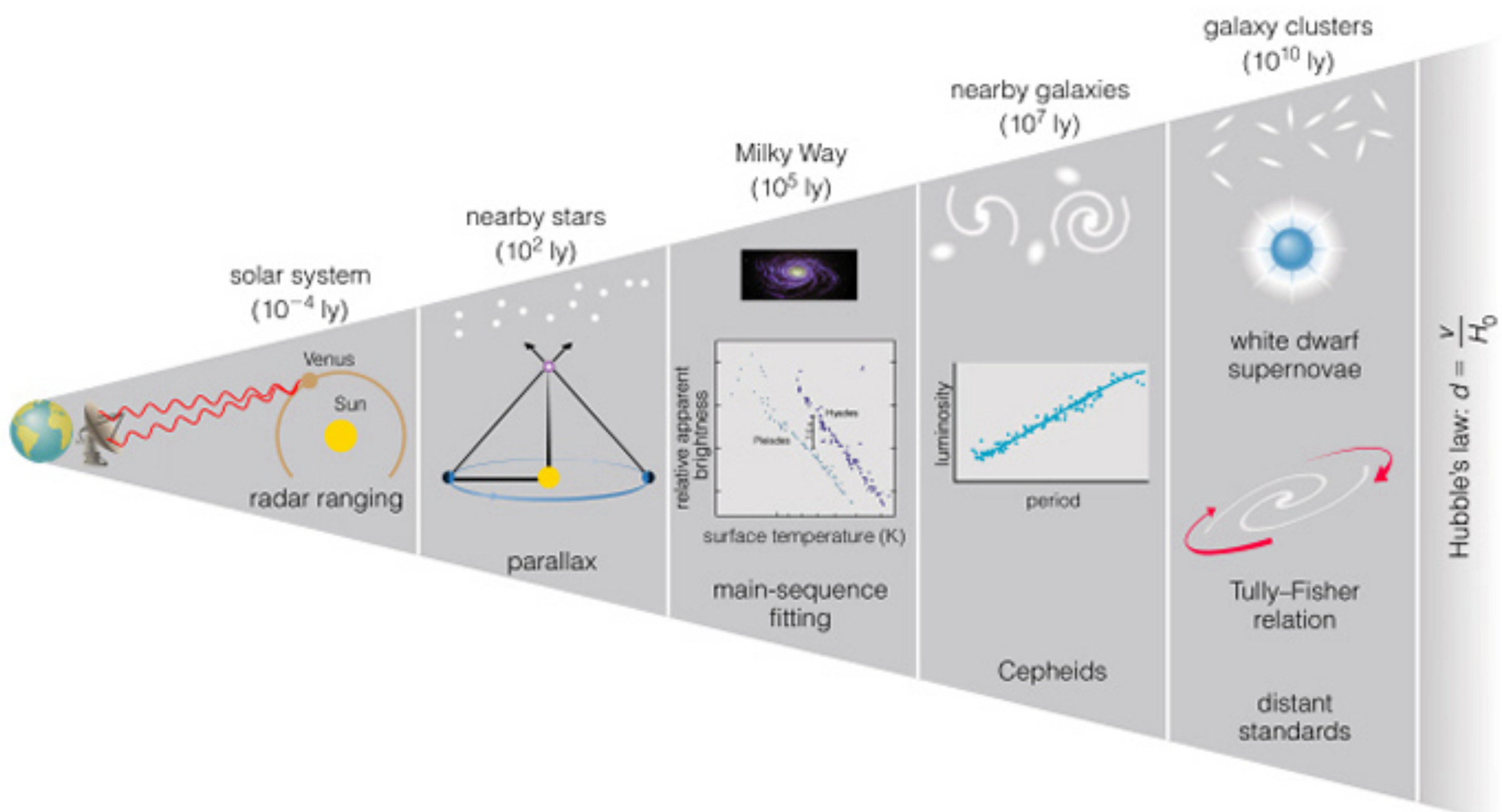
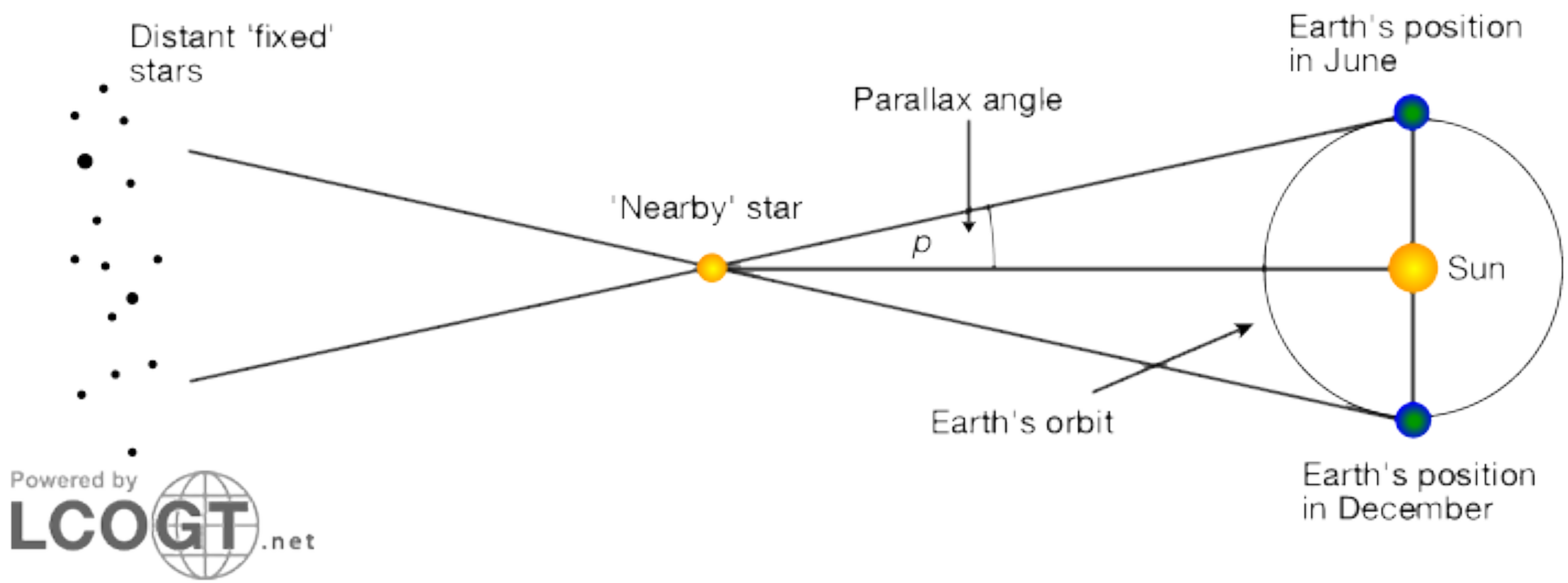
Cosmic Distance Ladder

