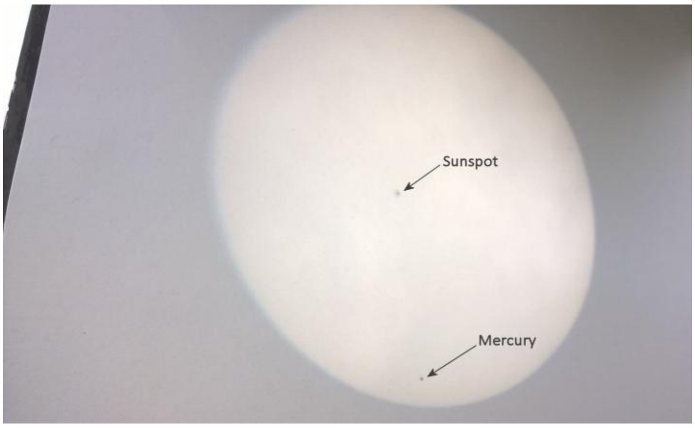
NEWBURY ASTRONOMICAL SOCIETY
MONTHLY MAGAZINE – NOVEMBER 2019

MERCURY TRANSIT 11TH NOVEMBER 2019

During the afternoon of Monday 11th November there will be a Transit of the planet Mercury. Transits occur when the inner planets Mercury or Venus pass directly between the Sun and Earth. Mercury will appear as a small dot that can be seen to slowly move across the Sun. The last transit of Mercury was on Monday 9th May 2016 and the next will be 13th November 2032.



The projected image of the 7th May 2003 transit

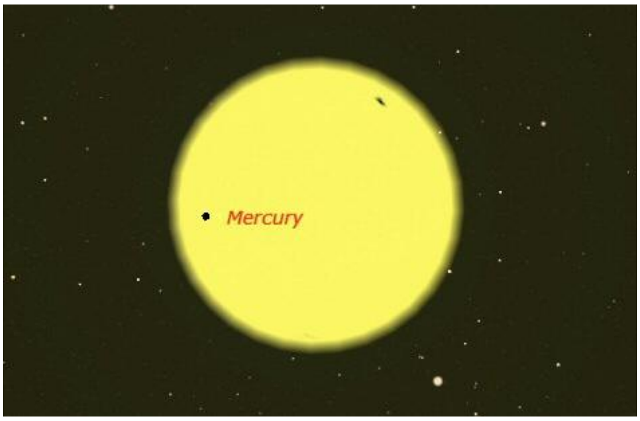
A telescope fitted with a suitable and safe solar filter will be required to see Mercury during the transit. Alternatively the image from a telescope must be projected on to a screen for safe viewing (see the images above and below). Never look directly at the Sun and never use binoculars or a telescope to look at the Sun without a solar filter.

The telescope set up used to take the picture above.

Here are the key times for watching the transit:

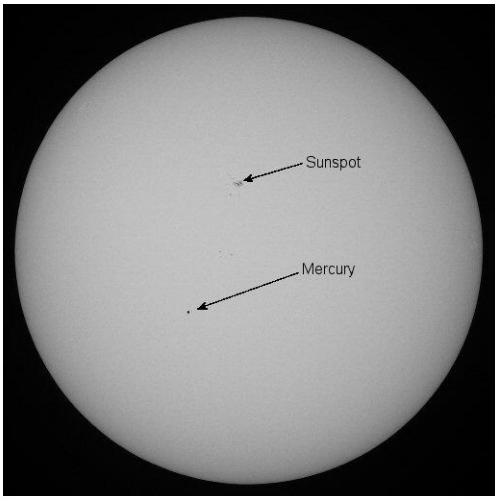
Begins:	Monday 11th November 2019	12:35
Midpoint:	Monday 11th November 2019	15:19
Ends:	Monday 11th November 2019	16:17
Duration:	3 hours, 42 minutes	

The very end of the transit will not be visible from the UK as the Sun sets over the western horizon at 16:15.



Location of Mercury at 13:00 (sky darkened)

Transits of Mercury usually occur every 10 years then 3 years and then another 10 years and 3 years. The 10th year always occurs in May and the 3rd year transit is always in November. The last transit of Mercury was on the 9th May 2016 three years ago so this coming transit will be on Monday 11th November 2019. The next transit will be an odd one occurring on 13th November 2032 (13 years) then 7th November 2039 (7 years) It then reverts back to 7th May 2049 (10 years) and 8th November 2052 (3 years).



A SOHO image of the 9th May 2016 transit

Transits of Mercury are not spectacular but they are interesting because Mercury is difficult to see as it is always close to the Sun. A transit does allow us to see Mercury even though it is in silhouette. If it is cloudy or it is not possible to follow the transit, SOHO images can be obtained at: http://sohowww.nascom.nasa.gov/.

NEWBURY ASTRONOMICAL SOCIETY MEETING

1st November How We Will Live on Mars
Website: **www.newburyastro.org.uk**

NEXT NEWBURY BEGINNERS MEETING

20th November Spectroscopy the colour of light
Website: **www.naasbeginners.co.uk**

SHOULD I ASK SANTA FOR A TELESCOPE FOR CHRISTMAS?

A typical Refracting Telescope

A typical Reflecting Telescope

A beginner to the hobby astronomy is bound to ask the question 'Do I need a telescope for astronomy?' The answer is as with most questions like this is Yes and No. It all depends on how we progress in the hobby and what we want to do in astronomy.

Initially it is useful to start by finding our way around the night sky and to learn from books and magazines what the hobby of astronomy is all about. Another thing is to join your local Astronomical Society where you will find more experienced astronomers who will be willing to give you all the advice you need.

Usually advice will be to start with obtaining a good pair of binoculars. This is sound advice and all astronomers should have a pair. However if we want to see detail on the Moon and planets or see some of the deep sky objects (galaxies and star clusters) we will need a telescope.

Before looking at the range of telescopes that is available, there are two important factors to be considered. First: how much can be afforded to buy the telescope and second what is it primarily going to be used for. The worst possible choice is the one that never gets used. A telescope that is too complicated and expensive or too cumbersome to set up will spend most of its time at the back of a shed or garage and never be used.

The first telescope should be easy to set up, easy to use yet give reasonably impressive views of the sky but do not spend a lot of money on it.

Possible uses to be considered are:

General interests in looking at objects around the night sky

Special interest in studying the Moon and the planets

Searching out deep sky objects (clusters, nebulae & galaxies)

Possible use for astro-photography

Does the telescope need to be portable?

Before starting to look at the many instruments on the market there are a few of guidelines to keep in mind:

● First guideline is - do not buy a cheap telescope from a high street shop. The minimum sum required to purchase a new 'first' telescope that is worth having for astronomy must be in the region of £100 to £200 (a second hand telescope will be less). This sounds like a lot of money but it will buy a very useful telescope that will not be a disappointment and will not be confined to the back of the shed or discarded in the garage.

● Second guideline – a first telescope should, ideally, have a minimum aperture of at least 90mm for a refractor or 130mm for a reflector if finances permit. This will ensure that the instrument can capture enough light to enable faint objects to be seen.

● Third guideline – The telescope should have a focal length of about 1,000mm for a general purpose instrument. About 750mm will be best for a more specialised wide field telescope for deep sky objects. A longer focal length may be considered if planetary studies are to be the main purpose for the telescope.

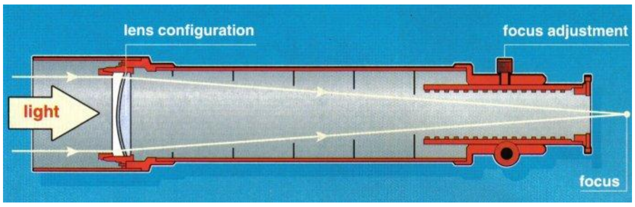
● One final point to consider, if the telescope is to be used for astro-photography then it should be mounted on an 'Equatorial Mounting'. This is required if longer exposures are to be taken with a camera fitted in place of the eyepiece.

