Prospects for constraining Dark Energy and Early Universe with the B-modes of CMB polarization

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Claudia Antolini 17 September 2012, IESC Cargèse - XIth School of Cosmology

Gravitational Lenses, their impact in the study of galaxies and Cosmology

Gravitational Lensing on Cosmic Microwave Background

GL is a phenomenon occurring when the path of a ray of light passes close to a mass and gets deflected by an angle α.

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CMB lensing is a secondary anisotropy
It has been observed by various collaborations in the T-modes

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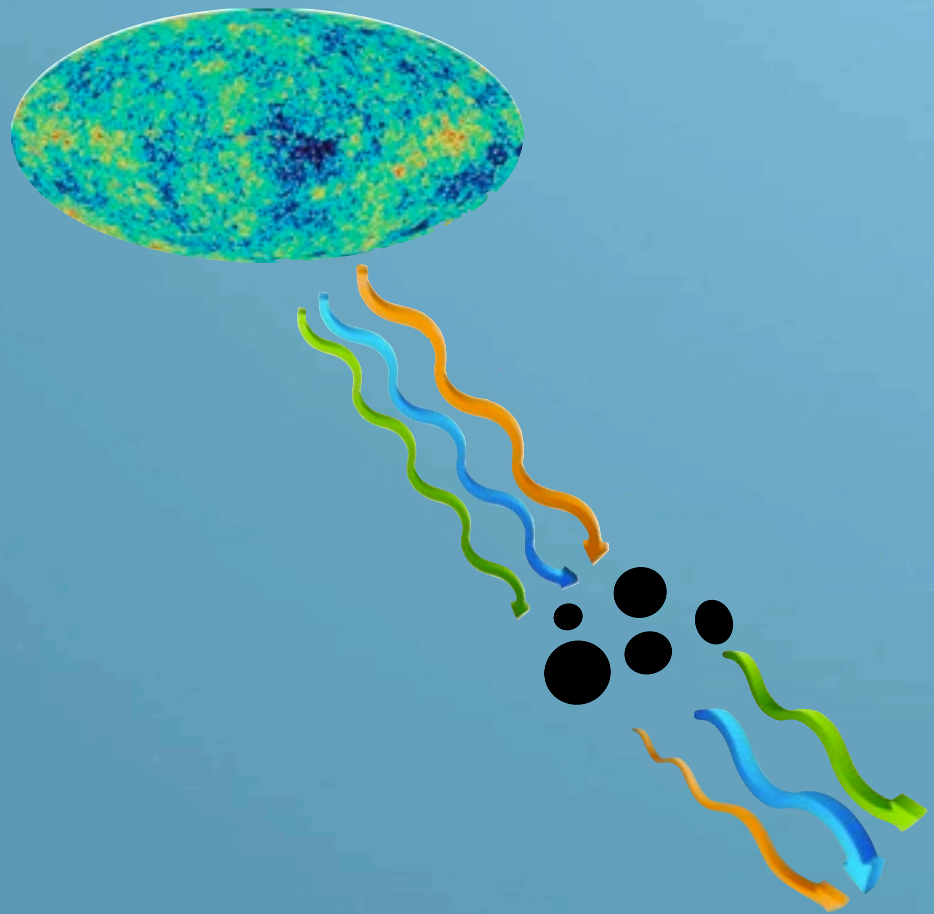

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$$\tilde{T}(\hat{\mathbf{n}}) = T(\hat{\mathbf{n}} + \alpha)$$

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$$\Rightarrow \alpha = \nabla_\perp \psi$$

$$\tilde{T}(\hat{\mathbf{n}}) = T(\hat{\mathbf{n}} + \nabla_\perp \psi) \approx T(\hat{\mathbf{n}}) + T(\hat{\mathbf{n}})\nabla_\perp \psi + \ldots$$

- Lensing generated by structures at large scales (~ cluster of galaxies to hundreds of Mpc) generates a distortion at small scales
- r.m.s. of deflection is ~ 2 arcmin
- Deflections are coherent over several degrees (Hanson, Challinor, Lewis 2009)

