

GCSE Astronomy Topic 3 Key Facts

What's in the sky?

A double star may be 2 or more stars orbiting each other (True binaries)

Stars in a cluster are relatively close and may influence each other gravitationally

An optical double is two stars which appear close but may be very different distances from us

A constellation is a part of the sky. The stars in a constellation may be at very different distances from us.

There are 88 constellations. The system we use now was adopted in 1930

An asterism is a pattern of stars in the sky, e.g. The Plough

Brightness

Stars have traditional names, e.g. Betelgeuse, Rigel

They also have Bayer designations, e.g. Alpha Orionis, Beta Orionis

Greek letters are used with alpha the brightest, beta the second etc. (α β γ δ ϵ)

Using Constellations

I can sketch the Plough, Orion, Cygnus and Cassiopeia and I can use these pointers

- Arcturus and Polaris from the Plough
- Sirius, Aldebaran and the Pleiades from Orion
- Fomalhaut and the Andromeda Galaxy from the Great Square of Pegasus

Certain constellations can be seen on any evening throughout the year. Their stars are circumpolar.

Other constellations are best viewed at certain times of year, when the Sun is opposite them on the ecliptic. (E.g. stars in Orion have a RA of about 6H so Orion is best viewed when the Sun has a RA of about 18H, i.e. in winter.)

What constellations you can see also depends on your latitude

Declination and Right Ascension

Declination is similar to latitude. The declination of a star is its angle, North or South, above the celestial equator.

Right ascension is similar to longitude but is measured in hours and minutes, not degrees.

The right ascension of a star is the time it would be at on a 24 hour clock which starts on an imaginary line called the prime meridian.

Circumpolar Stars

You can find your latitude by measuring the elevation of Polaris above the horizon

A star is circumpolar if it never sets below your horizon, this will depend on your latitude.

A star is circumpolar from latitude L if its declination is greater than $90 - L$

Stars cross the observers meridian and culminate when they are due south

Star Charts

A star chart is a map of all or part of the sky with Right Ascension and Declination as coordinates.

On a full sky chart the celestial equator passes through the middle horizontally at declination 0

The ecliptic is the path of the Sun. The position of the Sun changes as follows through the year.

March 21st	RA 0h Dec 0	(the ecliptic crosses the celestial equator, the prime meridian is here)
June 21st	RA 6h Dec 23.5	(the Sun is highest in the sky, the summer solstice)
September 21 st	RA 12h Dec 0	(the autumnal equinox)
December 21 st	RA 18h Dec -23.5	(the Sun is lowest in the sky, the winter solstice)

In 1771 Charles Messier catalogued 110 celestial objects. E.g. the Andromeda Galaxy is M31

Parallax

When we observe nearby stars at different times of the year they appear to have moved relative to the background of much more distant stars. This is called heliocentric parallax.

By measuring the parallax angle we can calculate how far away these stars are

We can use this method for about 2000 stars. The rest are too far so the angle is too small to measure accurately.

If a star has a parallax angle of 1 second over a period of 6 months ($1/60^{\text{th}}$ of a minute which is $1/60^{\text{th}}$ of a degree) then the star is 1 parsec away. 1 parsec is equal to 3.2 light years.

Apparent magnitude (m)

The apparent magnitude of a star is how bright it appears to be

Hipparchus devised a scale where the dimmest stars we can see are $m=6$ and the brightest $m=1$

$m=1$ stars are actually 100 times brighter than $m=6$. The difference between magnitudes works out as 2.51 times. This is called Pogson's ratio. (e.g. a star which is $m=3.4$ is $2.51 \times$ brighter than $m=4.4$)

Absolute magnitude (M)

The absolute magnitude of a star is how bright it would appear to be if it were 10 parsecs (32 light years) away

We can use this to compare how bright stars actually are, their luminosity

The relationship between M and m is $M = m + 5 - 5 \log_{10}d$ where d is the distance in parsecs

if $d=10$ then $\log_{10}d = 1$, if $d=100$ then $\log_{10}d = 2$, if $d=1,000$ then $\log_{10}d = 3$, if $d=10,000$ then $\log_{10}d = 4$

E.g. a star 1,000 parsecs away is $m=8.6$. Calculate M $M = 8.6 + 5 - (5 \times 3) = -1.4$

Light Curves

The apparent magnitude of some stars varies with time. You should recognise the light curves for Eclipsing binaries, Super Novae and Cepheid variables.