= succession of methods by which astronomers determine the distance to celestial objects



Parallax



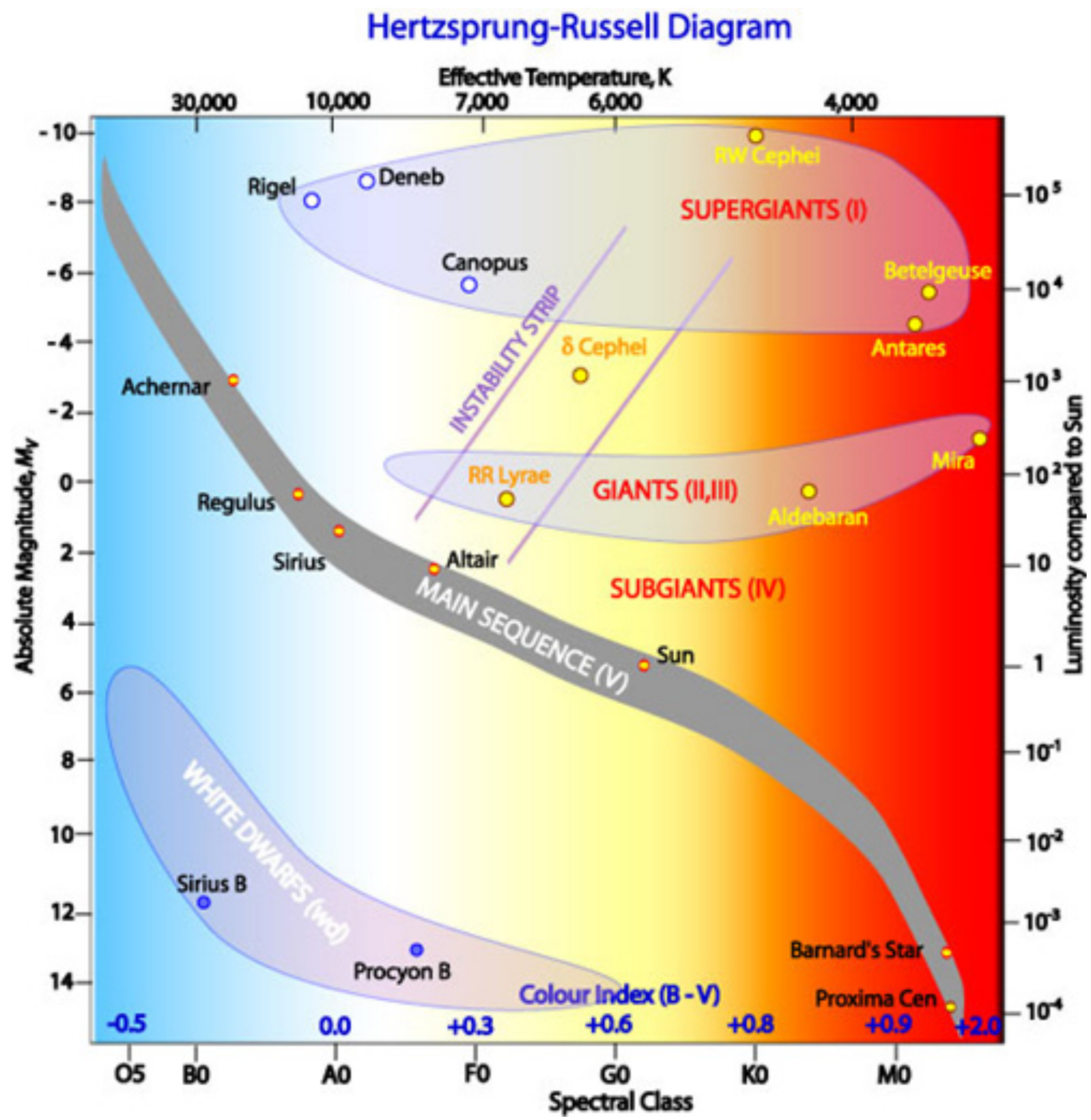
Def. Parsec: $\frac{1\,\mathrm{Au}}{1\,\mathrm{pc}} = 1'' = 1\,\mathrm{arcsec}$

