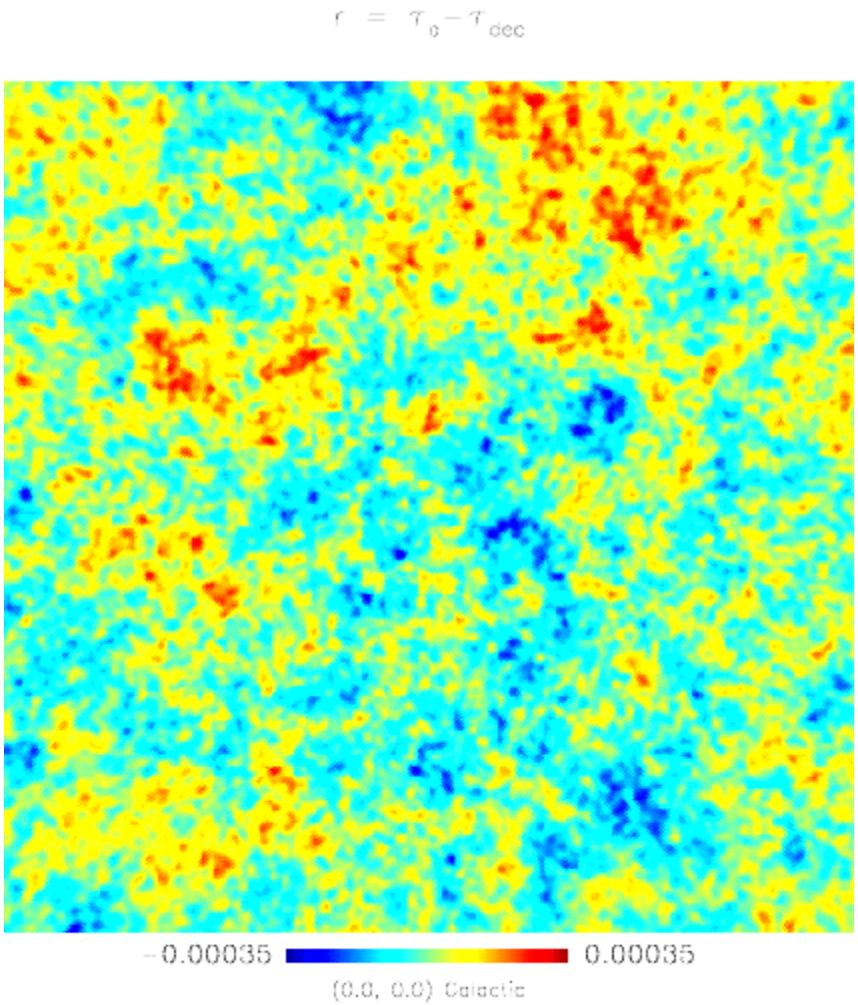
The Largest Scale Perturbations in the Universe and the Physics of the Beginning



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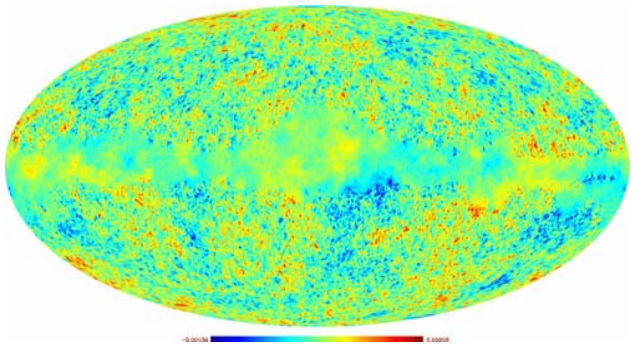
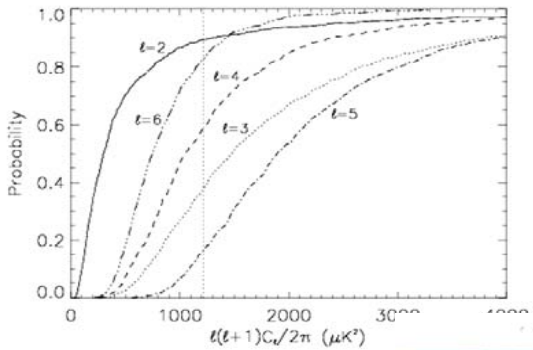
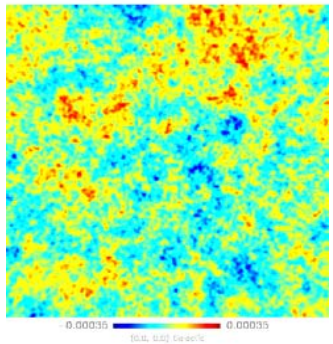
To learn about the Physics of the Beginning we must understand the largest scale perturbations



