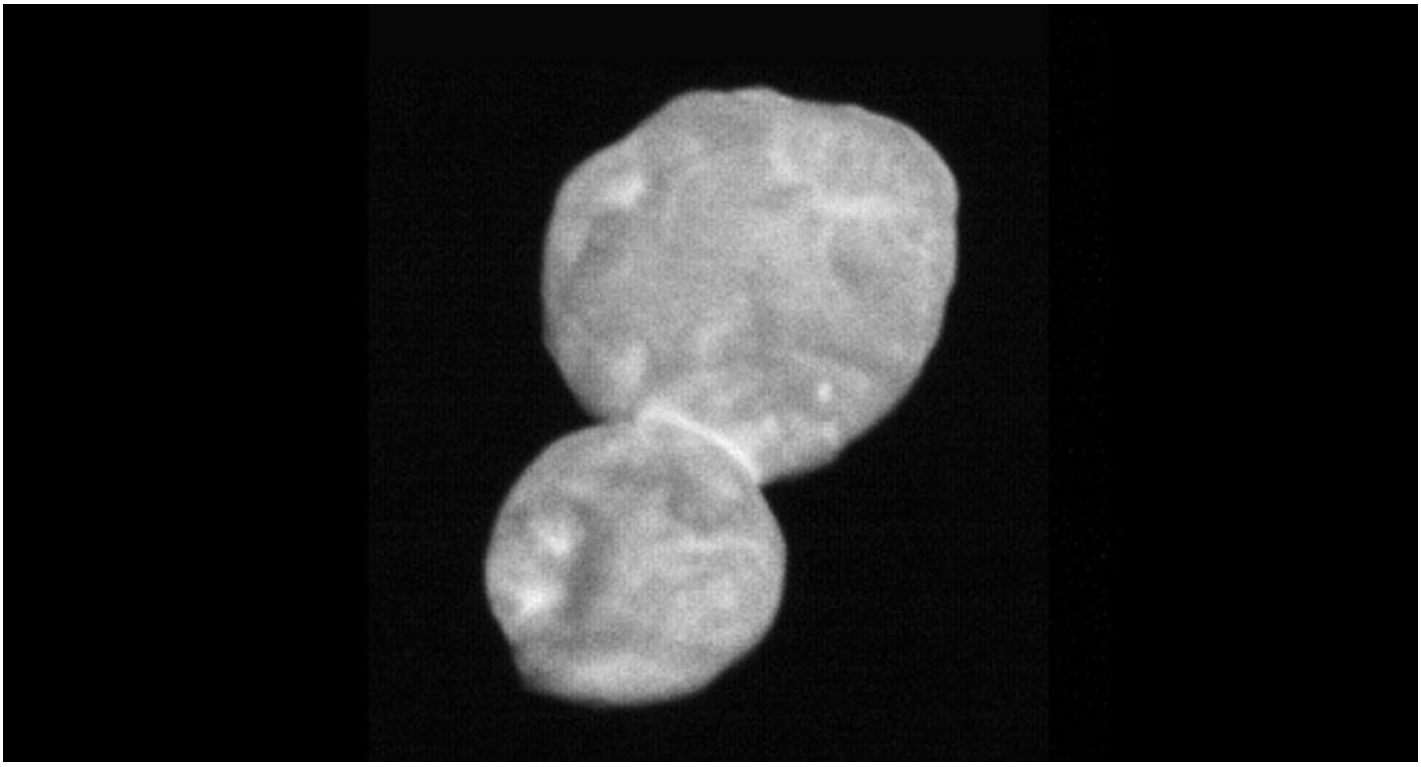
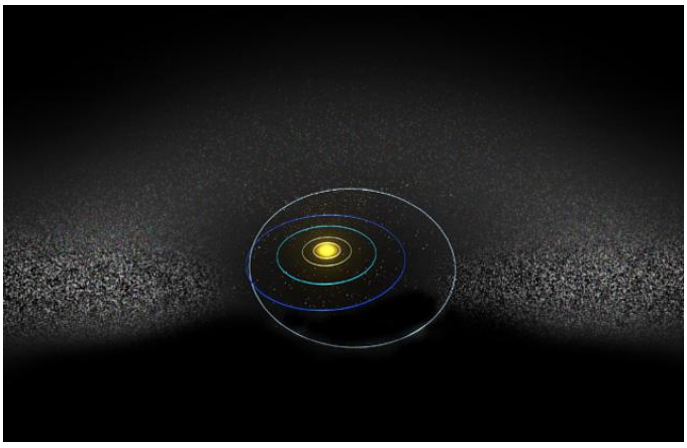
NEWBURY ASTRONOMICAL SOCIETY
MONTHLY MAGAZINE – FEBRUARY 2019

NEW HORIZONS SWEEPS PAST ULTIMA THULE



Ultima Thule imaged by New Horizons (early image received)

After its very successful encounter with the Dwarf Planet Pluto, NASA's New Horizons space probe has flown past the Kuiper Belt object known as 2014MU now known as Ultima Thule. This encounter on 1st January 2019 has been a very important event because we have never before had an opportunity to study one of these enigmatic, small and distant solar system objects.



The Kuiper Belt surrounding our main planets

The Kuiper Belt is a 'Doughnut' shaped cloud of millions of small frozen objects orbiting our Sun beyond the orbit of the outer planets. Over the last decade or so a number of 'Pluto' like objects have been discovered at long and distant orbits around the Sun. The first of these Kuiper Belt objects were, what was thought to be, just the largest and closest of a vast cloud of frozen objects.

It was the discovery of these 'Pluto like' objects that lead to Pluto to be reclassified as a 'Dwarf Planet' as these newly discovered Kuiper Belt objects have been called. A number of these objects have been found to be similar in size to Pluto with some even larger. So rather than trying to name all these and the millions of smaller objects as planets, they have all been recorded as members of a sub-group of planets called 'Dwarf Planets'.

As our telescopes have become larger and more advanced the larger and closer members of the Kuiper Belt have been studied but still with great difficulty. Some smaller members have been identified but they are mainly too small to reveal any useful information about their actual size and physical composition.

After its encounter with Pluto, New Horizons was found to have a significant amount of manoeuvring fuel left and its nuclear power pack still had plenty of power left. NASA gave permission for the probe to be directed to encounter a suitable known Kuiper Belt object. (Cont.)

