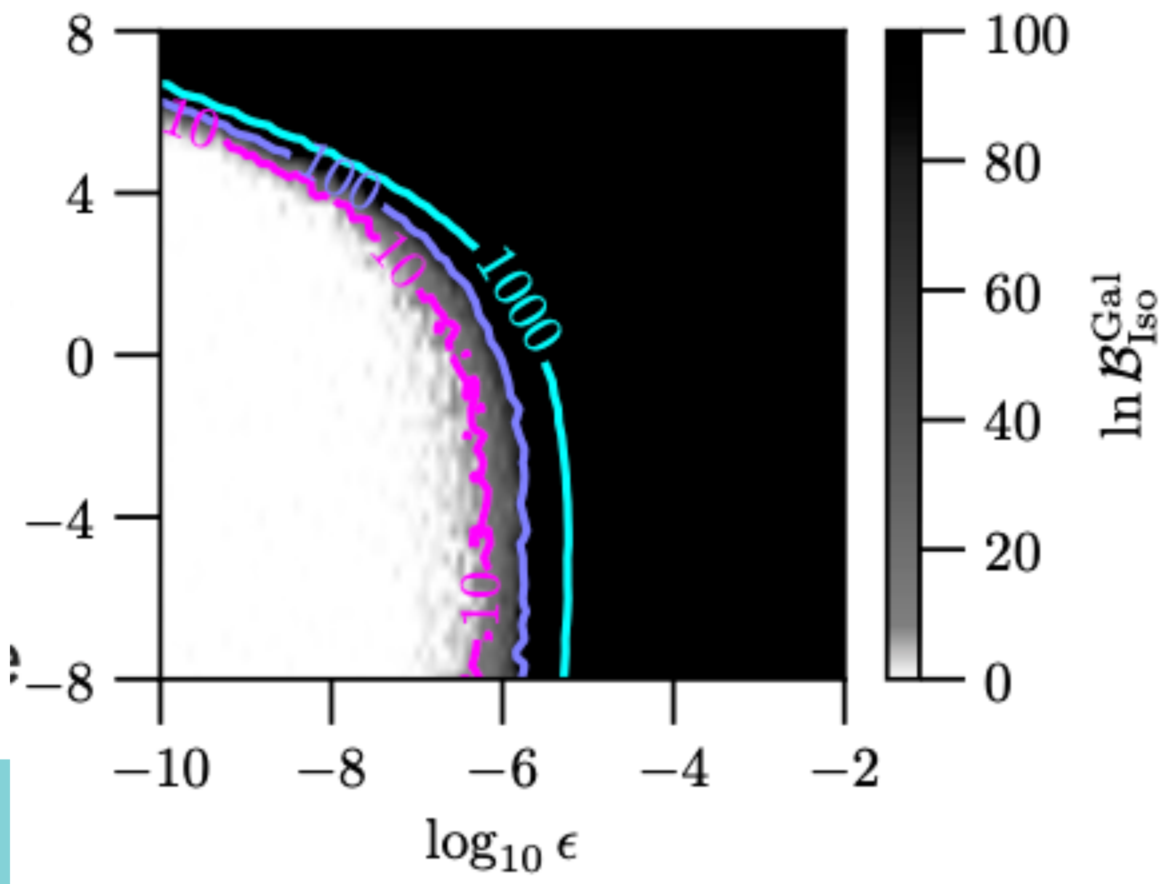
$\mathcal{P}_{\ell m} = \epsilon\bar{\mathcal{P}}_{\ell m}$ (fixed), $\{\vec{\theta}\}$: model parameters, $\ell_{\max}$: cut off scale

Posterior

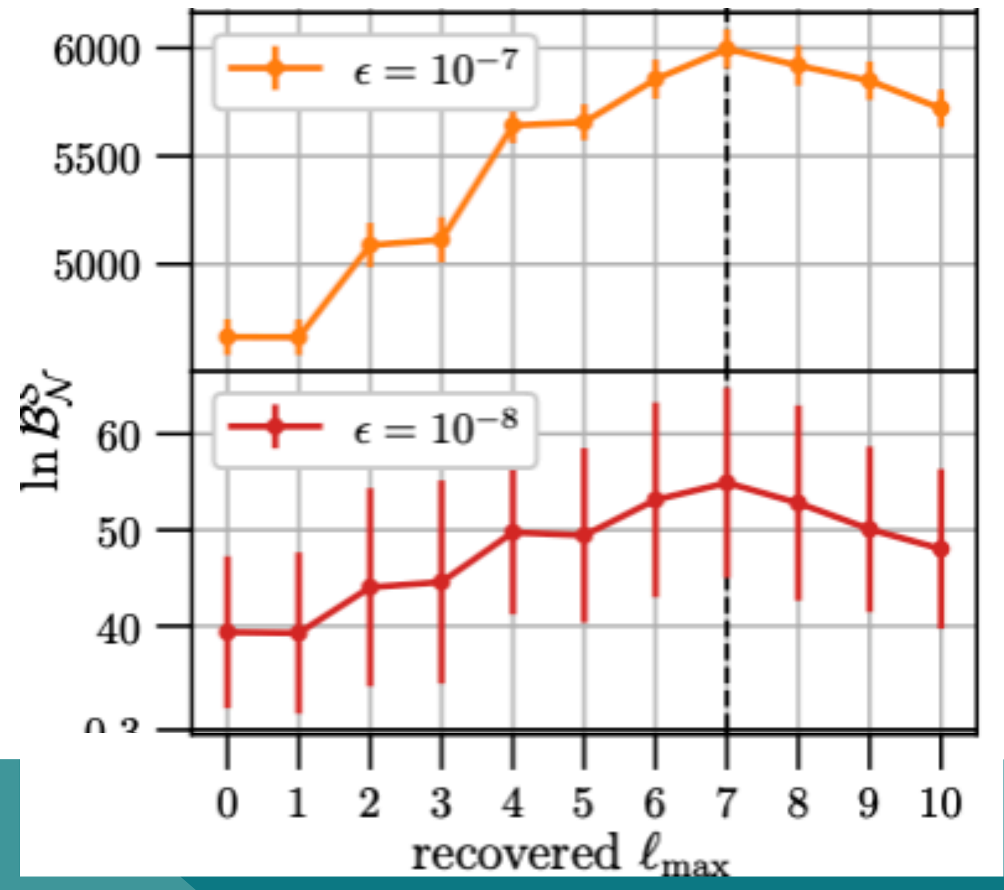


- We can do more than just PE.

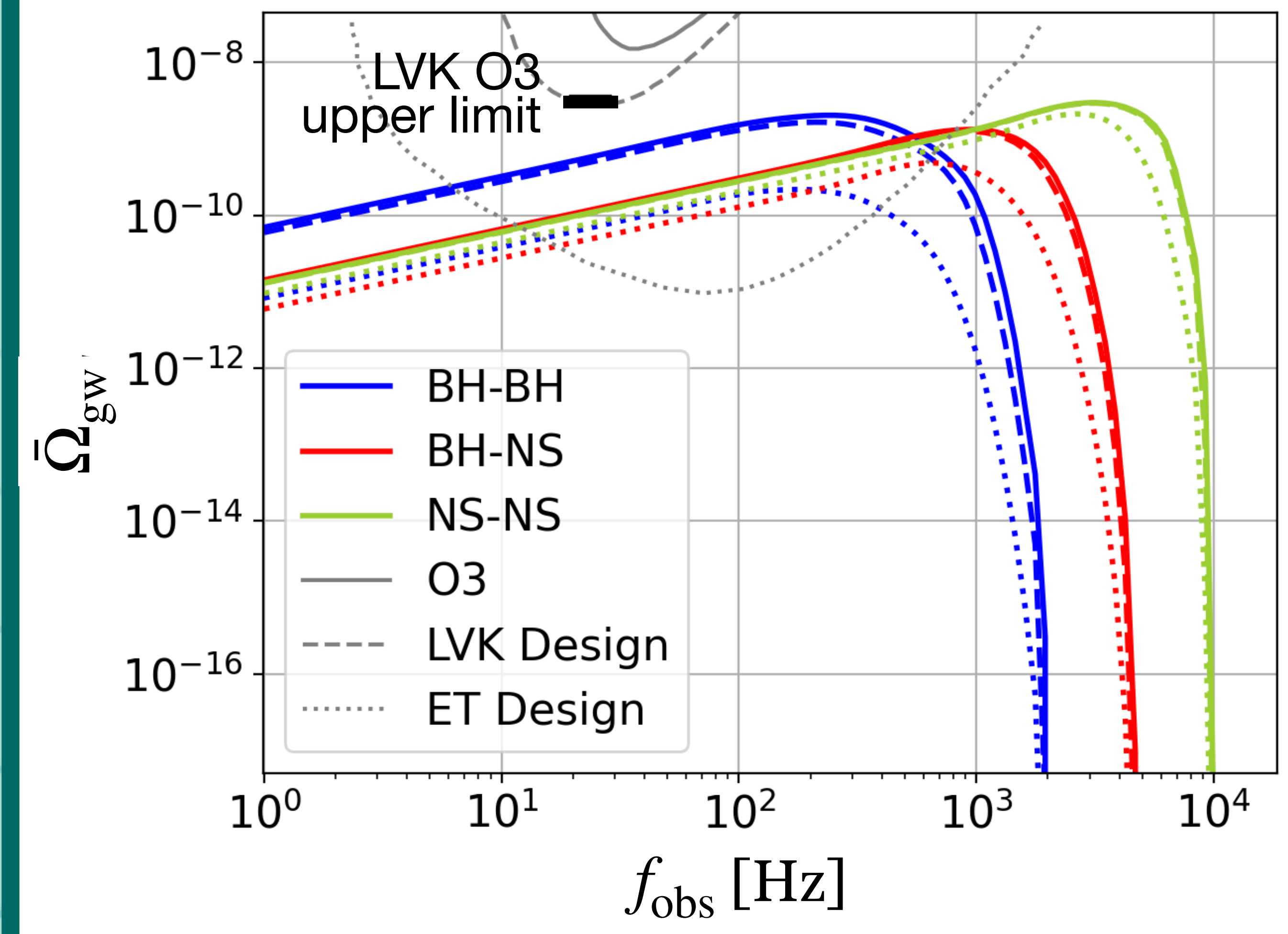
  - model selection
  Galactic plane
  vs
  isotropic model