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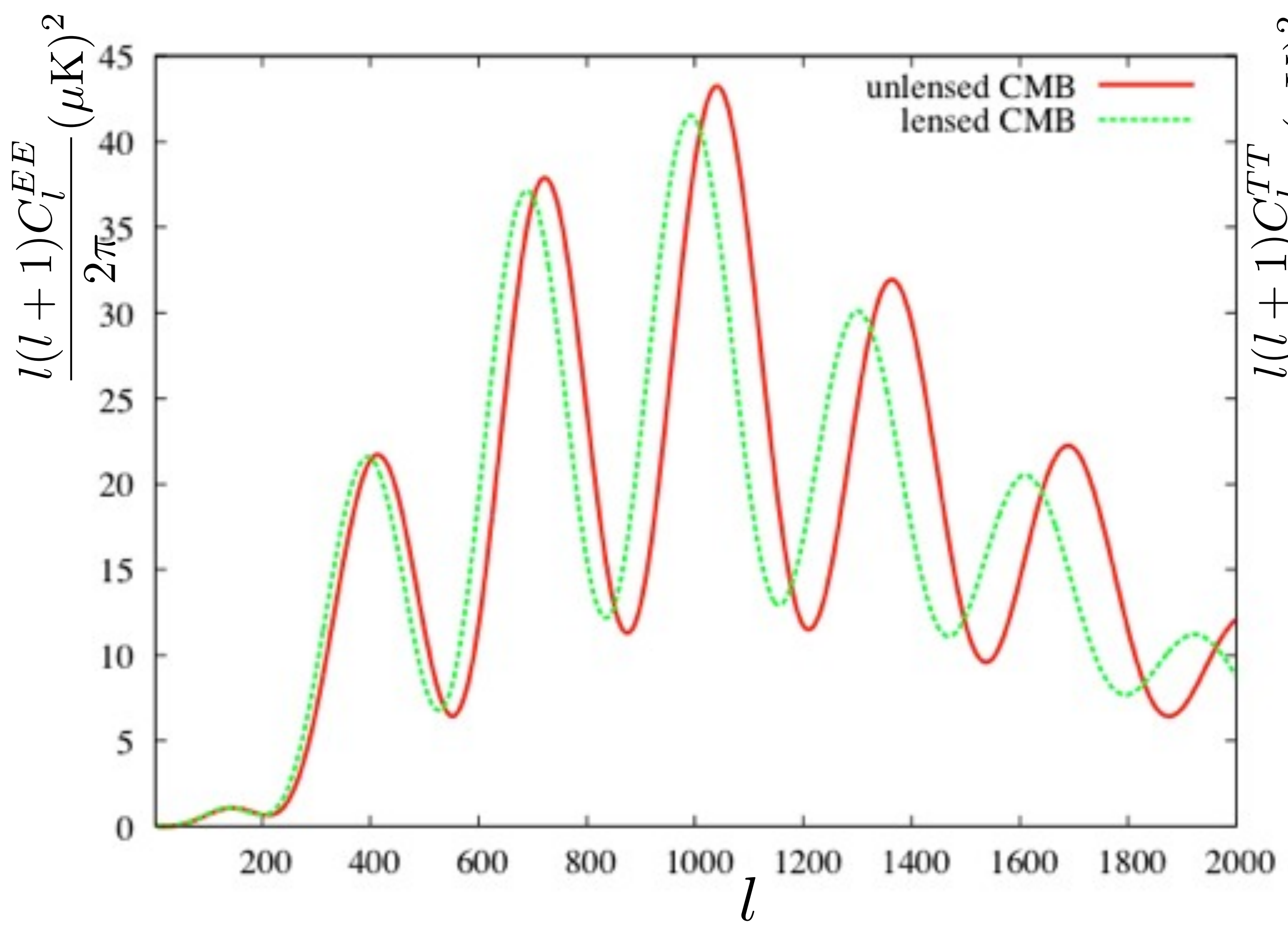
CMB lensing forecast: phenomenology

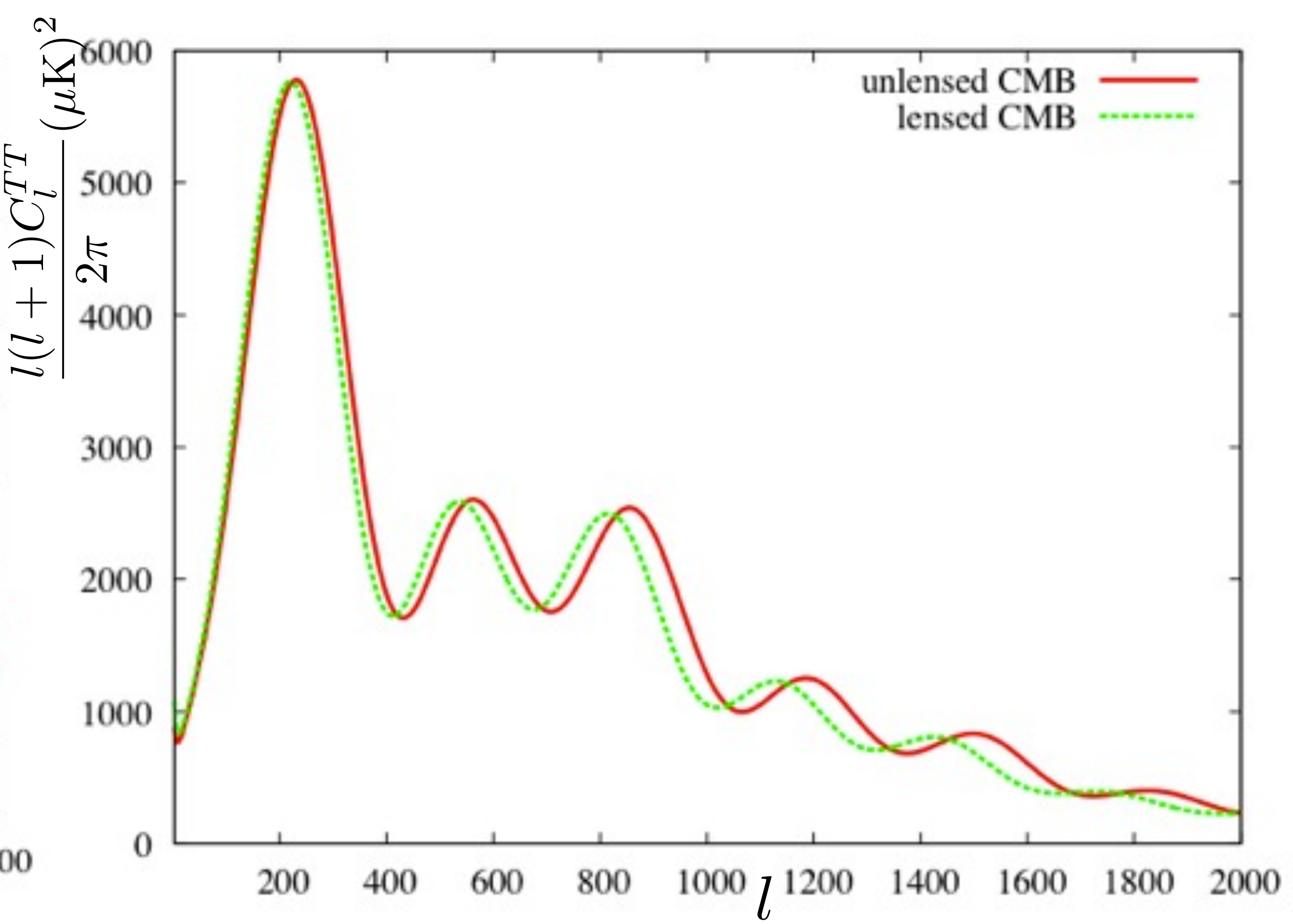
As a lensing estimator we are now using only the spectra (soon: forecast of the deflection spectrum on Planck mock data).