There are basically two kinds of optics used in the manufacture of telescopes these are REFRACTING telescopes and REFLECTING telescopes. A Refractor uses a lens to gather light from a distant object. A Reflector uses a mirror to gather light from a distant object

The following pages should provide some guidance on how telescopes work and how to operate them. There is an introduction to describe how each kind of telescope is used to gather the light and direct it into our eye. There is also an introduction to the different types of mounting used to support and move the telescope to find an object to be observed..

OPTICS OF REFRACTING TELESCOPES

All refracting telescopes use a glass lens as their primary focusing unit. This lens is normally made up from two or more lens elements to produce a clearer image and reduce colour distortions caused by refraction as explained below.

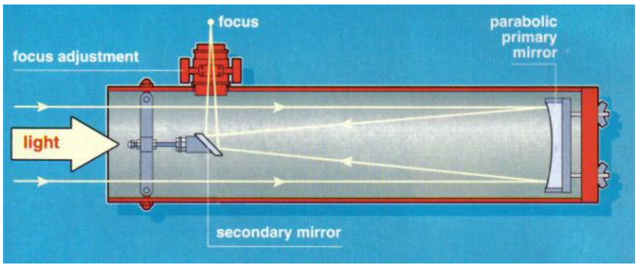


Lenses use the property called REFRACTION to change the direction of rays of light from a distant object and direct them towards a desired focal point. Refraction occurs when light passes between two different transparent materials such as glass, air and water.

When light passes, at an angle, through the surface of a block of glass the angle is changed. As the light re-emerges through the opposite side of this material its angle will be changed again back to its original angle. To utilise this phenomena lenses are produced with a curved surface so when parallel rays of light meet the surface it will present an angled surface to each ray. The paths of all the rays hitting the lens will be bent towards the centre line of the lens. As the light emerges from the back face of the lens it is again bent. If the back surface is convex the same as the front surface then the light will be bent even more towards a Focal Point to form an image.

OPTICS OF REFLECTING TELESCOPES

A Newtonian is the simplest type of reflecting telescope. Below is the layout of the optics of a Newtonian tube assembly. The Newtonian configuration is the simplest layout and therefore generally the cheapest of all the reflecting type telescopes. Used with the simple Dobsonian mounting this type of telescope can make a very useful and cheap option for a first telescope at around £200 for a 150mm (6″) instrument.



Light from a distant object enters the open tube and is reflected back up the tube by a parabolic (concave) mirror. Because the mirror is curved the light is focused into a Focal Point where an image is formed. To enable the observer to study the image without blocking the light entering the tube, a second small 'flat' mirror is mounted at an angle of 45° at the top of the tube. This secondary mirror directs the light out through a hole in the tube. A focusing unit is fitted to the hole in the tube to hold and adjust the eyepiece.

There are other variations of the reflecting telescope such as the Cassegrain. This design replaces the flat angled secondary with a small convex mirror that redirects the light back down the tube and through a hole in the centre of the Primary Mirror where the eyepiece is mounted.

There is a misconception about the term 'Magnification' of a telescope. Strictly speaking magnification is not an attribute of the telescope it mainly depends on the eyepiece being used.

A set of Meade eyepieces and a Barlow Lens

The telescope is used to collect light from a distant object. It then has to focus the image carried by that light into a Focal Point where the image can be magnified and examined using the eyepiece.

A telescope of a specific focal length will produce an image of a specific size and this cannot be changed. For example a telescope of a certain focal length may produce an image of the full moon 10mm in diameter. A telescope with a longer focal length will produce a larger image and a shorter focal length will produce a smaller image but a wider view.

An eyepiece is then used, much like a microscope, to magnify that image. The eyepiece also changes the converging light rays gathered by the main optic (lens or mirror) into parallel rays that the eye can register as an image.

A long focal length 25mm (low power) eyepiece used on a 1000mm telescope will produce a magnification of 1000 ÷ 25 = 40x. A short focal length 10mm (high power) eyepiece used on the same 1000mm telescope will produce a magnification of 1000 ÷ 10 = 100x. However the same eyepieces used on a 1500mm focal length telescope (that naturally produces a larger image) will have magnifications of: 1500 ÷ 25 = 60x and 1500 ÷ 10 = 150x.

The object to be observed should first be selected using the finder and centralised. This may be a small telescope attached to the main telescope or a Red Dot Finder. When starting to observe a low magnification eyepiece (marked 25mm or higher) should be fitted to the main telescope focuser. This will allow a wider view of the sky to be seen.

The object centralised in the finder should appear in the eyepiece of the main telescope where it can be centralised and focused to give the best view of the object. To obtain a closer view, the low power eyepiece should be replaced with a higher magnification eyepiece (perhaps one marked 10mm).

To summarise, if a large Open Cluster (like M45 the Seven Sisters) is to be observed the lowest possible powered eyepiece should be used. If a high power eyepiece is used only a part of the cluster will be seen. The highest magnification eyepiece can be used to increase magnification to obtain a detailed view of Moon craters or detail on the surface of a planet.

REFLECTING TELESCOPES

Reflecting telescopes are generally cheaper than the equivalent sized refracting telescope. This is because they use a mirror as the main optic and not a more expensive lens. A mirror has only one surface to be ground and polished but the typical refractor, that has two or sometimes three lens elements, has four or up to six surfaces to be ground and polished.

The cheapest and simplest reflecting telescope is a Newtonian tube assembly mounted on a Dobsonian mount. The mount is a simple Alt azimuth with a turntable for rotation and a trunnion mount for up and down movement. These are very easy to set up and simple to use. This type of mount is used by many amateur astronomers who build their own telescopes because it is so simple to make.

Because the Newtonian (invented by Sir Isaac Newton) has a secondary mirror at the top of the tube there is a small loss of light so a 130mm will give a just slightly brighter image than a 100mm refractor.

The Skywatcher Skyliner 150mm FL 1200mm £219

Discontinued but can be obtained second hand.

Skyliner	200mm (8″)	FL 1200mm	£299
Skyliner	250mm (10″)	FL 1200mm	£469
Skyliner	300mm (12″)	FL 1500mm	£699

Other manufacturers may still have a similar range.

A major advantage, beside the cheapness, of the Dobsonian is its simplicity of use. It just needs to be placed down on a flat surface and it is ready to use. A finder scope is attached to the main tube to help find a desired object. Once the object is located in the main telescope it can be tracked by moving the tube gently, up or down (by hand) and around while looking through the eyepiece to keep the object central.

The owner can soon master the technique of moving the telescope manually to track an object as it appears to move across the sky. The usual method is to move the telescope towards the east until the object is at the west side of the field of view. As the image is optically reversed this means the object has to be moved to the right of the field of view. The object is then allowed to drift across the field of view until it is about to disappear. The telescope is then moved again.

The Newtonian tube assembly can also be fitted to an equatorial mounting. This does make the telescope more expensive but can make it easier to track objects across the sky. This combination gives the advantage of a large aperture telescope on a mount that can easily be driven to track objects. Most Dobsonian telescopes use a fairly long focal length tube assembly whereas a shorter focal length is generally favoured for the equatorially mounted Newtonian.

Skywatcher Explorer130 FL 900 EQ2 Newtonian £169

Models in this range:

Explorer 150P EQ3	150mm (6″)	FL 750mm	£319
Explorer 150PL EQ3	150mm (6″)	FL 1200mm	£319

Most of the larger manufacturers have a similar range.

As previously stated the main advantage of an equatorial mounting is in its ability to track an acquired object across the sky using just one drive. The mount has two rotating axes. In the image above the shaft with the optical tube at one end and the counter balance weight at the other is called the Declination (Dec) axis. This is used to elevate the telescope or move it down. The axis that is parallel to the telescope tube is called the Right Ascension (RA) and is used to move the telescope from east to west or west to east.

