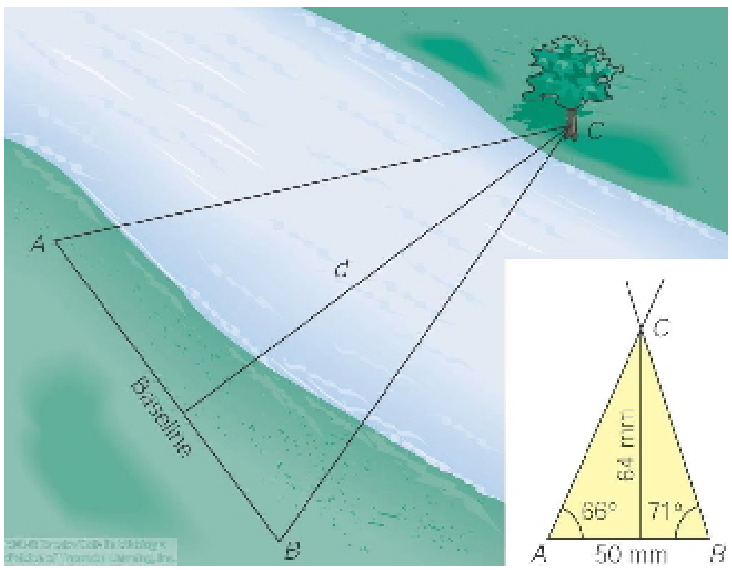
1 Measuring Stars

Gaining knowledge of stars can be done by applying direct measuring techniques or by using indirect methods.

1.1 Measuring distances

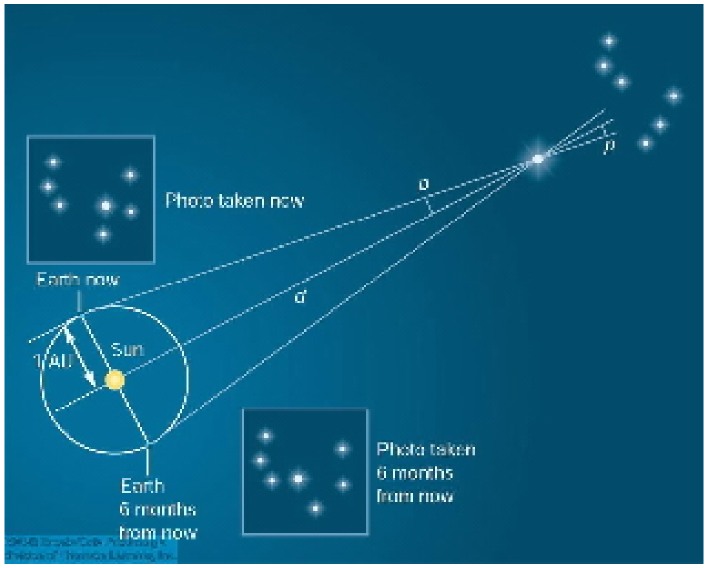
1.1.1 Surveyor's method - direct

Parallax - requires a baseline



Angle is measured in arc-seconds (or milliarc-seconds)

