Can the inflationary paradigm ever be more than a plausible myth?

Scott Dodelson, with Ewan Stewart & Albert Stebbins

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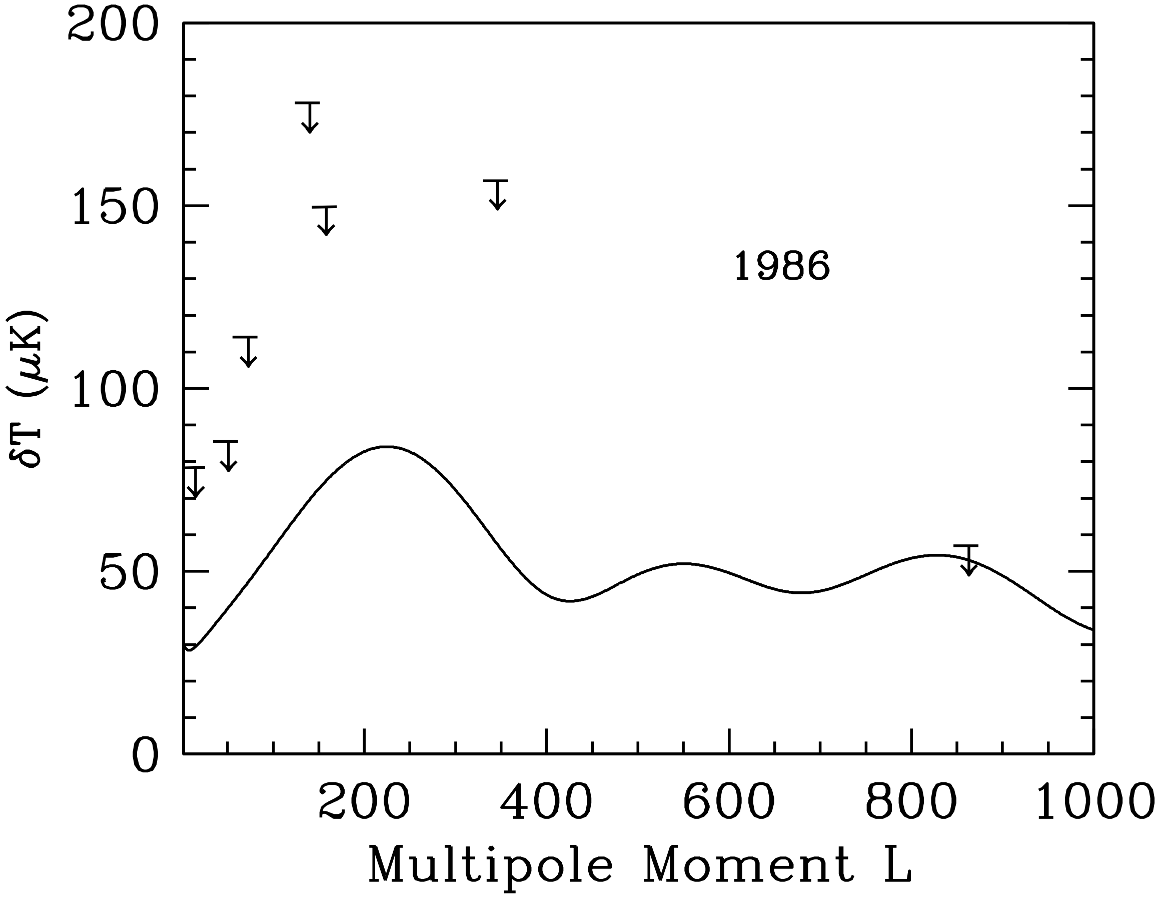
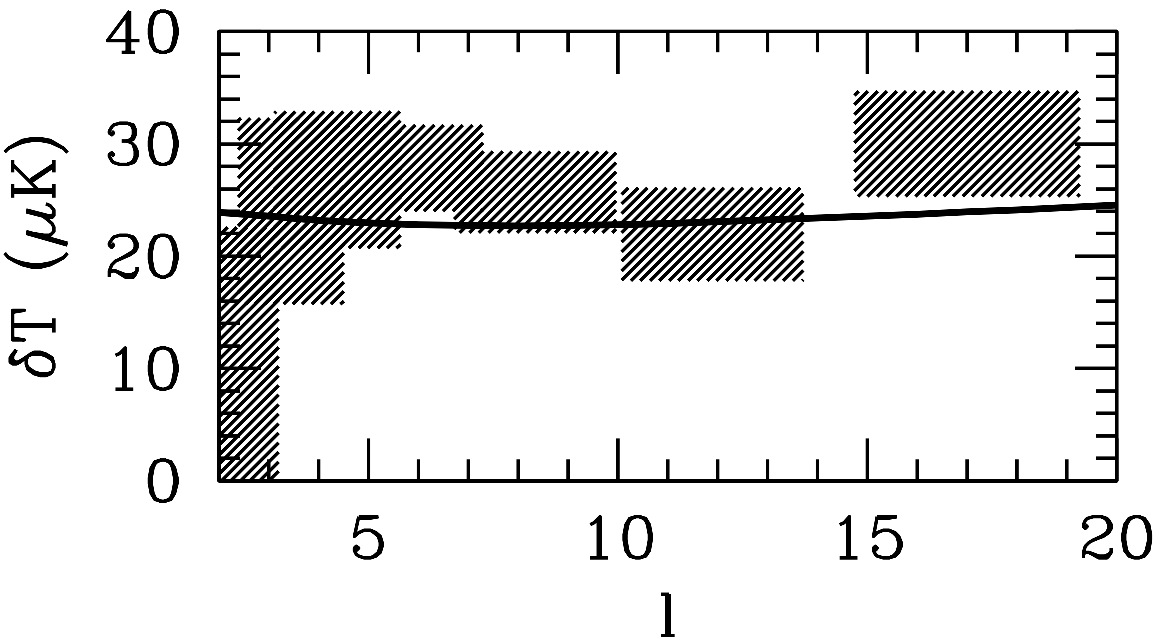
History

