

Wilkinson Microwave Anisotropy Probe

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Introduction

■ Time

→ Proposed in 1995 and Launched on June 30, 2001

■ Work

→ Make a map of the temperature fluctuations of the CMB radiation

■ Differential experiment

→ WMAP measures the temperature difference between two points in the sky.

Reasons

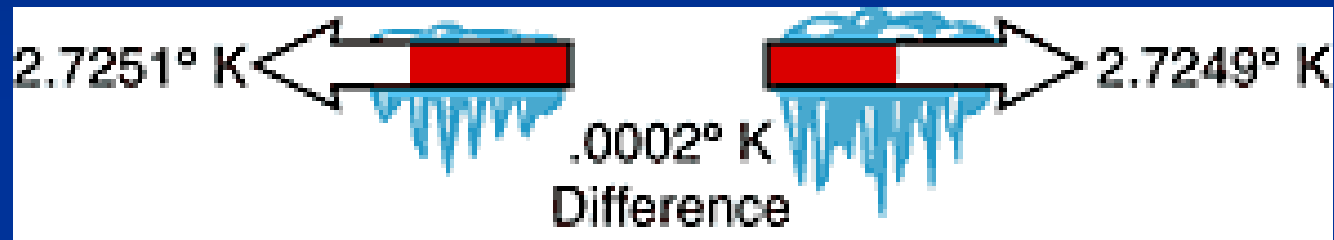
■ Predictions of Inflation

- The Universe is flat.
- The spectral index ~ 1 . (but less)
- The initial perturbation is adiabatic.
- The distribution of initial perturbation is Gaussian.
- The initial perturbation including scalar and tensor parts.

All above can be proved by
CMB measurement

Reasons

■ Anisotropy result of COBE



■ To know the early universe

→ fluctuations are related to fluctuations in the density of matter in the early universe and thus carry information about the initial conditions for the formation of cosmic structures

Instrument

- **Range** ($\sim 141^\circ$)
- **Temperature sensitivity**
→ $35 \mu\text{K}/(0.3^\circ)^2$
- **Angular resolution**
→ $<0.23^\circ \sim 0.93^\circ$
- **Frequency bands**
→ 94 GHz \sim 22 GHz

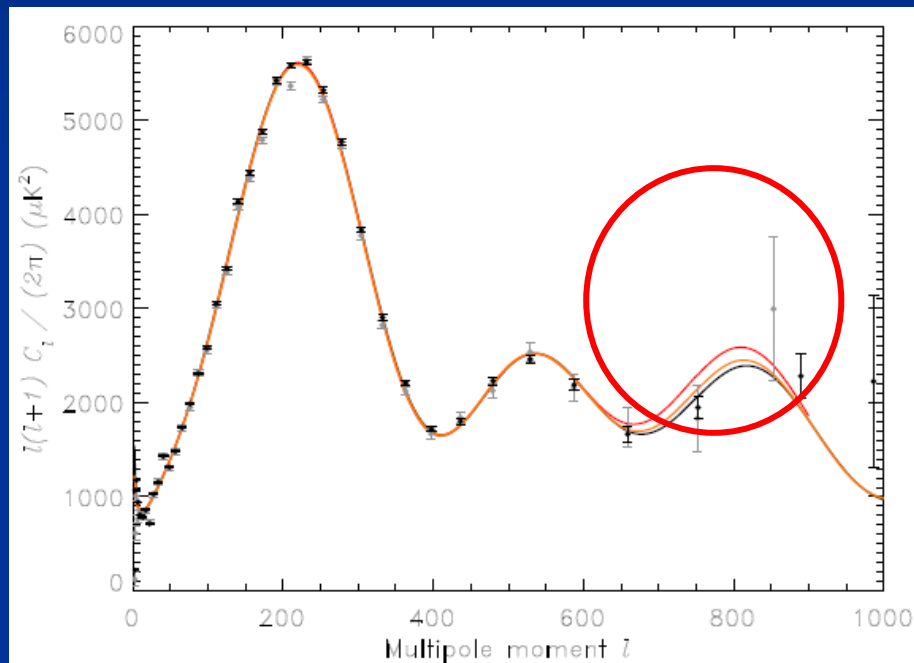
WMAP Frequency Bands					
Microwave Band	K	Ka	Q	V	W
Frequency (GHz)	22	30	40	60	90
Wavelength (mm)	13.6	10.0	7.5	5.0	3.3

