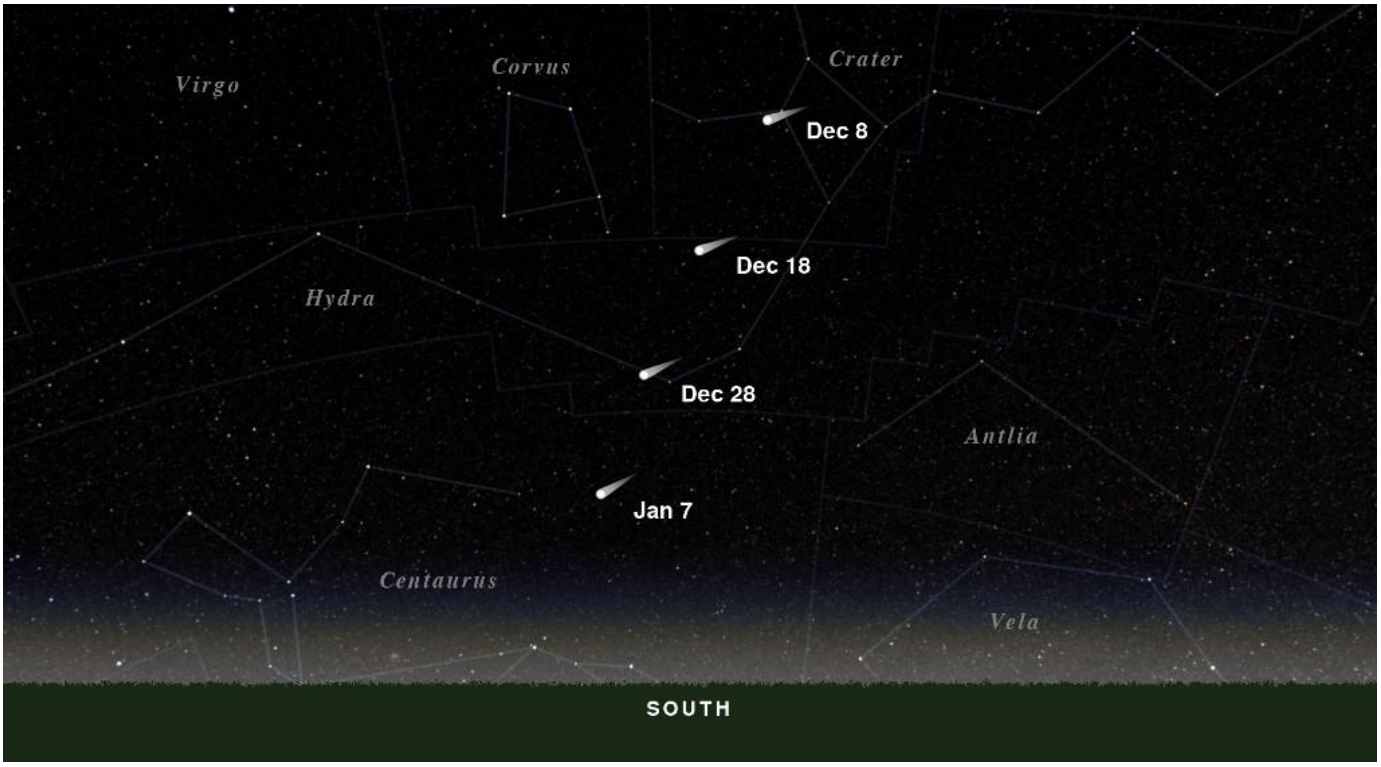
NEWBURY ASTRONOMICAL SOCIETY
MONTHLY MAGAZINE – JANUARY 2020

ANOTHER INTERSTELLAR TRAVELLER IS VISITING US



The predicted path that 2I/Borisov will take across our sky

Astronomers are getting very excited about a new object that has been found and is thought to have originated in another solar system. This is only the second such object to be found so far. The first object was 1I/Oumuamua seen in 2017. The first object was only detected as it was moving away and out of our solar system. This new object, named 2I/Borisov is moving towards and past the Sun so we will be able to investigate it as it passes by.

2I/Borisov appears to be an interstellar comet, meaning that it came from outside our solar system. It is the first such comet ever observed and only the second interstellar object of any kind, after the asteroid-like 'Oumuamua. The comet was discovered by amateur astronomer Gennadiy Borisov on 30th August 2019, using a 25.6-inch (0.65-meter) telescope that he designed and built specifically to hunt for small, faint 'comet like' objects.

The path of the comet entered our solar system from the north and crossed the ecliptic, the plane of Earth's orbit around the Sun, on 26th October 2019. The best chance to see it was during December when it made its closest approach to the Sun (on 8th December) and closest to Earth (on 28th December). The comet will then be passing through the constellations Crater and Hydra.

At mid-northern latitudes, these constellations are fairly low in the south about two hours before sunrise. The comet will be much too faint to see without a telescope and it will be a challenge even in fairly large amateur instruments. Its maximum brightness is currently predicted to be only magnitude 15 this about as faint as Pluto.

'Magnitude' is the measure of brightness used by astronomers. It works on a scale that increases by 1 magnitude when an object is approximately 2.5 times fainter than another object. So a magnitude 2 star is 2.5 times fainter than a magnitude 1 star. A star 2.5 times brighter than a magnitude 1 star is classified as a magnitude -1 star. See page 2

The first object 1I/Oumuamua appeared to be a rocky and metallic object that did not produce any trace of a tail. So it was thought to have been more like an asteroid. However the new object 2I/Borisov is producing a tail so it is comprised partly or completely of volatile icy material very much like a comet.

This will be very interesting for our scientists because they will be able to identify the elements and compounds that are subliming (boiling) off the surface as it warms closer to the Sun. It will then be possible to compare its composition with comets from our solar system. This will provide information about the formation of our solar system compared to the origins of 2I/Borisov.

