

Today: *Magnitude Terminology*
Photometry Applications

Reading: 10

Magnitude Terminology

***Instrumental Magnitude:** measured with a particular telescope+detector combination with respect to arbitrary zero point and uncorrected for the atmospheric conditions; physically meaningless.*

***Differential Magnitude:** difference between instrumental magnitudes of two stars in the same image; corrects for instrumental response and atmospheric conditions; gives a true measure of relative brightness.*

***Calibrated Magnitude:** physically meaningful brightness of a star calibrated relative to the known flux standard (e.g. Vega); typically obtained by calculating differential magnitude w.r.t. a known standard star.*

Magnitude Terminology

Apparent Magnitude: the same as calibrated magnitude; measures the observed brightness of a star

Absolute Magnitude: calibrated magnitude of star as it would be observed from a distance of 10pc.

Bolometric Magnitude: measure of the total flux from a star, integrated over the entire spectrum; could refer to apparent or bolometric magnitude

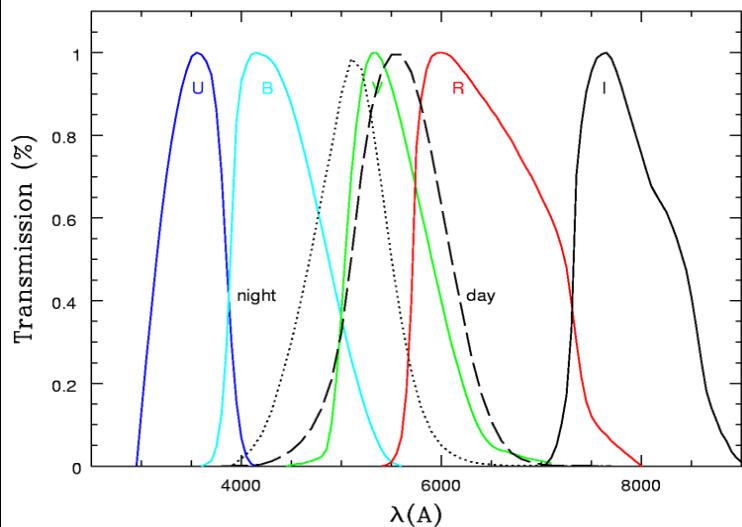
Color Magnitude: instrumental, calibrated (apparent) or absolute magnitude measured with color filters

Color or Color Index: difference between color magnitudes of the same object obtained in different filters, usually defined so that larger positive color index indicates a redder object

Apparent Magnitude to Flux Conversion

Band	U	B	V	R	I
Central Wavelength λ_X [Å]	3650	4400	5500	7000	9000
Effective Width W_X [Å]	680	980	890	2200	2400
Specific flux for $m_X = 0$ $\log_{10}(f_{\lambda,X})$ [erg cm ⁻² s ⁻¹ Å ⁻¹]	-8.37	-8.18	-8.42	-8.76	-9.08

Standard Photometric Filters



Specific flux in the center of band X:

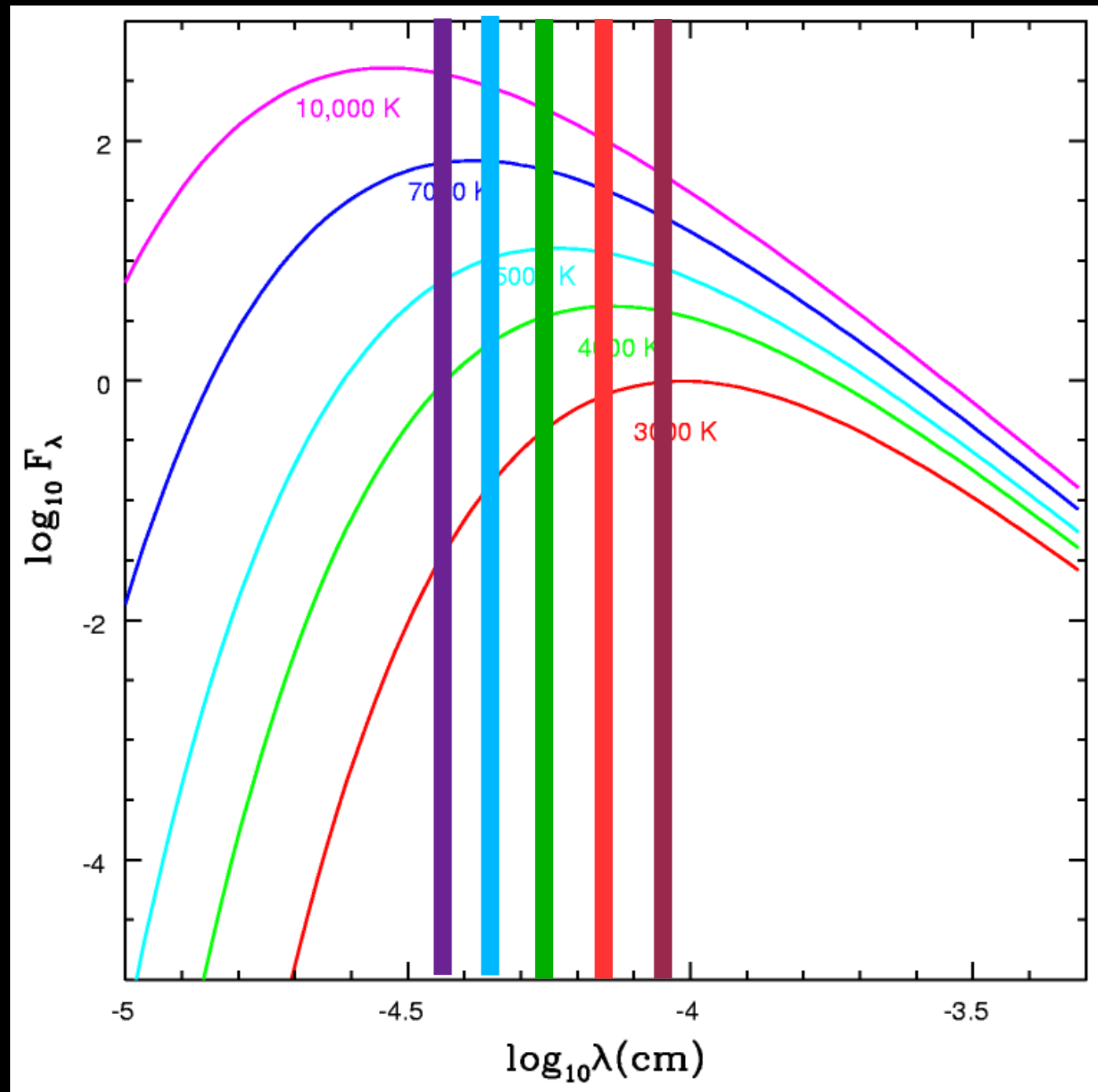
$$F_{\lambda}(\lambda_X) = f_{\lambda,X} 10^{-m_X/2.5}$$

Total flux in band X:

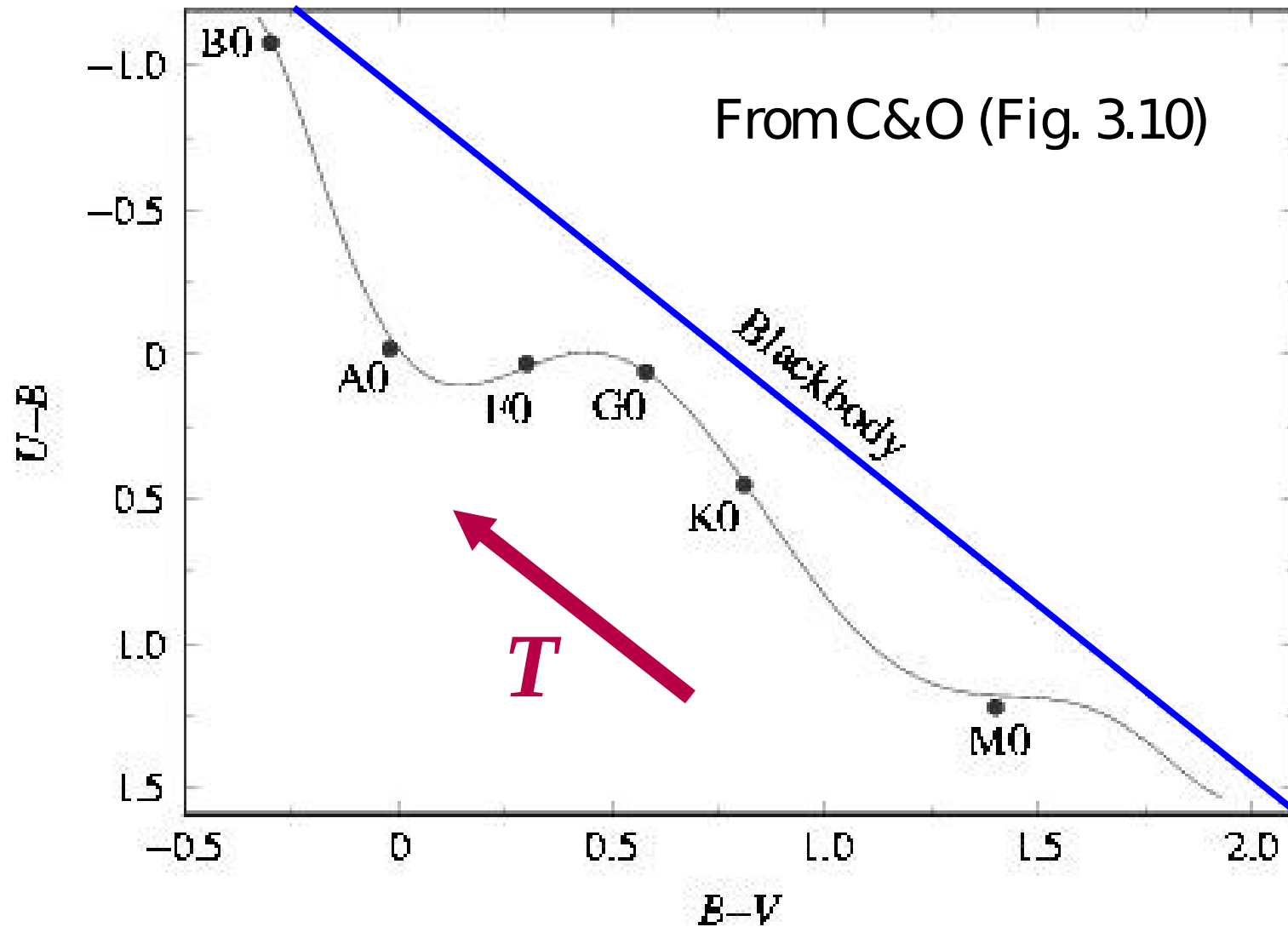
$$F_X = F_{\lambda}(\lambda_X) W_X$$

Stellar spectra are roughly blackbodies.

Color index, e.g. B-V, is a good measure of blackbody temperature.



Color-Color Diagram for Normal Stars



Color-Magnitude diagram combining the stars closer than 10pc and the stars with apparent magnitudes less than 3. Data is from Hipparcos catalog.

