Tilted Physics

[All the hard parts done by postdocs Adam Moss & Jim Zibin]

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Cosmos may show echoes of events before Big Bang

By Jason Palmer
Science and technology reporter, BBC News

Evidence of events that happened before the Big Bang can be seen in the glow of microwave radiation that fills the Universe, scientists have asserted.

News Flash!

Renowned cosmologist Roger Penrose said that analysis of this cosmic microwave background shows echoes of previous Big Bang-like events.

The events appear as "rings" around galaxy clusters in which the variation in the background is unusually low.

The unpublished research **has been posted on the Arxiv** website.

The ideas within it support a theory developed by Professor Penrose - knighted in 1994 for his services to science - that upends the widely-held "inflationary theory".

That theory holds that the Universe was shaped by an unthinkably large and fast expansion from a single point.

The variation in the background shifts sharply within the rings

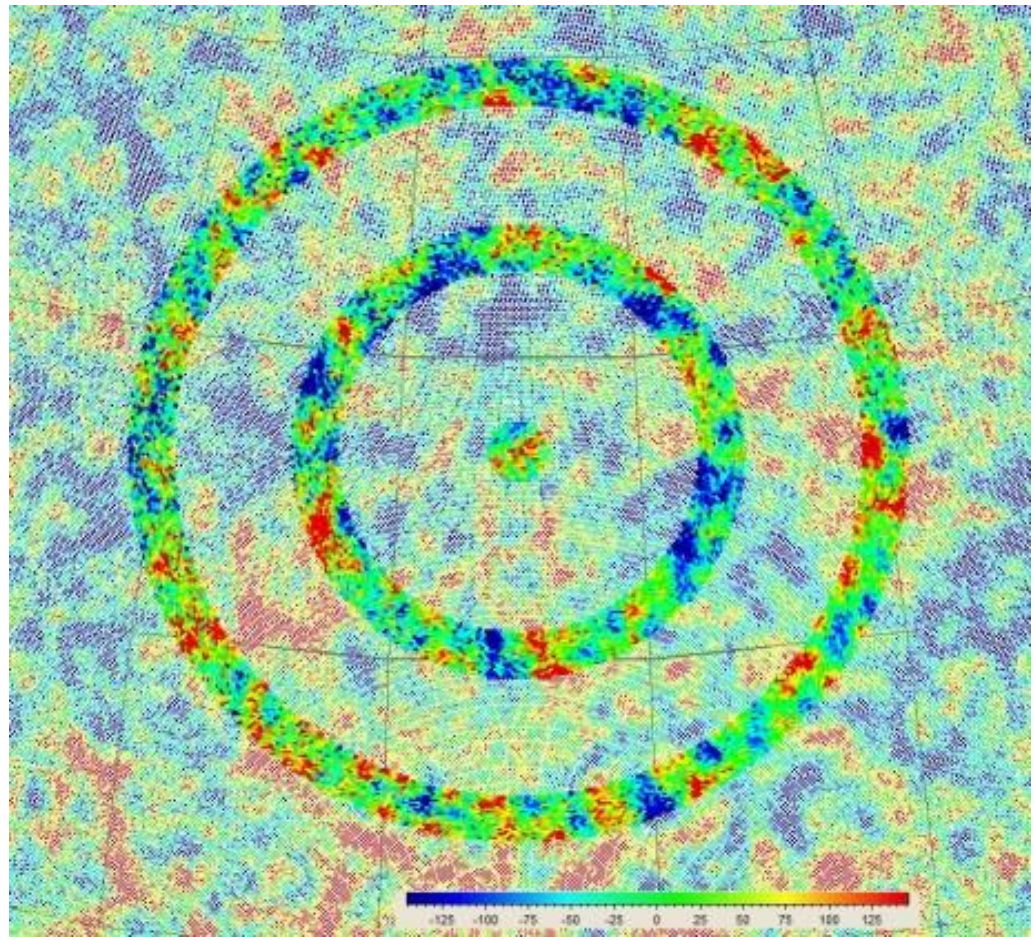
Related stories

'Big Bang follows Big Bang follows Big Bang'

The clearest observational signal of CCC results from numerous supermassive black-hole encounters occurring within clusters of galaxies in the aeon previous to ours. These encounters should yield huge energy releases in the form of gravitational radiation bursts. From the perspective of our own aeon (see [3]), these would appear not in the form of gravitational waves, but as spherical, largely isotropic, impulsive bursts of energy in the initial material in the universe, which we take to be some primordial form of dark matter, the impulse moving outwards with the speed of light up to our last-scattering surface (see Fig. 1).

Pre-primordial gravitational waves from pre-primordial black holes!