$$1\,\mathrm{pc} = 3.26\,\mathrm{lyr}$$
$$= 3.09 \cdot 10^{16}\,\mathrm{m}$$

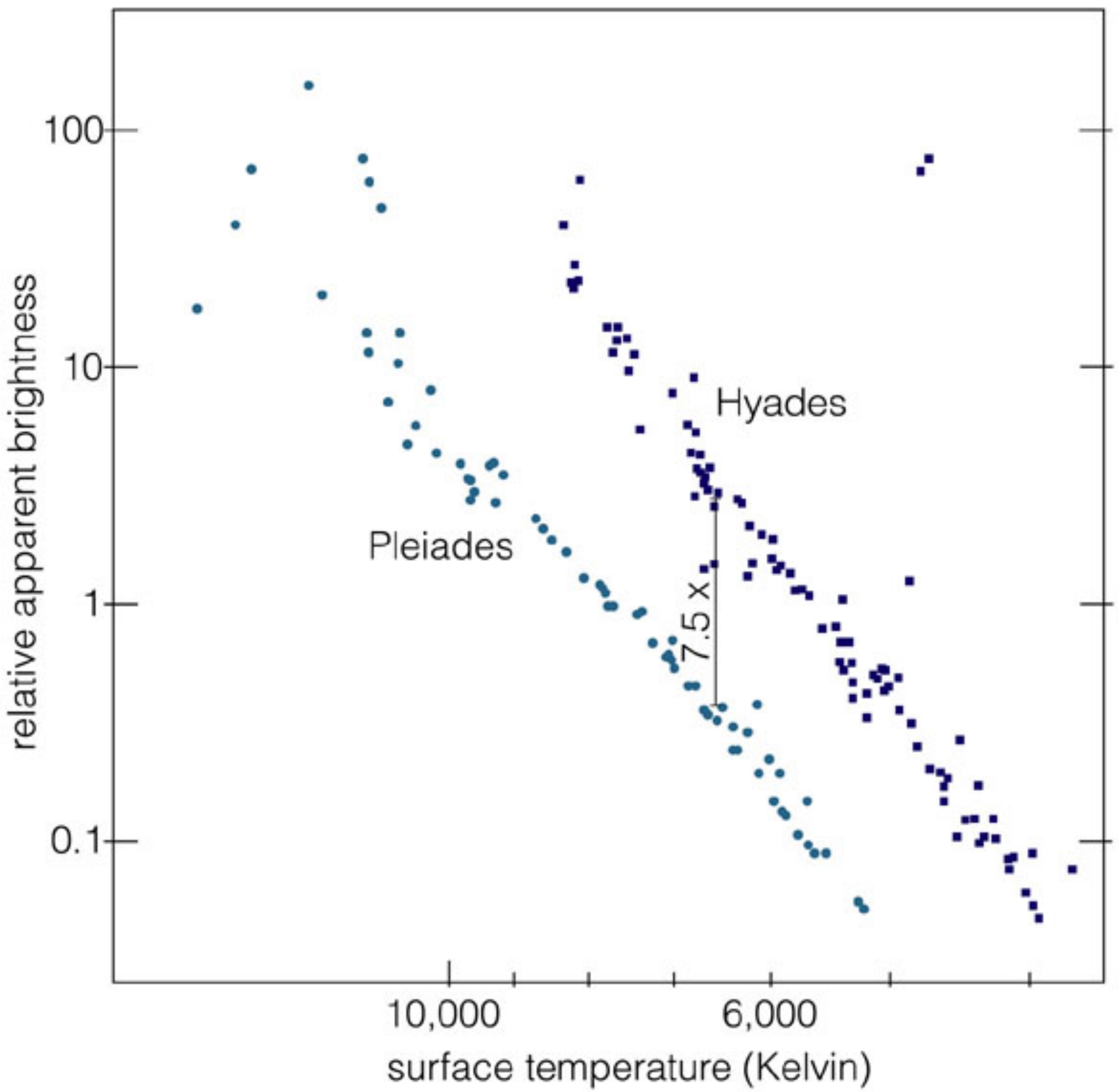
With the Hubble telescope: Can reach up to 5000 parsec.

