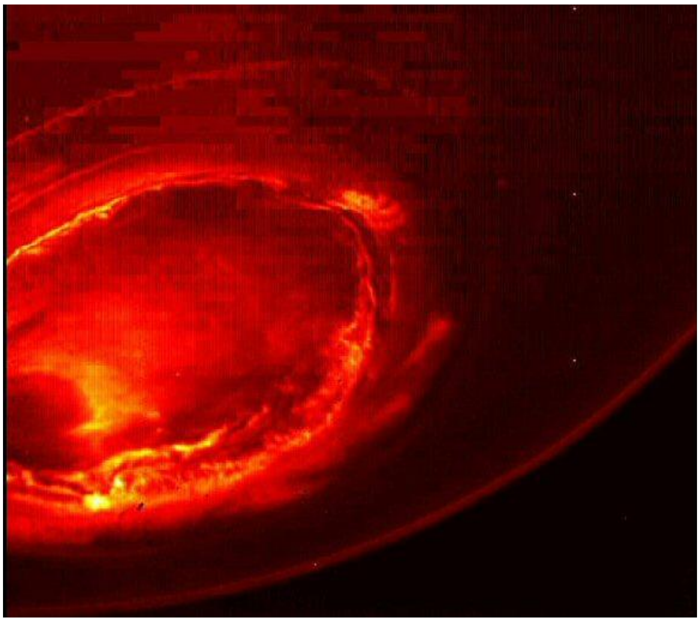
NEWBURY ASTRONOMICAL SOCIETY
MONTHLY MAGAZINE – October 2016

NASA's LATEST EXPLORATION PROBE ARRIVES AT JUPITER

Juno's image of Jupiter's north pole



Juno's image of Jupiter's southern aurora

Juno is NASA's latest space probe to visit the planet Jupiter. It entered orbit on 5th July 2016 to begin 20 months of scientific data collection. Its mission will end with a planned de-orbit when it will be sent crashing into Jupiter. Juno was launched from Cape Canaveral Air Force Station on 5th August 2011, as part of the New Frontiers programme and entered into Jupiter's orbit on 4th July 2016.

A delicate manoeuvre on 4th July put Juno into a polar orbit to study Jupiter's composition, gravity field, magnetic field, and polar magnetosphere. Juno will also search for clues about how the planet formed, including whether it has a rocky core. It will also measure the amount of water present in the deep atmosphere. It will also explore the mass distribution of Jupiter and its deep winds that can reach speeds of 618 kilometres per hour.

Juno is only the second spacecraft to orbit Jupiter and the first solar powered craft to do so. The first was the nuclear powered Galileo that orbited Jupiter from 1995 to 2003. Juno has three solar array wings, the largest ever deployed on a planetary probe. They also have a role in stabilising the spacecraft as well as generating its power.

Jupiter's gravity accelerated the approaching spacecraft to 266,000 km/h. On 5th July an insertion burn decelerated Juno by 542 m/s and changed its trajectory from a hyperbolic (flyby) orbit to an elliptical, polar Jovian orbit with a period of about 53.5 days. On 4th and 5th July 2016, the most difficult part of the mission, entering the correct polar orbit, was achieved. This set the stage for the next twenty months of gathering hard science data leading up to a planned crash of the probe. Juno will be crashed into Jupiter, rather than being left in orbit, to avoid it crashing into one of the Moons and contaminating the surface. Future probes may be searching for signs of life on Europa.

On 27th August 2016 Juno was commanded to pass just 4,200km above the cloud tops of the gas giant. No previous spacecraft has been so close to Jupiter during the main phase of its mission. Juno had all its instruments and its camera switched on and primed for the encounter.

Juno's highly elliptical polar orbit takes it close to the planet within 4,300 kilometers but then far beyond even the orbit of Callisto the outer of Jupiter's four largest moons. An engine burn will reduce the eccentricity of Juno's orbit and will then drop the probe into a much closer orbit. This is designed to bring the spacecraft within 2,000 km of the cloud tops. This is necessary for the key data gathering phase that is planned for 19th October 2016 after which the orbital period will be 14 days. Each of the lower science gathering orbits takes 14 days and the spacecraft is expected to complete 37 orbits until the end of the mission. Both orbits exploit a gap in the shape of the radiation envelope near the planet, flying past quickly in a region of minimized radiation, to protect the spacecraft.

These orbits minimize contact with Jupiter's dense radiation belts that can damage spacecraft electronics and solar panels. The spacecraft completed its first flyby of Jupiter on 27th August 2016, and sent back the first-ever images of the planet's poles. See images the above.

