Taking the Universe's Baby Picture



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Overview

Cosmology after WMAP: Standard Model
Last Two Years:

Improving Sensitivity and Resolution
ACT, SPT, and Planck

Looking to the Future: Advanced ACTPOL



13.7 billion years

What Have We Learned?



- Simple model fits a wide range of data (only 5 numbers)
- Age of universe: I3.7 Gyr
- Composition:
 - Atoms: 4%
 - Matter: 23%
 - Dark Energy: 73%
- Scale Invariant Fluctuations seed growth of galaxies
- First Stars formed ~200 Myr

From Baby Pictures to Today's Universe



Growth of Structure



SUCCESS OF STANDARD MODEL OF COSMOLOGY



Conclusion: A Simple Model

- Density of universe determines its fate + shape
- Universe is flat (total density = critical density)
 - Atoms 4%
 - Dark Matter 23%
 - Dark Energy (cosmological constant?) 72%
- Universe has tiny ripples

The pieces seem to fit....

- Supernova distanceNOBEL PRIZE 2011!
- Hubble Constant
- Age of Universe
- Cluster Properties
- Cosmic Abundances
- Gravitational Lensing
- Absorption Line
 Statistics





Models make predictions....



Atacama Cosmology Telescope











Planck



Consistent Picture of the CMB







Planck vs.ACT

ACT 148 GHz



Planck 143 GHz







-4

-8

-1

 $^{-1}$



LCDM Model Fits CMB



(Mostly) Consistent Parameters

		WMAP9+ACT	PLANCK+WP
Spectral Index	n	0.973 ± 0.011	0.9603±0.0073
Matter Density	10	I.146±0.044	1.199±0.027
Baryon Density	100	2.260±0.040	2.205±0.028
Hubble Constant	н	69.7±2.0	67.3±1.2

Shift relative to WMAP+SPT parameters larger

Parameter Concerns

- High matter density seems 2-3 σ higher than cluster and lensing estimates
- Low Hubble Constant deviates from most recent measurements
- High amplitude of density fluctuations



New physics or systematics in multiple data sets or systematics in Planck?







Planck Reconsidered

- Work with Renee Hlozek and Raphael Flauger
- Use publically available Planck data and likelihood codes
 - cross-season spectra
 - use 353 and 545 GHz for cleaning





Sensitivity to 217x217

	P -217x217	WMAP9+ACT	PLANCK+WP
Spectral Index	0.9743±0.0087	0.973 ± 0.011	0.9603±0.0073
Matter Density	1.149±0.028	I.146±0.044	1.199±0.027
Baryon Density	2.231±0.033	2.260±0.040	2.205±0.028
Hubble Constant	69.5±1.4	69.7±2.0	67.3±1.2

Allows Large Sky











Anisotropies to Polarization



ACTPol



Four deep fields D1,D2, D5, D6 Concentrate on night time obs (for first paper) 11 16 µK-arcmin sensitivity (T)

THE ATACAMA COSMOLOGY TELESCOPE: CMB POLARIZATION AT 200 $< \ell < 9000$

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TT

TE-

EE

ΤВ

EB.

BB-

Advanced ACTPol Survey:

20,000 square degrees, complete overlap with LSST



5 times Planck sensitivity5 times Planck resolution





AdvACT: Cosmological Forecasts



Constraining structure formation





Exploiting Cross correlations



State of Cosmology

- Successful model (but possible deviations?)
- Big open questions
 - Why is the universe accelerating today?
 - Why did the universe accelerate in the past?
 - What is the dark matter?

Next CMB Observational Steps

- 5 season Planck data (End of month!)
- South Pole Telescope Polarization Data
- ACT Polarization Data
- •Polar Bear Polarization Data
- BICEP3 and Keck Array
- SPIDER balloon flight (In Flight!)

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DOES IT FIT? WE WILL KNOW MORE SOON