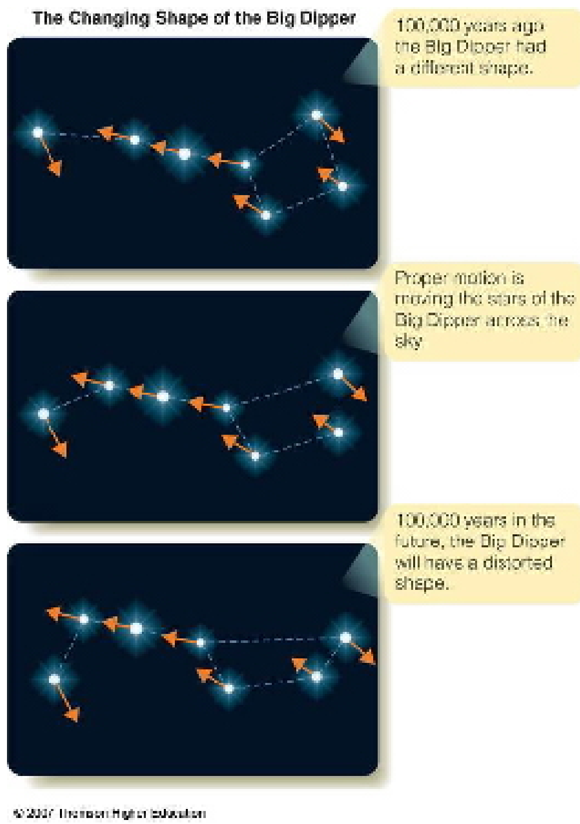
$$d = \frac{1}{p}$$



If p is in arc-seconds, then d is in parsecs
1 parsec $\simeq$ 3.26 light years

1.1.2 Proper motion

Position of stars changes slowly over time



Units of arc-seconds per year
Same as transverse motion
Different from radial motion
True motion is the combination of proper and radial
Distant stars usually have small proper motions
Close stars tend to have larger proper motions

1.1.3 Intrinsic Brightness

What determines the brightness of a star?
Temperature
Size
Distance

Absolute Visual Magnitude The magnitude that a star would have if it were at a distance of 10 parsecs
Only includes the visible light

Magnitude-distance formula

$$m_v - M_v = -5 + 5\log_{10} d$$

$$\text{distance modulus} = m_v - M_v$$

$$d = 10^{\frac{m_v - M_v + 5}{5}}$$

Table 9-1 | Distance Moduli

$m_v - M_v$	d (pc)
0	10
1	16
2	25
3	40
4	63
5	100
6	160
7	250
8	400
9	630
10	1000
⋮	⋮
15	10,000
⋮	⋮
20	100,000
⋮	⋮

1.1.4 Luminosity, L

The total amount of energy the star radiates in 1 second

Need to take into account all wavelengths of light, even the ones we can't see

1.1.5 Absolute Bolometric Magnitude

Hot and cool stars have a large correction

Medium temperature stars have a small correction

Absolute Bolometric Magnitude of Sun is +4.7

Example, Arcturus has an absolute bolometric magnitude of −0.3, the difference between Arcturus and Sun is 5 magnitudes, therefore, Arcturus is 100 times more luminous than Sun

1.1.6 Diameters of Stars

Recall, luminosity is

$$
\begin{aligned}
L &= \sigma A_s T^4 \\
L &= \sigma \left(4\pi R^2\right) T^4
\end{aligned}
$$

Comparing a star that has a radius of 10 times Sun but only half the temperature then

$$\frac{L}{L_\odot} = \frac{\sigma \left(4\pi (10R)^2\right) (.5T)^4}{\sigma \left(4\pi R^2\right) T^4}$$

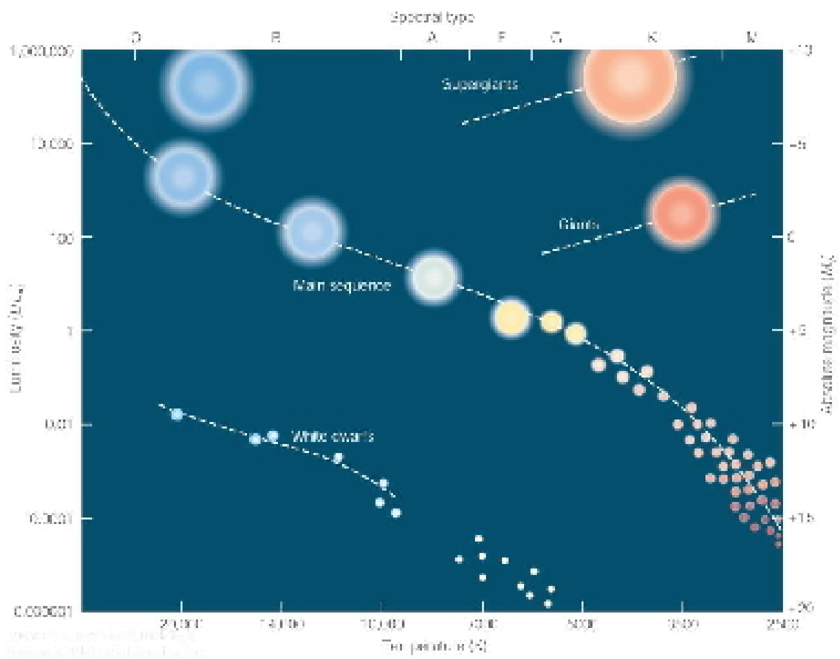
Then the luminosity will be 6.25 times the Sun's luminosity

