

Is there evidence for anisotropy in CMB data?

Daniela Saadeh

with A. Pontzen, H. V. Peiris, S. M. Feeney, J. D. McEwen

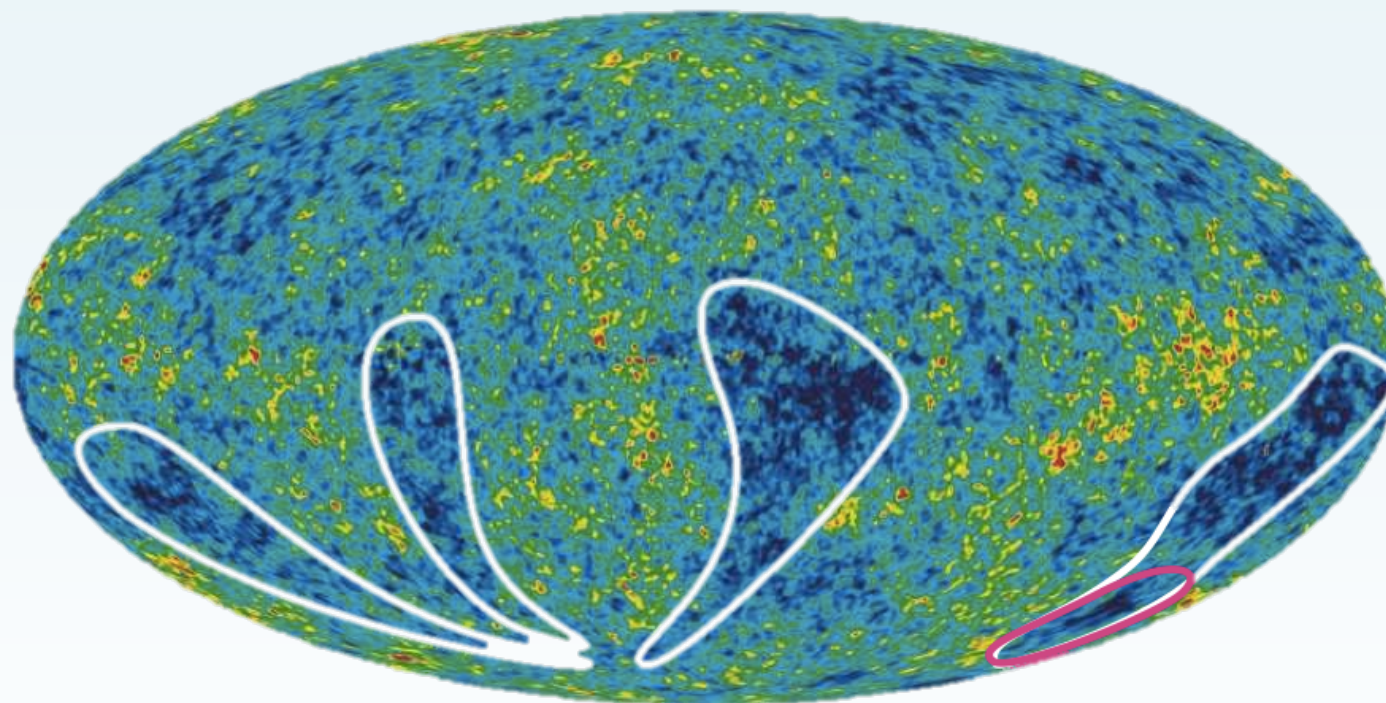
arXiv: coming soon!

The problem

The Standard Model of Cosmology relies on the fundamental assumption that the large-scale Universe is

isotropic + **homogeneous**

Large scale anomalies?



WMAP collaborations, 7-year data

The problem

The Standard Model of Cosmology relies on the fundamental assumption that the large-scale Universe is

~~isotropic~~ + homogeneous

The problem

= Bianchi models

~~isotropic~~

+

homogeneous

The goal

- We test for the **most general** departure from isotropy in the CMB
 - that keeps homogeneity
 - that deals with a flat or open Universe
 - that keeps anisotropy small: must be consistent with observations!

