


**COMBINED ANALYSIS OF
COSMIC MICROWAVE
BACKGROUND (CMB) AND
LARGE SCALE STRUCTURE
(LSS) MEASUREMENTS**

**Ana Vasile,
Institute for Space Sciences
Magurele, Romania**

The background is a composite image. The upper right portion shows a satellite in space, with a large, multi-faceted structure and a prominent red and orange spherical component. The lower left portion shows a vibrant nebula with swirling patterns of blue, purple, and pink. The rest of the background is a dark field of stars.

**What do cosmologists
want?**

A satellite in space, with a view of Earth and a starry background. The satellite is a complex structure with various instruments and antennas. The Earth is visible in the background, showing a mix of blue and white. The background is filled with stars and some nebulae.

Extraction of the maximum amount of information from the cosmological data

Estimate and improve the error bars on cosmological parameters

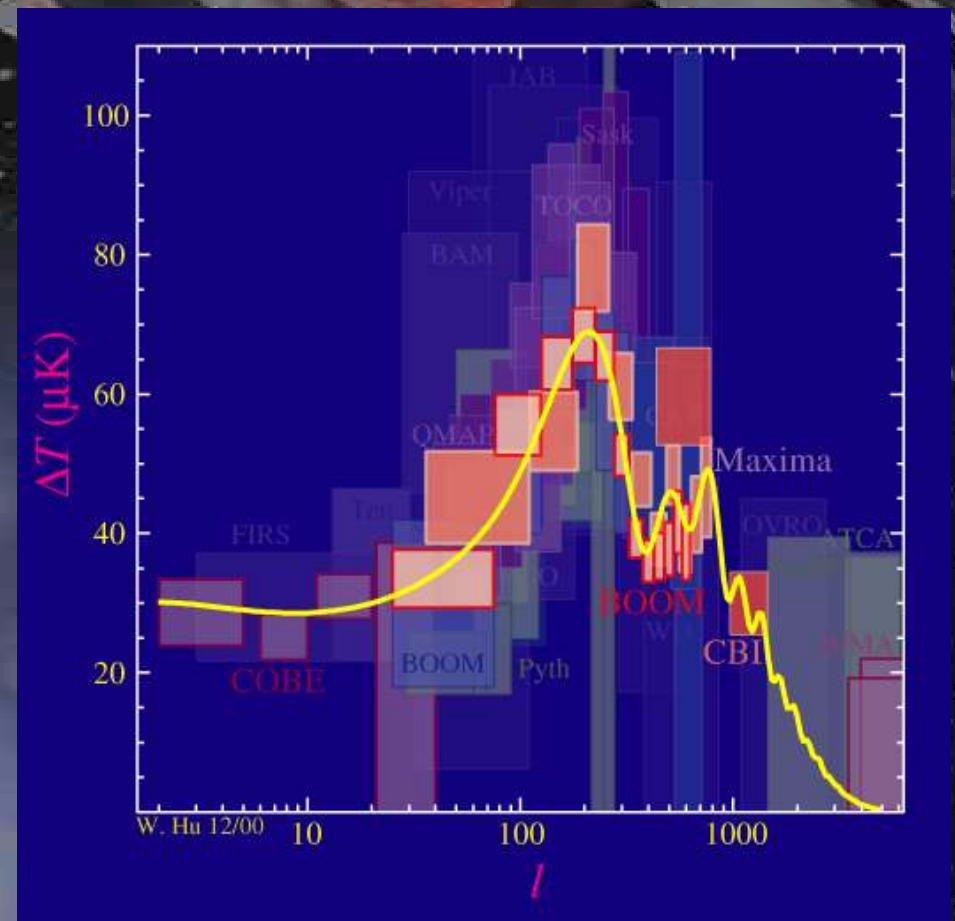
Answering some fundamental qualitative questions about the primordial Universe

The image is a composite. The upper right portion shows a satellite or space station in orbit, with a large, reddish-orange spherical component and a complex metallic structure. The background is a dark, star-filled space. The lower and left portions of the image show a vibrant, multi-colored nebula with shades of blue, purple, and red, set against a dark background with scattered stars.

