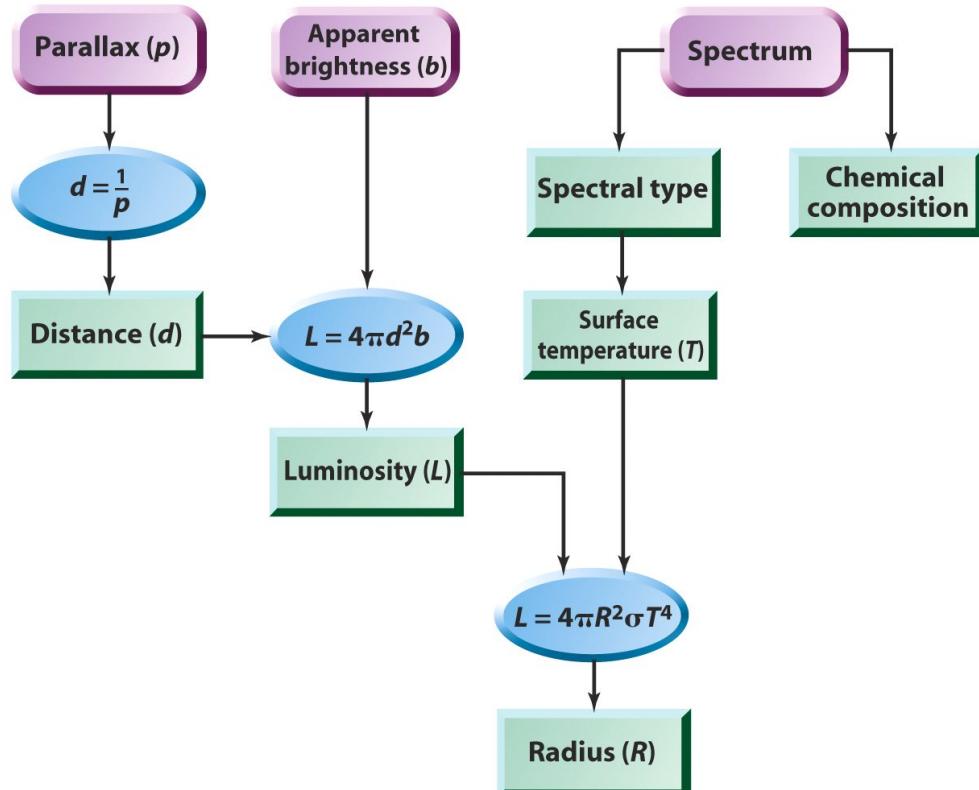


Chapter 11: Characterizing Stars

Chapter 11: Characterizing Stars Pg 339 #1 - 5, 9, 10, 12, 13, 15 - 19, 26 - 29, 31, 32, 35, 36, 40.

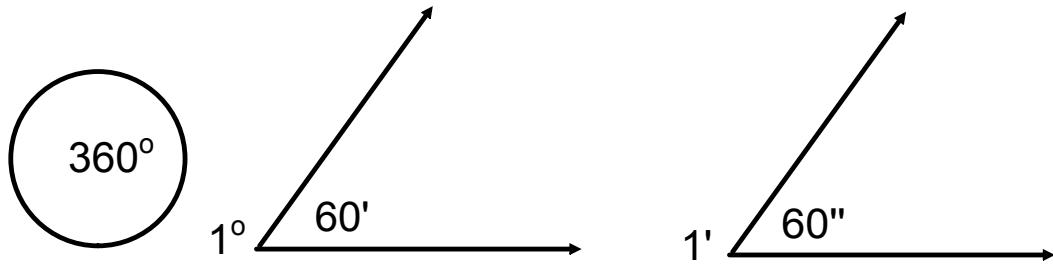


$$L_* = 4\pi R_*^2 \sigma T_*^4 \quad L_\odot = 4\pi R_\odot^2 \sigma T_\odot^4$$

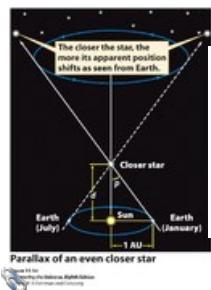
$$\frac{L_*}{L_\odot} = \frac{4\pi R_*^2 \sigma T_*^4}{4\pi R_\odot^2 \sigma T_\odot^4}$$

$$\left\{ \frac{L}{L_\odot} = \frac{R^2}{R_\odot} \frac{T^4}{T_\odot^4} \right\}$$