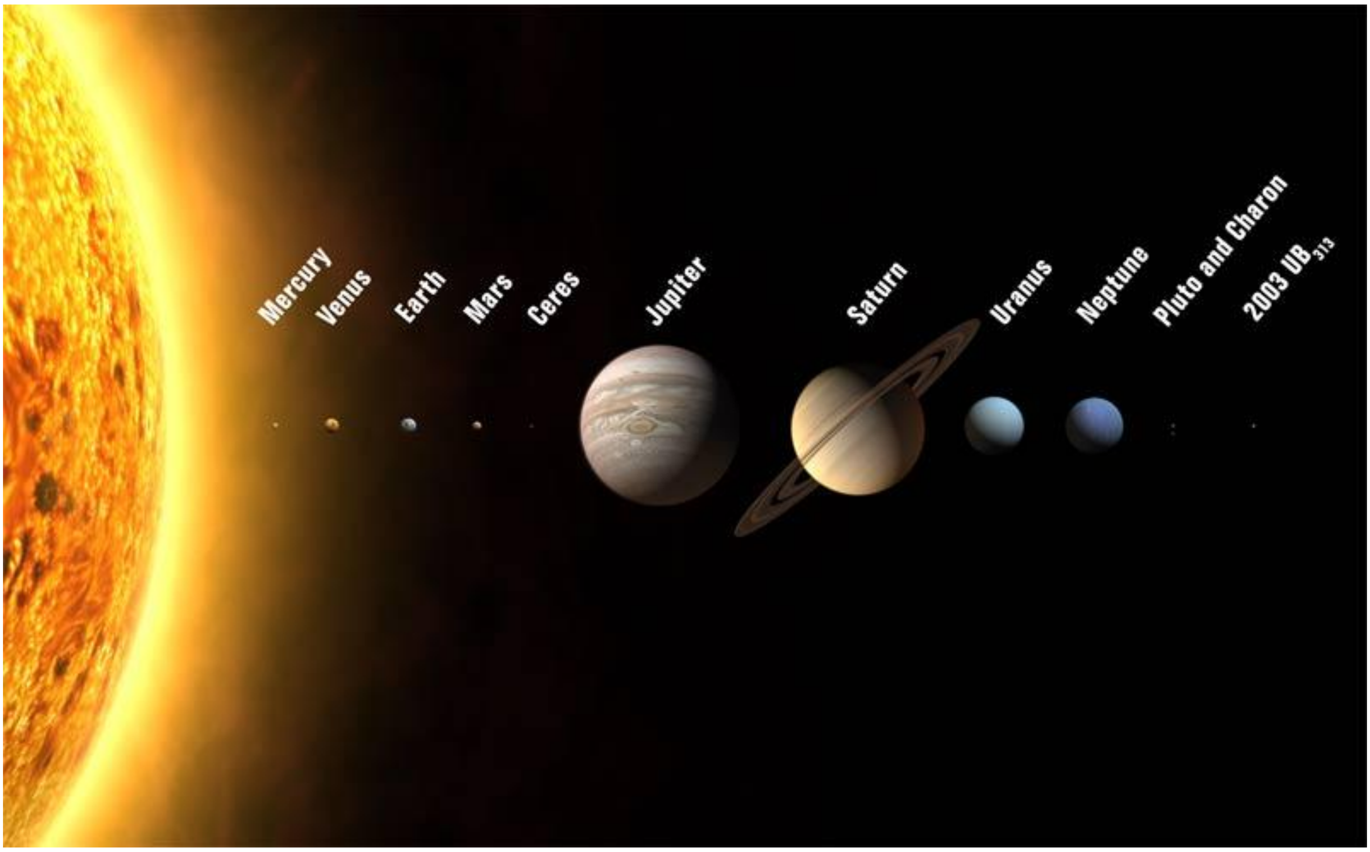
NEWBURY ASTRONOMICAL SOCIETY 2016 - 2017

7th October What Makes the World Tick?
Website: **www.newburyastro.org.uk**

NEXT NEWBURY BEGINNERS MEETING

19th October Planets and Exoplanets
Website: **www.naasbeginners.co.uk**

PLANETS AND EXOPLANETS



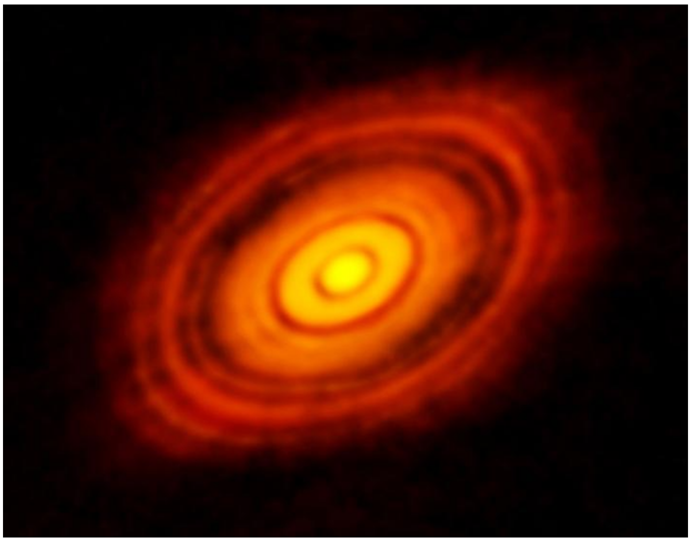
The Planets of our Solar System

Until the last 30 years we had only been able to speculate that other stars may have planets. Now, we can not only detect them, we have the technology to actually study the nature of exoplanets (planets orbiting other stars). Let us first think about what a planet actually is, how we define a planet and what attributes are used to qualify an object as a planet.

The first requirement for a planet relates to the size of the object. It is generally accepted that the defining size is that it must be big enough for its gravity to make it spherical. This is in the region of 200 to 400 kilometres in diameter and depends on the material that the object is comprised of. An icy body will be relatively soft and can be easily compressed into a spherical shape so it can be smaller. A rocky and metallic object will be much more rigid and stronger and will not compress into a sphere so easily and needs be larger and more massive to become spherical.

The second requirement is that the object must be in orbit around a star. An object in orbit around an even larger object that is orbiting a star is a Moon and not a planet in its own right. Some of the moons in our Solar System are actually larger than some of the planets.

A more precise description to define a planet is: the object is to be in orbit around a star and large enough to clear a path around its orbit. This is done by the planet attracting any other objects in its orbit on to its surface by its own gravity. When a planet is forming around a star and actively clearing its orbit it is known as a proto-star. We can see this process happening around stars in the large nebulae in our neighbourhood like Messier 42 (M42) the Great Orion Nebula.



