Distinguishing Primordial B Modes from Lensing

Abstract:" If the main science goal of BPol is to detect B modes from inflation, we must demonstrate that this it is feasible to the claimed sensitivity. This section would provide a detailed analysis supporting our claims."

F. Finelli
INAF/IASF-BO & INAF/OAB

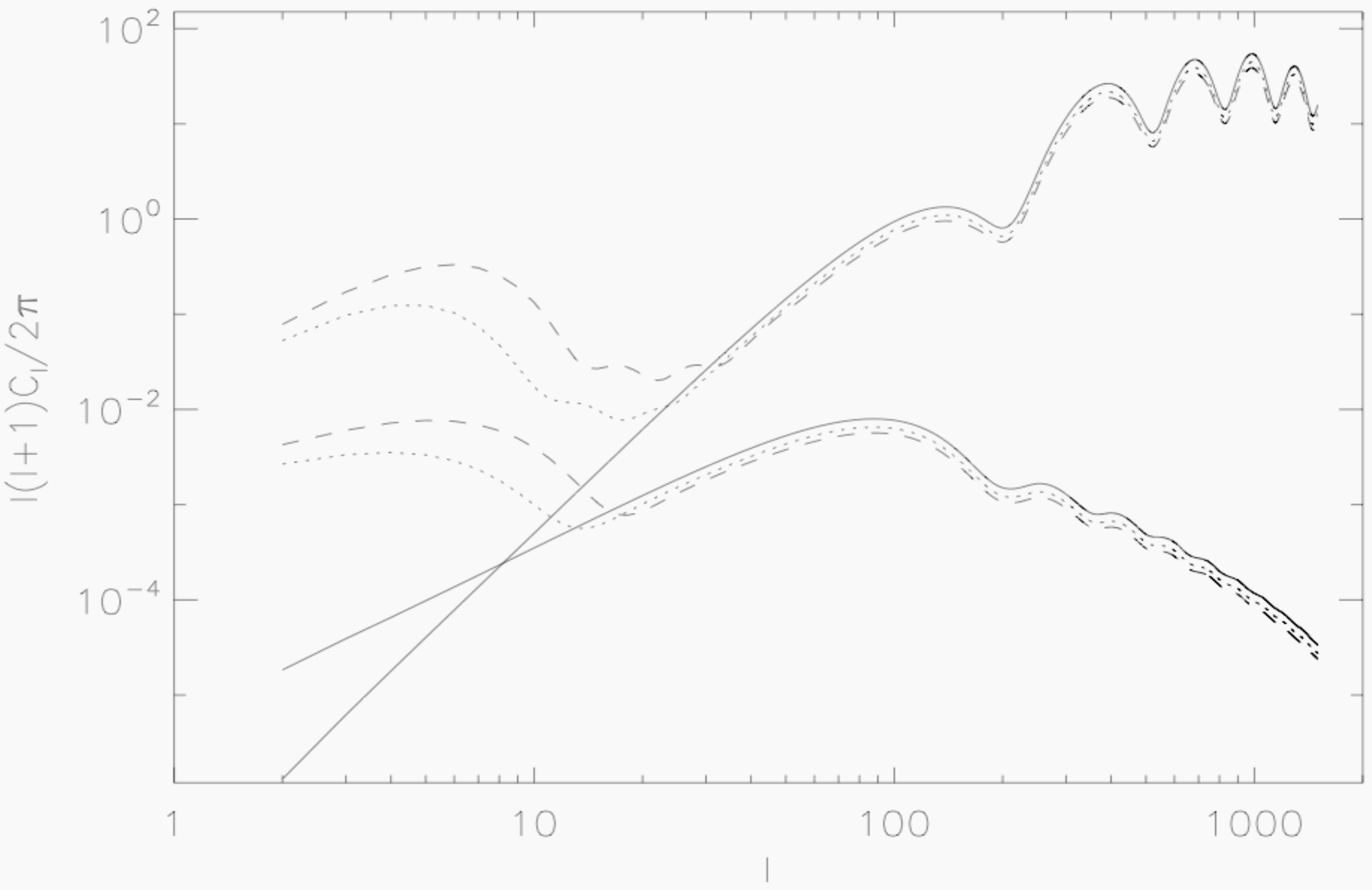
Section 5: F. Finelli, A. Lewis, M. Bucher, A. Balbi, V. Aquaviva, J. Diego, F. Stivoli

Sources

- “Science requirements for SAMPAN” by F.R. Bouchet et al. (2006)
- “Weak Gravitational Lensing of the CMB”, by A. M. Lewis and A. Challinor, Phys. Rept. 429 (2006).

Primordial B polarization

- E, B basis has an advantage wtrt Q,U for studying polarization of CMB since B is (linearly) produced only by tensor modes (GW). E is produced by both scalar and tensor fluctuations.
- The APS of the primordial B can be divided in 3 regions: reionization bump, primordial peak and damping tail.
- The APS of the primordial B depends linearly on r (tensor to scalar ratio = ratio of PS in Fourier space of tensor to curvature perturbations). r is unknown and can vary many order of magnitude.
- Present limits on $r=P_T/P_S$ (at $k_*=0.01$ Mpc^{-1}) are < 0.26 (no running) or < 0.50 (with running) for WMAP3+CMBsmall+2dF at 2σ (FF, Rianna and Mandolesi, astro-ph/0608032): this constraint mainly comes from T, TE and E.