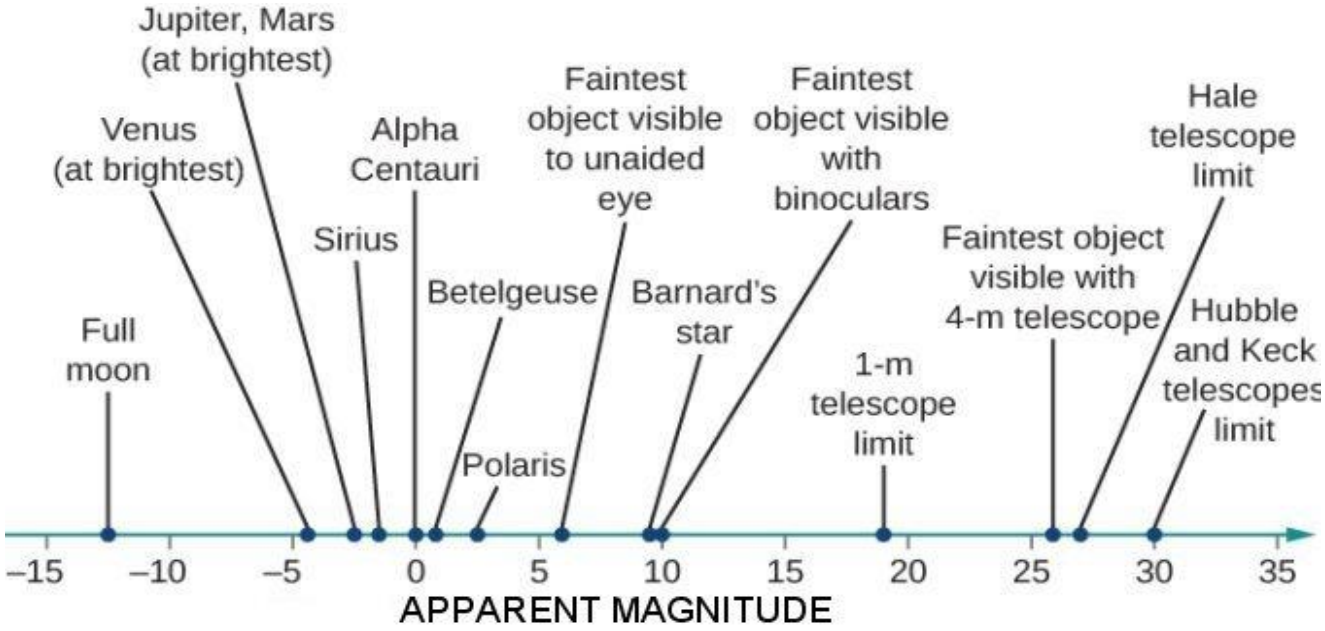
NEWBURY ASTRONOMICAL SOCIETY MEETING

3rd January Music of the Spheres
Website: **www.newburyastro.org.uk**

NEXT NEWBURY BEGINNERS MEETING

15th January The Voyager legacy
Website: **www.naasbeginners.co.uk**

MAGNITUDE (measuring brightness)



When astronomers talk about the brightness of a star they will describe the star as a Magnitude 1.2 (Mag 1.2) or perhaps Magnitude -6.7 (Mag -6.7) so what does this mean?

Ancient astronomers estimated the brightness of stars by comparing a star's brightness to the brightness of other stars with a known and recorded (standard) brightness. The ancient brightness scale used six steps of brightness from 1 (the brightest star) to 6 for the faintest star visible to the 'naked eye' in a completely dark and clear sky.

In more modern times, when scientific measurements of brightness had been developed, these 6 steps were found to be inaccurate for astronomers. So a more accurate system was developed. It was decided to keep the familiar six magnitude system but refine the accuracy of the brightness comparison.

The comparison steps were obtained by taking the fifth root of 100 $\sqrt[5]{100} = 2.51$. So the brightness scale was set at 2.51 times fainter than the next standard brightness star. This scale was standardized and became known as the Star Magnitude Scale.

Magnitude 1	Brightness =	1	
Magnitude 2	Brightness =	2.51	times fainter
Magnitude 3	Brightness =	6.3	times fainter
Magnitude 4	Brightness =	15.8	times fainter
Magnitude 5	Brightness =	39.8	times fainter
Magnitude 6	Brightness =	100	times fainter

So a magnitude 3 star is (1 x 2.51 x 2.51) = Mag 6.3

A Mag 4 star is (1 x 2.51 x 2.51 x 2.51) = Mag 15.8

A Mag 6 is the faintest star seen by the naked eye

Objects brighter than Mag 0 have minus magnitudes

Sirius in Canis Major is the brightest star at Mag -1.46

Venus can be as bright as Mag -4.6

The Full Moon is Mag -12.7

The Sun is Mag -26.8

There are two magnitude scales used in astronomy these are termed: Apparent Magnitude and Absolute Magnitude.

Apparent Magnitude is a scale of how bright an object appears to be in the sky as we perceive it optically and telescopically.

Absolute Magnitude is a scale indicating how bright an object actually is and how bright it would appear if it was at a standard distance from the observer. This standard distance has been set at 10 parsecs which is equivalent to 32.6 light years

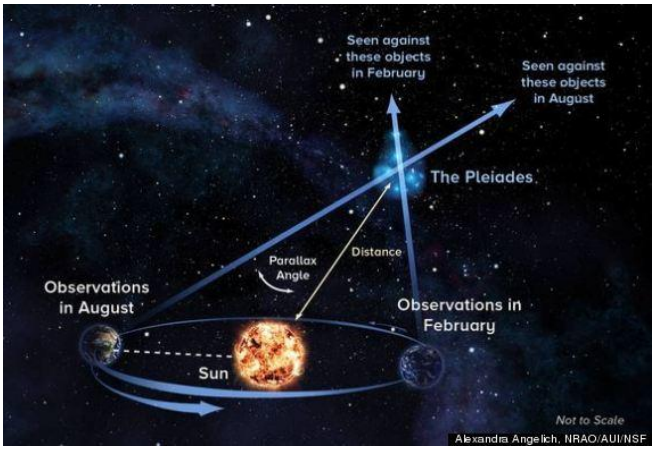


Diagram showing how parallax is used

Parallax is the method used to measure the distance to astronomically near objects. The method utilises the branch of mathematics called Trigonometry. This uses the length of a side and an included angle of a right angled triangle to measure a distance. If we know the length of one side and an angle we can calculate the other sides and angles.

Parallax uses the Earth's distance from the Sun as the known length of a side (150 million kilometres). Shown as the dotted line on the diagram above. The position of the object is recorded against the background stars. Three months later Earth will be at the position shown by the dotted line (150 million km to the left). The angle to the object is measured and the Earth to object distance can be calculated.

THE CONSTELLATION OF ORION (THE HUNTER)

The constellation of Orion imaged by Nicky Fleet using her DSLR camera

Orion is one of the easiest constellations to recognise and dominates the southern sky at this time of the year. There are many depictions of Orion shown on many different star charts. Some old pictures of Orion are very beautifully drawn in fact some are so beautiful that the artists even moved the positions of some of the stars so they would fit the image they had drawn.

Orion the Hunter appears in the winter sky, with his club held over his head and his shield (sometimes shown as a lion's skin) held out in front of him. His hunting dogs, Canis Major (the star Sirius) and Canis Minor (the star Procyon) following behind him.

