Cosmic birefringence

Merry Duparc
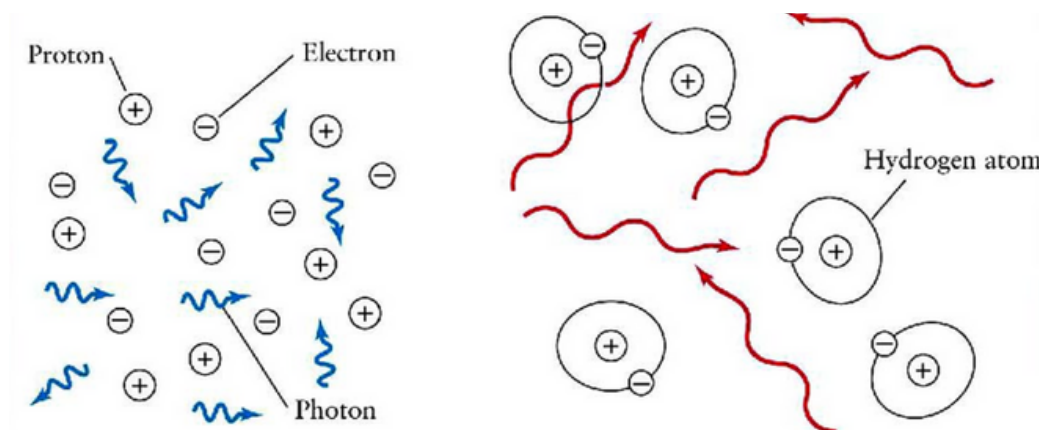
21 juin 2024

Introduction : CMB

Cosmic microwave background

Big Bang | Inflation | Protons form | Nuclear fusion begins | Nuclear fusion ends | Neutral hydrogen forms | Modern universe