The object to be observed is first found by pointing the telescope, by eye, in the approximate direction. Most equatorial mounts have a clutch release mechanism that allows the telescope to be slewed freely with the drives disengaged. With the clutches still released the object is located at the centre of the finder scope (the small telescope or Red Dot Finder attached to the main tube). The RA and Dec drive can then be engaged by tightening the clutches. The required object should be visible in the main telescope eyepiece. Using the RA and Dec drives the object can then be centred in the main telescope. Once centred the object can be tracked by adjusting the RA drive only.

Most basic equatorial mounts are supplied with manual drives on RA and Dec. Electric motor drives can be fitted when purchased for additional cost or can be fitted as upgrades at a later date. An electric drive is not necessary on the Dec axis but a driven RA is very useful to save continual manual tracking of objects being observed. With the mounting set up approximately level and closely aligned on the north polar axis, tracking for in excess of 20 minutes without manual adjustment is easy to achieve.

REFRACTING TELESCOPES

Refracting telescopes are generally more expensive than reflecting telescopes but they do have some advantages over their cheaper cousins. Firstly the main optic (the lens assembly) is mounted in the tube by the manufacturer and should remain there untouched for the life of the telescope. The mirrors of reflecting telescopes do need to be collimated from time to time. Being enclosed in a tube the internal surfaces of the lenses can stay clean for a long time and may never need internal cleaning. The outer surface of the lens assembly may need a gentle clean every few years but this is a relatively easy thing to do.

There is also an optical advantage due to the requirement of a reflecting telescope to have a secondary mirror in the light path to direct the gathered light out of the tube to a viewing position. This secondary mirror is an obstruction in the light path and reduces the amount of light available to the observer. A short focus reflecting telescope needs a larger secondary than a long focal length instrument. The presence of the secondary mirror also slightly reduces the quality of the image compared to a refracting system that does not require a secondary optic and is therefore obstruction free. For these reasons the minimum aperture for a refracting telescope should be 90mm whereas 130mm is recommended for a reflecting telescope.

A Skywatcher Evostar 90 on EQ2 Mount £155

This telescope represents the minimum specification for the perfect first refracting scope for a beginner. It has an aperture of 90mm and a focal length (FL) of 1000mm. It is supplied with a tripod fitted with a basic EQ2 (equatorial mounting), two eyepieces, even a camera adaptor. The current price is £155 from Rother Valley Optics.

Other telescopes in this range are:

Evostar – 90	EQ3	FL 900	£250	A little small but ok
Evostar – 102	EQ3	FL 1000	£329	Perfect
Evostar – 120	EQ3	FL 1000	£379	A bit expensive
Evostar – 150	EQ5	FL 1200	£778	Big and expensive

Most of the larger manufacturers have a similar range. The telescopes in these ranges are typically supplied on a tripod and with an equatorial mounting. They usually have two eyepieces (25mm and 10mm) and sometimes include a Barlow Lens. All are supplied with a 90° Star Diagonal. This is a mirror set at 45° to direct the image into a comfortable position for viewing through the eyepiece.

SO WHAT SHOULD YOU BUY?

A first telescope must be easy to use, portable enough to move around and set up and be within a modest budget. The budget available is important but if possible at least £150 should be spent on a new telescope or the pro-rata amount for a second hand instrument (say £100 for a telescope that costs £200 new). **Avoid the models that are sold in high street stores as they tend to be poor quality**.

Some of the best manufacturers to look out for are:

MEADE, CELESTRON, ORION, SKY WATCHER, TAL, KONUS and BRESSER. Suppliers of these telescopes can be found in the adverts in popular astronomy magazines such as ‘Astronomy Now’ and ‘Sky at Night’.

Modern telescopes bought from reputable manufacturers are all good quality these days so it is difficult to choose from the huge and varied selection available. The choice between reflecting and refracting telescopes is really a matter of choice, bearing in mind the advice given previously regarding comparative aperture size. A reflector should, if finances permit, be over 90mm and a reflector over 130mm. A general purpose telescope should have a focal length of around 1000mm. An equatorial mounting is desirable as it will make tracking an object easier.

Do not spend too much money on a large or complex telescope as a ‘first scope’. Using the telescope on the cold damp winter nights (which are the best for observing) does not suit everyone. So a starter scope will provide a relatively low cost trial for the hobby with not too much lose. Like most equipment bought for a hobby the telescope can always be upgraded later.

The smaller examples are usually supplied with a Red Dot Finder or a 30mm aperture finder scope whereas a 50mm aperture finder telescope would be better but this can be upgraded later. The cheapest equatorial mountings are usually good enough to start out with. Once the new astronomer becomes more discerning a heavier and more robust mounting (EQ3 or EQ5) can be fitted to make the telescope more stable. This will be required if astro-photography is to be an interest.

There are other telescopes available with 60mm to 70mm aperture that are not bad if only a small budget is available (£60 to £100). Their capability is however really limited to observing the Moon or the moons of Jupiter. They may also just be able to give a glimpse of Saturn’s ring system or Jupiter’s cloud patterns on a good night.

If anyone is considering buying a telescope for someone as a Christmas present then the best advice is to contact a local Astronomical group. The members will always give advice freely and usually offer a look through their telescope and those of other members so a practical comparison can be made.

Almost any telescope has the ‘wow’ factor when first used, particularly if used to look at the Moon. However if it is too small it may soon become a disappointment if the objects talked about in books and magazines cannot be seen. This is why a minimum aperture is recommended. The extra cost of a worthwhile telescope can be made more acceptable when the instrument is used by the whole family and friends. Almost everyone will want to have a look when it is set up. So £100 to £150 can be used to purchase a telescope which is quite comparable with many other Christmas gifts.

SPECTROSCOPY (Deciphering the messages in starlight)

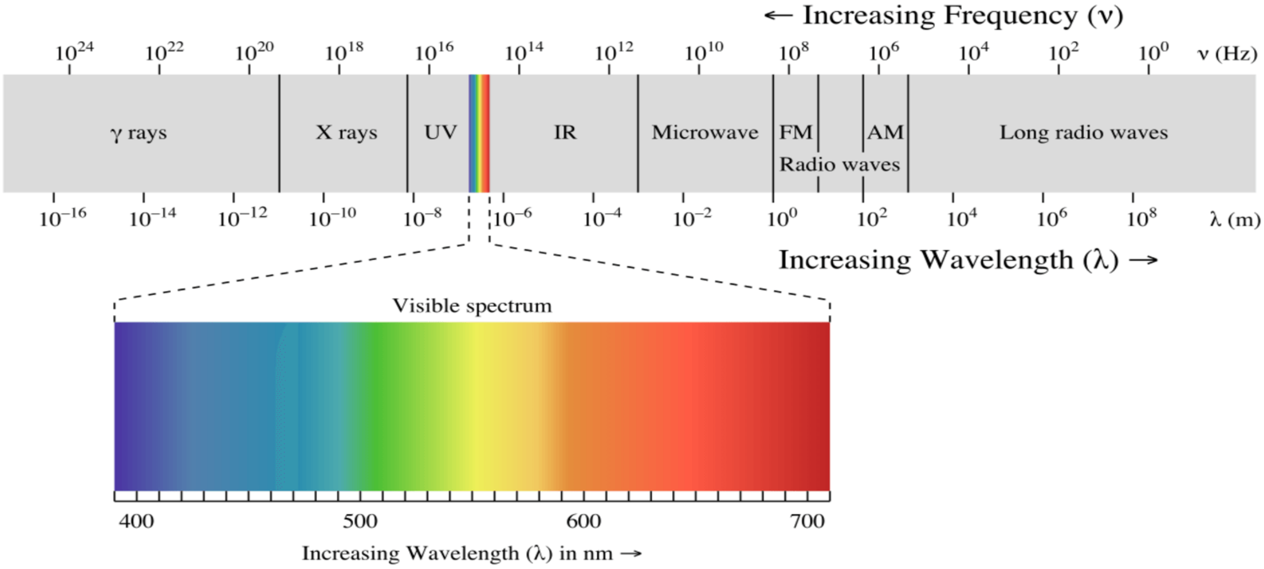


Chart showing the Electromagnetic Spectrum

As astronomers, we are studiers of light because all the information about the objects of the night sky is brought to us by light. When we use the word light we generally mean the wavelengths of the Electromagnetic Spectrum that we can detect with our eyes. However as can be seen from the chart above, visible light is just a small part of the whole Electromagnetic Spectrum.