Greek mythology tells us that Orion was known as a great hunter. He boasted that he could rid the earth of all the wild animals however this angered the Earth goddess Gaia. She sent a scorpion to defeat Orion. Orion tried to battle the scorpion but he quickly realised that he could not shoot his arrow through the creature's armour. To avoid the scorpion he jumped into the sea.

It was then that Apollo (the Greek god of the Sun) decided to take action. He pointed out to his twin sister Artemis a small black object in the sea. Claiming it was a horrible villain he dared her to shoot it with her bow and arrow. Artemis easily hit the target. However when she swam out to retrieve her victim she discovered that the villain was in fact her friend Orion.

Artemis begged the gods to bring Orion back to life but they refused. Instead she put Orion's picture in the sky so she could always see him.

Orion is one of the few constellations that does look (with a little imagination) like what it is named after. The most obvious feature is the line of three stars, called Alnitak, Alnilam and Mintaka that make up Orion's belt. From his belt we can see two bright stars called Saiph and Rigel below. These define the bottom of his 'skirt like' tunic. Above the belt are two stars Betelgeuse and Bellatrix that denote the position of his shoulders. Above and between his shoulders is a little group of stars that mark out the head. From his right shoulder (Bellatrix) he holds out a shield. From his left shoulder (Betelgeuse) a club is held above his head. It almost looks as if Orion is fending off the charge of the great bull Taurus who is located above and to the west (right) of Orion. See the chart on page 6.

Down from Orion's very distinctive belt there is a line of stars, ending at the star Nair al Saif that looks very much like a sword attached to his belt. Here can be found the main interest in Orion, the Great Nebula.

If an imaginary line is traced down from the belt for about six belt length towards the south eastern horizon, a bright twinkling star will be seen. This is Sirius, Orion's Large Hunting Dog in the constellation of Canis Major. It is the brightest and closest star to be seen from the UK at just 8.6 light years from us. To Orion's left (east) of Betelgeuse a bright star in a rather large empty area of sky can be seen. This is Procyon in Canis Minor, Orion's Small Hunting Dog. Coincidentally both of these 'dog stars' are double stars that have an invisible companion, a White Dwarf Star. See page 7.

M42 THE GREAT NEBULA IN ORION

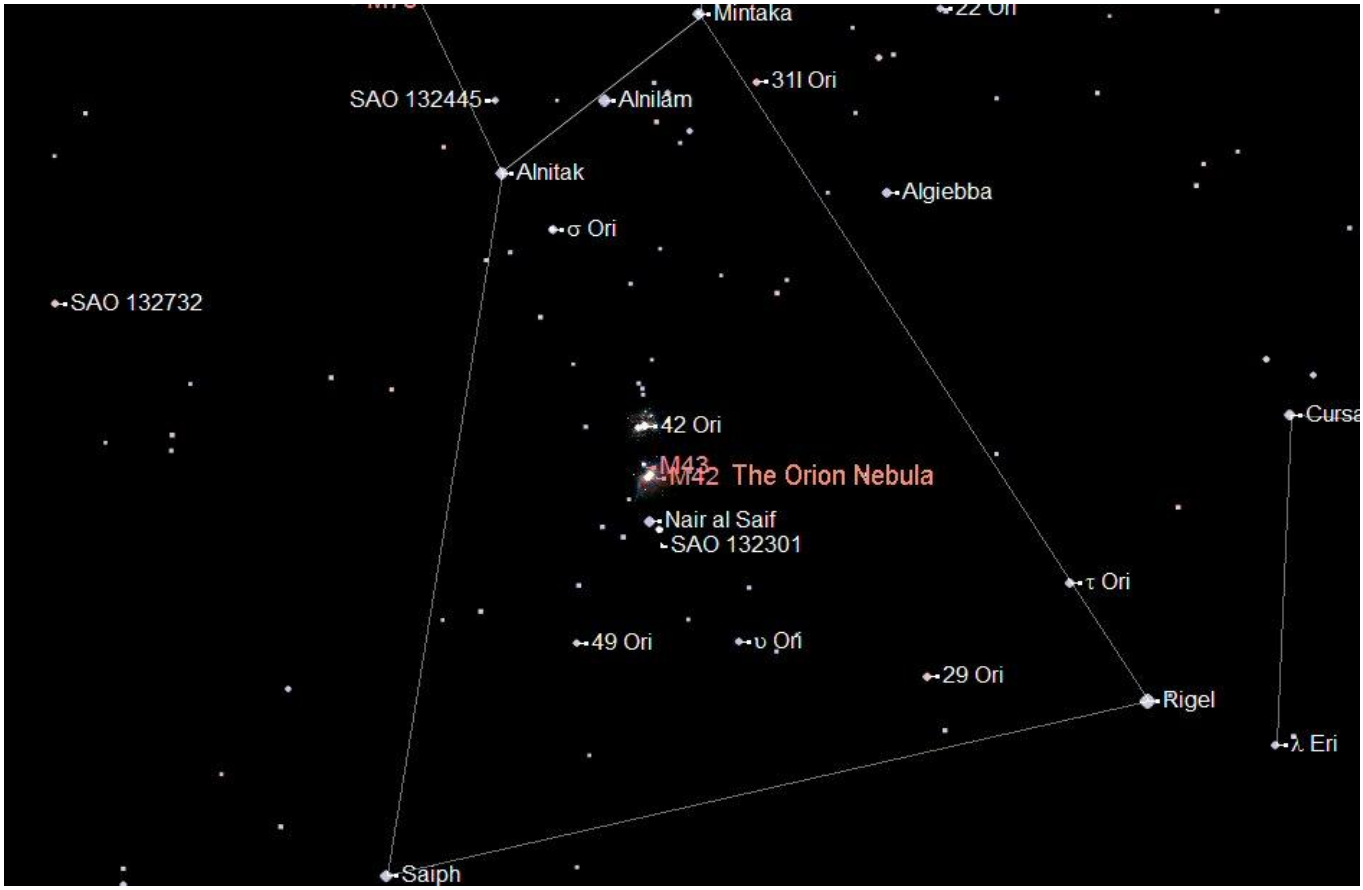
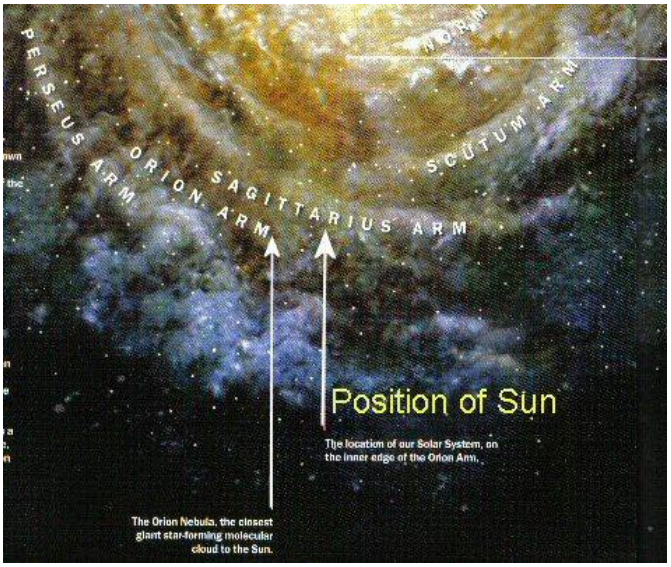