WRITES A PAPER IN 1898

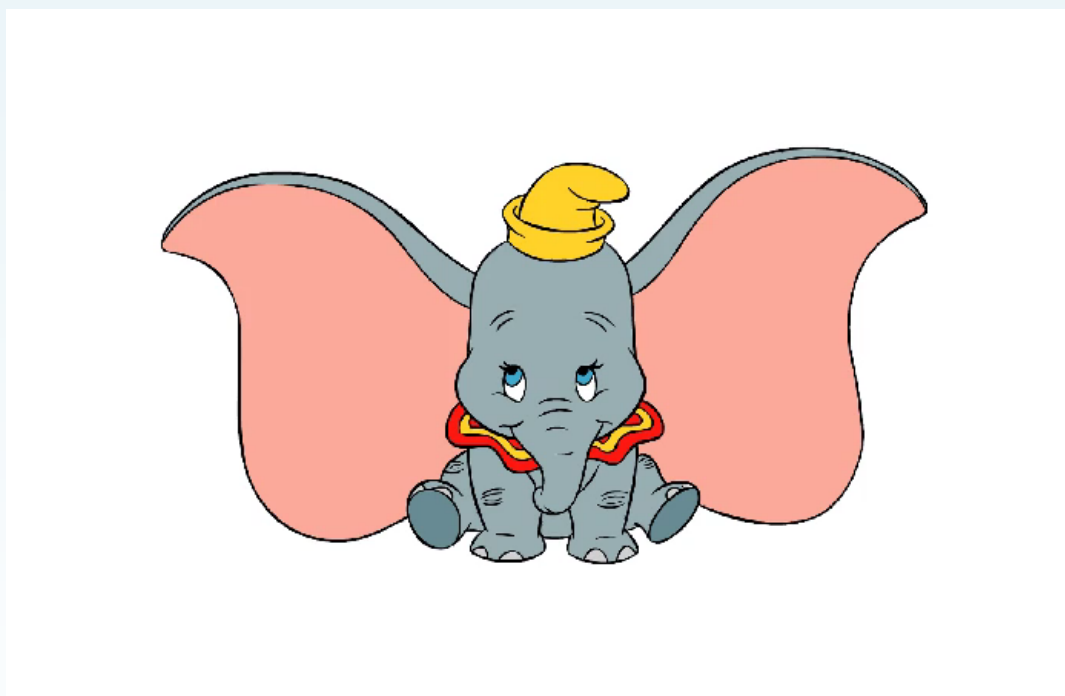


STILL TALKING ABOUT IT

Highlights of the method

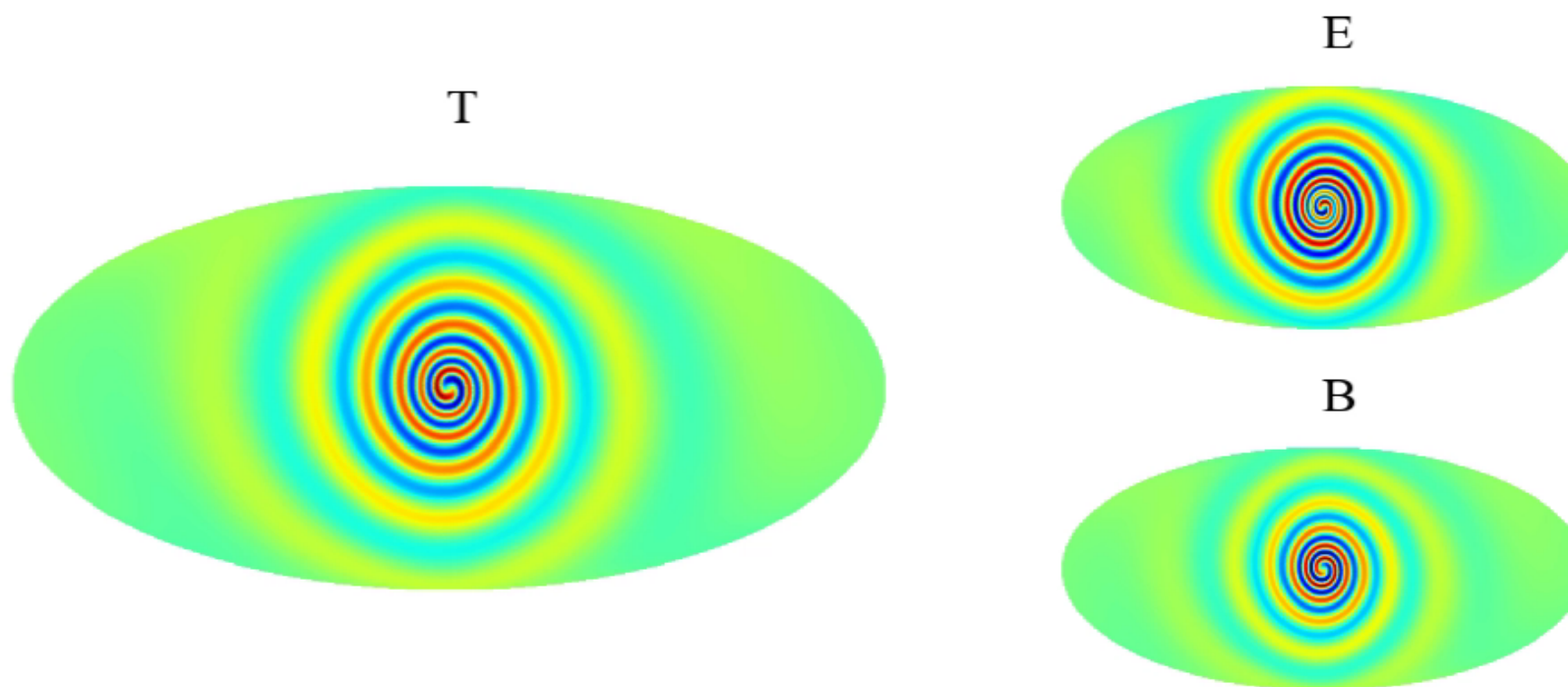
- We take into account **all the degrees of freedom** of anisotropic expansion (as opposed to just 2)
- We require **self-consistent** models in the background and stochastic components
- We use temperature and **polarisation** data (in progress!)
- We extend the likelihood to higher l 's – i.e. **small scales**

Implementing anisotropy



Vector modes

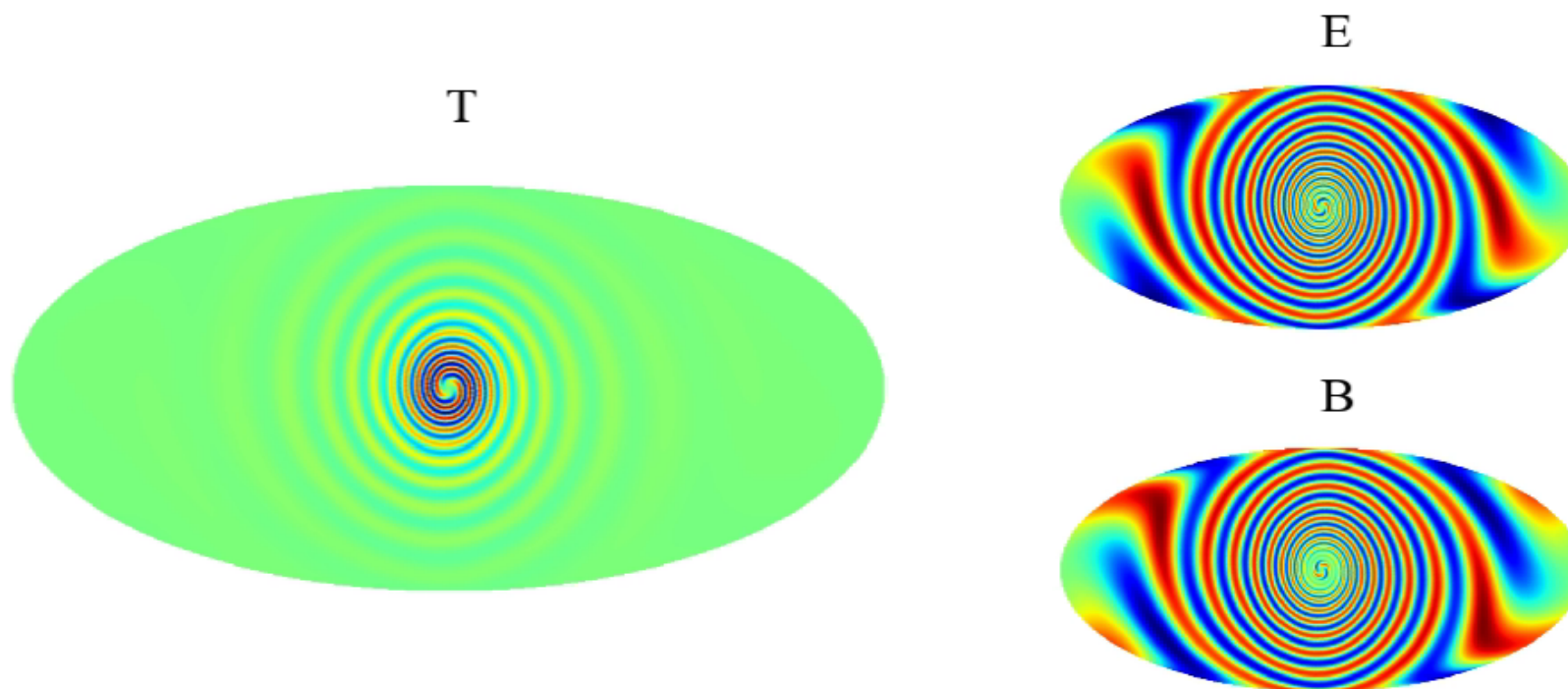
$$\Omega_{M,0} = 0.05 \quad \Omega_{\Lambda,0} = 0.70 \quad x = 0.30$$



New, fast implementation of
 Pontzen A., Challinor A., 2011, *Class. Quant. Grav.*, 28, 185007