Protoplanets clearing orbits around a young star

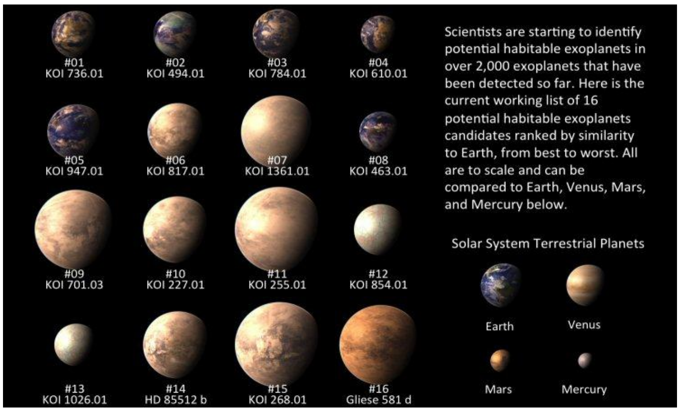
The image above shows a very young star called HL Tauri in the constellation Taurus. It is approximately 450 light-years from Earth in the Taurus Molecular Cloud. The luminosity and effective temperature of the star imply that its age is less than 100,000 years. The clear lanes in the disc around the star are formed by proto-planets clearing debris from their orbits.

We now accept that our Sun has eight 'main' planets: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune. Our Sun also has a huge number of Dwarf Planets. These are made up from the largest asteroids and icy bodies that orbit the Sun beyond the orbit of the outermost planet Neptune. There are thought to be many thousands of these including Pluto.

EXOPLANETS

An exoplanet or extra-solar planet is a planet that orbits a star other than the Sun. Starting in 1988, and as of 1st September 2016, there have been 3,518 exoplanets in 2,635 planetary systems discovered and 595 multiple planetary systems now confirmed.

The European Space Observatory's (ESO's) High Accuracy Radial velocity Planet Searcher (HARPS) Telescope has, since 2004, discovered about a hundred exoplanets. NASA's Kepler space telescope has, since 2015, found more than three thousand. Kepler has also detected a few thousand candidate planets, of which about 11% may be false positives. On average, there is at least one planet per star, with a percentage having multiple planets. About 1 in 5 Sun-like stars have an 'Earth-sized' planet in the habitable zone. Assuming there are 200 billion stars in the Milky Way, it can be hypothesized that there are 11 billion potentially habitable Earth-sized planets in our galaxy. This could rise to 40 billion if planets orbiting the numerous red dwarfs are also included.



An artist's impression of some of the exoplanets

The least massive planet known is Draugr (also known as PSR B1257+12 A or PSR B1257+12 b) which is about twice the mass of our Moon. The most massive planet listed on the NASA Exoplanet Archive is DENIS-P J082303.1-491201 b which is about 29 times the mass of Jupiter. The nearest exoplanet is Proxima Centauri b, located 4.2 light-years (1.3 parsecs) from Earth and orbiting Proxima Centauri. This planet was featured in the September 2016 issue of this magazine.

Besides exoplanets, there are also rogue planets which do not orbit any star. They tend to be considered separately, especially if they are gas giants which are often counted, as sub-brown dwarfs. Rogue planets in the Milky Way may number into the billions. They have been detected using a microlensing technique. See the graph in the next column.

These planets are thought to have been ejected from their star's planetary system during the early formation process. Planets often form in unstable orbits that make it likely that there would be close encounters and even collisions. During close encounters the interaction of the gravity of the planets can disturb and alter their orbits. One or both planets could be disturbed so much that they may be placed on a trajectory that will lead to a collision with the star or be thrown out of orbit altogether to wander through the galaxy forever.

FINDING EXOPLANETS

There are three main detection techniques that can be used to find extra-solar planets. All of them rely on detecting a planet's effect on its parent star, to infer the planet's existence.

The three techniques are simple in principle but difficult in practice because extreme precision is needed to register the planet's effect on the much larger star. This is also difficult from Earth because the atmosphere distorts our view of the stars, limiting the accuracy of the observations. Space missions can overcome this problem. The methods in question are:

- the radial velocity method
- the astrometry method
- the transit method

These methods are all referred to as 'indirect' methods.

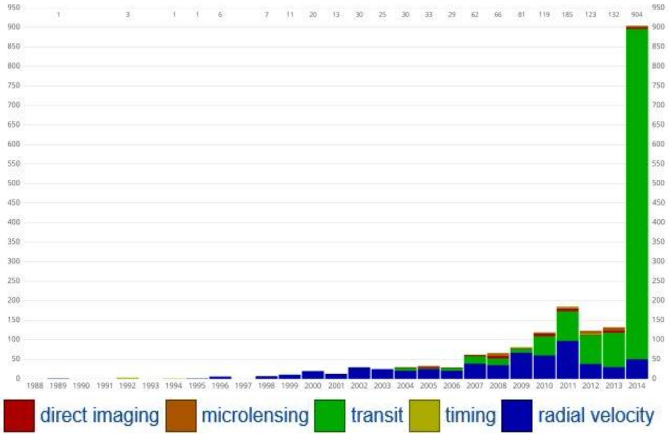


Chart showing the number discovered by method

On the chart above the first technique known as direct imaging has not yet been developed enough to be used to detect exoplanets. If it can be made powerful and sensitive enough it will mean we will be able to actually image an exoplanet and see what it looks like. This is still some way off at the moment.

