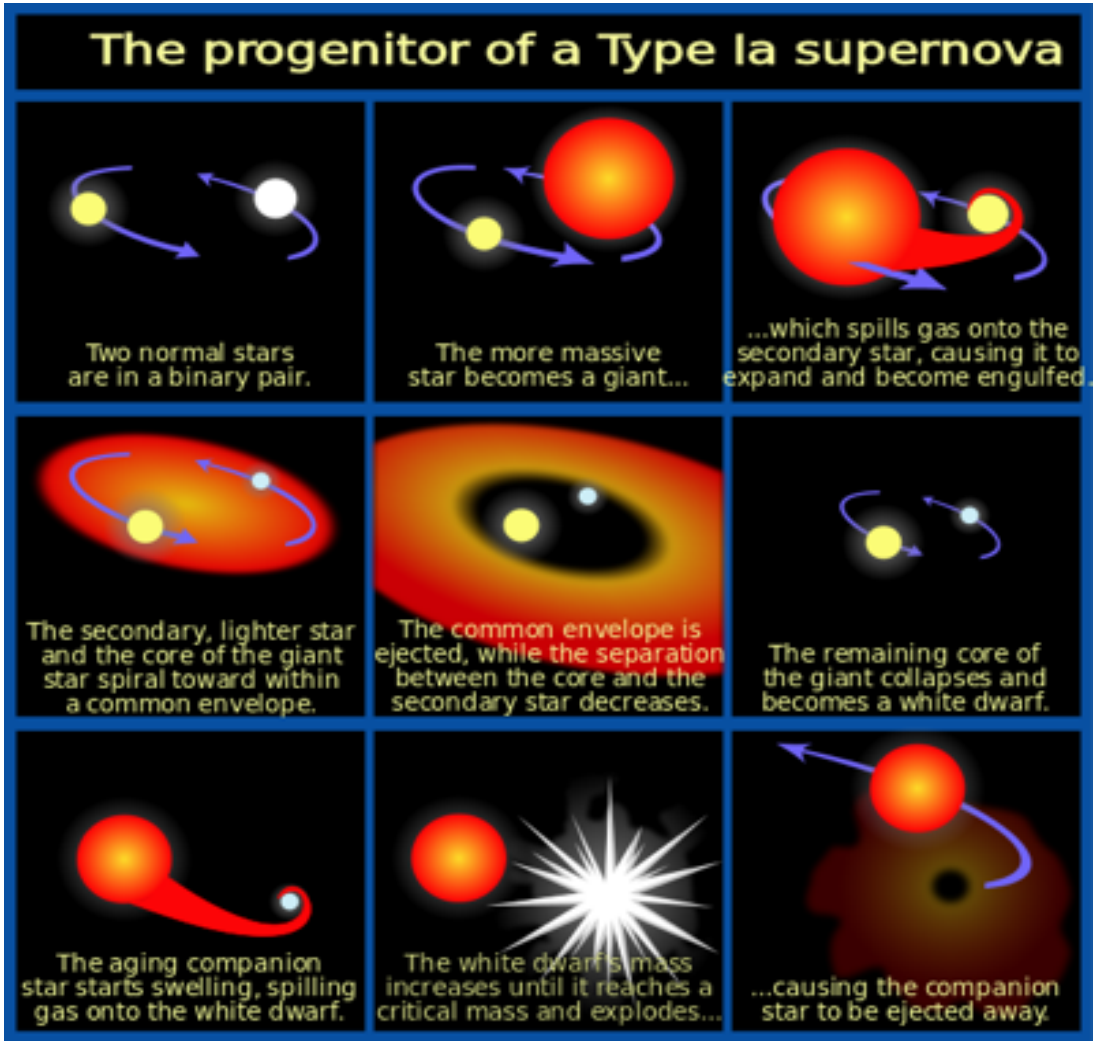
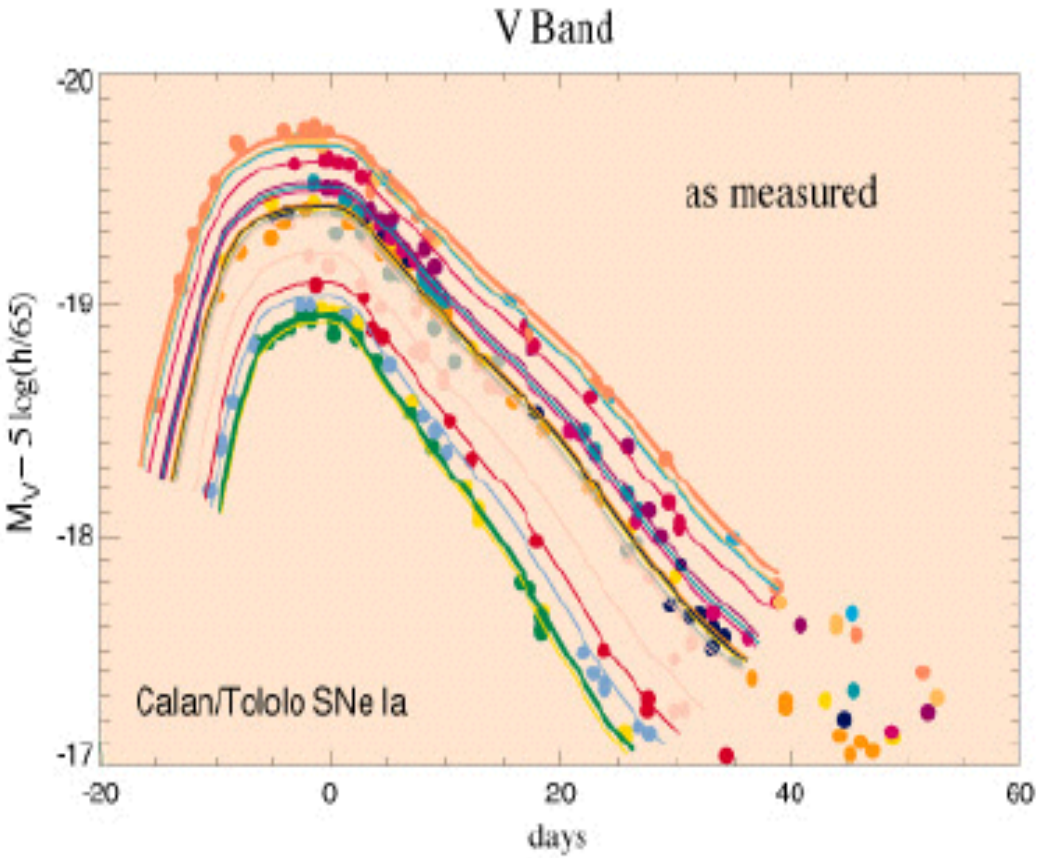
The ultimate standard candles for large luminosity distances: Supernovae type Ia