There are a number of ways to define the type of Electromagnetic Radiation in the spectrum so here are a few of the terms used:

FREQUENCY (written as 'ν')

Frequency refers to the number of the cycles of the Electromagnetic waves per second. This is also referred to by the unit Hertz (Hz)

WAVELENGTH (written as 'λ')

This is the length of the Electromagnetic wave measured from the crest of one wave to the crest of the next, normally measured in metres and derivatives.

TYPE OF RADIATION

This describes classes of radiation linked by their attributes and the effects experienced in interactions with these types of Electromagnetic waves.

Gamma (γ) are very shortest Electromagnetic waves with a very high frequency and carry very high energies. These are found to the left of the chart above. Gamma rays can have a frequency of from a billion, trillion cycles per second to a million, trillion, trillion cycles per second. They therefore have the shortest wavelength, carry the most energy and are very dangerous to life.

Radio waves are the longest Electromagnetic waves and can have wavelengths of hundreds of kilometres. These are found at the right hand end of the chart above.

The 'types' of wavelengths, in rising frequency and energy are: Long and Short Wave Radio, Microwave, Inferred, Visible, Ultraviolet, X Rays and Gamma.

For non-mathematical readers the expressions above written as 10^2 and 10^{-23} are the method of showing large or small numbers. So 10^2 represents the number 1 followed by two 0s (zeros) meaning 100. 10^{20} would be 1 followed by twenty '0s' (zeros). The expression 10^{-3} represents the number 1 in the third decimal position and proceeded by two decimal places 0.001.

So when we see the number of wave cycles written as 10^{24} we are looking a huge number actually 1 followed by 24 noughts 1,000,000,000,000,000,000,000,000. With a number written as 10^{-16} we are looking at the very small number 0.0000000000000001 this is 1 at the 16th decimal place. Note 'Nanometre' written as 'nm' is 0.000000001m or 10^{-9} = 1 billionth of a metre.

The very narrow band of wavelengths between 400nm (0.4 x 10^{-6}) and 700nm (0.7 x 10^{-6}) are the range of wavelengths we can detect with our eyes. Within this band we see the different wavelengths as different colours. Our Sun produces most light in the green to yellow so our eyes have developed to be most sensitive to green and yellow and overlaps into the blue and red. However our eyes cannot detect any further beyond the red (inferred) or further beyond the blue (ultraviolet)

Some wavelengths of the electromagnetic spectrum cannot penetrate Earth's atmosphere so special telescopes must be used on mountain tops or in space.

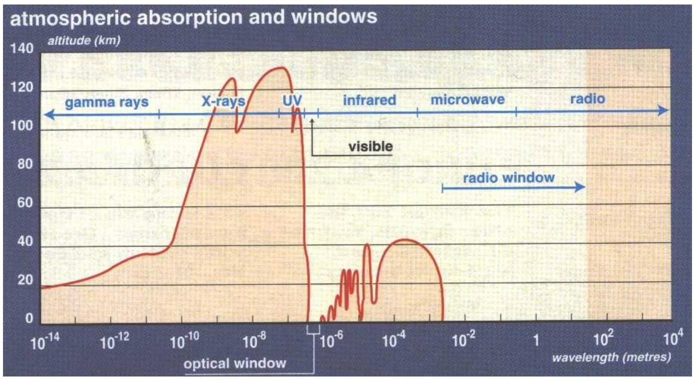
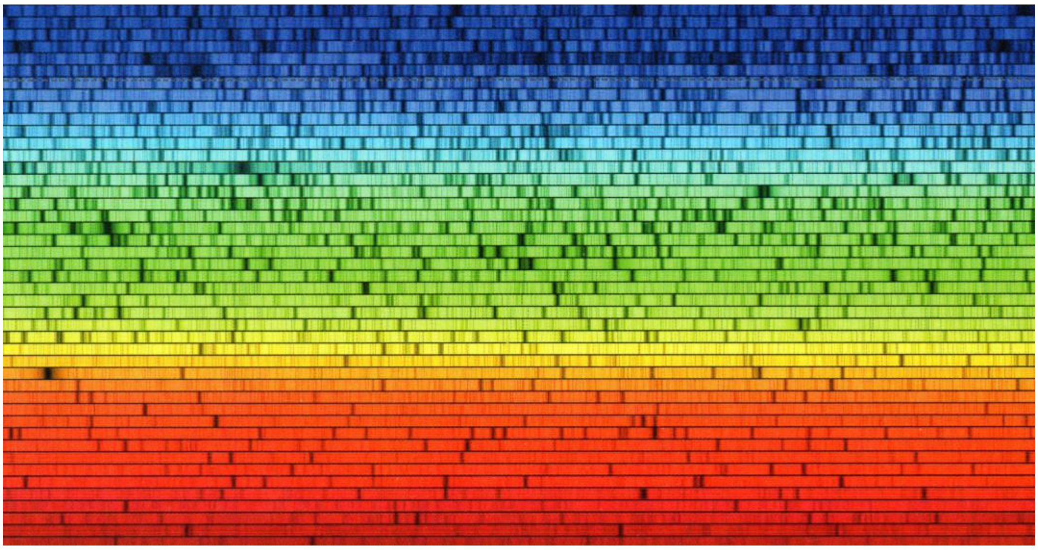


Diagram showing light waves blocked by our atmosphere

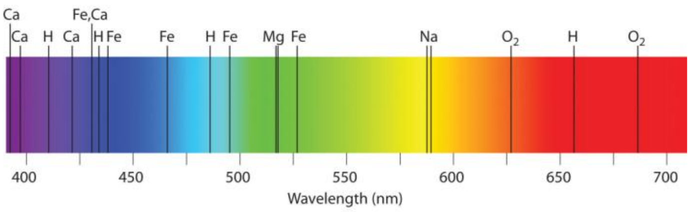
Extracting information from starlight



The spectrum of the light from our star – the Sun

When any element is heated until it burns it will produce a unique colour. For instance Sodium will always produce an orange glow as we see from Sodium street lights. Hydrogen will produce red light and Copper green. If we examine this light by separating the light into its specific wavelengths using a prism or fine grating we will see a pattern of discrete coloured bands. These patterns of discrete colour bands are unique to that particular element.

If a continuum (all wavelengths) of light from a star passes through a cloud of atoms or molecules of atoms those same discrete colour patterns will be absorbed by the same atoms in the cloud. The absorption of these patterns will appear in spectrum of the continuum of the starlight as dark lines where the colour pattern is missing. Every different elementary atom will produce its unique pattern of absorption bands on the spectrum.



Spectral lines of some elements

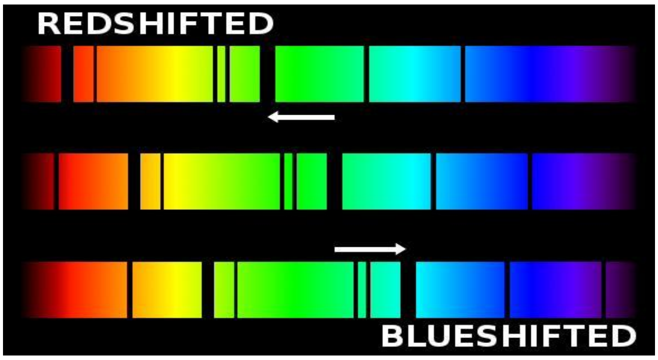
The image at the top of this page shows the continuum of light produced by our Sun. It has all the bands of missing wavelengths of light absorbed by the gas in and surrounding the Sun. The spectrum is displayed starting with the blue wavelengths at the top left. Wavelengths lengthen along the top row and continue down the rows through green, yellow and red to the bottom row.

If these discrete patterns can be identified then we can identify all the elements present in and around the Sun. Now we have a method of identifying the elements present in other stars by examining the spectrum of light from that star. The science of this process is called 'Spectroscopy'.

