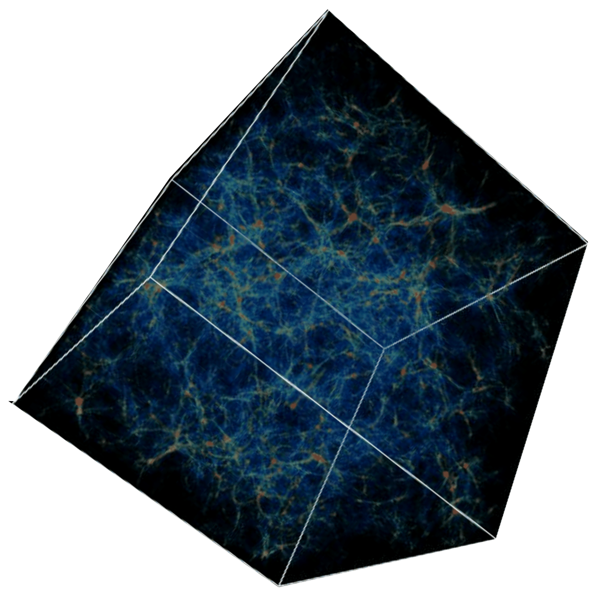
Our Universe

Observables?

We have discussed the role the different parameters in the Friedmann equation may play, especially how different contributions to the energy density and the curvature affect the evolution of the scale factor.

We have also seen how these parameters can be linked to "observables" like the Hubble constant and the deceleration parameter.

The obvious question now is: What kind of Universe do we <u>really</u> live in?

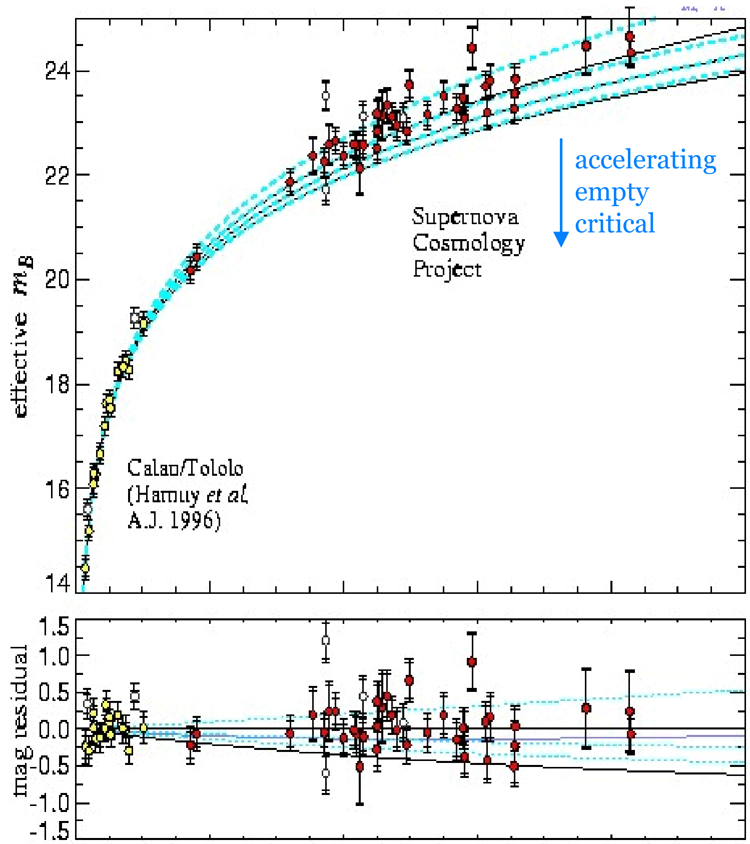


1st clue: Supernovae

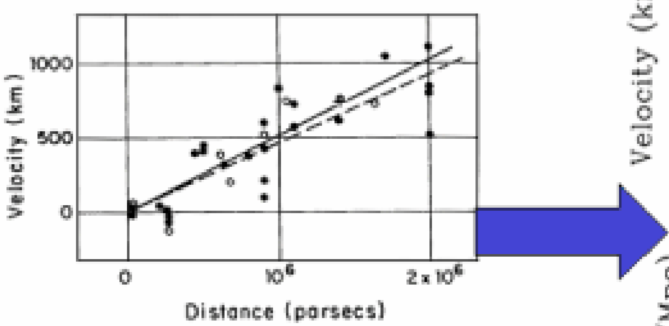
Type Ia supernovae :
Absolute luminosity depends on decay time, they are "standard candles”.