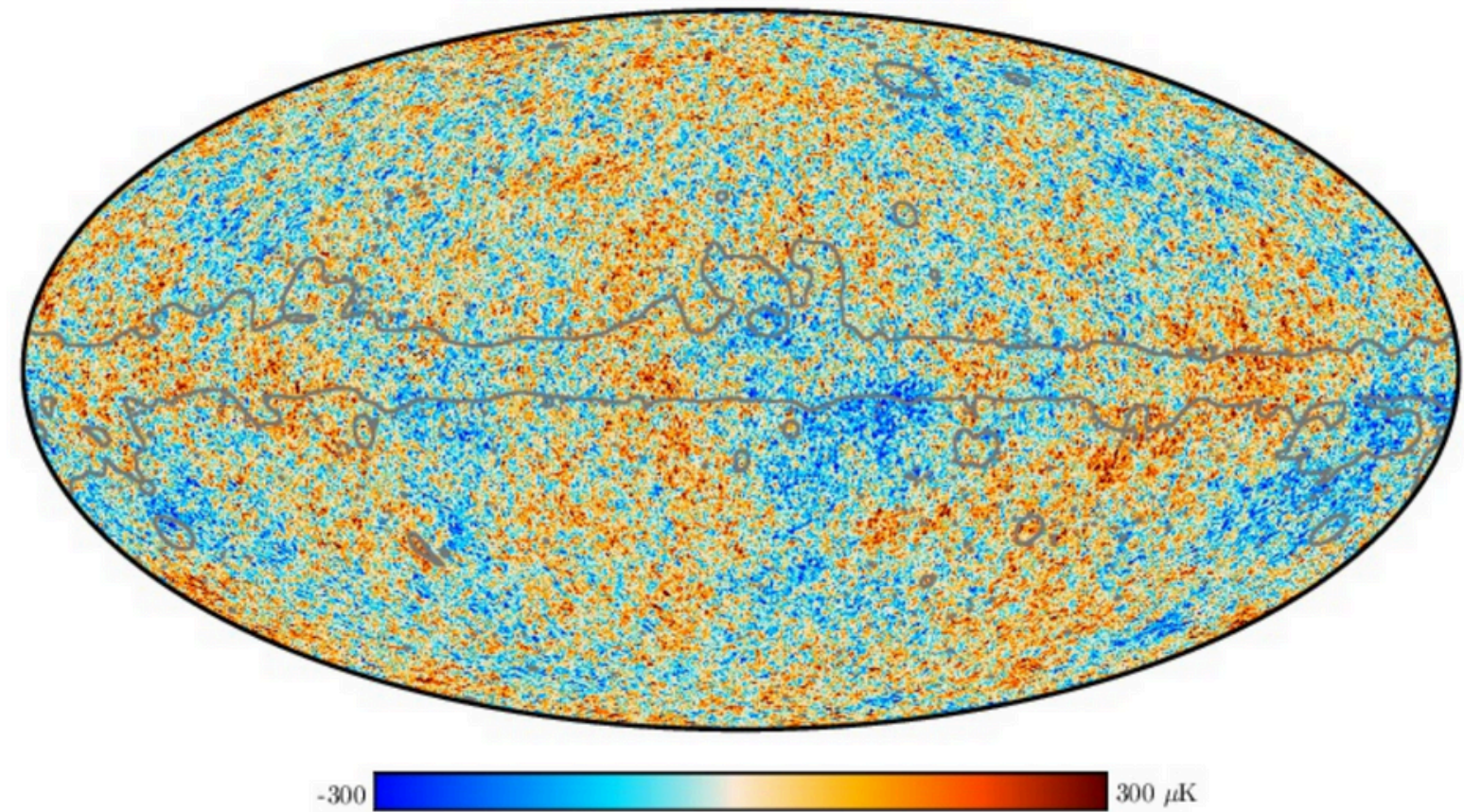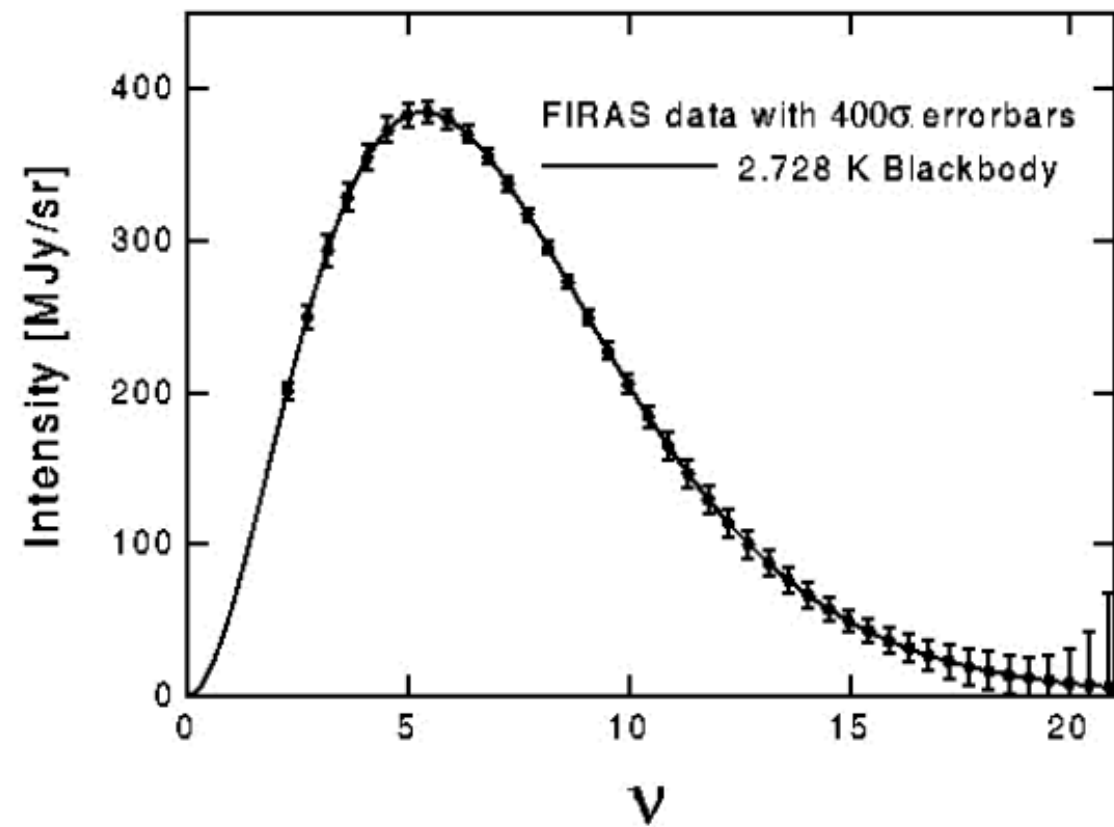Age of the universe
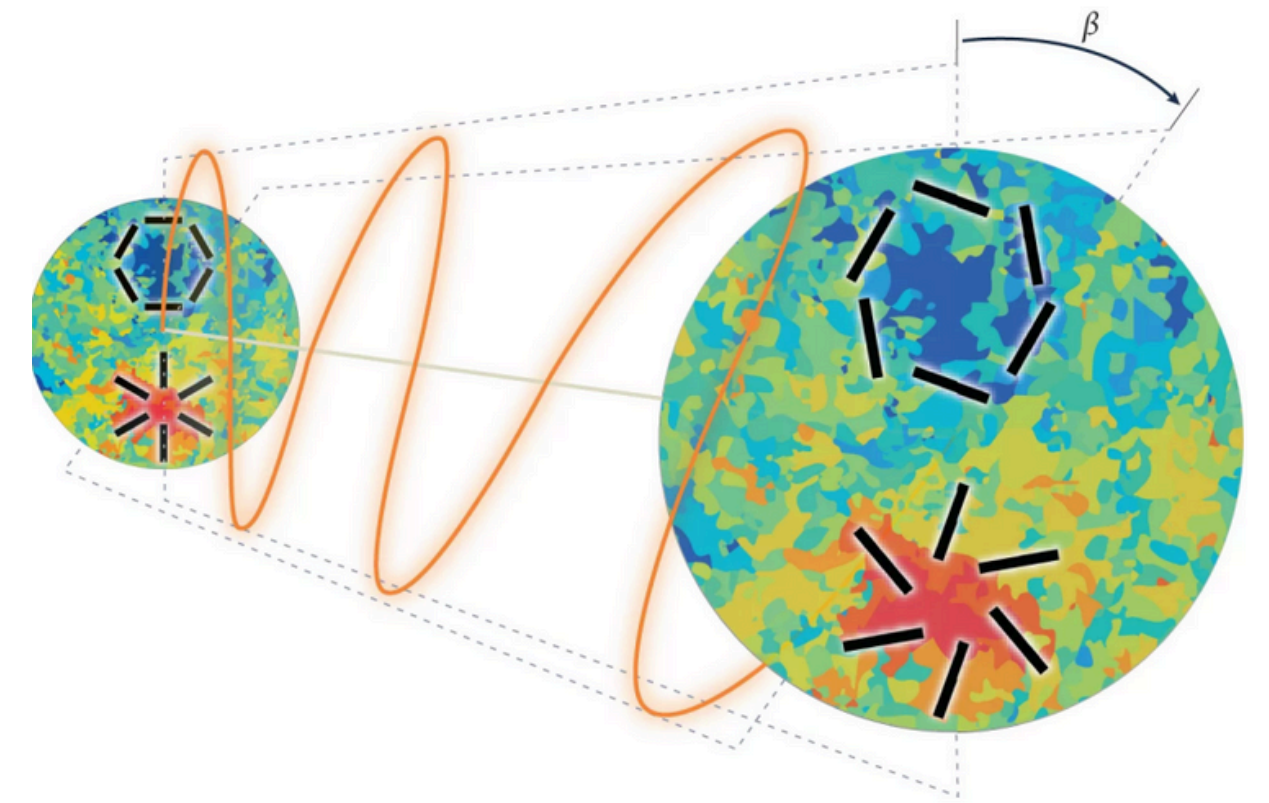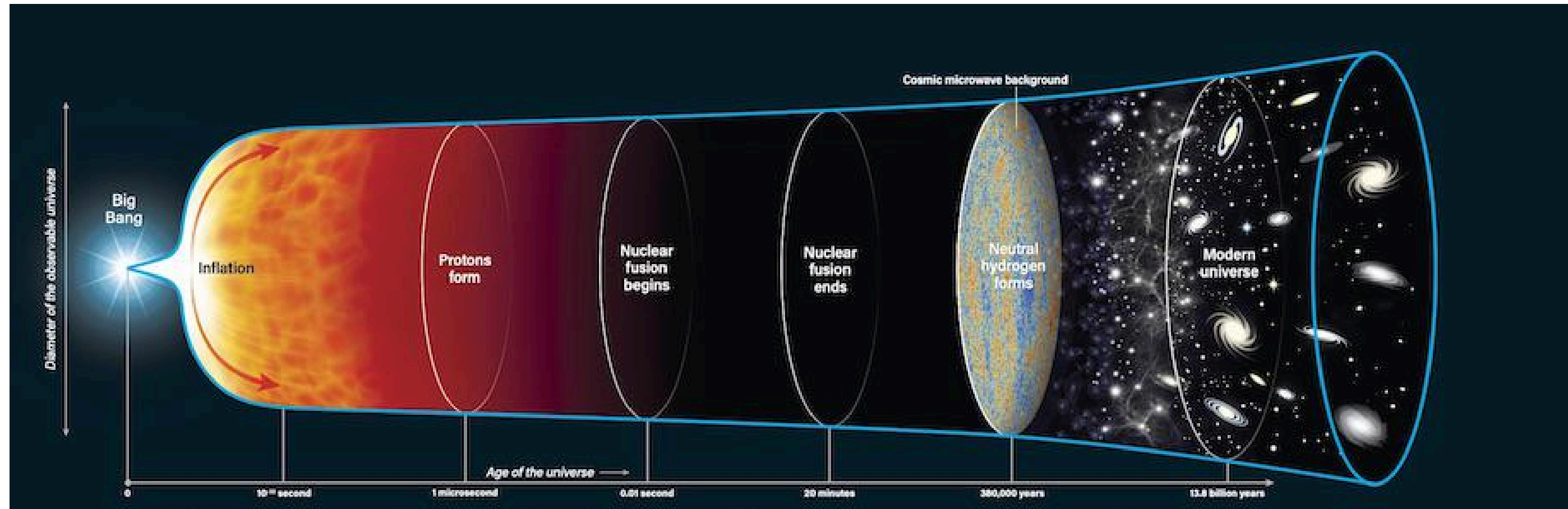
Ionised plasma
-> Opaque for photons