Tensor modes

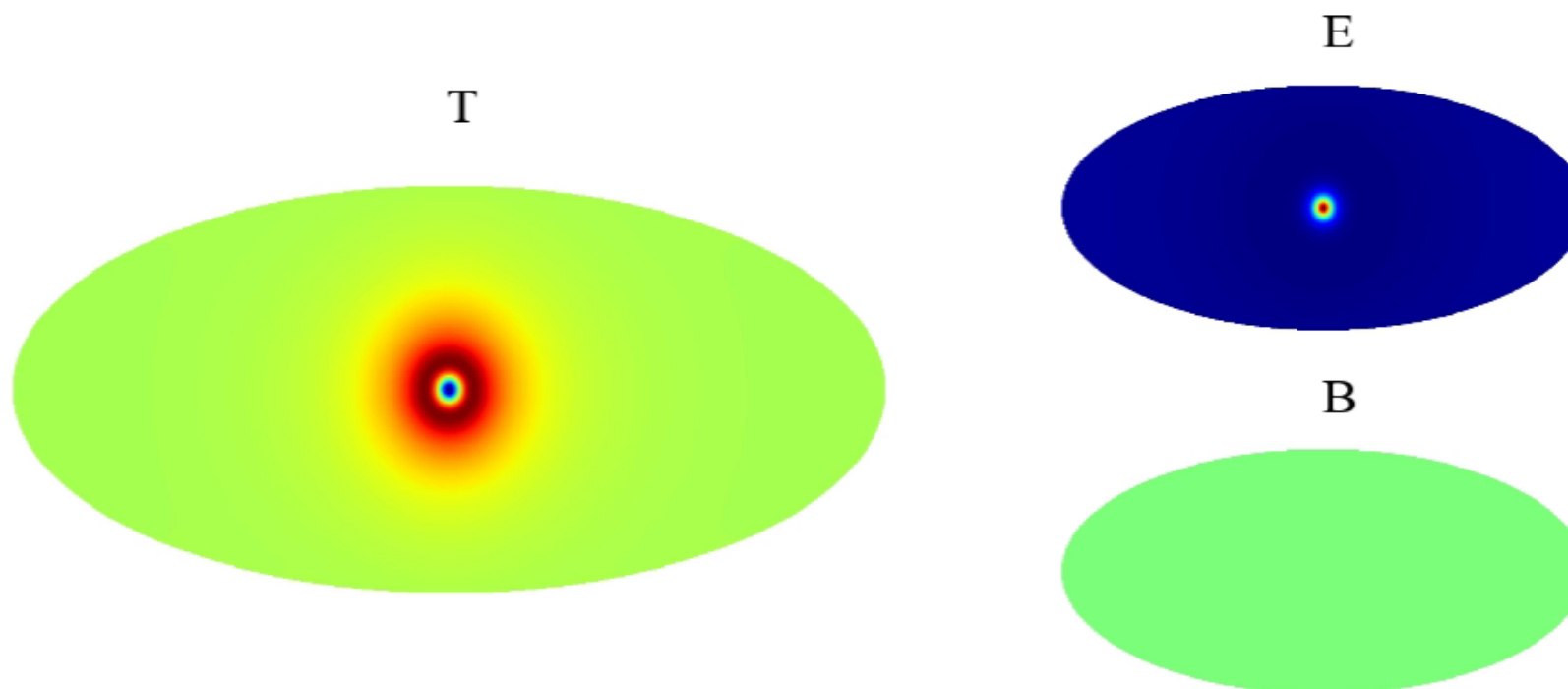
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Scalar modes

$$\Omega_{M,0} = 0.05 \quad \Omega_{\Lambda,0} = 0.70 \quad x = 0.30$$

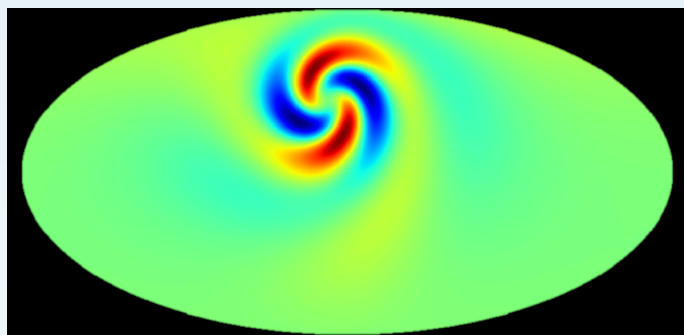


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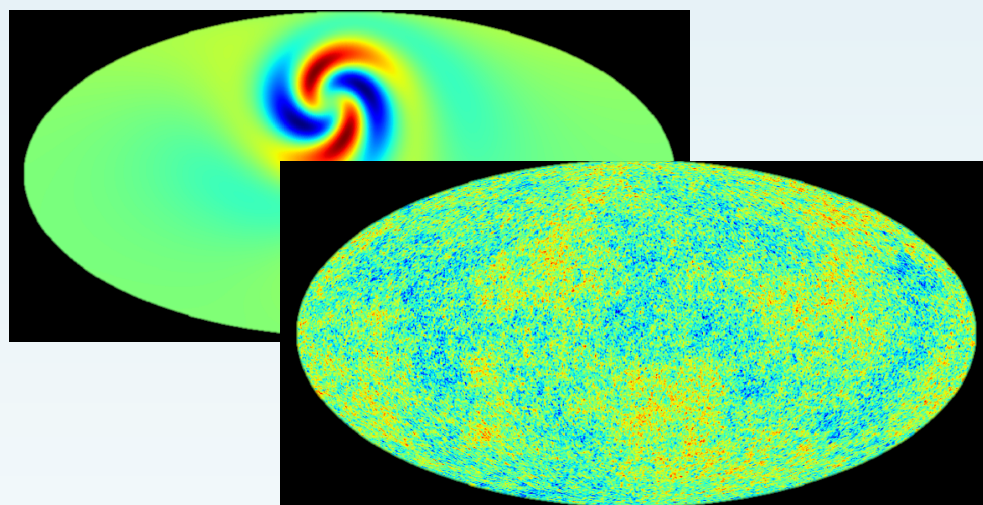
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Statistical analysis



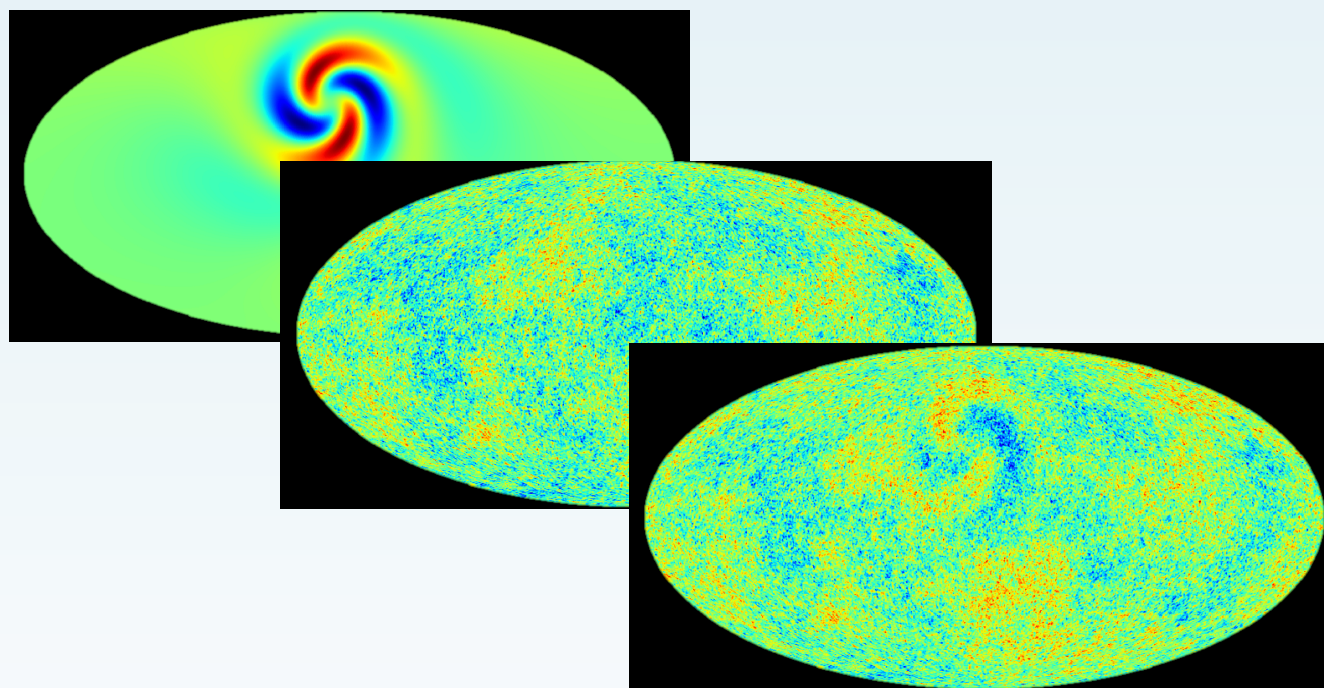
Updated statistical search based on
McEwen *et al.*, MNRAS, 436(4):3680-3694, 2013