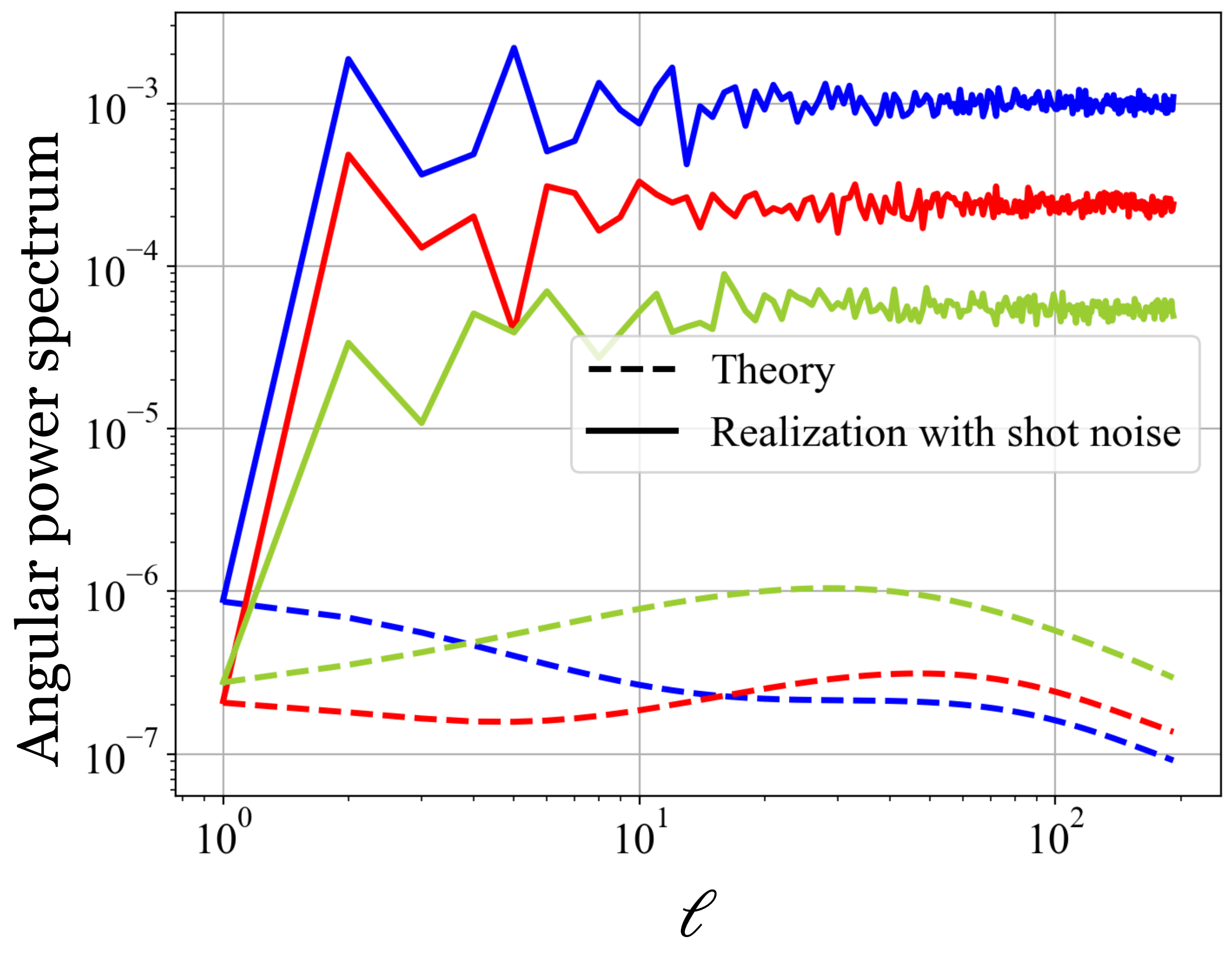


  - optimize $\ell_{\max}$
  compare
  Bayes factors

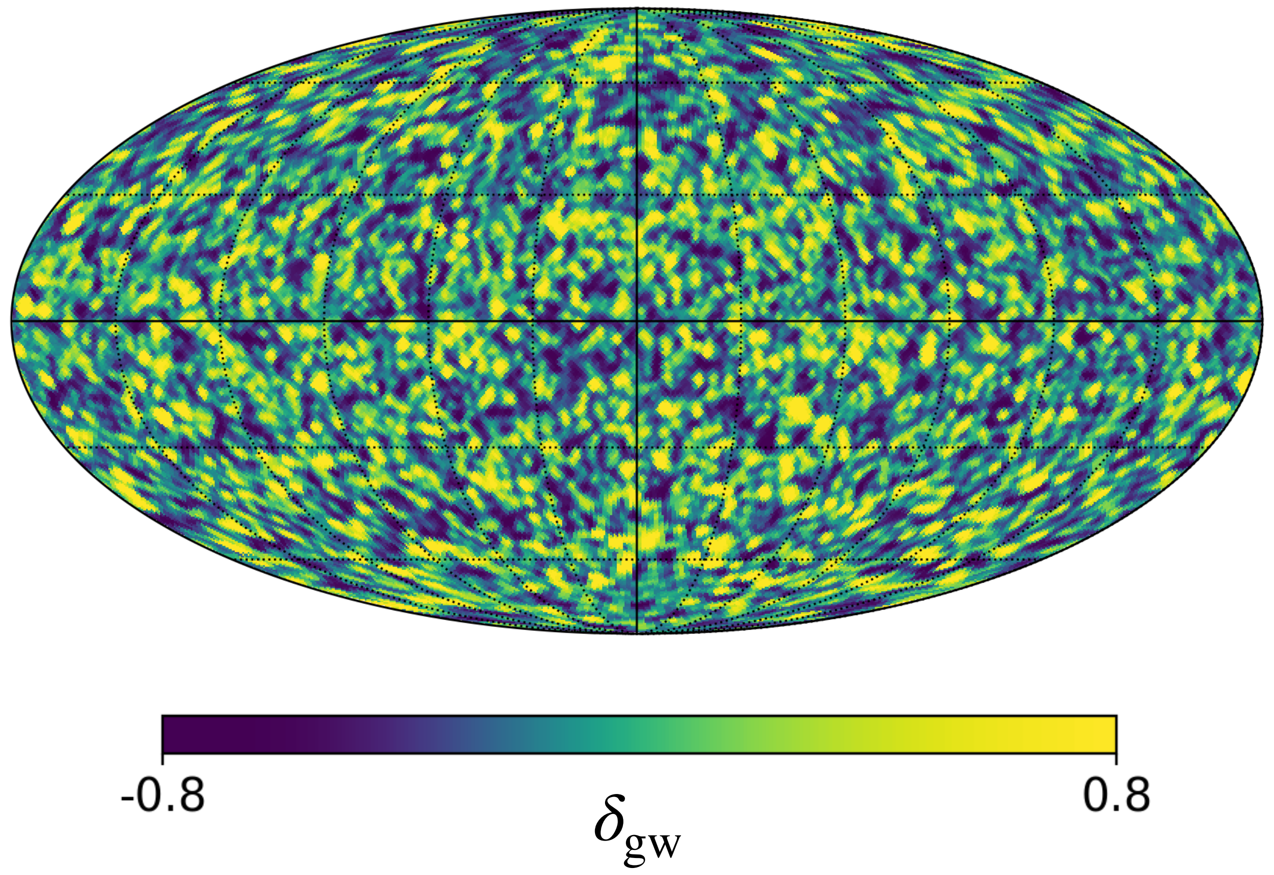


Intensity and anisotropies

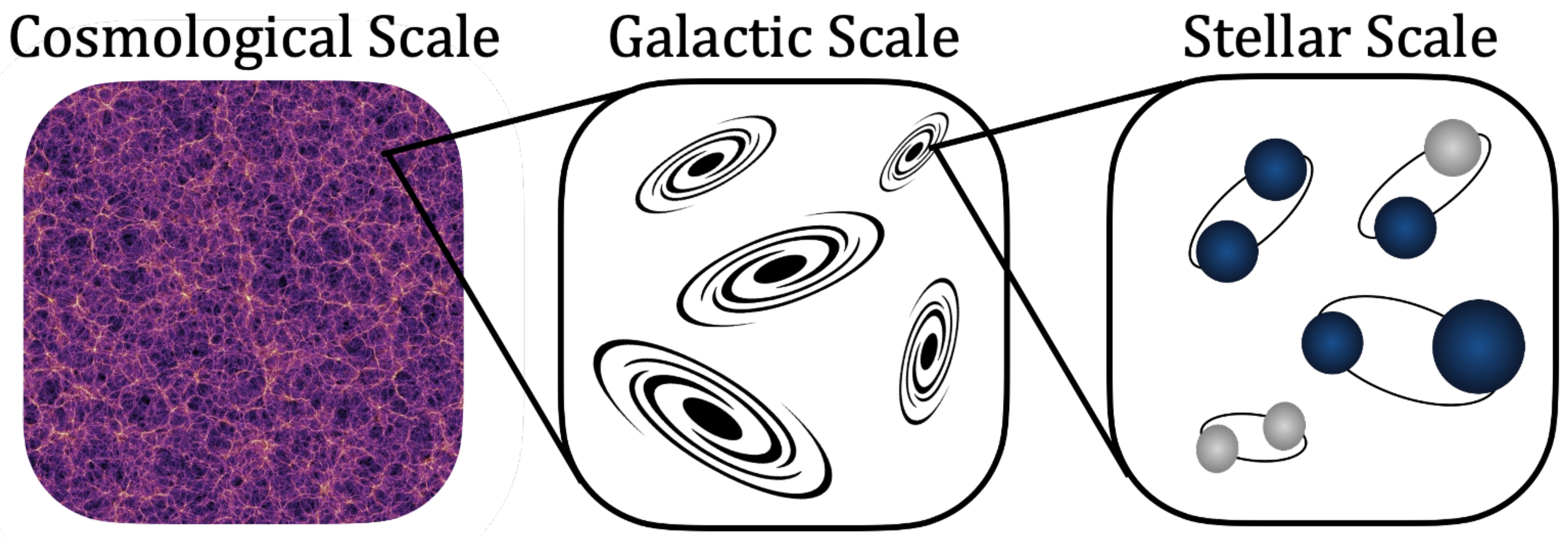




of the stochastic gravitational-wave background



from merging compact binaries in galaxies



Based on:
Capurri et al. JCAP 2021 11:032
Capurri et al. Universe 2022, 8(3), 160

GWO

UCL, Louvan-la-Neuve, Belgium
September 8-9, 2022

Giulia Capurri
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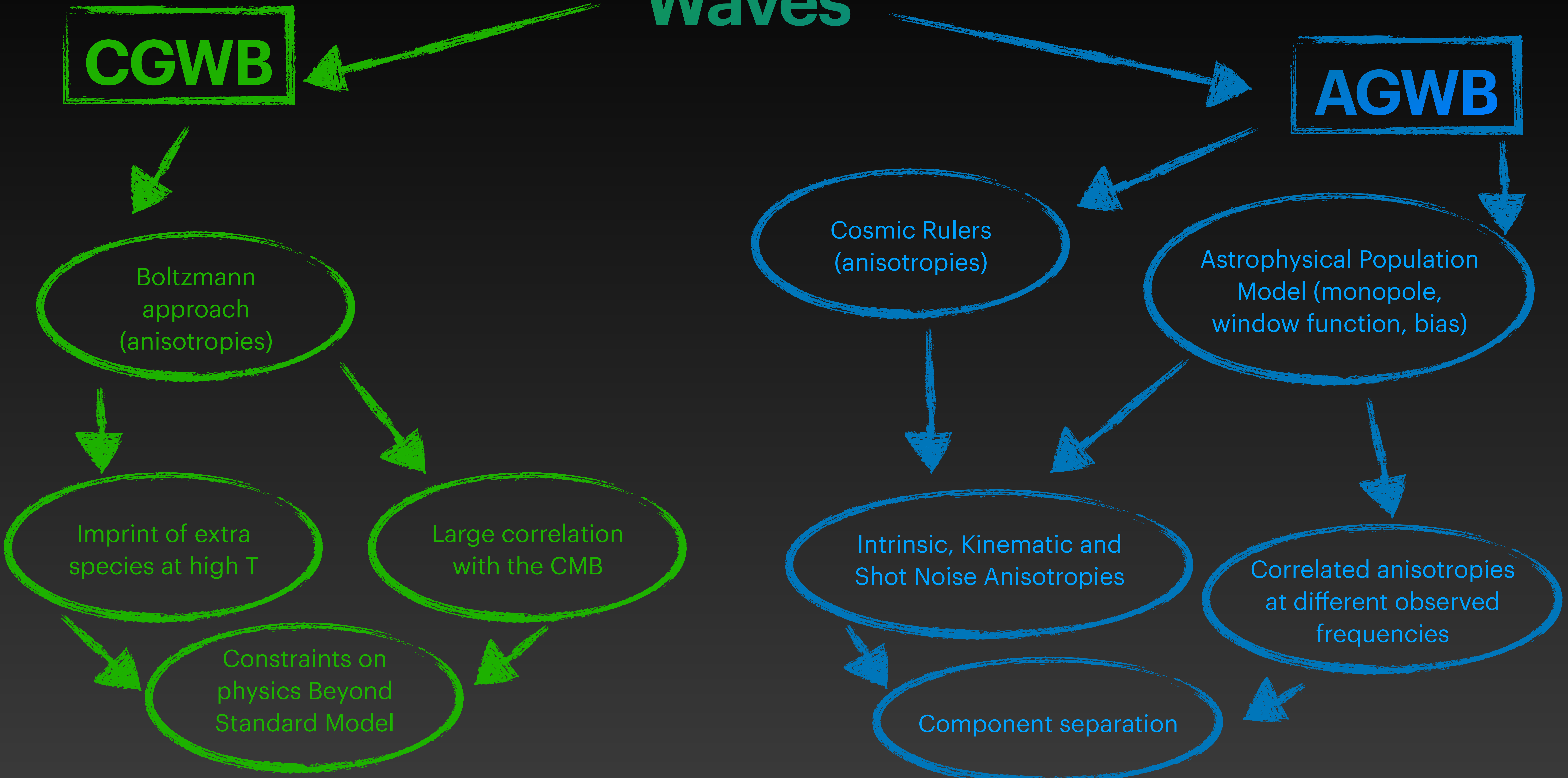
SISSA

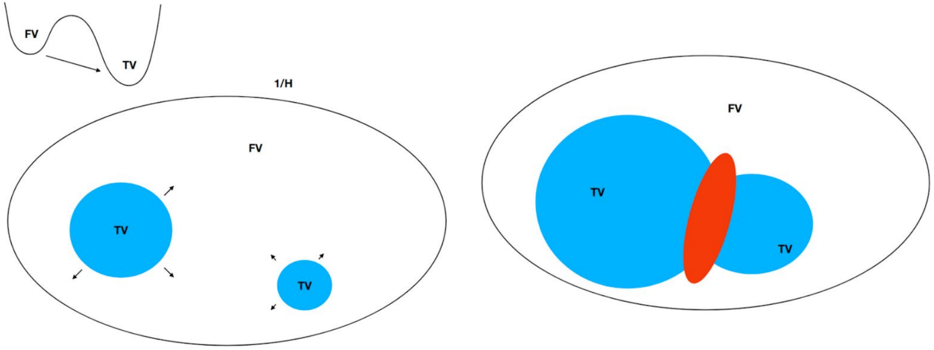
Cosmology with cross-correlation of Gravitational Waves

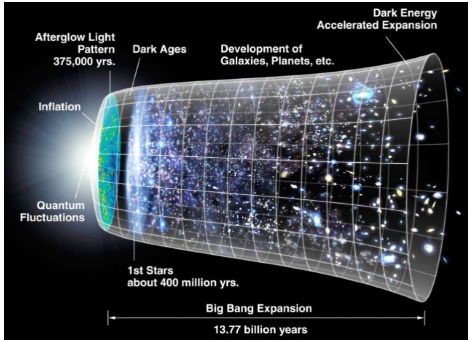


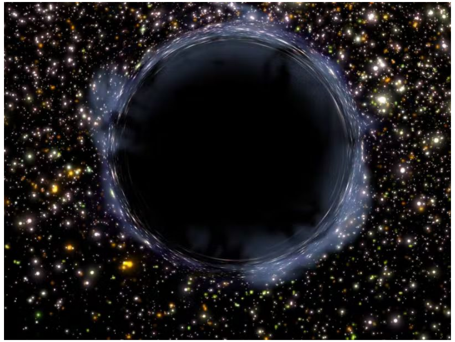
Implications for first-order cosmological phase transitions (FOPTs) and the formation of primordial black holes (PBHs) from the third LIGO-Virgo observing run

Alba Romero-Rodríguez. aromero@ifae.es / alba.fugit.umbra@gmail.com

- We set upper limits over model parameters of FOPTs and the formation of PBHs using a Bayesian formalism introduced by V. Mandic et al. [1] and using O1-O3 LIGO-Virgo data.
- FOPTs: We achieve exclusions at 95% CL on high temperatures not reachable at colliders [2].
- PBHs: Bounds on the integrated power of the peak in the curvature power spectrum lower than those from PBH abundance. With ET the constraints could be tighter than those from PBH abundance [3].