"Prediction" for concentric rings of low variance



Claim for detection in WMAP data

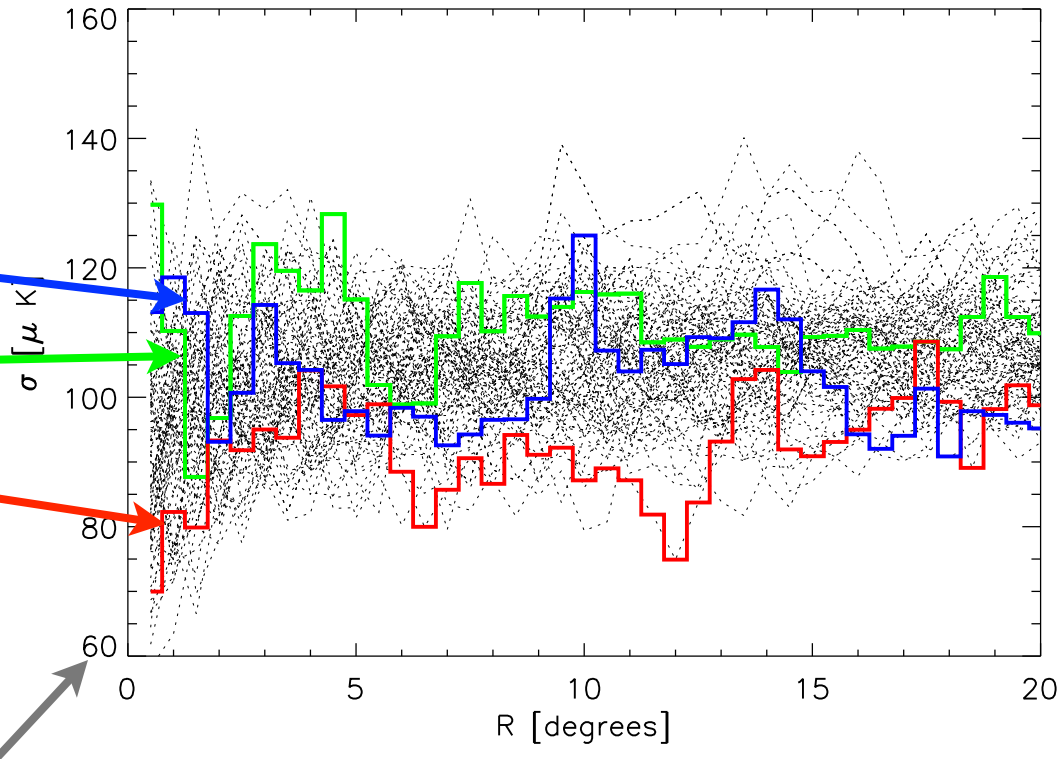
So let's look at some real data

G&P-selected position

MSZ-selected position

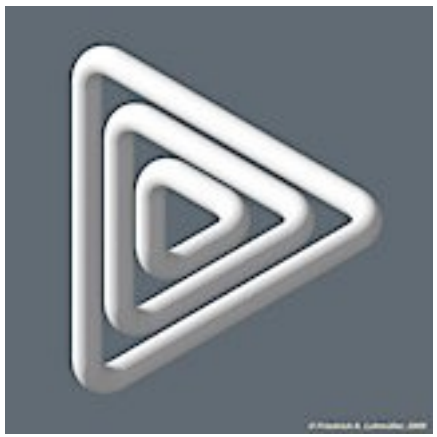
G&P-selected position

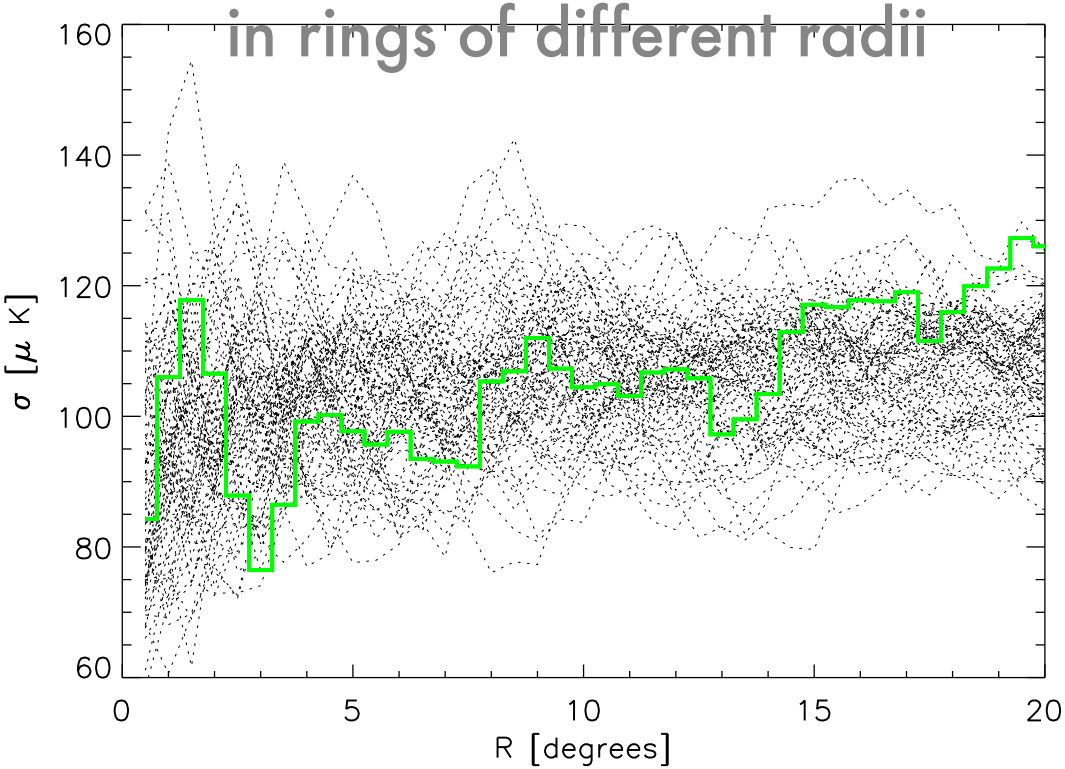
Variance of temperature



Not zero!

in rings of different radii





Triangles are just as good (maybe better!)

(see Moss, Scott & Zibin, arXiv:1012.1305)

New paper (by the Z-men)

Non-standard morphological relic patterns in the cosmic microwave background

Joe Zuntz[*], James P. Zibin[†], Caroline Zunckel[‡], Jonathan Zwart[§]

1 April 2011

Abstract

Statistically anomalous signals in the microwave background have been extensively studied in general in multipole space, and in real space mainly for circular and other simple patterns. In this paper we search for a range of non-trivial patterns in the