Compare;
– apparent magnitude (a measure of distance)
– redshift (recession velocity).

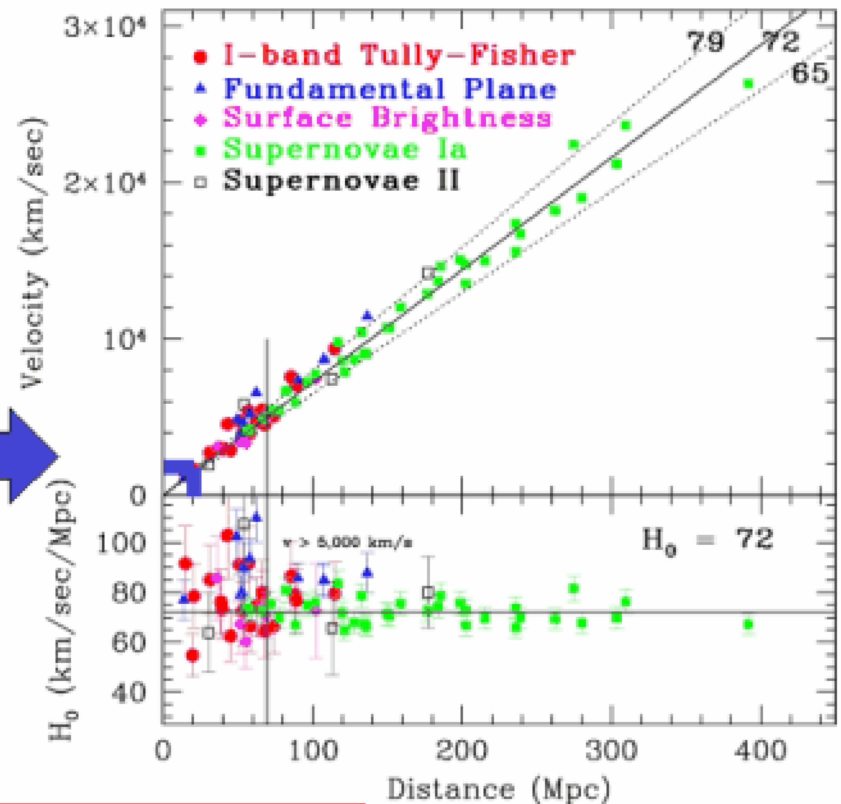
Different cosmologies leads to different curves.



2nd clue: Hubble constant



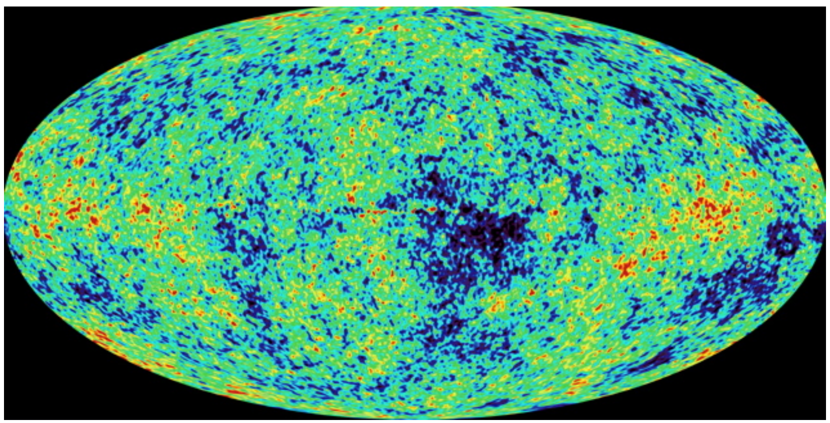
1st tick mark

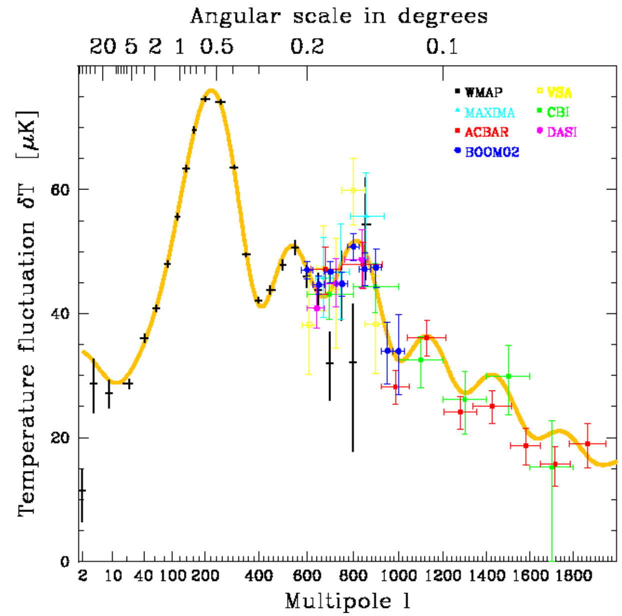


Current value:
$H_0 = 71 \pm 6$ km s^{-1} Mpc^{-1} $\rightarrow t_0 = 1.3 \times 10^{10}$ yr