[1] V. Mandic, et. al., Phys. Rev. Lett.109, 171102 (2012)
[2] A. Romero, et. al., Phys. Rev. Lett., vol. 126, p. 151301, Apr 2021.
[3] A. Romero-Rodríguez, et. al., Phys. Rev. Lett., vol. 128, p. 051301, Feb 2022.

Ready-to-use $h_c(f)$ expression to stochastic GW background from SMBH binaries in general relativistic eccentric orbits

Subhajit Dandapat, A. Susobhanan, A. Gopakumar, S. Chen, & A. Sesana

- For MBHs inspiralling along Newtonian eccentric orbits, GWs are emitted at the multiples of the orbital frequency.

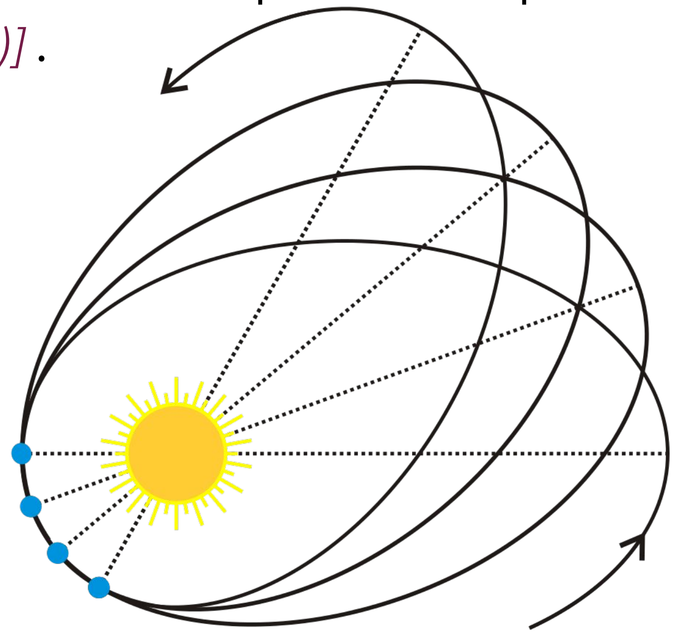
$$f_p = \frac{f_r}{p};\, f_r = f(1+z)$$

- When periapsis advance is included, each Newtonian harmonic splits into a triplet [Seto, 2001, Tessmer & Gopakumar (2007)] .
    - Newtonian f_n ➪ $f_n \pm \delta f$ and f_n , where $\delta f = 4\pi k\ f_{orb}$.

$$\frac{dE}{df_r} = \frac{1}{3}\frac{\mathcal{M}c^2}{f_r}\left(\frac{2\pi G\mathcal{M}f_r}{c^3}\right)^{2/3}\sum_{p=1}^{\infty}\sum_{q=0,\pm2}\underbrace{\frac{g_q(p,e_{pq})}{F(e_{pq})}\left(\frac{1}{p}\right)^{2/3}}_{\Phi_{pq}}$$

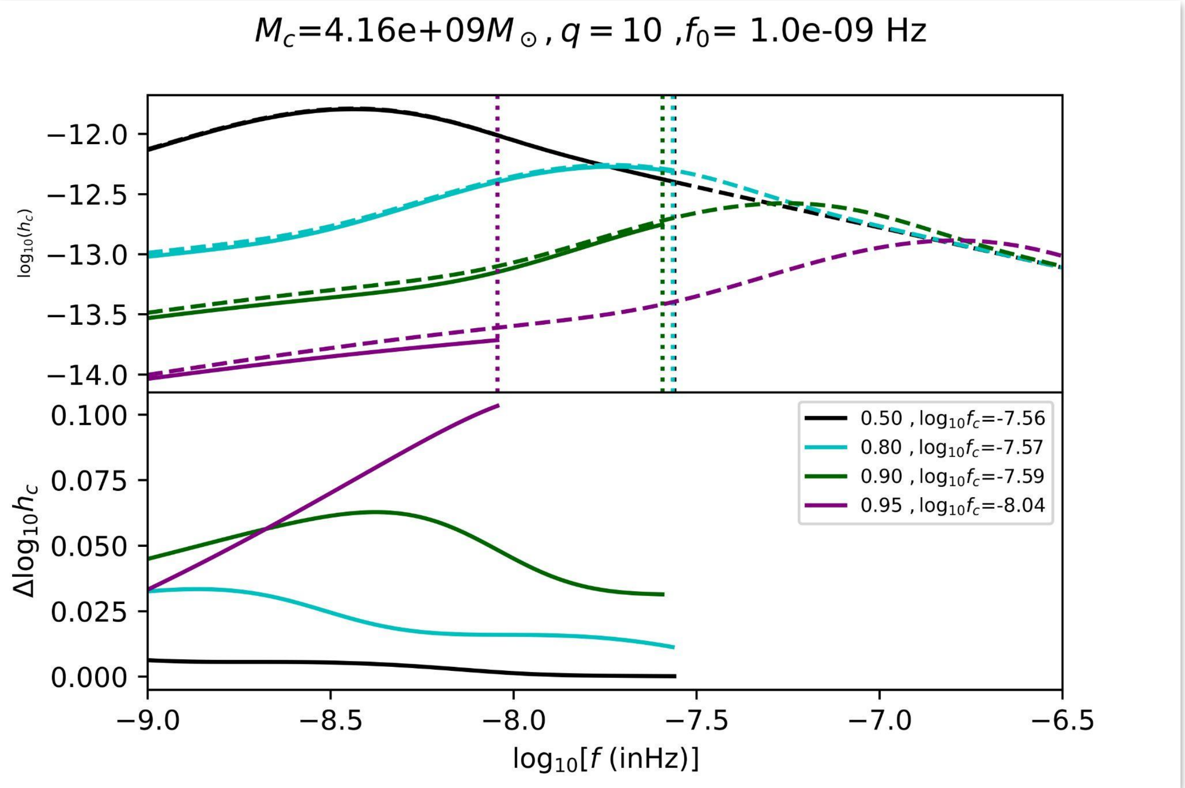
where $e_{pq} = e(f_{pq})$ with $f_{pq} = \frac{f_r}{p+q\,k_{pq}}$

- *For BH binary to slowly precess along quasi-Kelperian orbit, a cutoff on the upper frequency need to be applied.*



- $k = \Delta\Phi/2\pi$, $\Delta\Phi$ being the advance of periastron in an orbital period

Results

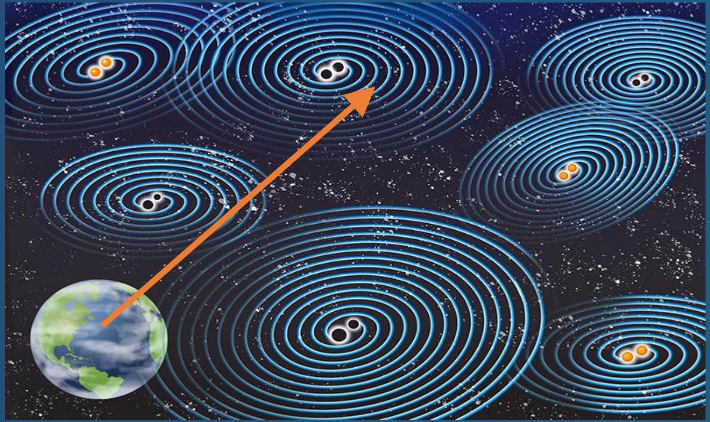


M_c=4.16e+09$M_\odot$, $q = 10$,f_0= 1.0e-09 Hz
$\log_{10}(h_c)$
−12.0
−12.5
−13.0
−13.5
−14.0
$\Delta\log_{10}h_c$
0.100
0.075
0.050
0.025
0.000
0.50 , $\log_{10}f_c$=-7.56
0.80 , $\log_{10}f_c$=-7.57
0.90 , $\log_{10}f_c$=-7.59
0.95 , $\log_{10}f_c$=-8.04
−9.0
−8.5
−8.0
−7.5
−7.0
−6.5
$\log_{10}[f$ (inHz)]