Chart showing M42 the Great Nebula in Orion's sword

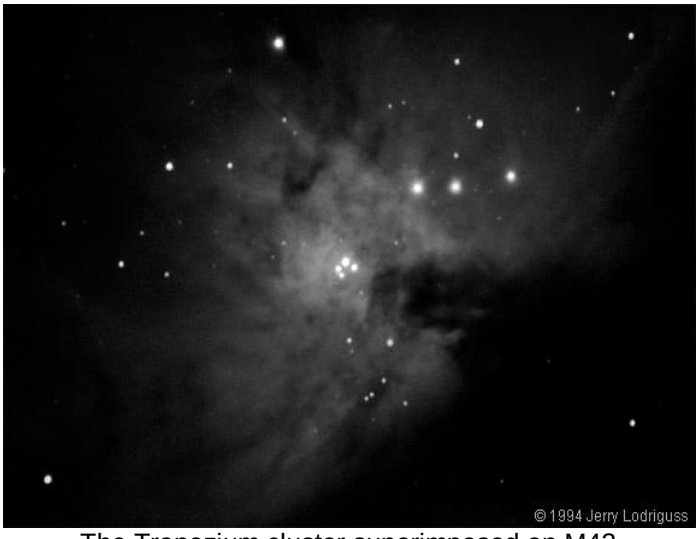
When we look towards Orion we are looking into one of the nearest spiral arms of our galaxy the Milky Way. Our Sun appears to be located in the area between two spiral arms. Towards the centre of the Galaxy from our point of view is the Sagittarius Arm and looking away from the centre is the Orion Arm.



An artist impression of our position in the Galaxy

Most of the stars in Orion are located about 900 light years away from us including Rigel but Betelgeuse is much closer at only 650 light years distant. Because the stars of Orion are in a spiral arm there is a lot of gas and dust around the whole area of the constellation. Huge numbers of young bright stars are hidden by the gas and dust.

Below the line of three stars of Orion's belt there is a vertical line of stars forming his sword (hanging below his belt). In the line of stars making up Orion's sword a small hazy patch can be seen using binoculars or even with just the naked eye on a clear night. The hazy patch is known as M42 (Messier 42), the Great Orion Nebula. This Nebula is a gigantic cloud of mainly Hydrogen gas mixed with other gases and dust from which new stars are being formed. Using a pair of binoculars the nebula looks like a small fuzzy patch in the line of stars.



The Trapezium cluster superimposed on M42

When seen through a telescope the 'fan shaped' cloud like structure can been made out. Swirls of gas and dust can be seen, some are lit up but some are dark and silhouetted against the illuminated clouds behind.

The cloud is actually illuminated by the young stars forming in it. Most of the energy illuminating this nebula comes from a group of four stars known as the Trapezium. These stars have formed from the gas and dust in the nebula; they are young, hot and very active. The Trapezium can be seen easily using a small telescope. The four stars of the trapezium (there is a fifth fainter star) are just the brightest of what is an Open Star Cluster in the process of being created. The Orion Nebula actually contains many more very young stars that are still hidden by the gas and dust of the nebula.

Special telescopes, that can detect ultraviolet and inferred radiation, can be used to penetrate the gas and dust to see the stars forming inside the nebula. The image below shows another 300+ stars forming the new Open Cluster that are currently hidden by the gas and dust clouds.

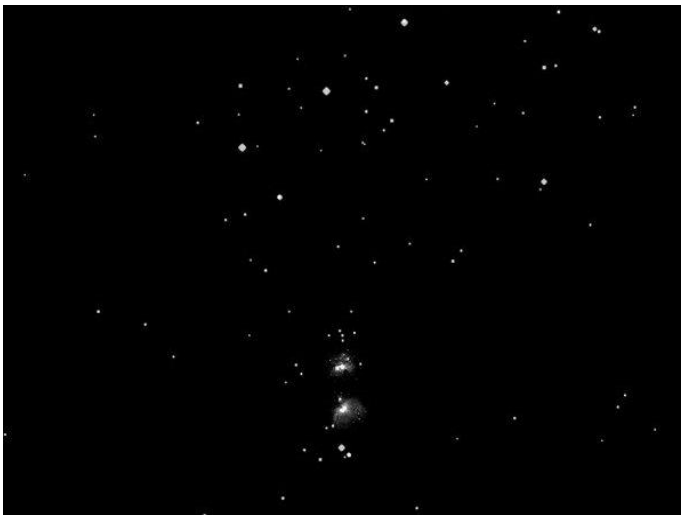
Stars forming in M42

Gravity draws the atoms of Hydrogen gas together and as the gas gets denser it pulls in even more until huge contracting spherical spheres of gas are formed. As the pressure in the core of a sphere increases the temperature rises to tens of millions of degrees and the Hydrogen atoms begin to fuse together to form an atom of Helium. In this process, known as Nuclear Fusion, a small amount of mass is lost and converted into energy in the form of a flash of X-Rays. This heats the mass of gas and it begins to shine as a bright new star.

Much of the gas and dust of the nebula is illuminated by reflecting light from the very young stars of the Trapezium in the centre of the nebula. Some gas also produces its own light because the ultraviolet radiation energy from the powerful young stars excites the gas atoms causing them to emit light somewhat like a fluorescent light.

When a photon of ultraviolet light from the powerful young stars hits a gas atom it is absorbed and causes an electron to jump from its normal orbit to a higher orbit. After a short time the electron jumps back to its original orbit and emits energy in a flash of light. The colour of this light is unique to the type of atom that has emitted it. For example Hydrogen always emits red light. See the image opposite.

The Orion Nebula can be seen with the naked eye from a dark location on a clear moonless night. It is easily seen using a pair of binoculars. The image below shows the sort of view seen using a pair of 8 x 50 binoculars.