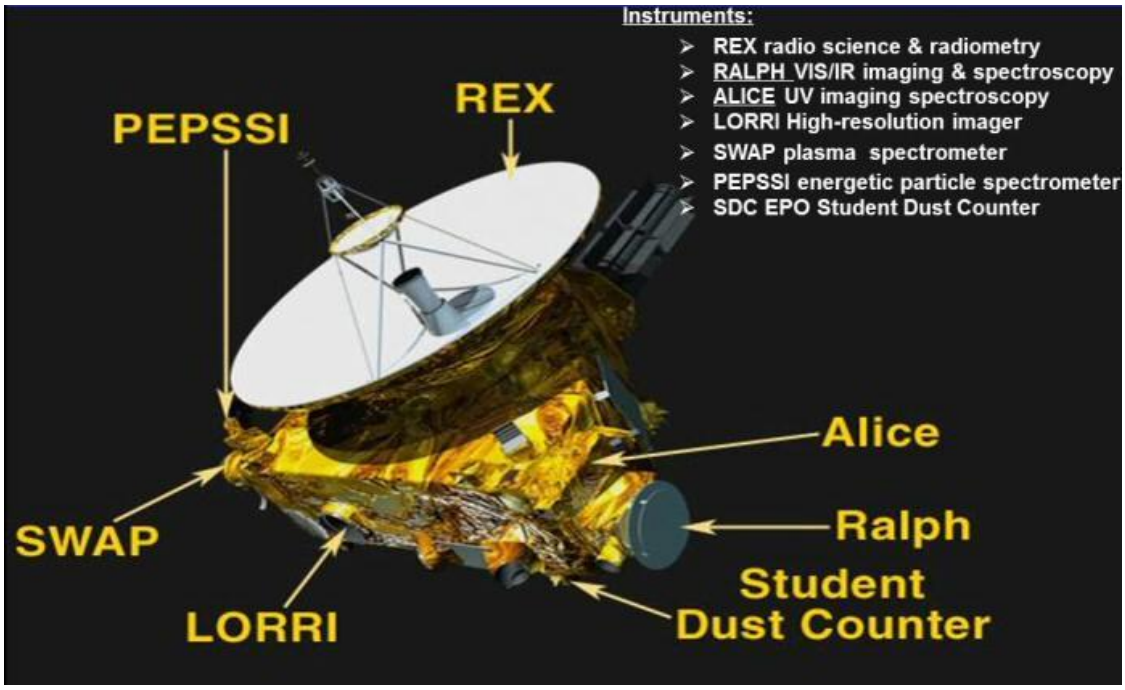
NEWBURY ASTRONOMICAL SOCIETY MEETING

1st February Women in Astronomy
Website: **www.newburyastro.org.uk**

NEXT NEWBURY BEGINNERS MEETING

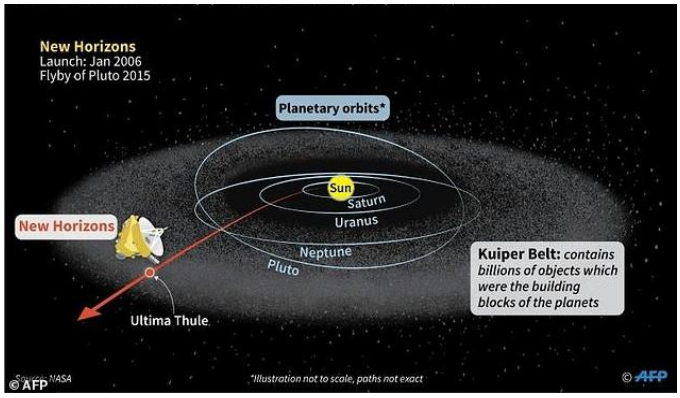
20th February Juno at Jupiter
Website: **www.naasbeginners.co.uk**

NEW HORIZONS AT ULTIMA THULE cont.



NASA's New Horizons Space Probe

New Horizons was launched on 19th January 2006 and swung past Jupiter for a gravity boost and scientific studies in February 2007. It conducted a six month long reconnaissance flyby study of Pluto and its moons in summer 2015, culminating with its closest approach to Pluto on 14th July 2015. As part of an extended mission the spacecraft was directed further into the Kuiper Belt to examine another of these ancient, icy mini-worlds. The object selected was a small Kuiper belt object called (486958) 2014 MU.



The trajectory of New Horizons

On 19th January 2006, New Horizons was launched from Cape Canaveral Air Force Station by an Atlas V rocket directly into an Earth-and-solar escape trajectory with a speed of about 16.26 km/s (58,500 km/h). It is the fastest probe ever launched from Earth.

After a brief encounter with asteroid 132524 APL, New Horizons proceeded to Jupiter, making its closest approach on 28th February 2007, at a distance of 2.3 million kilometres. The Jupiter flyby provided a gravity assist that increased New Horizons' speed; the flyby also enabled a general test of New Horizons' scientific capabilities, returning data about the Jupiter's atmosphere, moons and magnetosphere.

Most of the post Jupiter voyage was spent in hibernation mode to preserve on-board systems, except for brief annual checkouts. On 6th December 2014, New Horizons was brought back online for the Pluto encounter and instrument check-out began. On 15th January 2015, the spacecraft began its approach phase to Pluto.

On 14th July 2015 at 11:49 UTC, it flew just 12,500 km above the surface of Pluto, making it the first spacecraft to explore the dwarf planet. On 25th October 2016 at 21:48 UTC the last of the recorded data from the Pluto flyby was received from New Horizons. Having completed its flyby of Pluto, New Horizons was then instructed to manoeuvre and adjust its trajectory for a flyby of Kuiper belt object (486958) 2014 MU now known as Ultima Thule

The objects in the Kuiper Belt are thought to have been formed from material left over from the nebula in which the Sun formed 4.3 billion years ago. This material is thought to be water ice and other frozen materials that having been frozen all this at just 3 degrees above absolute zero, remains completely unchanged. As such it may be able to give us an insight into how the Sun and planets formed.

New Horizons is equipped with instruments that can analyse many physical and chemical characteristics of Ultima Thule during its very brief encounter. It will however take about 20 months to return all its recorded data back to Earth.

'Thule' is the farthest north location mentioned in ancient Greek and Roman literature and cartography. Modern interpretations have included Orkney, Shetland, the island of Saaremaa in Estonia and the Norwegian island of Smøla. In classical and medieval literature, Ultima Thule acquired a metaphorical meaning of any distant place located beyond the "borders of the known world". By the late middle ages and early modern era, the Greco-Roman Thule was often identified with the real Iceland or Norway. It is a very apt name for this distant Dwarf Planet.

ASTRONOMICAL DISTANCES

Astronomical objects are usually a long way apart and in many cases can be vast distances so we must choose units that will accommodate these distances. There are four units that are commonly used so we shall consider them in order of the size of the units.

Objects within our Solar System are relatively close to us and each other so we tend to use conventional units mainly kilometres. This is a derived unit of the standard SI unit of length the Kilometre being 1000 metres. So we would use this unit to define the distance to the Moon (384,400 km) and to the Sun (149,600,000 km).

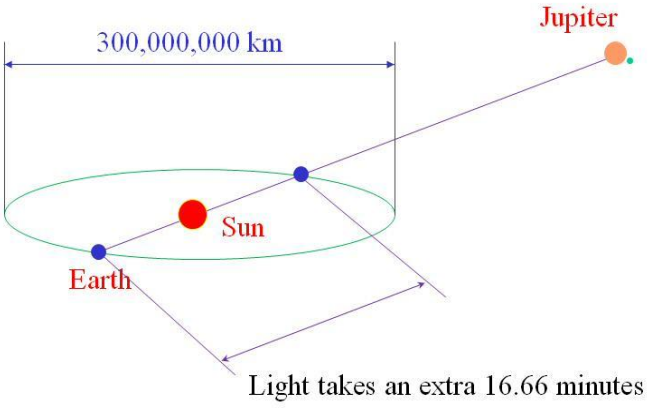
This is good for the Moon but for greater Solar distances these numbers become rather cumbersome so we would normally use the unit millions of kilometers. So we can write this, for the Sun, as: 149.6 million km or 149.6 M km or more commonly 149.6 x 10^6 km. The 10^6 is the mathematical term used to imply a whole or whole and decimal followed by six zeros for example 149.6 x 10^6 km.