Lensing induces small variations in the T and E-modes while it is more effective in modifying the B-modes.

Introducing a varying DE modifies the primordial tensors up to 30% at the B-modes peak; this can contaminate the measurement of the parameter r.

Up to now no forecasts for simultaneous contraints were given on a parametric DE and r





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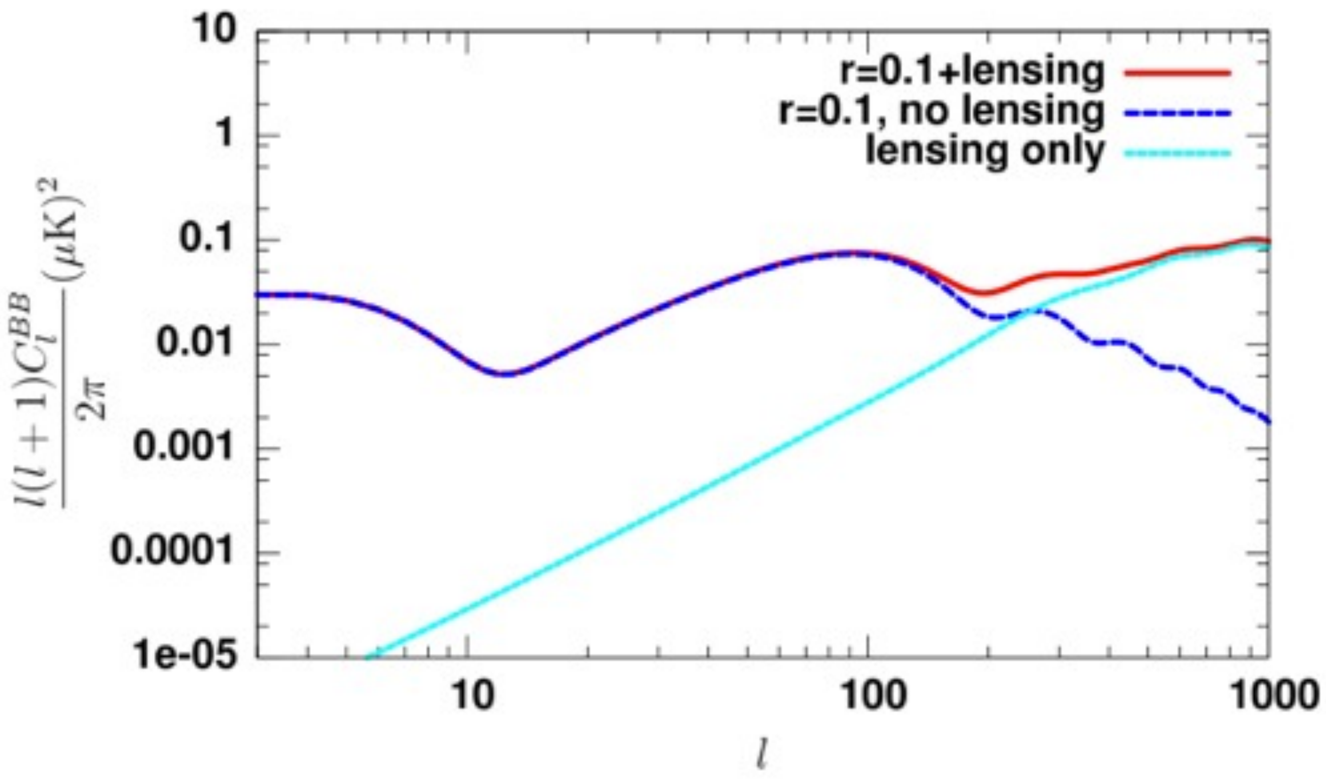
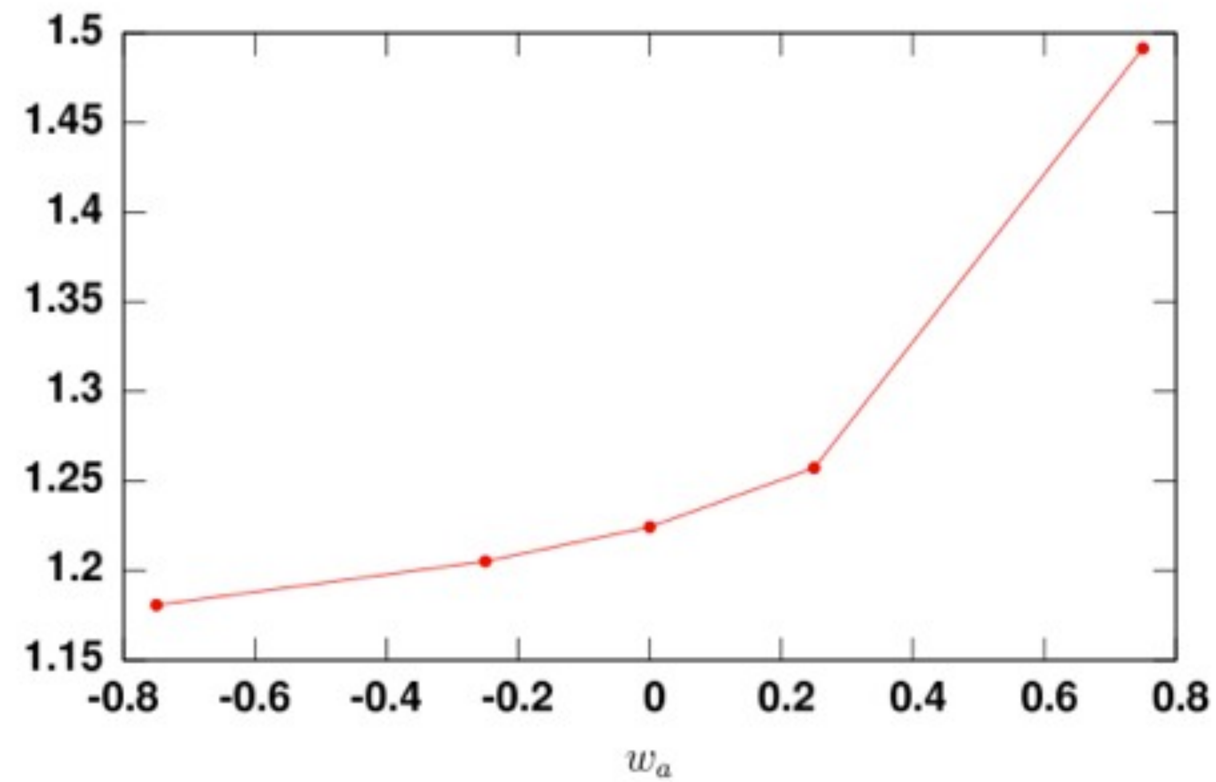