Statistical analysis



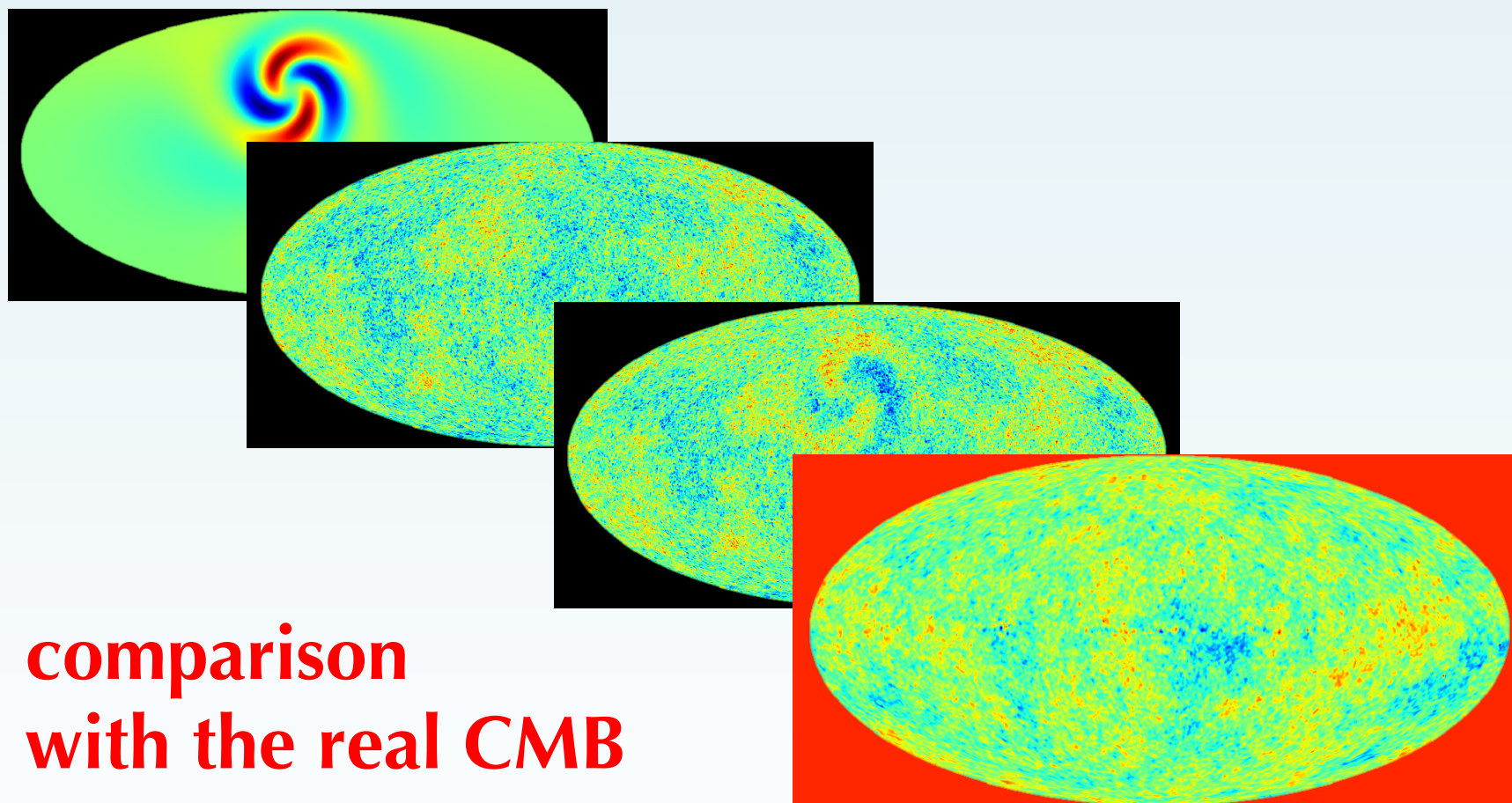
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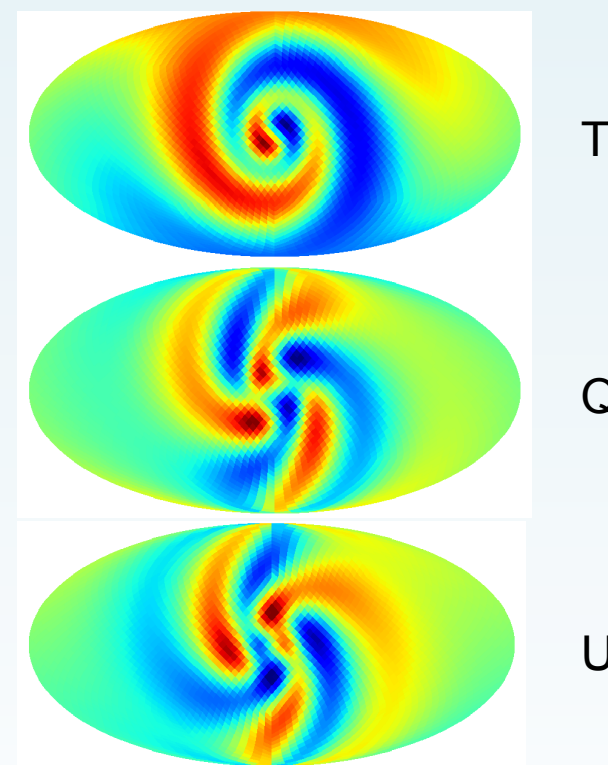
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The datasets

Temperature and polarisation
have complementary
constraining power!