Eventually, astronomers hope to be able to isolate either the light being reflected by exoplanets or the thermal infrared radiation emanating from the planetary surface itself. These techniques are known as 'direct' detection methods. It would result in actual pictures being taken of the extra-solar planets or in electromagnetic 'spectra', the analysis of which gives us information about the atmospheric composition of these planets.

RADIAL VELOCITY (ASTROMETRIC) METHOD

The vast majority of planetary detections so far have been achieved using the radial-velocity technique from ground-based telescopes. This method will use data from studying the star and does not detect planets directly. The method requires the light from a star to be passed through a prism or grating and split into a spectrum, rather like water droplets in the atmosphere splitting sunlight into a rainbow. By measuring the amount of movement with time, the mass of the planet and its orbit can be determined.

When the spectrum is magnified, straight black lines can be seen superimposed on the colours. These spectral lines correspond to the wavelengths of light that have been absorbed by chemicals on the surface of the star from which the light originated. Every element and molecule generates its own chemical fingerprint through unique 'spectral lines' at different wavelengths. These provide an indication of the amount of that element present in the object and under what conditions (like temperature and pressure).

Studying these lines (Astrometric 'finger print') can show which stars have large planets around them. As the planet orbits the star, it pulls on it with its gravitational field, forcing the star into a small orbit or wobble. It makes it look as if the star is pirouetting around a point in space. The star will sometimes be moving towards Earth and at other times moving away.

When the star moves towards Earth, the wavelengths of the spectral lines in the light it emits move towards the blue end of the spectrum. When the star travels away from Earth, the opposite happens and the wavelengths are moved towards the red part of the spectrum. Astronomers therefore look for stars where the spectral lines are moving back and forth, since these must be the ones with planets in orbit around them. This method is similar to measuring the change in the sound of an object passing, known as the Doppler Effect.

This technique is limited however because it will never be able to detect small, Earth-sized worlds. With the best spectroscopes, astronomers can confidently detect motions of about 15 metres per second. However, Earth only forces the Sun to move at 0.1 metres per second. Even if a spectroscope could be made to detect this, the boiling of the star's gaseous surface (the acoustical modes studied on the Sun by ESA's SOHO and to be studied on stars with the COROT mission) would mask the effect of the planet.

TRANSIT METHOD

The most promising method for detecting small worlds is to look for the drop in brightness they cause when they pass in front of their parent star. Such a celestial alignment is known as a transit. From Earth, both Mercury and Venus occasionally pass across in front of the Sun. When they do, they look like tiny black dots passing across the bright surface.

Such transits block a tiny fraction of the light. If a distant star were transited by the equivalent of Jupiter, it would cause 1% of the starlight to be lost from view. One gas giant planet, found by the radial-velocity method, has also been detected using the transit method from a ground-based telescope. Star HD 209458 was discovered to possess a 51 Pegasi b-like planet (a large planet orbiting its parent star in a close circular orbit is also known as a 'hot Jupiter') and subsequently seen to dim at precisely the time that the planet was predicted to pass in front of the star.

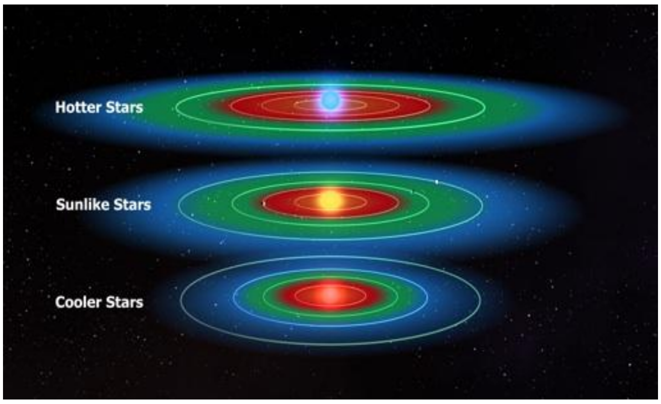
As of January 2015, Kepler and its follow-up observations had found 1,013 confirmed exoplanets in about 440 star systems, along with a further 3,199 unconfirmed planet candidates. Many more are expected to be found by a new mission called Gaia.

ESA's astrometric mission, Gaia, was launched on 19th December 2013 and is designed to be the most precise astrometric satellite ever created and will survey a billion stars. Among a great many other scientific goals, Gaia is expected to find between 10,000 and 50,000 gas giant planets beyond our Solar System. Once again however, the wobbling motion caused by an Earth-sized planet will be too small to be detectable, even by Gaia.

Through this method many more planets have now been detected. By having both the transit and the radial velocity information, the planets orbit can be determined exactly and the true mass and size of the planet can be found.

THE SEARCH FOR LIFE ON EXOPLANETS

The discovery of exoplanets has intensified interest in the search for extraterrestrial life. There is special interest in planets that orbit in a star's habitable zone where it is possible for liquid water, a prerequisite for life on Earth, to exist on the surface. The study of planetary habitability also considers a wide range of other factors in determining the suitability of a planet for hosting life.