Degrees - Minutes - Seconds



Stellar Distances: Parallax

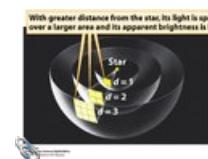
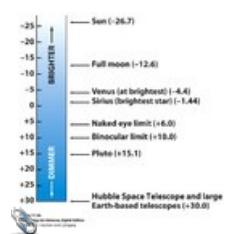
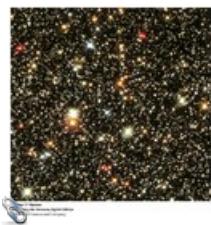


$$d = \frac{1}{p}$$

d = distance in parsecs
 p = parallax angle in arcseconds

1 pc = 3.26 ly

Counter Intuitive Brightness Scale



m = apparent magnitude
 M = absolute magnitude

Star of $m = 6$ is 100x brighter than a star of $m = 1$

Distance-Magnitude Relationship

$$M = m - 5 \log\left(\frac{d}{10}\right)$$

$$m - M = 5 \log(d) - 5$$

Try These Page 323

A star is observed to have an apparent magnitude $m = +0.268$ and an absolute magnitude $M = -0.01$. How far is it from Earth in parsecs and light years?

$$m = 0.268 \quad m - M = 5 \log(d) - 5$$

$$M = -0.01 \quad (0.268) - (-0.01) = 5 \log(d) - 5$$

$$d = ?$$

$$0.278 = 5 \log(d) - 5$$

$$5.278 = 5 \log(d) \quad \text{Isolate}$$

$$1.0556 = \log(d) \quad 11.4 \cancel{pc} \times \frac{3.26 \text{ ly}}{1 \cancel{pc}}$$

$$10^{1.0556} = d$$

$$11.4 \cancel{pc} = d$$

$$= 37 \text{ ly}$$

A star is observed to have an apparent magnitude $m = +1.17$ and is at a distance of 25.1 ly from Earth. What is its absolute magnitude?

$$m = 1.17$$

$$M = ?$$

$$d = 25.1 \cancel{\text{ly}} \times \frac{1 \cancel{pc}}{3.26 \text{ ly}} = 7.7 \text{ pc}$$

$$m - M = 5 \log(d) - 5$$

$$1.17 - M = 5 \log(7.7) - 5$$

$$1.17 - M = 5(0.886) - 5$$

$$1.17 - M = -0.5675$$

$$1.17 + 0.5675 = M$$

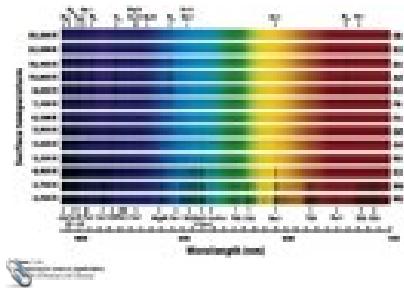
$$1.74 = M$$

Wolf 359 has a parallax angle of $0.419''$ and an apparent magnitude of $+13.44$. What is its absolute magnitude?

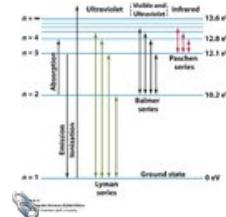
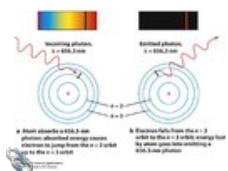
Surface Temperature by Colour and Spectra



Surface colour corresponds to the peak of the blackbody curve.



A star's spectra is a result of the surface temperature and composition. *Stellar Spectroscopy.*



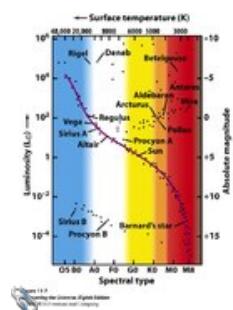
Classifying Stars - Another Unconventional Naming Scheme

Oh Be A Fine Girl (Guy) Kiss Me [Right Now Smack]