We can refine this process by examining the relative boldness of these lines to give an indication of the proportions of the elements present in a specific star. We can see from the image above that there is much more absorption in the blue than in the red.

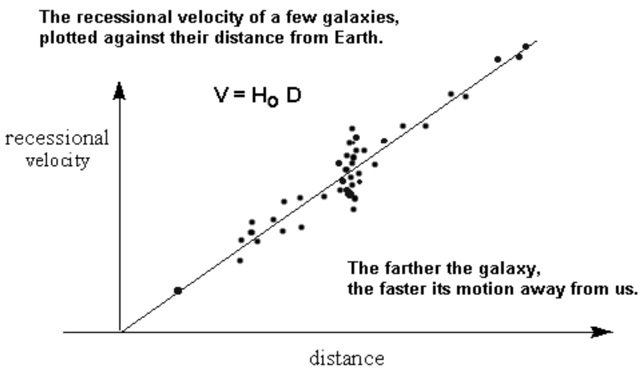
Modern spectrographs (instruments that are used to examine spectra) can display the spectrum in a graphical form. By producing a graph with noticeable peaks much more information can be obtained from the spectra. These graphical presentations are now the usual way that the spectral data is displayed rather than the beautiful diagrams as we see shown above.

We can also extract more information from star light in particular the speed, direction and distance of the object emitting the light.



The Spectral Lines moved towards red or blue

If the spectral lines of elements have been shifted towards the red then that object is moving away from us. If shifted towards the blue it is moving towards us. The further the shift the faster the object is moving.



Edwin Hubble discovered that the spectral lines from distant galaxies were shifted more the further away they were, indicating they are moving away faster. From this he realised the Universe was expanding.

THE BIRTH, LIFE AND DEATH OF STARS

When we look up into the night sky and see the stars. They look much the same although some are obviously brighter than others. Their brightness depends on two obvious factors. Some stars are actually brighter than others but in many cases they are at different distances from us. Some just appear brighter than others. Stars that are closer to us will obviously look brighter than stars that are much further away. So we can then say a star's APPARENT BRIGHTNESS is dependent on the intrinsic brightness of that star and its distance from us.

To compare the actual brightness we calculate how bright any star would appear if it was at the same distance from us. The distance that has been set as our standard is 32.6 light years (this is also 10 parsecs). We call this measure of the actual brightness of a star its ABSOLUTE BRIGHTNESS.

In some ways all stars are the same. All stars are actually just a cloud of gas. The vast majority of the gas in a star is Hydrogen (87%) with a smaller amount of Helium (10%) and other gases (Lithium and others 3%). This is the mix of atoms that existed in the universe after the 'Big Bang' and created by the Big Bang.

Galaxies formed as the atoms were attracted towards each other due to their own gravity. As the clumps of atoms grew larger their combined gravity pulled in even more atoms and other clumps of atoms. Eventually vast clouds of gas were created, that we call these Nebulae (plural) Nebula (singular). As more gas was drawn into these vast clouds they began to spin and become flattened into a flat spinning disc that we call a galaxy.

Within these huge discs that developed into galaxies, the gas was drawn into more localised clumps that also began to spin. Much of the gas in these clumps was compressed into the tightest volume possible and became a sphere (ball) of gas. The tremendous gravity in these spheres created an enormous pressure in the centre (core) which caused the temperature to rise rapidly to hundreds of millions of degrees.

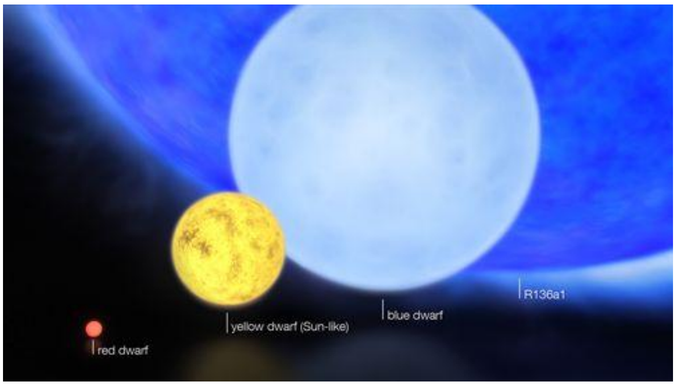
Atoms in the core of these spheres were forced together by the tremendous pressure which combined with the very high temperature forced the Hydrogen atoms to fuse together. In fusing together the two atoms were transformed into a single (and heavier) Helium atom. This single Helium atom weighed slightly less than the mass of the two Hydrogen atoms from which it had formed. The lost mass (stuff) had been converted into energy in the form photons of Gamma or X-Rays. We call this process Nuclear Fusion.

Although the loss of mass was tiny the energy created from the lost mass was enormous in comparison. We can see this in Albert Einstein's famous formula $E = mc^2$. Where E is the energy created, m is the mass lost and c is the speed of light squared (multiplied by its self). As the speed of light is a very large number it can be seen that E (the energy created) will be an extremely large number when the m (the lost mass) is multiplied by the speed of light twice.

All this created energy heats up the sphere of gas and it radiates the energy and a new shining star is born.

We have seen in the previous column that stars are fundamentally all the same. However we see that they may look different and their existence is different and their final death can be very different. We will now look at why there is something that creates the difference. This is the mass or the size of the star when it is created.

If we think of our star, the Sun, as being the base standard for comparing the size of other stars then we call the mass of our Sun 1 and think of other stars as being a number of times larger or smaller than the Sun. The smallest stars that we can detect can be 100 times less massive than our Sun. At the other end of the scale the largest stars that are thought to have ever existed may have been 300 times more massive than our Sun.



The range of sizes of stars

The diagram above shows the relative diameters of the smallest to the largest stars known today. The small red star is called a Red Dwarf, our Sun is shown as the yellow star and the blue stars are the range of the largest stars.

Our Sun is a fairly typical star in many ways. It is known as a Yellow Dwarf. This does not mean it is particularly small it is just that there are some types of star that are much bigger. Our Sun appears slightly yellow because the hot gas on the visible surface emits this wave length of light. The temperature of the gas in the photosphere of our Sun is at about 5500ºK. Gas heated to this temperature will shine white hot with a slight yellow tinge. Hotter gas will appear pure white and even hotter will appear blue and even hotter may appear slightly green. Stars cooler than our Sun will look more yellow through to orange and if much cooler can appear distinctly red.

Class	Surface temperature[8] (kelvin)	Conventional color	Apparent color[9][10][11]
O	≥ 33,000 K	blue	blue
B	10,000–33,000 K	white to blue white	blue white
A	7,500–10,000 K	white	white to blue white
F	6,000–7,500 K	yellowish white	white
G	5,200–6,000 K	yellow	yellowish white
K	3,700–5,200 K	orange	yellow orange
M	2,000–3,700 K	red	orange red
L	1,300–2,000 K	purple-red[citation needed]	red[citation needed]
T	700–1,300 K	brown[citation needed]	purple-red[citation needed]
Y	≤ 700 K	dark brown[citation needed]	brown[citation needed]

Chart showing the classification of stars

So the colour of a star is due to the temperature at the surface but what makes a star hotter or cooler? There is a general rule: the more massive a star is the hotter it will be but like most rules there are exceptions. We refer to the size of stars in two ways: MASS is the measure of how much stuff there is in a star (sort of how much it weighs). DIAMETER is the measure of how physically large the star is from one side to the other.

Stars come in a wide range of sizes and in general they are categorised in order of size. The chart in the previous column shows stars categorised in order of their rising temperature from coolest at the bottom to the hottest at the top. This is closely followed as increasing mass from the least massive at the bottom to the most massive at the top. Column 1 on the chart has the class of the stars shown represented by a single capital letter in the sequence: Y, T, L, M, K, G, F, A, B and O. These classes were originally in alphabetical order but as our understanding of star formation was refined the order charged but the classification letter remained the same.