electron-photon decoupling
-> CMB Emission

-> (almost) Free travel of photons

Introduction : CMB

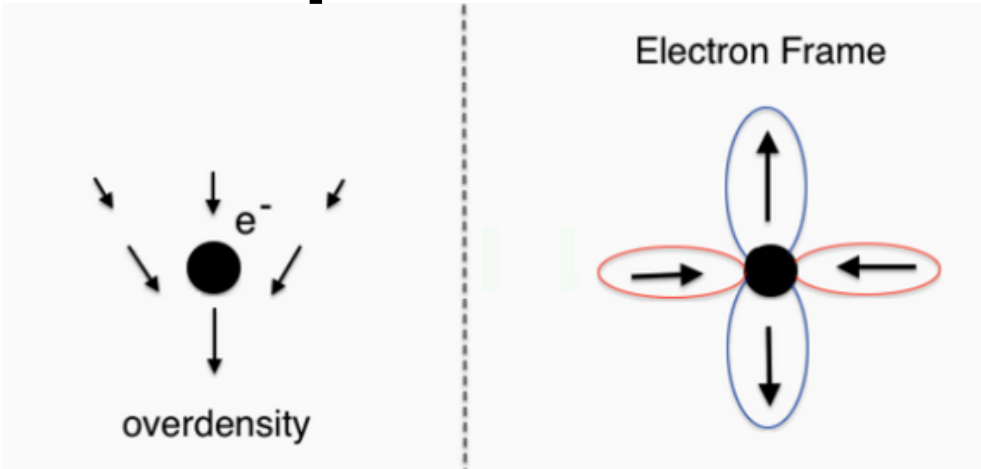Perfect black body spectrum
at 2.728K
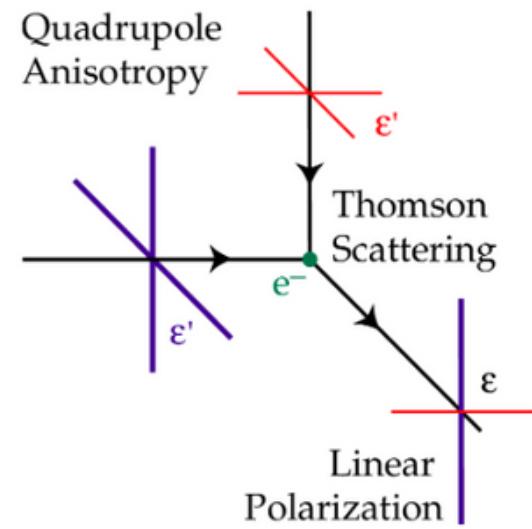

