Star parallax See Kirk p.126

In the following $x(\text{unit})$ means the number for x in those units.

$$d(AU) \times \theta(rad) = 1 \quad \text{(arc of circle length 1AU)}$$

$$1\ AU = 1.5 \times 10^{11}\ m.$$

So $d(AU) = \dfrac{1}{\theta(rad)}$

We now invent a new distance unit: pc.
so that $\boxed{d(pc) = \dfrac{1}{\theta('')}}$ where $1'' = \dfrac{1}{3600}^\circ$. (arcsec)

We want to know how to get from pc to AU:

$$k\, d(pc) = d(AU).$$

~~[illegible]~~

$$\theta('') = 3600 \times \frac{180^\circ}{\pi}\, \theta(rad)$$

So: $k = \dfrac{d(AU)}{d(pc)} = \dfrac{\theta('')}{\theta(rad)} = 3600 \times \dfrac{180}{\pi}$

or $k = 206\,265$

so: $1pc = 206265\ AU =$ ~~[illegible]~~ $3.26\ ly.$

Minimum measurable $\theta = 0.01''$ $\Rightarrow$
Maximum measurable dist. $= 100\ pc.$

(Se eventually Stjerner.pdf, drawings p.2).

Luminosity, brightness, magnitude

(Se Kirk p. 122, 127)

Luminosity (absolute) [W] : Total power radiated from star.

Brightness (apparent) [W m^{-2}] : Intensity of starlight at Earth.

$$(*1) \qquad \boxed{b = \frac{L}{4\pi d^2}, \quad d \text{ distance to star}}$$

Apparent magnitude : Logarithmic measure of brightness.

Comparing two stars, 1 & 2 :

$$(*2) \qquad \boxed{m_2 - m_1 = -\frac{5}{2}\log\left(\frac{b_2}{b_1}\right)}$$

If $m_2 - m_1 = 5$, then $\frac{b_2}{b_1} = 10^{-2}$ (OBS! $m_2 > m_1 \Leftrightarrow b_2 < b_1$)

If $m_2 - m_1 = -1$, then $\frac{b_2}{b_1} = 10^{\frac{2}{5}} = 2.512$.

(The zero-point of the m-scale tradionally was defined, first so m = 6 correspond to faintest observable star w. naked eye, later so m = 0 for the star Vega, now more modern definition).

Absolute magnitude M

	Real position	Virtual position
Dist.	d	10pc
Magnitude	m	M
Brightness	b	b_{10pc}

> Definition: The absolute magnitude M for a star is the apparent magnitude it would have if positioned at dist. 10pc.

From (*1) and (*2):

$$m - M = -\frac{5}{2}\log\left(\frac{b}{b_{10pc}}\right) \quad \& \quad \frac{b}{b_{10pc}} = \frac{10^2}{d^2}$$

$$\Rightarrow m - M = -\frac{5}{2}\log\left(\frac{10^2}{d^2}\right) = 5\log\left(\frac{d}{10}\right)$$

so

$$\boxed{m - M = 5\log\left(\frac{d}{10}\right) = 5\log d - 5 \quad (d \text{ in pc})}$$

Luminosity & absolute magnitude M

Compare an arbitrary star (*) with the Sun (s).

(*2) $$m_* - m_s = -\frac{5}{2}\log\left(\frac{b_*}{b_s}\right)$$

Now imagine we move the star * and the Sun s to dist. 10pc.

then: (*3) $$M_* - M_s = -\frac{5}{2}\log\left(\frac{b_{*10pc}}{b_{s10pc}}\right)$$

The luminosity $L = 4\pi d^2 b$ (*1) is of course independent of the position of the star. At dist. 10 pc we get:

$$\left\{\begin{array}{l} L_* = 4\pi(10pc)^2 b_{*10pc} \\ L_s = 4\pi(10pc)^2 b_{s10pc} \end{array}\right\} \text{ or } \left\{ \frac{L_*}{L_s} = \frac{b_{*10pc}}{b_{s10pc}} \right.$$

Inserting this in (*3) we get:

(* 4) $$\boxed{M_* - M_s = -\frac{5}{2}\log\left(\frac{L_*}{L_s}\right)}$$

Compare with (*2): apparent magnitude $\rightarrow$ abs. magnitude

brightness $\rightarrow$ luminosity

Luminosity, temperature, wavelength

For a star with radius R, temperature T and radiation wavelength λ we have (Kirk p.74):

Stefan-Boltzman law: $\boxed{L = \sigma A T^4 = 4\pi R^2 \sigma T^4}$

(σT^4 [$W m^{-2}$] is also called the radiation flux at the (F) surface of the star. Compare with brightness b being the radiation flux from the star at the Earth).

$$\sigma = 5.67 \times 10^{-8}\, W m^{-2} K^{-4}$$

Wien's displacement law: $\boxed{\lambda_{max} \cdot T = 2.90 \cdot 10^{-3}\, m \cdot K}$

Data compared to Sun The Sun is often used as reference for star data

Sun: $L = 3.9 \cdot 10^{26} W$. $T = 5800K$. $\lambda_{max} = 5.0 \times 10^{-7} m$

$R = 6.96 \cdot 10^{8} m$. $M = 4.8$ $F = \sigma T^4 = 6.42 \cdot 10^{7} W m^{-2}$.

mass $m = 2.00 \times 10^{30} kg$. Spectral class: G2. Lifetime: $10^{10} y$

Mass-luminosity relation & lifetime of star.