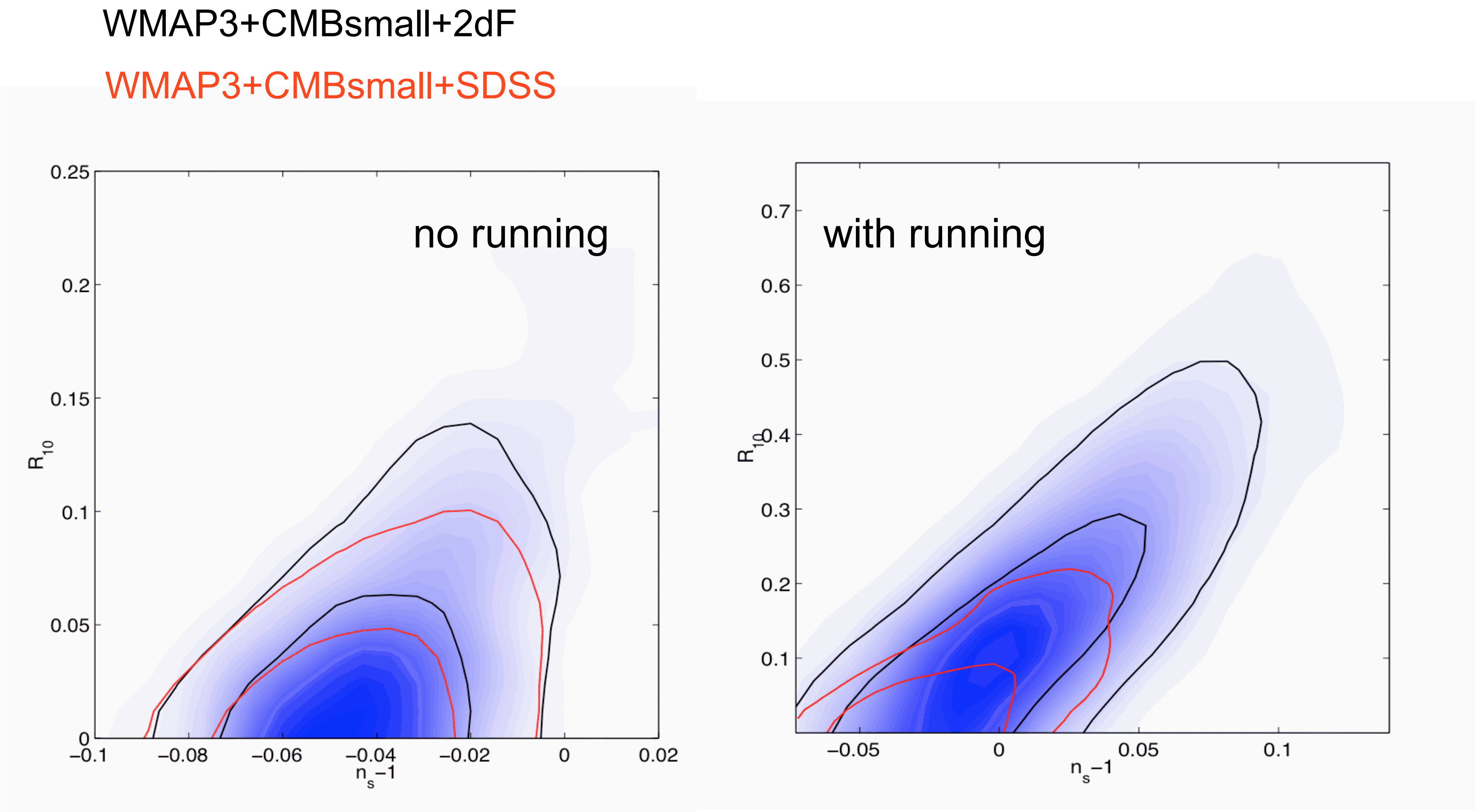


Solid - $\tau=0$

Dotted - $\tau=0.1$ ~ WMAP3

Dashed - $\tau=0.17$ ~ WMAP1

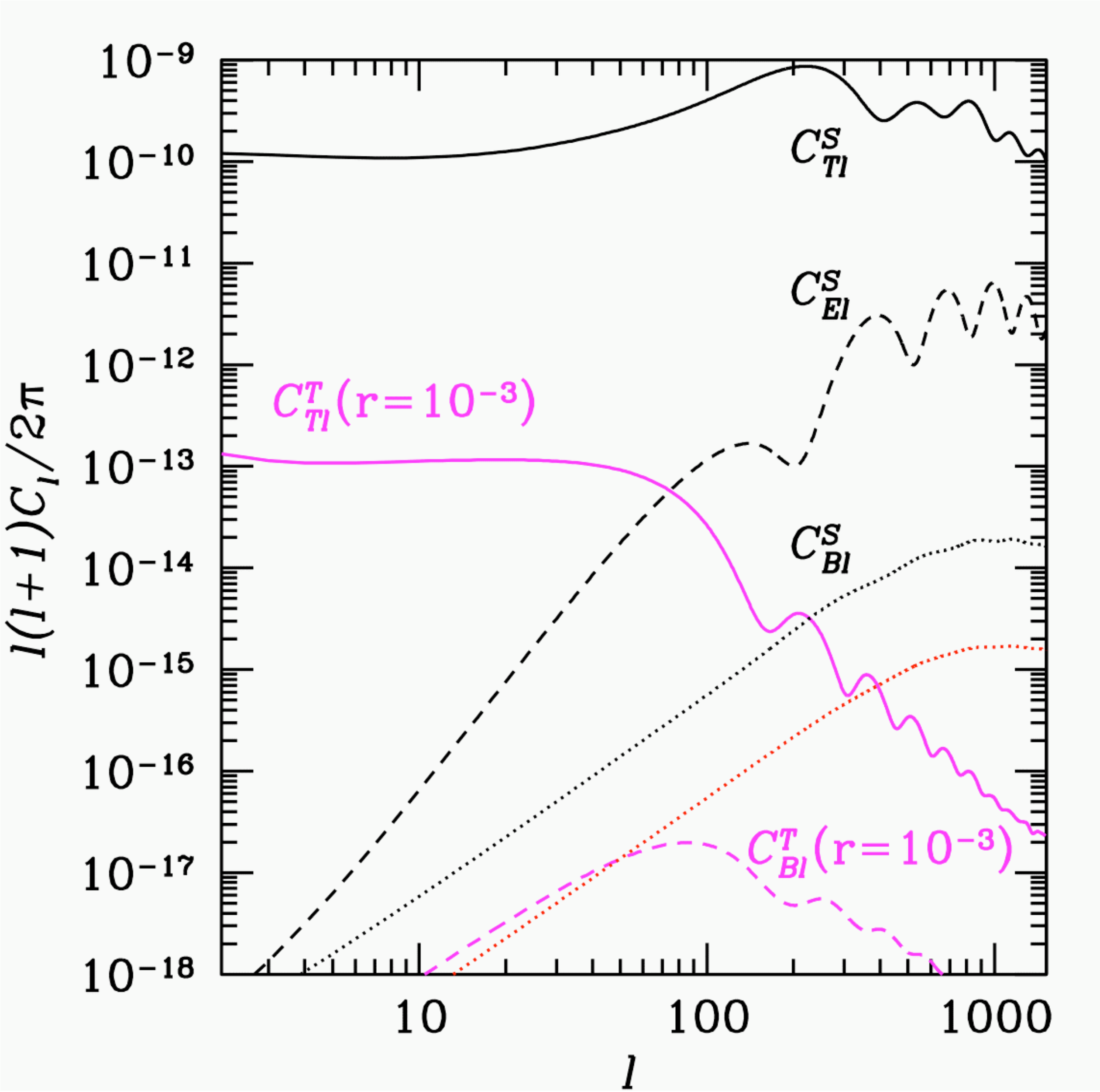