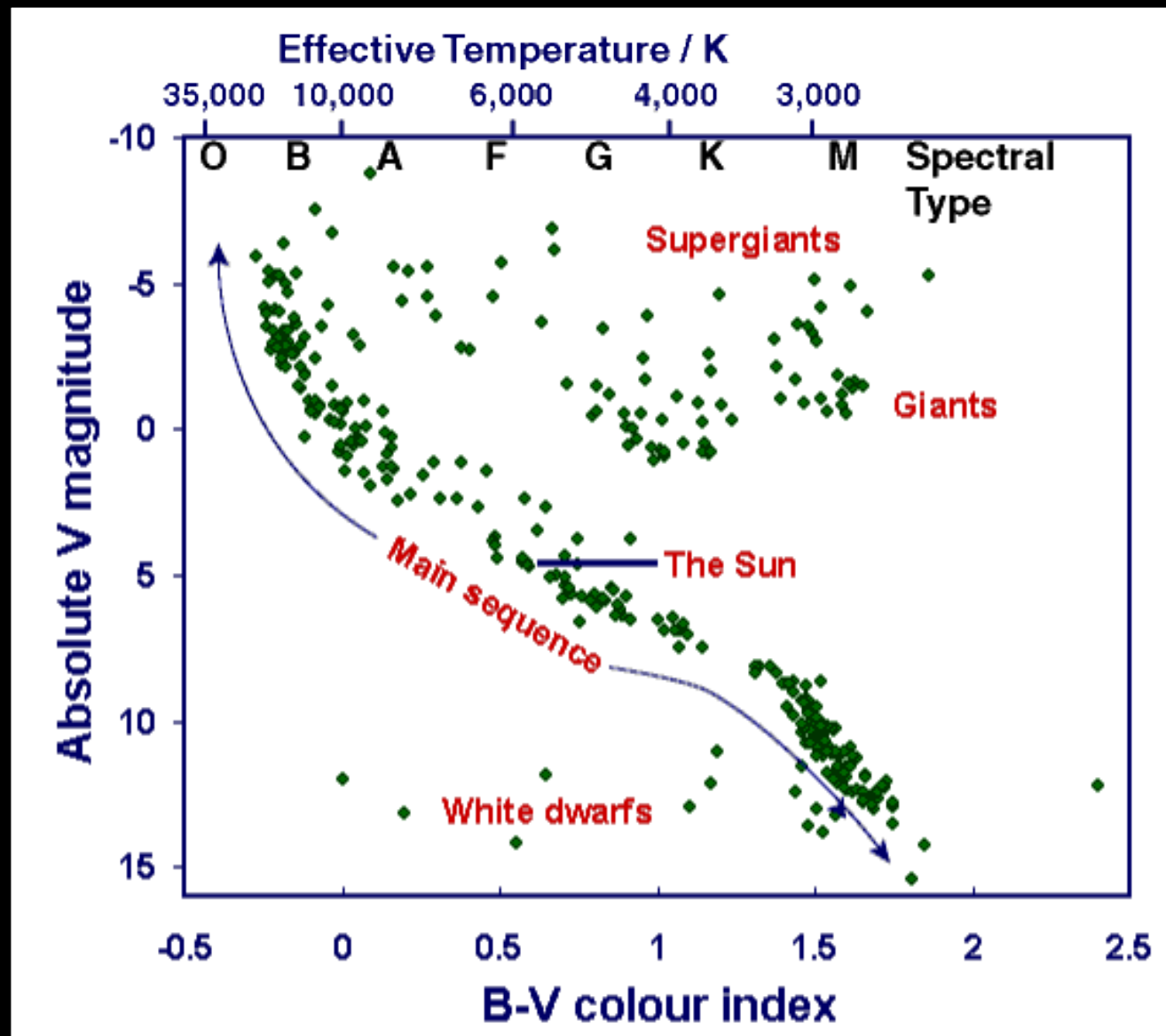
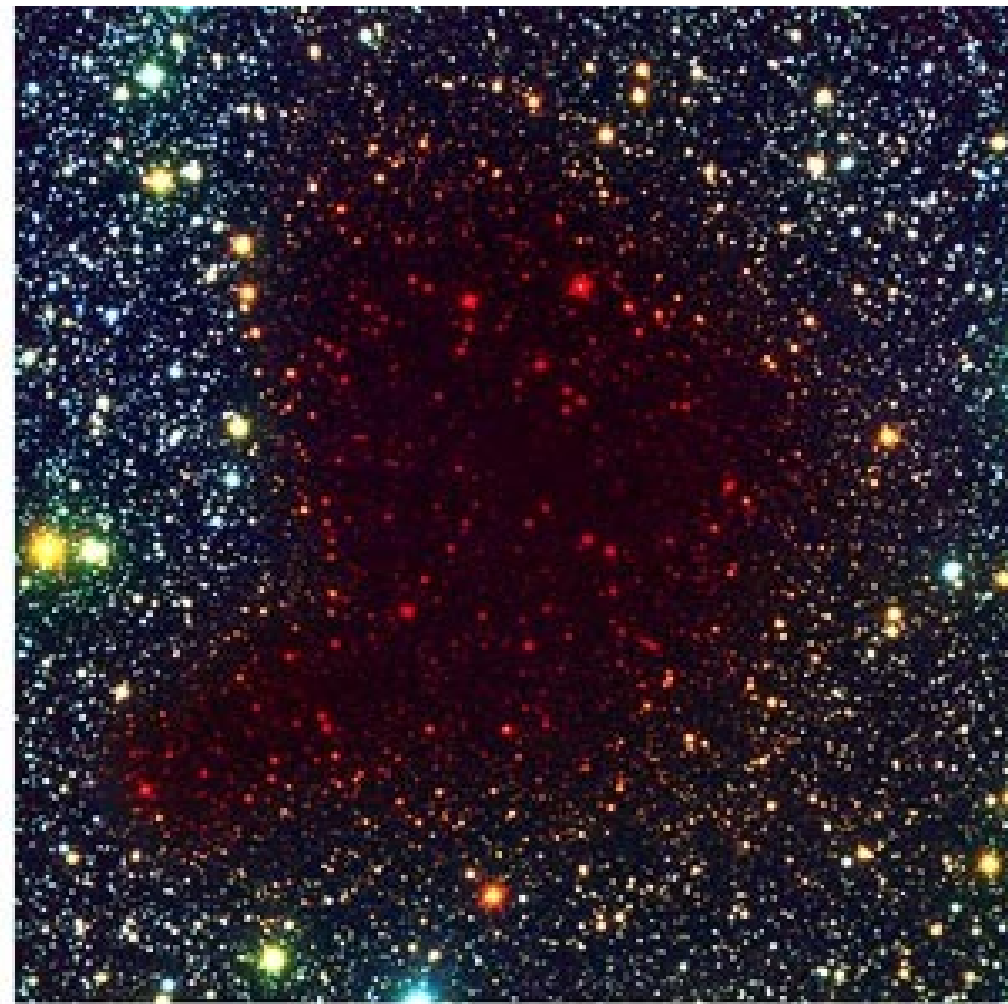


Image from: www.jb.man.ac.uk/.../sample/stars/hrdiag.gif



B, V, I



B, I, K

Pre-Collapse Black Cloud B68 (comparison)
(VLT ANTU + FORS 1 - NTT + SOFI)

Effects of Reddening

$$m_V - M_V = 5 \log_{10} \left(\frac{d}{10 \text{ pc}} \right) + A_V$$

$A_V = \text{extinction coefficient}$

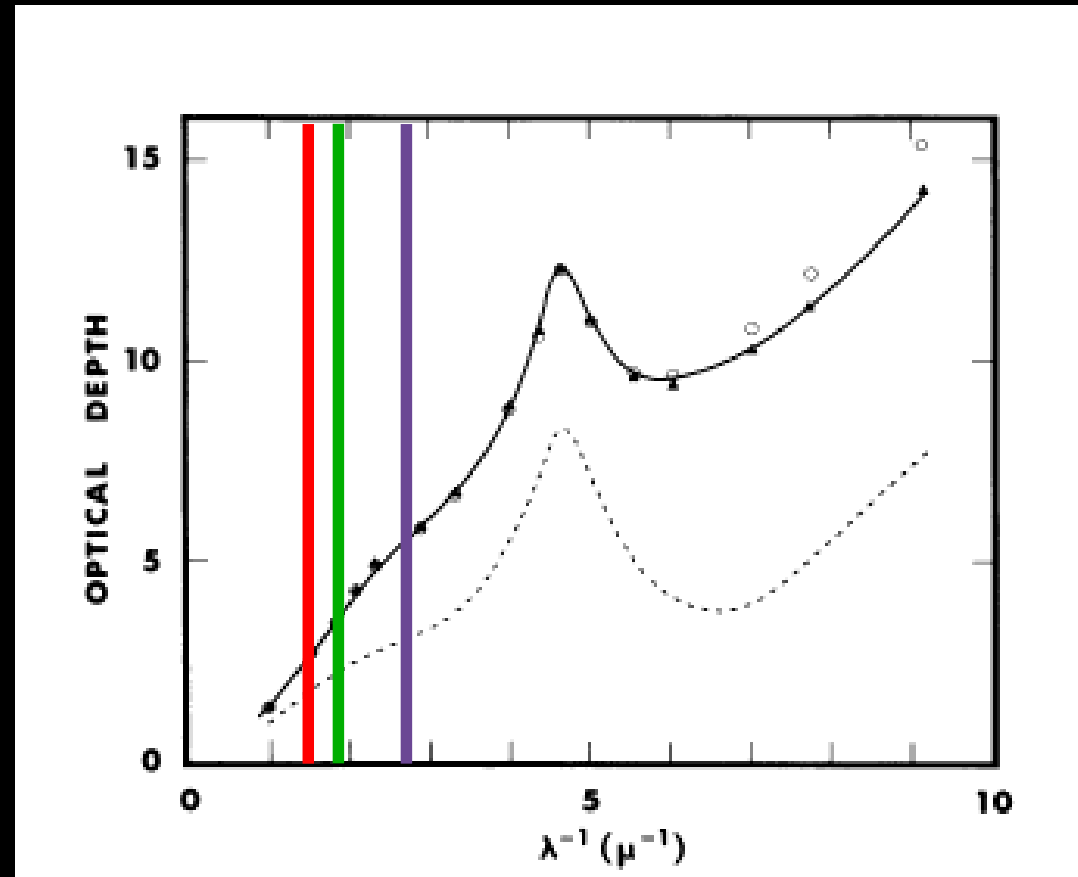
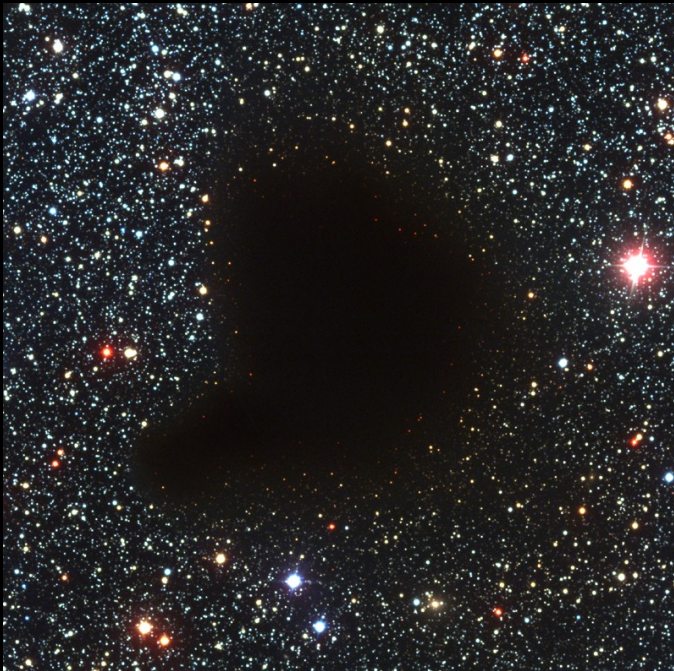


Image Credit: Mathis, Rumpl, and Nordsieck (1977)

Effects of Reddening

$$m_V - M_V = 5 \log_{10} \left(\frac{d}{10 \text{ pc}} \right) + A_V$$

$A_V = \text{extinction coefficient}$

To determine A_V we need to observe extinction at different wavelengths to find the color excess, for example

