Homework One

Friday, September 2, 2022 3:44 PM

Savannah Gramze

1. $\rho_\star \sim 0.08\ \star/pc^3$

Ground based $R = 0.02''$

→ upper limit on # ★'s distance

$$0.02'' = \frac{1}{d}$$

$d = 50$ parsecs

$$\rho = \frac{\#\star}{V} \Rightarrow 0.08\frac{\star}{pc^3} = \frac{\#\star}{\frac{4}{3}\pi(50)^3}$$

$$\boxed{\#\star s \sim 41{,}888}$$

Hipparcus $R = 0.001$ arcsec

$0.001'' = 1/d \rightarrow d = 1000$ parsec

$$0.08\frac{\star}{pc^3} = \frac{\#\star}{\frac{4}{3}\pi(1000)^3}$$

$$\boxed{\#\star's = 3.35\times10^8}$$

Gaia $R = 5\times10^{-6}$ arcsec

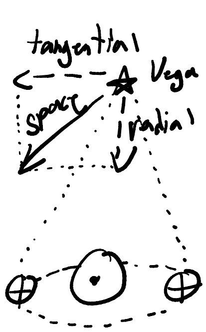
$$d = \frac{1}{5\times10^{-6}''} = 2\times10^5 \text{ parsec}$$

$$\#\star = (0.08)\frac{4}{3}\pi\left(2\times10^5\right)^3$$

$$\boxed{\#\star = 2.68\times10^{15}}$$

Assuming that the telescopes can detect all stars w/in a given distance.

2.



$\lambda_{obs} = 6562.5$ Å

$p = 0.13''$ → parallax

$\Delta\theta = 0.35''/yr$ → Δpos on sky

$$\frac{V_r}{c} = \frac{\Delta\lambda}{\lambda_0}$$

$\lambda_0 = 6562.79$ Å

$\Delta\lambda = 6562.79 - 6562.50 = 0.29$ Å

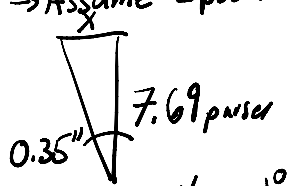
$$\frac{V_r}{3\times10^5 km/s} = \frac{0.29\,\cancel{Å}}{6562.79\,\cancel{Å}} \Rightarrow \boxed{V_{radial} = 13.3\ km/s}$$

$$d = \frac{1}{0.13''} \Rightarrow d = 7.69 \text{ arcsec}$$

→ Assume Δpos on celestial sphere takes into account parallax.

0.15''

→ Assume Δpos on celestial sphere takes into account parallax.



$$\sin(0.35'') = \frac{x}{7.69}$$

$$x = 7.69 \sin(1.69 \times 10^{-6}\ \text{rad})$$

$$0.35'' \cdot \frac{1'}{60''} \cdot \frac{1^\circ}{60'} \cdot \frac{\pi\ \text{rad}}{180^\circ} \qquad V_{tan} = 1.3 \times 10^{-5}\ \text{pc}/\text{yr}$$

$$\frac{1.3 \times 10^{-5}\ \text{pc}}{\text{yr}} \cdot \frac{3.086 \times 10^{13}\ \text{km}}{1\ \text{pc}} \cdot \frac{1\ \text{yr}}{365\ \text{d}} \cdot \frac{1\ \text{d}}{24\ \text{hr}} \cdot \frac{1\ \text{hr}}{3600\ \text{s}}$$

$$\boxed{V_{tan} = 12.8\ \text{km/s}}$$

$$V_{space} = \sqrt{V_{tan}^2 + V_{rad}^2} = \sqrt{(12.8)^2 + (13.3)^2}$$

$$\boxed{V_{space} = 18.4\ \text{km/s}}$$

3. $M_{bolo}^{abs} = -5$

$T = 3000\text{K}$

Estimate L & R

$$f = \frac{L}{4\pi D^2}$$

$$F = \frac{L}{4\pi R^2} \qquad \frac{L}{4\pi R^2} = \sigma T^4$$

$D = 10\text{pc}$

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

$$M_2 - M_1 = 2.5 \log(L_1/L_2)$$

$$M_\odot - M_* = 2.5 \log(L_*/L_\odot)$$

$$4.75 + 5 = 2.5 \log(L_*/L_\odot)$$

$$\boxed{L_* = 7943 L_\odot}$$

$$\frac{7943 L_\odot}{L_\odot} = \left(\frac{R_*}{R_\odot}\right)^2 \left(\frac{3000\text{K}}{5770\text{K}}\right)^4$$

$$\boxed{R_* = 329.7\ R_\odot}$$

$1\ \text{AU} = 215.032\ R_\odot$

$R_* = 1.53\ \text{AU}$ → This star's radius reaches past the orbit of Mars!