Mock data and analysis

We simulated data for a standard LCDM Universe from 3 CMB experiments: Planck and 2 upcoming suborbital missions, EBEX and PolarBear. The latter could be able to detect primordial B-modes.

We simulated two datasets: one with no primordial tensor modes (r=0) in order to set an expected upper limit and one with r=0.05 to estimate the sensitivity of the instruments in a realistic case.

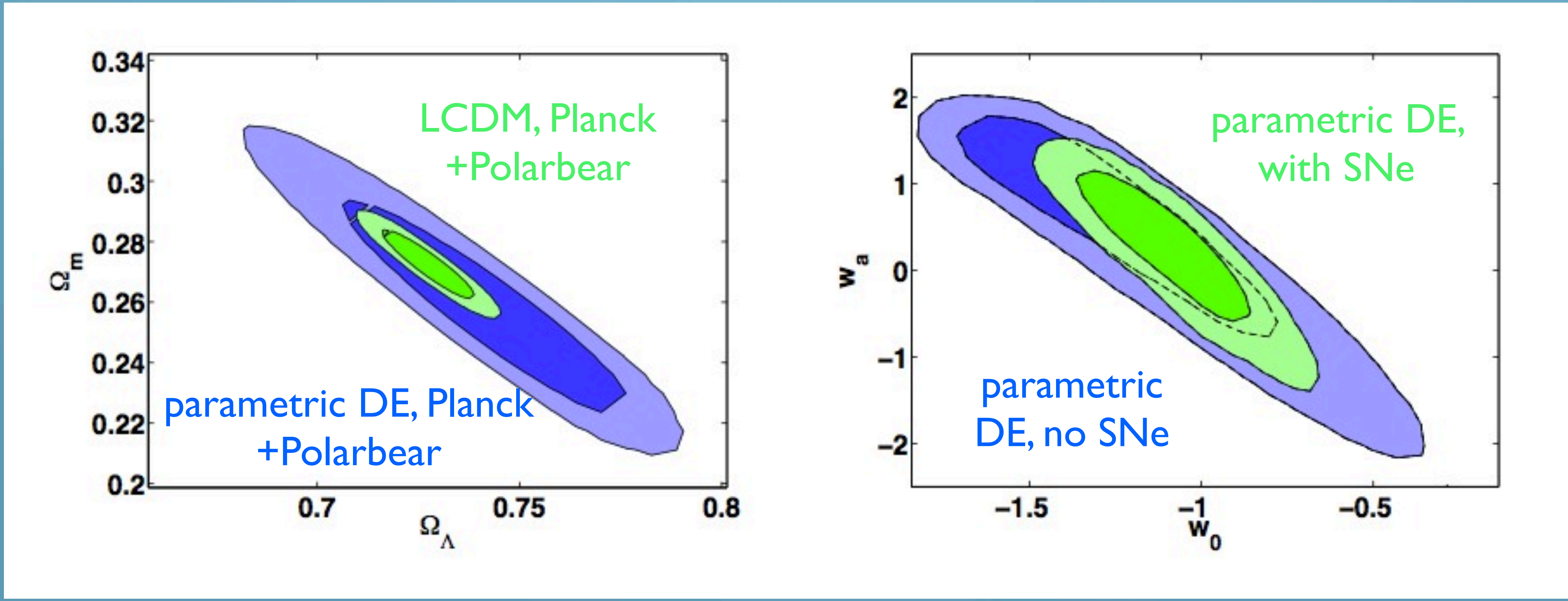
We performed a MCMC analysis with the CosmoMC-CAMB software using different combination of experiments.