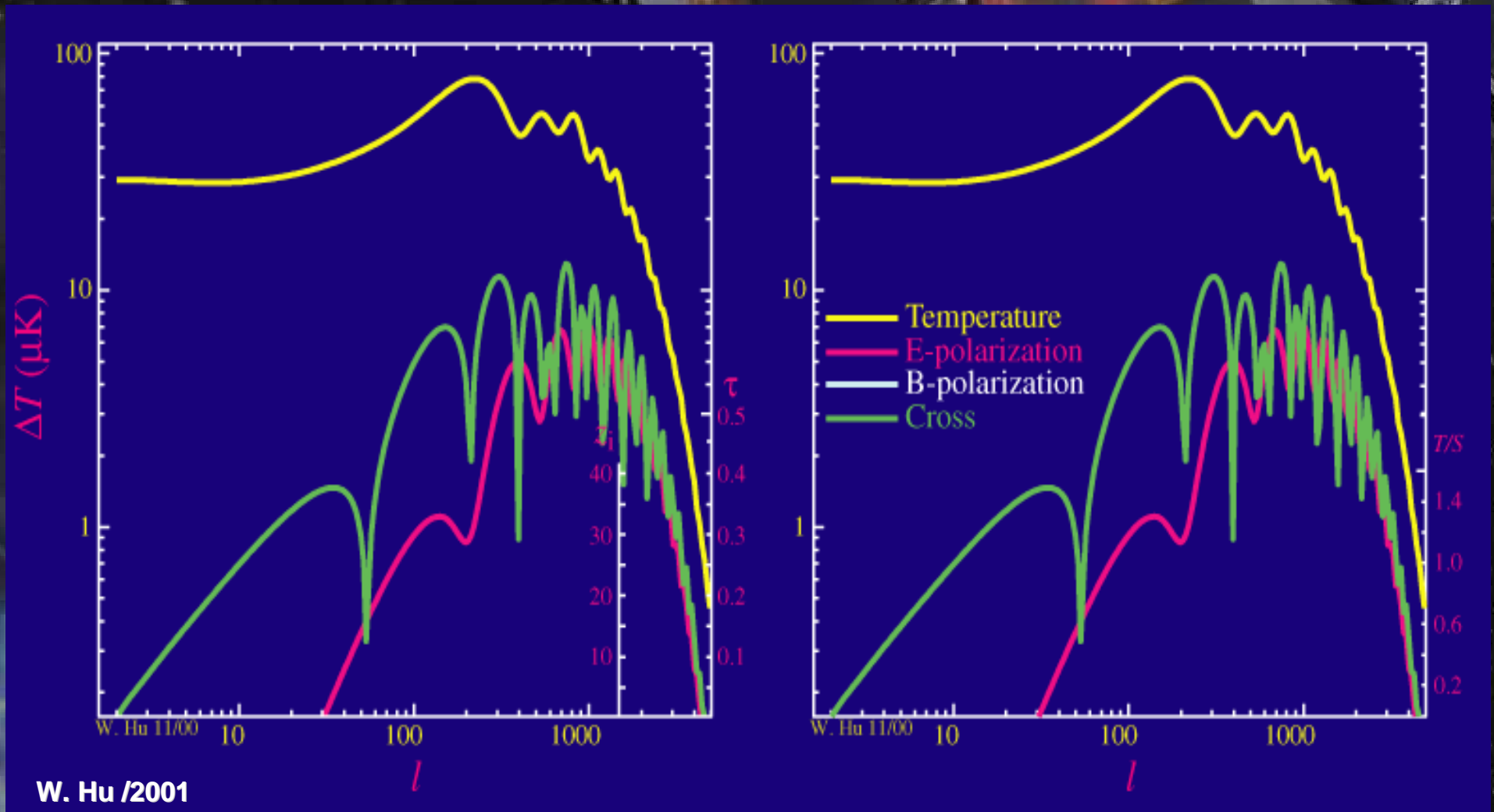
What do cosmologists get?

CMB POWER SPECTRUM

- The CMB power spectrum contains a wealth of cosmological information
- Nevertheless not enough to get the complete cosmological picture



DEGENERACY – MAJOR PROBLEM



Left: the reionization of the universe parameterized by both the optical depth (or fraction of the CMB rescattered during reionization) and the redshift of reionization. Right: the gravitational waves parameterized by their contribution relative to density fluctuations at the quadrupole ($l=2$).