ASTRONOMICAL UNIT

The Earth – Sun distance (149.6 million kilometres) is often used as a unit of distance that we call 'ASTRONOMICAL UNIT' or 'AU'. This is usually used in relation to Solar System sort of distances and even in describing the separation of close binary stars.

LIGHT YEAR

Fortunately nature has given us a perfect standard unit that we can use to define and measure very large distances. This is the 'finite' speed at which light travels through a vacuum, such as interstellar space. The speed of light was measured very accurately by the Danish Astronomer Ole Rømar in 1676.



Rømar calculated the exact orbital period of Jupiter's moon Io. He therefore knew exactly when Io would appear around the edge of Jupiter and then when it would disappear again on the other side of Jupiter. He then noted the time Io appeared when Earth was on the side of the Sun nearest to Jupiter. Six months later he again noted the time when Io appeared again. This time Io appeared 16.66 minutes later. Light from Io had taken 16.66 minutes (~1000 seconds) to travel across Earth's orbit (~300 x 10^6 km). From this Rømar calculated the speed of light was 300,000 km/sec by: (300 x 10^6 km ÷ 1000sec = 300,000 km/sec). So a light-year is the distance travelled by light in one year. This is very close to the actual light speed used today.

PARSEC

The PARSEC is a measurement used to measure the distance to relatively near-by objects. It is actually an angular measurement that uses parallax. This is the process of measuring the distance optically from two observing points. This process increases in accuracy the further the two observing points are apart. When measuring the distance to a nearby star we can use the orbit of Earth around the Sun as our vantage points. First accurately record the position of the star and then do the same measurement six months later. Earth is on the opposite side of the Sun so it will be 300 million kilometres away from the first point.

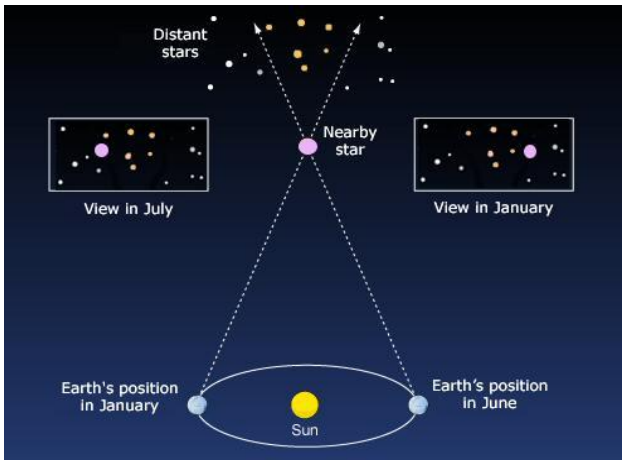
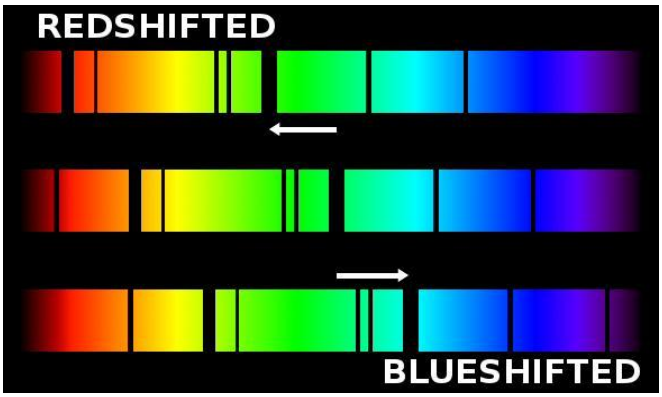


Diagram showing the process of measuring parallax

The diagram above shows the position of the target star measured in January and again in June. The star has appeared to move against the more distant background stars so the angle it has moved can be calculated. The measured angle uses the unit of arc-seconds this is 1/3600 of a degree (60 arc-minutes or 3600 arc-seconds). For example: 2.75 parsecs.

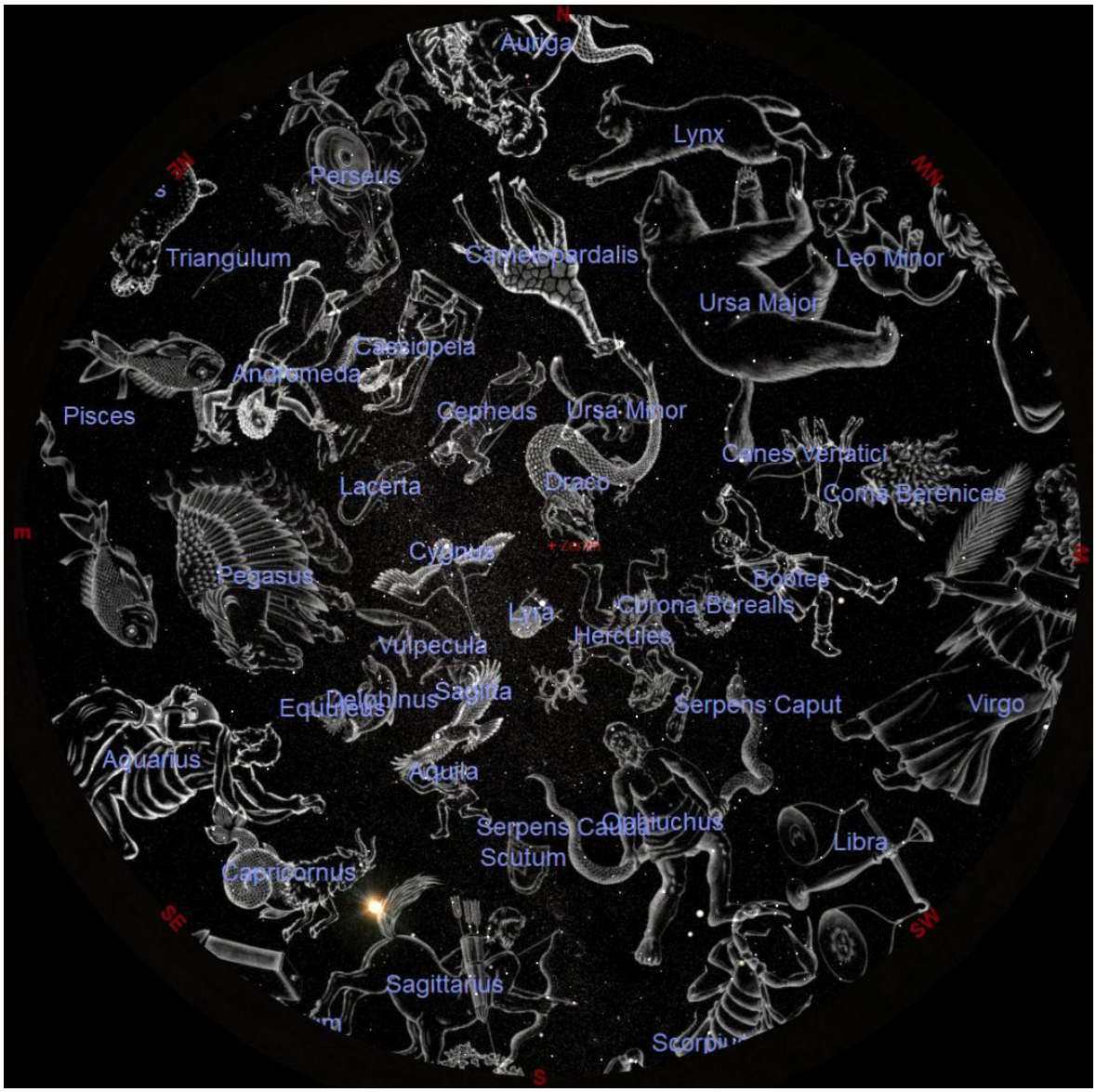
REDSHIFT (for very distant objects)