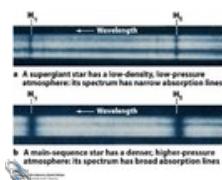
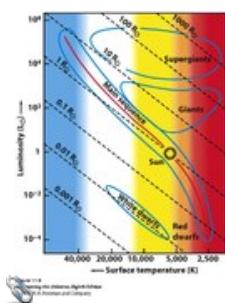
Special Class	Color	Temperature (K)	Special Features	Examples
O	Blue-white	30,000–40,000	Hottest stars; hydrogen fusion in core	Beta Pegasus, Alpha Monocerotis
B	White	10,000–30,000	Hydrogen fusion in core; hydrogen fusion in outer layers	Alpha Pegasi, Alpha Ursae Majoris
A	White	7,000–10,000	Strong hydrogen fusion, outer hydrogen shell	Alpha Herculis, Alpha Aquila
F	Yellow-white	5,000–7,000	Hydrogen shell and helium fusion in core	Alpha Centauri A, Alpha Fornax
G	Yellow	5,000–5,500	Hydrogen shell and helium fusion in core; helium fusion in outer layers	Alpha Virgo, Alpha Arcturus
K	Orange	3,500–5,000	Hydrogen shell and helium fusion in core	Alpha Librae, Alpha Centauri B
M	Red-orange	2,000–3,500	Hydrogen shell and helium fusion in core	Alpha Tauri, Alpha Centauri C

Subdivided into subclasses based on surface temperature.

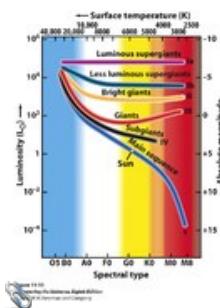
The Hertzsprung-Russell Diagram



Spectral Classes



Luminosity Classes



Knowing a star's position on the H-R Diagram leads to a value of absolute magnitude - *Spectroscopic Parallax*

- Stellar Masses are difficult to determine.
- Calculated through Kepler's Third Law

Spectral Classification Assignment Examples

Kraz
G5 III

$m = 2.62$

$M = -0.54$

$T = 5097 \text{ K}$

$L = 188 L_{\text{sun}}$

$R = ? R_{\text{sun}}$

$D = ? \text{ parsecs}$

State of evolution

$$\frac{L}{L_0} = \frac{R^2}{R_0^2} \frac{T^4}{T_0^4}$$

$$\frac{(188 L_0)}{L_0} = \left(\frac{R}{R_0} \right)^2 \left(\frac{5097}{5800} \right)^4$$

$$L = R^2 \left(\frac{T}{5800} \right)^4$$

$$x \sqrt{y}$$

$$x^y \approx 0.25$$

$$188 = R^2 \left(\frac{5097}{5800} \right)^4$$

$$188 = R^2 (0.8788)^4$$

$$188 = R^2 (0.5964)$$

$$315 = R^2$$

$$17.8 R_0 = R$$

Calculate Star's radius in A.U.

$$17.8 R_0 \times \frac{6.96 \times 10^8 \text{ m}}{R_0} \times \frac{1 \text{ AU}}{1.5 \times 10^{11} \text{ m}}$$

$$= 0.083 \text{ AU}$$

Will not engulf any planets.