- 10^-5 anisotropies in temperature
- slightly polarised
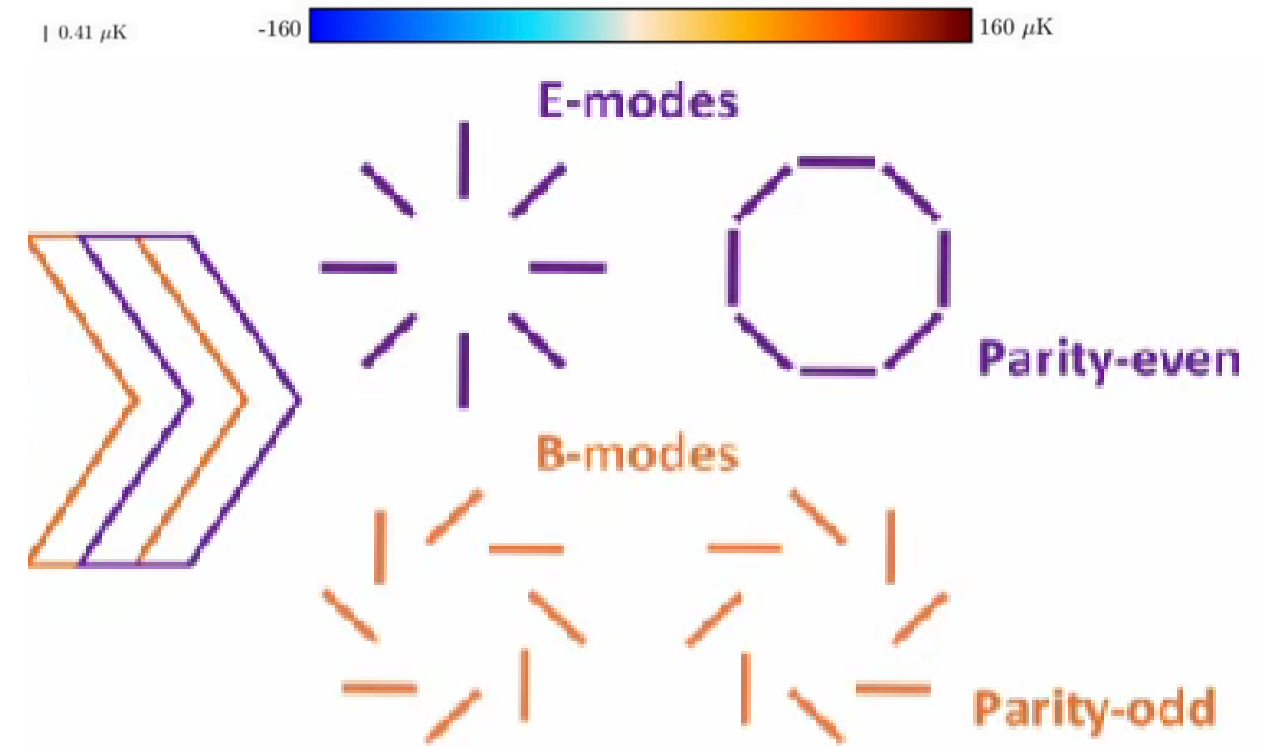
CMB polarisation spectra