Low Redshift Type Ia Template Lightcurves

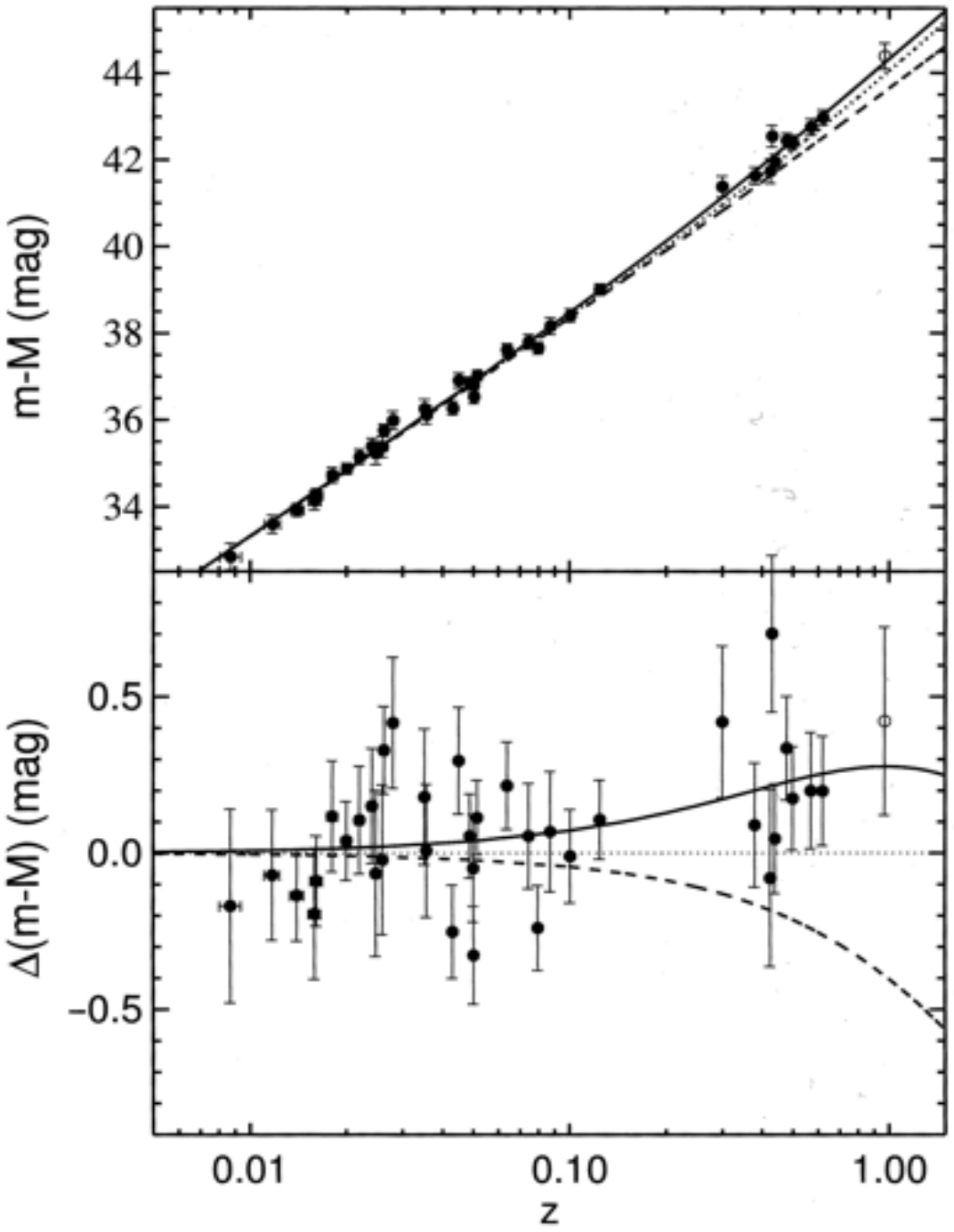


Why they are good Standard Candles:

Empirical Relation:

Peak Luminosity-inversely proportional to decay timescale of brightness

- well calibrated locally where luminosity can be determined by other methods



Top:**Hubble diagram with Supernovae type Ia:**

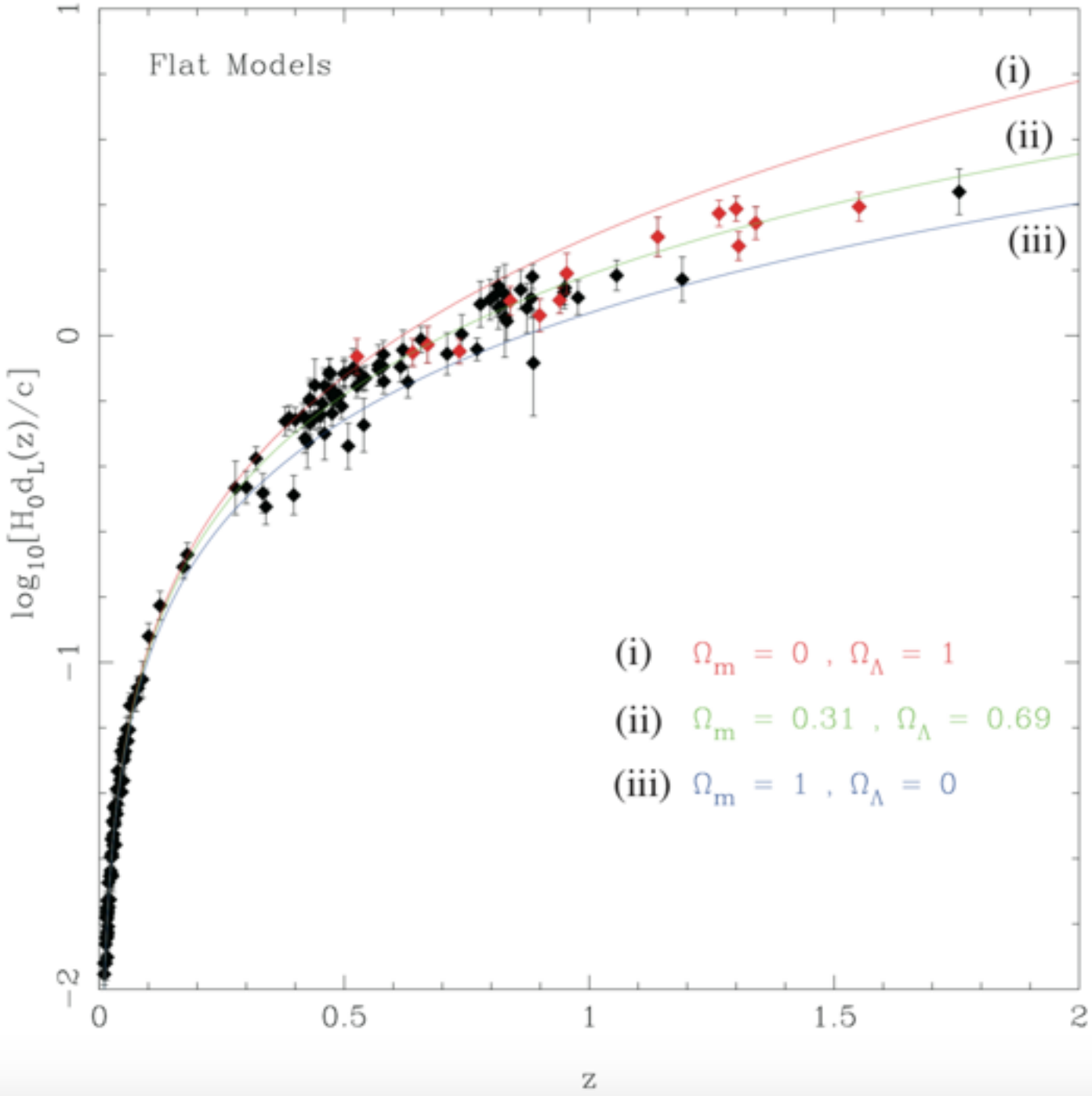
Distance modulus m – M = $5\log(d_L/10pc)$

-uses “astronomer” units rather than “physicist” units (eg Mpc)