Hertzsprung-Russell diagram

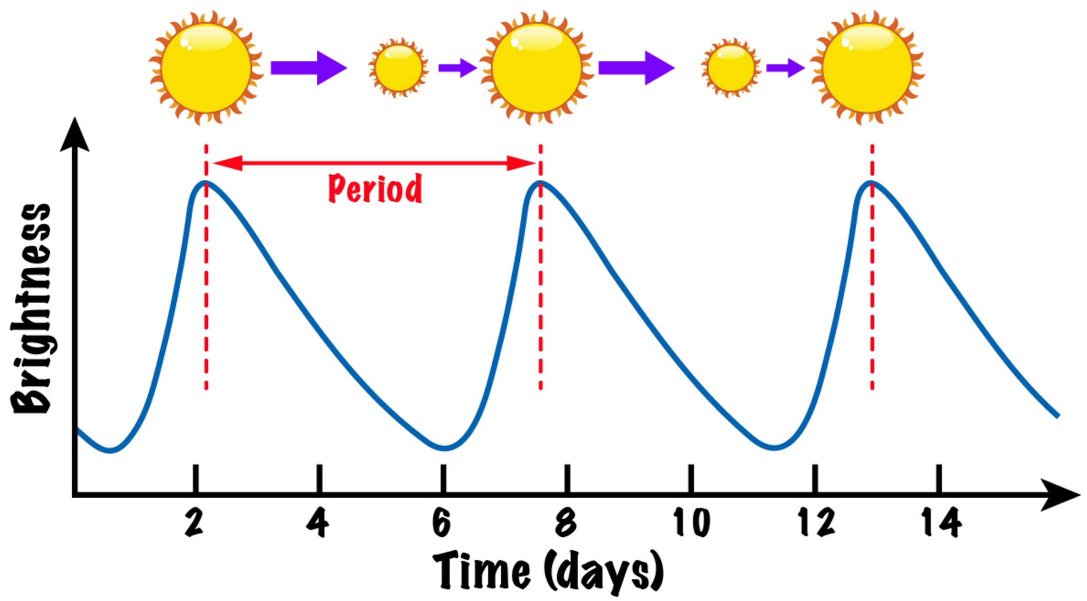
„Main sequence stars“ have a known relation between temperature (spectral class) and luminosity!