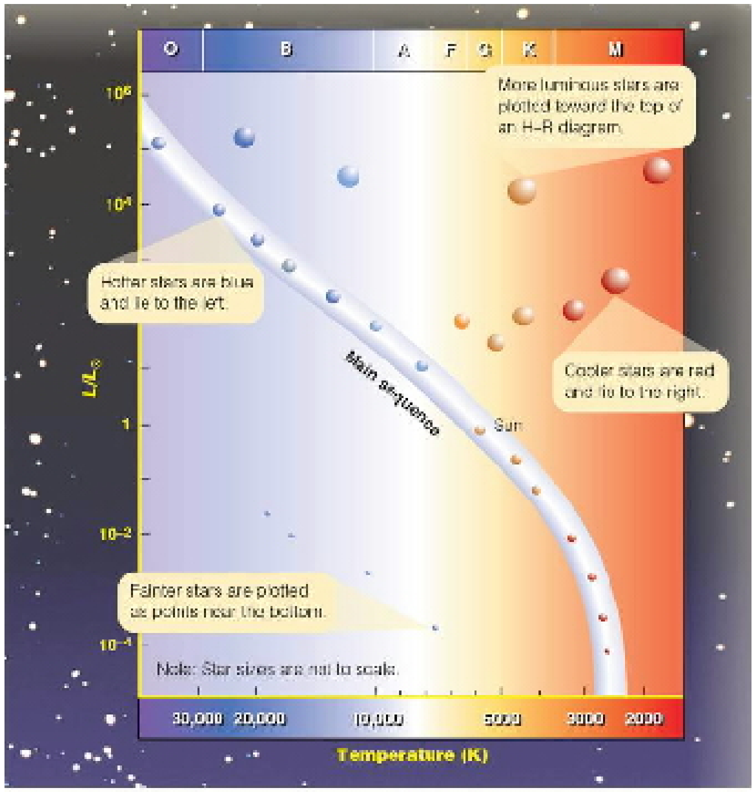
1.2 The Hertzsprung-Russell Diagram

The $H - R$ Diagram is the most important diagram in astronomy

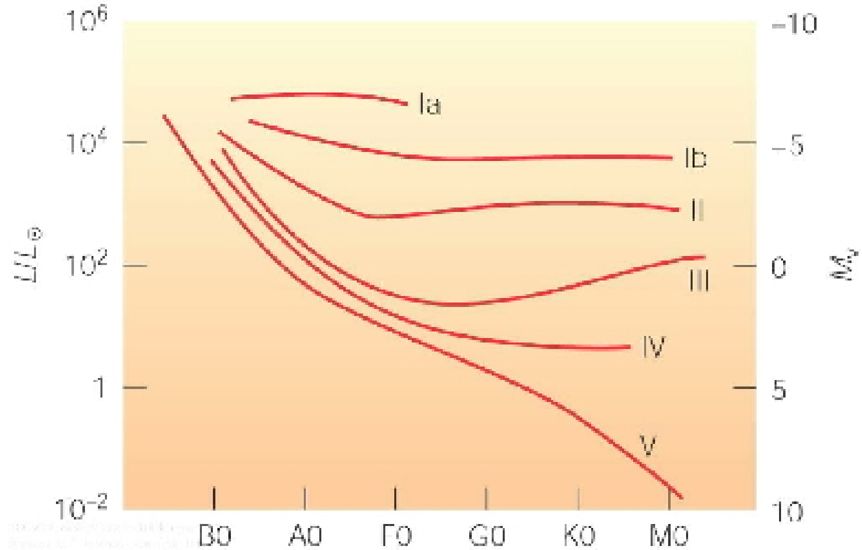
It relates Luminosity to Temperature

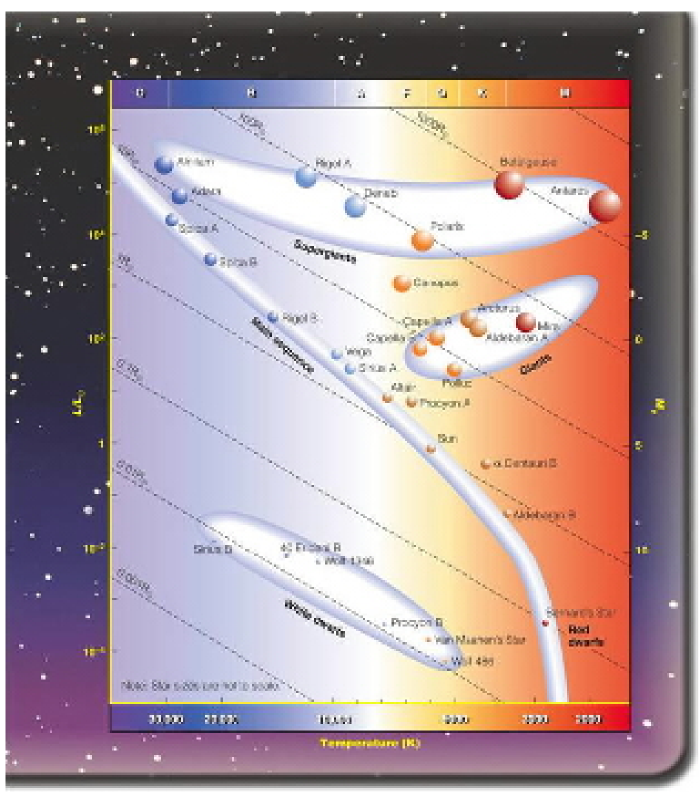