Edwin Hubble discovered that the further away an object is from us the faster it will be moving away from us. If we examine the spectrum of a star we see dark lines where elements around the star absorb some of the light waves at discrete positions on the spectrum. If the star is moving away from us these lines will be moved towards the red end but if it is moving towards us the lines will be moved towards the blue.



The pattern of lines have been moved, the faster the object (further away) the more the lines are moved. More about 'Redshift' next month.

STAR CHARTS



The constellations as shown on old star charts

We Humans seem have a need to place things into groups whether it is plants, animals, people or stars. When we look up at the stars we see some are brighter than others and we have a tendency to make familiar shapes out of the star patterns in our mind. This is rather like seeing the shapes of rabbits or elephants in the clouds. Many of the patterns seen in the stars were recorded in ancient times but are still used today. We call these recognised patterns Constellations.

Constellations are groups of stars that appear to make up a recognisable pattern. The stars are not normally associated with each other but are just located in the same area of the sky. Some patterns do look remotely like what they are named after which is normally a character from mythology. Most constellations however need an awful lot of imagination to relate the pattern of stars to the figure from mythology or anything else.

The ancient Greeks recognised 48 constellations including the 12 constellations of the Zodiac. Many people are familiar with the constellations of the Zodiac because of the horoscopes and their life predictions published in magazines and newspapers.

These constellations are those that the Sun Moon and planets pass through over the course of a year. An imaginary line drawn through these constellations and following the path taken by the Sun is known as the Ecliptic, see the chart on page 8 of this magazine.

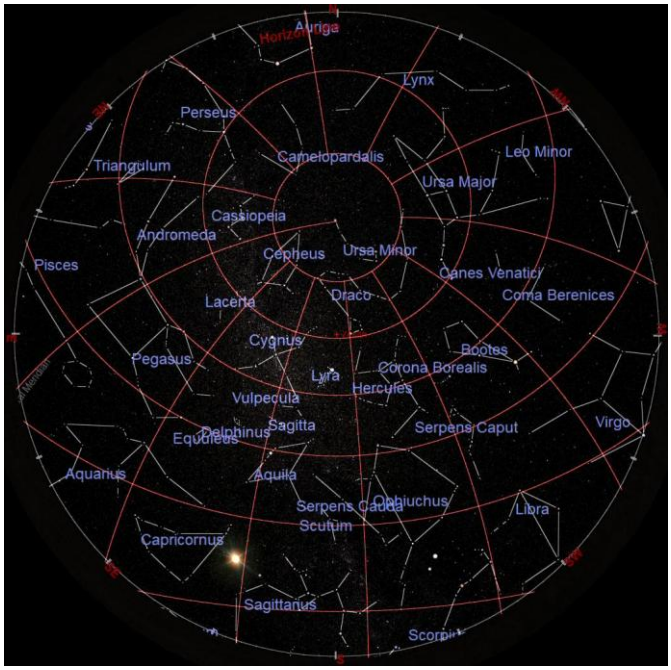
As the axis of the Earth's rotation is tilted, the ecliptic is also tilted at about 23.4° to Earth's equator (Celestial Equator). Until the 1930's there was no standard list of the constellations. Then the International Astronomical Union, astronomy's governing body, adopted the list of the 88 constellations we recognise today.

Old star charts were often beautifully drawn and decorated with pictures of the mythological figures representing the constellations and are now regarded as valuable works of art. Although these magnificent charts were wonderful to look at each artist depicted the figures using his own interpretation of what the mythological figures should look like. As a consequence no two charts looked alike. Before the invention of the telescope this was not a problem because there were only a limited number of stars to be seen with the naked eye so they could be plotted on the chart and the figure overlaid.

With the introduction of the telescope more accurate star charts were needed so the beautifully illustrated charts began to disappear and were replaced by the more scientific charts we see today. Constellations remain as the accepted system of identifying the various parts of the night sky. Most of the star patterns of the constellations are easily recognisable even if they do not resemble what they are named after. Alternative methods using co-ordinates may be more accurate but it would be much more difficult to define areas of the sky. It is not so easy to optically identify objects using just coordinates.

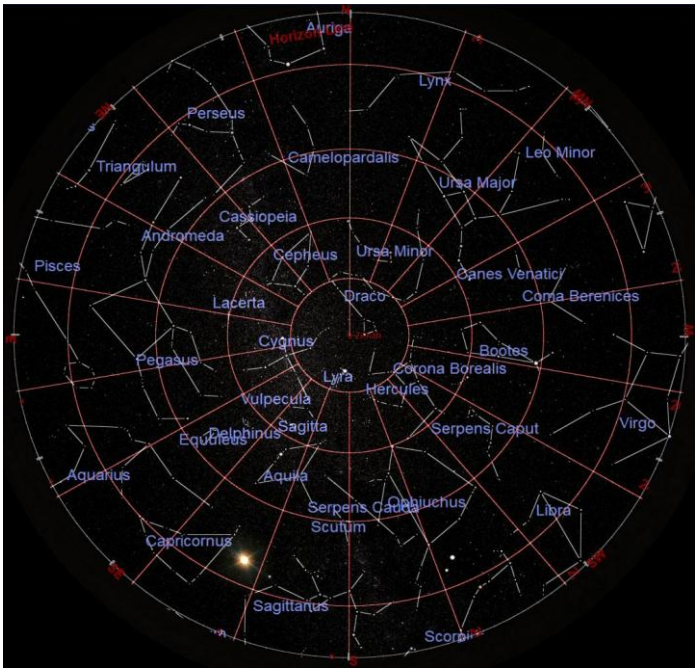
Stars are often allocated an identifying reference within the constellation in which they are located, using a letter from the Greek alphabet. If there are not enough letters then identification continues using numbers. An example would be α (alpha) in Orion the Latin form of the constellation name is usually used so we call this star α *Orionis*. Many of the brighter stars also have real names so α *Orionis* is also called Betelgeuse.