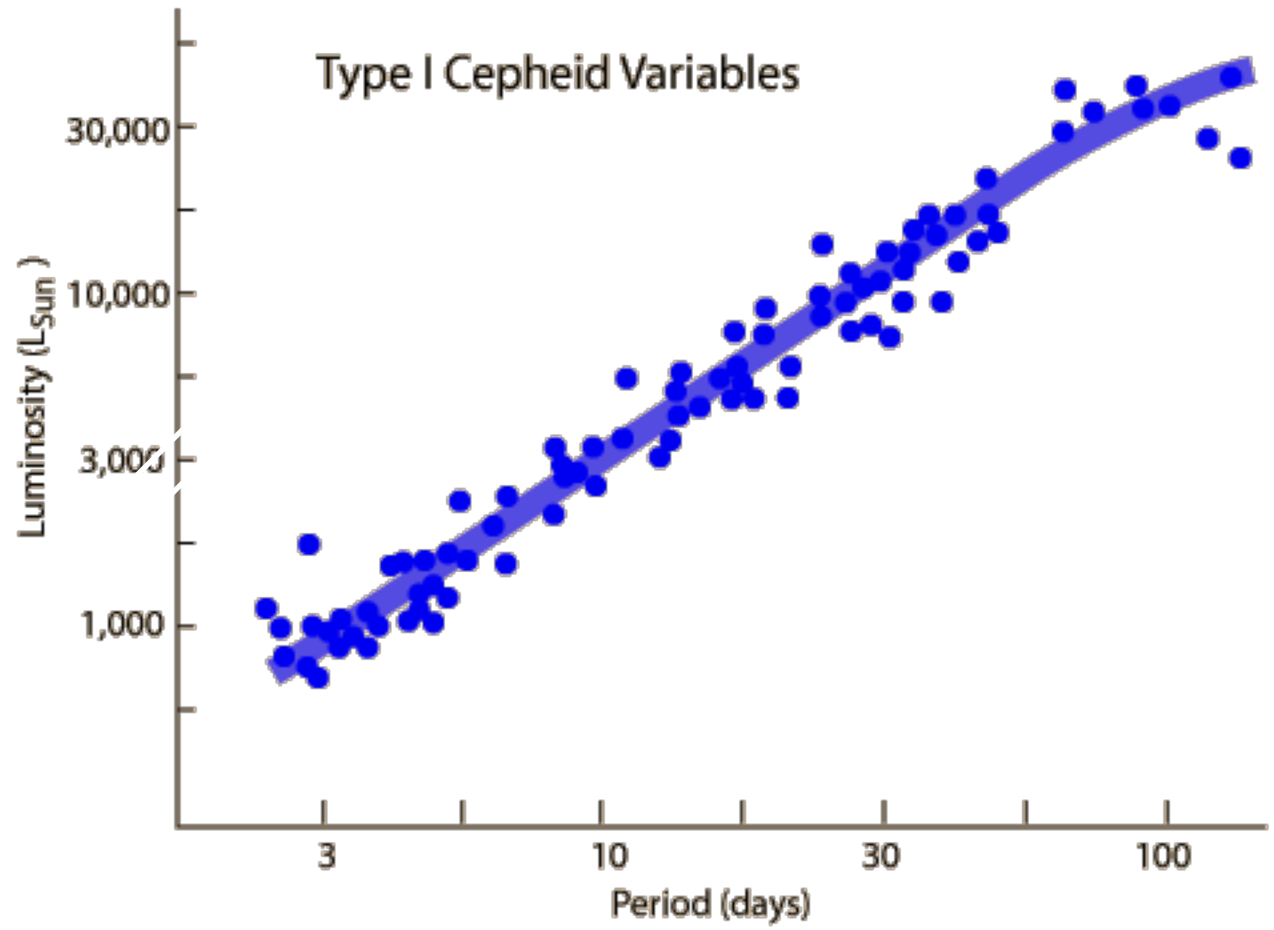


Main sequence fitting



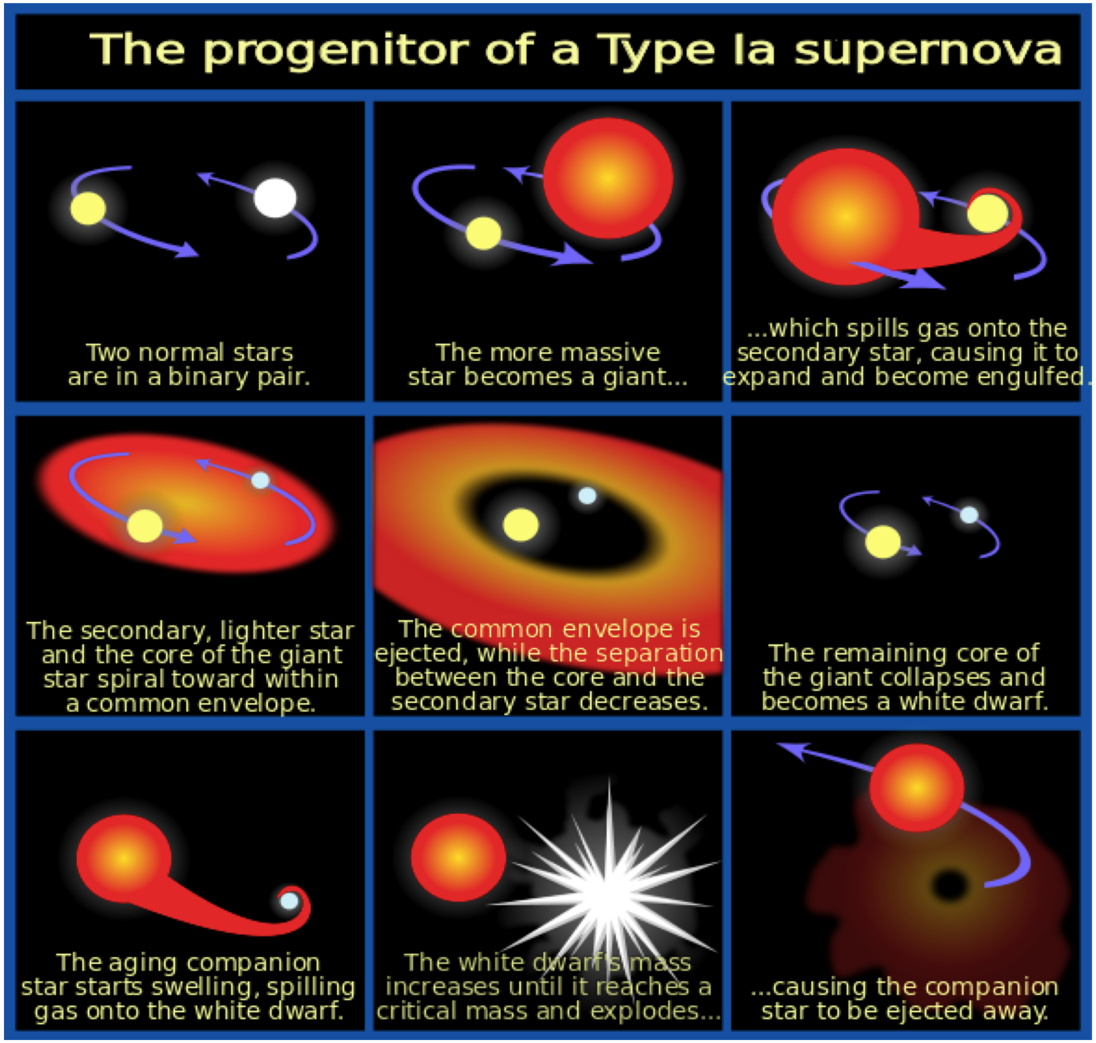
Cepheids = periodically pulsating stars



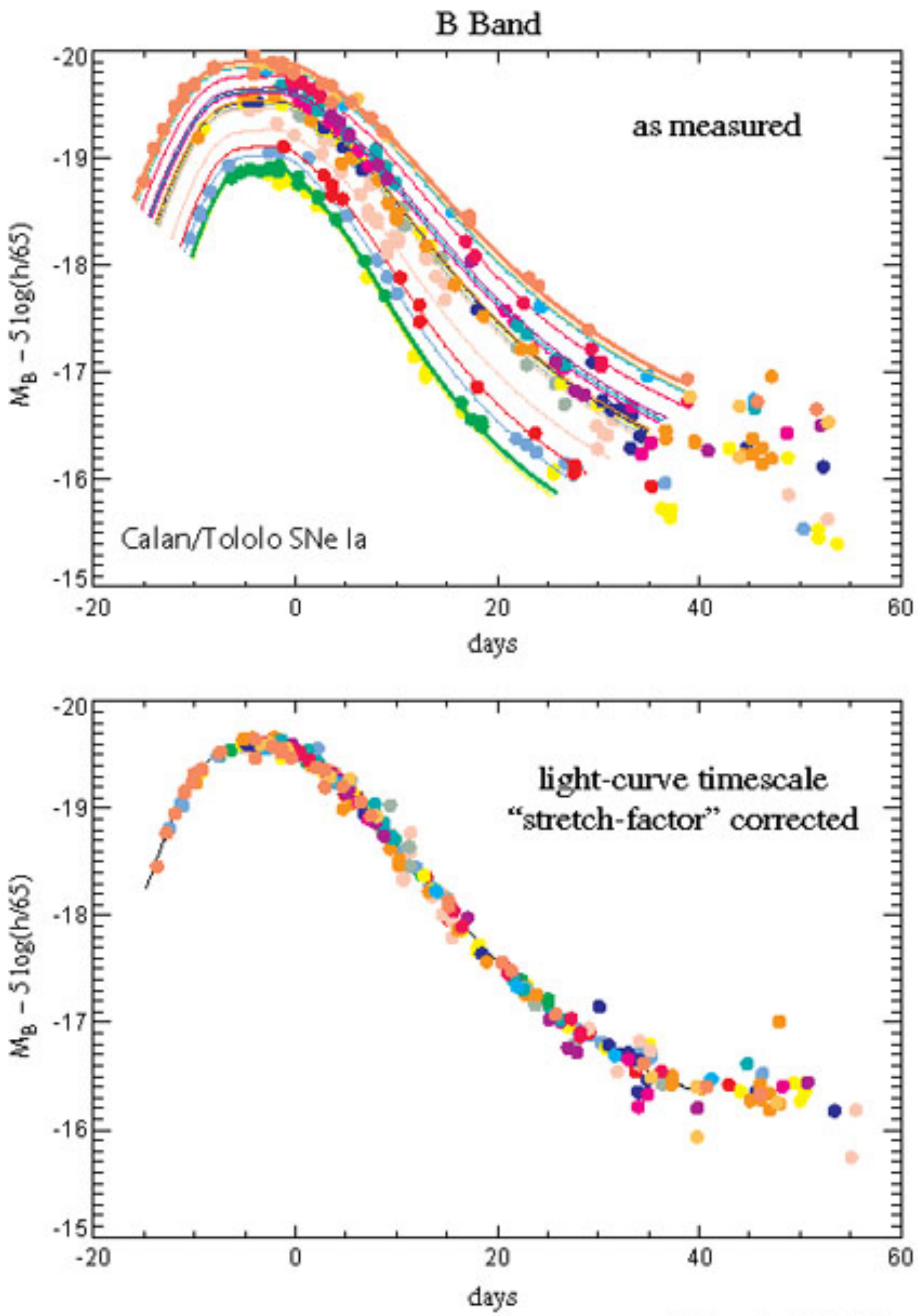