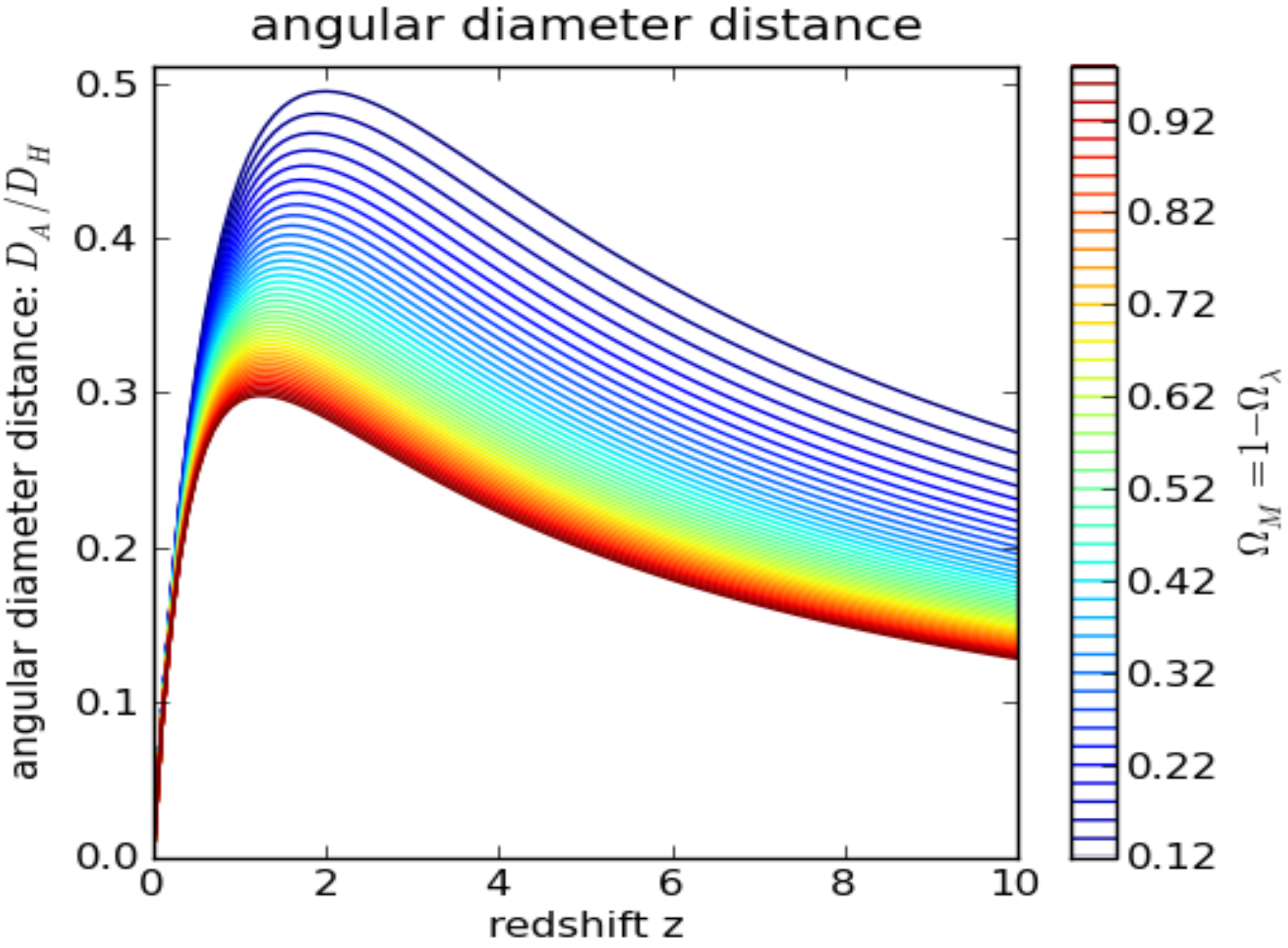
Points= observations
Curves= fits with different cosmological models (best fit = LCDM model)