$M \sim 10\ M_\odot$

Max avg density? ... $3M$ ... $M_\odot$ ... $2 \times 10^{33}\ \text{g}$ ... $R_\odot^3$

$M = 10 M_\odot$

Max avg density?

$$\rho_{avg} = \frac{M}{V} = \frac{10 M_\odot}{\frac{4}{3}\pi R_*^3} = \frac{30}{4\pi} \cdot \frac{M_\odot}{(329.7 R_\odot)^3} \cdot \frac{2\times10^{33}\,g}{1 M_\odot} \cdot \frac{R_\odot^3}{(6.96\times10^{10}\,cm)^3}$$

$$\boxed{\rho_{avg} = 3.94\times10^{-7}\, g/cm^3}$$

This star would be in the top right of the HR diagram

4. $M_v = -2.76 \log P_d - 1.4$ Cepheid Variables

D to M100 $m_v = 24.9$

$P = 52$ days $\Delta m = 0.15$ mag

$$M_v = -2.76 \log(52) - 1.4$$

$$M_v = -6.14$$

$$m_v - M_v = 5 \log D - 5 + A$$

$$24.9 + 6.14 = 5 \log D - 5 + 0.15$$

$$\boxed{D = 1.5\times10^{7}\,pc = 15\ Mpc}$$

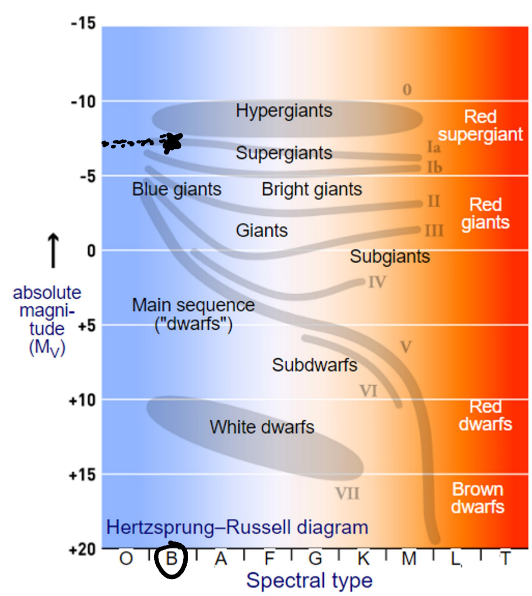
5. Rigel is a B8Ia star

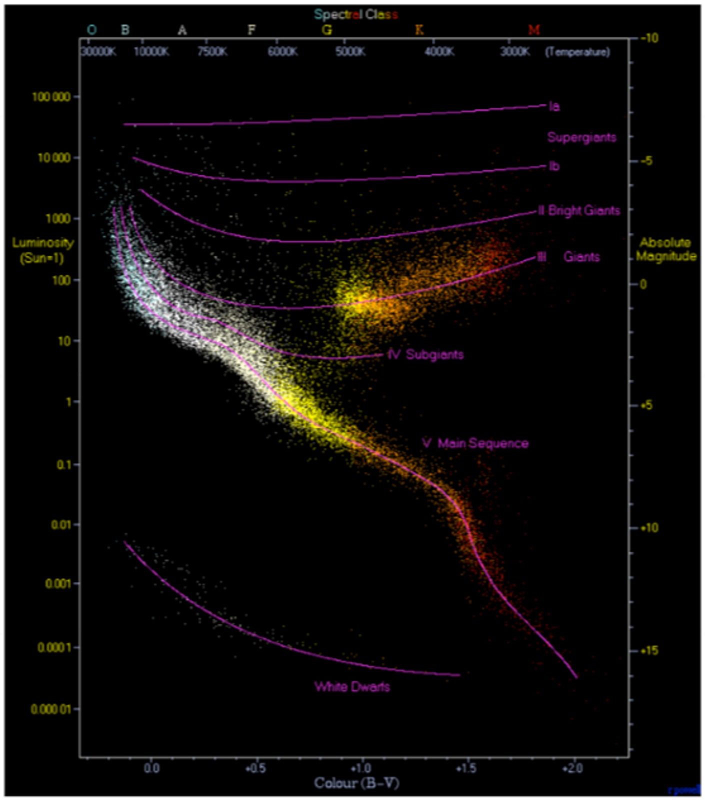
Spectral Type = B8

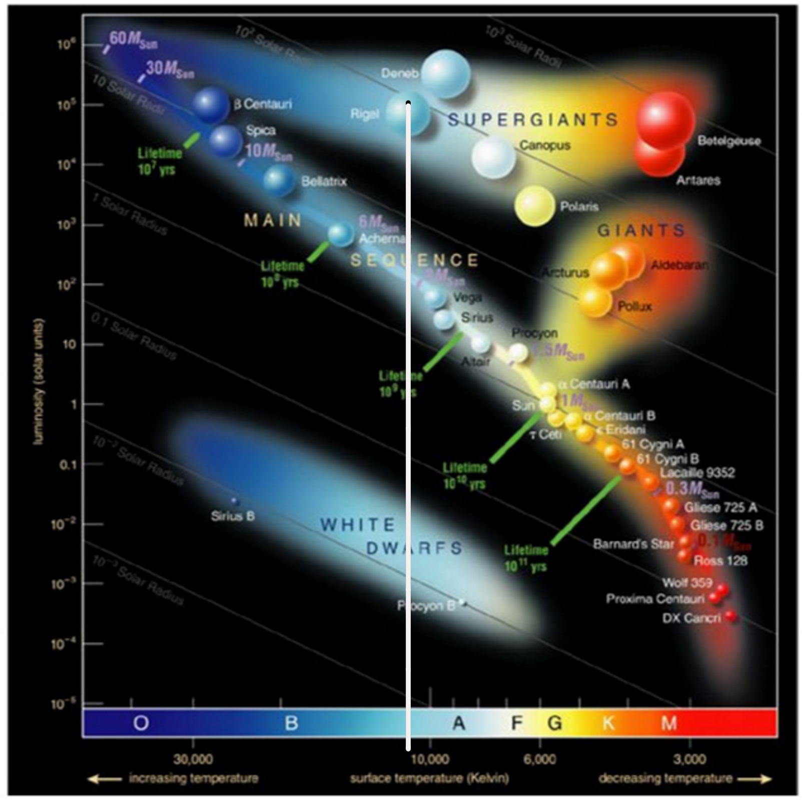
Ia = Very Luminous Supergiant

approx. $M \approx -7$

approx $T \sim 12{,}000\,K$




Spectral Class
O B A F G K M
30000K 10000K 7500K 6000K 5000K 4000K 3000K (Temperature)
Luminosity (Sun=1)