Known luminosity (when period is measured) → **Standard candle**

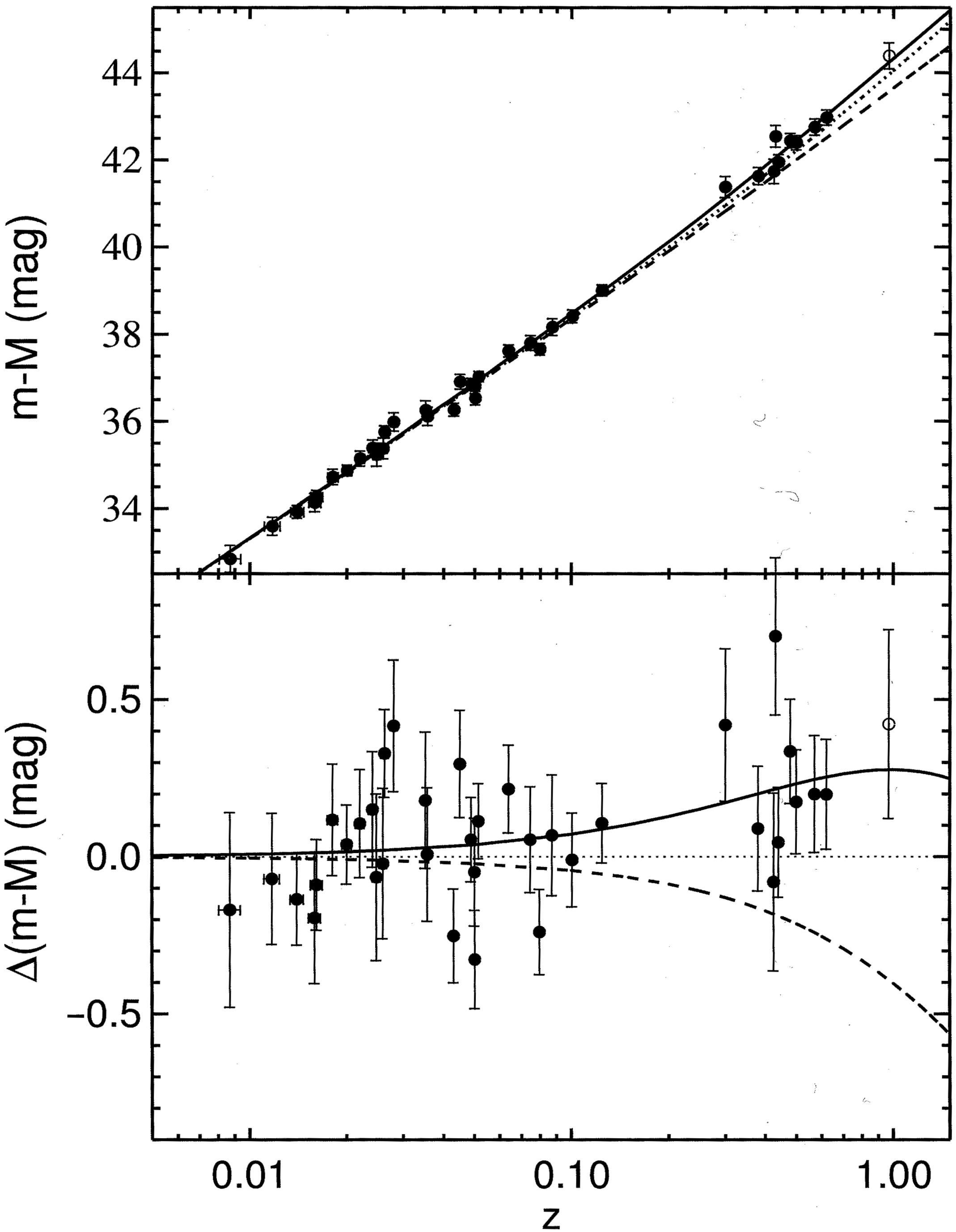
The ultimate standard candles for large luminosity distances: Supernovae type Ia