Scalar perturbations
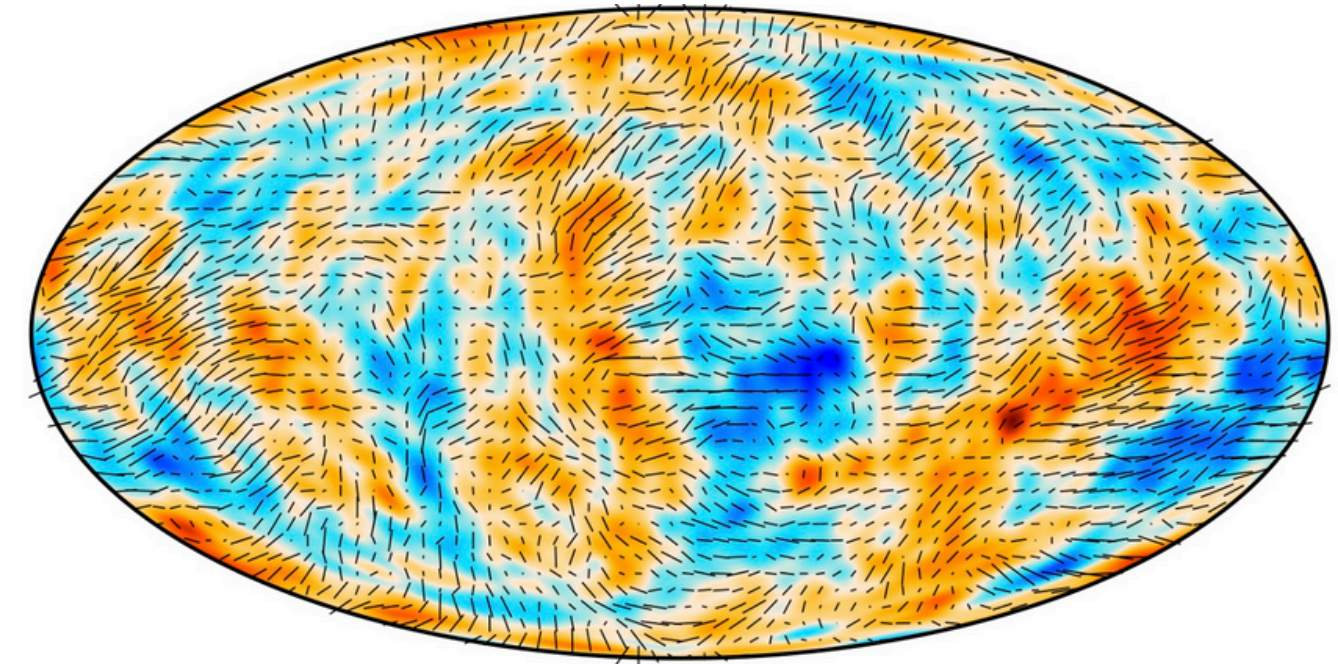

Electron Frame

overdensity

Quadrupole Anisotropy

Thomson Scattering

Linear Polarization

→ E-modes only

Tensor perturbations

→ E-modes and **B-modes**

| 0.41 μK   -160 ▬▬▬ 160 μK

E-modes

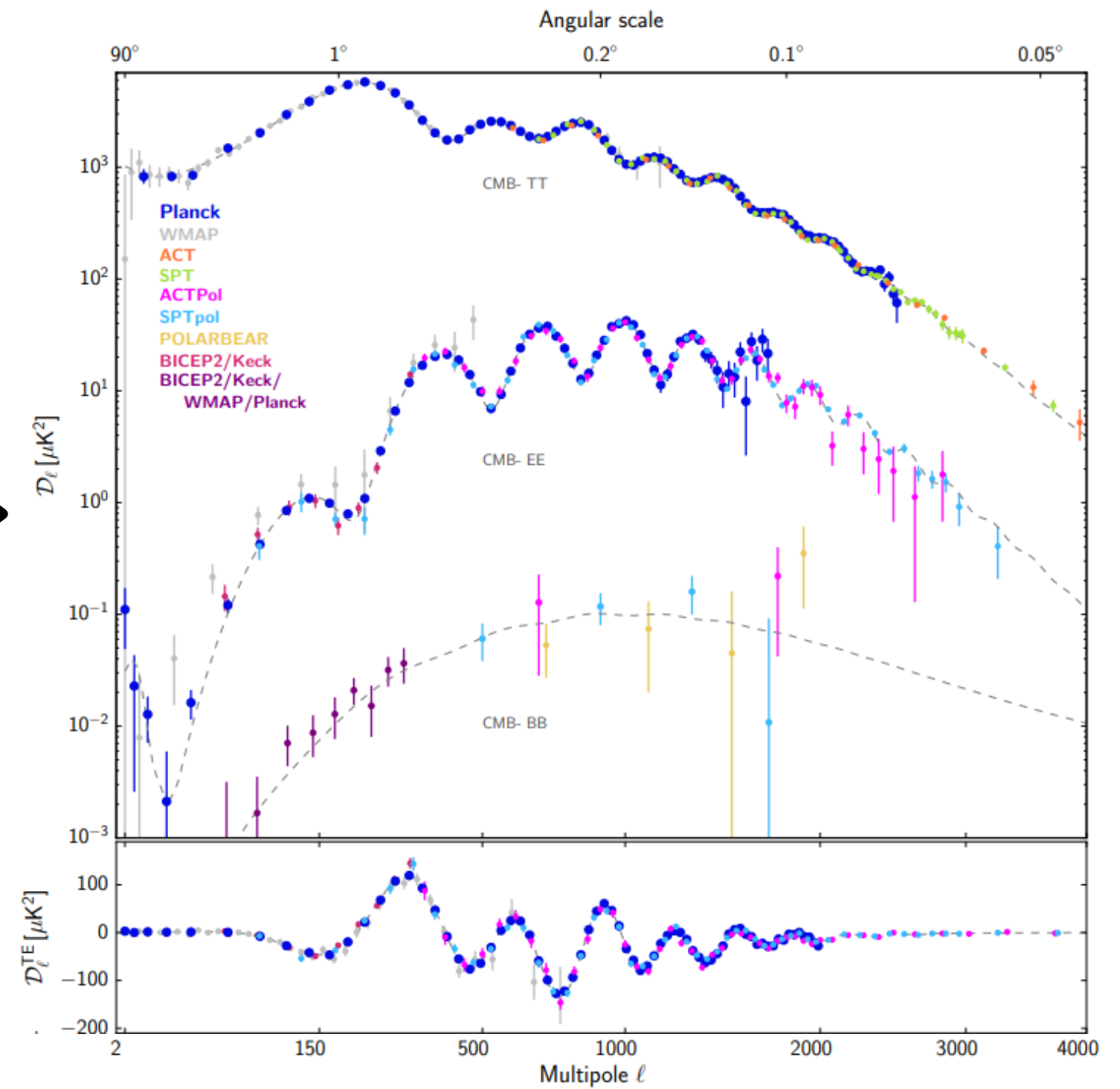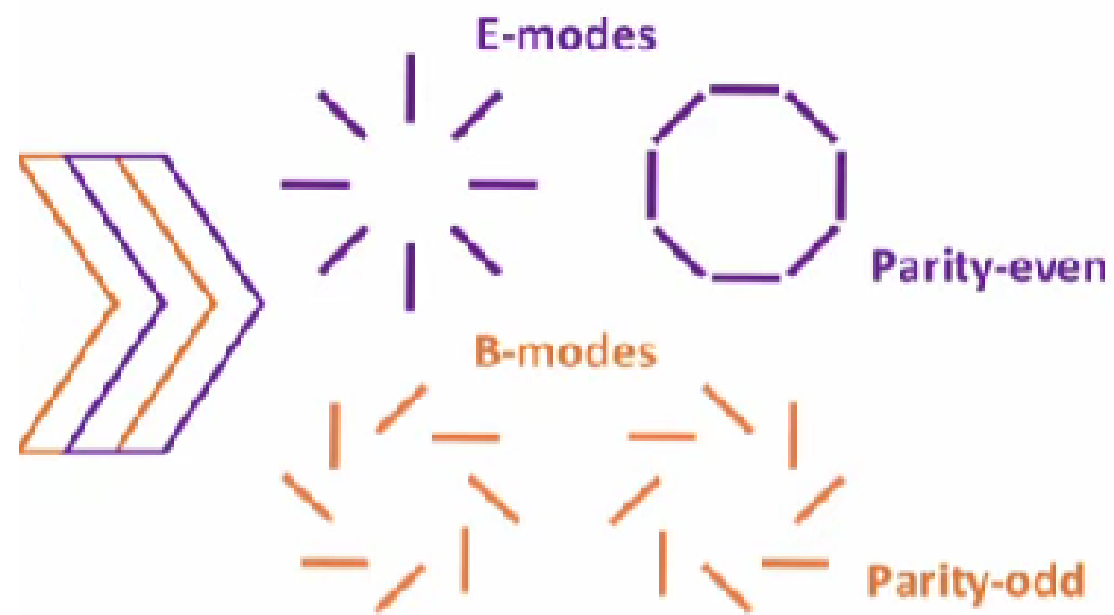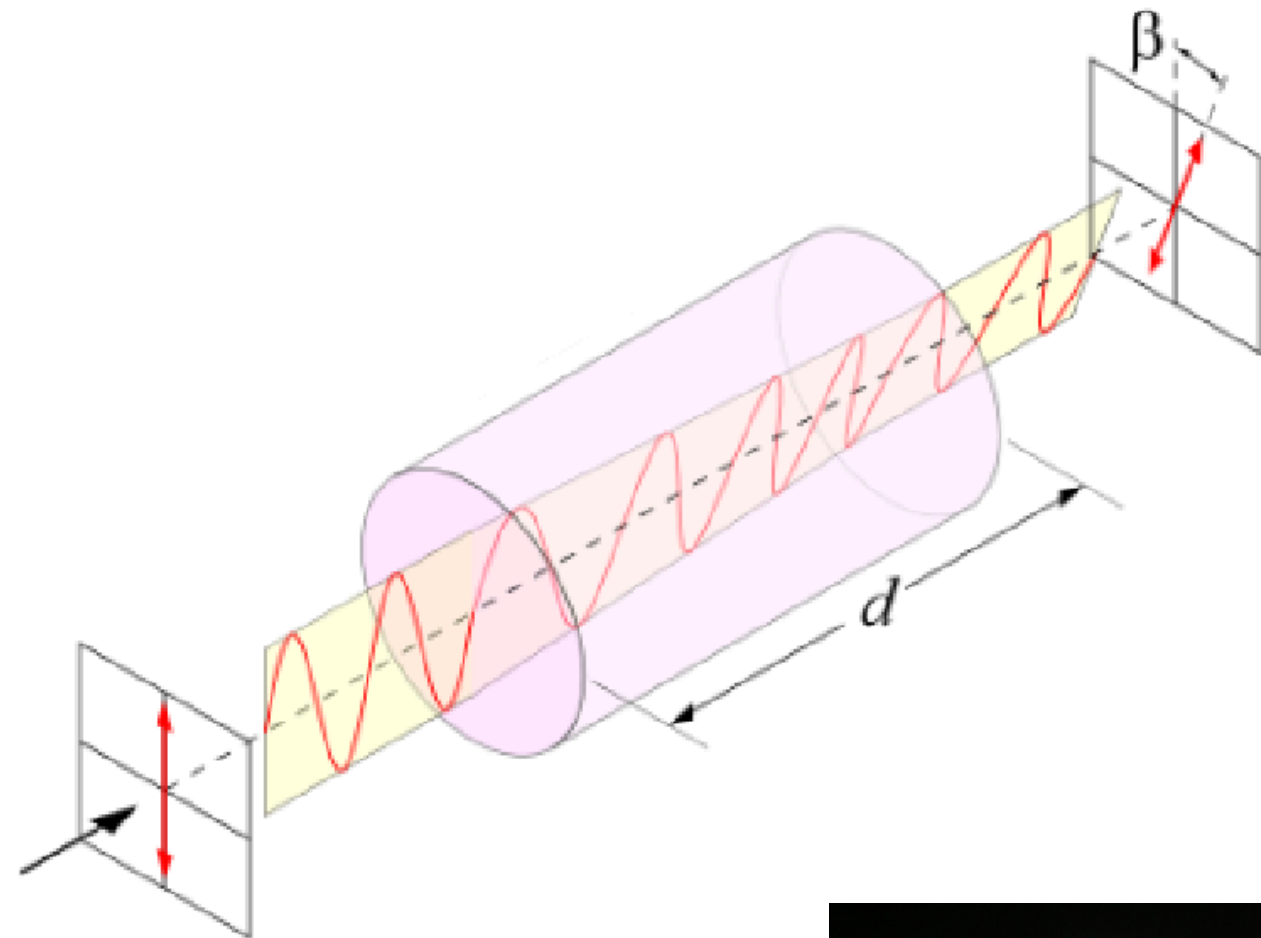Parity-even