Present constraints from CMB and LSS on $(n_S, R_{l=10})$ plane



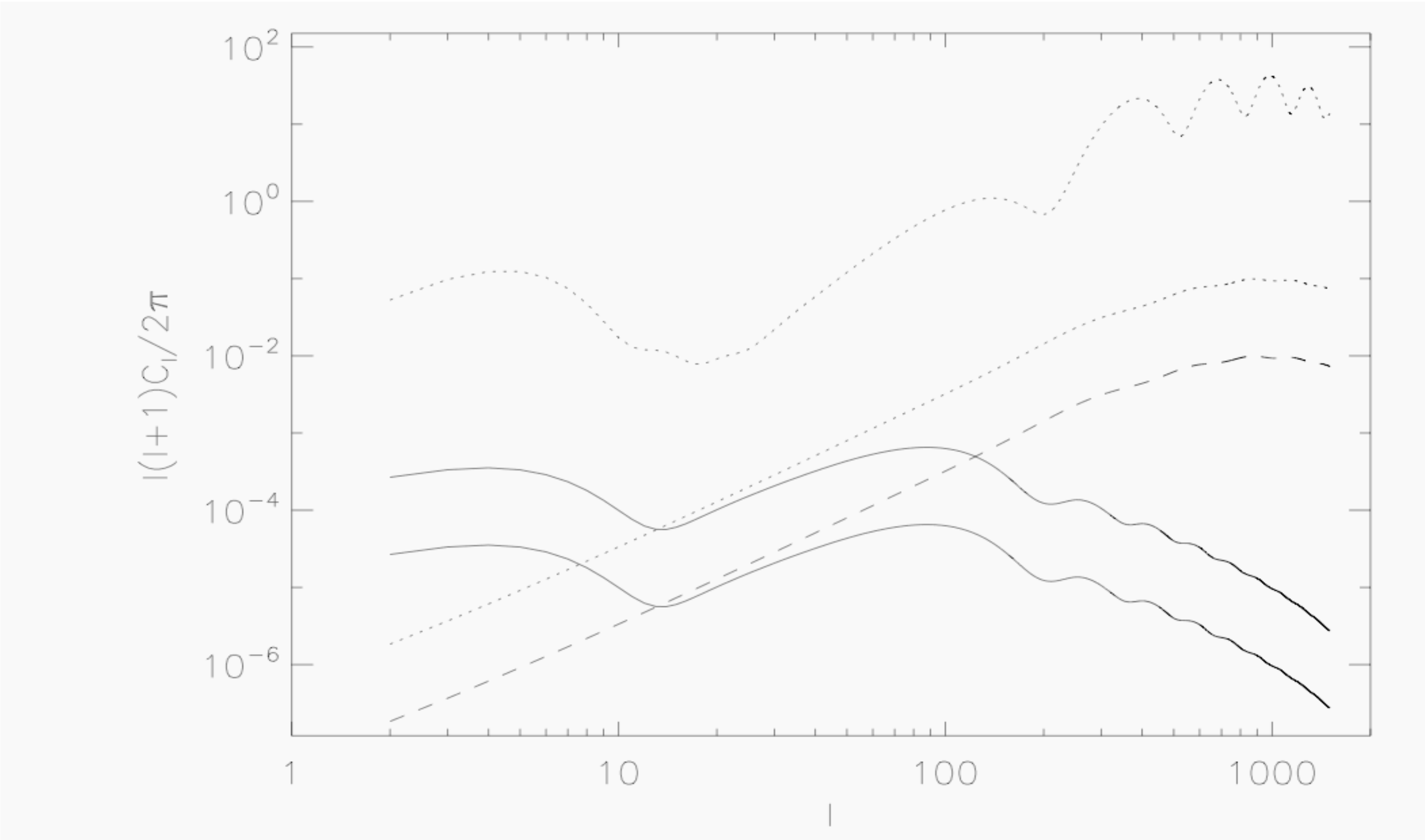
From FF,Rianna and Mandolesi, astro-ph/0608032