Binocular view of M42 with Orion's belt at the top

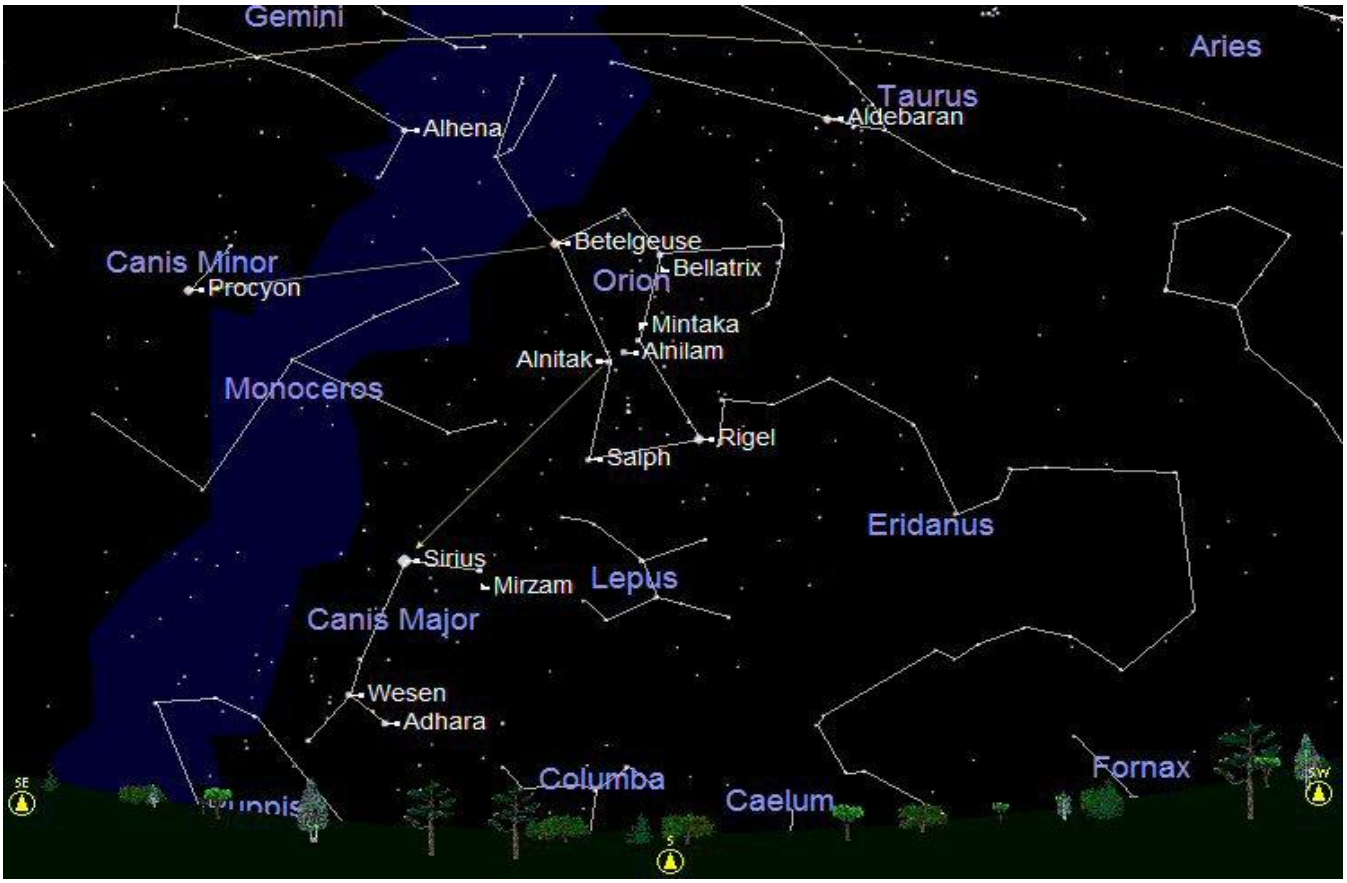
A small telescope will show a larger view and some detail in M42. Structure in the nebula can be seen with parts of the nebula illuminated and other parts appearing dark.

The sort of view seen using a small telescope

A larger telescope will show more detail and the structure of the nebula with wisps of gas appearing. Photographic images show much more detail including colour in the clouds of gas and dust. The red in the image below is typical of the emissions from Hydrogen gas.

A photographic image of M42

THE STARS OF ORION



The constellation of Orion in the south at midnight in mid January

As well as being one of the most spectacular and beautiful constellations, Orion is also very interesting because we can see evidence of all the stages of the life cycle of stars from birth to death. Obviously we can't see the life cycle of an individual star but we can observe stars at various stages of their existence.

Stars are not actually living things like us but they do exist in various stages of evolution that resemble the life cycle of living entities. We have seen in the previous pages that stars are being 'born' in the stellar nursery in Orion's sword in the Great Nebula M42. These stars are still very young and at this stage are very active. After a few tens or hundreds of millions of years they will settle down to live the longest stage of their lives as normal 'Main Sequence' stars. Our Sun is about 4.3 billion years old and approaching half way through its main sequence. We can see many stars at this stage in Orion and others older and many much younger. Other stars as we saw on the previous page are in the process of being created.

There is another factor that affects the life span of a star and that is its mass (the amount of gas it is made of). Large stars have denser and hotter cores and their nuclear fusion process produces much more energy and consumes the Hydrogen at a much fast rate. These large stars use up the fuel supply very quickly and therefore have short lives (less than a billion years). There are two bright stars in Orion that demonstrate this very well. The first is Rigel at the bottom right of Orion. This is a star about 30 times the mass of our Sun and about 120,000 times more powerful than our Sun.

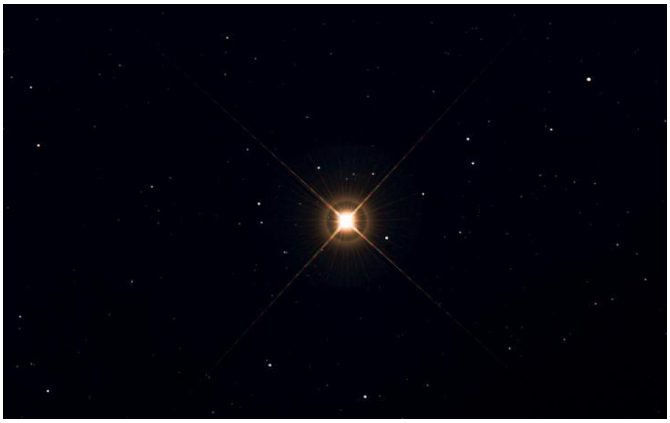
A star like our Sun will fuse Hydrogen into Helium and towards the end of its life will begin to fuse some of the Helium. A larger star like Rigel will be able to fuse the Helium and manufacture other heavier atoms until Iron is produced. At this point it will have become a Red Giant and will eventually explode as a Super Nova.