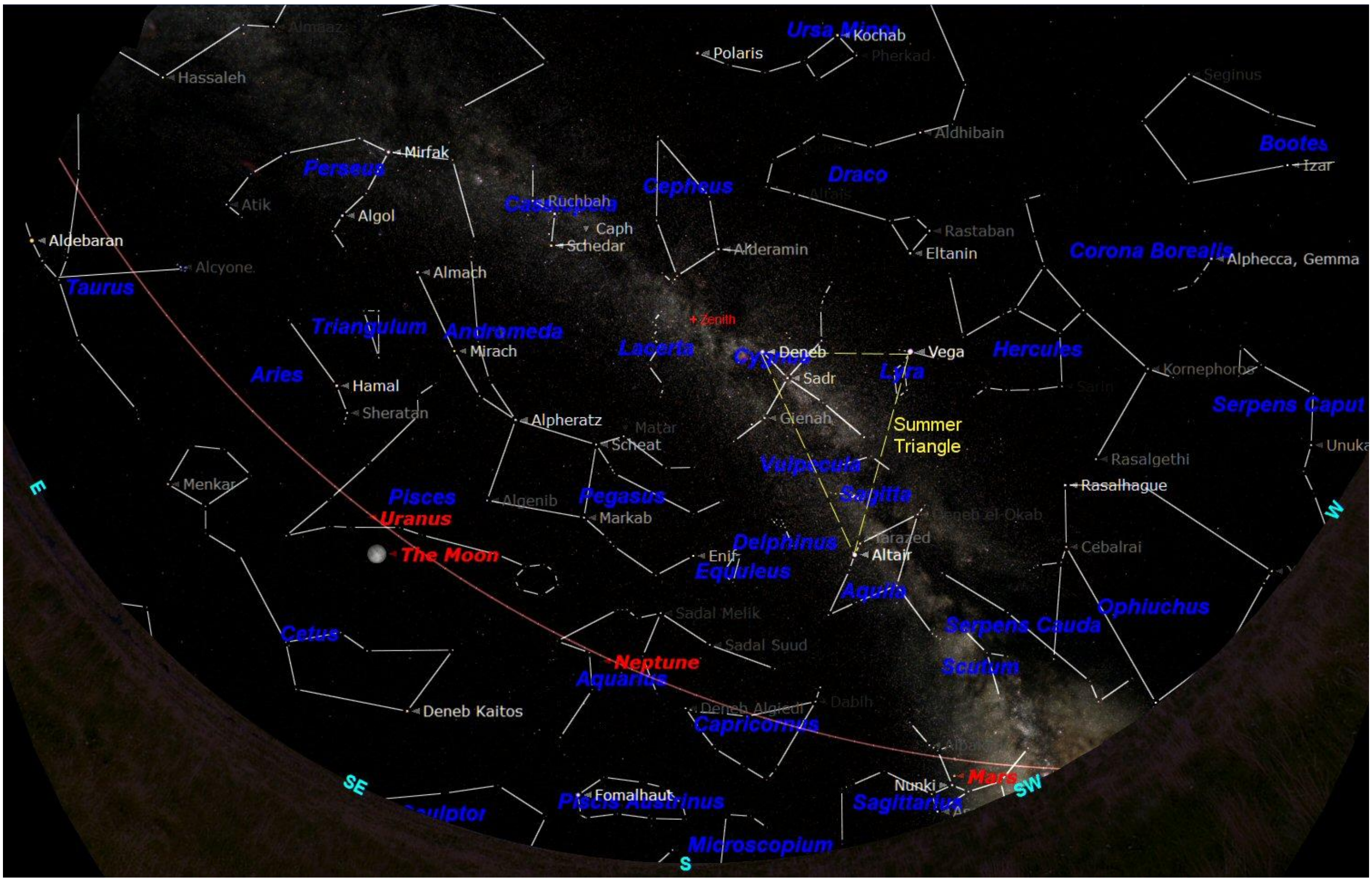
The Habitable Zones of Stars

Most normal stable stars will have a Habitable Zone. This is a zone around the star where life may exist. This zone is called 'the Goldilocks Zone' where is not too hot and not too cold but 'just right'. The Habitable Zone around our star (the Sun) extends from just outside the orbit of Venus to just beyond the orbit of Mars. With larger stars, that produce much more heat and light, the Habitable Zone would have to be further away from the star where it was not too hot. Smaller stars are cooler so their Habitable Zone would be closer to the star where it is not too cold.

In the future, detailed analysis of the composition of the atmosphere of a planet could even reveal signs of life. This can be done by analysing the spectrum of the light passing through the atmosphere. It is possible to digitally subtract the light received directly from a star but leave the light that had passed through a planet's atmosphere. The composition of the atmosphere could then be analysed using the method described in the previous column.

If Oxygen is found then this could indicate that life might be present. Oxygen is readily combined with many atoms and would quickly remove any naturally occurring Oxygen from the atmosphere. On Earth the Oxygen in our atmosphere is replenished in the photosynthesis process by plants. This would only identify the type of life we have on Earth but this is the only kind of life we know.

THE NIGHT SKY - OCTOBER 2016



The chart above shows the night sky looking south at about 21:00 BST on 15th October. 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 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 constellations through which the ecliptic passes are known as the constellations of the 'Zodiac'.

Constellations through which the ecliptic passes this month are Sagittarius (the Archer), Capricornus (the Goat), Aquarius (the Water Carrier), Piscis (the Fishes), Aries (the Ram) and Taurus (the Bull) is rising over the eastern horizon.

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 deep sky objects that we seek out.

The summer constellations are still prominent in the early night sky and lead 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 still 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 through Aquila to the horizon in Sagittarius.