Or it relates Absolute Magnitude to Spectral class





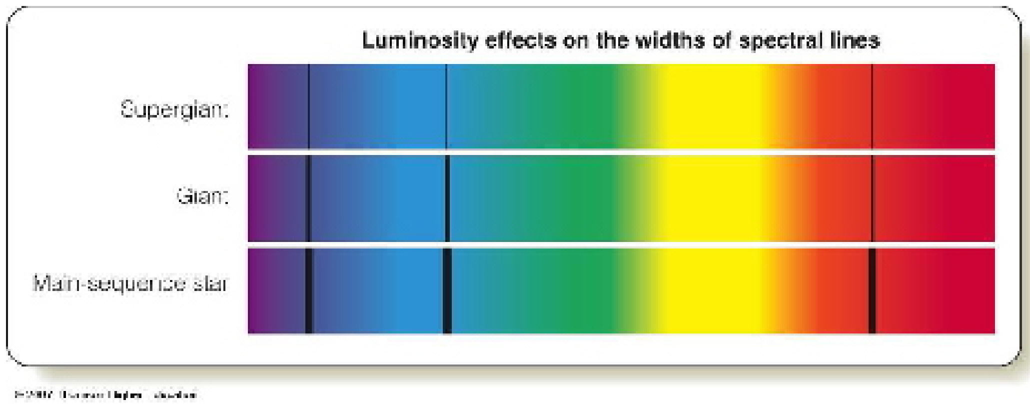
Luminosity Classification Ia - Bright Supergiant
Ib - Supergiant
II - Bright giant
III - Giant
IV - Subgiant
V - Mainsequence
wd - White Dwarf