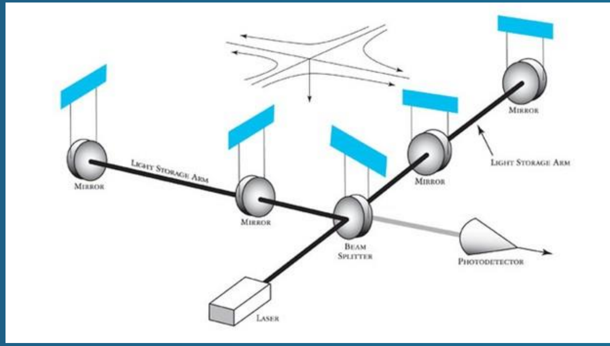
Gravitational Wave Orchestra – Louvain-la-Neuve, September 2022

GW background anisotropies with ground-based detectors

- We study a polarized and anisotropic GW background



$$\langle h^*(f,\hat{n})h(f,\hat{n})\rangle \propto H_\lambda(f)P(\hat{n})$$



- Which can produce a signal on a ground-based interferometer

$$m(t) \equiv \frac{\Delta T}{T} \propto s(t) + n(t)$$

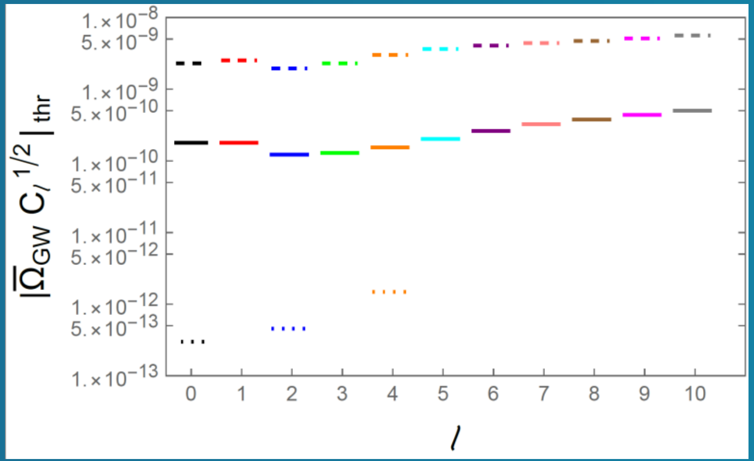
- …and on a network of instruments

- We correlate the signals from each interferometer

$$\langle C_{ij}\rangle \propto \langle m_i(t)m_j(t)\rangle$$

- And write a Likelihood function on the cosmological parameters (θ)

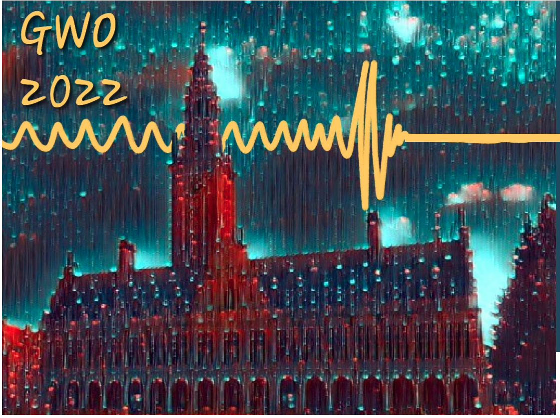
$$\mathcal{L}(\theta;\bar{\theta}) = \frac{1}{\mathcal{N}(\bar{\theta})}e^{-\frac{\chi^2(\theta;\bar{\theta})}{2}}$$



- To forecast the detectability and the uncertainties on the measurement

Giorgio Mentasti

Department of Physics, Imperial College of London

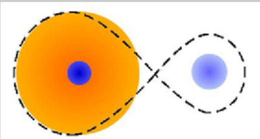


Astrophysical background

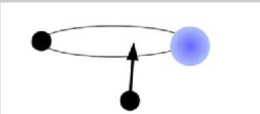
A new observation channel for binary formation and evolution in 3G detectors

Carole Périgois

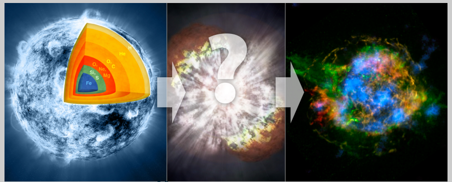
Stellar evolution



Mass transfer,



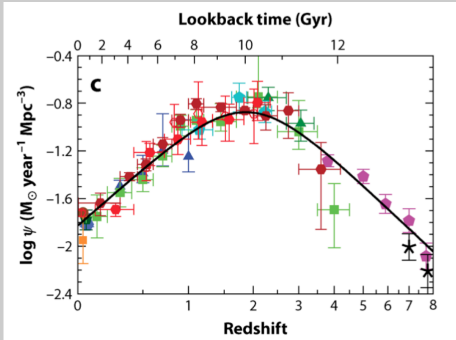
3-body encounter,

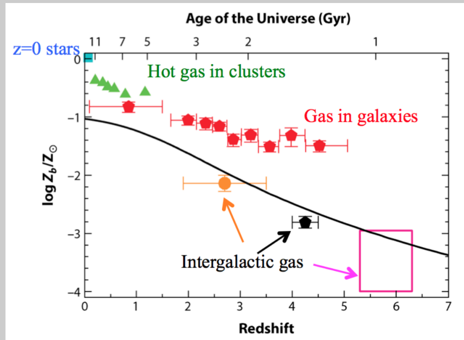


core-collapse supernovae,

common envelope phase, stellar winds...