Rigel as seen using a telescope

Rigel is currently a star in its prime and is very large at about 30 times the mass of our Sun. This makes it very powerful and perhaps just moving towards the end of its middle age. It has another smaller star orbiting it and that star can be seen using a medium sized telescope.

Another star Betelgeuse, located at the top left of Orion, is much further along its pathway of 'life'. It is approaching the last phases of its existence as a normal star. It has grown into a (really huge) Red Giant with a diameter greater than the orbit of Jupiter in our Solar System.

Betelgeuse is so big and unstable that it pulsates and wobbles rather like a water filled balloon. By carefully observing the brightness of Betelgeuse it can be seen to brighten and fade. At its brightest it can be as bright as magnitude 0.2 and at its dimmest only magnitude 1.2. It is quite difficult to determine the cycle of the pulsations and brightening because there seems to be a number of intertwined cycles. So it appears to vary at different rates of between 150 to 300 days.



Betelgeuse as seen using a telescope

Betelgeuse appears to be edging towards the end of its life. In fact it is the closest star to us that might explode as a super nova at any time in the near future (astronomically speaking). It could explode and destroy itself sometime in the next million years (maybe as soon as tomorrow). For all we know it may have already exploded but its light will take 650 years to reach us.

These two stars are close enough to us and so bright that we can even see their nature with our naked eyes. Rigel is obviously very white in appearance which is even more obvious using binoculars or a telescope. This is because it is very hot with a surface temperature of about 12,000ºK compared to our Sun at about 6400ºK. This is in contrast to Betelgeuse which is only 3500ºK and is distinctly orange to the naked eye and again even more so when viewed using binoculars or a telescope.

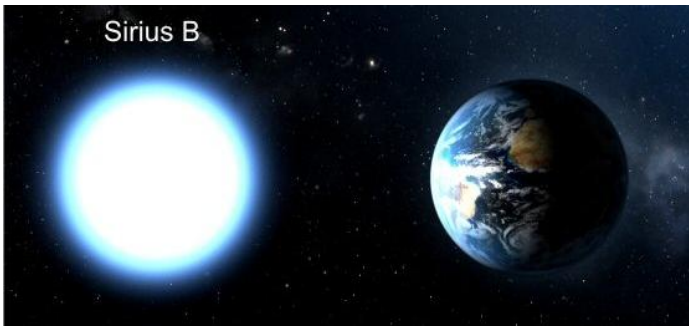
Betelgeuse looks red (orange) because it is more advanced in its life cycle than Rigel and has moved into its Red Giant Phase. The nuclear fusion process is fusing the heaver atoms it has produced into even heavier elements, with each fusion stage contributing additional energy to power the star. All this additional energy pushes out against the force of gravity pulling inwards. The additional energy has forced the outer regions of the star to expand outwards to produce this huge (in volume) bloated and unstable Red Giant.

An impression of what Betelgeuse might look like

Giant stars like Rigel and Betelgeuse destroy themselves dramatically in a massive super nova explosion but smaller stars like our Sun reach their end in a much less dramatic way. With less pressure and heat in their core they cannot fuse atoms heavier than Helium to create the heavier elements. They consume their fuel supply a lot slower and therefore last much longer. Our Sun had enough Hydrogen, when it formed, to last about 10 billion years and has so far, in the last 4.3 billion years, used just under half of its fuel.

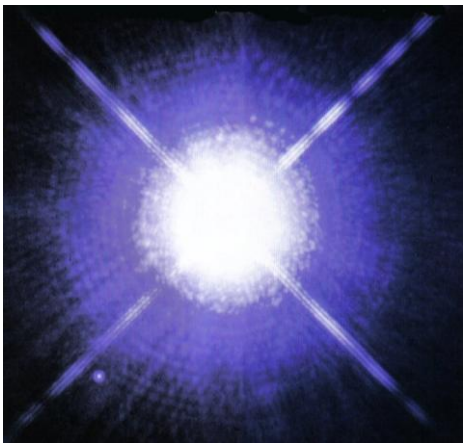
In another 4 billion years our Sun will begin to fuse the Helium that has accumulated in its core. The additional energy produced by the fusion of the Helium will cause the Sun to inflate to become a red giant. It is thought the Sun may reach a diameter equivalent to the orbit of Earth before its fuel supplies are exhausted. The outer layers will drift away into space to create a beautiful bubble called a Planetary Nebula. As fusion, in the core, begins to break down and stop, the radiation that had been overcoming the force of gravity also disappears and the star will begin to collapse inwards. It will collapse into a dense sphere called a White Dwarf about the size of Earth ~12,000 km in diameter but still weighing about the same as the Sun.

In mythology, Orion the Hunter has two hunting dogs so the constellation of Orion also has two hunting dogs in the form of the stars Sirius in the constellation of Canis Major (the large dog) and Procyon in Canis Minor (the little dog). These hunting dogs can be found to the east (left) of Orion on the chart on the previous page.