$$E_{B-V} = A_B - A_V$$

since the ratio A_B/A_V is more or less constant

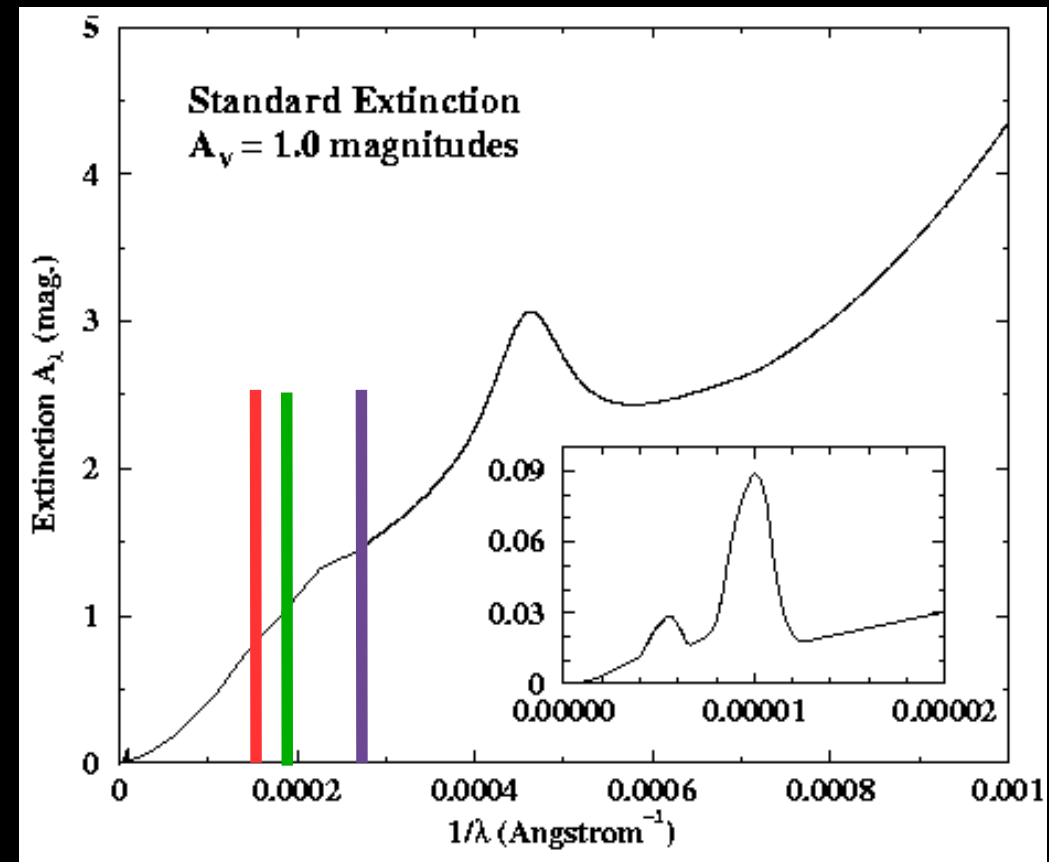
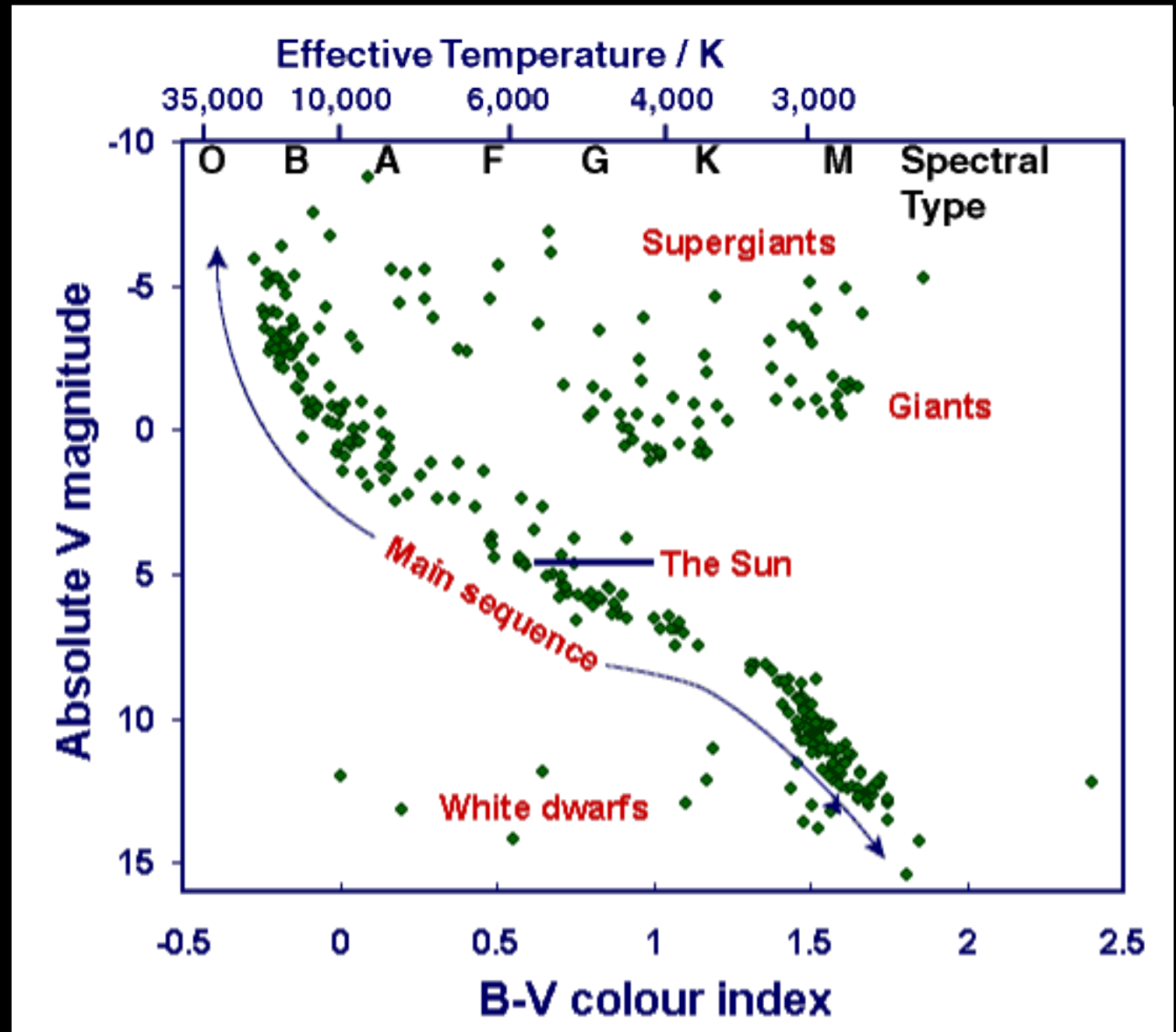
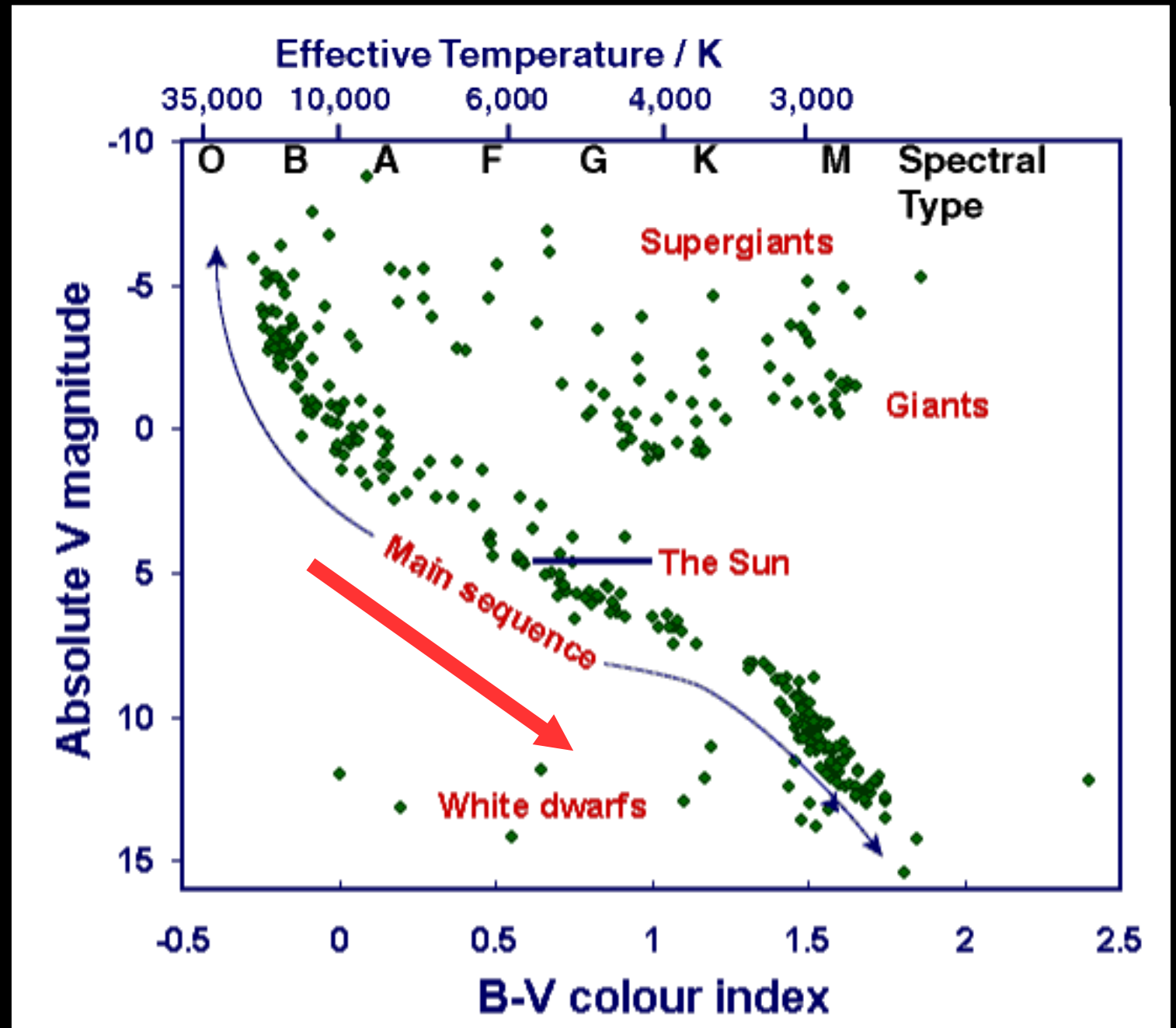


Image Credit: www.iras.ucalgary.ca/~volk

Effects of reddening



Effects of reddening

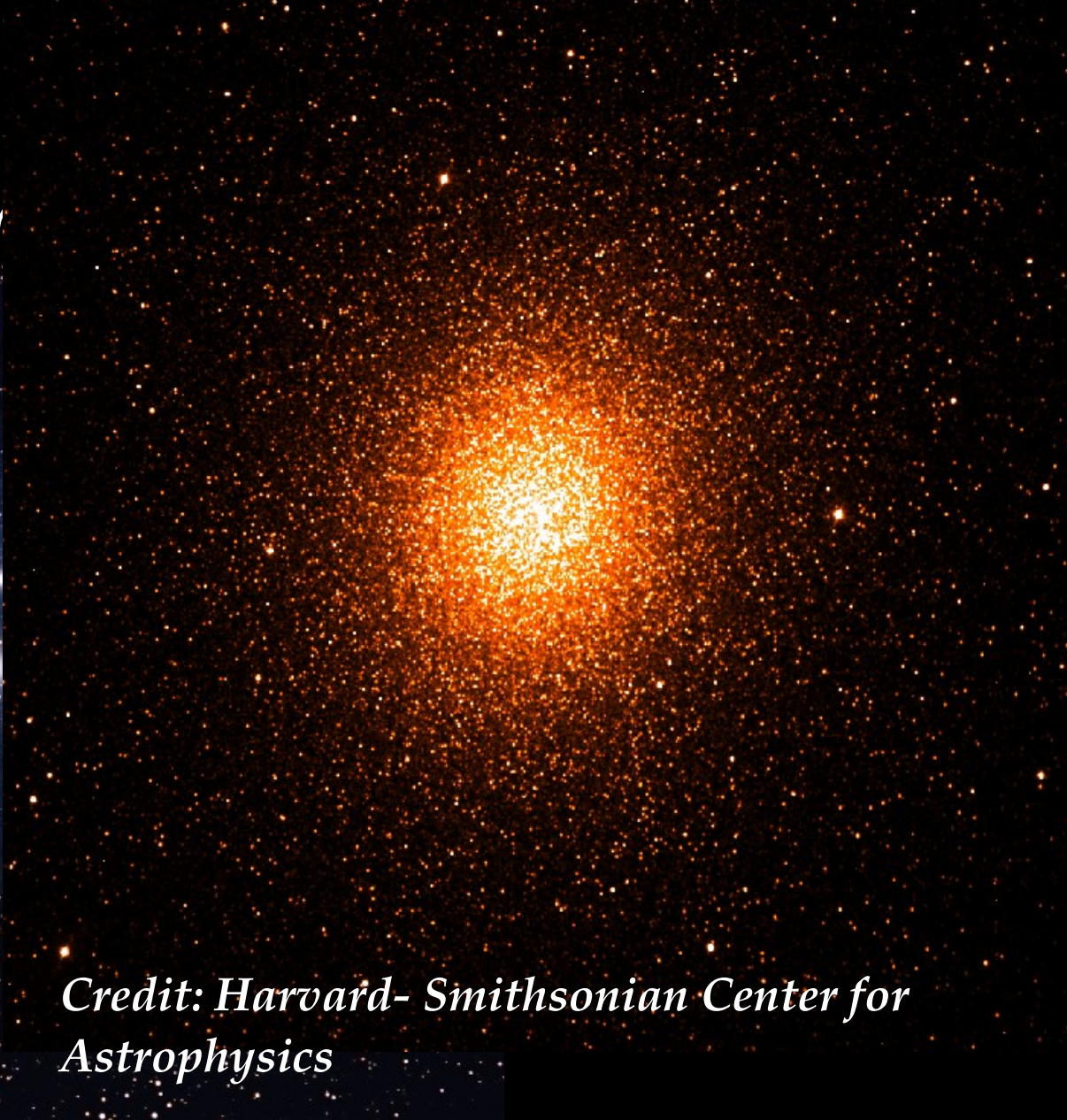


Pleiades (open cluster)