Star Formation History

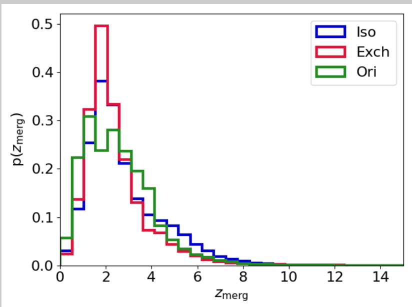


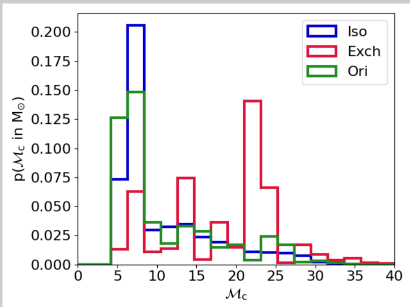


Madau & Dikinson, 2014, ARAA

Population specificities

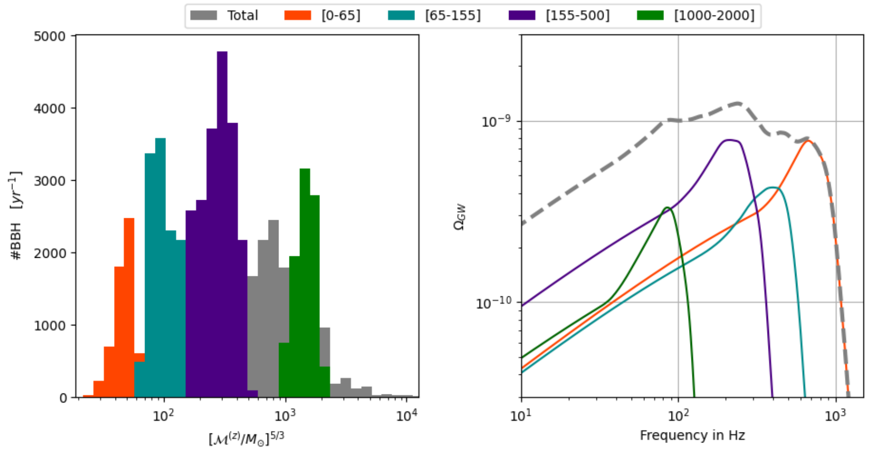
Example comparing Isolated and YSC





Périgois et al. 2022, PRD

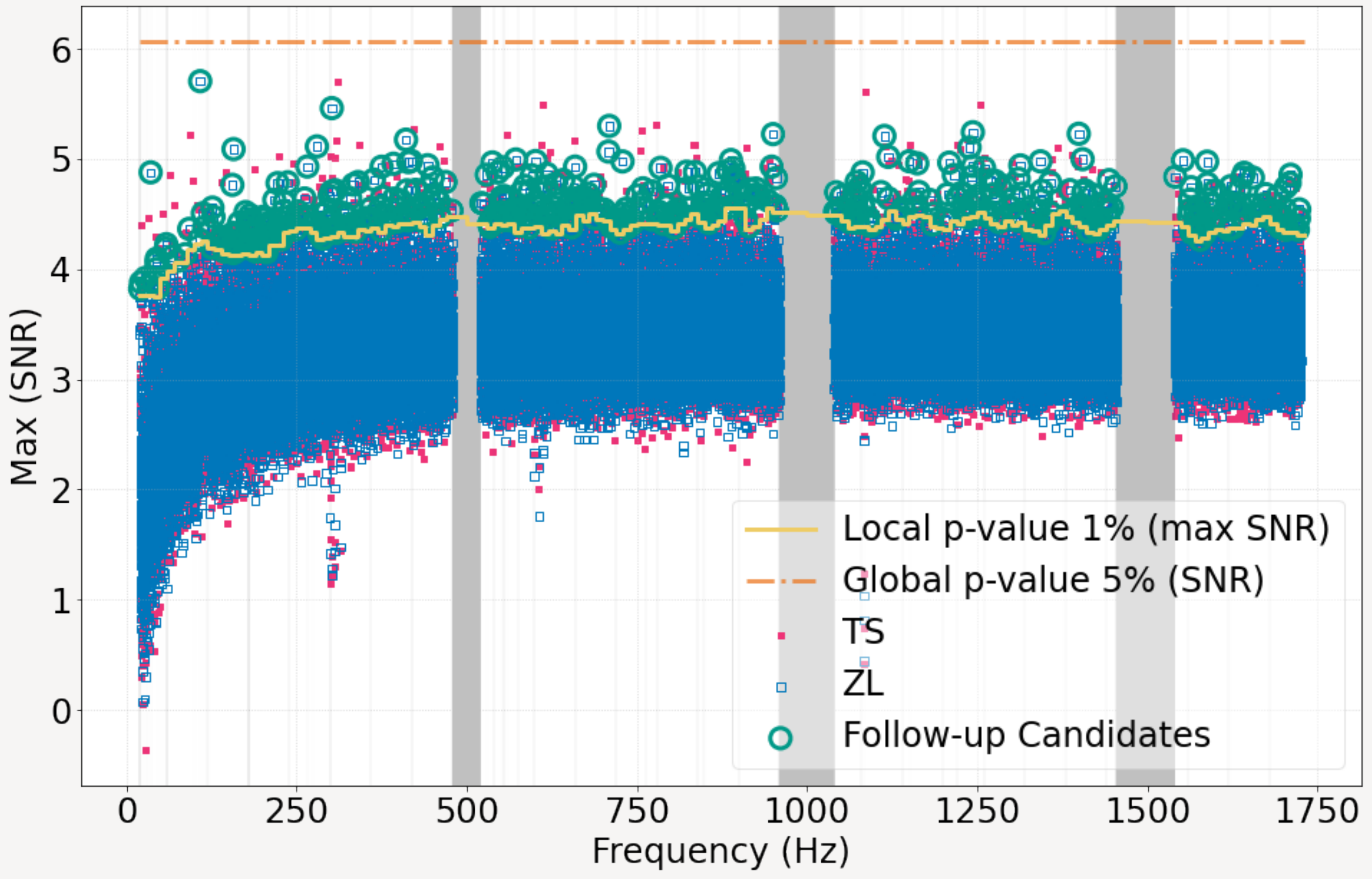
Impact on the background shape

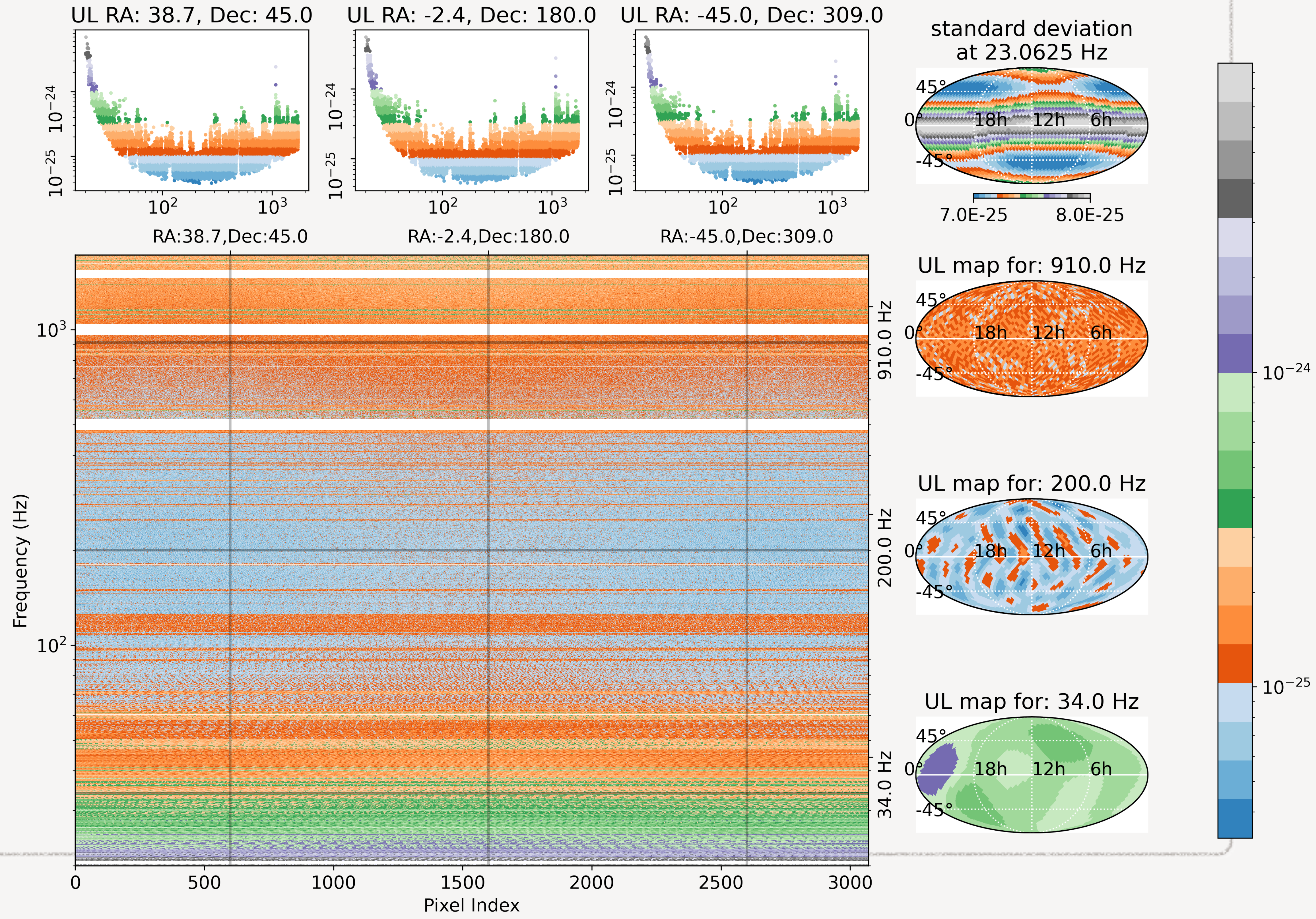


All-sky, all-frequency directional search for an anisotropic Stochastic Gravitational Wave Background

Deepali Agarwal (On behalf of LVK collaboration)

- *Search for narrowband point -like persistent GW sources*
- *GW Radiometer Algorithm (+ Folding + PyStoch pipeline)*
- ***Data** : first three observing runs of Advanced LIGO and Advanced Virgo*
- ***Search parameter:** 20-1726 Hz frequency band, 1/32 Hz resolution, 3072 equal area pixels*
- *No significant detection*
- *Upper limit on the strain amplitude (0.030-9.6)* $\times 10^{-24}$
- *Identified 515 candidates which can be followed up.*

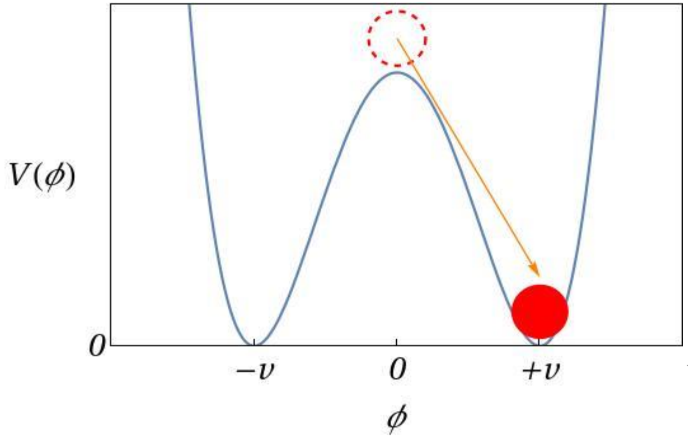


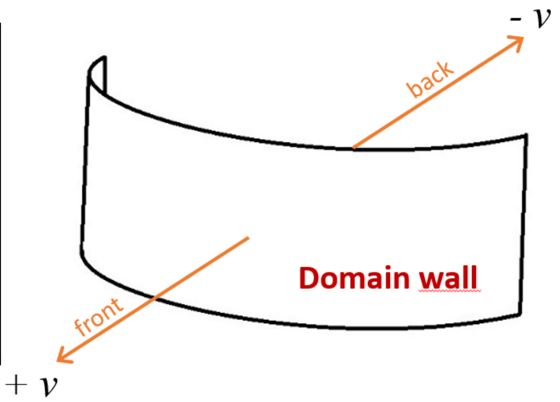


Gravitational Waves from Domain Wall Dynamics

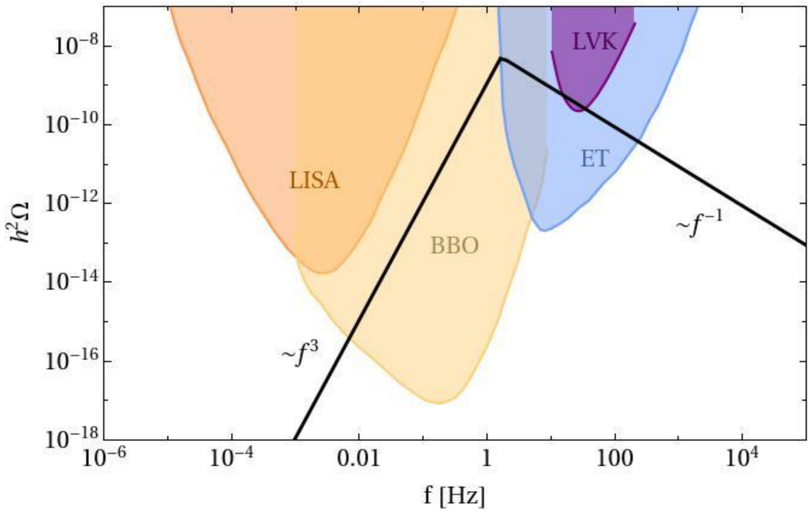
Simone Blasi, Alberto Mariotti, **Aäron Rase**, Alexander Sevrin, Kevin Turbang