SOLUTION

The background of the slide features a satellite in space. The satellite has a large circular dish and various instruments. In the foreground, there is a complex, multi-faceted geometric structure, possibly a model of a celestial body or a satellite component, rendered in a dark blue and grey color scheme. The overall scene is set against a dark, starry space background.

Combining CMB and LSS data can obtain complementary constraints and eliminate the degeneracies

Degenerate directions of one data set can be well constraint directions of another

Can make a consistency check between different sets of data and a certain cosmological model



TOOLS:

COSMOLOGICAL MONTE CARLO

A “random-walk” in the parameter space, where the probability to be anywhere in the space is proportional with the a posteriori probability

Advantage: It scales approximately linearly with the number of parameters so that many parameters can be included for only small additional computation costs

MCMC IN PRACTICE

1. Start with a set of cosmological parameters $\{\alpha_1\}$, compute C^1 , and the likelihood L_1
2. Take a random step in the parameter space \rightarrow new set of cosmological parameters $\{\alpha_2\}$.

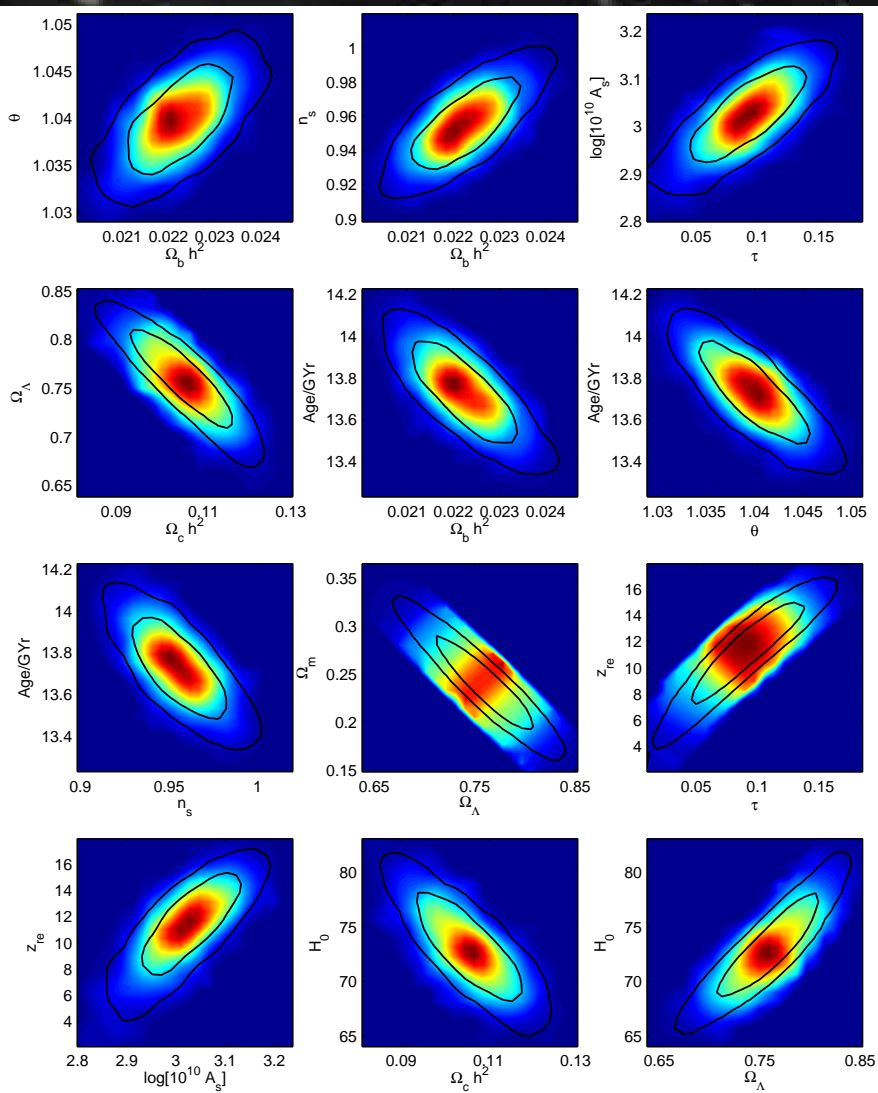
The probability distribution of the step \rightarrow
Gaussian in each direction i with r.m.s
 $\sigma_i \equiv$ “step size”