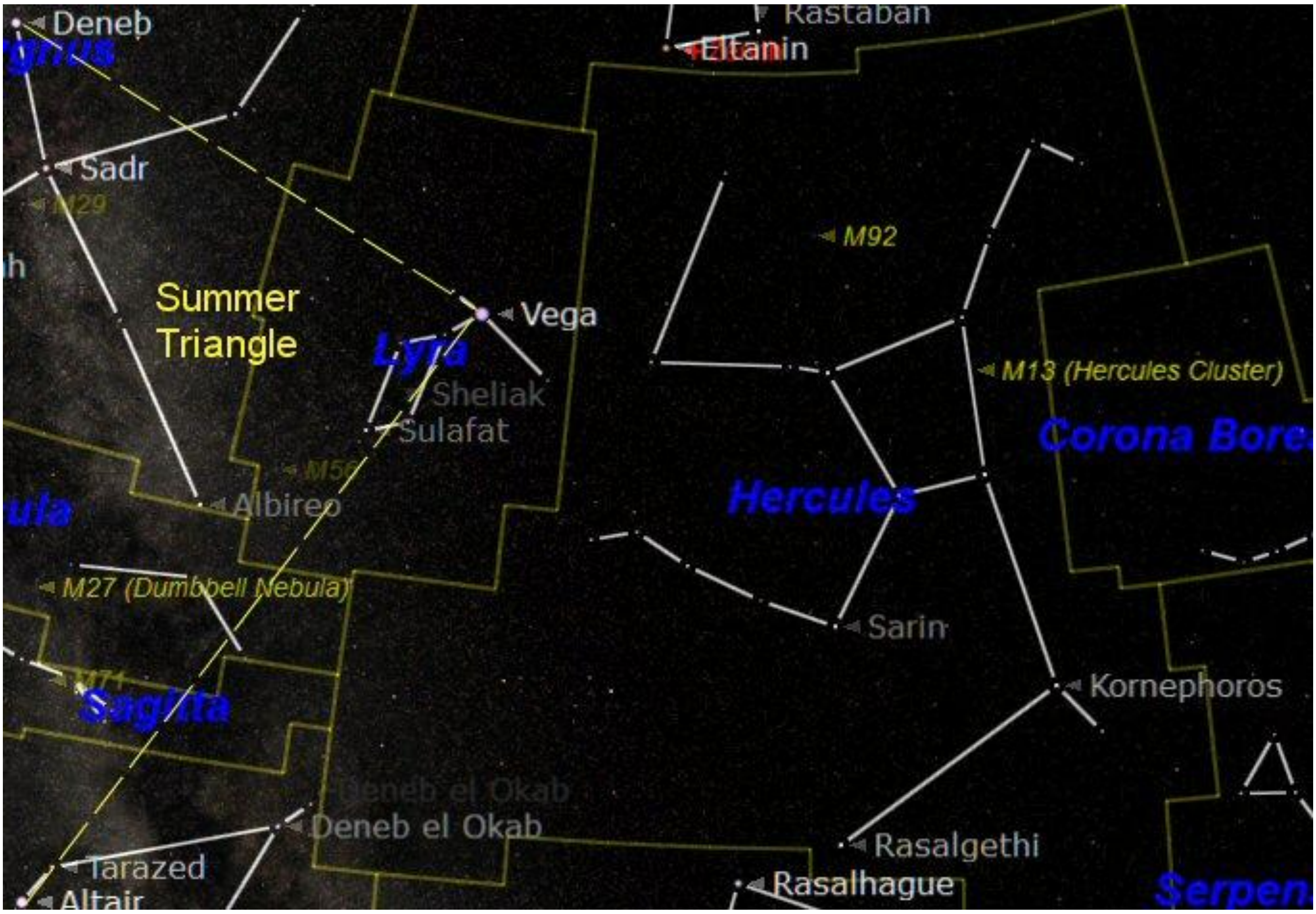
The Milky Way flows north from the Summer Triangle through the rather indistinct constellation of Lacerta (the Lizard), past the pentagon shape of Cepheus and on through the 'W' shape of Cassiopeia (a Queen).

At the top, centre of the chart above is the fairly faint 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 every 24 hours. This means Polaris is the only bright star that appears to remain stationary in the sky.

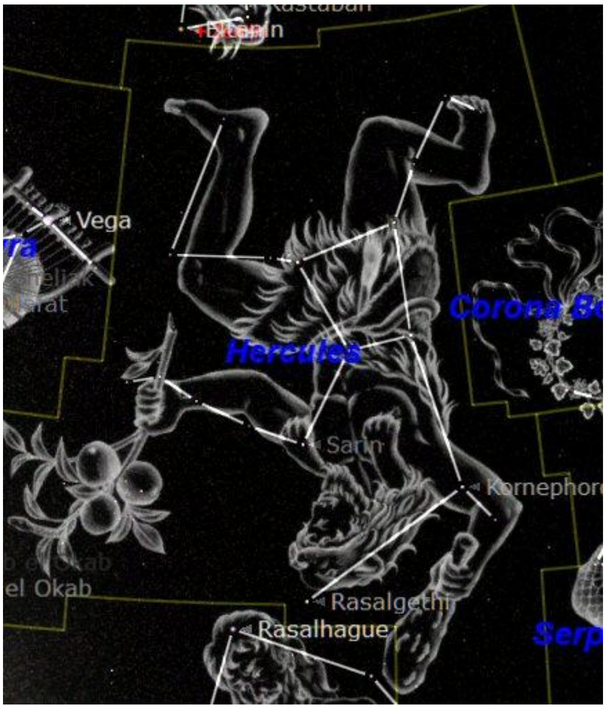
To the west of the Summer Triangle is the constellation of Hercules (the Strong Man). The body of Hercules is represented by a distorted square of stars. This misshapen square is known as the 'Keystone' because of its resemblance to the central stone of an arch. The nearest and brightest Globular Cluster can be found the western (right) vertical side of the 'Keystone'. It can be seen using a good pair of binoculars but the cluster of about a million stars is impressive through a telescope.