Goals

- **Size**
- **Age**
- **Matter content**
- **Geometry**
- **Fate**

Results

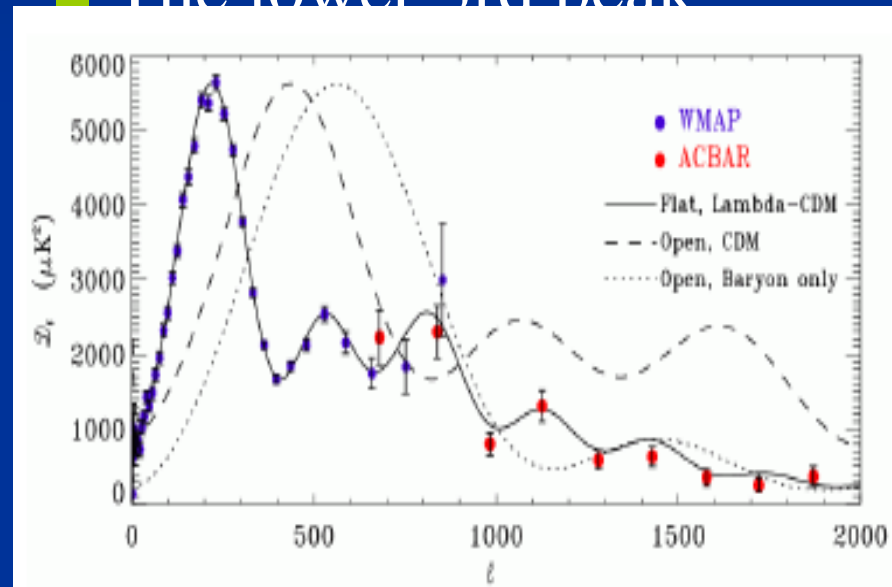
■ Angular power spectrum



Λ CDM model is good to fit
WMAP data

WMAP Three Year Results: Implications for Cosmology

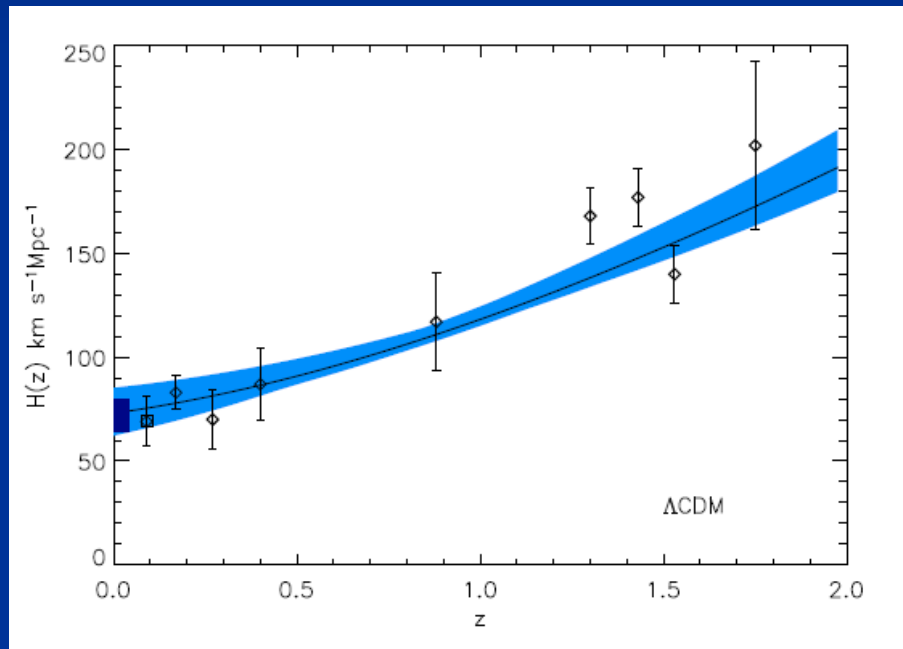
■ The lower 3rd peak



■ Implies less structure