Lensing

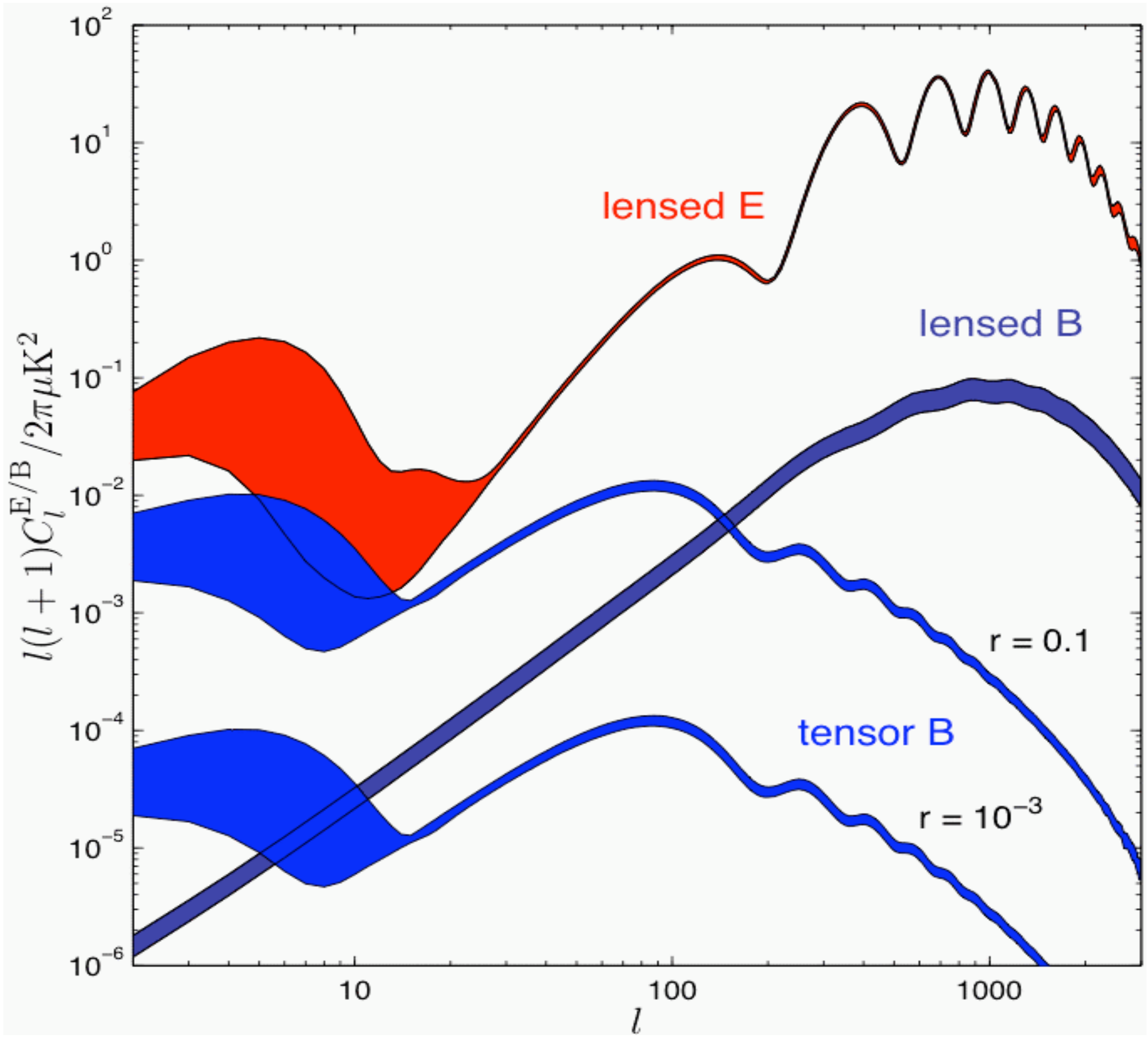
- The deflection of CMB photons coming from the last scattering surface by gravitational potentials along our line of sight produces a spurious B mode from the scalar E mode.
- Although such lensing induced B mode is a second order effect in perturbations amplitude, its magnitude can be comparable to the primordial one due to linear tensor.
- BB from lensing is the intrinsic limitation to detect GW from CMB for an ideal experiment (without foregrounds and systematics). It is the signal which fixes the ultimate scientific requirements.
- The lensing C_l^{BB} has a close-to-white spectrum for $l < 1000$ with amplitude 2 x 10 μK^2
- GW can be detected if r > few 10^{-3}



Taken from Knox and Song, PRL 89 (2002)



10^2
10^0
10^{-2}
10^{-4}
10^{-6}
1
10
100
1000
l
$l(l+1)C_l/2\pi$



Theoretical expectations with 95 % cl contours based on the present uncertainties on cosmological parameters.