temperature data from WMAP 7-year observations. We find a very significant detection of a number of such features and discuss their consequences for the essential character of the cosmos.

important information can be lost if we exclusively follow this approach.

One area of fertile or at least extensive research has been searches for non-gaussian statistics of the CMB. The bispectrum and trispectrum of Wilkinson Microwave Anisotropy Probe (WMAP) and other data have been analyzed for consistency with gaussianity, with varying results [1, 2, 3, 4, 5] and even single point statistics beyond the variance can provide strongly convincing evidence of non-gaussian behavior [6].

New paper (by the Z-men)

Figure 1: An example of a CMB map for which the application of posterior statistics would not be wholly unreasonable.

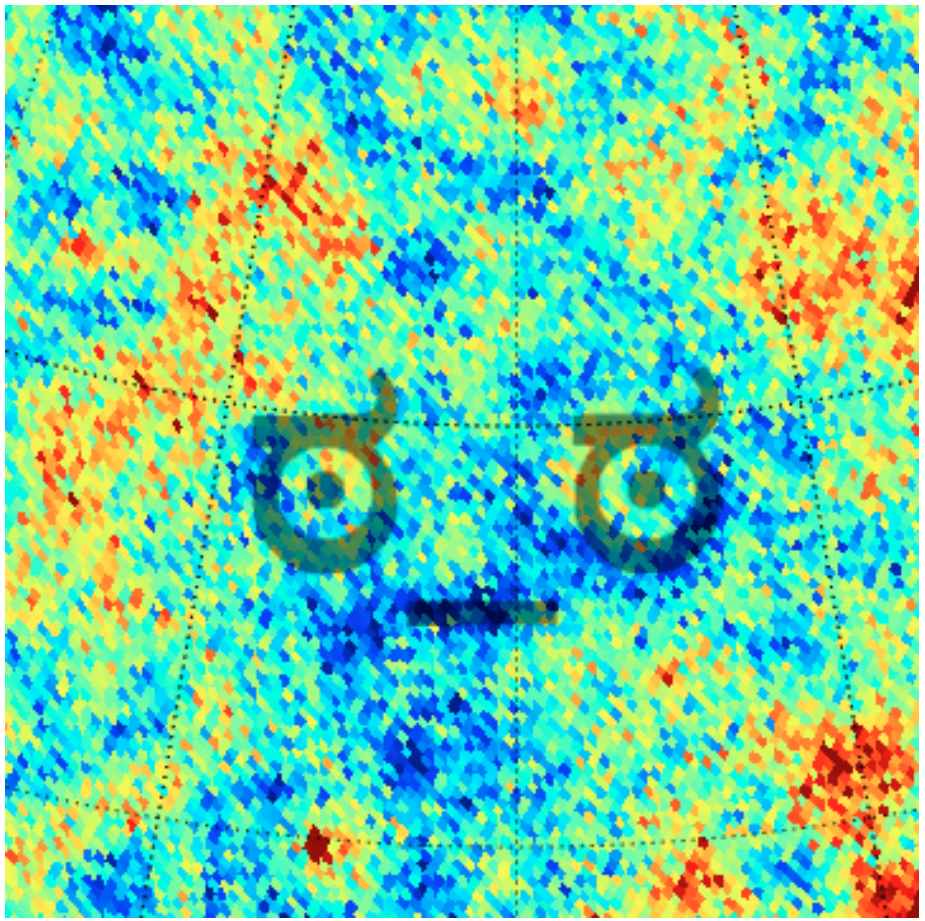


Figure 5: A detection of pattern E, the look of disapproval.