- Topological defects arising from spontaneously broken **discrete symmetry**

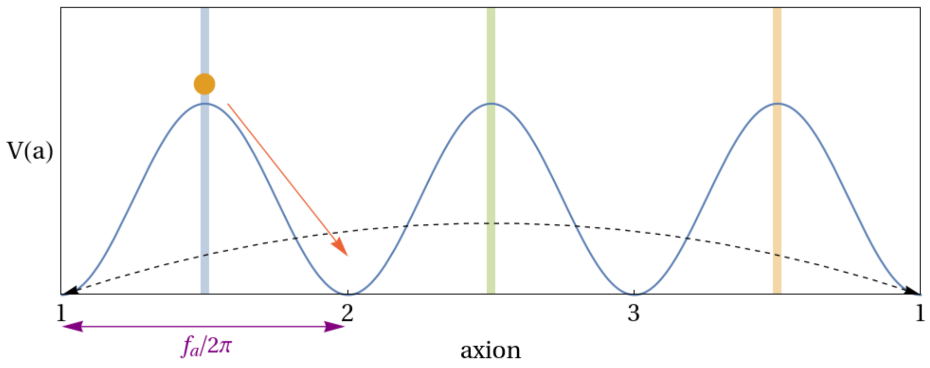




- Domain wall generates broken power-law GW spectrum



- Understanding domain wall evolution in **axion-like (ALP) particle** models



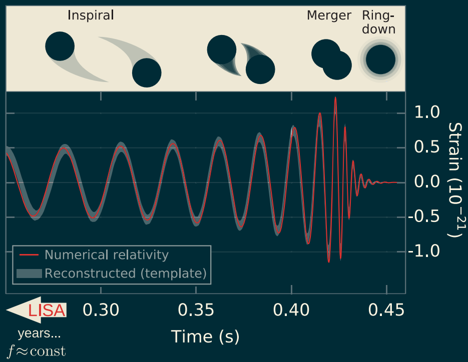
- Assessing effect of **friction** from fermions

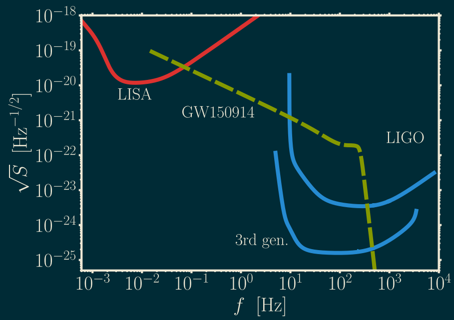
- Probing ALP parameter space with GW experiments?
- How to take friction effects into account?

VRIJE UNIVERSITEIT BRUSSEL

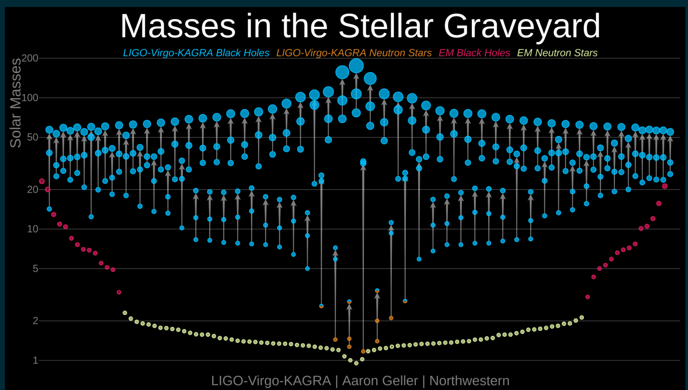
What can we learn about SOBBH with LISA?

Jesús Torrado (et al.) ULB

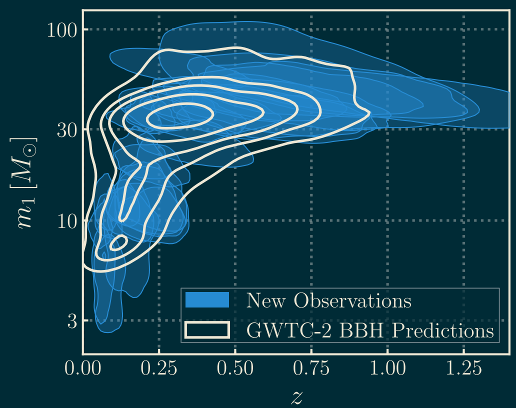




LIGO-Virgo-KAGRA GWTC-3

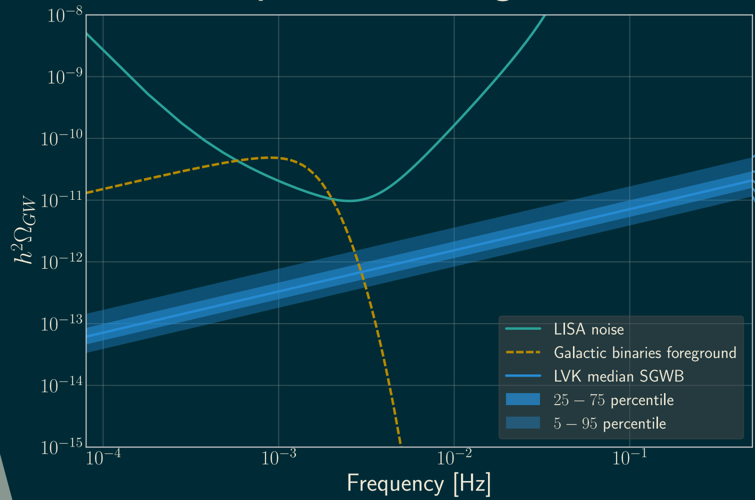


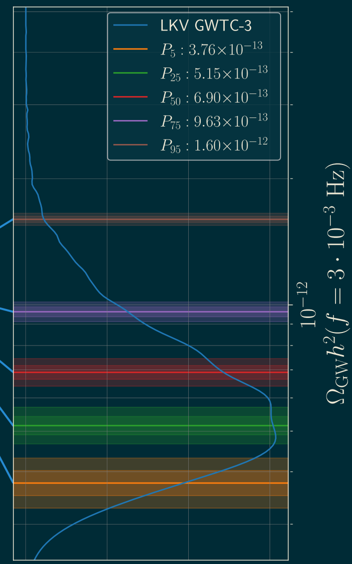
Population parameter constraints



LISA 4yr (our work)

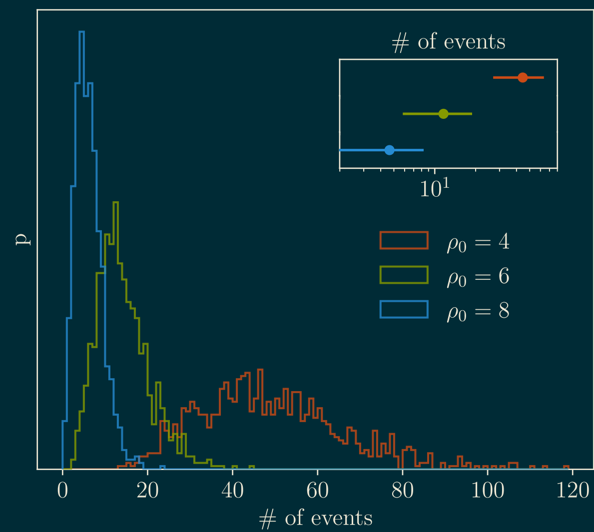
Expected background



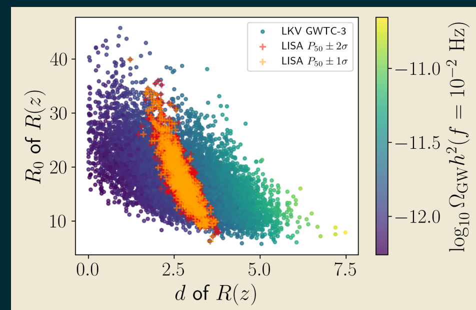


Sensitivity forecast

Expected individual events



FUTURE: population param. constraints?