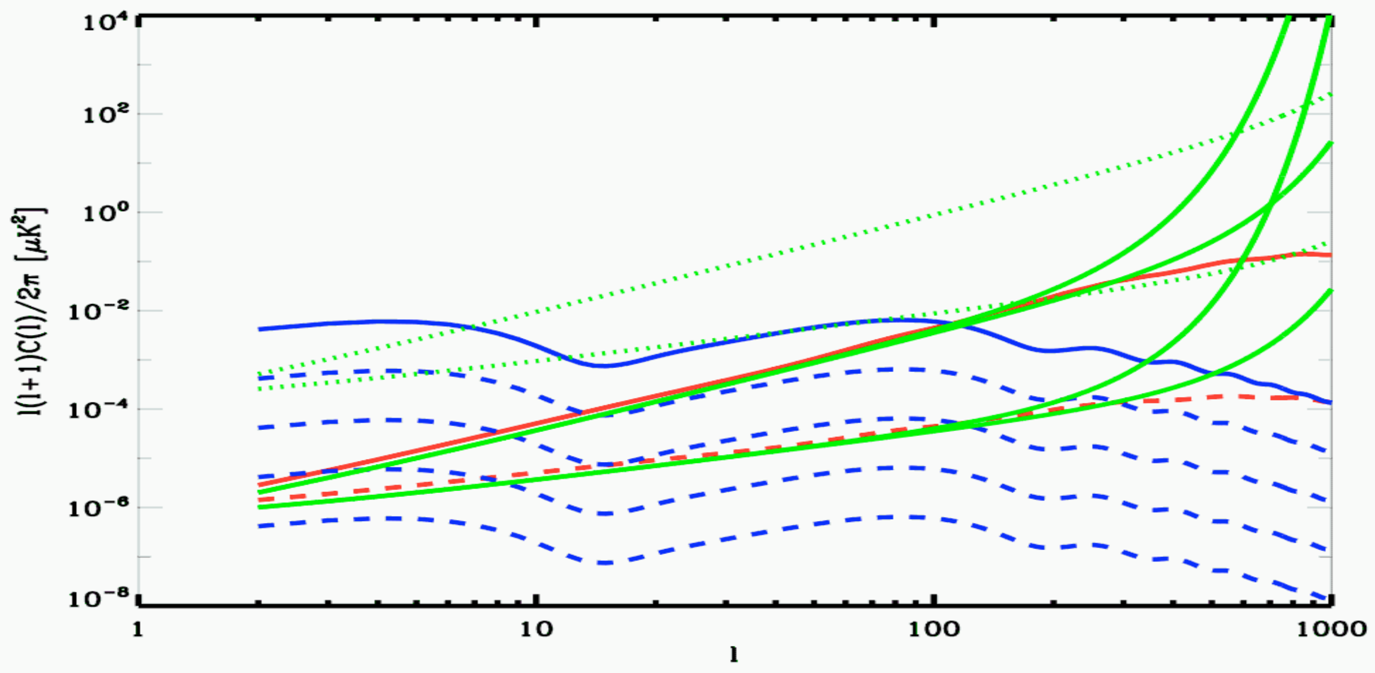
Courtesy from A. Lewis, astro-ph/0603753

$$C_{noise} = 2 \cdot 4\pi \cdot f_{sky}\, s_{det}^{2} / (N_{det}\, T_{pix})$$

$$[s_{det}] = [K\, s^{1/2}]$$

$$\Delta C_l = (2/(2\,l+1))^{1/2}\, C_{noise}\, \exp[l^2\, \sigma_B^{2}] \quad \text{with} \quad \sigma_B = \text{FWHM}/(\sqrt{8 \ln 2})$$

$C_{noise} \sim (5\ \mu K\ \text{arcmin})^2$ in the range of 10'-20'-40' FWHM with 5000 detectors for 2 yrs mission with $s_{det} \sim 140\ \mu K \sqrt{s}$



Relative sensitivities of PLANCK and of BPOL versus B modes, assuming for the latter 5 μK arcmin instrument noise and either 20' or 40' fwhm beams. Planck corresponds to the dotted green lines and BPOL to the solid ones. In each case, we plot both the expected detector noise power spectrum, and its division by l to suggest the detection achievable in broad bins ($\Delta l/l \sim 1$). From top to bottom, the B modes levels in blue correspond to values of T/S = 10^{-1}, 10^{-2}, 10^{-3}, 10^{-4}, 10^{-5}.