Before COBE, inflation was close to being ruled out:

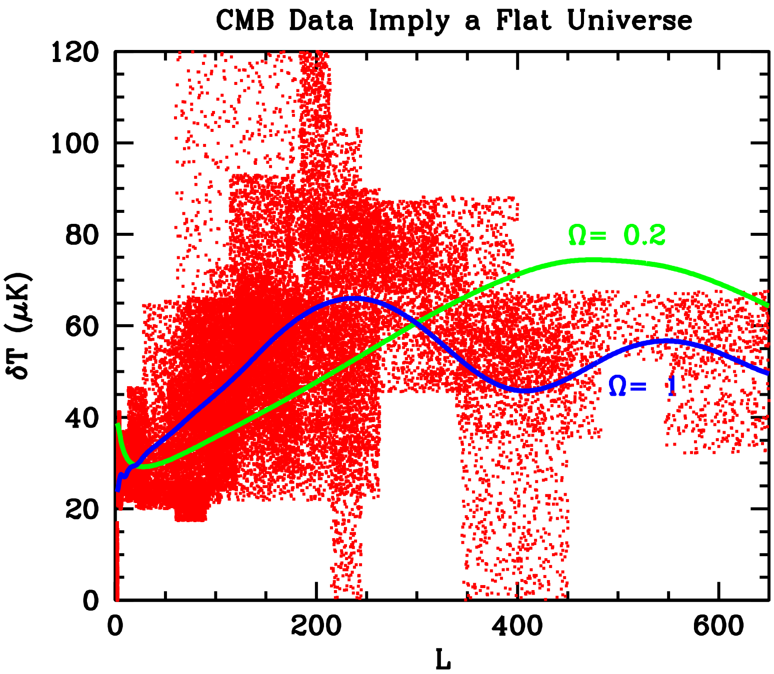


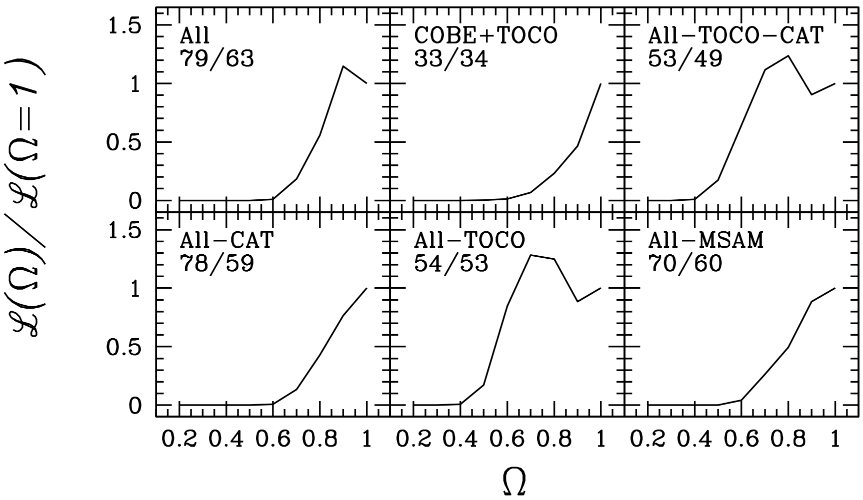
History

COBE *proved* inflation by getting the amplitude and slope right:



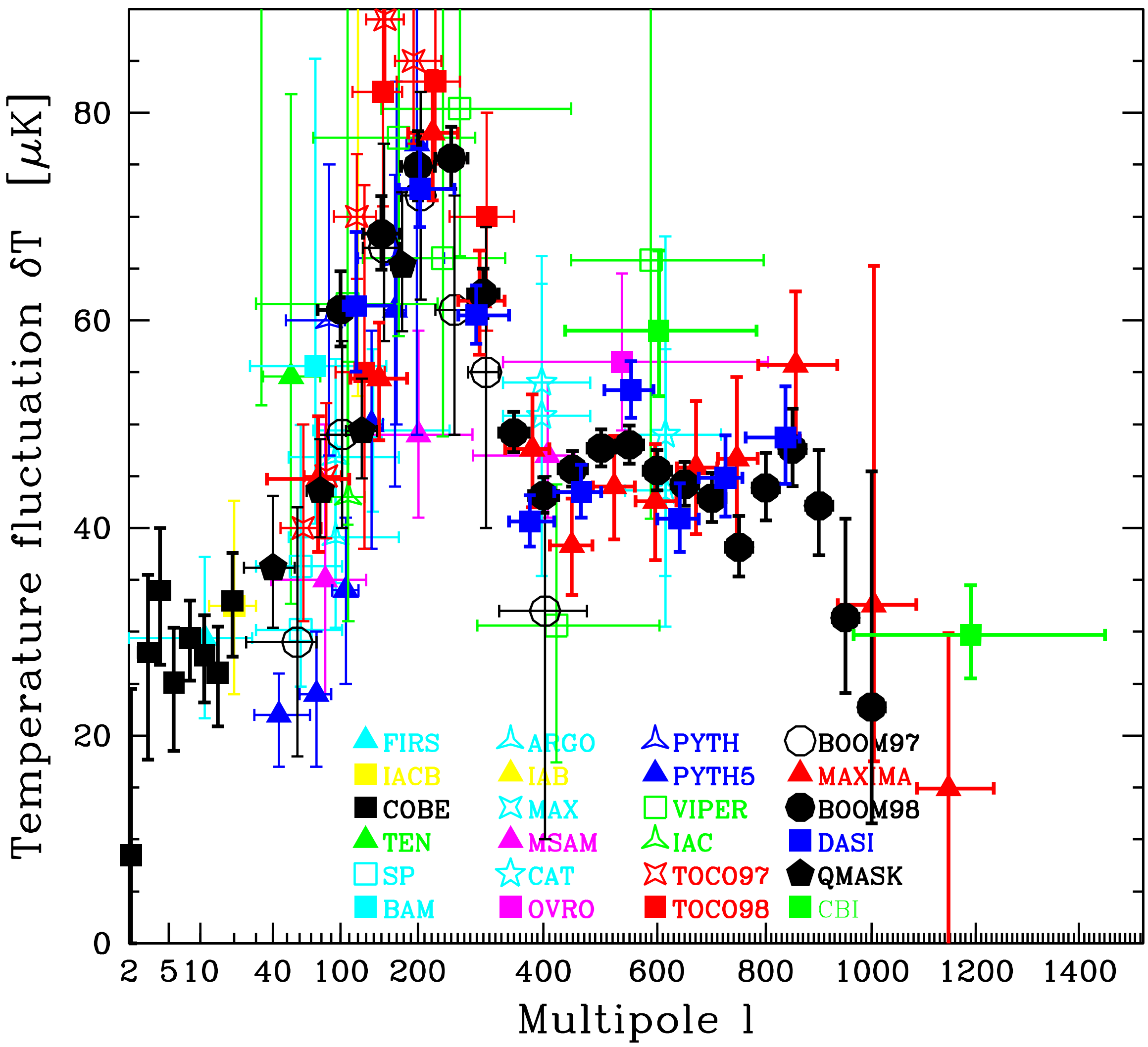
Subsequent experiments *proved* inflation by getting the position of the first peak right:





Today!

We have evidence for 3 peaks:



Compilation by Tegmark

Strong support with adiabatic perturbations in a flat universe with spectral index $n \simeq 1$.

Adiabatic perturbations with $n \simeq 1$ in a flat universe are generic predictions of inflation.

BUT

- No connection of inflationary models with the rest of physics

- No guidance on the form of the inflationary potential

- This is *Harrison-Zel'dovich* spectrum

Are there any unique signatures of inflation?

Deviations from H-Z spectrum

Some definitions:

$$\begin{aligned}\epsilon &\equiv \frac{1}{2}\left(\frac{\dot\phi}{H}\right)^2\\ \delta_1 &\equiv \frac{\ddot\phi}{H\dot\phi}\\ \delta_p &\equiv \frac{d^{p+1}\phi/dt^{p+1}}{H^p\dot\phi}\end{aligned}$$

Slow Roll Approximation: $\epsilon, \delta_1 = \mathcal{O}(\xi) << 1$

Spectral index is then

$$n - 1 = -4\epsilon - 2\delta_1 + \mathcal{O}(\xi^2) + \sum_{p=2}^{\infty} c_p\delta_p.$$

Since n is close to one [barring cancellations] slow roll is verified. Suggests δ_p is small.

Is $\delta_p = \mathcal{O}(\xi)$ OR $\mathcal{O}(\xi^p)$?

If one assumes incorrectly that $\delta_p = \mathcal{O}(\xi^p)$, map p incorrectly to parameters in potential.