Main sequence stars (in HR diagram) on the average follow an empirical mass-luminosity relation: $\boxed{L \propto m^{3.5}}$

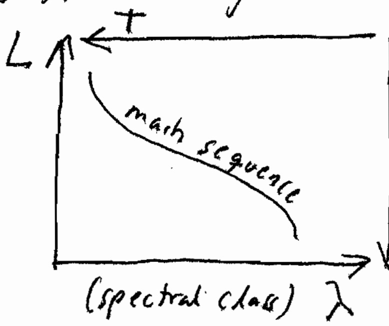
The amount of fuel $\propto m$.

Lifetime $\tau \propto m$ and $\tau \propto \frac{1}{L}$.

Average lifetime: $\tau_* = 10^{10} y \, \frac{M_*}{M_s} \cdot \frac{L_s}{L_*} = 10^{10} y \left(\frac{M_s}{M_*}\right)^{2.5}$

The H-R diagram (Kirk p.125)

As $M \leftrightarrow L$ (p.3 + 4) and $T \leftrightarrow \lambda$ (p.4, Wien)
the H-R diagram can be presented in several ways.



Assuming the star to be a main sequence star, H-R-diagram relates L to spectral class ("spectroscopic parallax")

Distance and knowledge of star

See strategy-charts 1 & 2 from "Physics" by Gregg Kerr and Paul Ruth, IBID Press.

Method	Range	Remark
Trigonometry	Solar system	
Parallax	< 100 pc	See chart 1
"Spectroscopic "parallax"	< 10 Mpc	See chart 2
Cepheid variables	< 60 Mpc (?)	See chart 2 Problem: Two types of Ceph.
Super redgiants, super blue giants, supernovae	< 250 Mpc	
Globular clusters, supernovae	< 900 Mpc	
Supernovae	— —	
Redshift	"edge" of Universe	Hubble's law (Kirk p.135)

Also lots of other special methods exists!
Hyade method, Tully-Fisher relation, - - -

Chart 1 Distance measured by parallax:

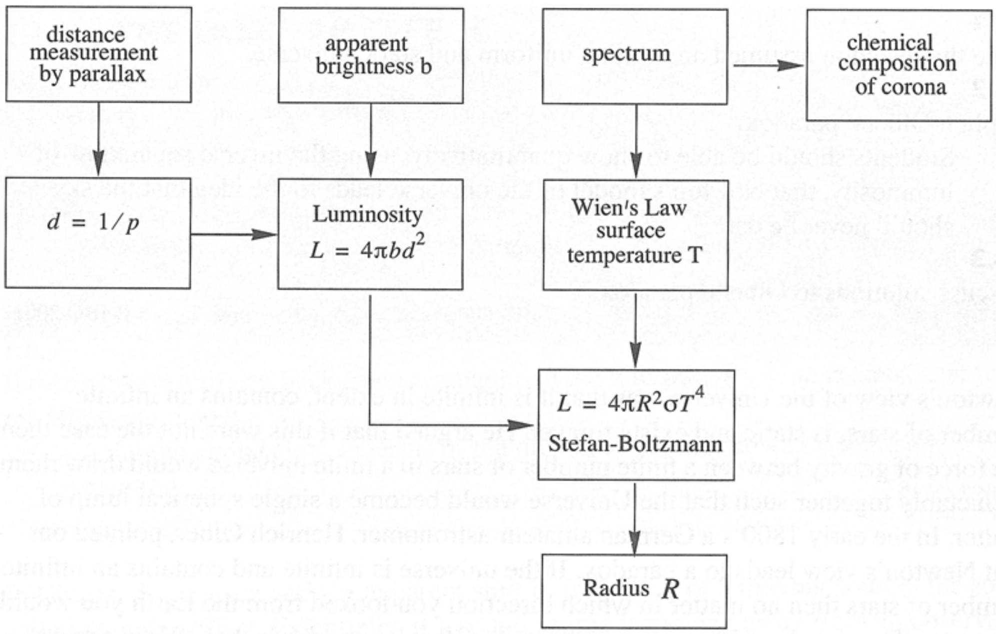


Chart 2 Distance determined by spectroscopic parallax/cepheid variables.