MCMC IN PRACTICE II

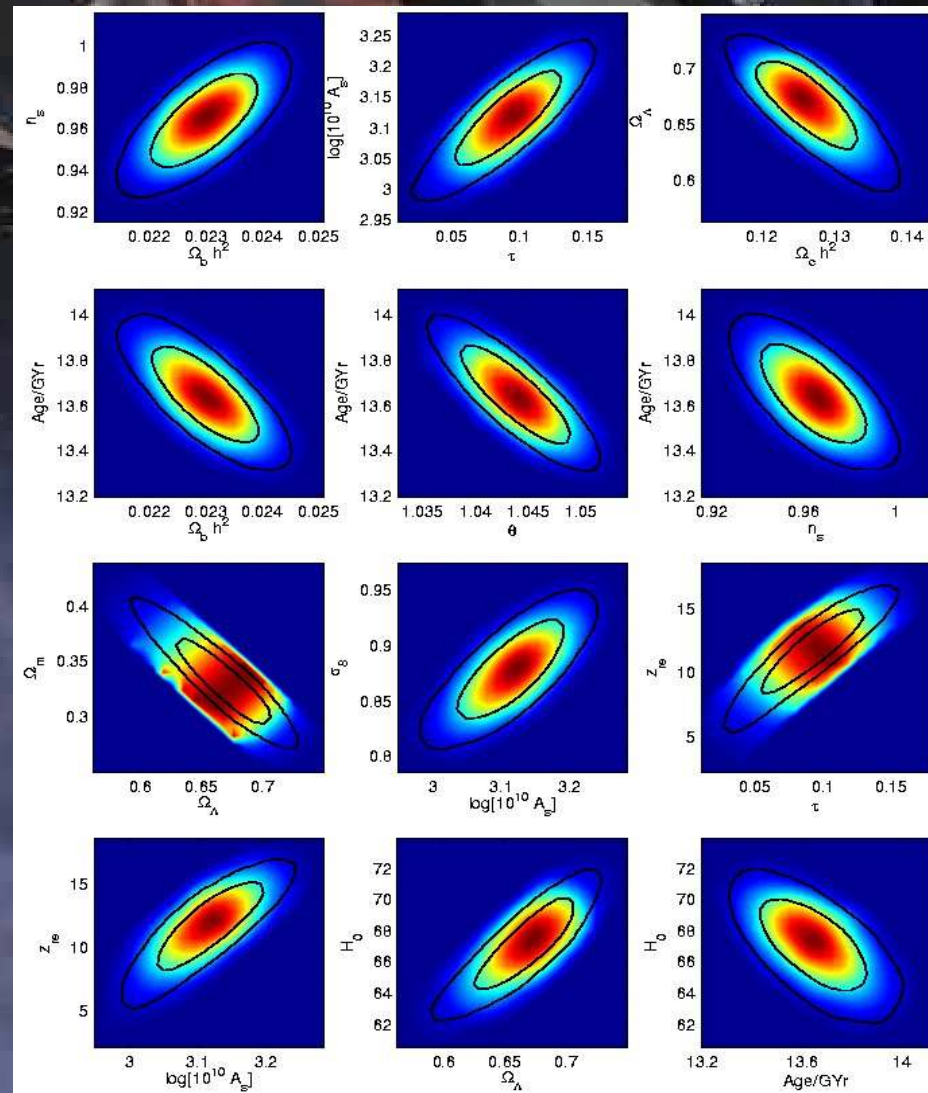


3. Compute again C^2 , and L_2
- 4a. If $L_2/L_1 \geq 1$ take the step. New set $\{\alpha_2\}$
- 4b. Else draw a random number x from a uniform distribution from 0 to 1. If $x \geq L_2/L_1$ do not take the step but return to step 2. Else, take the step and return to 4a
5. Run separate chains randomly chosen and stop when a certain convergence criterion is reached