growth at late times

Results

■ Age of the Universe



■ Best fit value for H_0

$$\rightarrow H_0 = 73.4^{+2.8}_{-3.8} \text{ km / s / Mpc}$$

$$H_0 = 72 \pm 8 \text{ km / s / Mpc} \quad \text{HST}$$

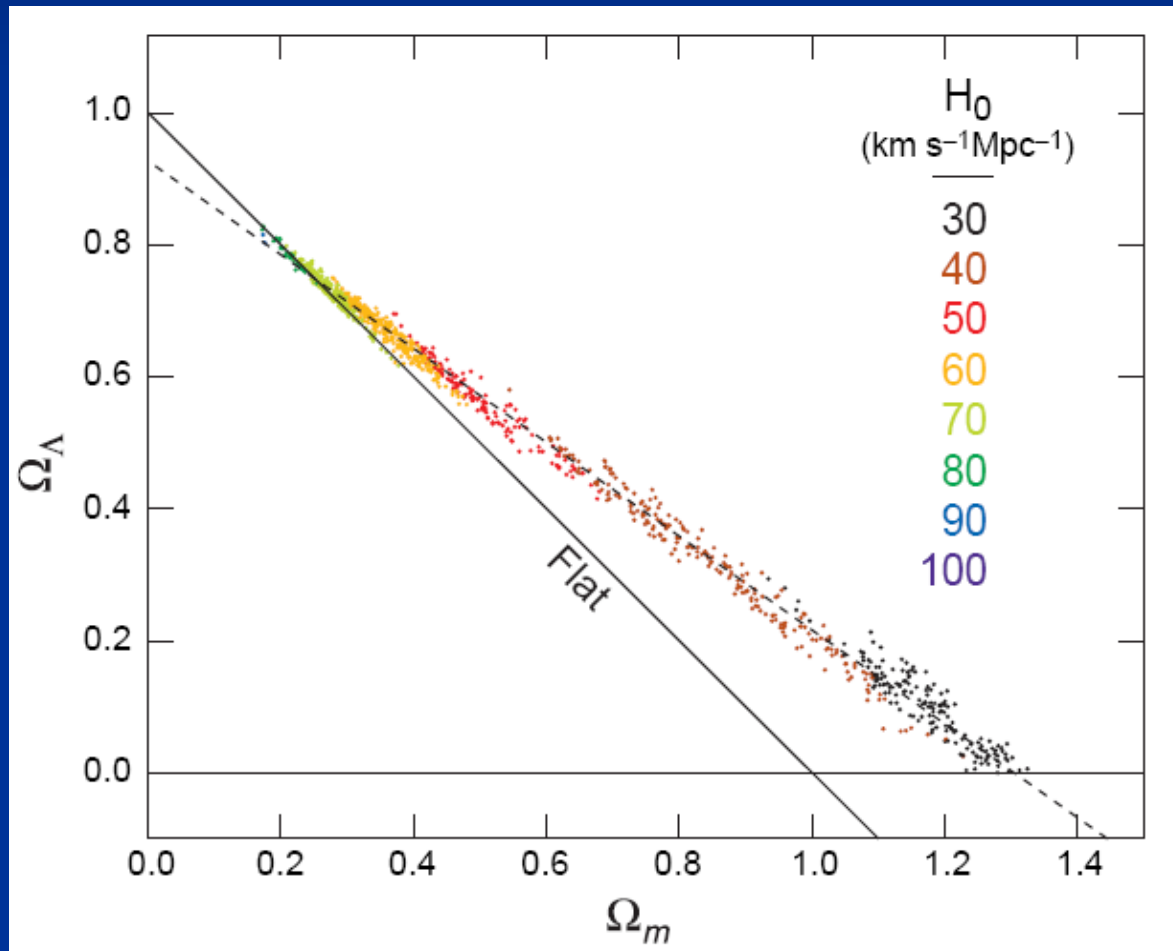
$$H_0 = 75^{+7}_{-6} \text{ km / s / Mpc} \quad \text{B1608+656}$$