Planck: temperature and low- l
polarisation



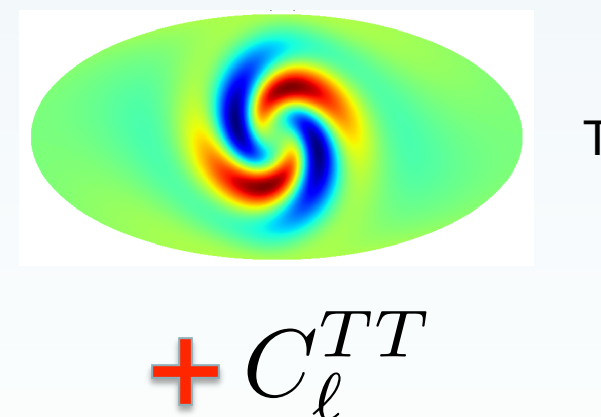
$$+ C_{\ell}^{TT}$$

The datasets

Temperature and polarisation
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Planck: temperature and low- l
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WMAP: temperature only

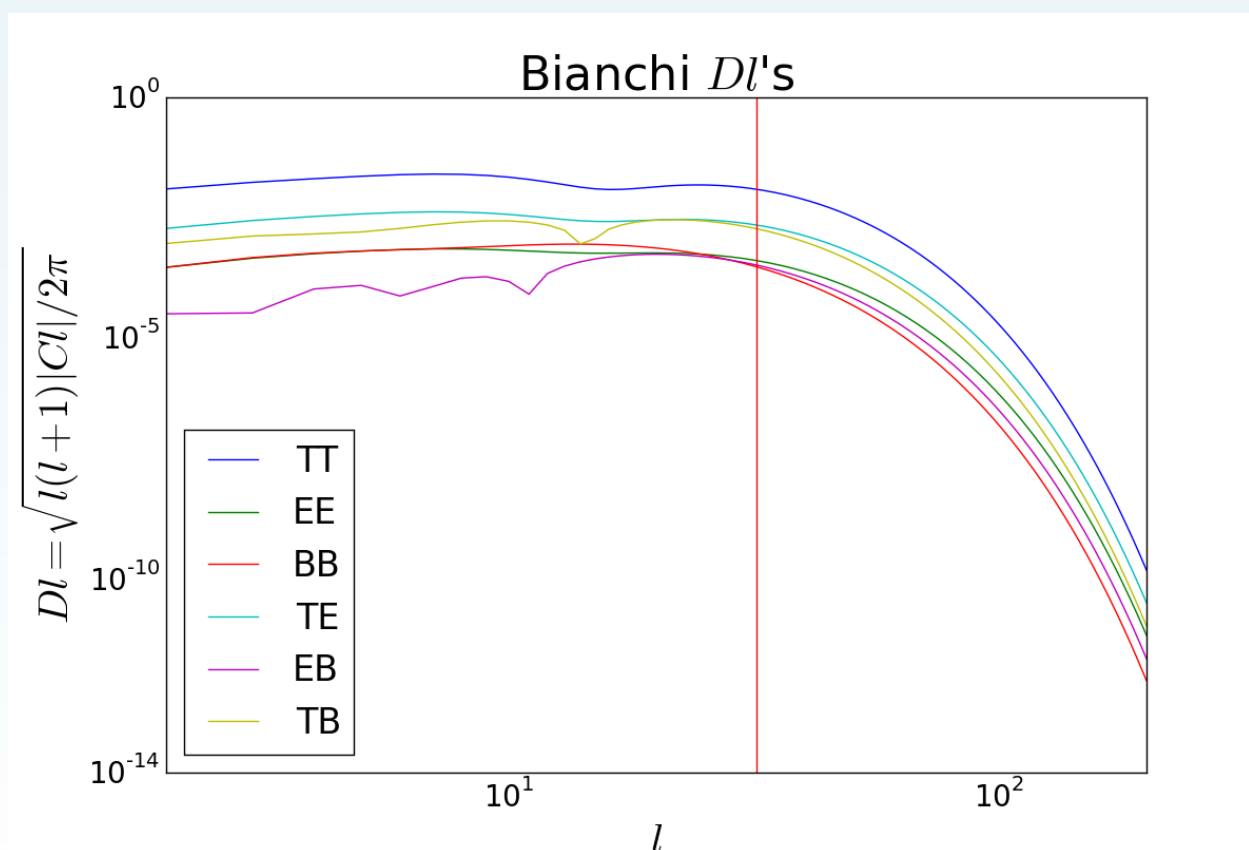


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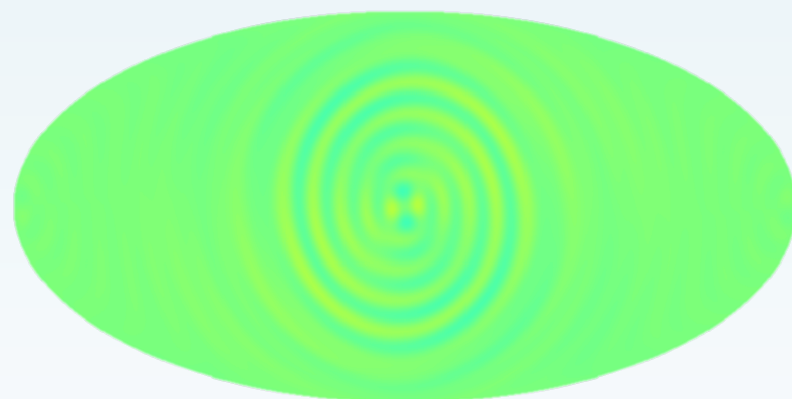
The small scales

Despite Bianchi models mostly affecting the large scales, small scales are important!



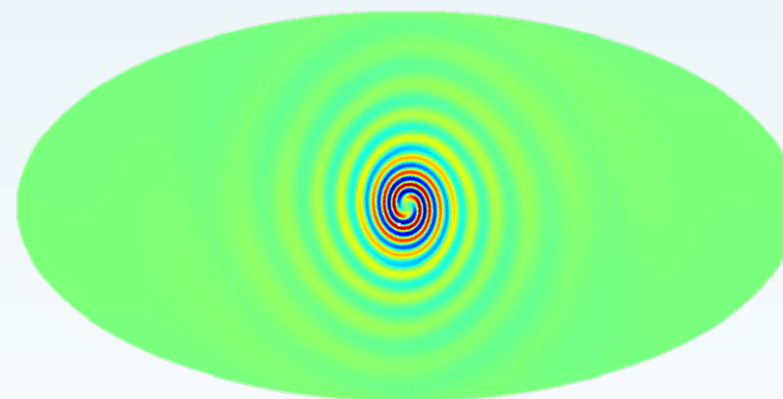
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truncated at
 $l=32$

(older method)



truncated at
 $l=200$

(correctly characterised)