Full Bayesian analysis of CMB data

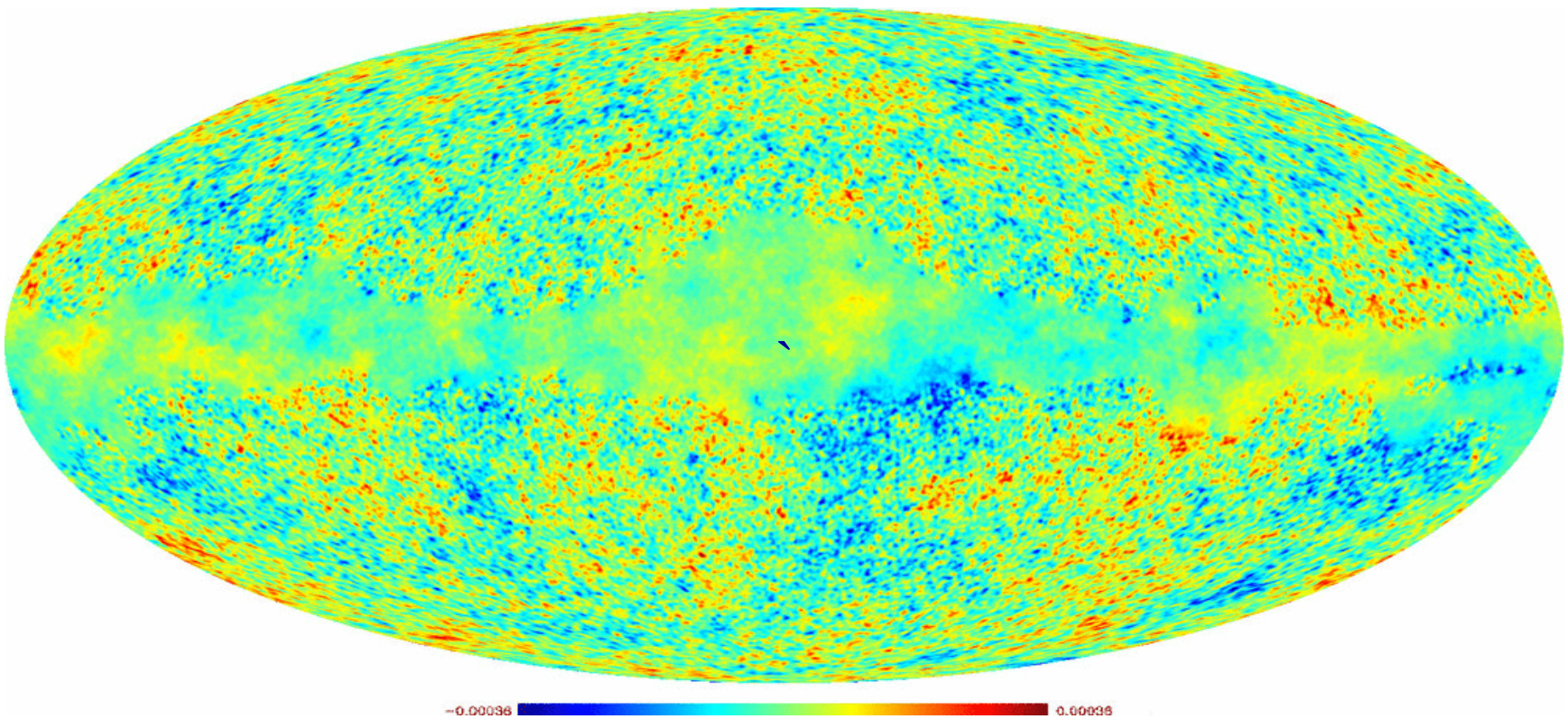


Is there a lack of fluctuation power on large scales?