Experiment	Channel	FWHM	ΔT/T
Planck	70	14'	4.7
	100	9.5'	2.5
	143	7.1'	2.2
	217	5.0'	4.8
$f_{sky} = 0.85$			
EBEX	150	8'	0.33
	250	8'	0.33
	410	8'	0.33
$f_{sky} = 0.01$			
PolarBear	90	6.7'	0.41
	150	4.0'	0.62
	220	2.7'	2.93
$f_{sky} = 0.03$			

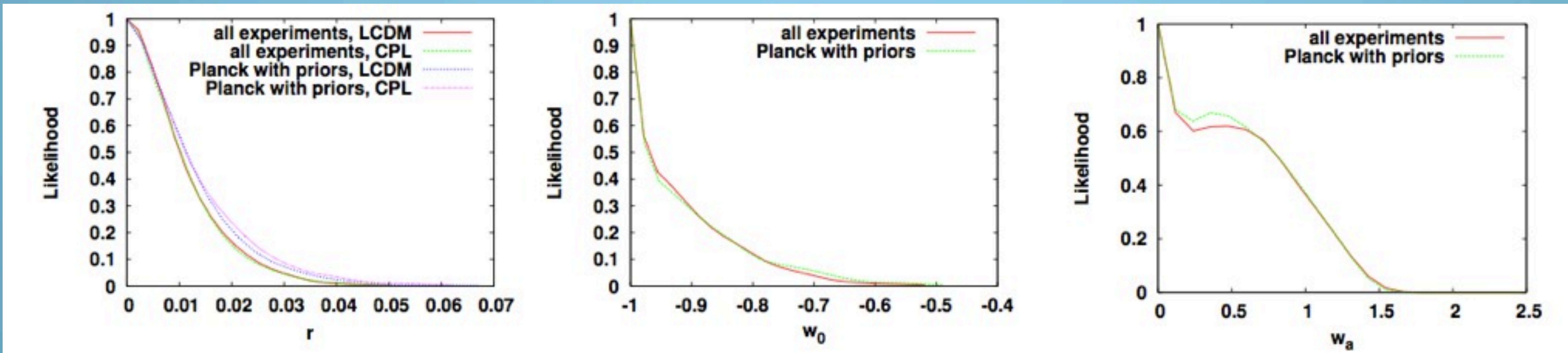
Table 1. Planck, EBEX and PolarBear performance specifications. Channel frequency is given in GHz, beam FWHM in arcminutes, and the sensitivity for T per pixel in μK/K. The polarization sensitivity for both E and $B-$modes is $\sqrt{2}\Delta T/T$.