More important,

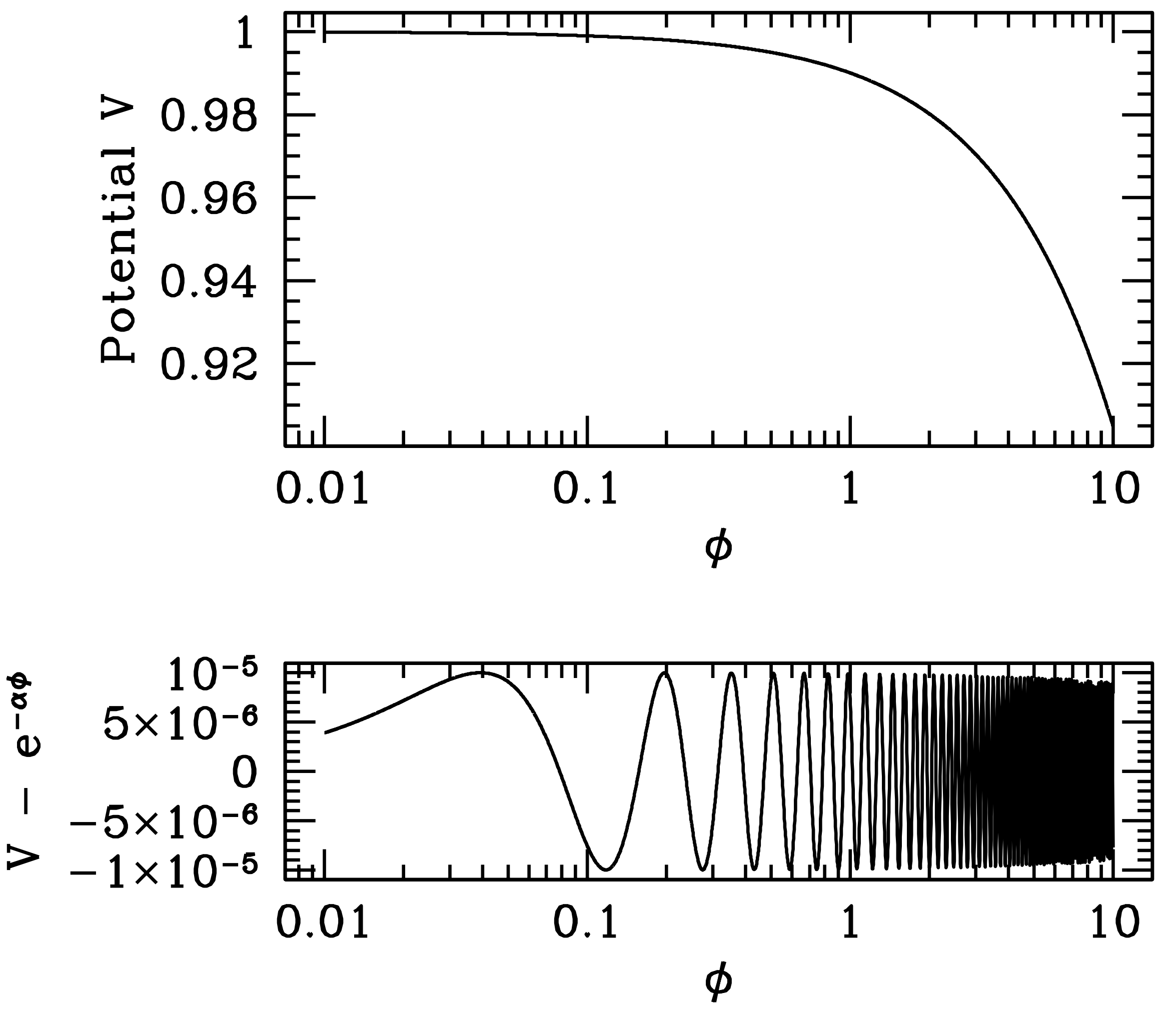
$$\frac{dn}{d\ln k} = \mathcal{O}(\xi^2) + \sum_{p=2}^{\infty} c_p' \delta_p$$

If $\delta_p = \mathcal{O}(\xi^p)$, running is of order ξ^2, small. If $\delta_p = \mathcal{O}(\xi)$, running is important.

Non-power law would be unique signature of inflation.

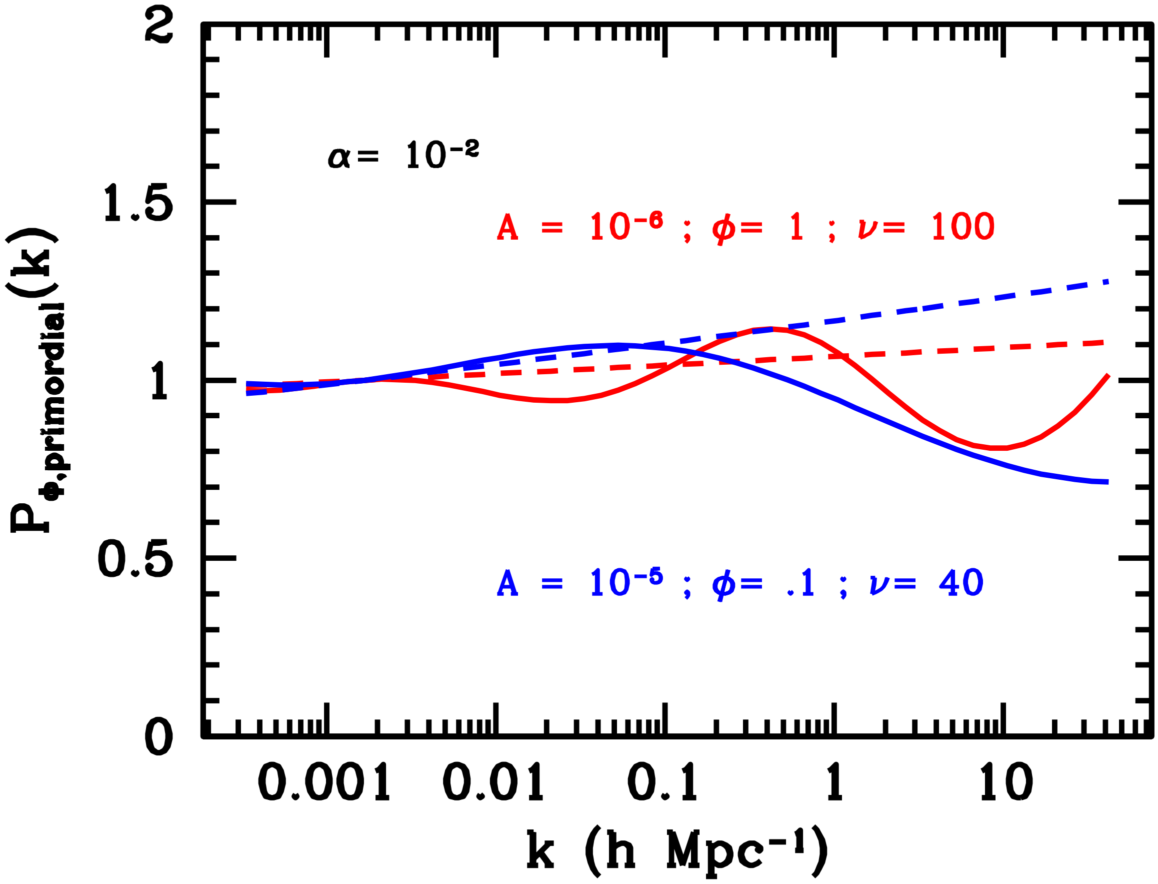
Have determined running assuming $\delta_p = \mathcal{O}(\xi)$.