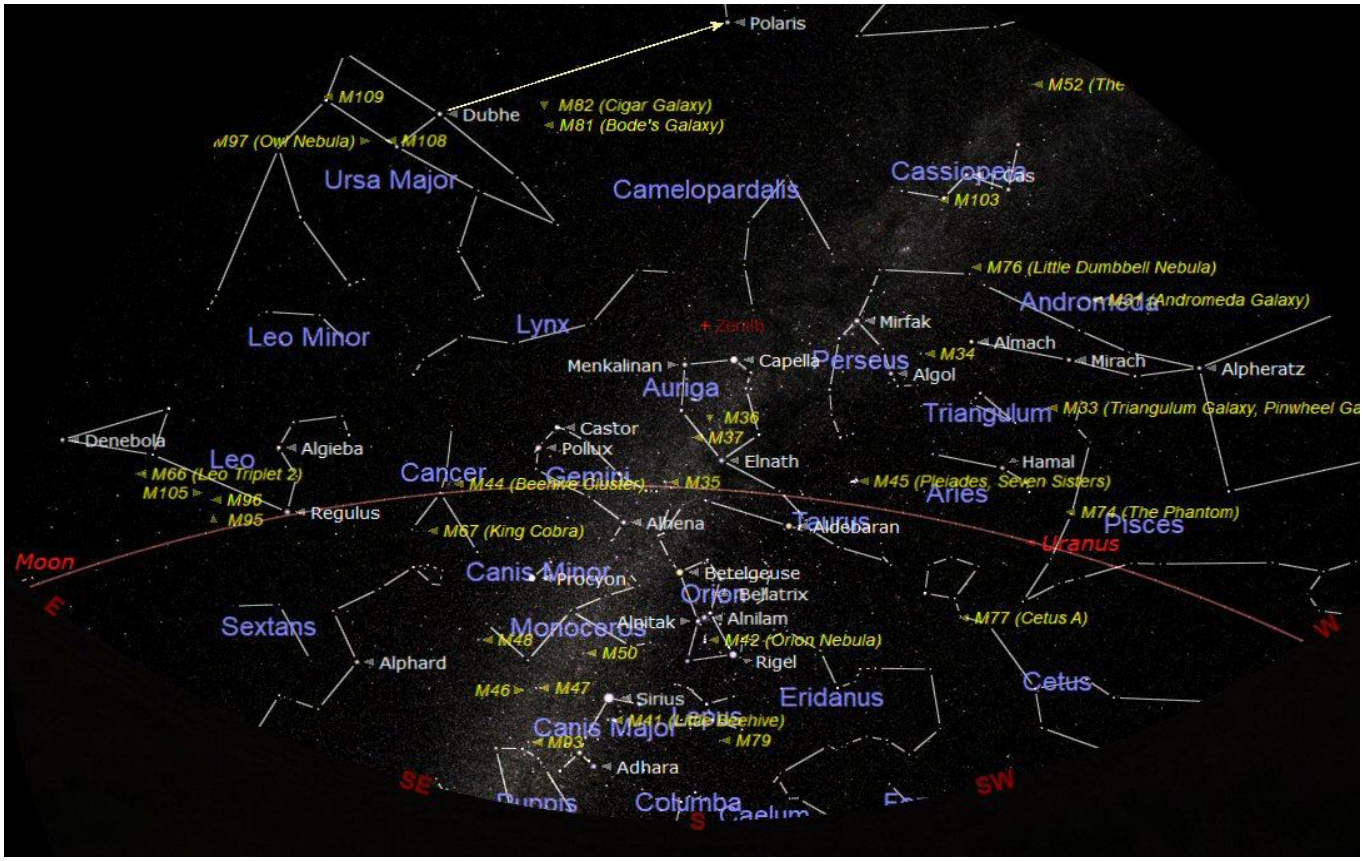
The White Dwarf Sirius B compared to Earth

Both Sirius and Procyon are double stars with their companions both being White Dwarfs. The companions must have been slightly larger, than the main stars we see now and used up their fuel supply quicker. The White dwarfs are too small to see but their great mass causes the stars to appear to wobble.



An image showing Sirius B (towards the lower left)

A TOUR OF THE NIGHT SKY - JANUARY 2020



The chart above shows the night sky looking south at about 20:00 GMT on 15th January. 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 Aquarius (the Water Carrier) just moving over the western horizon, Pisces (the Fishes), Aries (the Ram), Taurus (the Bull), Gemini (the Twins), Cancer (the Crab), Leo (the Lion) and Virgo (the Virgin) rising over the eastern horizon.

Just disappearing over the south western horizon is the constellation of Aquarius (the Water Carrier) followed by Pisces (the Fishes). The planet Uranus is in Pisces and can be found in the early evening using binoculars. It looks like a slightly fuzzy blue star. A telescope will reveal it as a small blue disc. It does need a magnification of 100x or more.

The summer constellations have now given way to the winter constellations that are now prominent in the southern sky. In the south west 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. The Great Square can be used to judge the condition of the sky for observing. If stars can be seen within the square there seeing should be good. If no stars can be seen then seeing will not be good.

From the top left star of the Square, called Alpheratz, we can find the Great Spiral Galaxy in Andromeda. First find Alpheratz then move two stars to the left to the star Mirach and then up two slightly fainter stars. Just to the right of the second star is a small fuzzy patch of light can be seen, this is M31 the Great Spiral Galaxy in Andromeda. This is a giant spiral galaxy similar to our own Milky Way Galaxy and the nearest of this type of galaxy. In a clear dark sky it is the most distant object that can be seen with our 'naked eyes' at 2.4 million light years. It is easier to find using binoculars but a telescope is required to see it as a 'cigar shaped' patch of light with a bright core at its centre.

Now prominent in the south 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 '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 'naked eye' Open Star Cluster Messier 45 (M45) known as the Pleiades (or the Seven Sisters). It really does look magnificent using binoculars.

Following Taurus is the constellation of Gemini (the Twins). The two brightest stars in Gemini are Castor and Pollux and they are named after mythological twins.

To the south of Taurus and Gemini is the spectacular constellation of Orion (the Hunter). Orion dominates the southern sky and is one of the best known constellations and hosts some of the most interesting objects for us amateur astronomers to seek out. Orion is the featured as constellation of the month and is the main feature in the magazine this month. See pages 3 through to 7.

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.

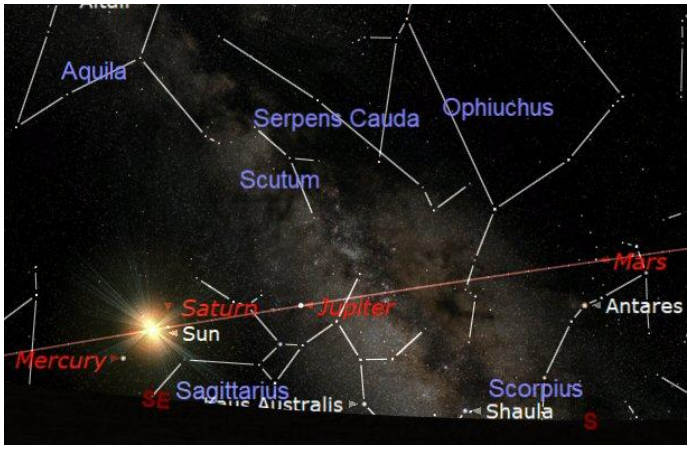
VENUS is difficult to observe this month as it will be very low on the south western horizon at sunset. It is moving out from its conjunction with the Sun (passed above the Sun) on 14th August and is now moving away from the Sun. See the Uranus and Neptune chart opposite.

If a telescope is used to look at Venus it will appear 'gibbous' (wider than a half moon shape). Over the next few months it will appear larger as it moves towards Earth but will reduce to a thinning crescent. As an inferior planet we will see Venus loop out from behind the Sun towards us then back to pass in front of the Sun.

How Venus will appear at Sunset on 15th January

MARS will be observable (with difficulty) this month low in the east before sunrise. Mars is still a long way from us on the other side of the Solar System so it looks rather small at just 4.1" (arc seconds) see the Jupiter chart below.