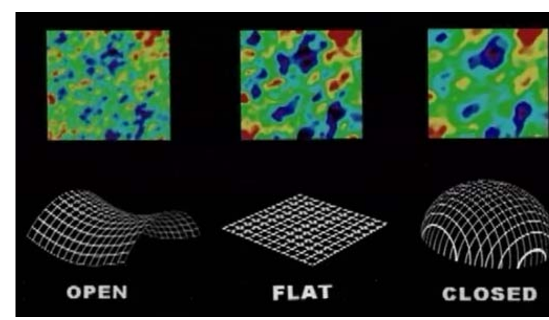
3rd clue: WMAP

Wilkinson Microwave Anisotropy Probe provided a detailed full-sky map of the oldest light in Universe.
It is a picture of the 380,000 yr old Universe.





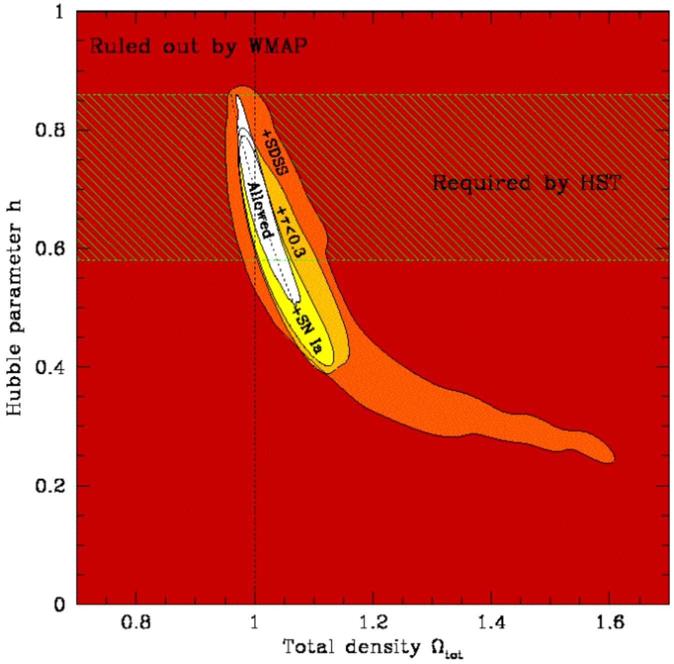
Temperature fluctuations over angular scales in the microwave background correspond to variations in matter/radiation density imprinted at "last scattering".



Scale of fluctuation indicate whether Universe is open, flat or closed.

4th clue: SDSS

Considering also the results of the Sloan Digital Sky Survey the evidence strongly favours a flat Universe, Ω=1.



Concordance model

The data leads to what is known as the "concordance model".

$\Omega_{tot} = 1.0$
$\Omega_{\Lambda} = 0.7$
$\Omega_m = 0.3$
$\Omega_b = 0.02$
$H_0 = 72\ km\ s^{-1}\ Mpc^{-1}$
$k=0,\ \Lambda>0$

This means that our Universe;

– expands monotonically
– approaches the de Sitter model at late times (when the cosmological constant dominates)
– decelerated at early times, but will accelerate at late times
– will end in a "Big Chill"

What may change?

Since we have no real idea what dark energy actually is, one may want to consider alternative models. Various proposed scenarios concern;

Violating the Copernican principle. If the Milky Way were located in an underdense region of the Universe observations may be explained without the need for dark energy. However, this would violate one of the main assumptions in cosmology.

Dark energy not vacuum energy? The value predicted for the vacuum energy is orders of magnitude larger than observations allow. This is a central problem for theoretical physics (quantum vs gravity).

Modifying gravity. Maybe we need to look beyond general relativity for an explanation? Many models involve extra dimensions (e.g. brane theory).

The multiverse. The key idea is that life would only be possible in a Universe very similar to ours. Probability theory predicts an infinite number of Universes in which Λ takes all possible values (string theory?).