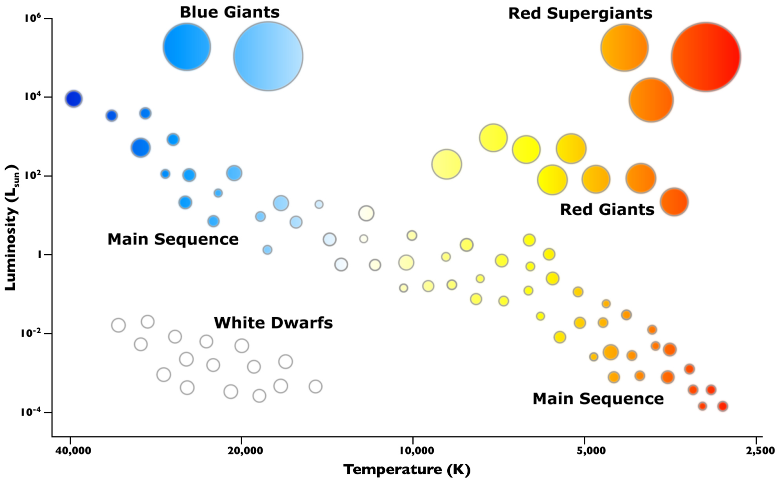
FLIPPED around PHYSICS

9.4 Spectral class

videos

Stars vary in their size and their surface temperature. Main sequence stars (see section 9.5) have a surface temperature which is linked to their mass. Larger mass stars have hotter surface temperatures than lower mass stars.



According to Wien's displacement law the peak wavelength of emitted light is related to the surface temperature of the star. This means that large mass stars on the main sequence are bluish in colour, and low mass stars are reddish.

The diagram (above) is called a Hertzsprung-Russell diagram. It plots the surface temperature of a star against its luminosity (i.e. the total power output of the star). (Note: In this diagram the luminosity is relative to that of the Sun.)

(1) What (roughly) is the relative luminosity and surface temperature of main sequence stars that are blue in colour?

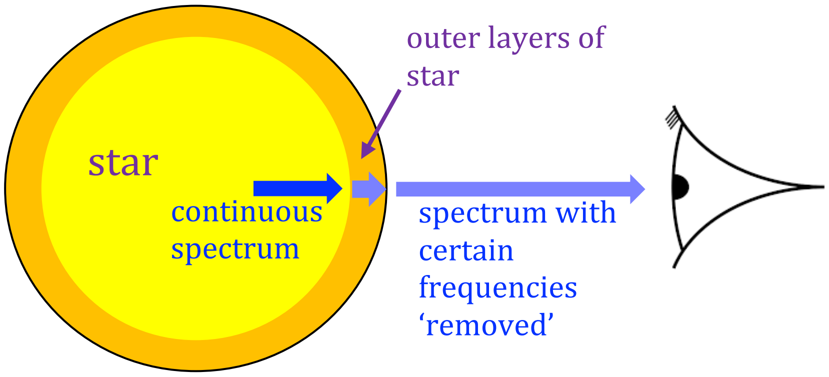
(2) What (roughly) is the relative luminosity and surface temperature of main sequence stars that are red in colour?

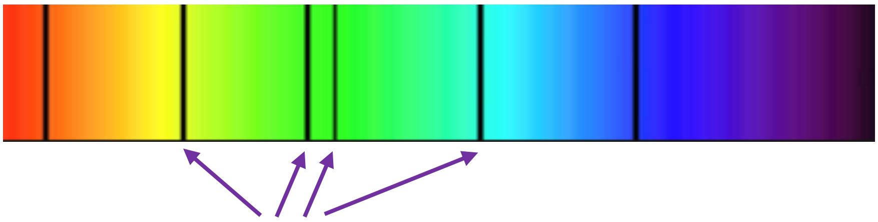
(3) Red giant, red supergiant and red main sequence stars have similar surface temperatures. How are they different?

(4) What is the relative luminosity and surface temperature of the Sun?

Absorption spectra

When a continuous spectrum of light passes out from a star the light passes through the outer layers of the star. Certain frequencies are absorbed by elements/ions in these layers as electrons in these elements/ions are excited to higher energy levels. These are precise frequencies related to the energy required for electrons to move from one energy level to another. The absorption lines produced are characteristic of the elements/ions in these outer layers. This gives us evidence for the composition and surface temperature of the star.





At the end of the nineteenth century, astronomers adopted a system for classification based on the relative strength of hydrogen absorption lines (see section 2.10.1) seen in a star's visible light spectrum. Initially, these were given sequential letters in the alphabet, A, B, C, etc. (With class A having the strongest hydrogen absorption lines). Subsequently, it was found that this order did not reflect any fundamental property (e.g. mass) of stars. The order was changed, and some letters eliminated, so that the order is now OBAFGKI. This order is directly related to the surface temperature of a star.

spectral class	colour	surface temperature (K)	prominent absorption lines
O	*blue*	*25000 - 50000*	He^{+}, He, H
B	*blue*	*11000 - 25000*	He, H
A	*blue-white*	*7500 - 11000*	*H strongest + ionised metals*
F	*white*	*6000 - 7500*	*ionised metals*
G	*yellow-white*	*5000 - 6000*	*ionised and neutral metals*
K	*orange*	*3500 - 5000*	*neutral metals*
M	*red*	*2500 - 3500*	*neutral atoms, TiO*

One way to remember the spectral class order (from hottest to coolest) is to use the following acronym:

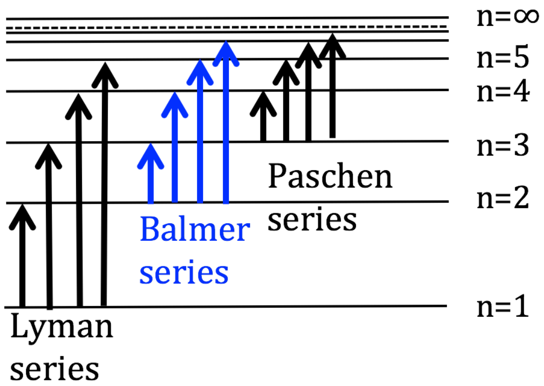
"Oh Be A Fine Girl(Guy), Kiss Me"

The Sun is a main sequence yellowish star with a surface temperature of 5800 K.

(5)✎ What spectral class is the Sun in?

(6)✎ What are the most prominent absorption lines seen for the Sun?

The final column in the table (above) shows the most prominent absorption lines in the visible part of the spectrum. For example, spectral class A stars have prominent hydrogen absorption lines. These correspond to electron transitions from n=2 to higher energy levels in hydrogen (the Balmer series).



(7)✎ Why are many electrons not in the lowest energy level (n=1) in these stars?

(8)✎ The Balmer series of absorption lines occur in the visible part of the spectrum. What part of the spectrum would the Lyman series of absorption lines occur? (Hint: They require larger energy transitions.)

(9)✎ What part of the spectrum would the Paschen series of absorption lines occur? (Hint: They require smaller energy transitions.)

(10)✎ Ionised helium are prominent absorption lines for the very hottest stars. Why might this be?