Y, T and L CLASS STARS (Brown Dwarf)

These are the smallest of all star like objects are between 7 and 80 times the mass of Jupiter. They are too small to sustain Nuclear Fusion. They are cool (up to 700ºK) and do not produce visible light. As they do not produce light from Nuclear Fusion in their core these objects are sometimes referred to as ‘Failed Stars’.

M CLASS STARS (Red Dwarf)

These are the smallest true stars with a mass between 0.08 $M_\odot$ (Mass of the Sun) and 0.45 $M_\odot$. They are small but massive enough to sustain Nuclear Fusion. They have a surface temperature of 3700ºK – 5200ºK and appear red. They will last a very long time with the very smallest possibly outlasting the life of the Universe.

K CLASS STARS (Orange Dwarf)

These are the smallest true stars with a mass between 0.45 $M_\odot$ and 0.80 $M_\odot$. They are therefore smaller than our Sun. They have a surface temperature of 2000ºK – 3700ºK and appear orange in colour. These stars will exist for much longer than our Sun.

G CLASS STARS (yellow Dwarf)

These are true stars like our Sun with a mass between 0.80 $M_\odot$ and 1.04 $M_\odot$. They are regarded as Dwarf stars. They have a surface temperature of 5200ºK – 6000ºK and appear white with a hint of yellow. Stars in this class will last for about 10 billion years.

F CLASS STARS (White Yellow Dwarf)

These are true stars like our Sun with a mass between 1.04 $M_\odot$ and 1.40 $M_\odot$. They are they are still regarded as Dwarf stars. They have a surface temperature of 6000ºK – 7500ºK and appear white with a hint of yellow. Stars in this class will last for about 7 billion years.

A CLASS STARS (White Blue Sub-Giant)

These are large stars with a mass between 1.40 $M_\odot$ and 2.10 $M_\odot$. They are they are still regarded as Dwarf stars. They have a surface temperature of 7500ºK – 10000ºK and appear white with a hint of blue. Stars in this class will last for about 5 billion years.

B CLASS STARS (Blue Giant)

These are large stars with a mass between 2.10 $M_\odot$ (Mass of the Sun) and 16.00 $M_\odot$. These are very large stars. They have a surface temperature of 10000ºK – 30000ºK and appear blue. Stars in this class may last for about 2 or 3 billion years.

O CLASS STARS (Blue Super-Giant)

These are very large stars with a mass greater than 30.00 $M_\odot$. They are gigantic and relatively rare stars. They have a surface temperature in excess of 30000ºK and appear blue. Stars in this class will only last for between 1 billion or just a few million years for the very largest these may have a mass of up to 150 $M_\odot$.

Stars in classes M, K, G, F and A are stable stars and quite long lived. After an initial more active phase they settle down to a long life fusing Hydrogen into Helium which settles down to fill the centre of the star. With the buildup of Helium in the core the fusion process moves out around the outside of the growing Helium inner core.

The larger stars in classes G, F and A the Helium will begin to fuse into Carbon and produce additional energy. This drives the outer layer outwards and the star grows in diameter to become a Red Giant. Eventually the Hydrogen begins to run out and the fusion process stops. With the loss of the outward pressure of the radiation from fusion, gravity begins to take over and the star gently collapses inward. The collapse continues until gravity compresses the star into a sphere about the size of Earth to form a White Dwarf Star.

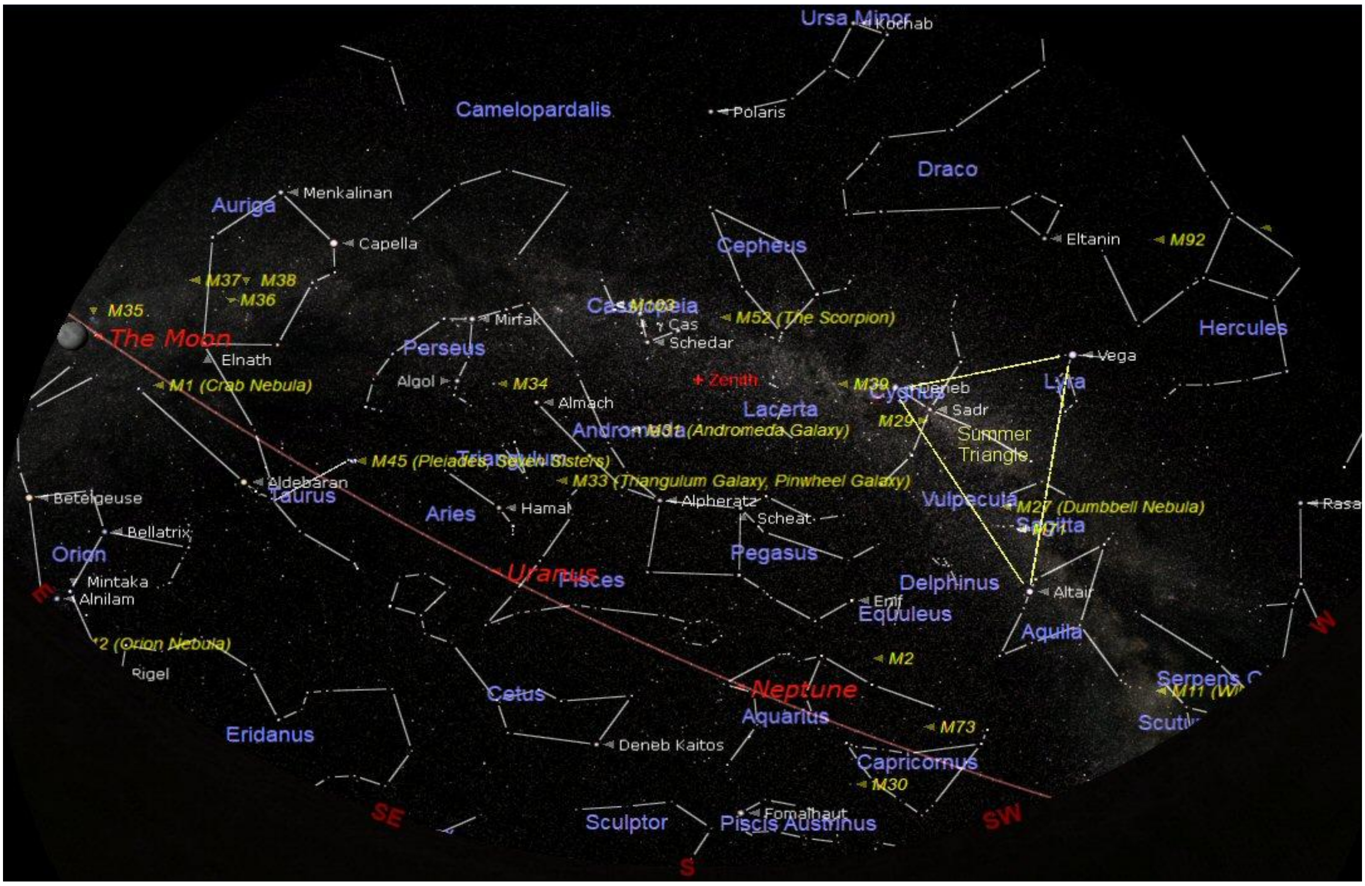
Many stars are in a double star system but it is quite likely one star will be larger than the other. The larger star will consume its Hydrogen faster and will become a White Dwarf first. When the smaller star becomes a Red Giant the tenuous outer layer of Hydrogen may be pulled off by the gravity of the White Dwarf. The Hydrogen gas accumulates on the surface of the White Dwarf and forms an extremely compressed layer of Hydrogen. When the total mass of the White Dwarf exceeds 1.4 $M_\odot$ the Hydrogen on the surface detonates and produces a massive Thermo Nuclear Explosion called a Nova.

Stars larger than class A have a much more violent end to their shorter lives. The extra mass and temperature of this stars allows heavier elements to be fused in the core. These heavier elements accumulate in the core with the progressively heavier elements sinking to the centre of the core. This process comes to an end when Iron is produced by the Nuclear Fusion process.