THE EQUATORIAL CO-ORDINATE SYSTEM



Most astronomical telescopes are Equatorial Mounted these days so an equatorial coordination system is used. The method of defining the position of a star used today is a co-ordinate system using Right Ascension and Declination. Right Ascension (RA) is measured in hours, minutes and seconds around the Earth's equator from a set point known as the Vernal (or Spring) Equinox. This is the point where the Ecliptic crosses the Celestial Equator when the Sun appears to be moving northwards in spring. This point was also known as 'The First Point of Aries'. This point in the sky was in the constellation of Aries (The Ram) 6000 years ago. However due to a process called 'Precession' (the wobbling of Earth on its axis every 26,000 years) it has now moved into the neighbouring constellation of Pisces (The Fishes). Declination is the measure of degrees from the Celestial Equator to the poles, +90° to the North Pole (the star Polaris in Ursa Minor) and –90° to the South Pole. Therefore the position of a star might be written as RA 12hr 13min 26.3 sec and Dec +25 deg 20 min 10.5 sec.

THE ALT – AZIMUTH CO-ORDINATE SYSTEM



The Alt-Azimuth co-ordinate system uses the Altitude (elevation) above the observers horizon 0º up to the position directly overhead (known as the Zenith) at 90º. The Azimuth or rotation angle is measured from 0º at North position, 90º to the East, 180º at South and 270º at West. This co-ordinate system is particularly useful when using Dobsonian telescopes and similar mountings known as Alt-Azimuth mountings.

MODERN STAR CHARTS

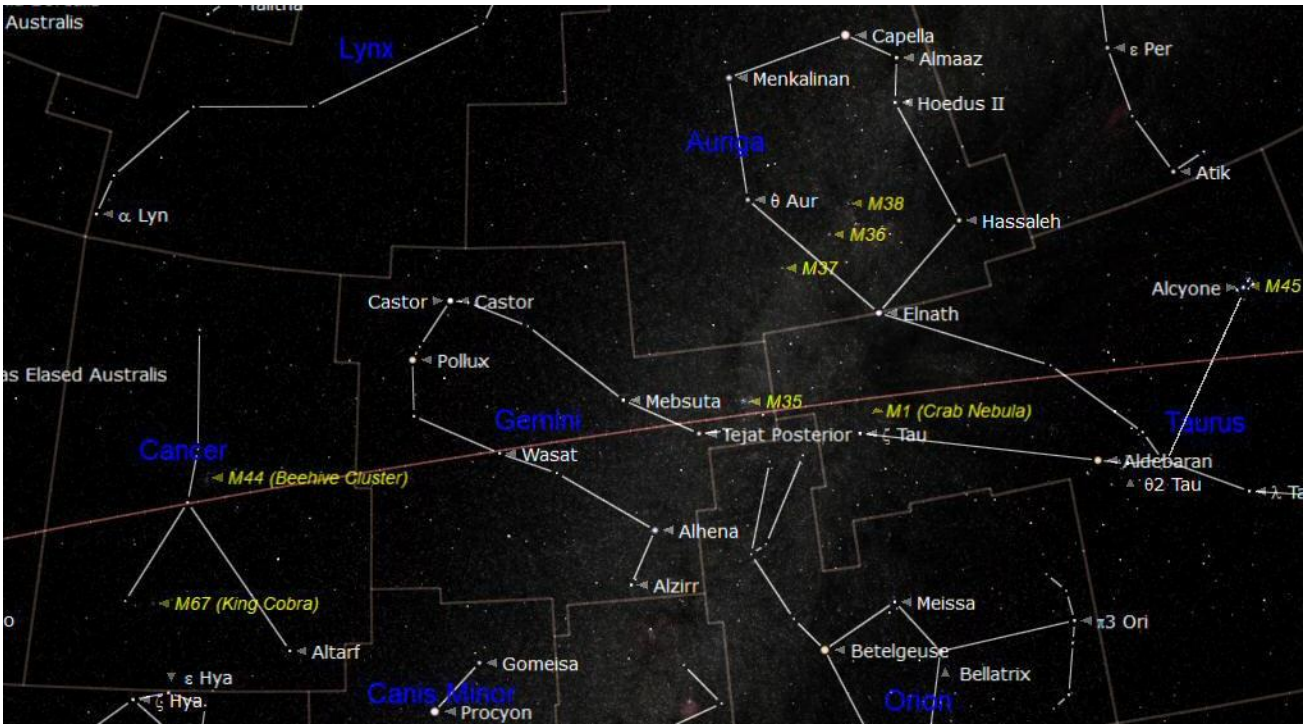
There are many modern star charts but one of the most widely used is Norton's Star Atlas. Norton's is a book of 14 charts with accompanying lists of objects of interest. The charts are laid out with one chart for each month of the year and two showing the polar regions. The Atlas also has very useful tables, lists and information covering most astronomical topics.

Modern technology has enabled very detailed charts to be produced using photographs. One of the most widely used is the Palomar sky chart produced from thousands of photos taken by the Schmidt camera at Mount Palomar USA. Another is the Hubble Guide Star Catalogue. This is a vast and very accurate catalogue of stars used to accurately guide and align the Hubble Space Telescope.

Probably the biggest advance in very detailed charts for the amateur astronomer, is the availability and technical progress of the personal computer. Very sophisticated charts are now available at a modest cost. These computer programmes are not only charts but are also active planetarium applications. This means that the current sky can be displayed showing the positions of the Sun, Moon, planets and many thousands of stars.

The positions of thousands of deep space objects such as galaxies, star clusters and nebulae can also be plotted. The charts included in this magazine were generated using a computer application called Starry Night Pro. By changing the time in the application it is possible to view the sky at any time in the past or the future 40,000 years and from any vantage point.

CONSTELLATIONS OF THE MONTH – AURIGA, GEMINI AND CANCER



The constellations of Auriga, Gemini and Cancer

The chart above shows the winter constellations of Auriga (the Charioteer), Gemini (the Twins) and Cancer (the Crab). These are interesting constellations to search out and have some very interesting objects to see even when using just a pair of binoculars. Gemini and Cancer are located on the Ecliptic and therefore are occasional hosts to the Sun, Moon and Planets as they appear to move along this imaginary line.

Capella is the brightest star in the constellation of Auriga, the sixth-brightest star in the night sky, and the forth-brightest in the northern celestial hemisphere after Sirius, Arcturus and Vega. A prominent object in the northern winter sky, it is circumpolar to observers north of 44°N. Its name means "little goat" in Latin. Capella is depicted as the goat Amalthea that suckled Zeus in classical mythology. The Capella system is relatively close, at only 42.9 light-years (13.2 pc) from the Sun.

Although it appears to be a single star to the naked eye, Capella is actually a quadruple star system with two binary pairs made up of the stars Capella Aa, Capella Ab along with Capella H and Capella L.

The first pair, Capella Aa and Capella Ab is composed of two bright yellow giant stars, both of which are around 2.5 times as massive as the Sun. The second pair, Capella H and Capella L is positioned around 10,000 astronomical units (AU) from the first pair and are two faint, small and relatively cool red dwarfs.

Auriga has three Messier Open Clusters that can be seen using binoculars. These are M36, M37 and M38. See the chart above. Open Clusters are groups of stars that have formed from the gas and dust in a Nebula (large cloud of gas and dust). These clusters look like small smudges of light using binoculars. They are best seen using a telescope which will show many of the individual stars in the clusters.

During the midwinter months Capella is almost directly overhead which makes it very easy to find. During the summer months it can be seen close to the northern horizon. The Milky Way (our galaxy) passes through Auriga and can be seen on the chart above. The three open clusters are seen against the dense star fields of the Milky Way.