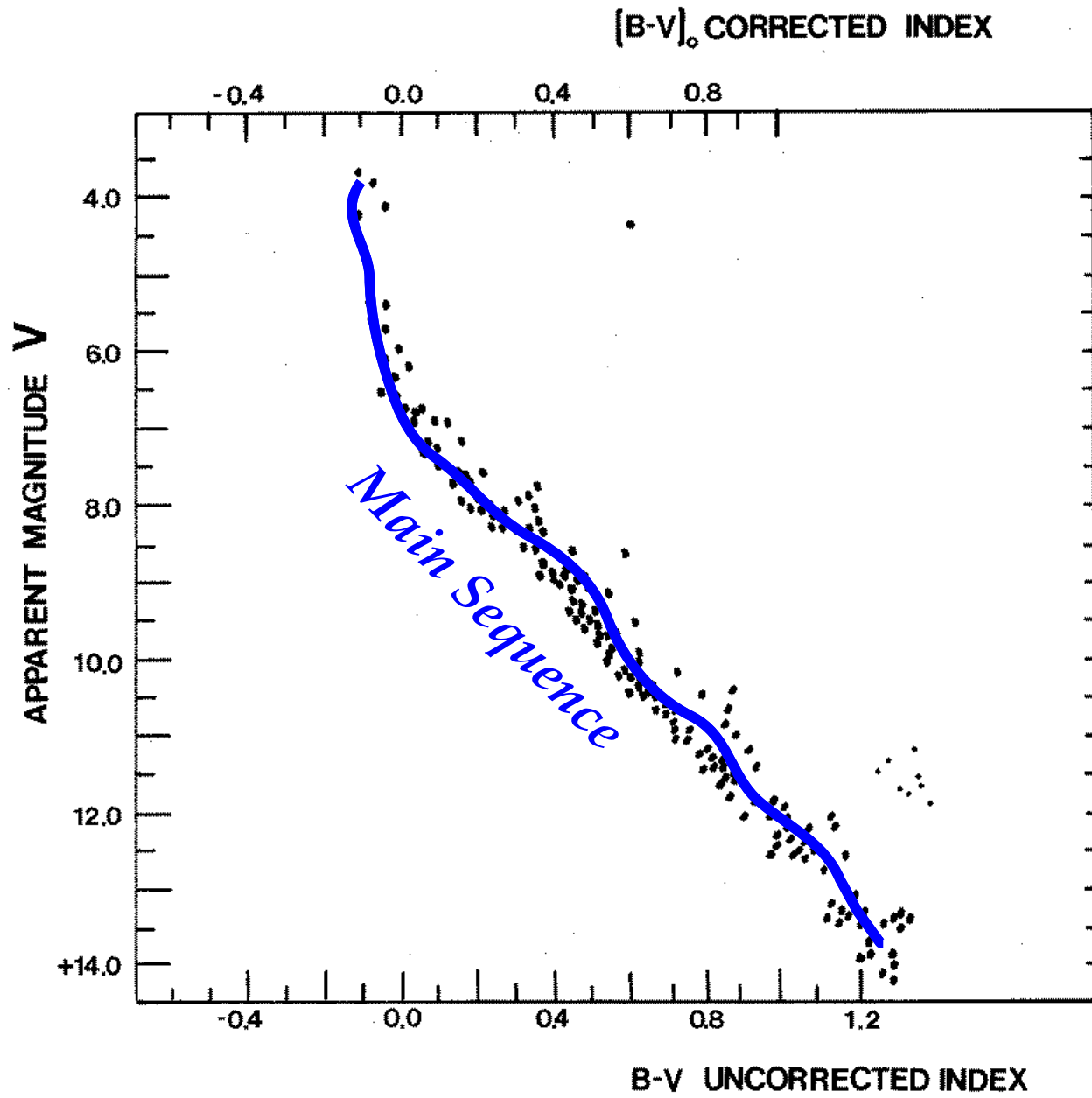
Credit: W. Keel (U of Alabama)

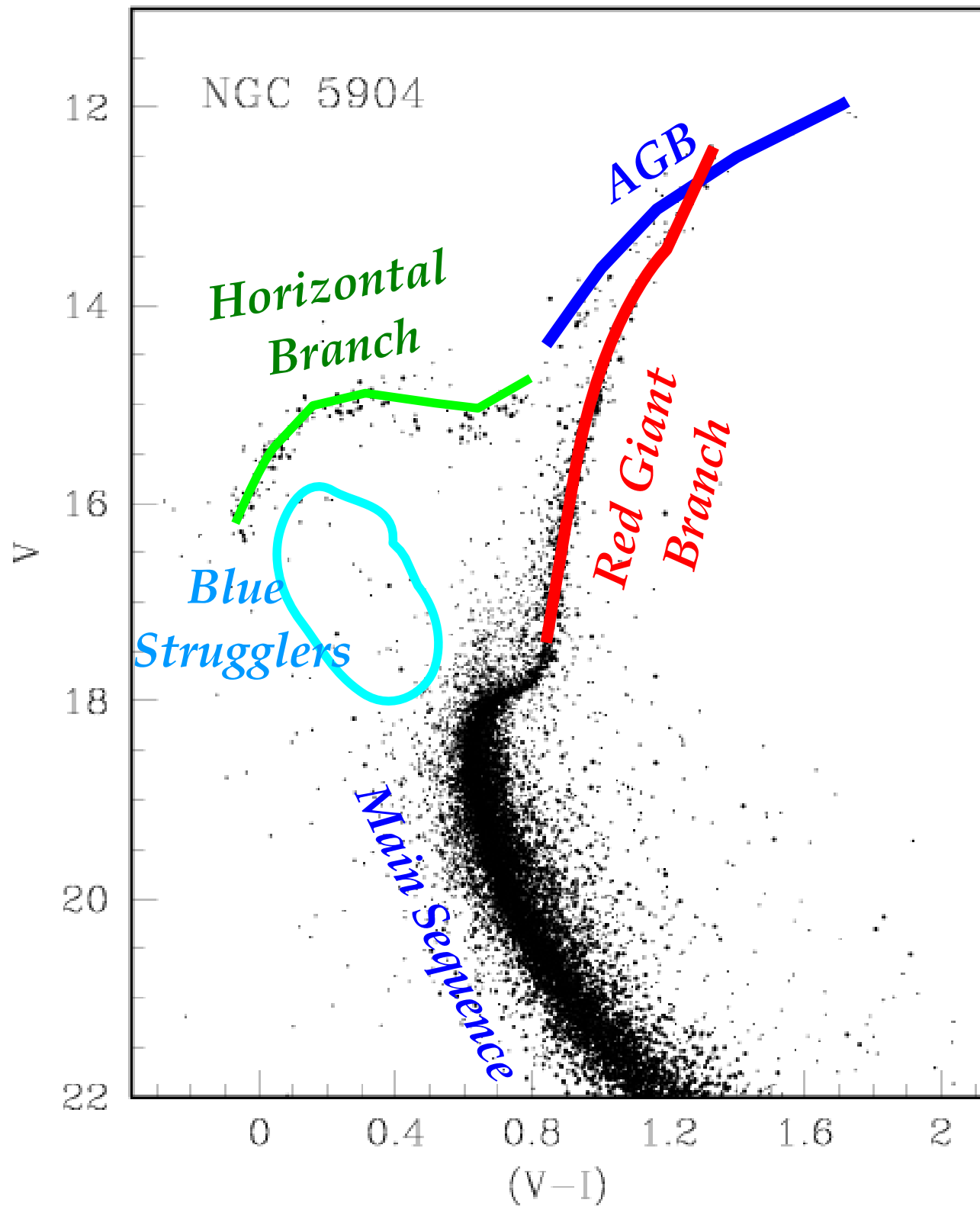
Omega Centauri (globular)

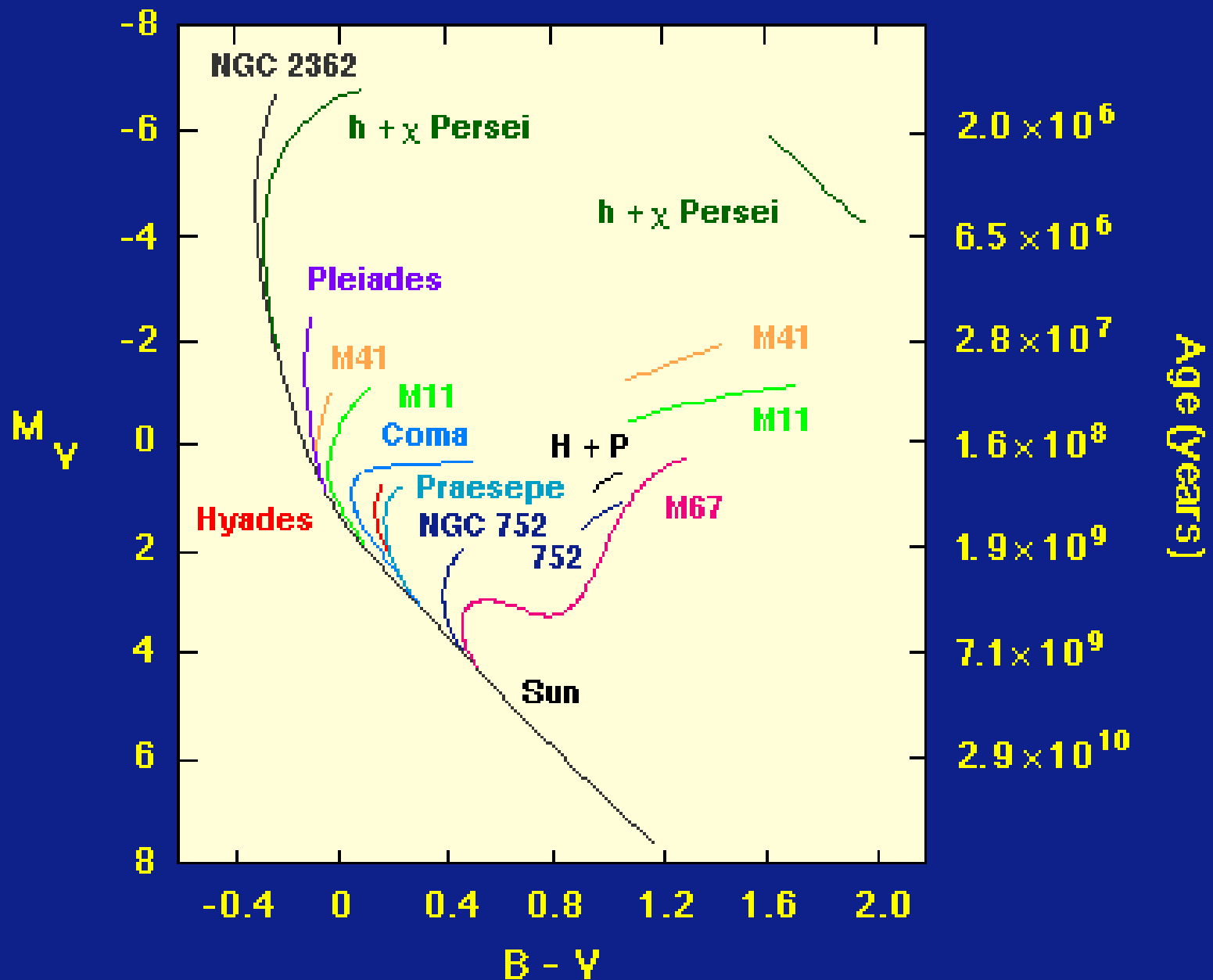


Credit: Harvard- Smithsonian Center for Astrophysics

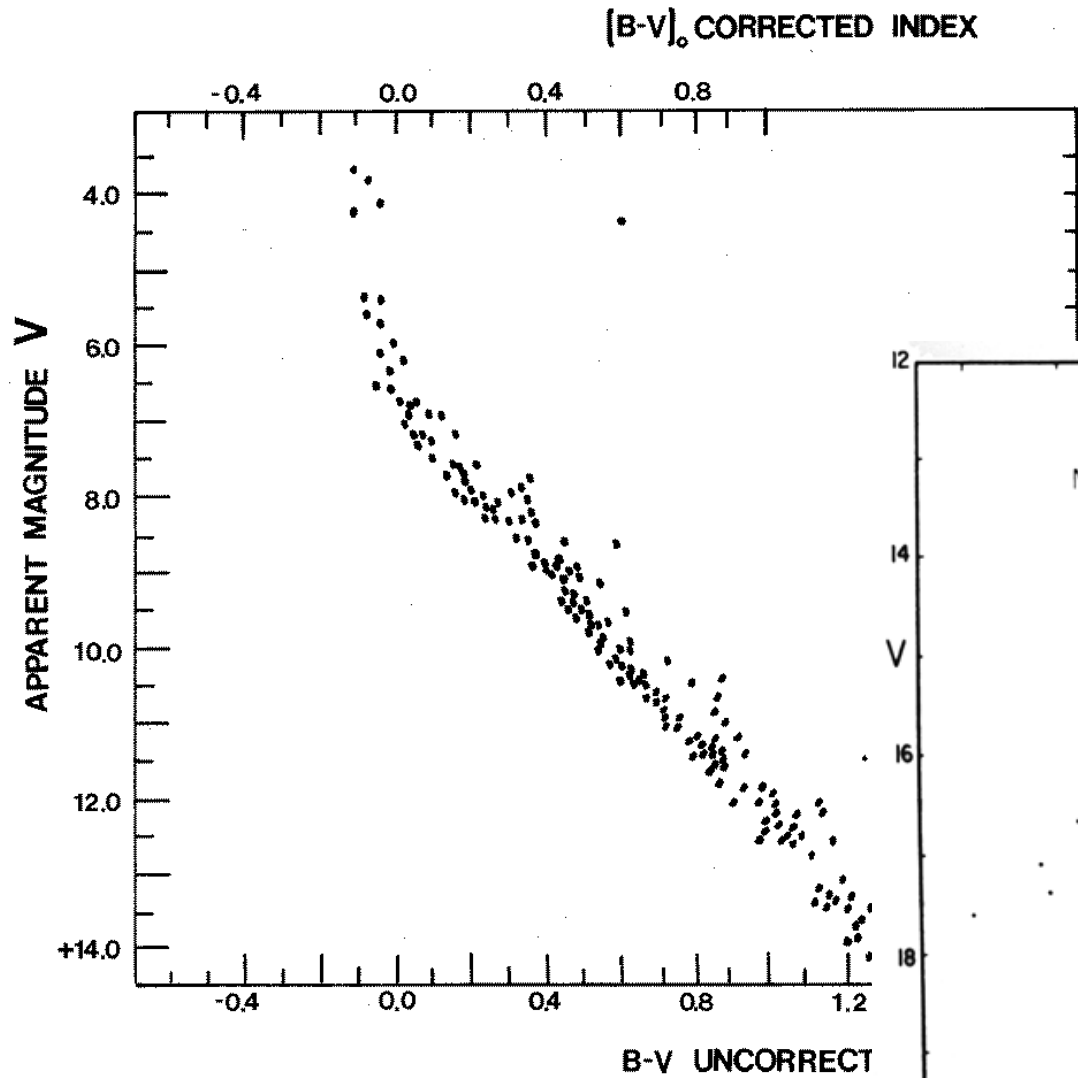
M45 (Pleiades)