To the East 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.

FIRST CONSTELLATION OF THE MONTH – HERCULES



The chart above shows the constellation of Hercules and its location to the west of the Summer Triangle. Hercules is the great strongman from Greek mythology. He is illustrated in the picture below (up-side-down), as he appears in the sky, with a club held above his head. The 'Keystone' asterism (shape) can be a little difficult to identify in a light polluted sky but easy to find again.



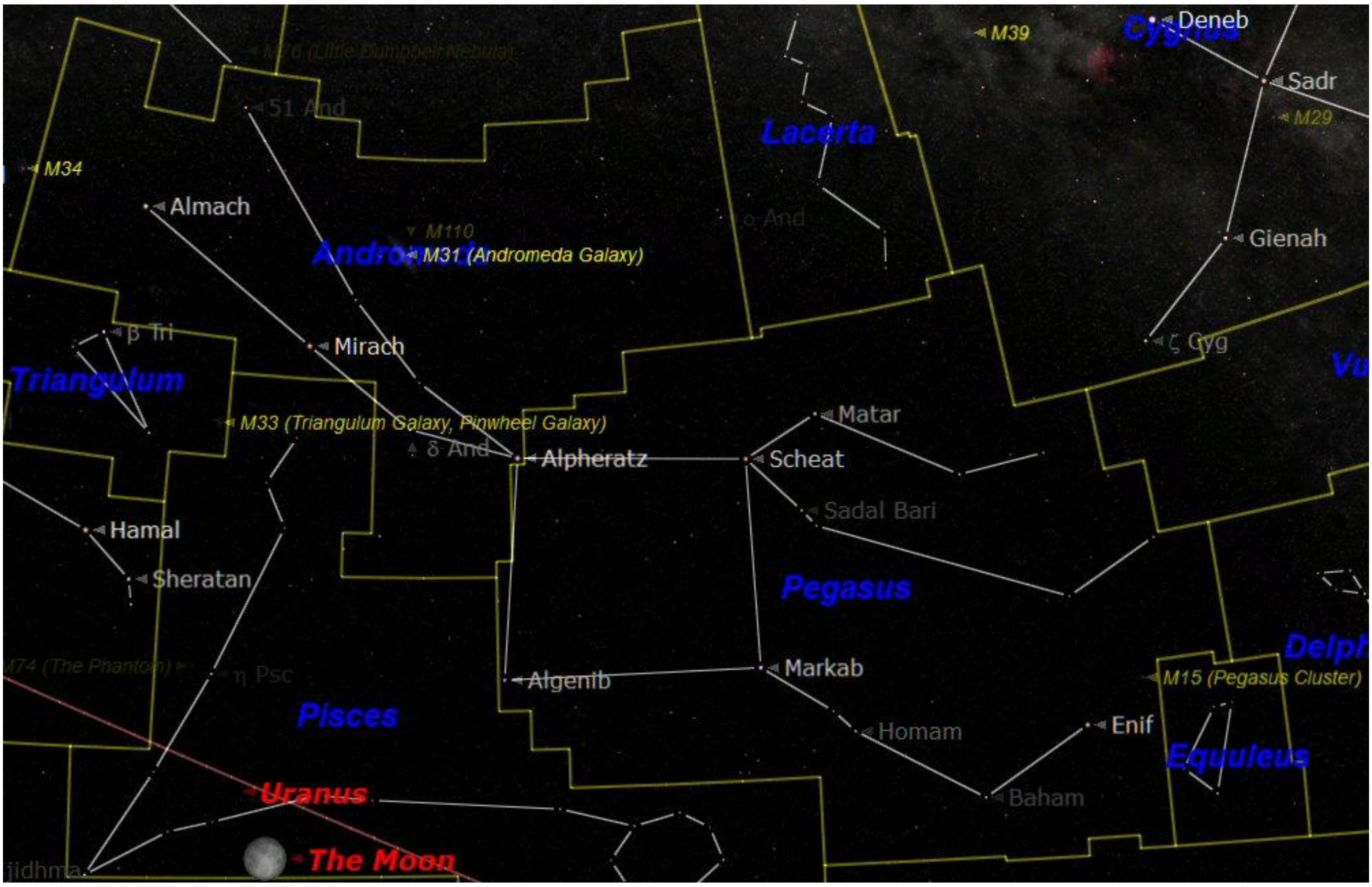
An illustration of the constellation of Hercules

The jewel of Hercules is without doubt is the Great Globular Cluster, Messier 13 (M13). M13 can be found in the western vertical imaginary line of the 'Keystone'. It is just visible using a good pair of 9 x 50 binoculars. The cluster of about a million stars can be seen using a 90mm *f*10 telescope but will look very impressive when using a larger telescope.