Advantages of the combined analysis

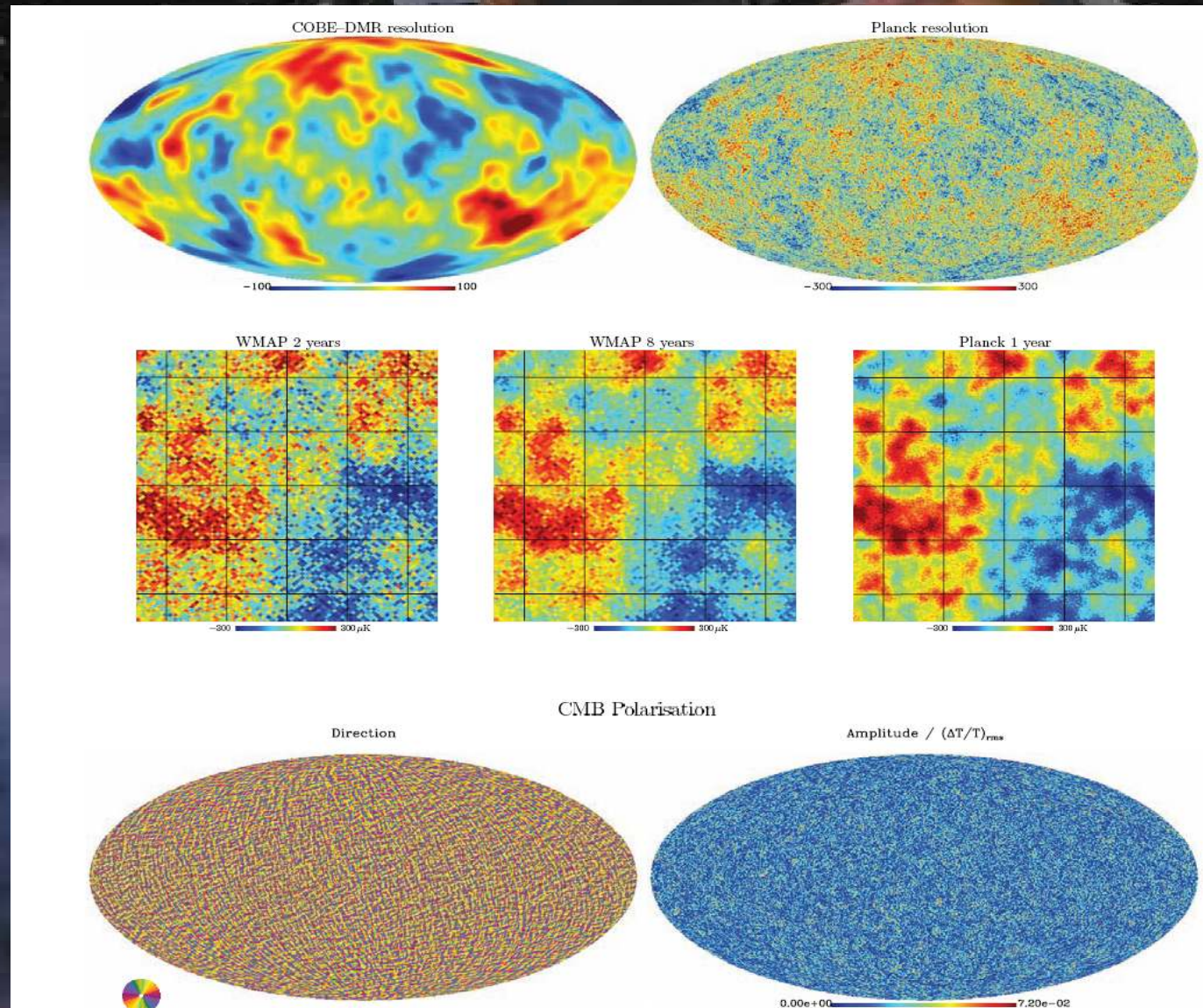


2D marginalized contours (68% and 95% confidence levels) for some combinations of parameters for WMAP only