Generation of gravitational waves from freely decaying turbulence

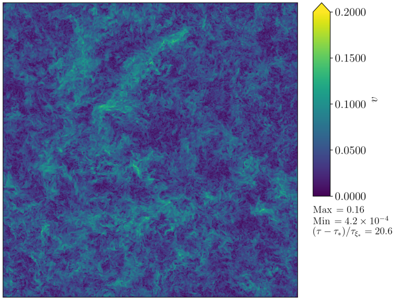
Pierre AUCLAIR, Chiara Caprini, Daniel Cutting, Mark Hindmarsh, Kari Rummukainen, Danièle A. Steer, David J. Weir arXiv:2205.02588

What is the system:

- Freely decaying turbulence
- produced after a first order phase transition
- in the early Universe
- New physics at the electro-weak scale source a signal around the frequency of LISA

What we did:

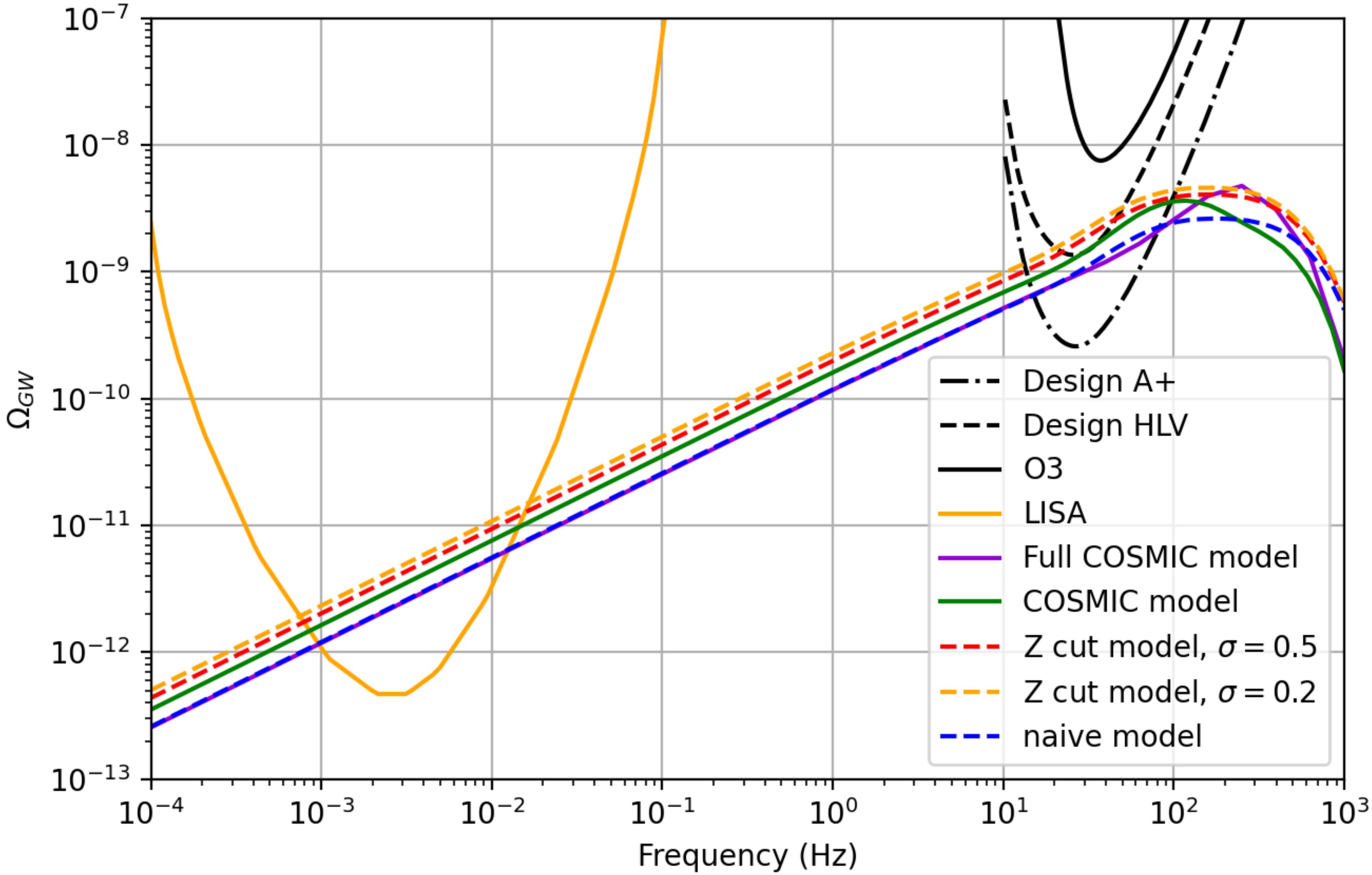
- Reviewed and improved on earlier models of decaying turbulence
- Computed the resulting GW background semi-analytically
- Performed massively parallel hydrodynamic simulations to calibrate and validate our models



Our results:

- Obtain up-to-date GW signal from freely decaying turbulence
- Provide approximate and easy-to-use analytical templates for LISA

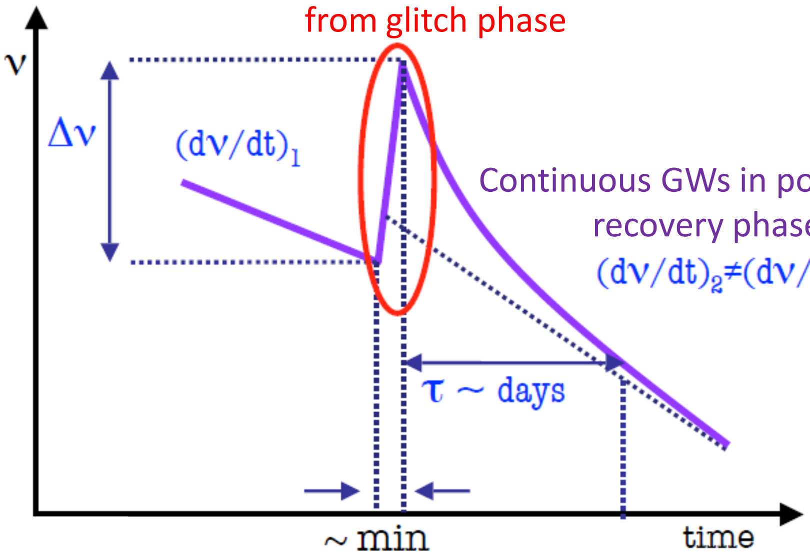
SGWB produced by BBHs : study of astrophysical models and predictions for LISA



Stochastic Gravitational-Wave Background and Pulsar Glitches

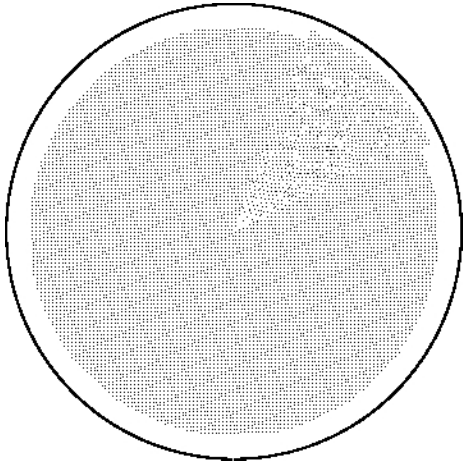
Federico De Lillo, Jishnu Suresh, Antoine Depasse, Magdalena Sieniawska, Andrew L. Miller
Centre for Cosmology, Particle Physics and Phenomenology (CP3),
Université catholique de Louvain, Louvain-la-Neuve, B-1348, Belgium

GW bursts
from glitch phase



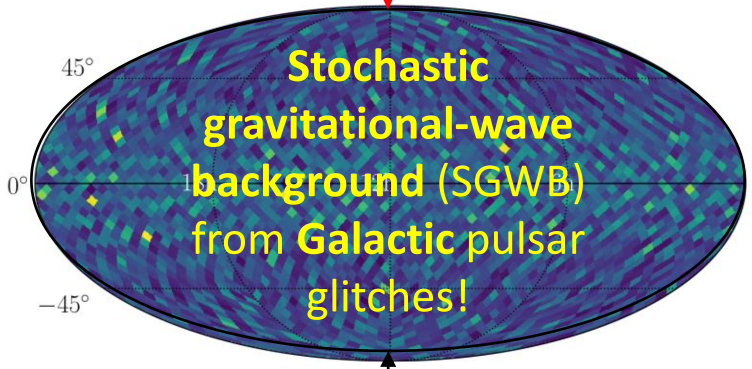
Pulsar glitches
as gravitational-wave (GW) sources

Focus on glitches from



Vortex avalanches

Superposition of individually undetectable, unresolved GW bursts



Searching for **glitch population properties** from Galactic pulsar glitches

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