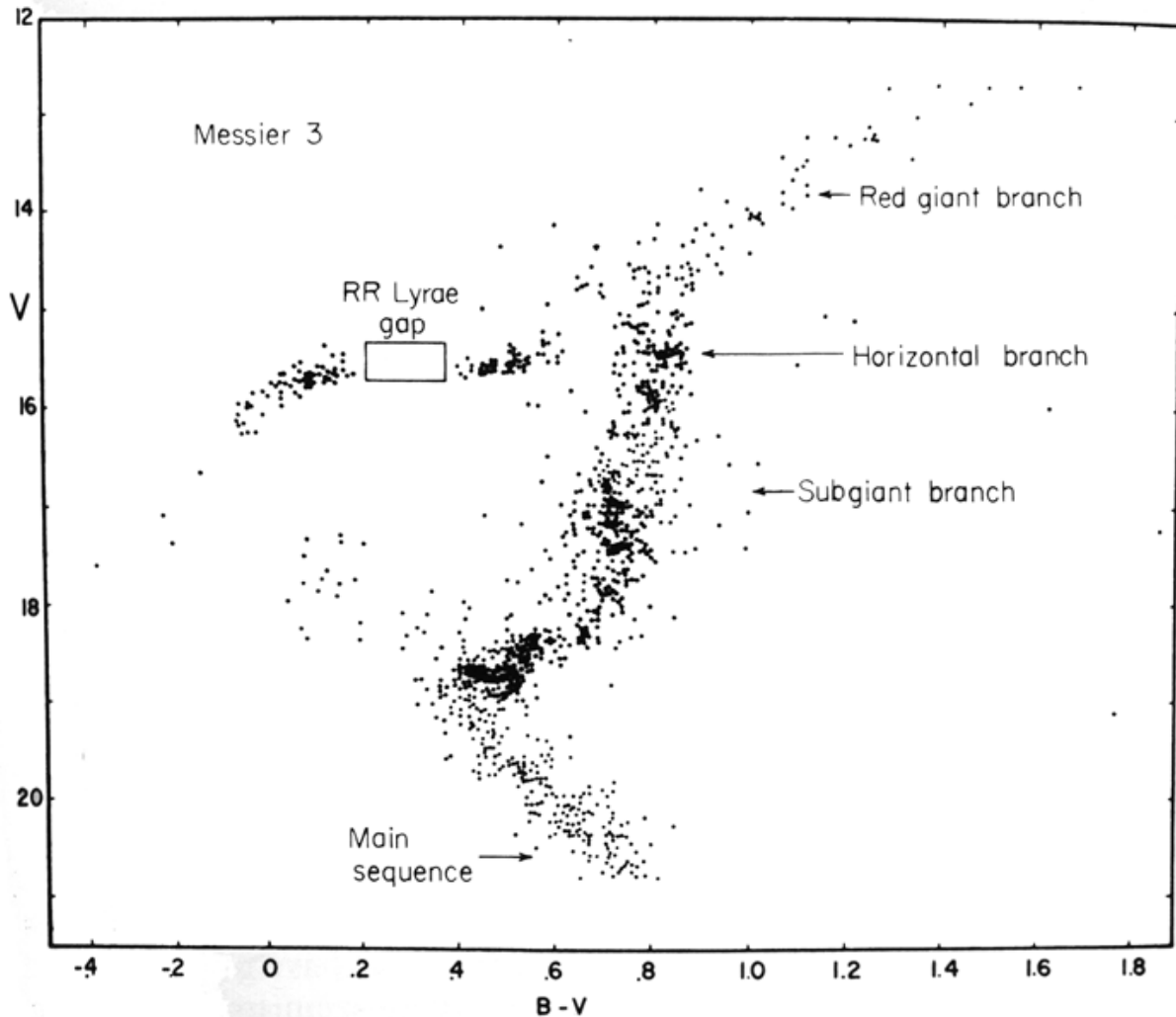




M45 (Pleiades)



The distance to Pleiades is 135pc. Estimate the distance to M3.



Metallicity definition:

$$[Fe/H] = \log_{10} \left(\frac{N_{Fe}}{N_H} \right) - \log_{10} \left(\frac{N_{Fe}}{N_H} \right)_{solar}$$

[Fe/H] = 0 means solar metallicity (Z = 0.019)

[Fe/H] > 0 means metal-rich stars (Z > 0.019)

[Fe/H] < 0 means metal-poor stars (Z < 0.019)

Effects of Metallicity

HR Diagram of Globular Cluster M3

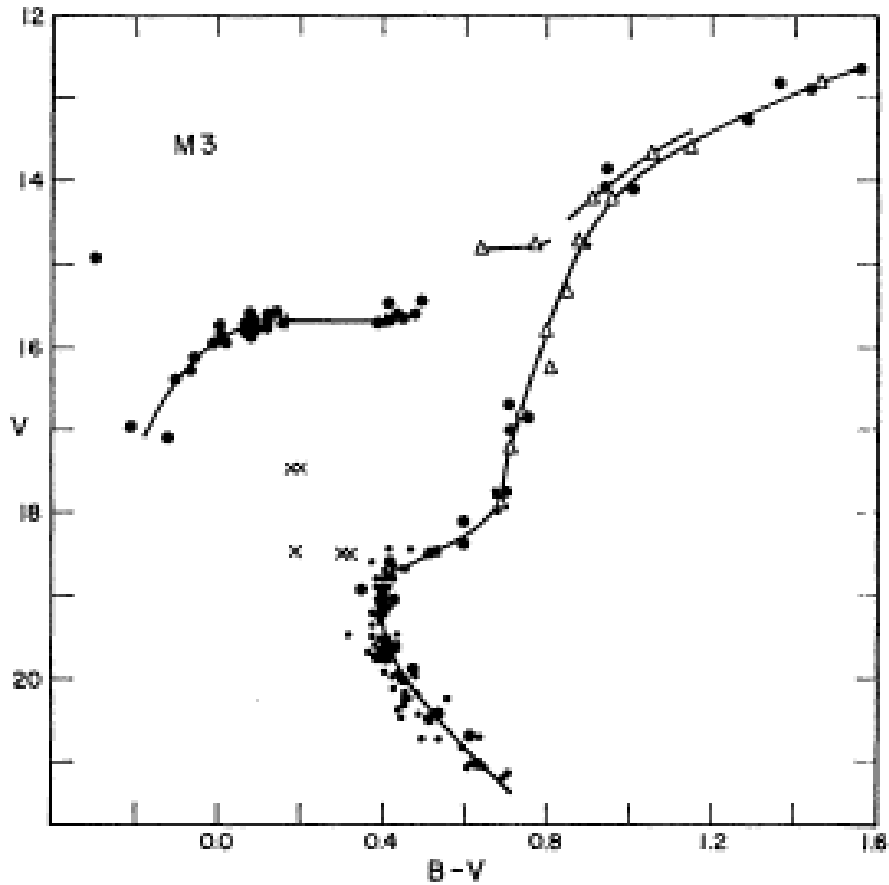
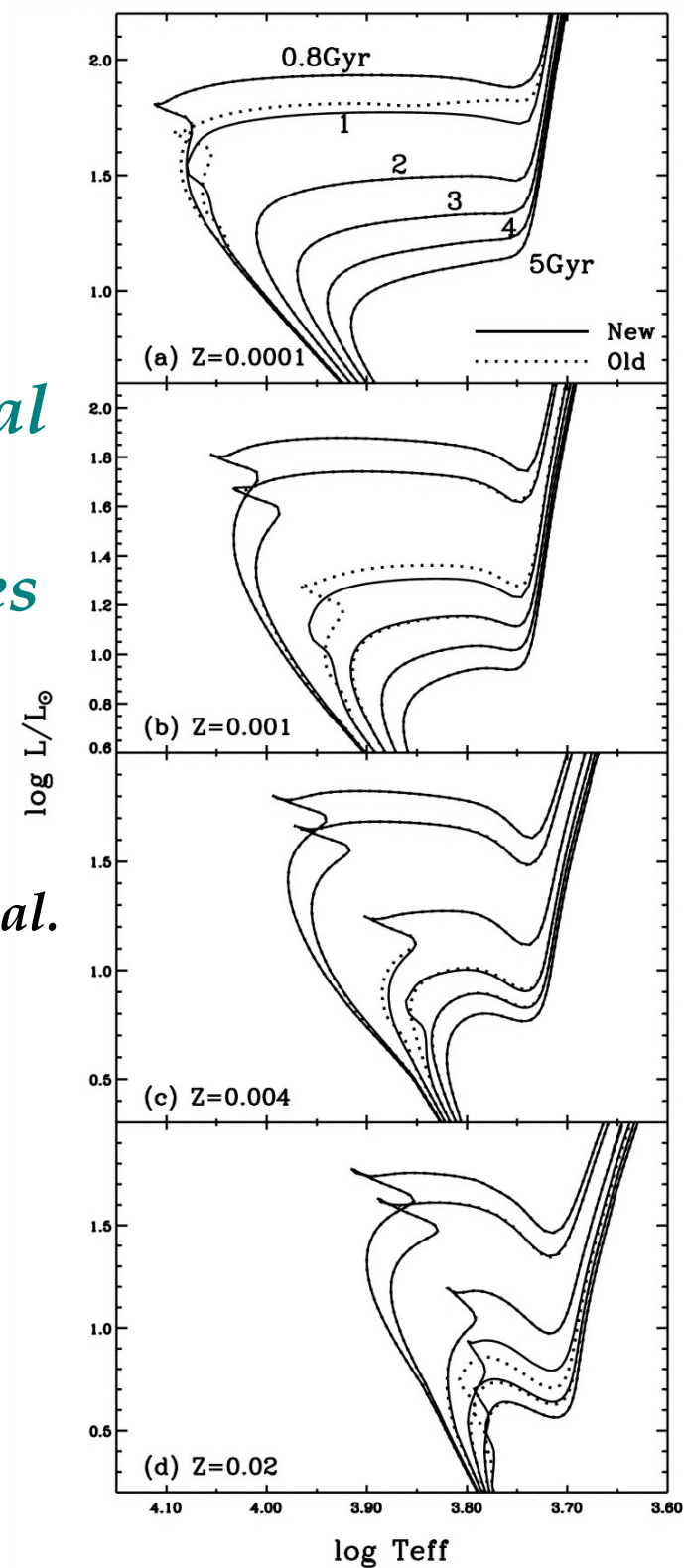