B-modes

Parity-odd

CMB polarisation spectra
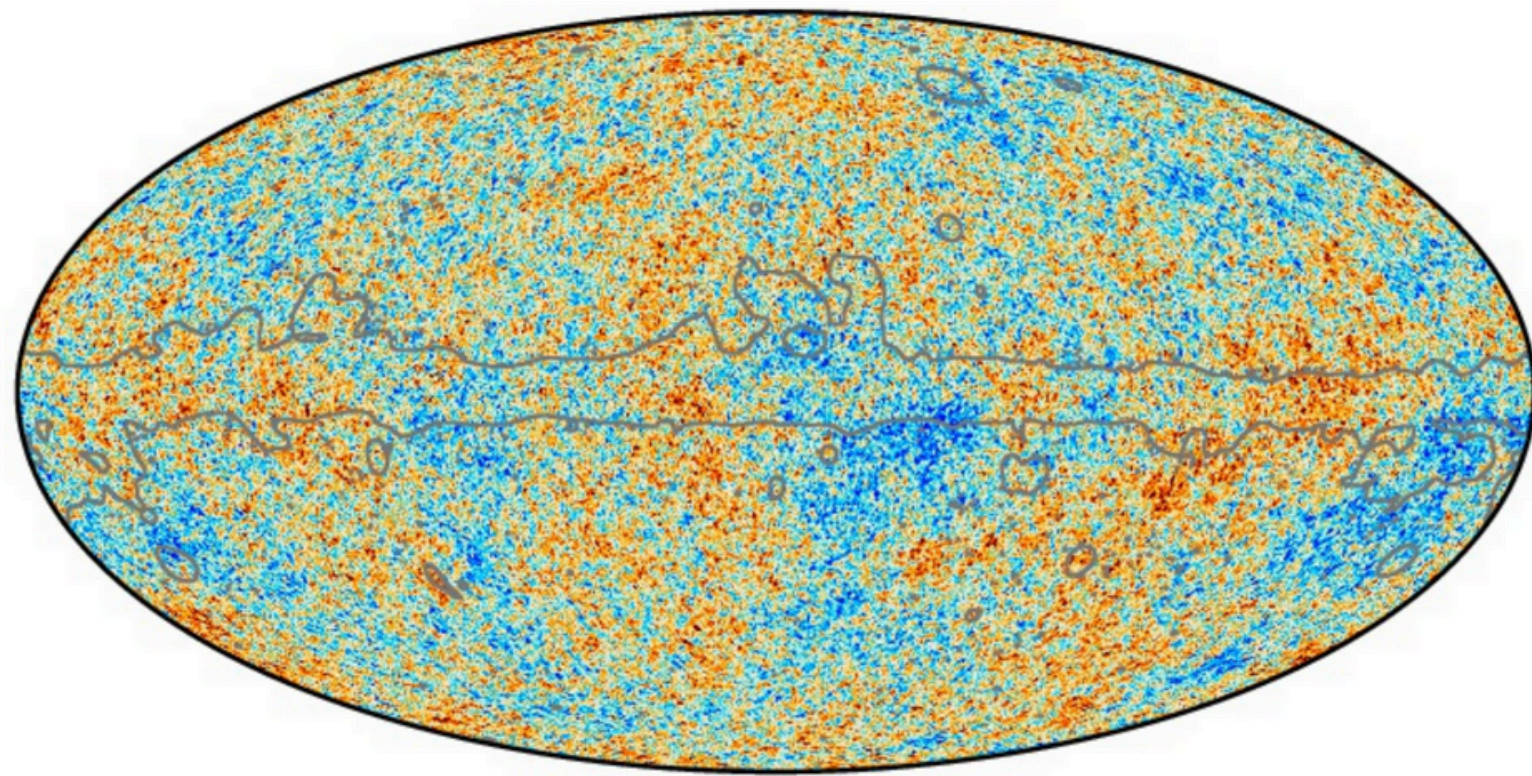
Spherical harmonics decomposition

