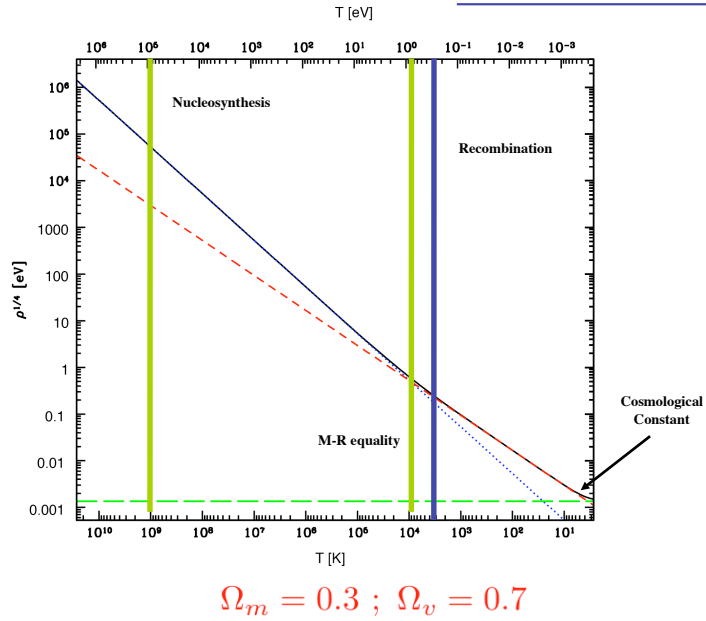


# Thermal History



Z	Age	Comoving distance	Comoving volume	Size-Angle kpc'' (physical)
0	13.6 Gyr	0	0	0
0.1	12.4 Gyr	0.4 Gpc	0.3 Gpc <sup>3</sup>	1.9
1	5.9 Gyr	3.3 Gpc	152 Gpc <sup>3</sup>	8.4
3	2.2 Gyr	6.5 Gpc	1100 Gpc <sup>3</sup>	7.8
10	0.4 Gyr	9.7 Gpc	3800 Gpc <sup>3</sup>	4.3
1100	380 kyr	13.9 Gpc	11500 Gpc <sup>3</sup>	0.062
3200	58 kyr	14.2 Gpc	11900 Gpc <sup>3</sup>	0.021
10 <sup>9</sup>	25.5 sec	14.3 Gpc	12153 Gpc <sup>3</sup>	0

$\rho_c \approx 1.4 \times 10^{11} M_{\odot}/\text{Mpc}^3$

# Horizon Scale

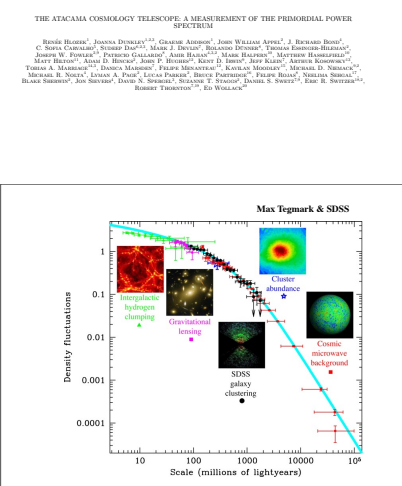
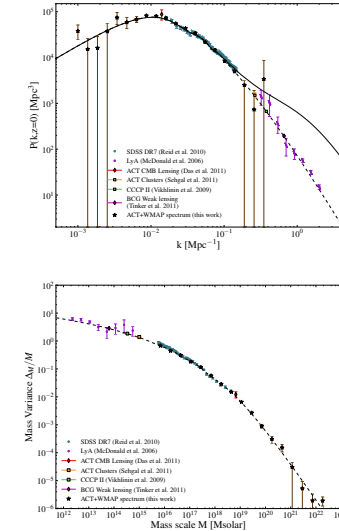
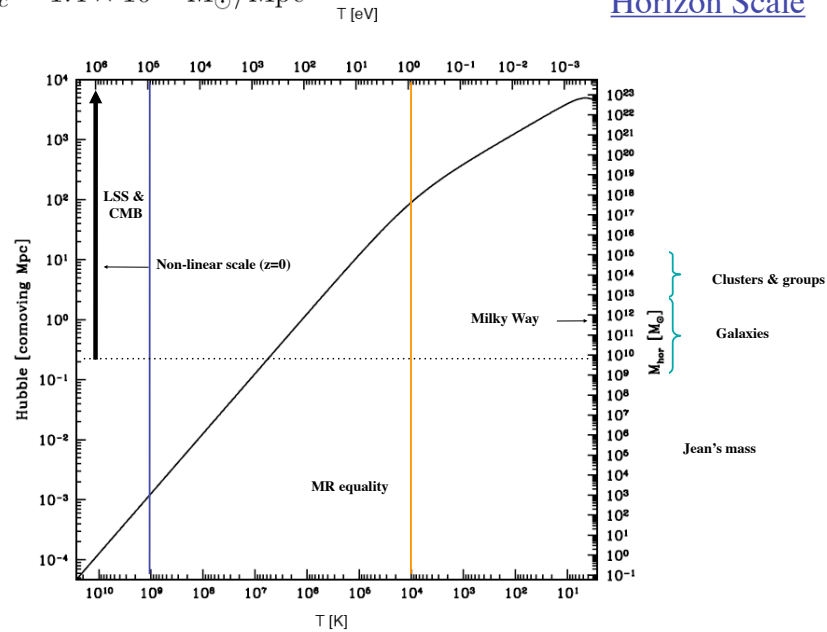
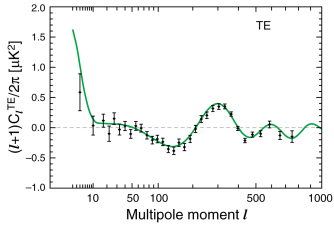
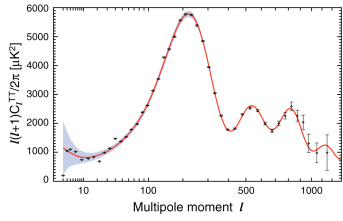