Image Credit: Sandage 1970

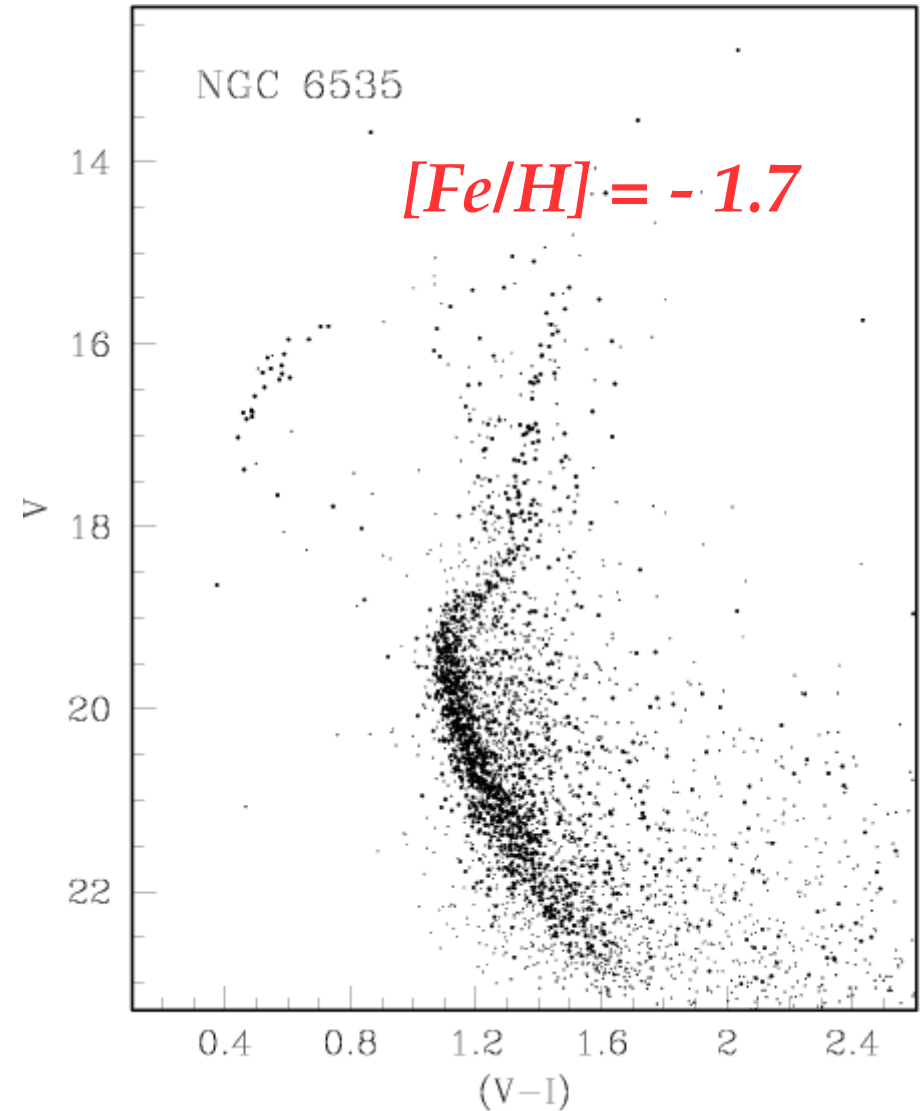
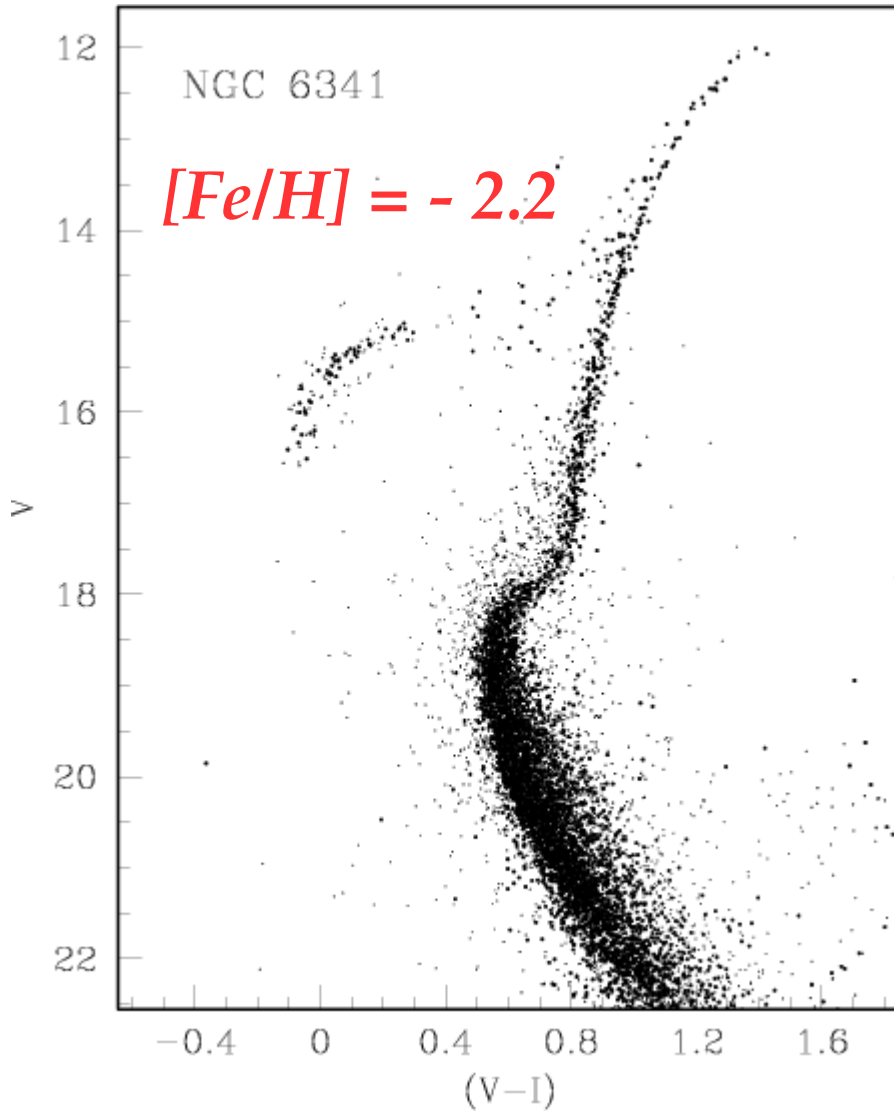
Theoretical Cluster Isochrones