Example: Nearly Exponential Potential



Can solve this model exactly!

Effect on Spectrum



- Dashed lines assume $\delta_p = \mathcal{O}(\xi^p)$

- Apparently blue spectrum can turn over and have less power on small scales

- Need large lever arm (e.g Lyα forest)

Gravity Waves

Inflation also produces *gravity waves* due to quantum fluctuations of the tensor part of the metric.

$$g_{\mu\nu} = \bar{g}_{\mu\nu} + \delta g_{\mu\nu}$$

Until now, we have considered scalar part of $\delta g_{\mu\nu}$. Inflation also produces fluctuations in tensor part.

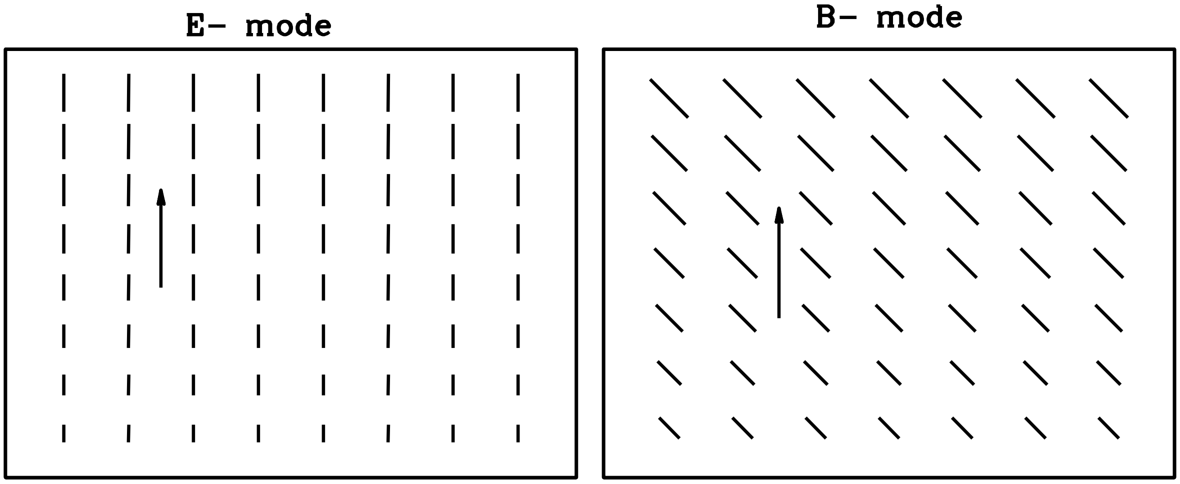
Can these be detected?