Supernovae of Type Ia



Kim, *et al.* (1997)



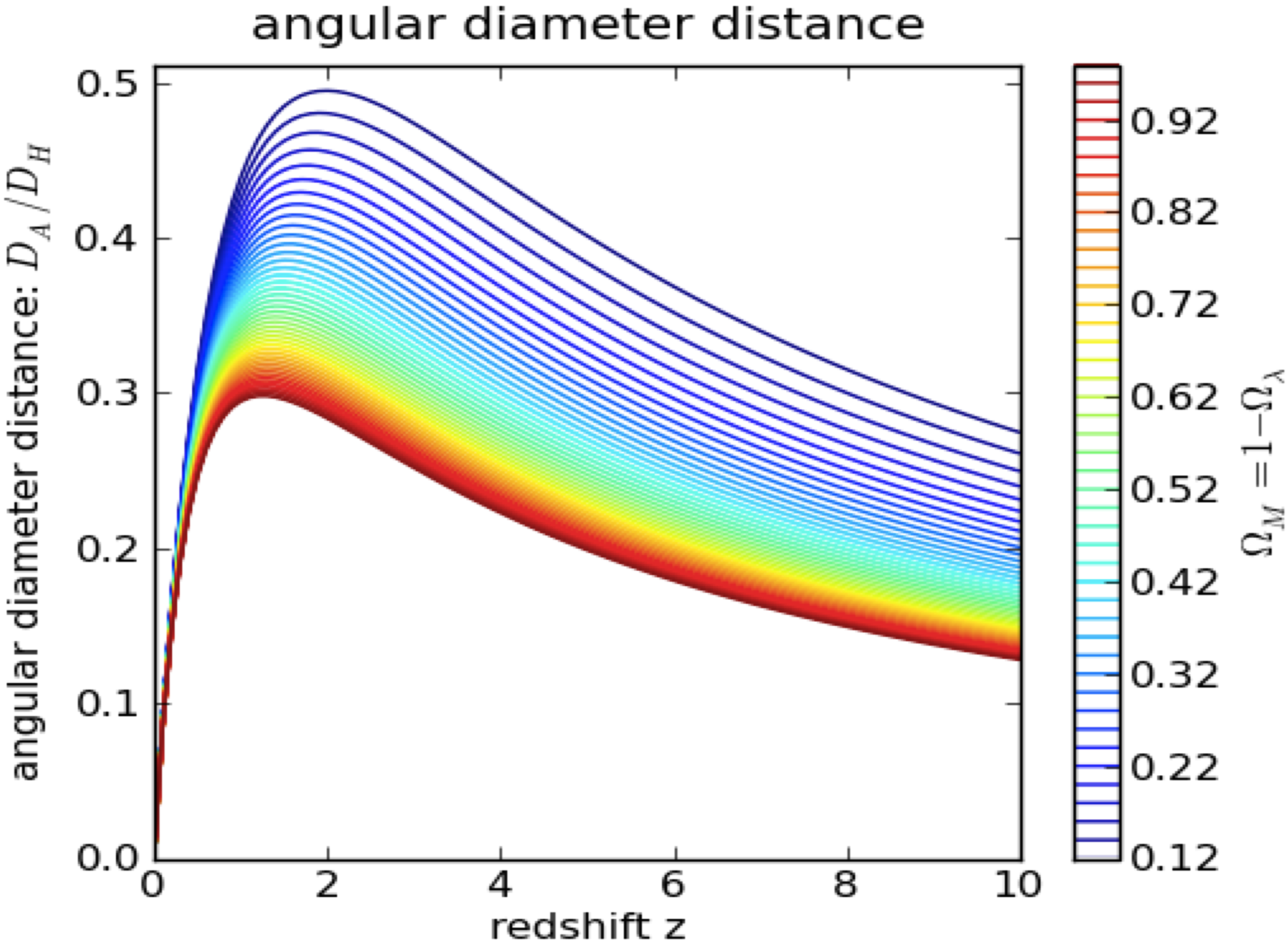
Top:**Hubble diagram with Supernovae type Ia:**