Image Credit:
Demarque et al.
2004

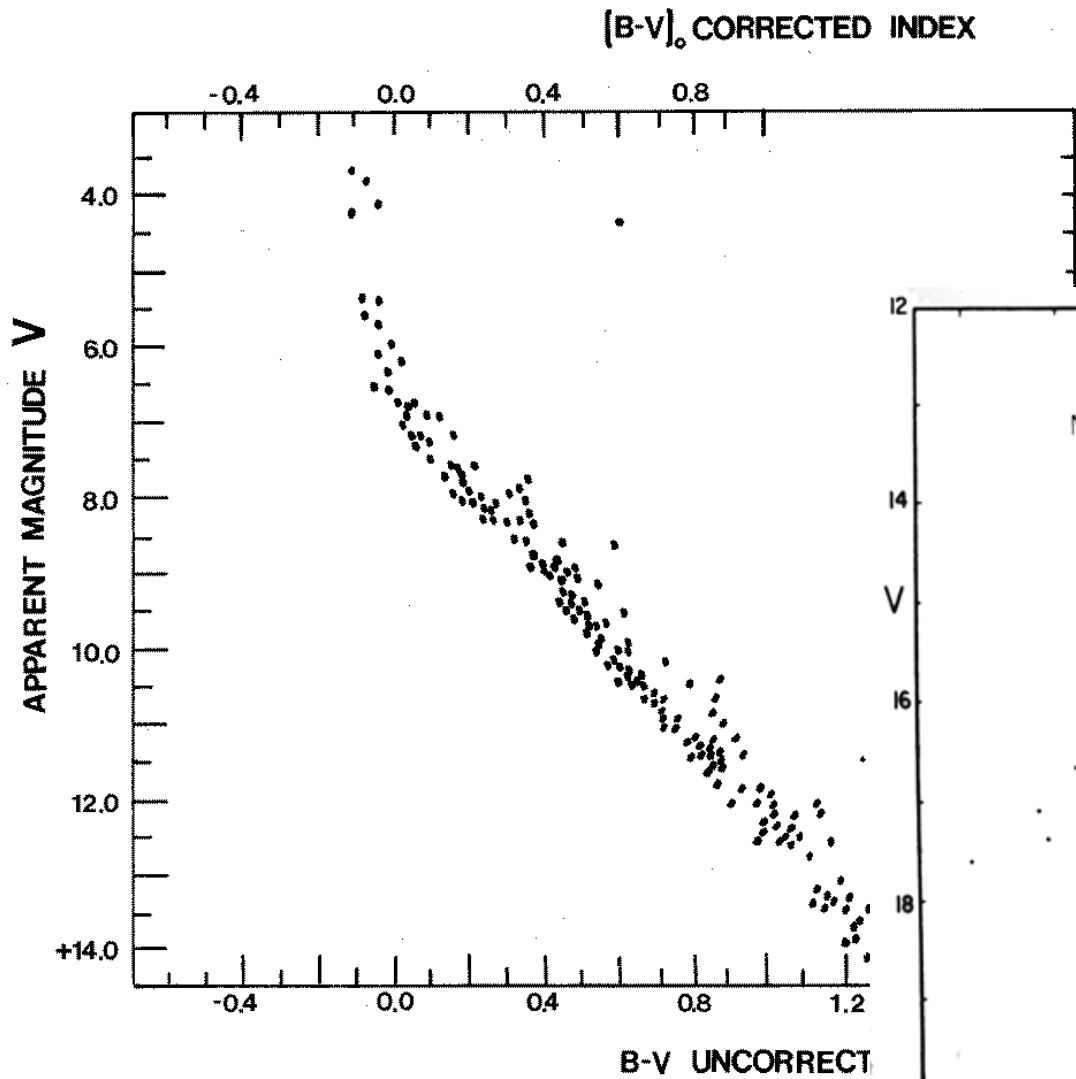


HR diagram of M92

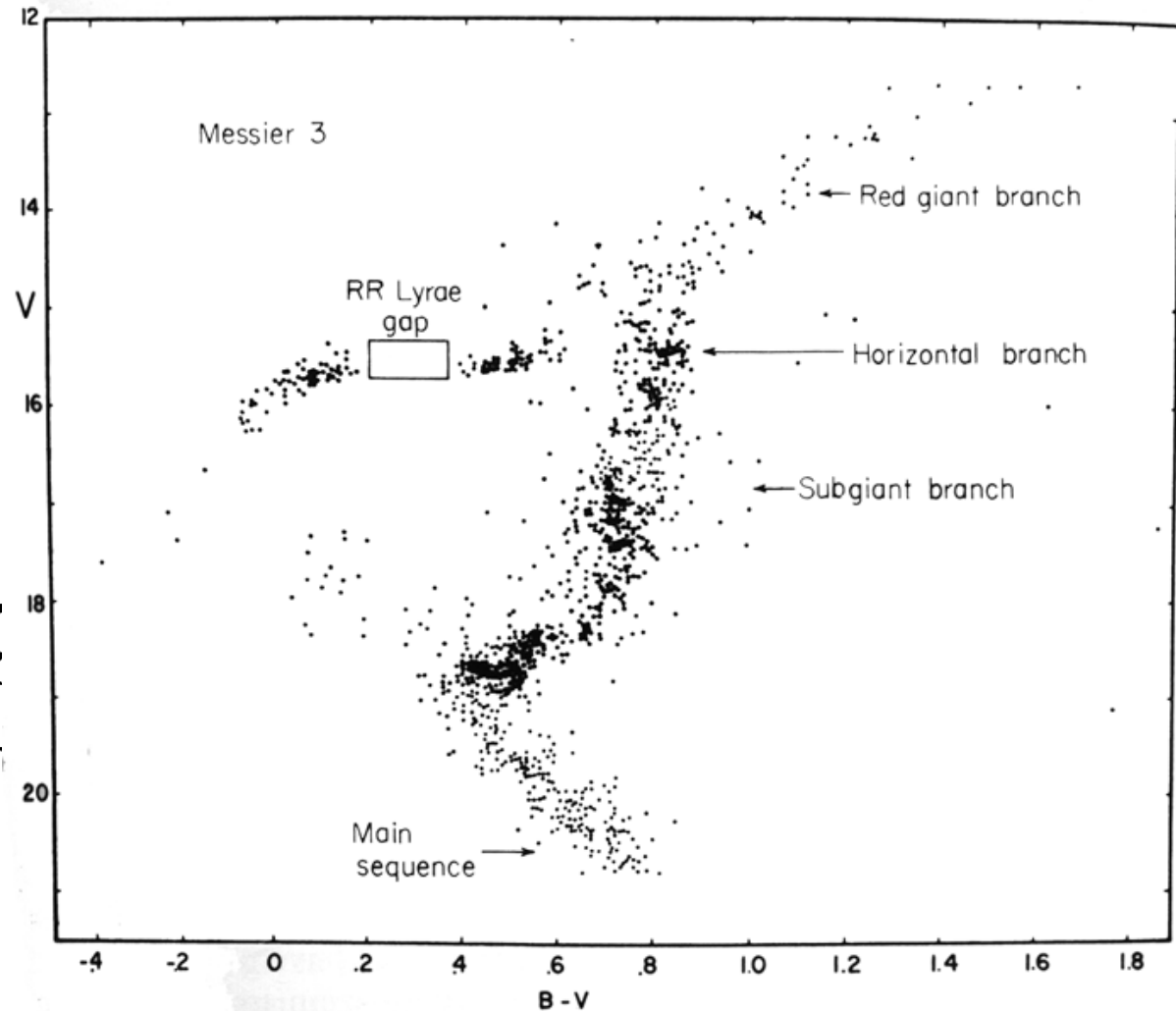
HR diagram of NGC 6535



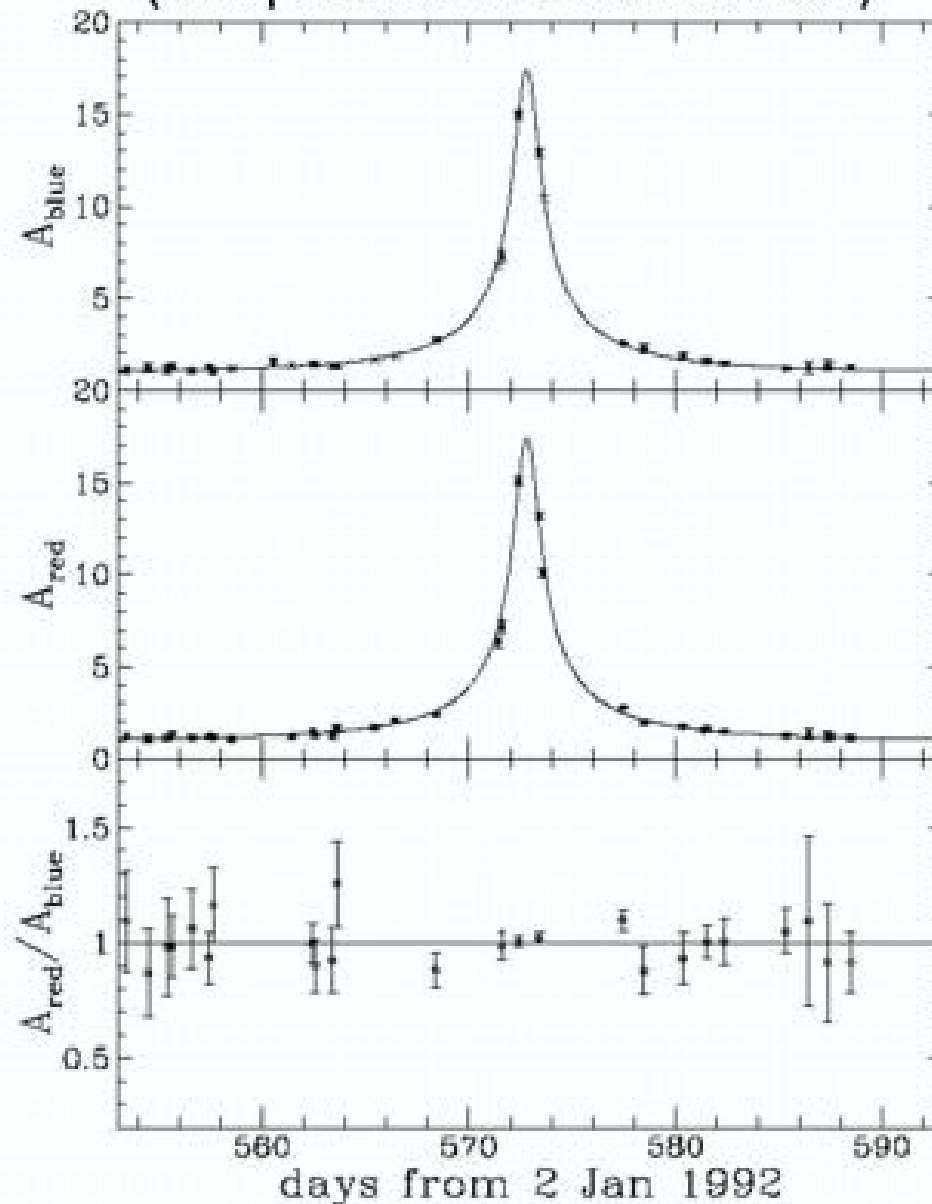
M45 (Pleiades)



How would taking metallicity into consideration affect your estimate for the distance to M3?



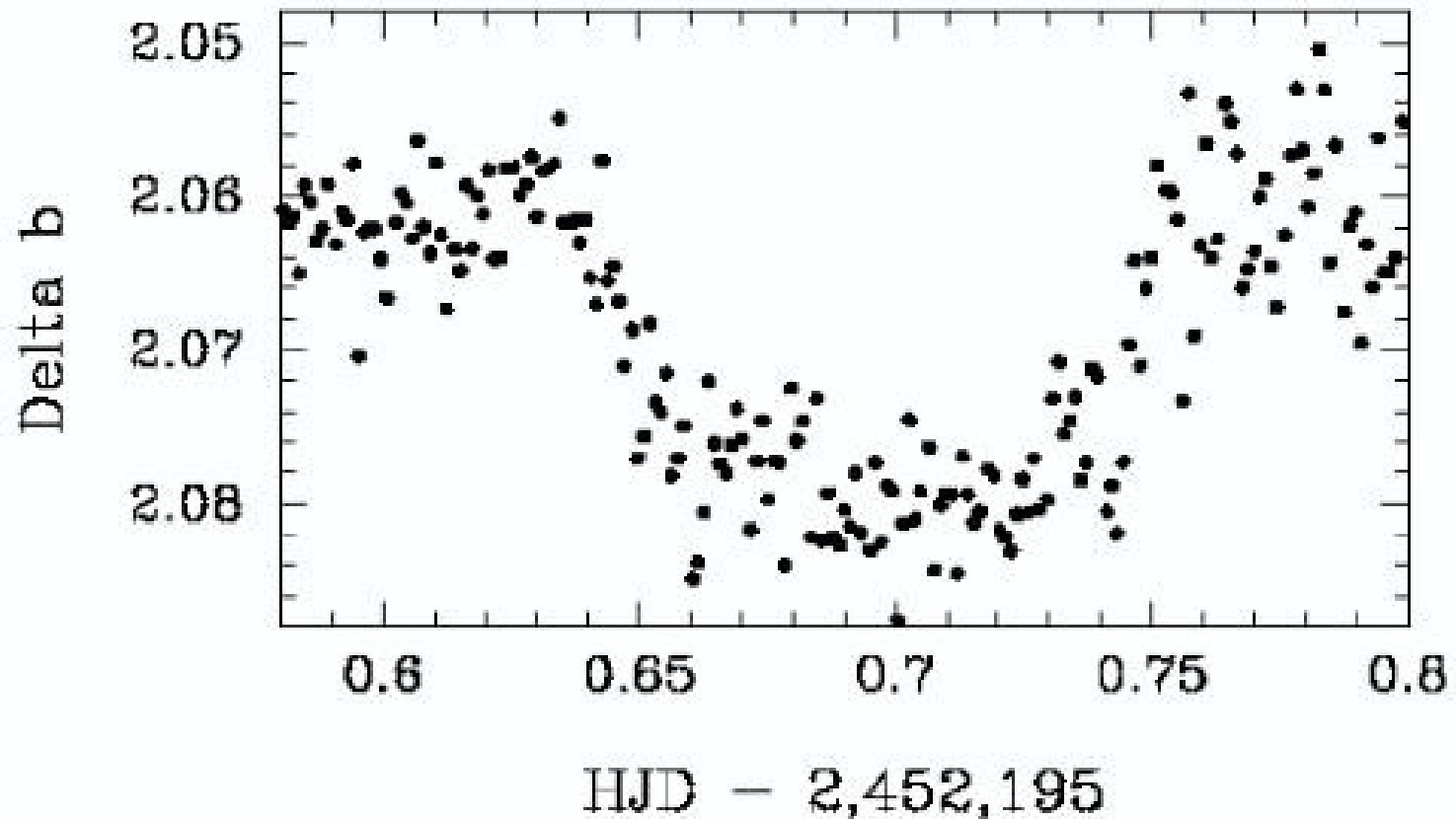
Applications of Photometry: Microlensing Light Curves (composition of Galactic halo)



see <http://www.macho.mcmaster.ca/>

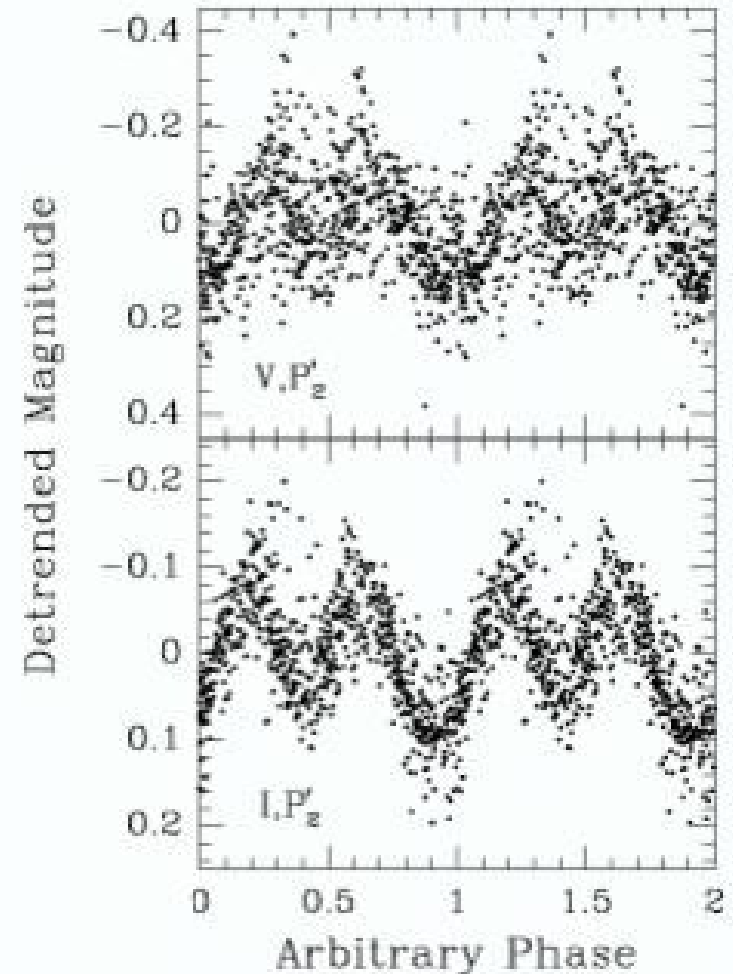
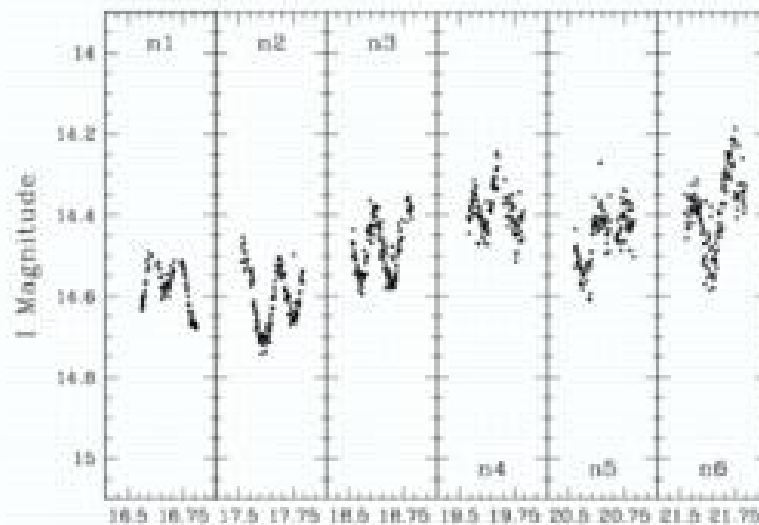
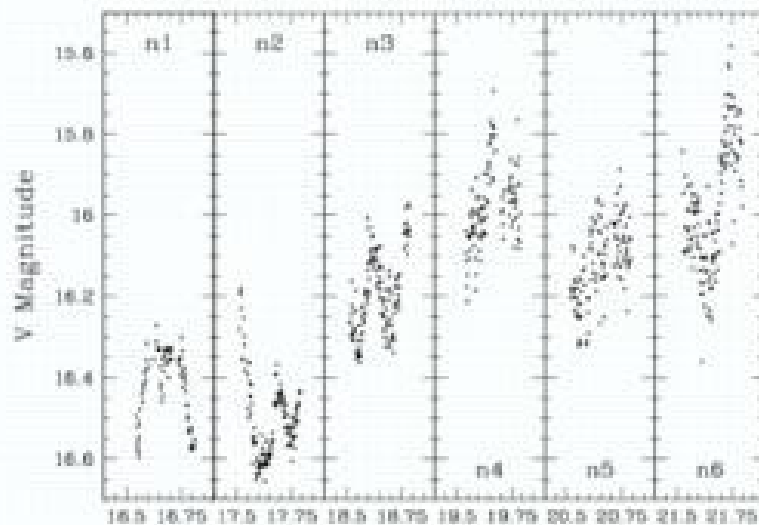
Applications of Photometry: Planetary Transit Light Curve (discovery of extrasolar planets)

Photometric observations of HD 209458 on October 12-13, 2001 taken with the T8 0.80m APT at Fairborn Observatory. Heliocentric time of mid-transit is 2,452,195.6991.