100 000
10 000
1000
100
10
1
0.1
0.01
0.001
0.0001
0.000 01
Absolute Magnitude
-10
-5
0
+5
+10
+15
Ia
Supergiants
Ib
II Bright Giants
III Giants
IV Subgiants
V Main Sequence
White Dwarfs
0.0 +0.5 +1.0 +1.5 +2.0
Colour (B−V)


luminosity (solar units)
10^6 10^5 10^4 10^3 10^2 10 1 0.1 10^{-2} 10^{-3} 10^{-4} 10^{-5}
$60 M_{Sun}$
$30 M_{Sun}$
$10 M_{Sun}$
$6 M_{Sun}$
$1.5 M_{Sun}$
$1 M_{Sun}$
$0.3 M_{Sun}$
$0.1 M_{Sun}$
10^3 Solar Radii
10^2 Solar Radii
10 Solar Radii
1 Solar Radius
0.1 Solar Radius
10^{-2} Solar Radius
10^{-3} Solar Radius
Lifetime 10^7 yrs
Lifetime 10^8 yrs
Lifetime 10^9 yrs
Lifetime 10^{10} yrs
Lifetime 10^{11} yrs
SUPERGIANTS
GIANTS
MAIN SEQUENCE
WHITE DWARFS
Deneb
Rigel
β Centauri
Spica
Bellatrix
Achernar
Canopus
Polaris
Betelgeuse
Antares
Arcturus
Aldebaran
Pollux
Vega
Sirius
Altair
Procyon
α Centauri A
Sun
α Centauri B
τ Ceti
ε Eridani
61 Cygni A
61 Cygni B
Lacaille 9352
Gliese 725 A
Gliese 725 B
Barnard's Star
Ross 128
Wolf 359
Proxima Centauri
DX Cancri
Sirius B
Procyon B
O B A F G K M
30,000 10,000 6,000 3,000
increasing temperature
surface temperature (Kelvin)
decreasing temperature