Spectral Classification Assignment Examples

Alphard

K3 II

$m = 1.96$

$M = ?$

$T = 5097 \text{ K}$

$L = ? L_{\text{sun}}$

$R = 113 R_{\text{sun}}$

$p = 0.0184''$

$$L = R^2 \left(\frac{T}{5800} \right)^4$$

$$L = (113)^2 \left(\frac{5097}{5800} \right)^4$$

$$L = (12769)(0.5964)$$

$$L = 7610 L_{\odot}$$

$$R = 0.524 \text{ AU}$$

$$m - M = 5 \log(d) - 5$$

$$M = 5 - 5 \log(d) + m$$

$$d = \frac{1}{p} = \frac{1}{0.0184} = 54.3 \text{ pc}$$

$$M = 5 - 5 \log(54.3) + (1.96)$$

$$= 5 - 8.674 + 1.96$$

$$= -1.71$$

Spectral Classification Assignment Examples

Arcturus

K3 II

$m = -0.07$

$M = -0.33$

$T = ? \text{ K}$

$L = 298 L_{\text{sun}}$

$R = 34 R_{\text{sun}}$

$p = ? \text{ "}$

$$L = R^2 \left(\frac{T}{5800} \right)^4$$

$$298 = 34^2 \left(\frac{T}{5800} \right)^4$$

$$\frac{298}{34^2} = \left(\frac{T}{5800} \right)^4$$

$$0.2578 = \sqrt[4]{\left(\frac{T}{5800} \right)^4}$$

$$0.7125 = \frac{T}{5800}$$

$4133^{\circ}\text{K} = T$

$$P = ?$$

$$m - M = 5 \log(d) - 5$$

$$d = ?$$

$$(-0.77) - (-1.33) = 5 \log(d) - 5$$

$$P = \frac{1}{d}$$

$$0.56 = 5 \log(d) - 5$$

$$5.56 = 5 \log(d)$$

$$1.112 = \log(d)$$

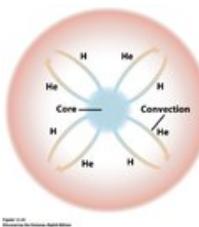
$$10^{1.112} = d$$

$$12.9 \text{ pc} = d$$

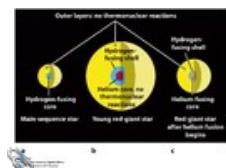
$$P = \frac{1}{12.9} = \boxed{0.077''}$$

Chapter 12.8 to 12.14: Stellar Evolution of Low Mass Stars

Mstar < 0.4 Msun



Mstar > 0.4 Msun

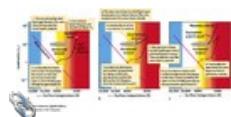


- Helium Fusion in the Core
- Helium Flash for 0.4 to 2 Msun stars
- Electron Pressure
- Helium burning creates more massive elements

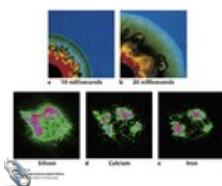
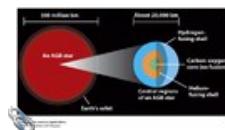
Pg 374 # 2, 6, 7, 10, 11, 14 - 16, 25 - 29.

Chapter 13

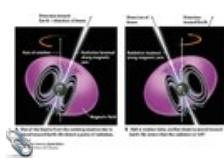
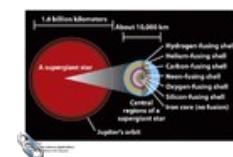
The Death of Stars



Low mass stars form planetary nebulae

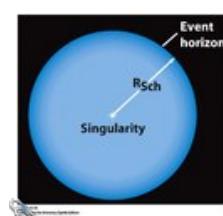
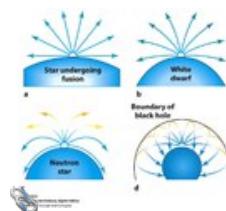
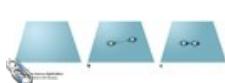


High mass stars explode in a supernova leaving behind a neutron star, pulsar, black hole, or nothing.



	Masses of stars	Masses in solar units	Dimensions of star
Protostellar Cluster	0.1 < M < 10	0.1 < M _{Solar} < 10	2 x 10 ⁻¹⁰
Hydrogen Fusing Cluster	0.1 < M < 100	0.1 < M _{Solar} < 100	2 x 10 ⁻⁹
Hydrogen Fusing Star	0.1 < M < 1000	0.1 < M _{Solar} < 1000	2 x 10 ⁻⁸
Red Giant Cluster	0.1 < M < 10000	0.1 < M _{Solar} < 10000	2 x 10 ⁻⁷
Red Giant Star	0.1 < M < 100000	0.1 < M _{Solar} < 100000	2 x 10 ⁻⁶
White Dwarf Cluster	0.1 < M < 1000000	0.1 < M _{Solar} < 1000000	2 x 10 ⁻⁵
White Dwarf Star	0.1 < M < 10000000	0.1 < M _{Solar} < 10000000	2 x 10 ⁻⁴
Neutron Star Cluster	0.1 < M < 100000000	0.1 < M _{Solar} < 100000000	2 x 10 ⁻³
Neutron Star	0.1 < M < 1000000000	0.1 < M _{Solar} < 1000000000	2 x 10 ⁻²
Black Hole Cluster	M > 1000000000	M > 1000000000	2 x 10 ⁻¹
Black Hole	M > 1000000000	M > 1000000000	2 x 10 ⁻¹

Black Holes (Chapter 14-1 to 14-5)



Pg. 404 # 1 - 3, 5, 7, 9, 17, 19, 23, 28.

Attachments

[figure_12_20.jpg](#)