Reconstructing the Initial Conditions of the Universe

Full Bayesian analysis of CMB data

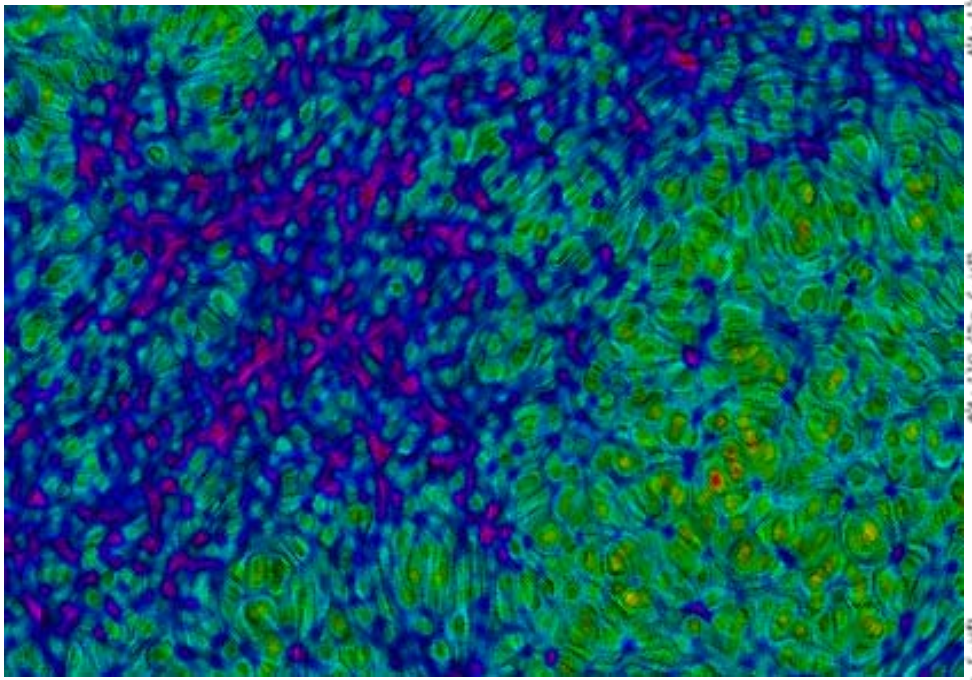


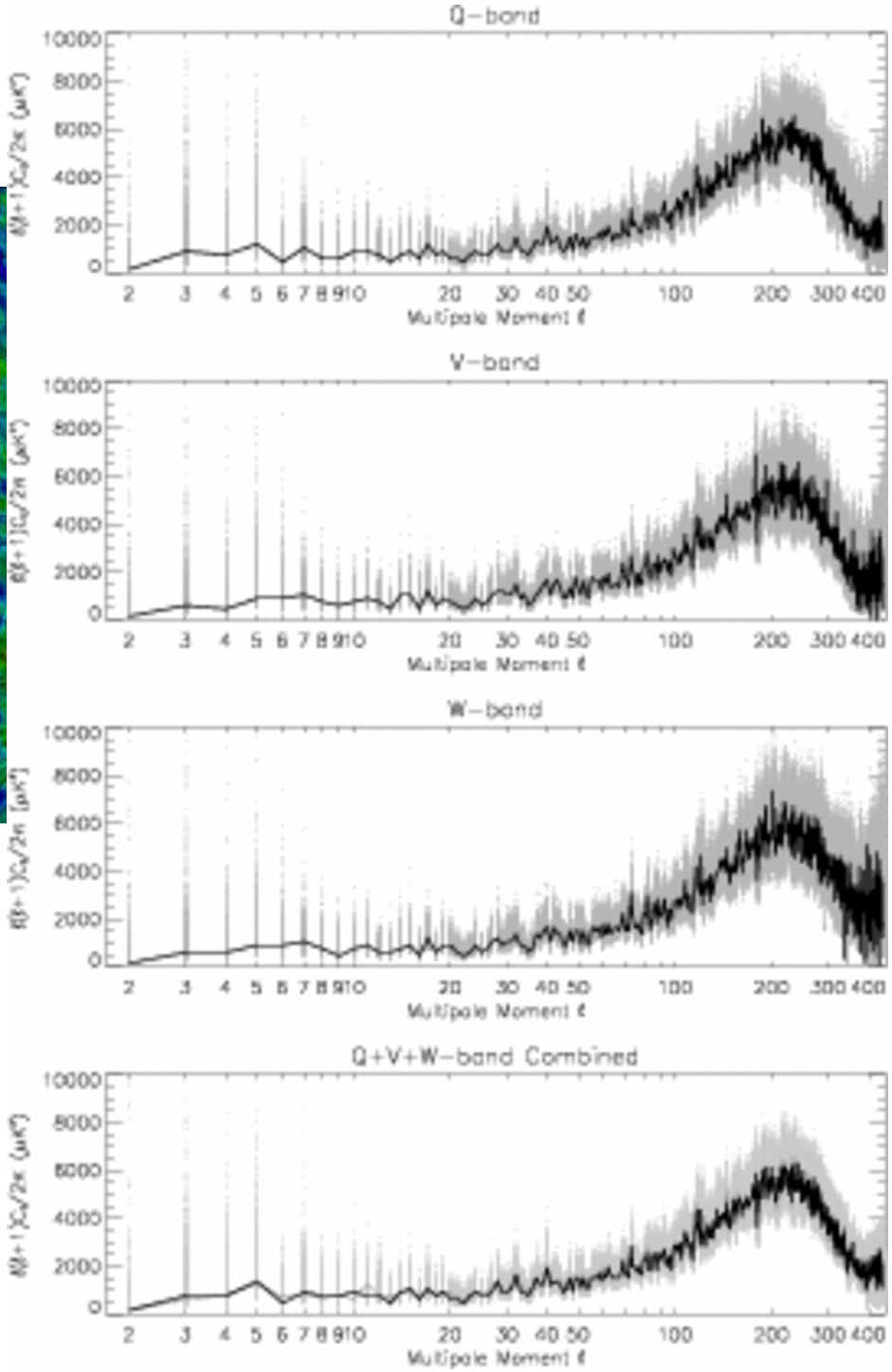
Powerful sampling techniques (*Gibbs sampling*) solve the N^3 problem in CMB power spectrum analysis. Reconstructs signal map "for free." The computational complexity is the same as for Pseudo-C_ℓ methods like MASTER etc.