FIG. 5.— The reconstructed matter power spectrum: the stars show the power spectrum from combining ACT and WMAP data (top panel). The solid and dashed lines show the nonlinear and linear power spectra respectively from the best-fit  $\Lambda$ CDM model with spectral index of  $n_s = 0.96$  computed using CAMB and HALOFIT (Smith et al. 2003). The data points between  $0.02 < k < 0.10 \text{ Mpc}^{-1}$  show the SDDS DR7 LRG sample, and have been deconvolved from their window functions, with a bias factor of 1.8 applied to the data. This has been rescaled from the Reid et al. (2010) value of 1.3, so we are explicitly using the Hubble constant measurement from Riess et al. (2011) to make a change of scale from  $h^{-1} \text{ Mpc}^{-1}$  to  $\text{Mpc}^{-1}$ . The constraints from CMB lensing (Das et al. 2011), from cluster measurements from ACT (Schlegel et al. 2011), CCFP (Vikharenko et al. 2009) and RGC halo (Tinker et al. 2011), and the power spectrum constraints from measurements of the Ly $\alpha$  forest (McDonald et al. 2006) are indicated. The CCFP and RGC masses are converted to solar mass units by multiplying them by the best-fit value of the Hubble constant,  $h = 0.738$  from Riess et al. (2011). The bottom panel shows the same data plotted on axes where we relate the power spectrum to a mass variance,  $\Delta_{\rho}^2(M)$ , and illustrate how the range in wavenumber  $k$  (measured in  $\text{Mpc}^{-1}$ ) corresponds to range in mass scale of 10 orders of magnitude. Note that large masses correspond to large scales and hence small values of  $k$ . This highlights the consistency of power spectrum measurements by an array of cosmological probes over a large range of scales.