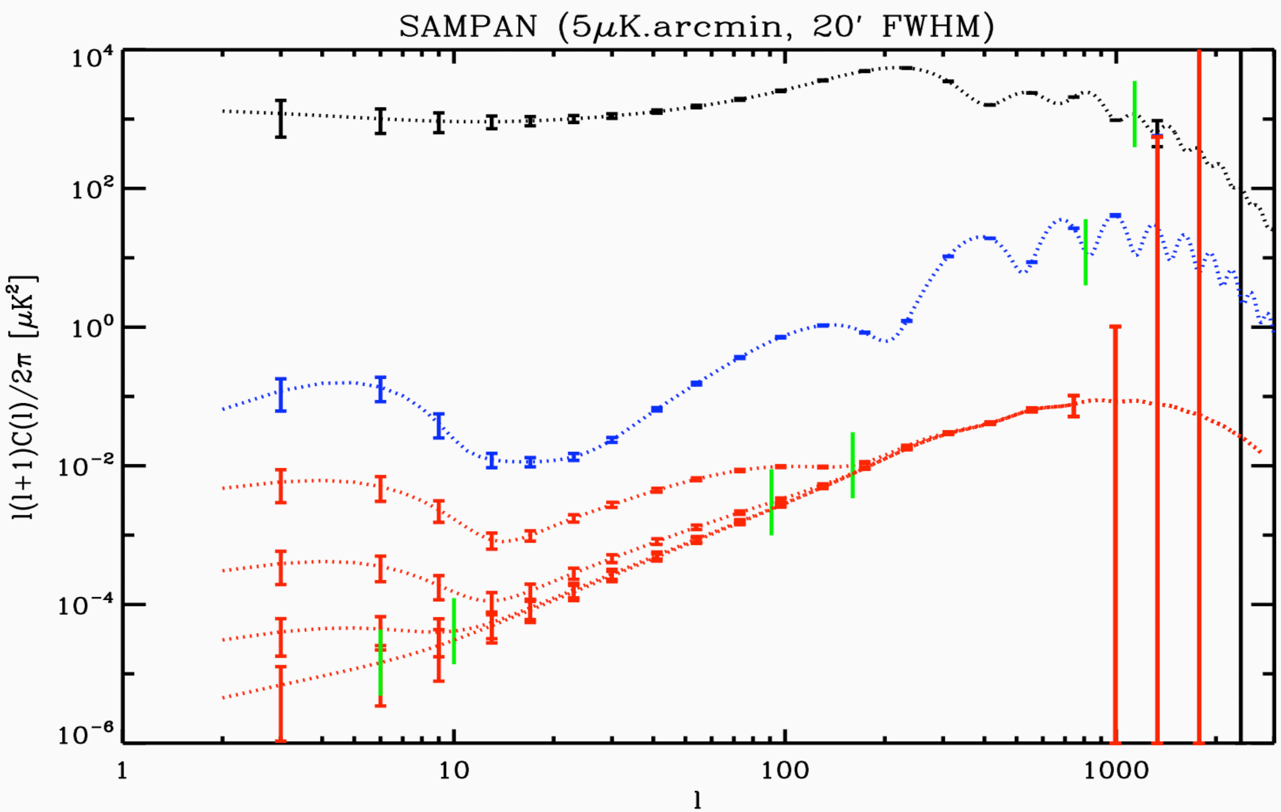


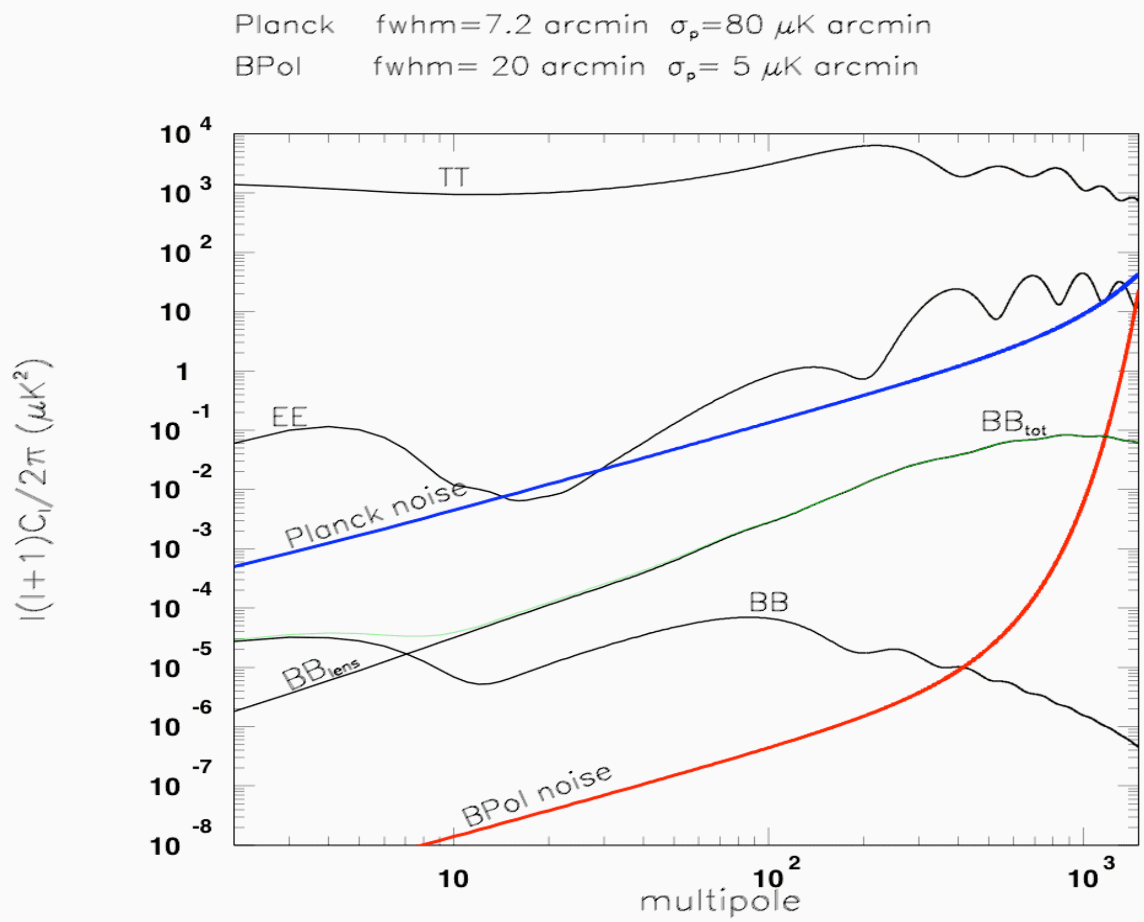
Illustration of the attainable error bars (including cosmic variance) on the (binned) power spectra for the temperature anisotropies (top, black), the E-modes (blue, middle) and the B-modes with T/S = 10^{-1}, 10^{-2}, 10^{-3}, 10^{-4} corresponding, respectively, to the red dotted lines from top to bottom. In the latter case, the spectrum is virtually indistinguishable from that induced by lensing only. The green ticks delimit the low-l region where the measurement would not be limited by detector noise (assuming f_{sky} = 0.8).