Back to Tilted Physics

[All the hard parts still done by Adam Moss & Jim Zibin]

- Imagine that physics varies over very large scales
- Maybe we could observe bubble collisions?
- But the second craziest idea is:

Perhaps we could detect a gradient across our patch?

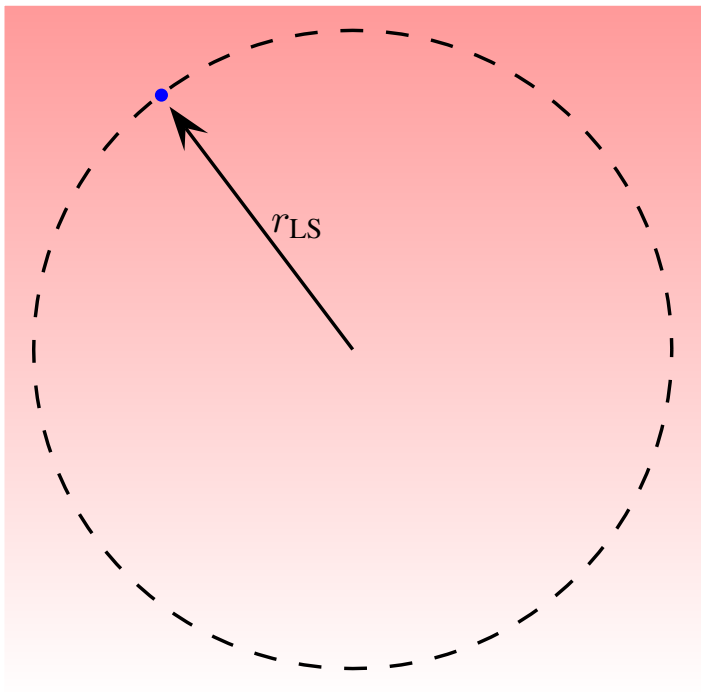


FIG. 1: Spatial gradient in a cosmological parameter (represented by the colour gradient), which is locally negligible at last scattering, but important over the free-streaming length scale. The filled circle shows (to scale) the comoving horizon size at last scattering.

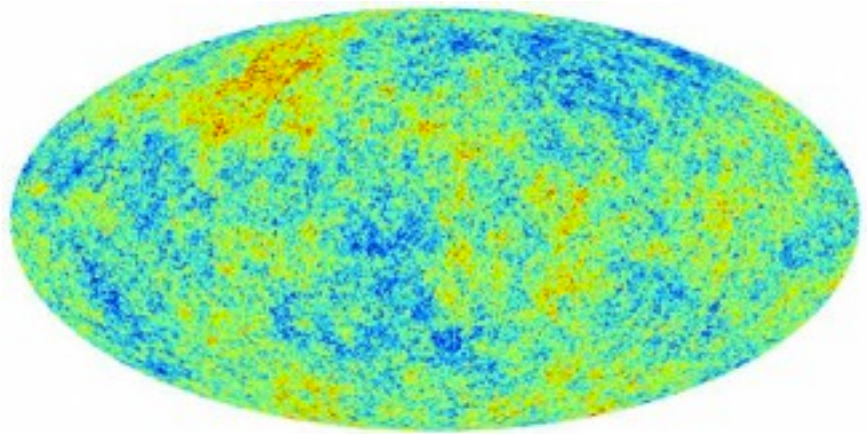
- → dipole modulation of sky
- Already studied for perturbation amplitude
- Effectively same as for "aberration"
- Recently suggested for α
- But could be <u>any</u> parameter

(Moss, Scott, Zibin & Battye, arXiv:1011.2990)

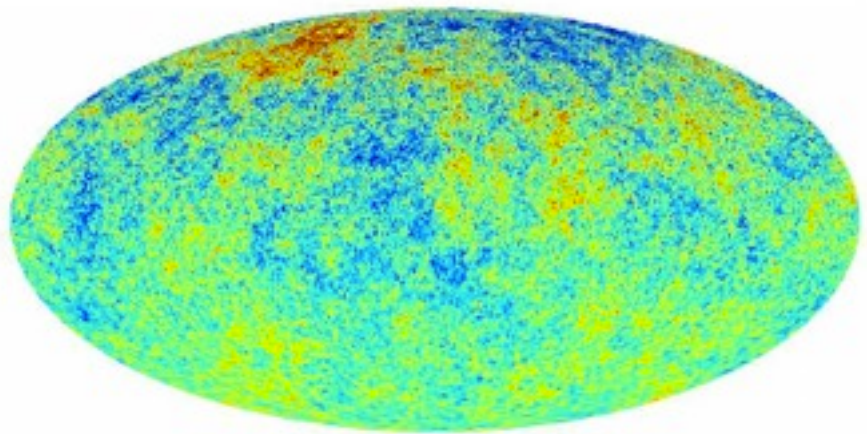
Let's look at aberration of the CMB

- Challinor & van Leeuwen 2002
- Burles & Rappaport 2006
- Kosowsky & Kahniashvili 2010
- Amendola et al. 2010
- Chluba 2011