Calibration and external priors

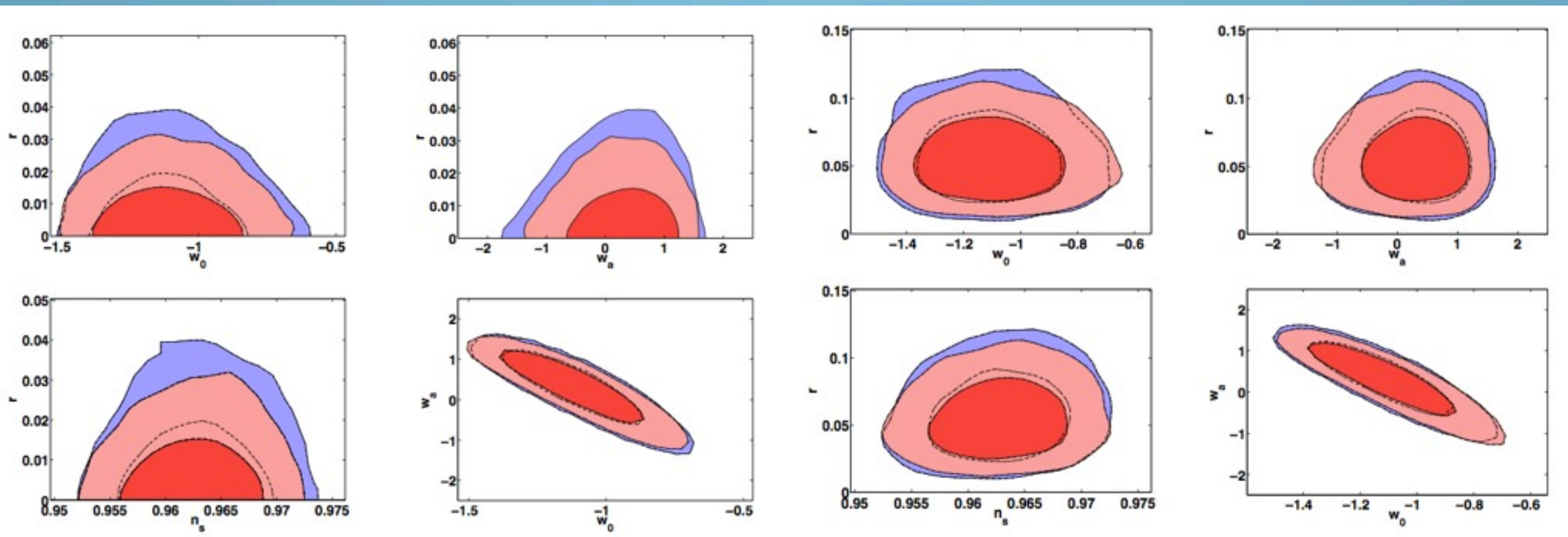
To check the consistency of our machinery we performed a few test runs assuming a standard LCDM Universe (fig. on the left) wih r=0 and w_0, w_a fixed, keeping the DE parameters fixed (green) and free to vary (blue) with a combination of Planck+Polarbear. We recover a decrease in constraining power due to the extra degrees of freedom, as expected. Adding an independent measurement at low z such as SNe (fig. on the right) helps reducing the degeneracies significantly (in blue Planck+PolarBear, in green the combination with SNe).



Results I



r=0



r=0

blue: Planck+priors

red: all experiments

r=0.05

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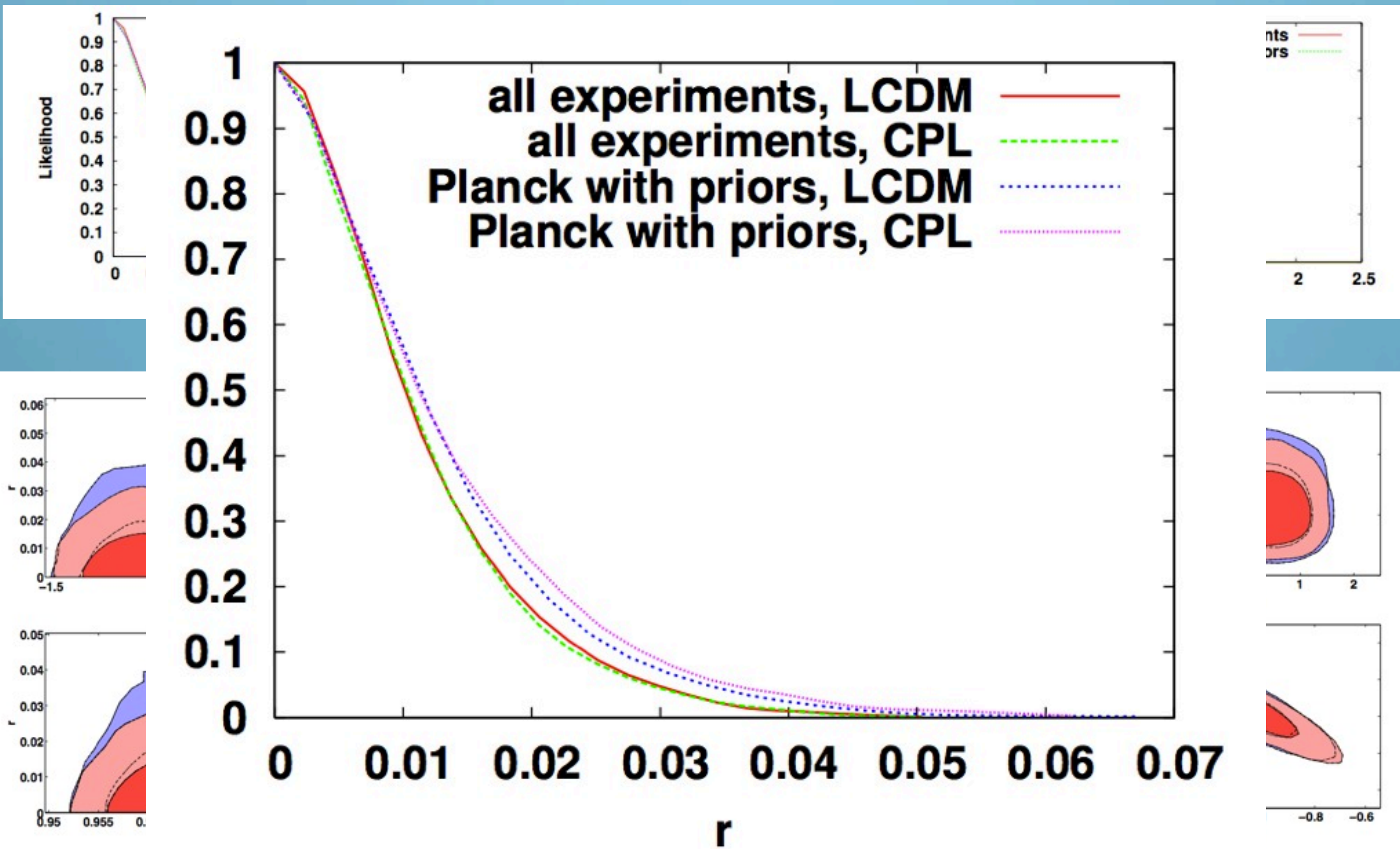