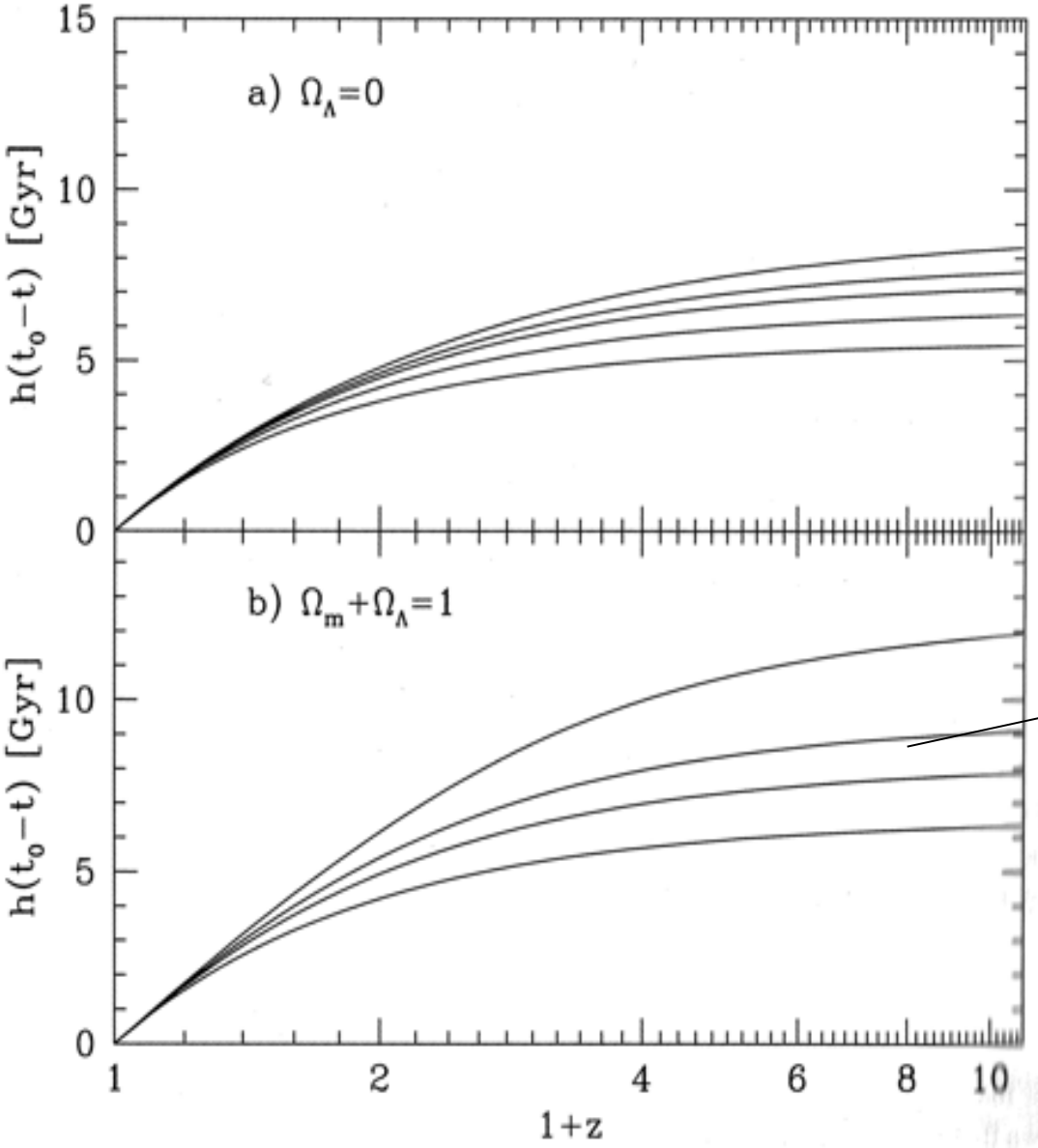
Bottom: residuals of data points from fits

Solid line shows Accepted model (LCDM): $Omega_M$= 0.27, $Omega_{Lambda}$ = 0.73


Flat Models
(i)
(ii)
(iii)
(i) $\Omega_m = 0$, $\Omega_\Lambda = 1$
(ii) $\Omega_m = 0.31$, $\Omega_\Lambda = 0.69$
(iii) $\Omega_m = 1$, $\Omega_\Lambda = 0$
$\log_{10}[H_0 d_L(z)/c]$
z
1
0
−1
−2
0
0.5
1
1.5
2

Angular diameter distance for flat cosmological models with different combinations of $Omega_M$ and $Omega_{Lambda}$





Lookback time vs. Redshift for different cosmological models

In both plots from top to bottom we have increasing contribution of Omega_m

Accepted model (LCDM): $Omega_M$~ 0.3, $Omega_{Lambda}$ ~ 0.7

Note age of the Universe (=asymptotic limit of curves) increases for increasing $Omega_{Lambda}$

Dependence on "h" (uncertainty in Hubble constant), which is measured to be ~ 0.7 (~0.68 from Planck 2015 results)