Cosmic birefringence

Birefringent cristal

$$\mathcal{L} \supset \frac{1}{4} g_{\phi\gamma} \phi F_{\mu\nu} \tilde{F}^{\mu\nu}$$
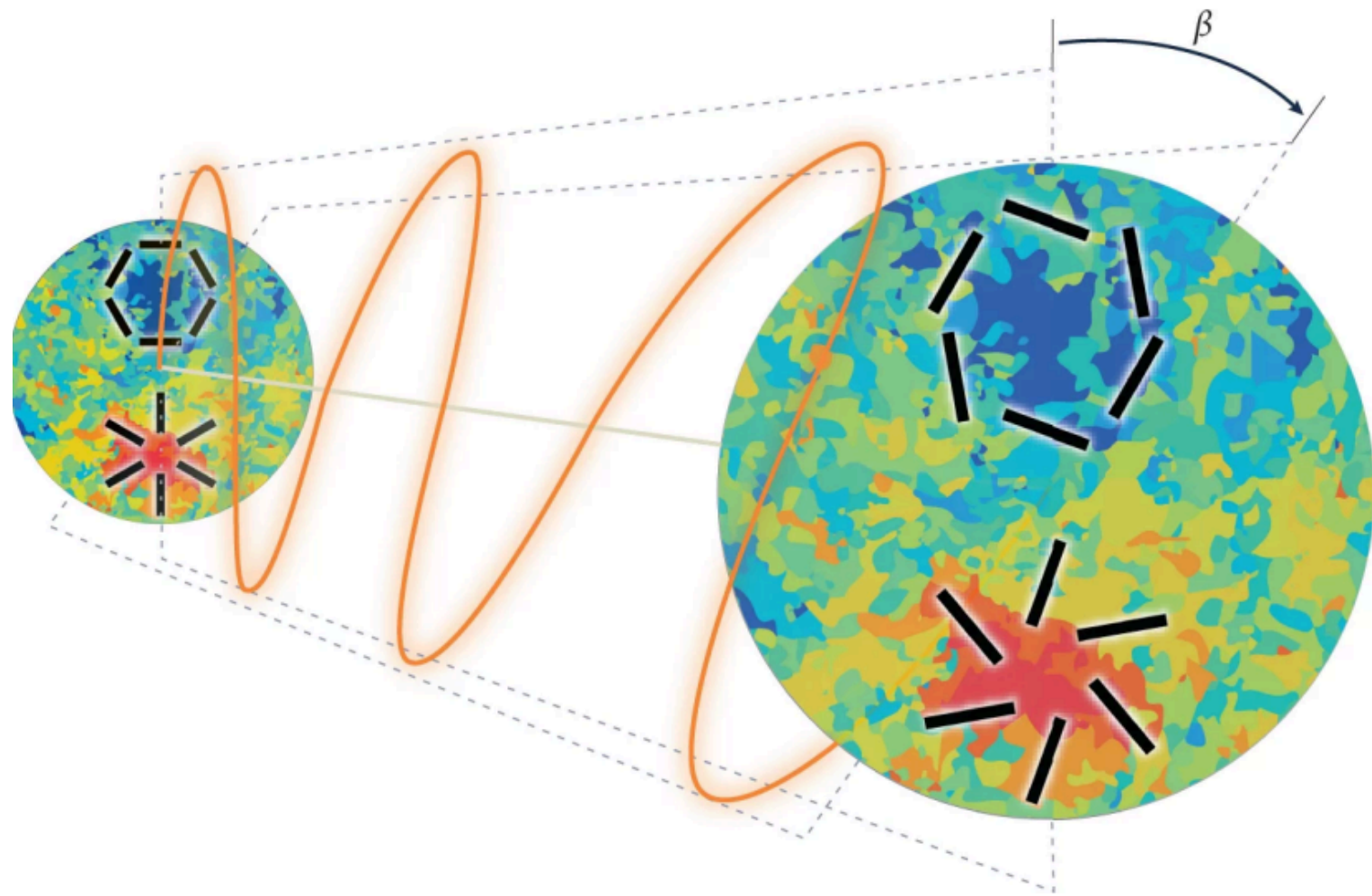
Axion-like Lagrangian with
a Chern-Simons term

-> New physics !