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Results

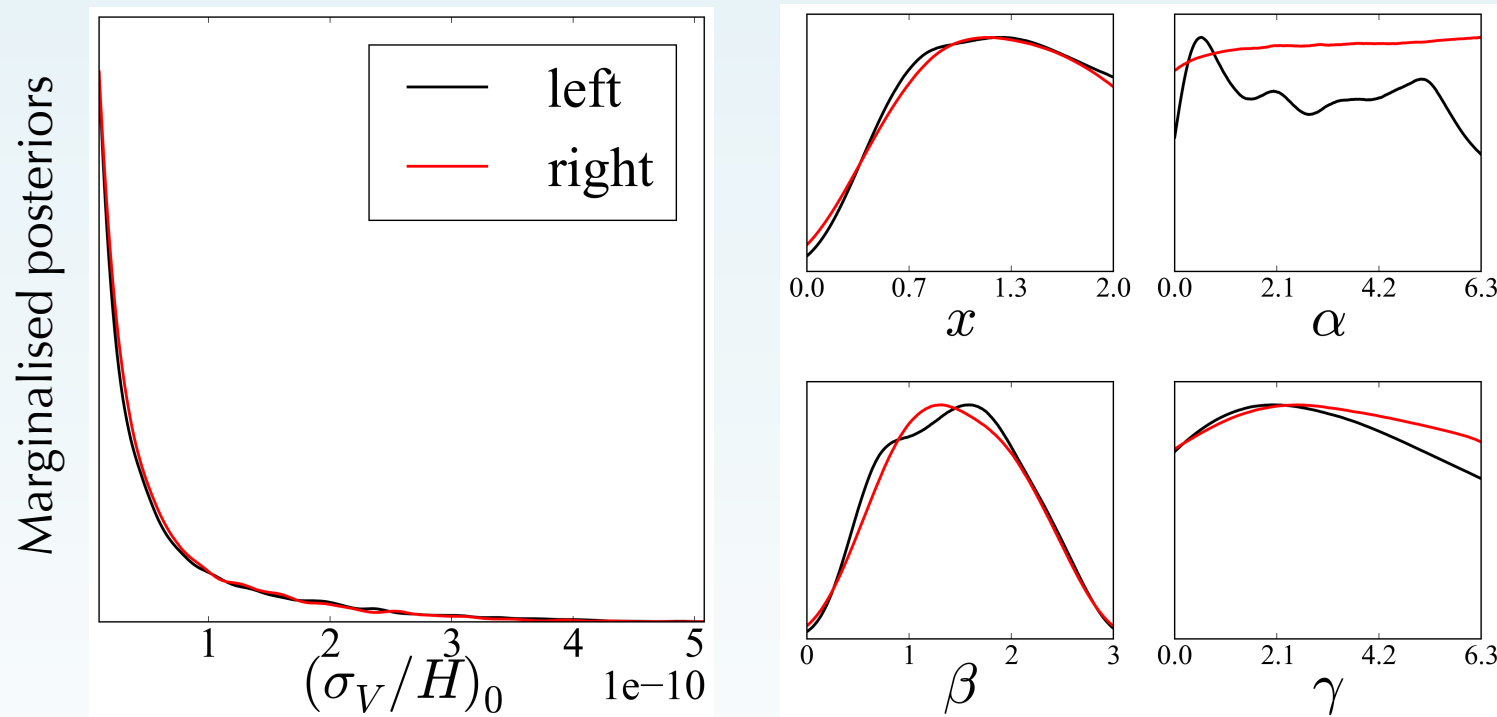
Spoiler...

Results

Spoiler...