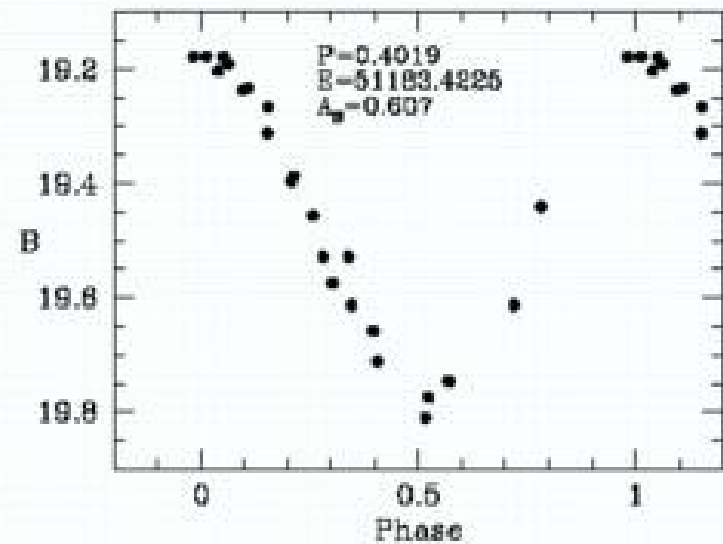
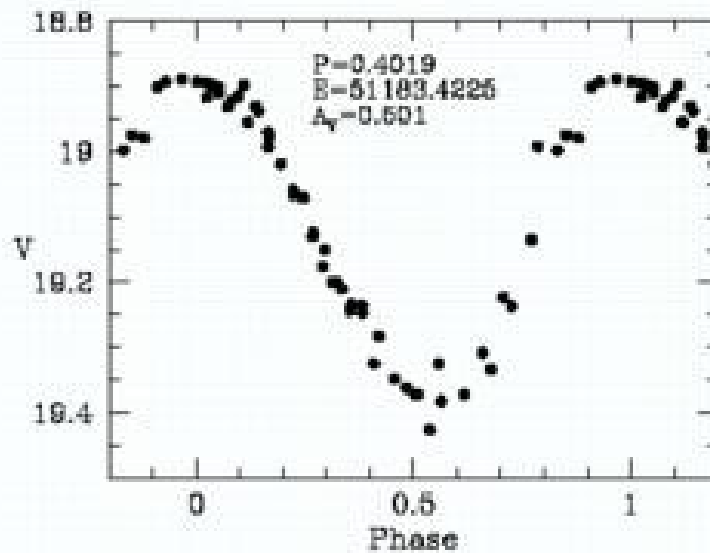
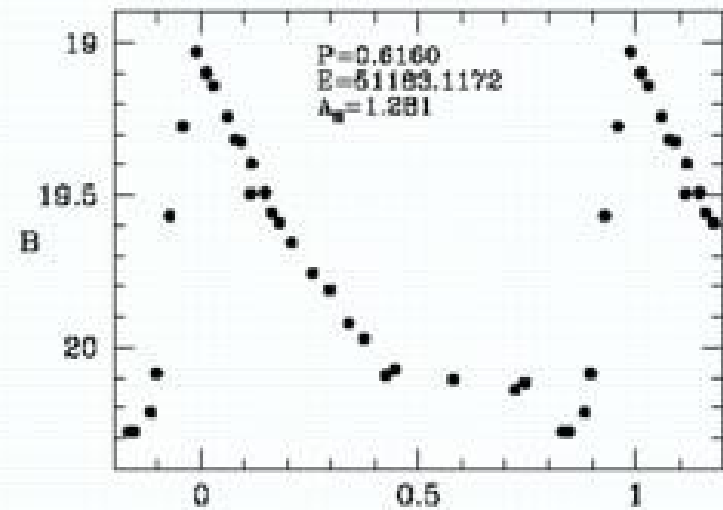
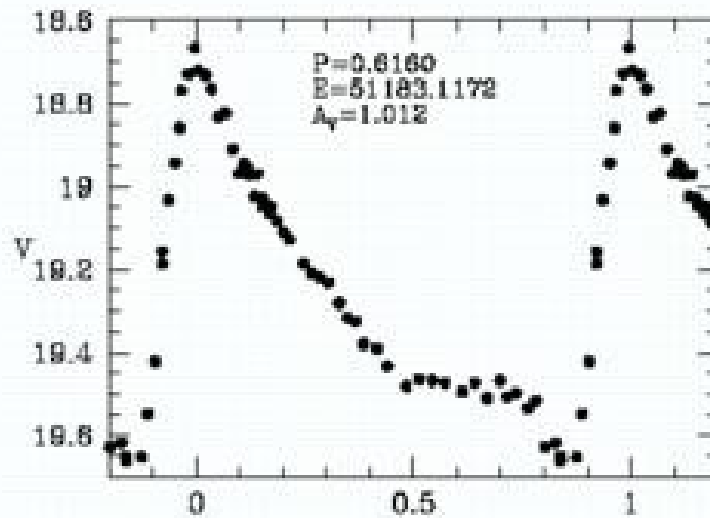


see <http://schwab.tsuniv.edu/t8/hd209458/newtransits.html>

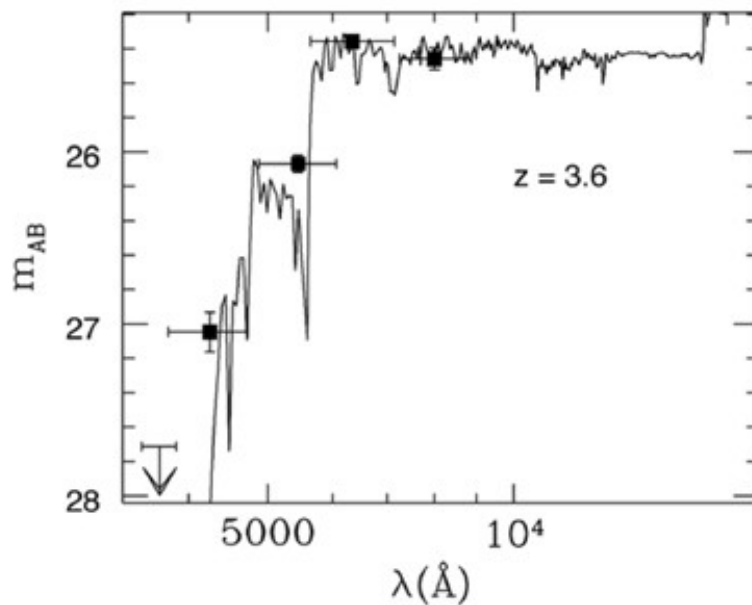
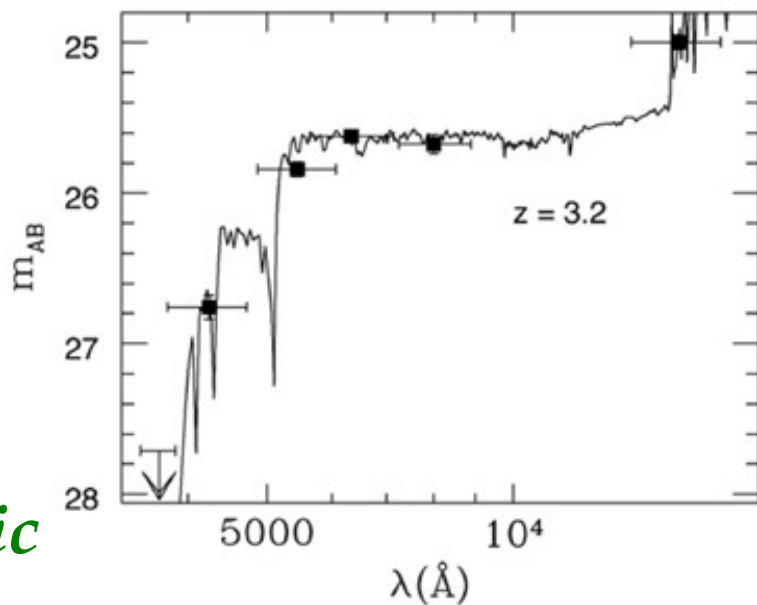
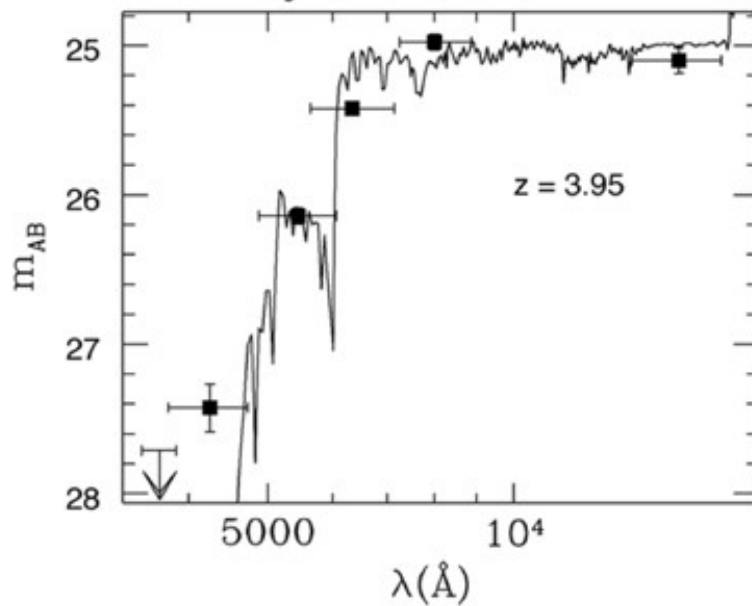
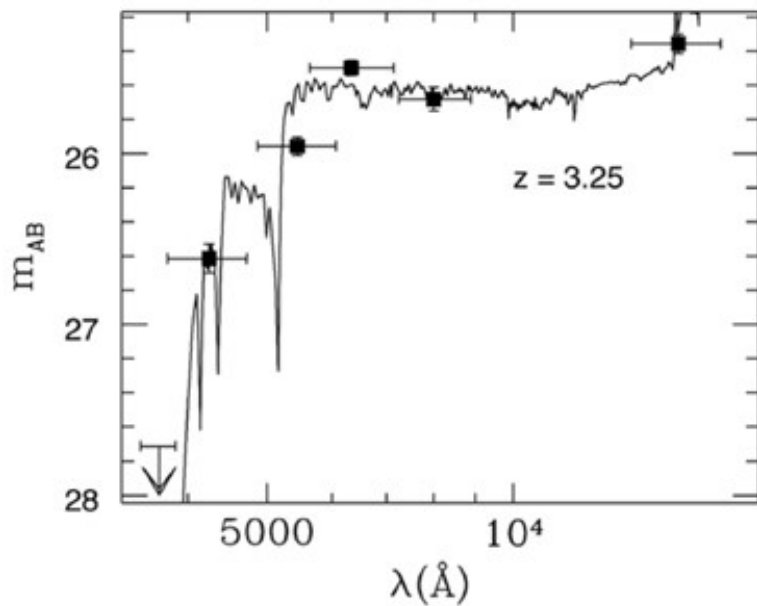
Applications of Photometry: Binary Star Light Curves (determine orbital period, system geometry)



Applications of Photometry: Variable Star Light Curves (RR Lyrae = distance via constant mean absolute magnitude)



ESO - Rome Observatory

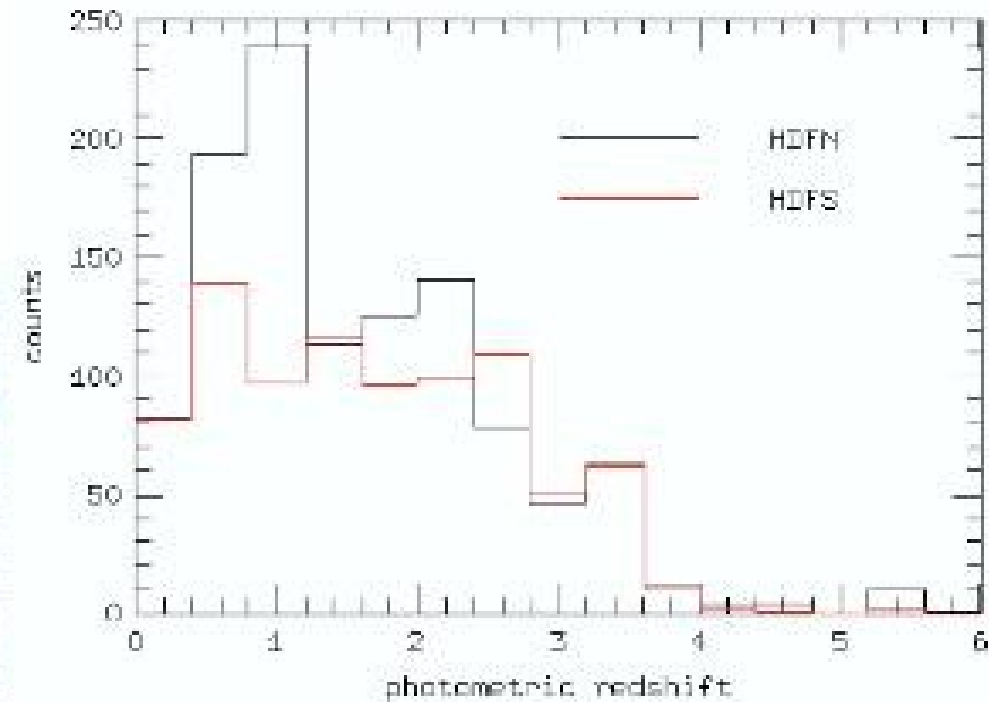


*Photometric
Redshifts*

$$\lambda_{obs} = \lambda_0 (1+z)$$

Photometric Redshifts of Galaxies in HDF-S NIC3 Field

Applications of Photometry: Photometric Redshifts (structure of the Universe)



see <http://astrowww.phys.uvic.ca/grads/gwyn/pz/>