■ Best fit value for “Age”

$$\rightarrow t_0 = 13.73^{+0.13}_{-0.17} \text{ Gyr}$$

Results

■ Geometry



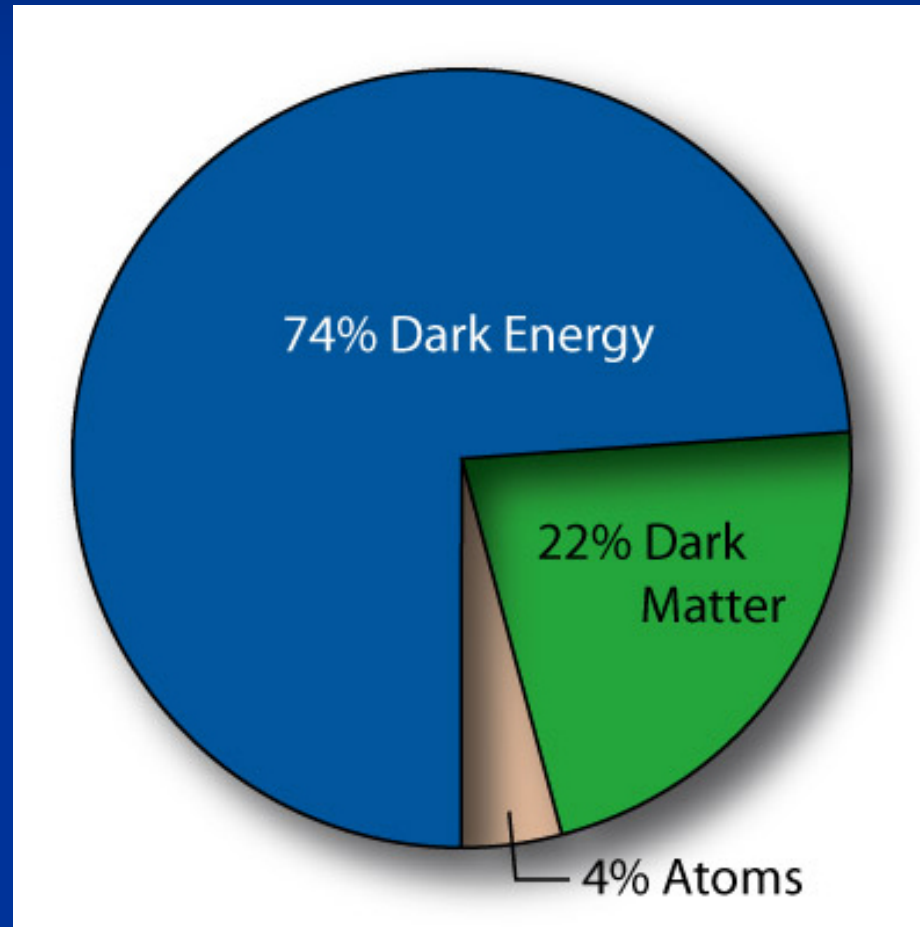
- Without the constraint that

$$\Omega_m + \Omega_\Lambda = 1$$

$$\Omega_K = -0.3040 + 0.4067\Omega_\Lambda$$

Results

■ Contents



WMAP Three Year Results: Implications for Cosmology

Conclusion

- The WMAP data are consistent with nearly flat universe in which the dark energy has equation of state, $w=-1$.
- The combination of WMAP data with measurement of H_0 , baryon oscillations, supernova data and large scale structure observation all reinforces the evidence for dark energy.
- The running spectral index is better for WMAP data.

**Thank you for
attention ~**