**no evidence for
anisotropy!**

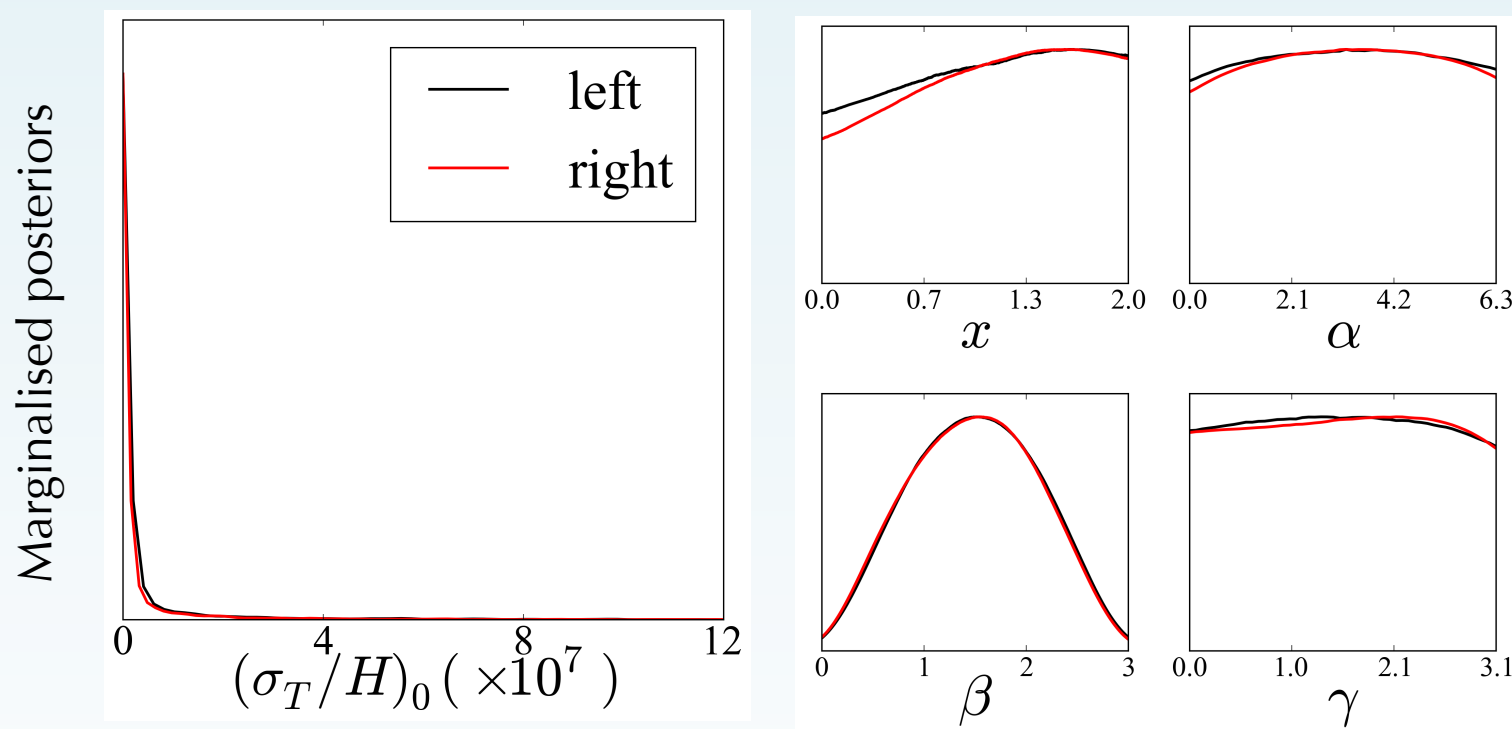
Results – vector modes



$$(\sigma_V/H)_0 < 5 \times 10^{-11}$$

Log prior on $(\sigma_V/H)_0$, uniform prior on x , α , γ , sine prior on β

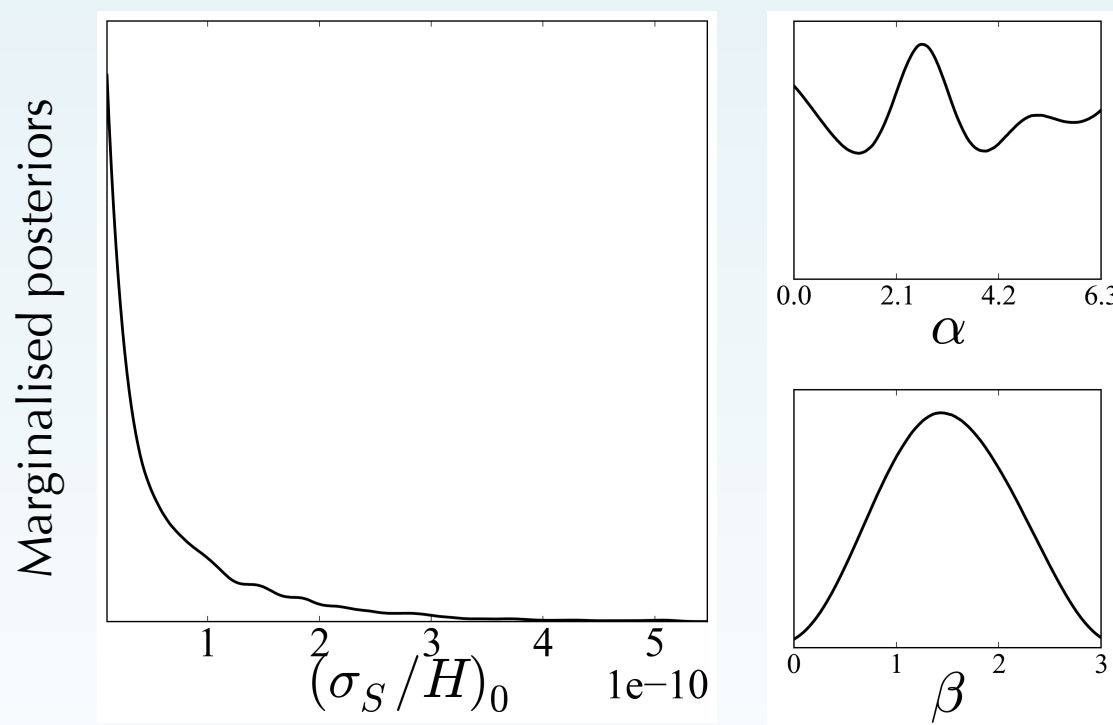
Results – tensor



$$(\sigma_T/H)_0 < 10^{-7}$$

Log prior on $(\sigma_T/H)_0$, uniform prior on x , α , γ , sine prior on β

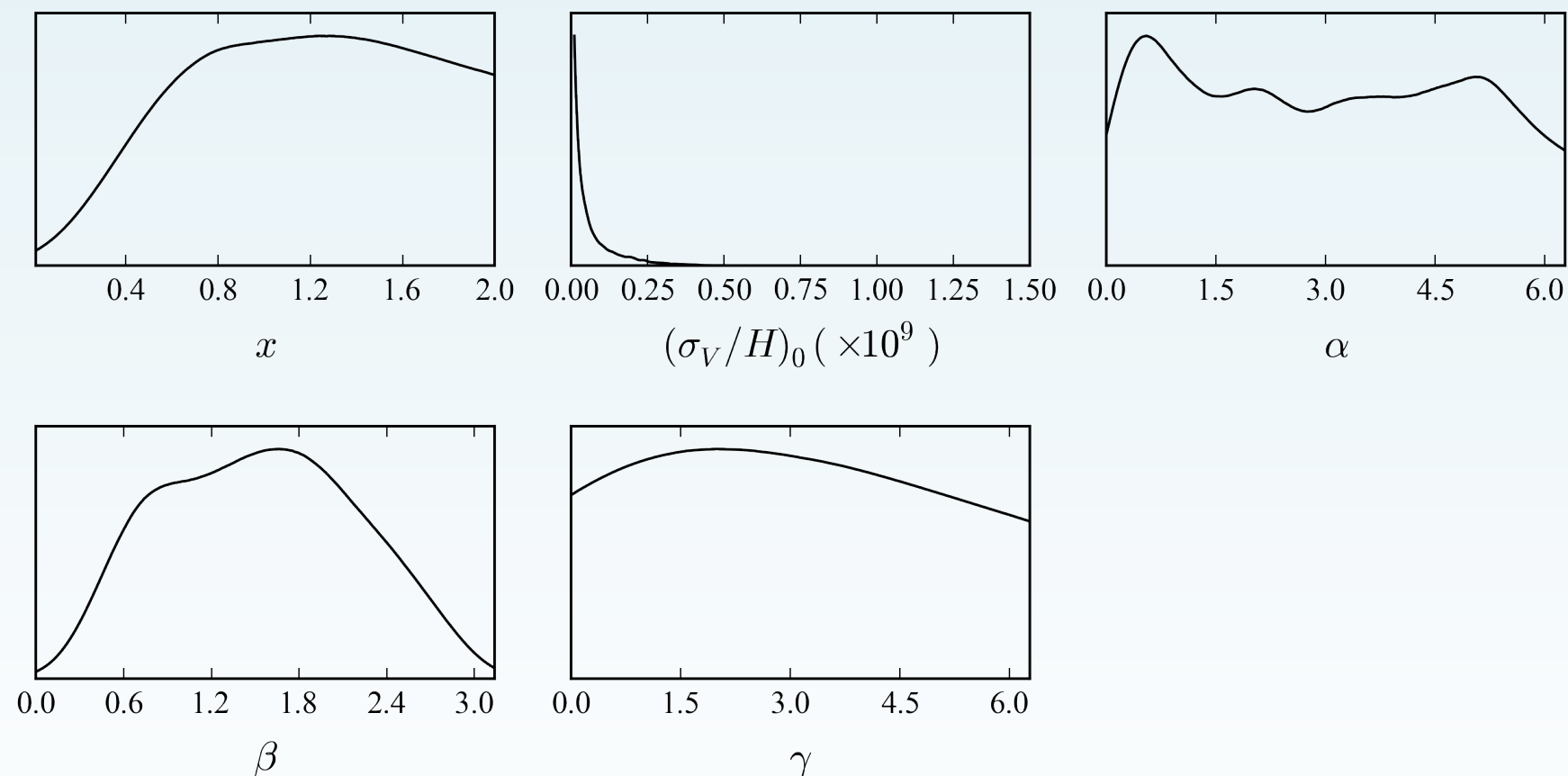
Results – scalars



$$(\sigma_S/H)_0 < 5 \times 10^{-11}$$

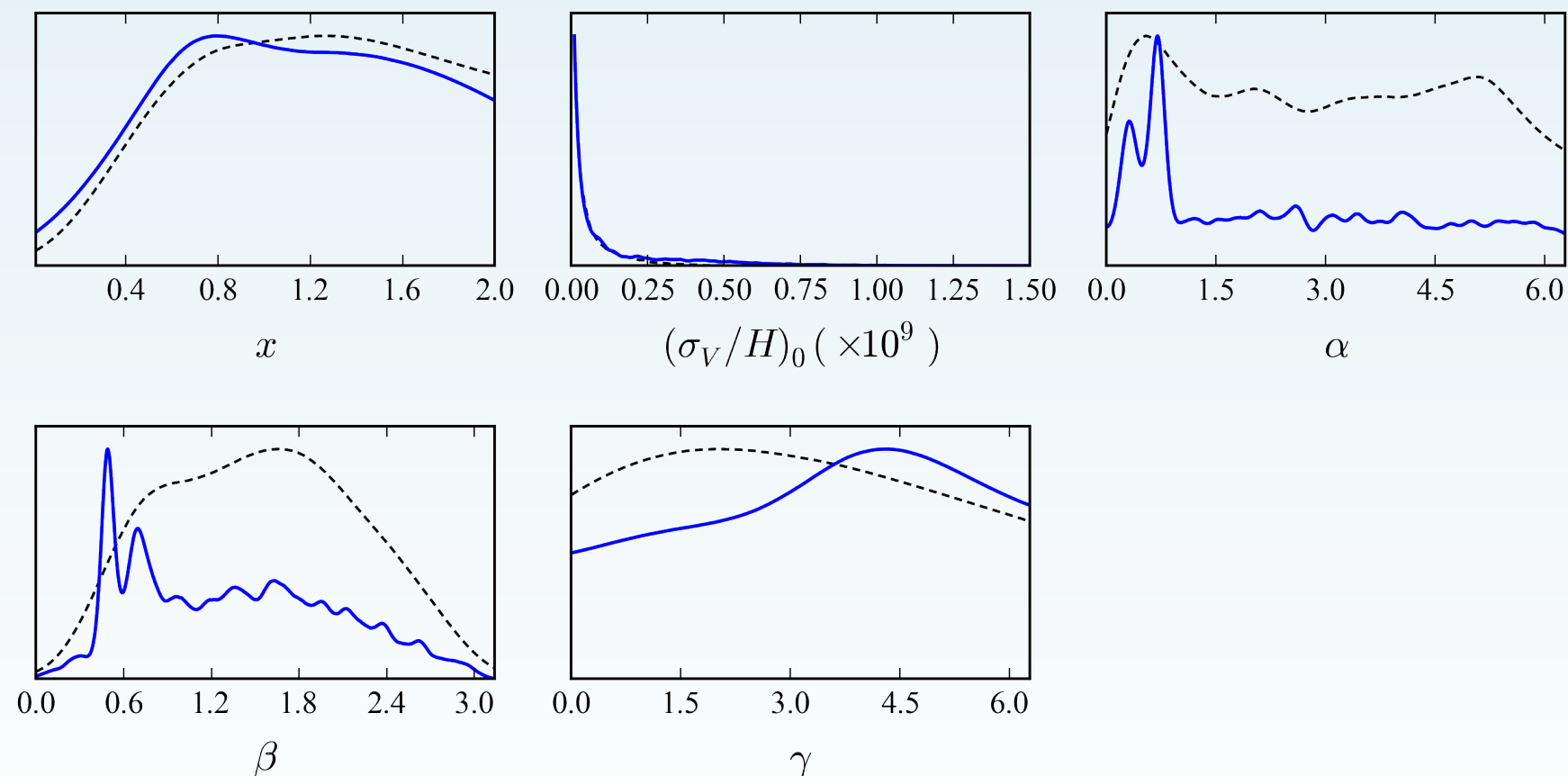
Log prior on $(\sigma_S/H)_0$, uniform prior on α , sine prior on β

Results – where have the detections gone?



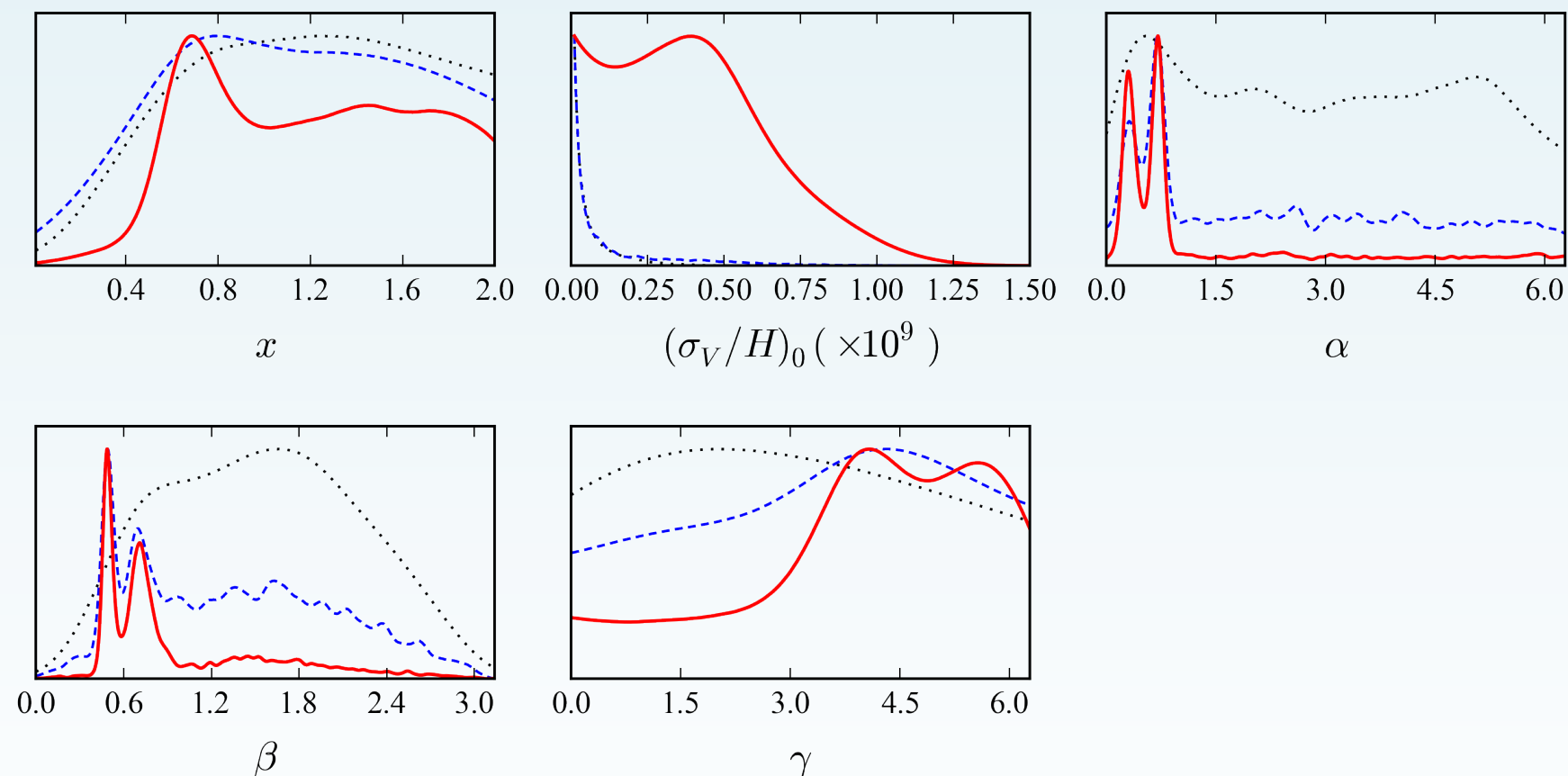
coupled model, log-uniform prior on the shear

Results – where have the detections gone?



decoupled model, log-uniform prior on the shear

Results – where have the detections gone?



decoupled model, uniform prior on the shear

Summary and conclusions

- We put the assumption of universal isotropy to the test
- We extended/improved existent analyses in several ways
- We find no evidence for anisotropy in the large scales and constrain it to

Vector anisotropy	Tensor anisotropy	Scalar anisotropy
$< 5 \times 10^{-11}$	$< 10^{-7}$	$< 5 \times 10^{-11}$

(WMAP constraints)

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PLANCK COMING SOON

(WMAP constraints)

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PLANCK COMING SOON
(with polarisation!)

(WMAP constraint)

**Thank you for your
attention!**