Wandelt, Larson and Lakshminarayanan 2004

O'Dwyer et al. 2005; Erikson et al 2005; Chu et al 2005

Full likelihood analysis of CMB data





This method can deal with *polarization*, produce *foreground* maps including error models, model *systematic errors* and enables *parameter estimation* without analytical approximations to the likelihood.

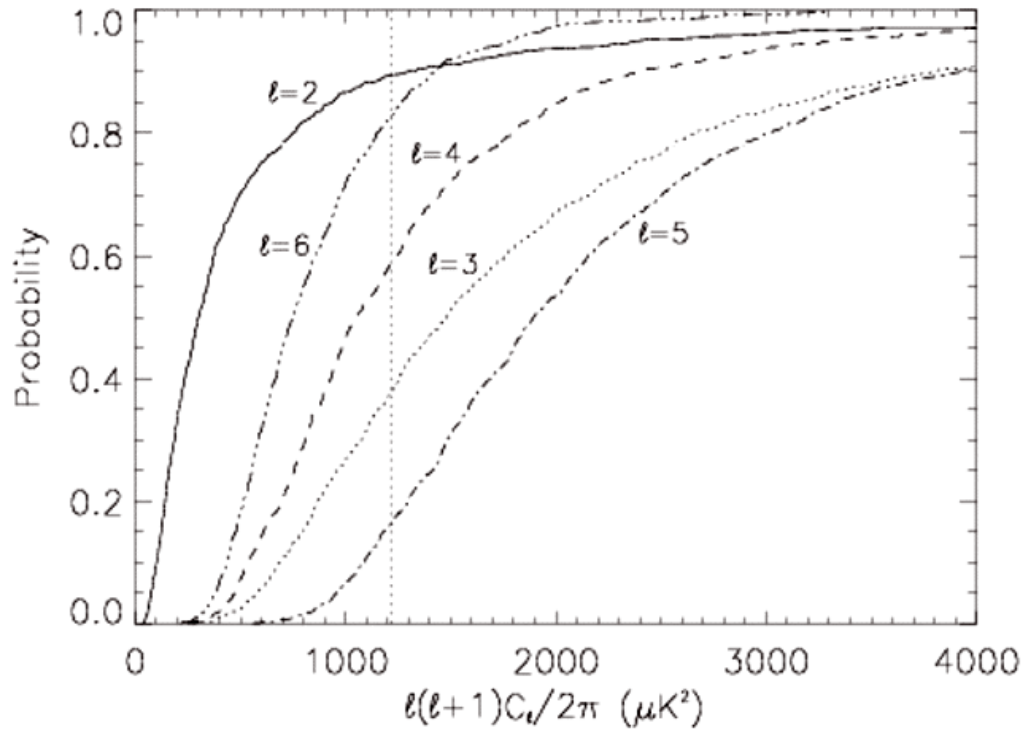
Main first result from Bayesian analysis: the significance of "low fluctuation power on large scales" is less than 10%

Our analysis demonstrates that the power spectrum likelihoods at low ℓ have strong tails to high C_ℓ.