The constellation of Auriga is joined to the constellation of Taurus at the most southerly star of Auriga called Elnath. Oddly Elnath is actually included in the lists of the stars belonging to both constellations.

There is a fourth Open Cluster that appears to be in the same line as M36, M37 and M38 over the border in the constellation of Gemini, this is Messier 35 (M35). Gemini is named after the mythical twins Pollux and Castor from Greek mythology.

The recognised shape of Gemini is in the form of a rough rectangle with Pollux and Castor at the eastern short side. A line of stars runs south west from Castor to the star Tejat Posterior. The line from Pollux takes a diversion south through kappa (κ) then south west through Wasat to Alhena and Alzirr.

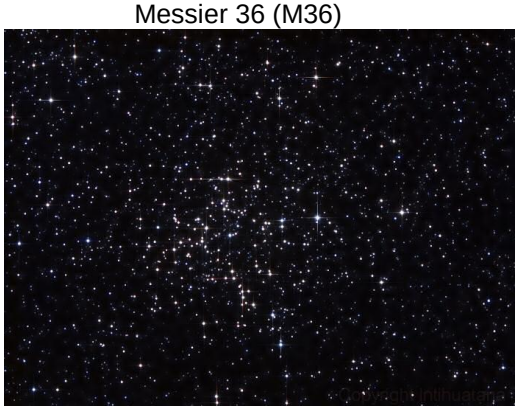
The two brightest stars in Gemini are Castor and Pollux which look quite similar and represent the twins. Castor and Pollux were the children of Leda. However Pollux was actually the son of Zeus who seduced Leda but Castor was the son of Tyndareus, King of Sparta and Leda's husband.

Gemini is easy to find because its two brightest stars are quite close together and similar in appearance. The two brightest stars are called Pollux (β) and Castor (α) and are known as the Gemini Twins. Although Castor has been given the Greek letter designation α (alpha), which is normally given, to the brightest star in a constellation, Castor is not actually the brightest Pollux is in fact the brighter of the two.

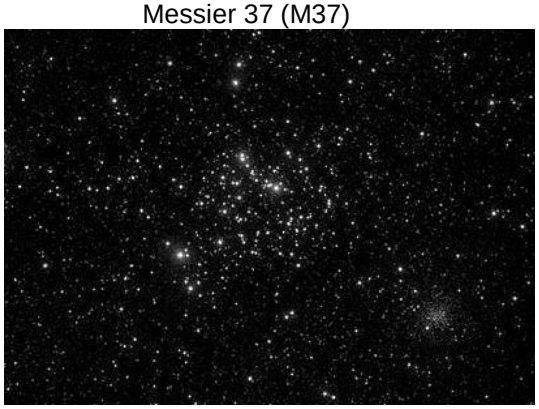
The open Clusters in Auriga and Gemini

Messier 36 (M36)

Messier 37 (M37)



Messier 38 (M38)



Messier 35 (M35) and NGC2158

Pollux is brighter at magnitude +1.59 compared to the +1.9 of Castor. However Castor is a double star with a fainter companion that has a magnitude of +2.9 and separated by 6 arc-seconds. The two stars, known as Castor A and Castor B, orbit their common centre of gravity every 467 years. The pair can be separated in a 75mm aperture telescope on a good clear night.

Messier 35 (M35) is located at the end of the upper of the two lines of stars that emanate from Pollux and Castor. It is the most spectacular of the four Open Clusters and is shown above.

Cancer is a faint and rather indistinct constellation but it does have a rather nice Open Cluster called Messier 44 (M44) Praesepe or 'the Beehive Cluster'. The stick figure shape of Cancer is an up-side-down letter 'Y'. Although M44 is large, the stars are dispersed and fairly faint. It is quite difficult to find in a light polluted area so will require binoculars to see it. See the chart on page 6.

Messier 44 (M44) Praesepe the Beehive Cluster

Open Star Clusters are listed in Charles Messier's Catalogue along with other objects of interest to amateur astronomers. Messier listed these objects along with Globular Clusters, Nebulae and Galaxies so they would not be mistaken for the comets he was searching for. Many of the brighter open clusters do look quite comet-like when viewed through binoculars. They are as the name suggests clusters of related stars and many are very beautiful to look at.

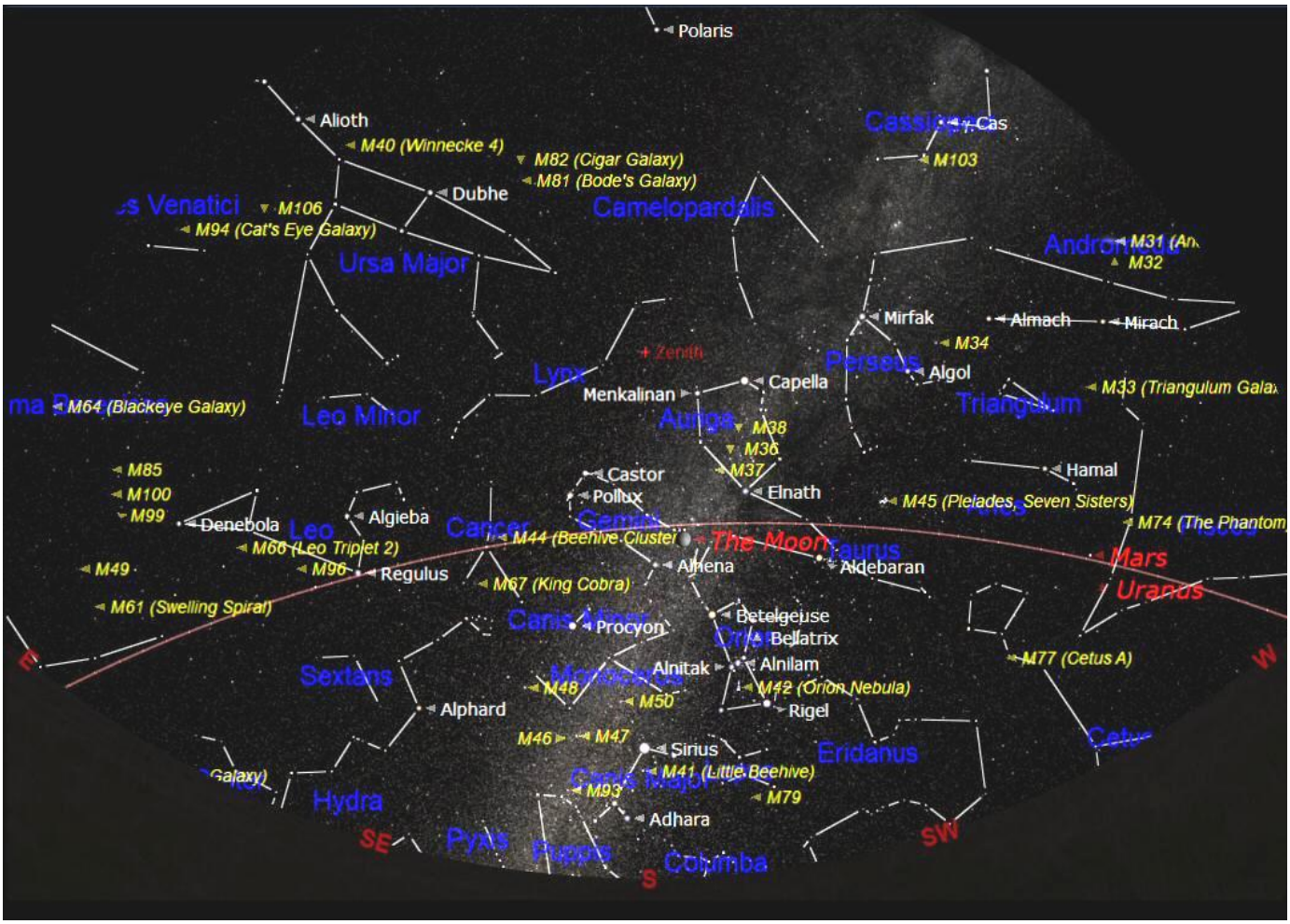
It is thought all stars form in vast clouds of gas and dust known as Nebulae (singular Nebula). Gravity pulls the atoms together into denser clumps until the gas and dust is compressed into very dense spheres. The temperature and pressure in the centre of the spheres rises until Nuclear Fusion begins. The Nuclear Fusion in the core produces an enormous amount of energy and the spheres begin to shine as stars and an Open Star Cluster is formed.