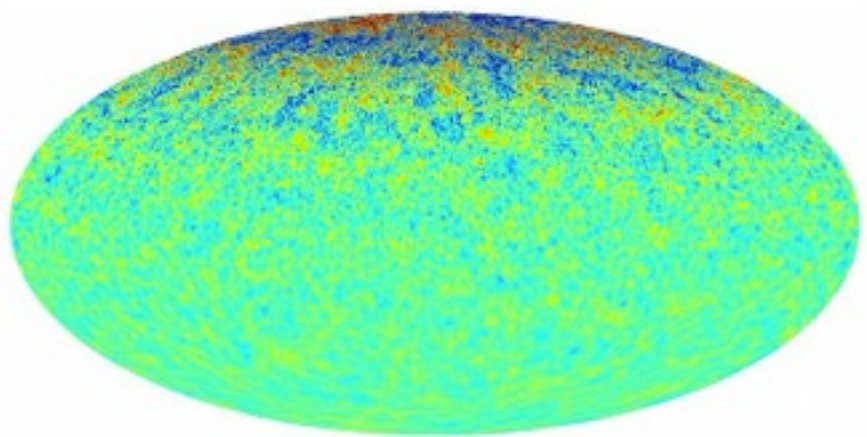
- Real effect has $\beta \approx 0.001$
- C_ℓ modulated by $\cos\theta$ pattern
- Detectable by Planck
- Just a poor way of measuring the dipole?