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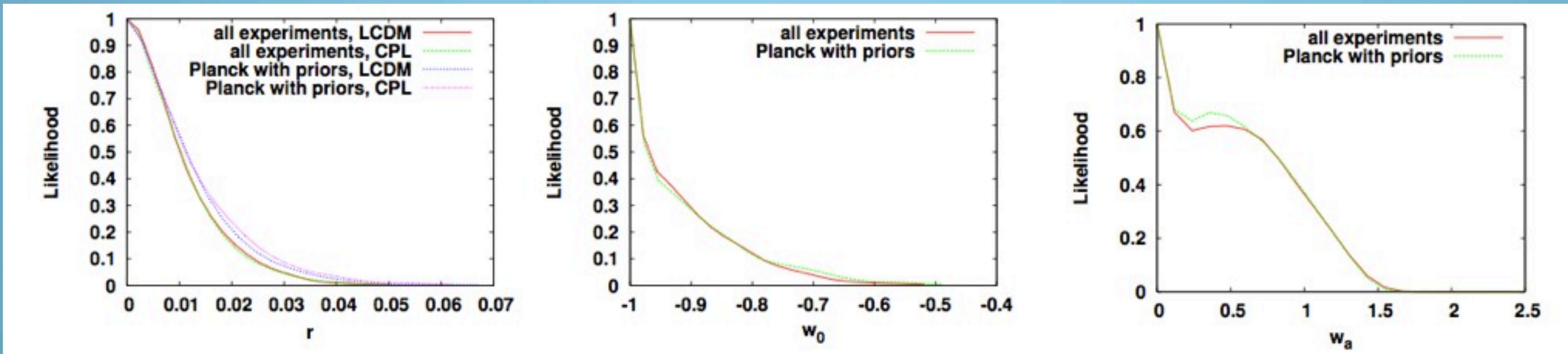
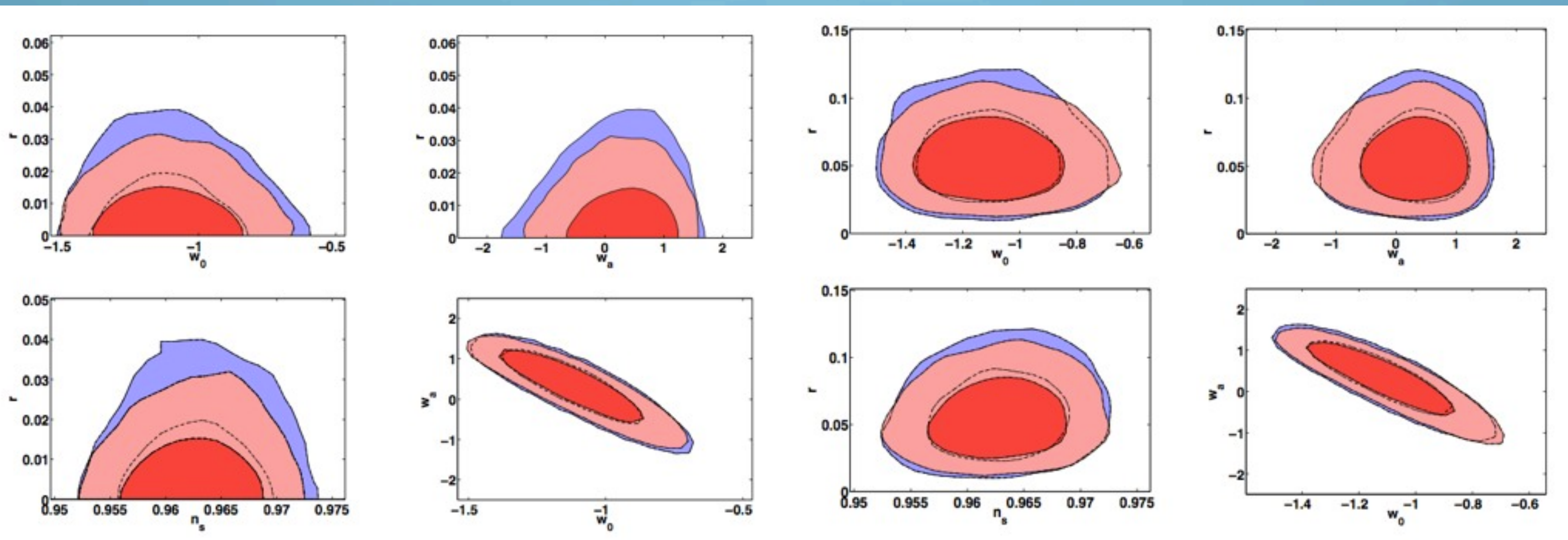