With a Fischer matrix approach on 8 parameters SAMPAN draft claims that r ~2 x 10^{-3} can be reached WITH the reionization bump at τ=0.17.

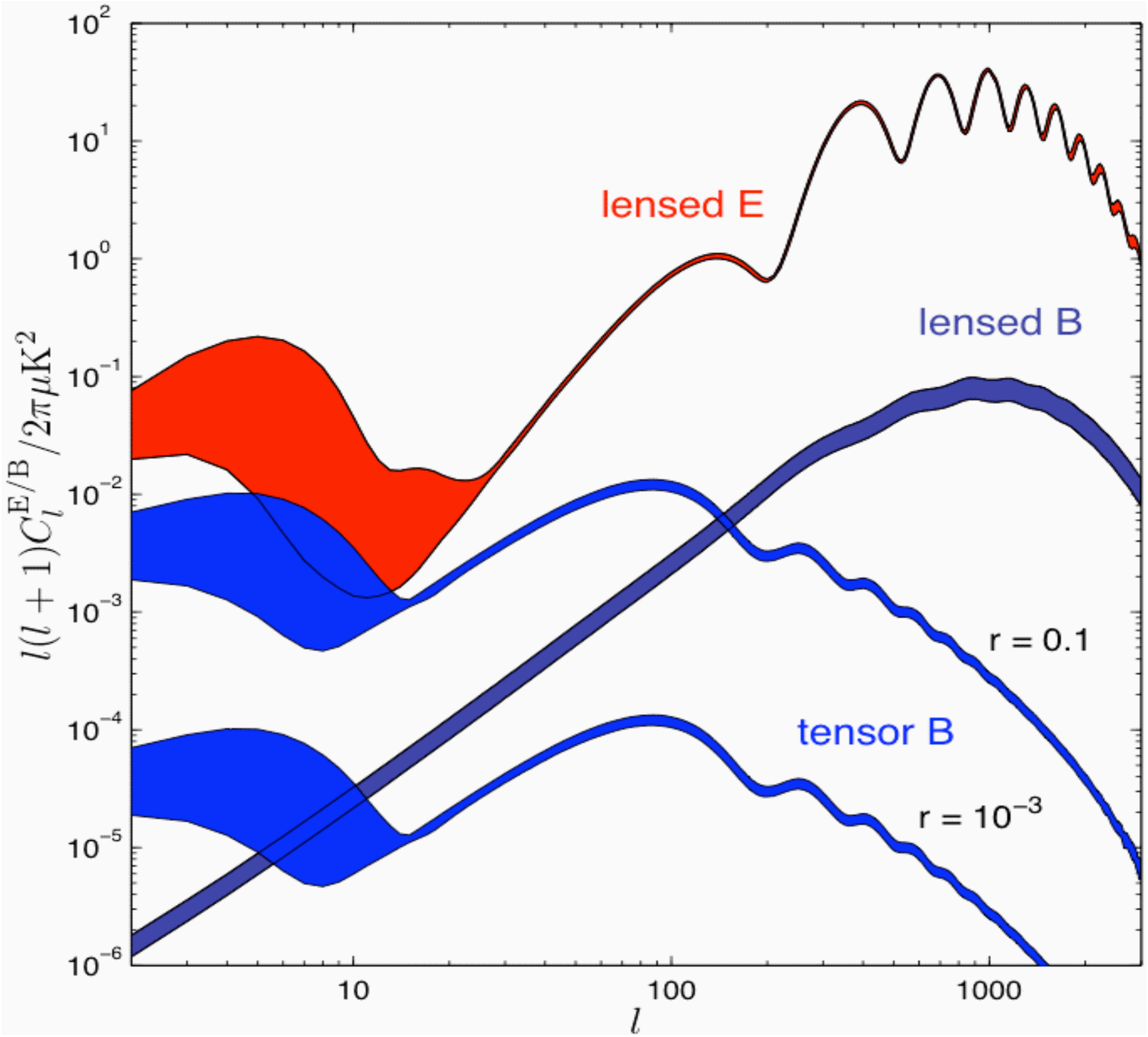
Issues and things to do

- Revise τ (r_{lim} increase): add the analysis τ=0.08-0.09
- Include estimates with E-B mixing effects in this section?
- Define the angular resolution of the experiment: higher resolution than what proposed in SAMPAN would be of scientific impact (1. added scientific goal if GW are not at