### The 6 parameter LCDM model

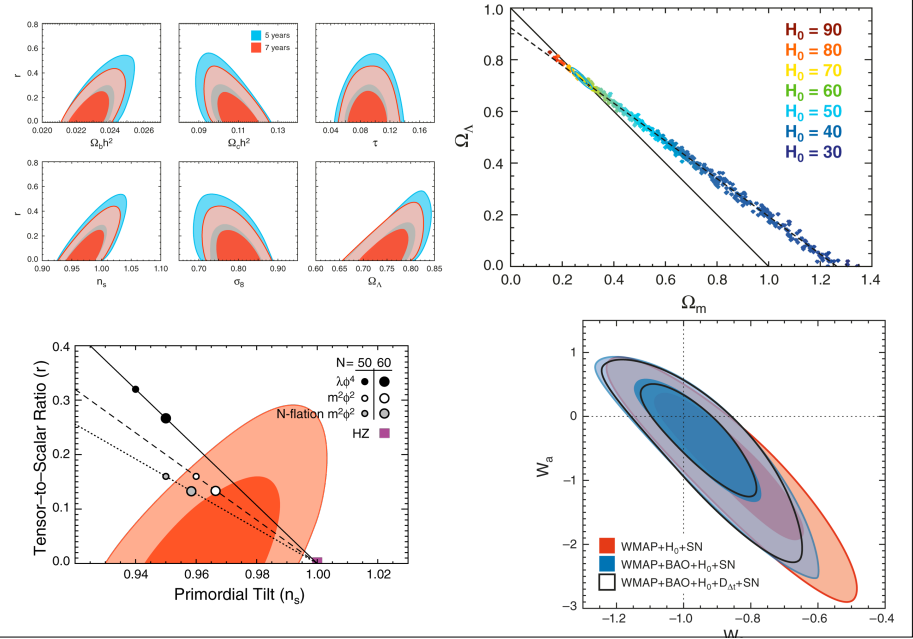


Parameter	Seven-year Fit	Five-year Fit
Fit parameters		
$10^2 \Omega_b h^2$	$2.258^{+0.057}_{-0.056}$	$2.273 \pm 0.062$
$\Omega_c h^2$	$0.1109 \pm 0.0056$	$0.1099 \pm 0.0062$
$\Omega_\Lambda$	$0.734 \pm 0.029$	$0.742 \pm 0.030$
$\Delta_c^2$	$(2.43 \pm 0.11) \times 10^{-9}$	$(2.41 \pm 0.11) \times 10^{-9}$
$n_s$	$0.963 \pm 0.014$	$0.963^{+0.014}_{-0.015}$
$\tau$	$0.088 \pm 0.015$	$0.087 \pm 0.017$
Derived parameters		
$t_0$	$13.75 \pm 0.13$ Gyr	$13.69 \pm 0.13$ Gyr
$H_0$	$71.0 \pm 2.5$ km s <sup>-1</sup> Mpc <sup>-1</sup>	$71.9^{+2.6}_{-2.7}$ km s <sup>-1</sup> Mpc <sup>-1</sup>
$\sigma_8$	$0.801 \pm 0.030$	$0.796 \pm 0.036$
$\Omega_b$	$0.0449 \pm 0.0028$	$0.0441 \pm 0.0030$
$\Omega_c$	$0.222 \pm 0.026$	$0.214 \pm 0.027$
$z_{eq}$	$3196^{+134}_{-133}$	$3176^{+151}_{-150}$
$z_{reion}$	$10.5 \pm 1.2$	$11.0 \pm 1.4$

Note. <sup>a</sup> Models fit to WMAP data only. See Komatsu et al. (2011) for additional constraints.

### WMAP 7 yrs Larson et al & Komatsu et al

### WMAP 7 yrs Larson et al & Komatsu et al.



### ACT Dunkley et al.

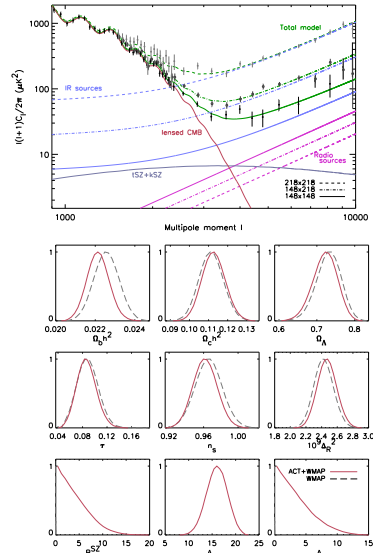


FIG. 6.— One-dimensional marginalized distributions for the 6  $\Lambda$ CDM parameters (top two rows) derived from the ACT+WMAP combination, compared to WMAP alone. The bottom row shows 3 secondary parameters from the ACT+WMAP data. With the addition of ACT data a model with  $n_s = 1$  is disfavored at the 3 $\sigma$  level.

### SPT Keisler et al.

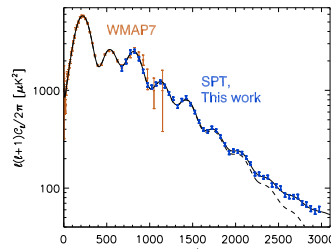


FIG. 5.— The SPT handpower, WMAP handpower, and best-fit  $\Lambda$ CDM theory spectrum shown with dashed (CMB) and solid (CMB+foreground) lines. The handpower errors do not include beam or calibration uncertainties.

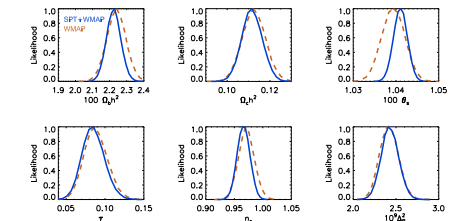


FIG. 6.— The one-dimensional marginalized constraints on the six cosmological parameters in the baseline model. The constraints from SPT+WMAP are shown by the blue solid lines, while the constraints from WMAP alone are shown by the orange dashed lines.

## Recombination