Cosmic birefringence

Effect of cosmic birefringence
on polarisation patterns

$$C_\ell^{EE,\text{o}} = C_\ell^{EE} \cos^2(2\alpha) + C_\ell^{BB} \sin^2(2\alpha),$$

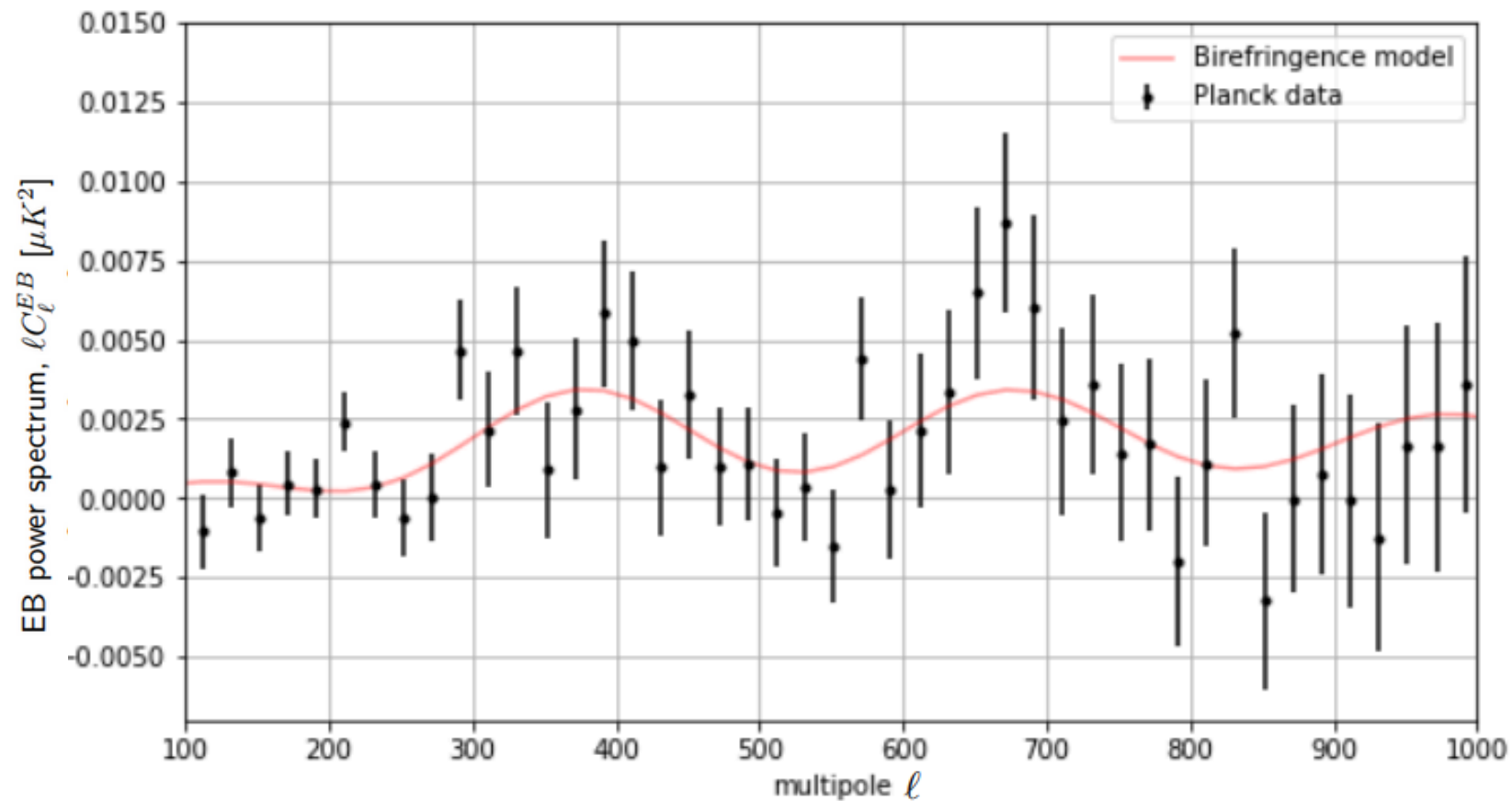$$C_\ell^{BB,\text{o}} = C_\ell^{EE} \sin^2(2\alpha) + C_\ell^{BB} \cos^2(2\alpha),$$

$$C_\ell^{EB,\text{o}} = \frac{1}{2}\left(C_\ell^{EE} - C_\ell^{BB}\right)\sin(4\alpha),$$

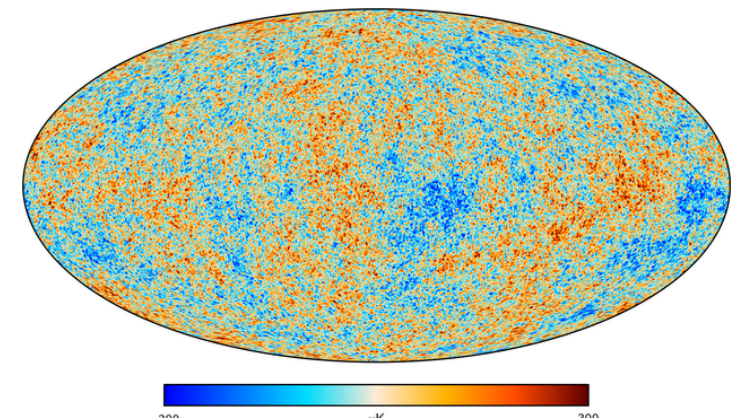$$C_\ell^{EB,\text{o}} \approx \frac{1}{2}C_\ell^{EE}\sin(4\alpha)$$

Actual Measurements

$$C_\ell^{EB,o} \approx \frac{1}{2} C_\ell^{EE} \sin(4\alpha)$$

Experiment	σ_{noise}	σ_{calib}
Planck	$\pm \sim 0.05°$	?
ACT	$\pm \sim 0.02°$	?
SO	$\pm < 0.01°$	?
LITEBird	$\pm < 0.01°$	?

red line : $\alpha = 0.3 \pm 0.05°$

Foregrounds

Stacked observed EB power spectrum

$f_{\mathrm{sky}} = 0.92$

EB power spectrum, ℓC_ℓ^{EB} [μK^2]

— Cosmic birefringence
— Miscalibration angle
— Best-fit total

Stacked observed EB power spectrum

$f_{\mathrm{sky}} = 0.62$

EB power spectrum, ℓC_ℓ^{EB} [μK^2]

— Cosmic birefringence
— Miscalibration angle
— Best-fit total