The brightest and most easily seen Open Cluster is Messier 45 (M45). See the chart on page 6. This is a cluster of about 300 stars in the constellation of Taurus. The cluster is known as the Pleiades but even more widely known as the Seven Sisters.

Six or possibly seven of the brightest stars in M45 are easily visible to the naked eye in a clear dark sky. They occupy an area of sky about the same size as the full Moon. Using a pair of 10 x 50 binoculars another thirty or so fainter stars can be seen embedded within the Seven Sisters.

The clusters M35, M36, M37 and M38 are further away so appear smaller and fainter. They can just about be seen using binoculars but a telescope is required to see them well. M35 is particularly lovely as it has a spectacular string of stars that appear to cascade through its centre and NGC2158 is close by.

A TOUR OF THE NIGHT SKY - February 2019



The chart above shows the night sky looking south at about 20:00 GMT on 15th February. West is to the right and east to the left. The point in the sky directly overhead is known as the Zenith or Nadir and is shown at the 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'. See page 4.

Constellations through which the ecliptic passes this month are Piscis (the Fishes), Aries (the Ram), Taurus (the Bull), Gemini (the Twins), Cancer (the Crab), Leo (the Lion) and Virgo rising over the eastern horizon.

The Milky Way (our Galaxy) flows up from the south horizon through Orion and Gemini. It continues up through Perseus and Cassiopea and on to Cygnus which is on the northern horizon.

Mars is still in a reasonable position, for observing during the early evening but is looking small now, in the constellation of Piscis. Uranus is just to the south of Mars but will need a good pair of binoculars or better still a telescope to find it.

Along the Ecliptic is the constellation of Taurus (the Bull). The stick figure representation of Taurus resembles a squashed 'X' with the bright orange coloured Red Giant star Aldebaran at its centre. This is a lovely star to look at especially using binoculars or a telescope and does look noticeably orange in colour.

Following the North western (upper right) arm of the 'X' shape of Taurus guides us to the beautiful Pleiades 'naked eye' Open Star Cluster. This bright Open Cluster with its seven brightest stars is known as Messier 45 (M45), the Pleiades or 'Seven Sisters'.

Attached to the upper left star of Taurus called 'Elnath' is the constellation of Auriga the Charioteer. Auriga appears like an odd shaped pentagon the beautiful bright white star Capella on the opposite side to Elnath.

To the east of Taurus along the Ecliptic is the constellation of Gemini (the Twins). The twin stars Castor and Pollux are easy to identify. Taurus is the constellation of the month.

Below Gemini is Orion the constellation of the month, in December. Orion is depicted as a hunter with two hunting dogs called Sirius and Procyon. The two stars that represent Orion's hunting dogs are also called Sirius and Procyon. Sirius and Procyon are the brightest stars in the constellations of Canis Major (the great dog) and Canis Minor (the little dog). These were the constellations of the month last month.

Further to the east (left) of Gemini is the constellation of Leo (the Lion). Leo is quite distinctive with the 'Sickle' shaped pattern of stars looking much like the head of the lion that Leo represents. In fact the traditional 'stick figure' shape of Leo as shown on the chart above does look rather like the lion's body or the Sphinx in Egypt. The 'Sickle' shape is also described as looking like a backwards question mark (?).

THE SOLAR SYSTEM THIS MONTH

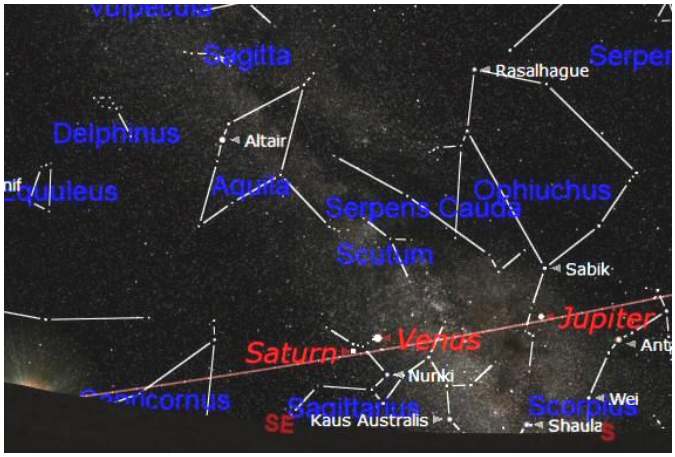
MERCURY sets over the western horizon soon after the Sun so it is just above the horizon and best placed low in the west in the evenings at the end of the month.

VENUS was at its Furthest Western Elongation from the Sun on 6th January. It rises over the eastern horizon at about 05:00 and will be very bright in the south east even at 06:30 as the sky brightens at dawn. Venus is very bright and always remains about the same brightness because as the diameter increases or decreases the phase narrows or widens. When it is on the other side of its orbit (far side of the Sun) it appears smaller but has a full phase. As it moves around and towards us it appears larger but develops into a narrow crescent therefore remaining at about the same overall brightness. See the Jupiter and Saturn chart below.

How Venus will appear using a telescope

MARS is still well placed in the early evening. It is low over the southern western horizon in turbulent and smoggy air. The Red Planet is moving away from Earth and looking smaller at 6.0 arc-seconds in diameter but still bright at magnitude +1.0.

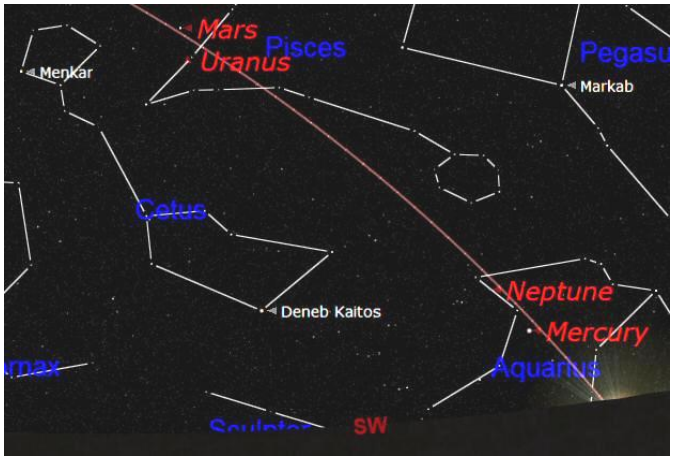
JUPITER is moving away from the Sun before sunrise. It now rises over the eastern horizon around 03:30 about 3 hours before sunrise. It is now becoming well worth getting up early to see. See the chart below.