$\beta = 0$

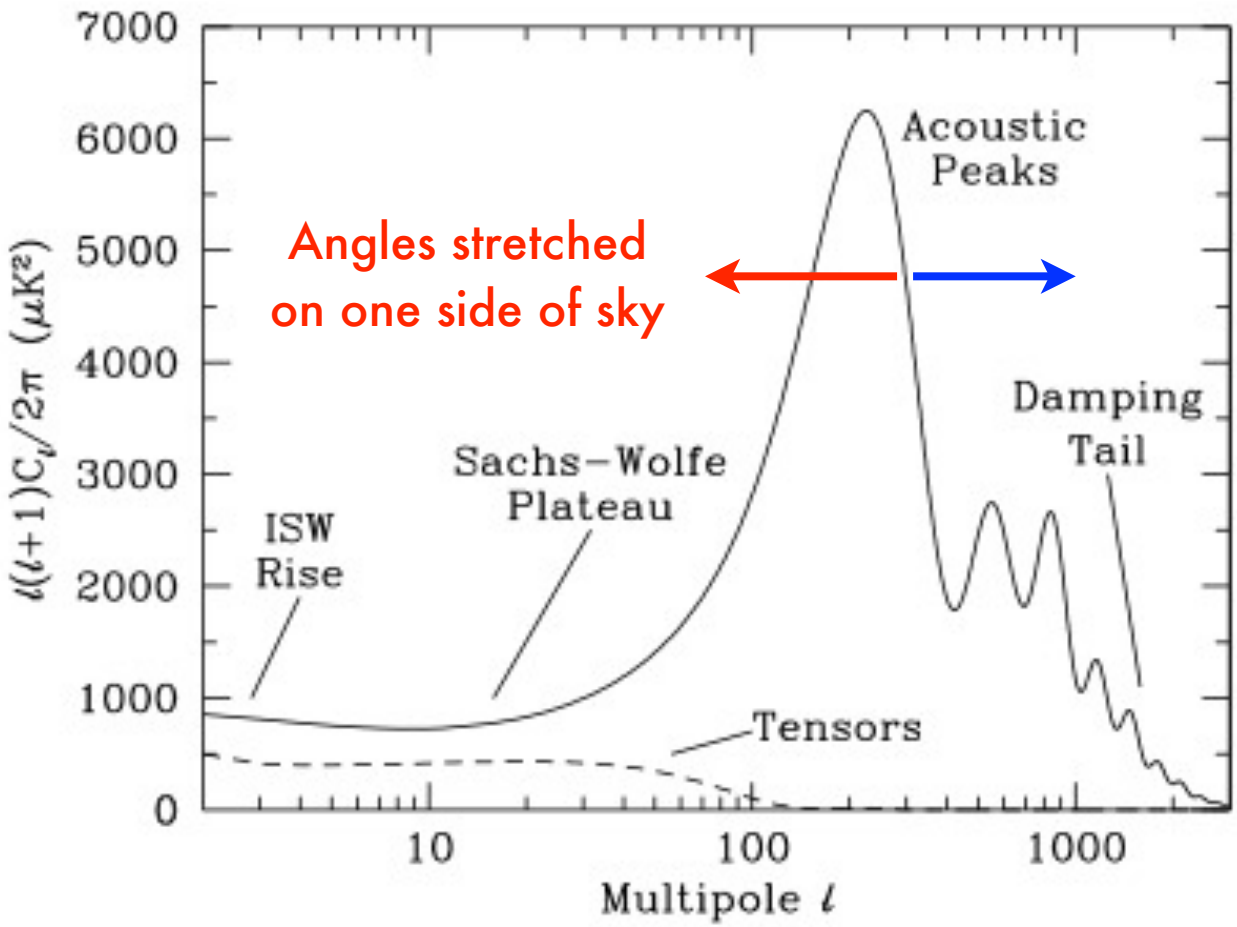


$\beta = 0.5$

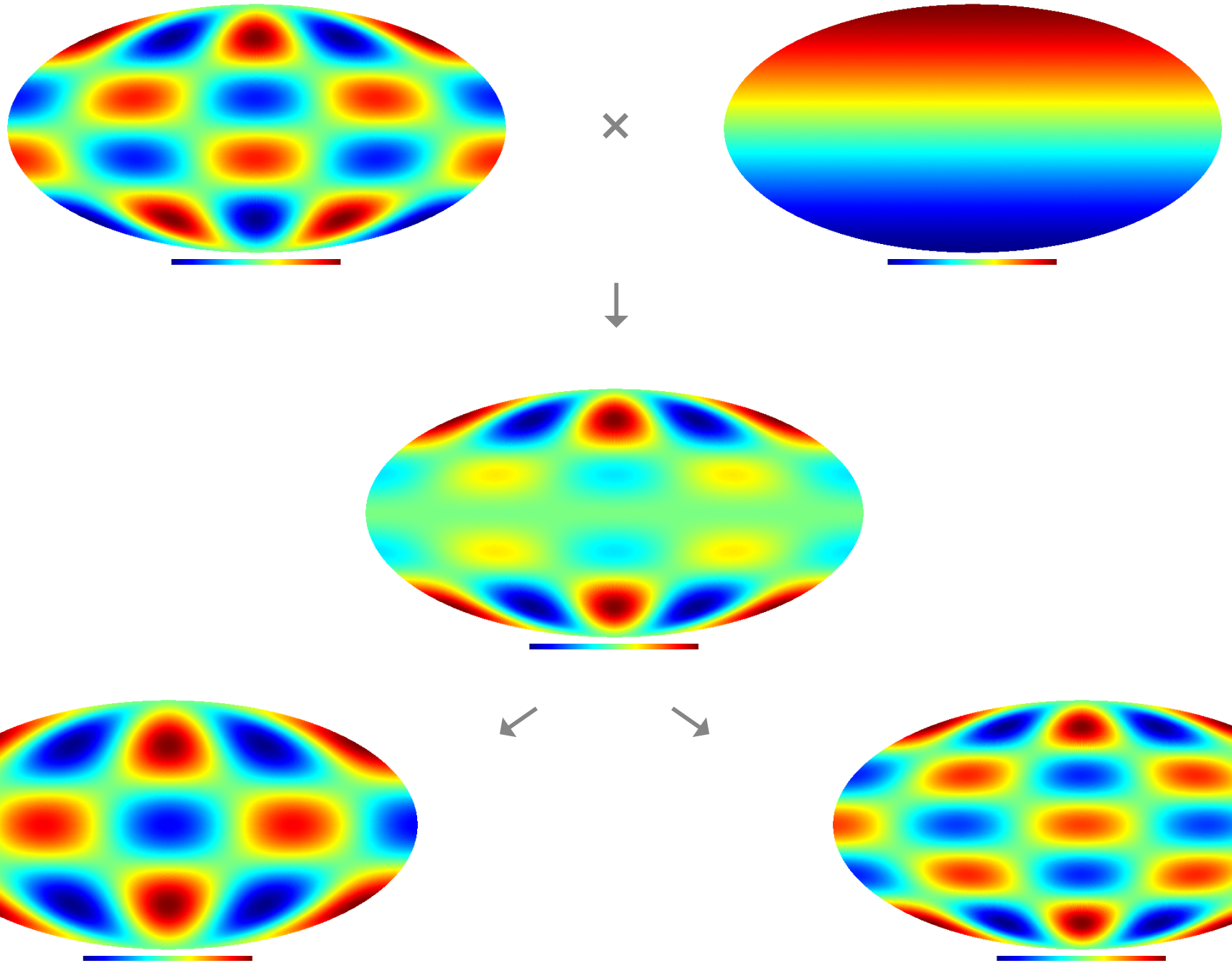


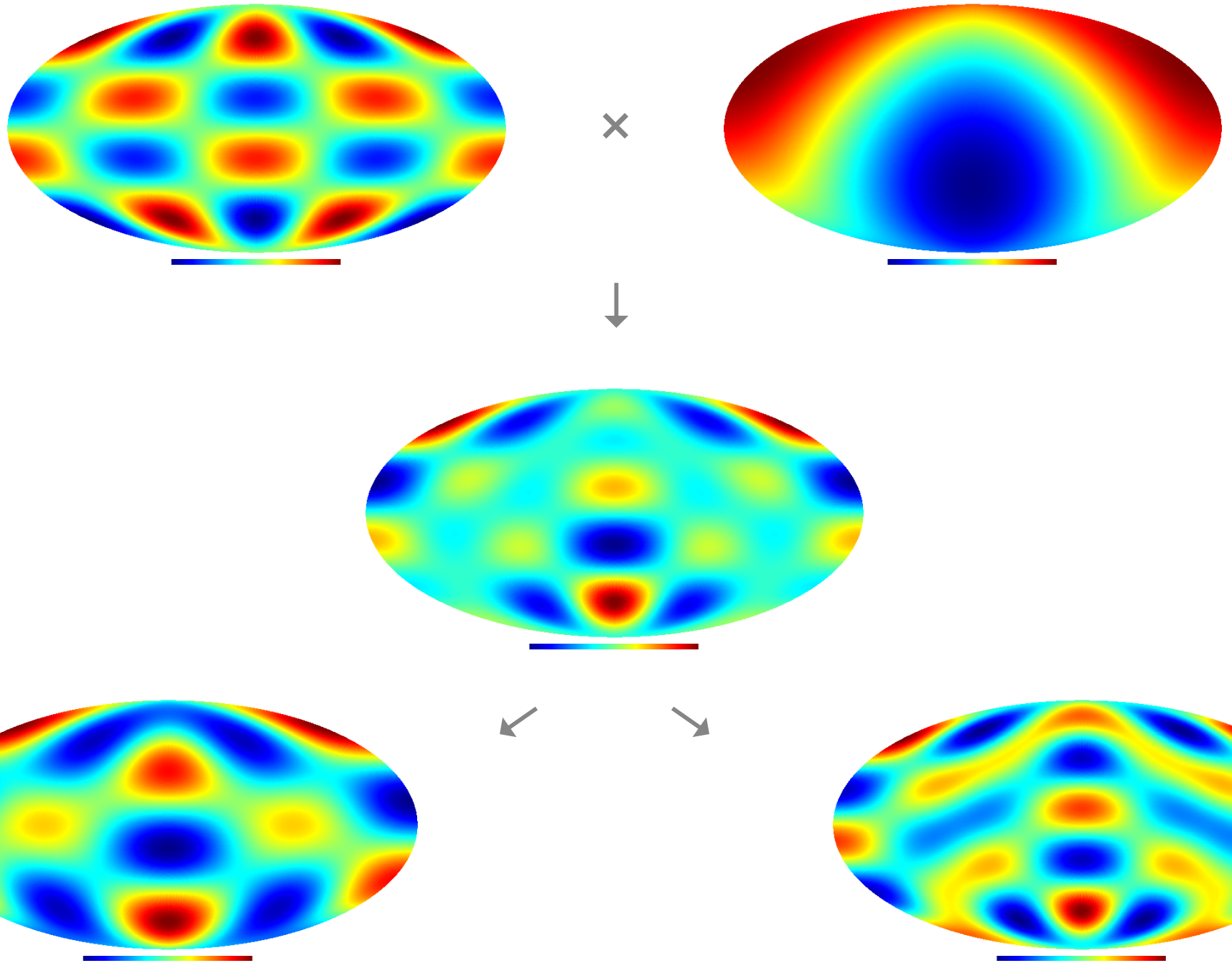
$\beta = 0.9$

Let's look at aberration of the CMB



Or can consider this as an effect which couples harmonics

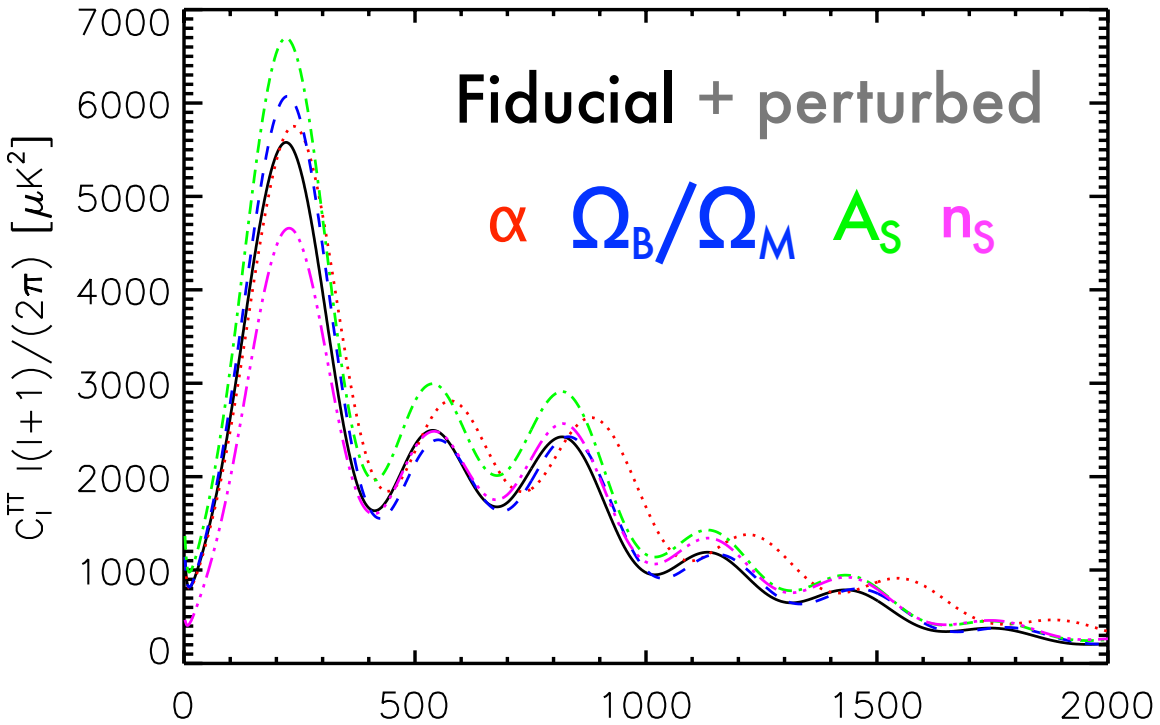




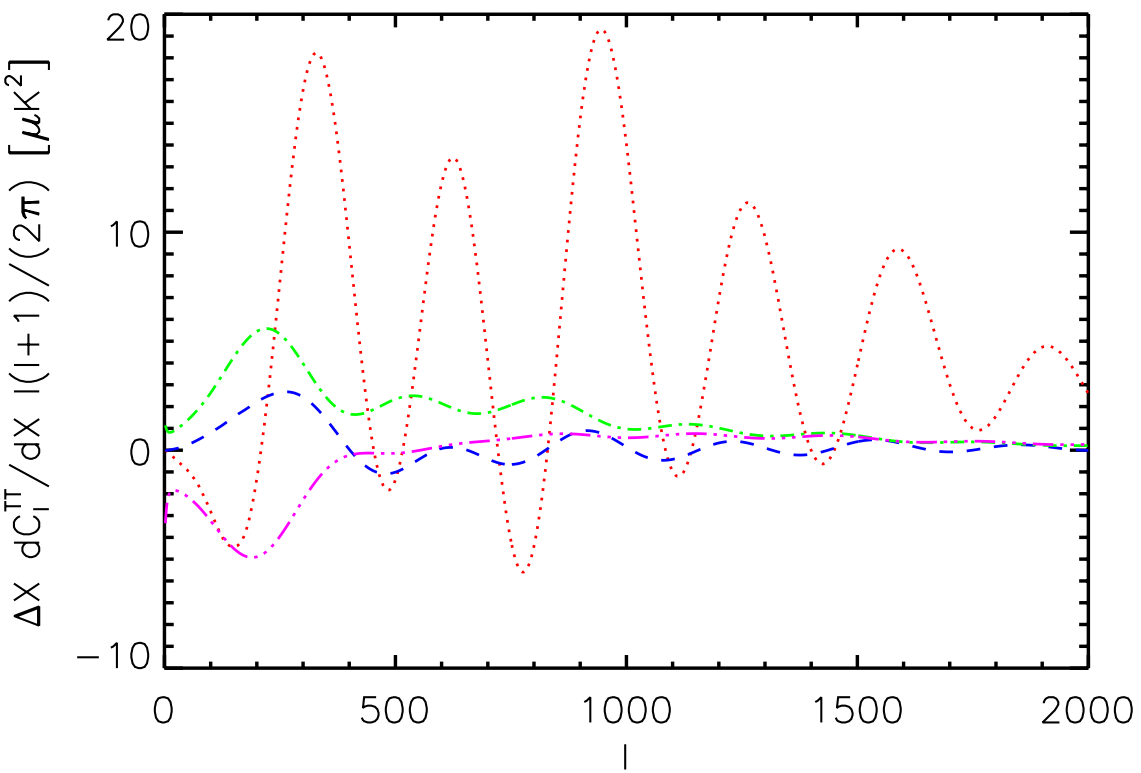
- Any modulation couples spherical harmonics
- Modulation by a dipole couples ℓ with $\ell \pm 1$
- True for any $T(\theta,\varphi|P) = T(\theta,\varphi|P_0+\Delta P)$, with $\Delta P \propto \cos\theta$

$$C_{\ell m \ell' m'} \equiv \langle a^*_{\ell m} a_{\ell' m'} \rangle$$
$$= C_\ell \delta_{\ell\ell'} \delta_{mm'} + \frac{\Delta X}{2} \left[\frac{dC_\ell}{dX} + \frac{dC_{\ell'}}{dX} \right] \xi_{\ell m \ell' m'}$$

$$\text{with } \xi = \delta_{\ell',\ell+1} \delta_{mm'} \sqrt{\frac{(\ell+1)^2 - m^2}{(2\ell+1)(2\ell+3)}}$$
$$+ \delta_{\ell',\ell-1} \delta_{mm'} \sqrt{\frac{(\ell^2 - m^2)}{(2\ell-1)(2\ell+1)}}$$



Different parameters have different effects on the power spectra



Different ℓ dependence for each parameter (same coupling kernel)

Could we detect it?