The core quickly fills with Iron but this phase of the Nuclear Fusion process produces no additional energy. The Fusion process suddenly shuts down and with no outward force pushing outwards gravity takes over and the core of the giant star collapses. The outer layer of the star collapses inwards on to the compressed core. The impact with the core causes a tremendous Thermo Nuclear Explosion that is called a Supernova.

The compressed core will be become a super dense Neutron Star about 25 kilometres in diameter. The largest Super Giants may compress the core further to form a Stellar Black Hole.

THE NIGHT SKY NOVEMBER 2019



The chart above shows the night sky looking south at about 20:00 GMT on 15th November. West is to the right and east to the left. The point in the sky directly overhead is known as the Zenith and is shown (in red) at the upper centre of the chart. The curved brown line across the sky at the bottom is the Ecliptic or Zodiac. This is the imaginary line along which the Sun, Moon and planets appear to move across the sky. The brightest stars often appear to form a group or recognisable pattern; we call these ‘Constellations’.

Constellations through which the ecliptic passes this month are Sagittarius (the Archer) just moving over the western horizon, Capricornus (the Goat), Aquarius (the Water Carrier), Pisces (the Fishes), Aries (the Ram), Taurus (the Bull) and Gemini (the Twins).

Just disappearing over the south western horizon is the constellation of Sagittarius (the Archer). It is really a southern constellation but we can see the upper part creep along the horizon during the summer. The central bulge of our galaxy is located in Sagittarius so the richest star fields can be found in the constellation along with many of the beautiful and interesting deep sky objects that we seek out. Saturn is currently in Sagittarius.

The summer constellations are still prominent in the early night sky led by Hercules (the Hunter). Following Hercules is the Summer Triangle with its three corners marked by the bright stars: Deneb in the constellation of Cygnus, Vega in Lyra, and Altair in Aquila. The Summer Triangle is very prominent and can be used as the starting point to find our way around the night sky. The Milky Way (our Galaxy) flows through the Summer Triangle passing through Cygnus, down to the horizon through Altair in the lower part of the Summer Triangle.

The Milky Way flows north from the Summer Triangle through the rather indistinct constellation of Lacerta (the Lizard), past the pentagon shape of Cepheus and on through the ‘W’ shape of Cassiopeia (a Queen).

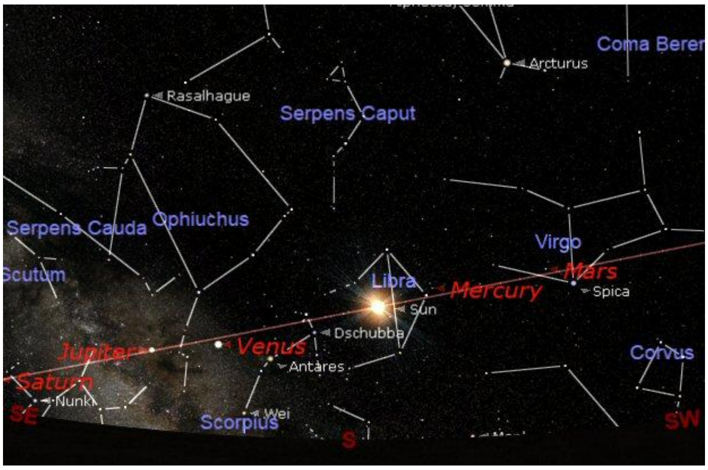
At the top of the chart above is Polaris in the constellation of Ursa Minor (the Little Bear) also called the Little Dipper by the Americans. Although Ursa Minor may be a little difficult to find in a light polluted sky it is one of the most important constellations. This is because Polaris the North Star is located in Ursa Minor. Polaris is the star that is located at the approximate point in the sky where an imaginary line projected from Earth’s North Pole would point to. As the Earth rotates on its axis the sky appears to rotate around Polaris once every 24 hours. This means Polaris is the only bright star that appears to remain stationary in the sky as Earth rotates.

To the East (left) of the Summer Triangle is the constellation of Pegasus (the Winged Horse). The main feature of Pegasus is the square formed by the four brightest stars. This asterism (shape) is known as the Great Square of Pegasus. The square is larger than might be expected but once found is easier to find again.

Coming into view in the east is the constellation of Taurus (the Bull). The most obvious star in Taurus is the lovely Red Giant Star called Aldebaran. It appears slightly orange to the unaided eye (we call the ‘naked eye’) but it is very obviously orange when seen using binoculars or a telescope. Aldebaran is located at the centre of the ‘flattened’ X shape formed by the brightest stars in Taurus. At the end of the top right (upper west) arm of the ‘X’ is the beautiful Open Star Cluster Messier 45 (M45) known as the Pleiades (or the Seven Sisters). It really does look magnificent using binoculars.

THE SOLAR SYSTEM THIS MONTH

MERCURY will not be observable this month as it will be too close to the Sun as it rises in the East. It will 'transit' the Sun (passing in front of the Sun) on 11th November. For more details about the Transit see page 1.

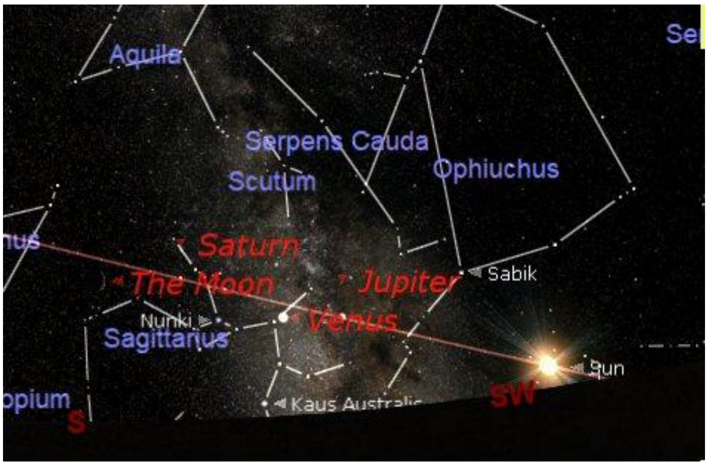


The Planets at Midday on 15th October

VENUS will not be observable this month as it will be too close to the Sun and very low on the south western horizon at sunset. It was in conjunction with the Sun (passed above the Sun) on 14th August and is now moving away from the Sun. See the charts above and below.

MARS will not be observable this month as it will be too close to the Sun as it rises in the east. It was in conjunction with the Sun (passing just above the Sun) on 2nd September. See the chart above.

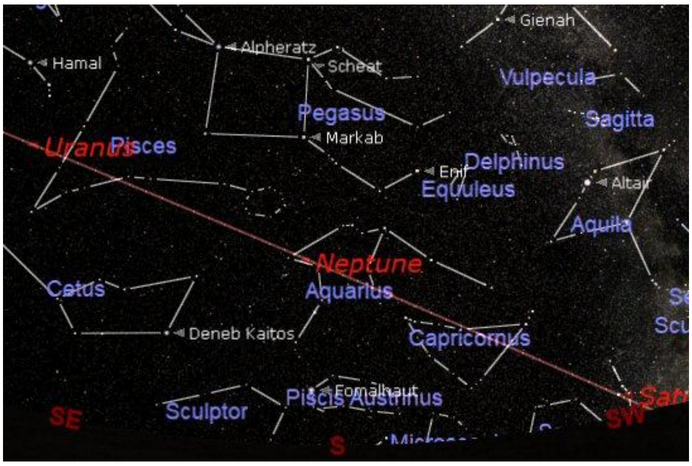
JUPITER is now past its best for this year and setting over the western horizon soon after sunset. It has been very low in the sky this year and looked rather disappointing in the dirty and turbulent air close to the horizon. We will now have to wait until next summer to see it again.



Jupiter, Saturn and Venus at Sunset

SATURN will be in the south west as the sky darkens and is following Jupiter along the ecliptic towards the western horizon. Saturn is low and in the murky and turbulent air close to the southern horizon. It may still just be possible to see the ring system although it will appear unstable due to the air movement close to the horizon. It will require at least a small telescope 75mm to 100mm and a magnification of about 100x to see the rings well. Saturn's largest moon Titan will also be visible in a telescope but the fainter moons will be difficult to see even using a larger telescope. See the charts above.