Saturn, Venus and Jupiter at sunrise 07:00

SATURN is moving away from the Sun before sunrise and will be close to Venus. It will be observable but difficult to find in the brightening sky however nearby Venus will help. See the chart above.

URANUS will be in an observable position in the south west in the early evening but is moving towards the south western horizon. A good pair of 9x50 binoculars will reveal a slightly fuzzy blue, magnitude +5.8, star like, object. A telescope at a magnification of 100x will show it as a small blue/green disc. See the chart below.



Uranus, Neptune and Mars at 18:30 on 15th February

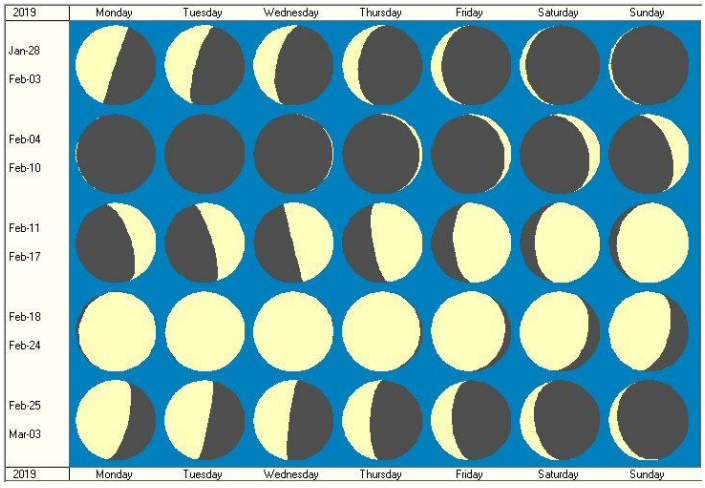
NEPTUNE is now close to the western horizon as the Sun sets but it is small and difficult to find.

THE SUN

The Sun has been very quiet over the last few months as can be expected in its inactive phase. There have been no significant sunspots. The Sun rises at 07:30 at the beginning of the month and at 06:50 by the end of the month. It will be setting at 16:50 at the beginning and 17:30 at the end of the month.

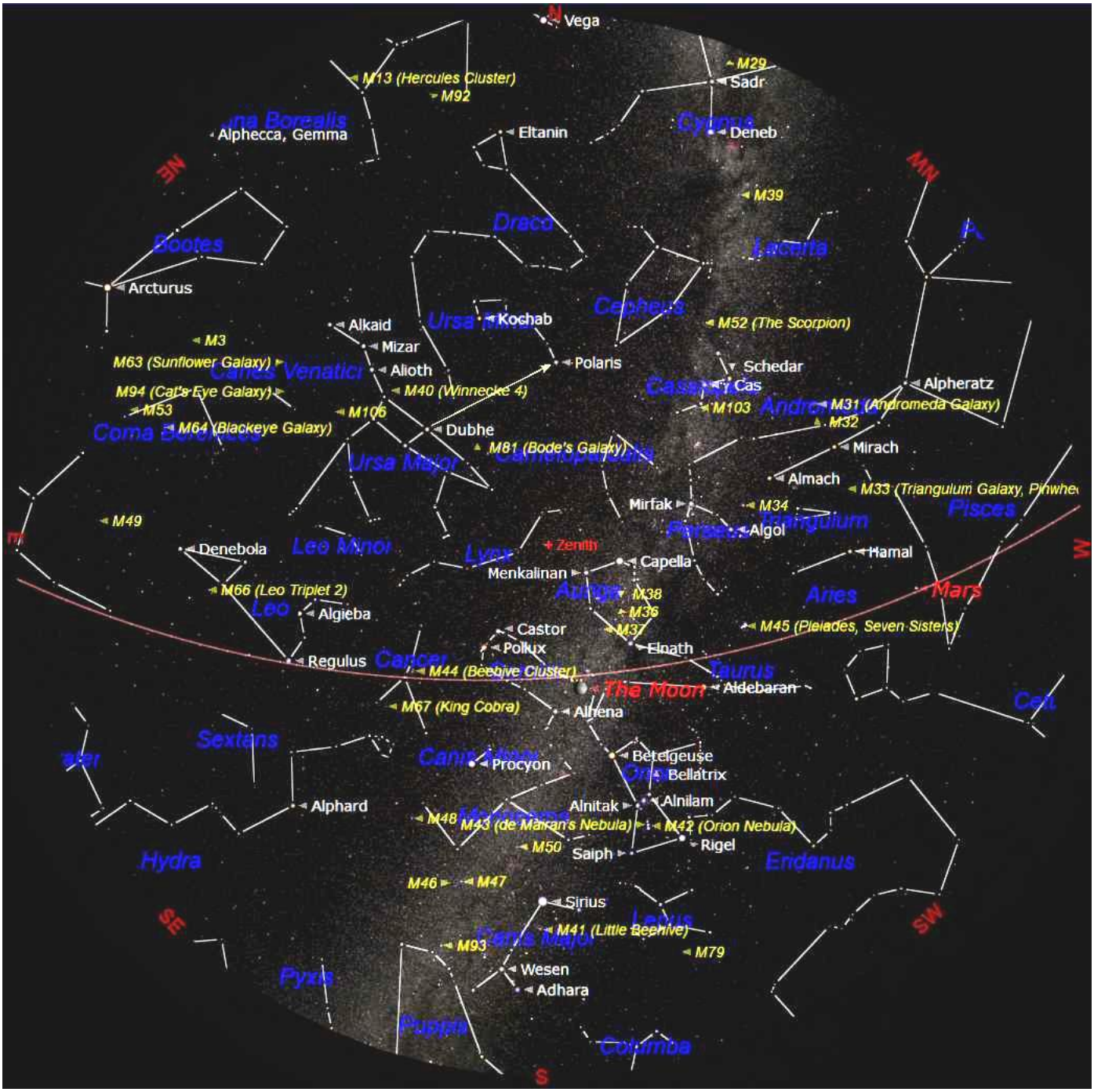
THE MOON PHASES IN FEBRUARY

The 'New Moon' will always be seen in the west after the Sun has set over the western horizon. At this phase the Moon will be emerging from conjunction with the Sun (passing between Earth and the Sun). The Moon orbits Earth once a month (Moonth). The cardinal phases listed below occur every seven days. Full Moon will always appear in the East as the Sun is setting in the West.



New Moon will be on the 4th February
First Quarter will be on 12th February
Full Moon will be on 19th February
Last Quarter will be on 26th February

THE NIGHT SKY THIS MONTH



The chart above shows the night sky as it appears on 15th February at 21:00 (9 o'clock) in the evening Greenwich Mean 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: Mars, Uranus and Neptune. Venus, Saturn and Jupiter are observable in the early morning.