Some stars grow brighter and dimmer over a period of several days. This is probably because the forces in them are not balanced. They are called Cepheid variables as the first one discovered was Delta Cepheus.

Bigger and brighter variables take longer to pulsate. By measuring how long it takes to pulsate we can calculate the absolute magnitude of the variable star. Knowing this we can then calculate how far away it is.

This is an important method for measuring the distance to stars and galaxies.

Spectrum of a Star

If we pass the light from a star through a spectrograph we can study its spectrum.

Stars emit more of some colours than others. Where this bulge is tells us the temperature and type of star.

There are certain wavelengths missing. These are due to the different elements that the star contains.

By measuring any red or blue shift we can calculate the velocity of the star relative to us.

OBAFGKM

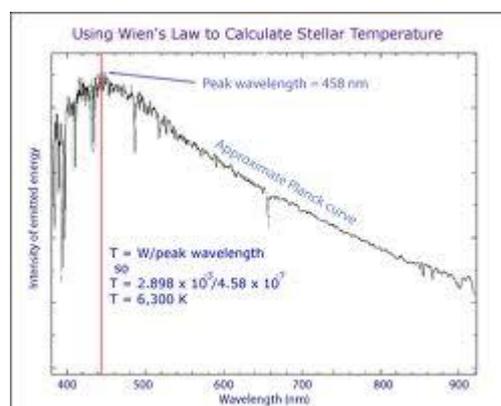
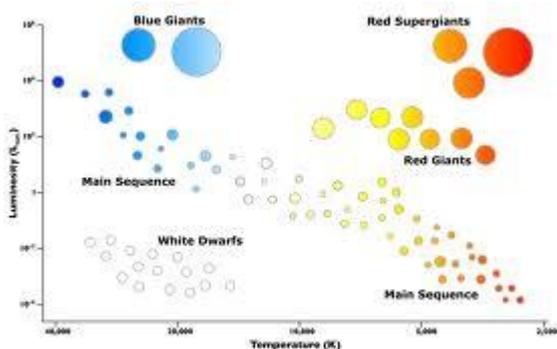
Each letter represents a different type of star from very hot blue stars to much cooler red stars.

Our Sun is a G2 yellow star.

The HR Diagram

If we plot OBAFGKM on the x axis and brightness on the y axis we get a very useful graph which helps us to understand different types of star and how stars evolve

You should be able to sketch a HR diagram and label the 4 main regions.



The life of our Sun

- Nebula** A huge cloud of hydrogen, dust and possibly other elements
- Protostar** The hydrogen has started to clump. Pressure and temperature is increasing. If the star is less than 0.1 solar masses then fusion never starts, e.g. Jupiter
- Yellow star** Fusion has started and is ticking over slowly. Our Sun will last about 10 billion years.
- Red Giant** Hydrogen in the core is dwindling so fusion spreads to outer layers. The star expands greatly
- Planetary nebula** The red giants outer layers are ejected into space as the stars shrinks
- White dwarf** A very small hot star remains which will eventually cool to become a black dwarf

The life of more massive stars

More massive stars are hotter and do not last as long as they burn their fuel much quicker

Stars greater than 8 solar masses explode at the end of their lives in a supernova leaving a neutron star or, if greater than 10 solar masses, a black hole.

A neutron star is an incredible dense small object which spins rapidly emitting jets of matter and radiation into space.

Scientists first thought these pulses of radiation may be extra terrestrial communications.

A black hole is even denser. Its gravity is so strong that even light cannot escape. As matter swirls around the black hole it emits x rays, the first evidence for their existence.

There are believed to be massive black holes at the centre of all galaxies including our own.

Nebulae

There are 4 types of nebula

- Emission** These are red. Stars within them excite hydrogen atoms causing them to emit red light
- Reflection** These are blue. Light from stars is scattered by dust and gas, just as our sky is blue
- Absorption** These are dark. Light from stars in the background is absorbed by dust and gas
- Planetary** These are the remnants of stars such as our own

Star Trails

A long exposure photograph will produce a picture showing star trails

By measuring the angle these trails make with Polaris we can calculate the length of a sidereal day