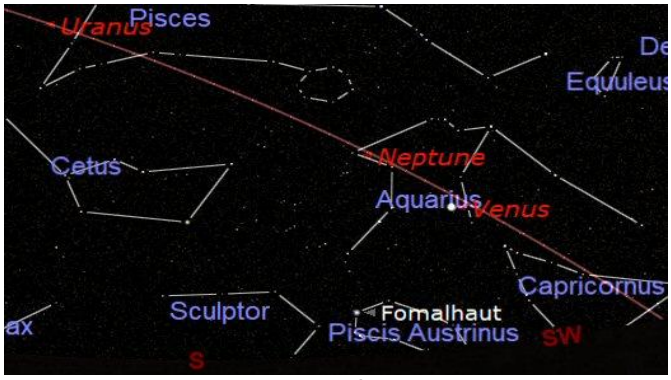
JUPITER is now moving away from the Sun and may just be glimpsed before the sun rises in the south east. It will be in the bright dawn sky very low and in the dirty and turbulent air just above the horizon.



Mercury, Saturn, Jupiter and Mars after sunrise

SATURN will not be observable this month as it will be in conjunction (passing behind the Sun) on the 3rd January. It will then move away from the Sun and will appear over the south eastern horizon earlier as move through the next few months. See the chart above.

URANUS the Ice Giant Planet 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 in the next column.



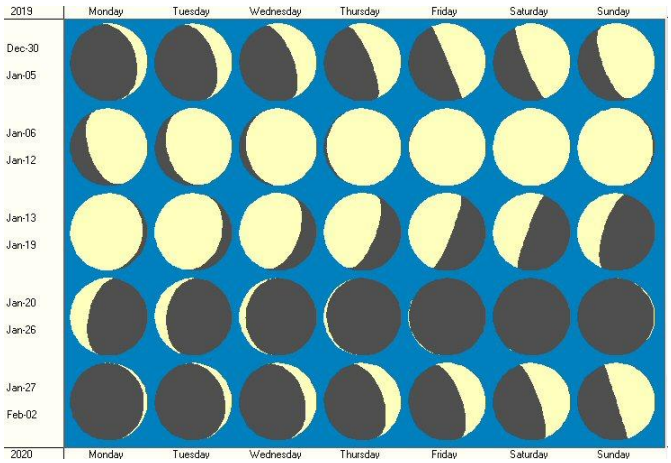
Uranus, Neptune and Venus at sunset

NEPTUNE is still in a good position for observing in the early evening sky but it is now moving towards the western horizon. A medium sized telescope using a magnification of 150x will be needed to see it.

THE SUN

The Sun rises at 07:45 GMT at the beginning of the month and at 08:00 GMT by the end of the month. It will be setting at 15:53 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 JANUARY

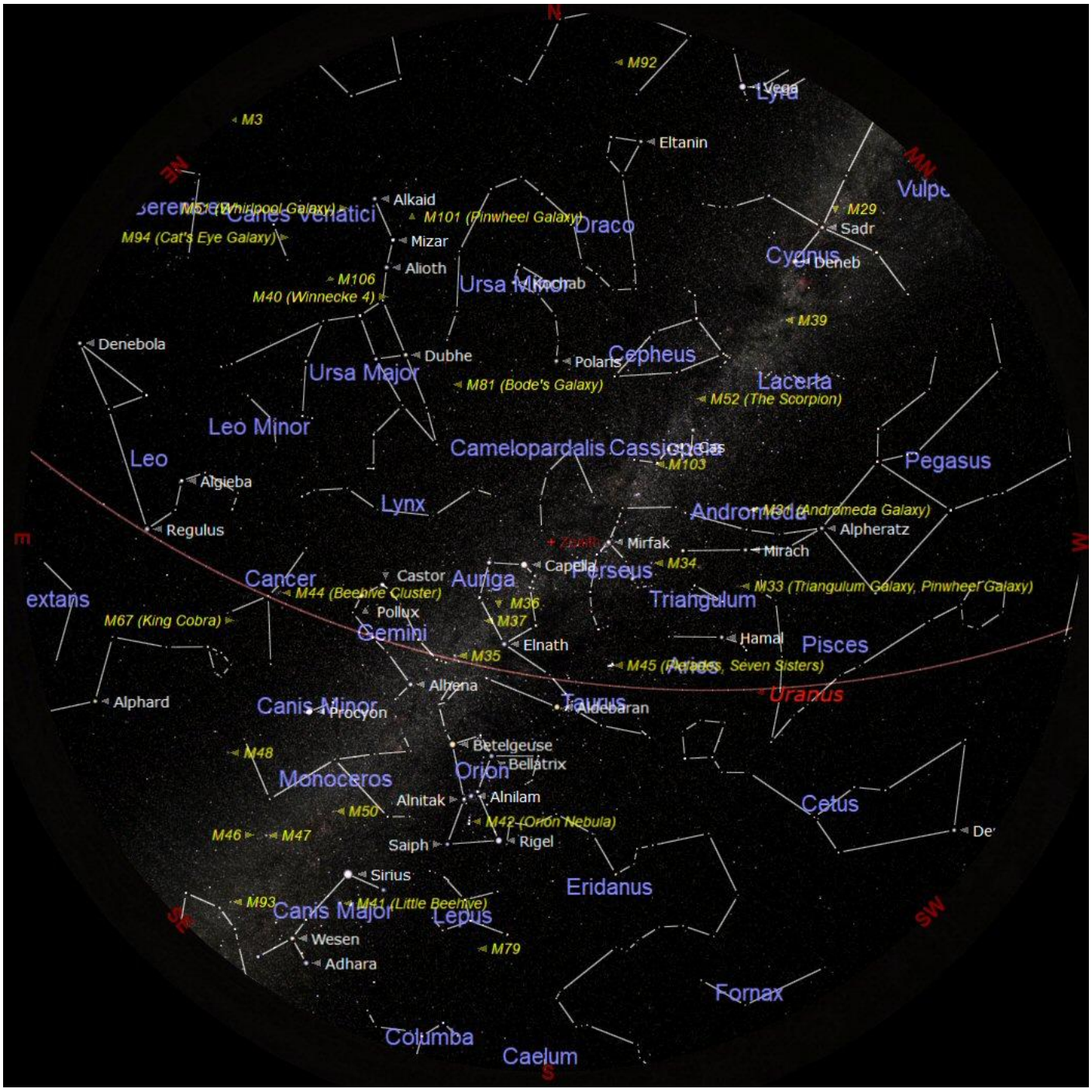


First Quarter will be on 3rd January
Full Moon will be on 10th January
Last Quarter will be on 17th January
New Moon will be on the 24th January

The Old Moon imaged at 07:20 on 24th December

We don't often see the 'Old Moon' because it appears just before sunrise and is always very low in the east.

THE NIGHT SKY THIS MONTH



The chart above shows the night sky as it appears on 15th January 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: Uranus and Neptune and Venus in the very early evening.