r=0



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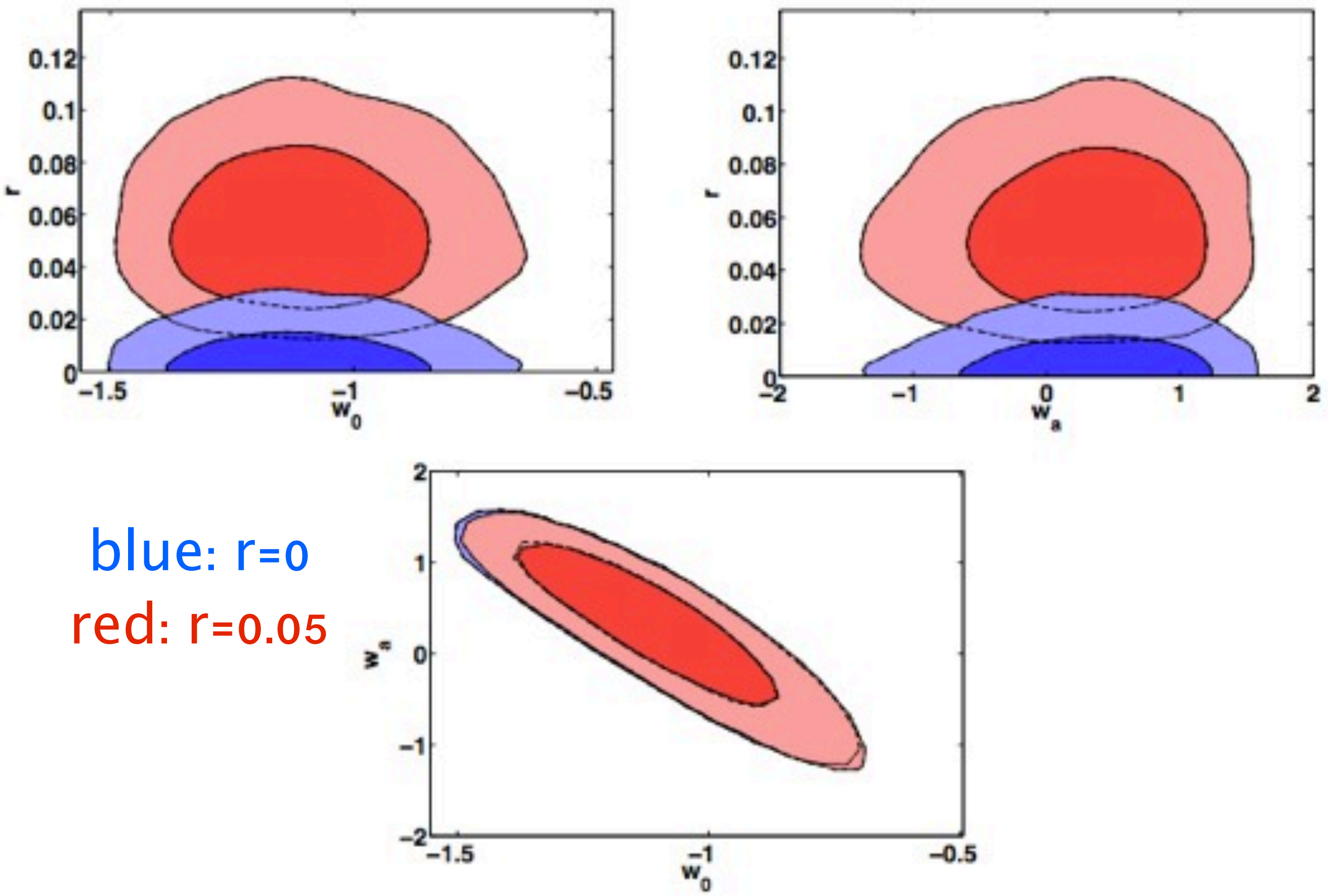
Results II



Experiments, fiducial	$r=0$	$r=0.05$
Planck with priors, ΛCDM	$r<0.029$	$r=0.057\pm0.022$
Planck with priors, CPL	$r<0.031$	$r=0.059\pm0.023$
all experiments, ΛCDM	$r<0.025$	$r=0.057\pm0.020$
all experiments, CPL	$r<0.025$	$r=0.056\pm0.020$
Planck with priors, CPL	$w_0=-1.1\pm0.2$	$w_0=-1.1\pm0.2$
all experiments, CPL	$w_0=-1.1\pm0.2$	$w_0=-1.1\pm0.2$
Planck with priors, CPL	$w_a=0.3\pm0.6$	$w_a=0.3\pm0.6$
all experiments, CPL	$w_a=0.3\pm0.6$	$w_a=0.2\pm0.6$

Remarks

In the case of Planck nominal performance, the constraining power on r is weakened by the inclusion of the extra degrees of freedom, resulting in an increase of about 10% of the upper limits on r as well as a comparable increase in the error bars in models with non-zero tensor power. The inclusion of sub-orbital CMB experiments, capable of mapping the B-mode power up to the angular scales which are affected by lensing, has the effect of making such loss of constraining power vanishing below a detectable level. No new degeneracies were detected with this approach.


Thanks for your attention!