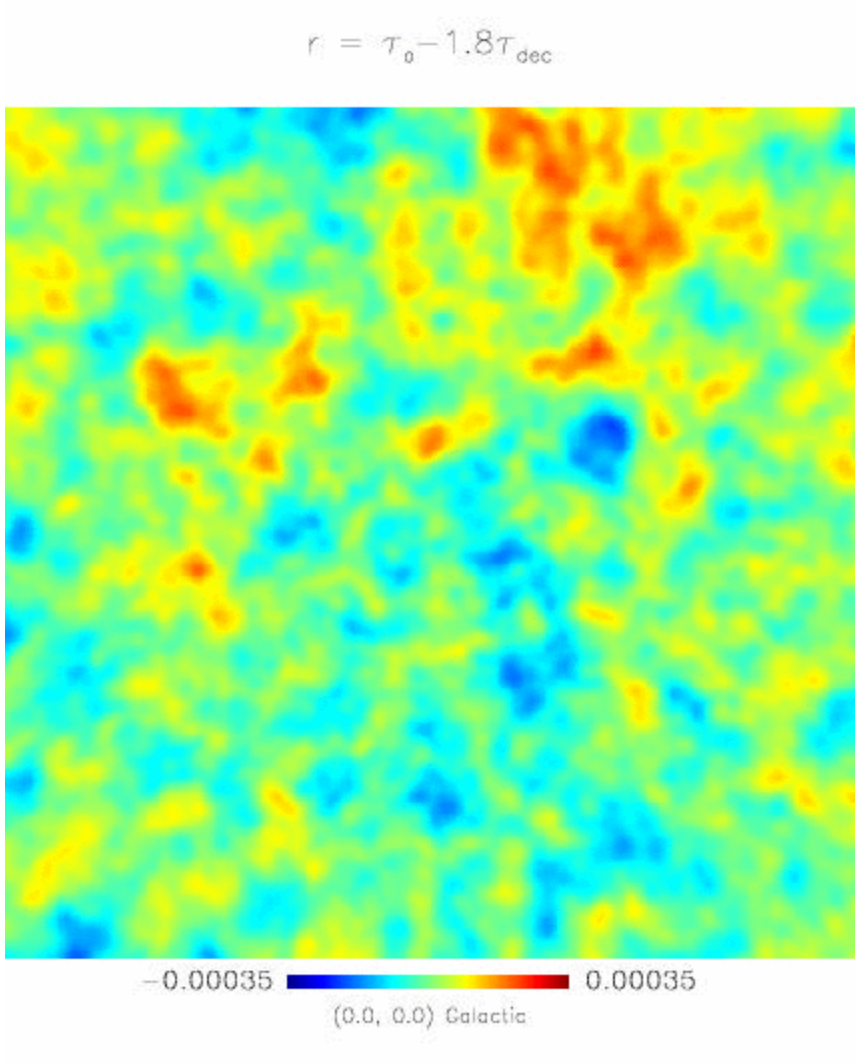
This leads to a probability in excess of 10% that the true C_2 is even larger than the WMAP best fit C_2.

C_3 is unremarkable.
(O'Dwyer et al. 2005)

$P(C_2 > x \mid \text{data})$



Tomographic reconstruction of inflationary scalar metric perturbations from CMB temperature and polarization.