Use polarization

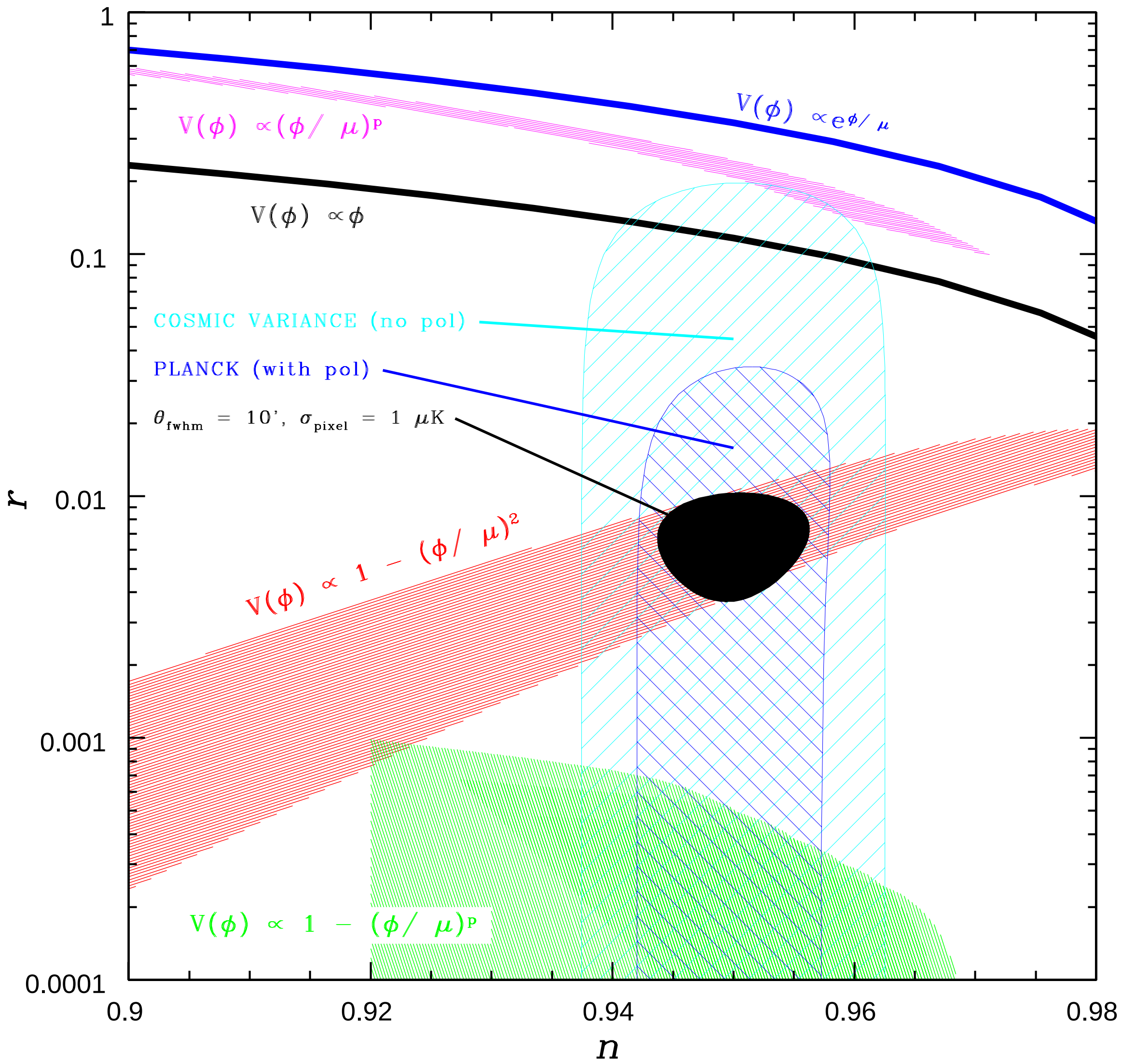
CMB anisotropies are polarized due to Compton scattering off quadrupole.

Polarization at any point has an amplitude and a direction and can be described by a symmetric, traceless tensor.

It can be decomposed into two modes:



Scalar perturbations produce only the $E-$ mode. Tensors (gravity waves) produce both E and B.



Kinney 1998

Can detect gravity waves in this way. Are there other ways?