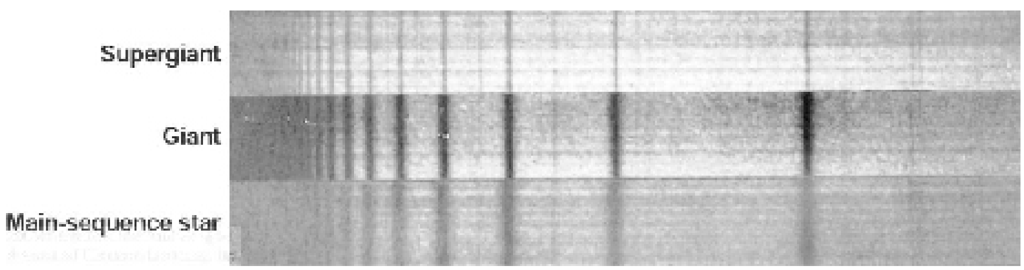




The widths of the spectral lines distinguish between the luminosity classes

(broadening mechanisms)





1.2.1 Spectroscopic Parallax

Photograph the star's spectrum

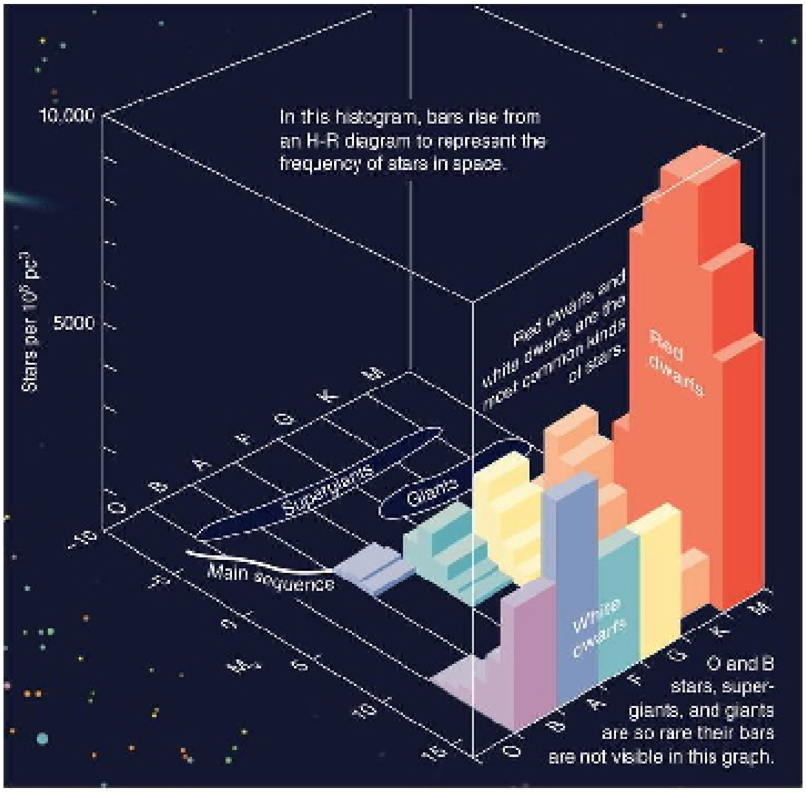
Determine the spectral class of the star, this determines its horizontal position on the HR diagram

Determine the luminosity class by looking at the widths of the spectral lines, this determines its vertical position on the HR diagram

Then read off the absolute magnitude of the star, this determines the brightness as compared to the sun

1.2.2 Sun - Majority or Minority

Frequency of stellar types



10,000
5000
Stars per 10^6 pc^-3
In this histogram, bars rise from an H-R diagram to represent the frequency of stars in space.
Red dwarfs and white dwarfs are the most common kinds of stars.
Red dwarfs
White dwarfs
Supergiants
Giants
Main sequence
O B A F G K M
-10 -5 0 5 10 15
M_v
O and B stars, supergiants, and giants are so rare their bars are not visible in this graph.