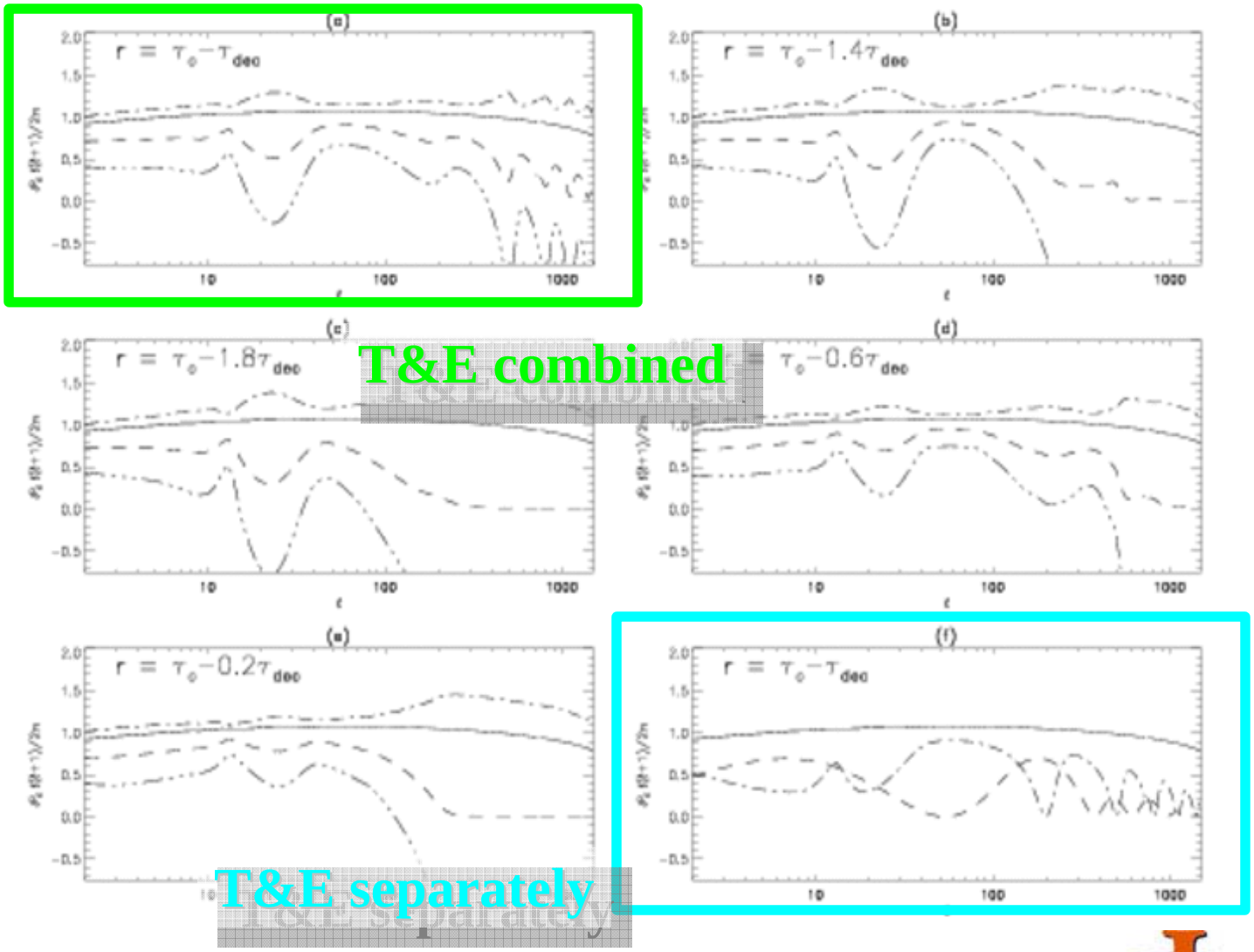
We construct filters that invert linear radiative transport.

Generates a single scalar that contains all the information from T&E.

We envision future tests of non-Gaussianity and anisotropy to be performed directly in the reconstructed primordial perturbations.

The reconstruction quality is dramatically better with T+E than with T or E alone

Please see Amit Yadav's poster for details.



Yadav and Wandelt 2005

Example application: Use to test for primordial non-Gaussianity from inflation

The optimal bispectrum estimator for f_{NL} from polarized CMB maps (Babic and Zaldarriaga 2005) reduces to the fast KSW estimator evaluated on the reconstructed potential.

Working with maps keeps information in higher order correlations that can be used as additional constraints and consistency checks.

Komatsu, Spergel, Wandelt 2005

Conclusions

- Statistically rigorous analysis of the CMB is now feasible using Bayesian sampling techniques.

- With T and E maps we can reconstruct the initial conditions of the Universe on the largest scales accessible to observation.

- Tomographic reconstruction maximizes the sensitivity to primordial features instead of searching for anomalies in the processed anisotropies.

- This is a new view of the Universe – a window to the Initial Conditions and the Physics of the Beginning beyond the power spectrum.

Advertisements

- Check out our poster on a new approach to fast cosmological parameter estimation (**Chad Fendt** & B. Wandelt, PRD submitted).

- **David Larson** has a poster on an updated and more detailed analysis of the hot and cold spots in the WMAP data.