URANUS the Ice Giant Planet was at opposition to the Sun (due south at midnight – 24:00 GMT) on 28th October when it was at its best position for observation this year. It will be visible during in the evening using a small telescope as a slightly fuzzy blue, star like, object. A larger telescope with a magnification of 100x or more will show it as a small blue/green disc. See the chart below.



Uranus, Neptune and Saturn in the south at 21:00

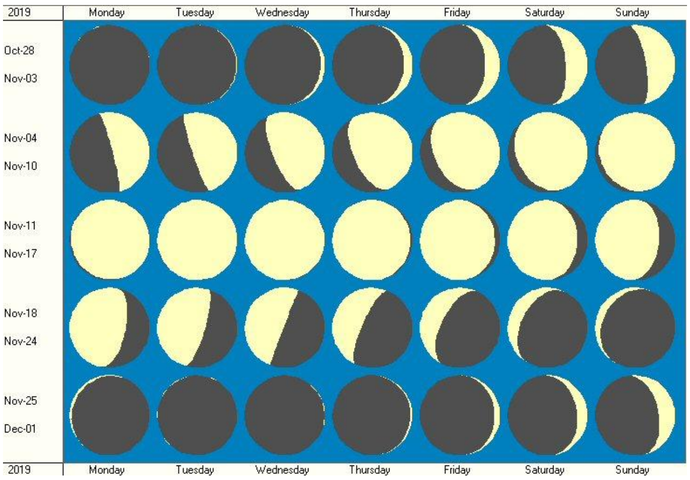
NEPTUNE was at opposition (due south at midnight – 01:00 BST) on 10th September and at its best position for observation this year. A medium sized telescope (100mm to 150mm) will be needed to show Neptune as a small blue/green disc using a magnification of 150x but it is small and difficult to find. See the chart above.

THE SUN

There may still be some occasional sunspots to see even though the active phase of the Solar Cycle is now over.

The Sun rises at 07:00 GMT at the beginning of the month and at 06:35 GMT by the end of the month. It will be setting at 16:30 GMT at the beginning and 16:00 GMT by the end of the month. Sunspots and other activity on the Sun can be followed live and day to day by visiting the SOHO website at: http://sohowww.nascom.nasa.gov/.

THE MOON PHASES IN NOVEMBER



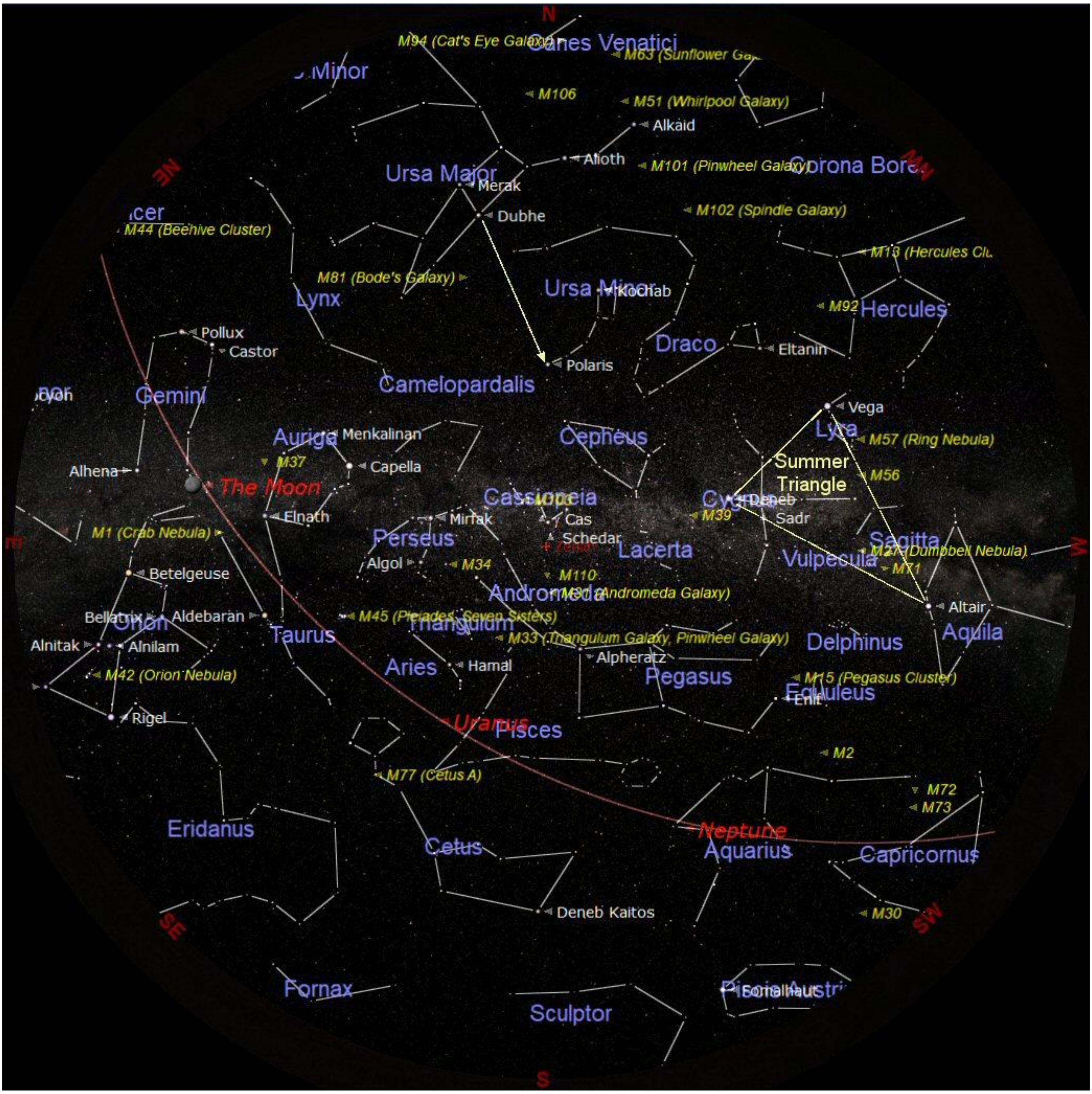
First Quarter will be on 4th November

Full Moon will be on 12th November

Last Quarter will be on 19th November

New Moon will be on the 26th November

THE NIGHT SKY THIS MONTH



The chart above shows the night sky as it appears on 15th November at 21:00 (9 o'clock) in the evening Greenwich Meantime Time (GMT). As the Earth orbits the Sun and we look out into space each night the stars will appear to have moved across the sky by a small amount. Every month Earth moves one twelfth of its circuit around the Sun, this amounts to 30 degrees each month. There are about 30 days in each month so each night the stars appear to move about 1 degree. The sky will therefore appear the same as shown on the chart above at 10 o'clock GMT at the beginning of the month and at 8 o'clock GMT at the end of the month. The stars also appear to move 15º (360º divided by 24) each hour from east to west, due to the Earth rotating once every 24 hours.

The centre of the chart will be the position in the sky directly overhead, called the Zenith. First we need to find some familiar objects so we can get our bearings. The Pole Star **Polaris** can be easily found by first finding the familiar shape of the Great Bear 'Ursa Major' that is also sometimes called the Plough or even the Big Dipper by the Americans. Ursa Major is visible throughout the year from Britain and is always easy to find. This month it is in the north east. Look for the distinctive saucepan shape, four stars forming the bowl and three stars forming the handle. Follow an imaginary line, up from the two stars in the bowl furthest from the handle. These will point the way to Polaris which will be to the north of overhead at about 50º above the northern horizon. Polaris is the only moderately bright star in a fairly empty patch of sky. When you have found Polaris turn completely around and you will be facing south. To use this chart, position yourself looking south and hold the chart above your eyes.

Planets observable this month: Uranus and Neptune.