  $r >$ few 10^{-3} - without taking into account lensing the determination of cosmological parameters is not significantly improved wrt Planck for 20’ FWHM in absence of GW, as shown by Lucia Popa - 2. scientific results from lensing characterization, see sections 6,7,8. 3. cleaning of the lensing signal with hope for hunting lower r).
- Can you reduce - can you clean at which level - the lensing contamination for FWHM 20’?
- …



Planck fwhm=7.2 arcmin σp=80 μK arcmin
BPol fwhm= 20 arcmin σp= 5 μK arcmin
10 4
10 3
10 2
10
1
10 -1
10 -2
10 -3
10 -4
10 -5
10 -6
10 -7
10 -8
l(l+1)Cl/2π (μK²)
TT
EE
Planck noise
BBtot
BB
BBlens
BPol noise
10
10 2
10 3
multipole



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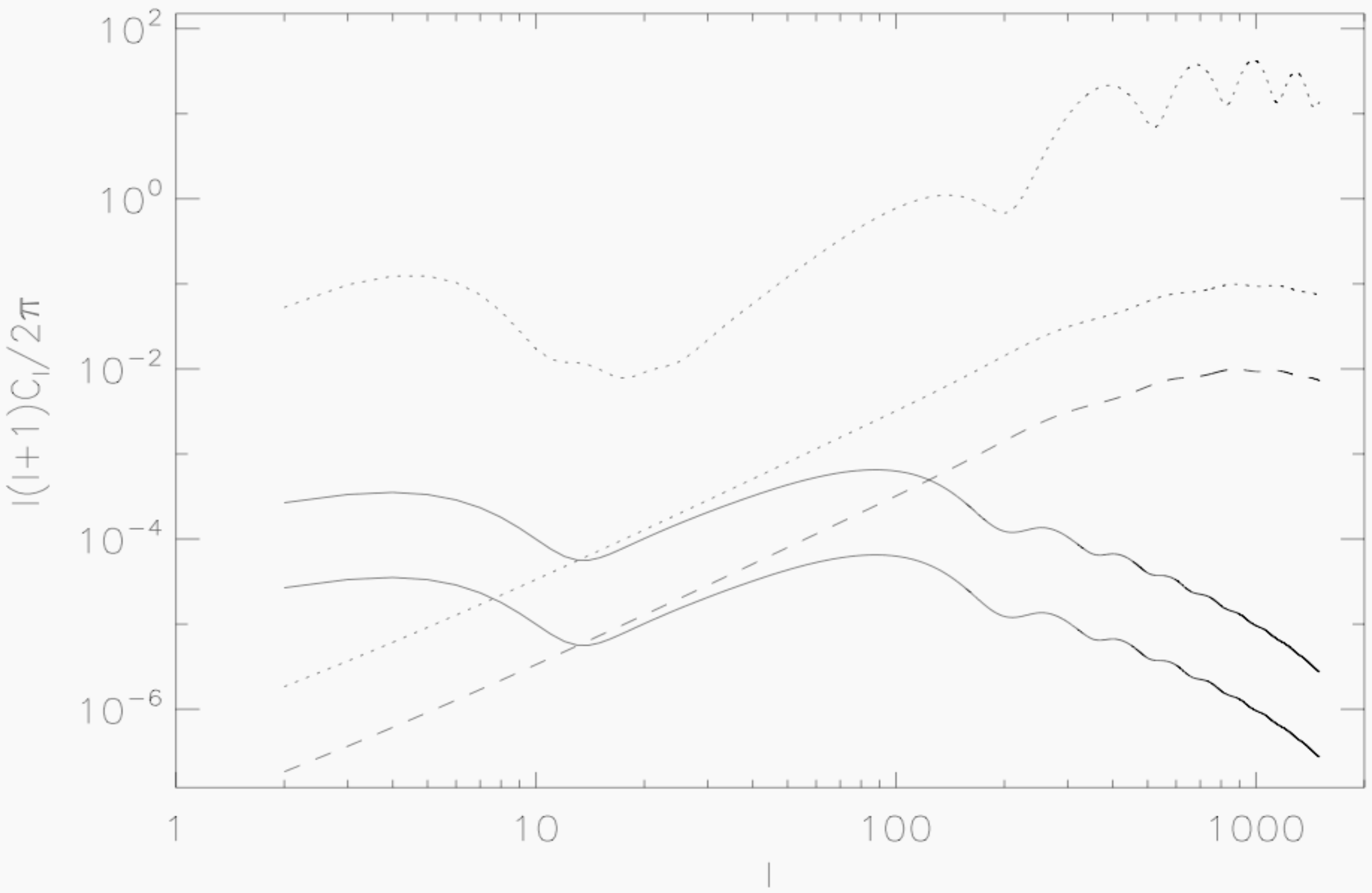

10^2
10^0
10^{-2}
10^{-4}
10^{-6}
$l(l+1)C_l/2\pi$
1
10
100
1000
l