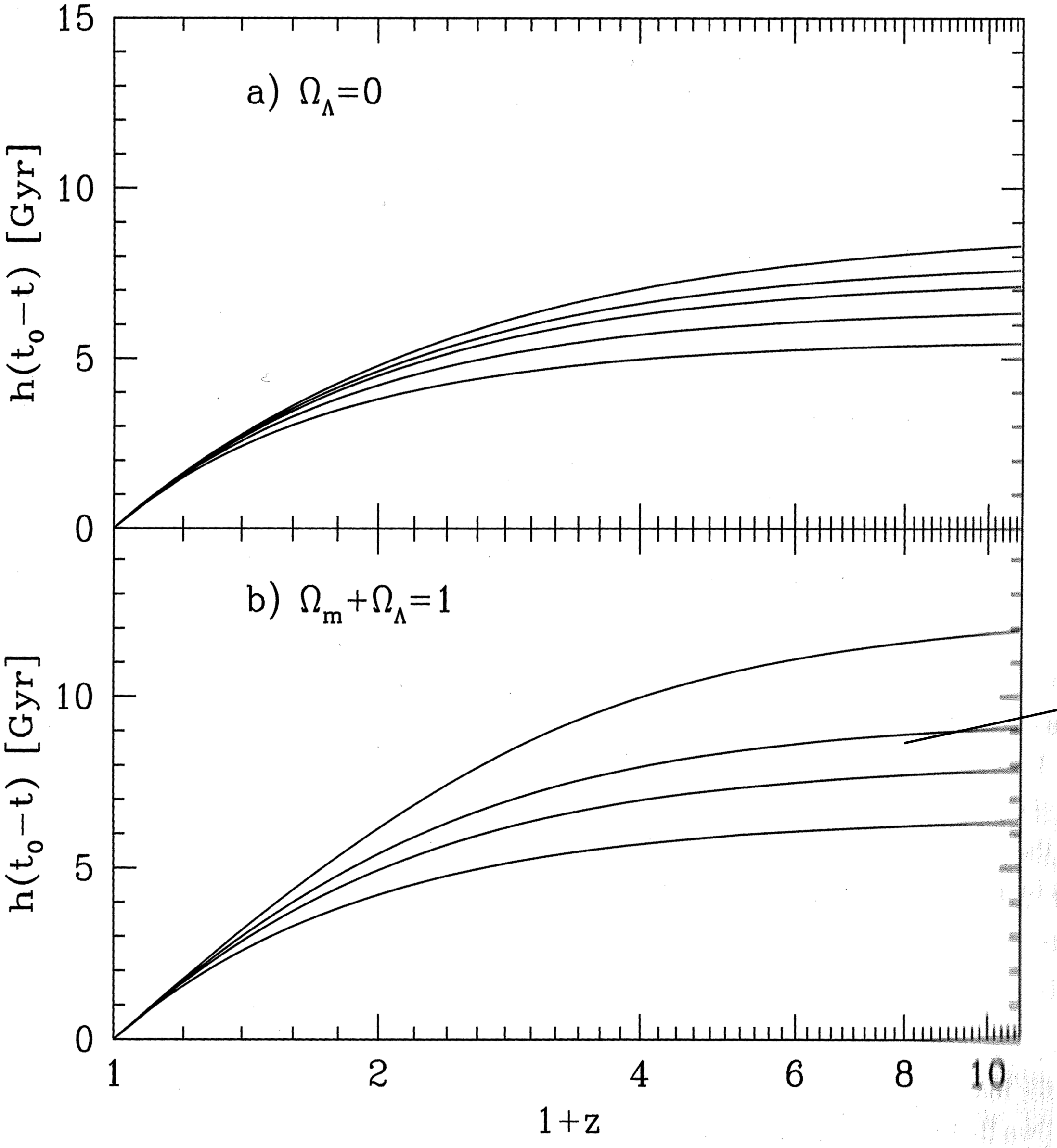
Distance modulus m – M = 5log(d_L/10pc)
-uses “astronomer” units rather than “physicist” units (eg Mpc)

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_ = 0.27,
Omega_Lambda = 0.73


angular diameter distance
angular diameter distance: D_A / D_H
redshift z
$\Omega_M = 1 - \Omega_\lambda$
0.0
0.1
0.2
0.3
0.4
0.5
0
2
4
6
8
10
0.12
0.22
0.32
0.42
0.52
0.62
0.72
0.82
0.92



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_ ~ 0.3,
Omega_Lambda ~ 0.7

Note age of the Universe (=asymptotic limit of curves) increases for increasing Omega_Lambda

Depends also on "h", which Is measured to be ~ 0.7