Weak Lensing

The shear at any point has an amplitude and a direction and can be described by a symmetric, traceless tensor.

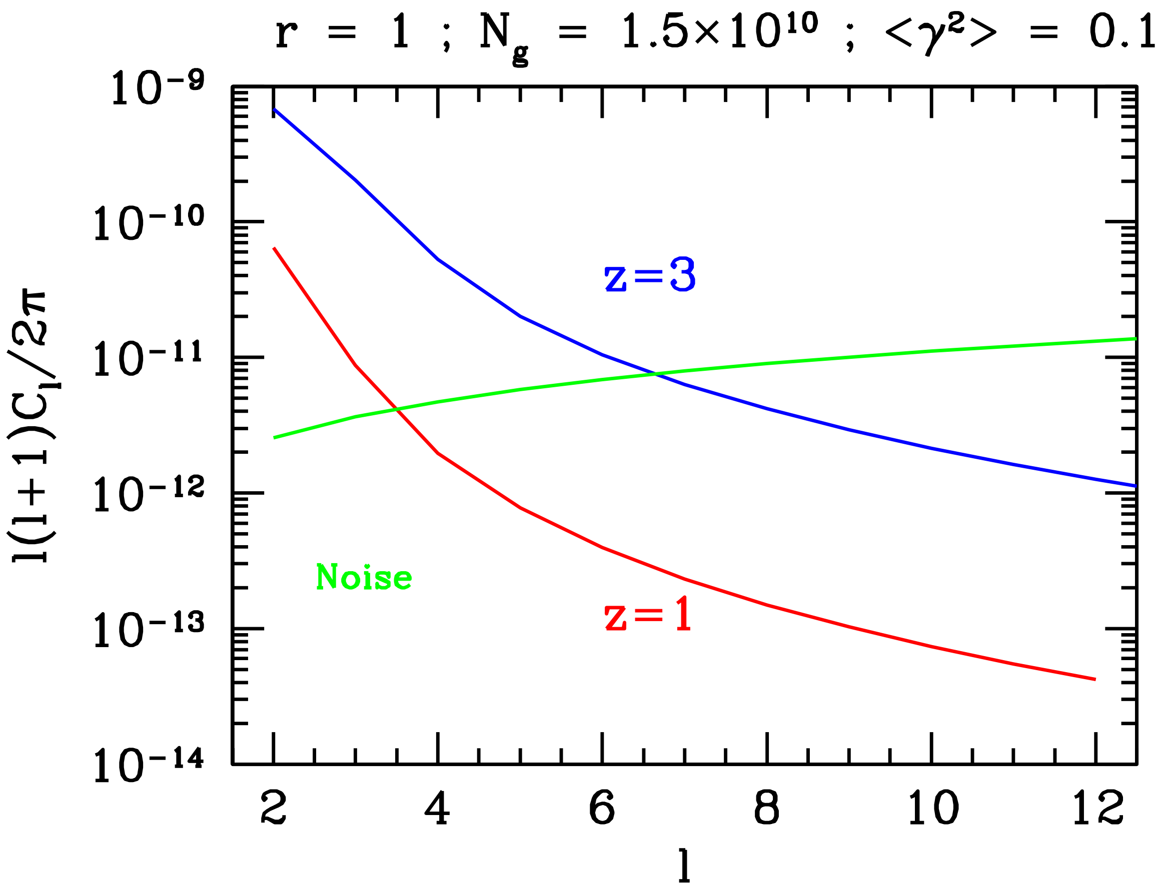
Just like polarization, can decompose into $E-$ and $B-$ modes.

$$C_l^{E,B} = \frac{l^2(l+1)^2}{2l+1} \int \frac{d^3k}{(2\pi)^3} P_{gw}(k) \left| T_l^{E,B}(k, \eta_s, \eta_0) \right|^2$$

Scalar perturbations do not produce $B-$ shear.

Is it possible to detect gravity waves by measuring $B-$ mode of shear?

Maybe!



Long term project: All sky survey, down to 28th magnitude

Demythologization of Inflation

- Theoretical help
- Detection of $n \neq 1$ or (better) non-power law
- Detection of Gravity Waves via CMB polarization or Weak Lensing.