Same as left panel for WMAP+2dFGRD+SDSS+CBI

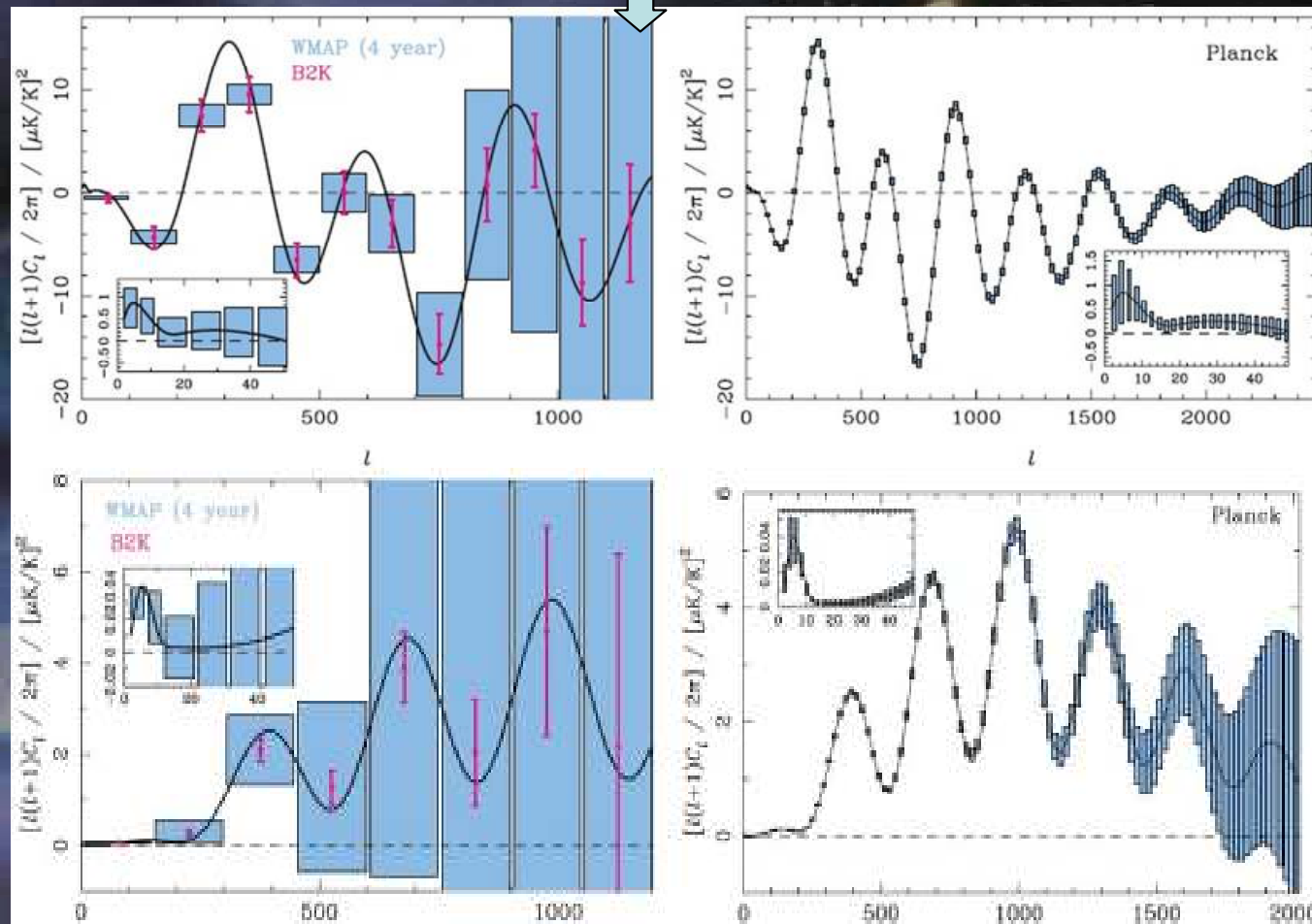
NEW DATA \equiv IMPROVED TOOLS



Simulated maps of the CMB sky in inflationary CDM models

The realisation of the CMB power spectrum of the Λ CDM model (red line) after 4 years of WMAP observations versus the same with the sensitivity and angular resolution of Planck

Forecasts for the $\pm 1\sigma$ errors on the temperature-polarization cross correlation power spectrum in a Λ CDM model



From Planck Bluebook