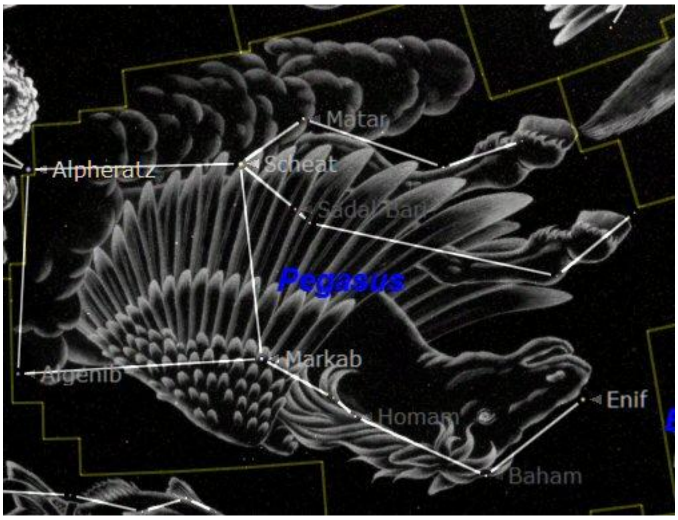
The Great Globular Cluster in Hercules

Globular clusters are thought to be the cores of small galaxies that have ventured too close to our Giant Spiral Galaxy (the Milky Way). The outer stars of these smaller galaxies have been stripped away, by the gravity of the giant spiral, leaving the dense core clusters of between 10,000 and a million stars. There are about 100 Globular Clusters in a halo around the Milky Way.

SECOND CONSTELLATION OF THE MONTH –PEGASUS



The chart above shows the constellation of Pegasus (the Winged Flying Horse). The main and very recognisable asterism (shape) of Pegasus is a square of four fairly bright stars. This asterism is known as the 'Great Square of Pegasus'. It is a bit larger than may be expected but once it has been found it is quite easy to find again.



An illustration of Pegasus the Flying Horse

The star Alpheratz is actually classified as the brightest star in the neighbouring constellation of Andromeda and is not officially a member of Pegasus. The two constellations are actually conjoined by Alpheratz because it is obviously also part of the Great Square. The square can be used to gauge the quality of the sky for observing. If 5 or more stars can be seen in the square then the sky should be quite clear.

If two or three stars can be seen then it will be difficult to see detail in the faint deep sky objects. If no stars can be seen then it will be a night for bright planets only.

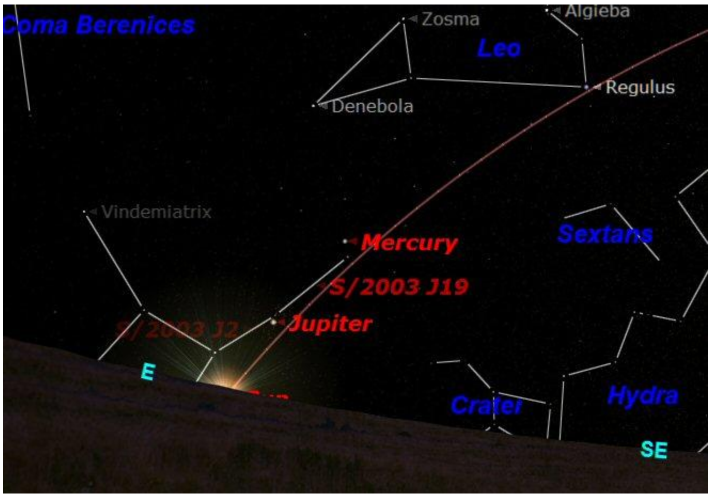
There is another nice Globular cluster in Pegasus. This is Messier 15 (M15). It is further away than M13 in Hercules so appears smaller and fainter but it is still a wonderful sight to see in a medium to large telescope.

Messier 15 (M15) Globular Cluster in Pegasus

To find M15 start at the star Markab, located at the bottom right of the Great Square. Follow the fainter line of stars to the west (right) through Homam and on to Baham. From Baham go north west (up and right) to the star Enif. Continue the imaginary line on for about the same distance to find the fuzzy patch of light that will be the Globular Cluster M15.

THE SOLAR SYSTEM THIS MONTH

MERCURY rises in the east at 04:30 at the beginning of the month and at 06:40 at the end of the month. It will rise before the Sun later towards the end of the month as it moving back towards the Sun. The Sun will be rising at 06:30 so it will be best in the beginning of the month. In the charts below the sky has been darkened so the position of the planets can be seen more clearly.



Mercury in the east at 07:00 BST on 5th September

VENUS is moving out from conjunction with the Sun and will just be visible towards the western horizon as the Sun sets. It will be just above the horizon so a very clear view to the western horizon will be required to see Venus. See the Mars chart below.

MARS will be in the south as the Sun is setting and the sky begins to darken. The Red Planet appears small at just 8.05 arc-seconds in diameter but is quite bright at magnitude -0.2. Mars is fairly low so will be in the turbulent air near the horizon. See the chart below.

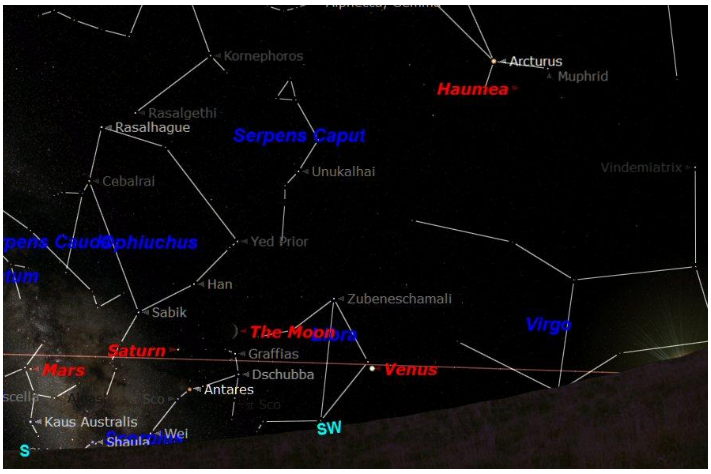
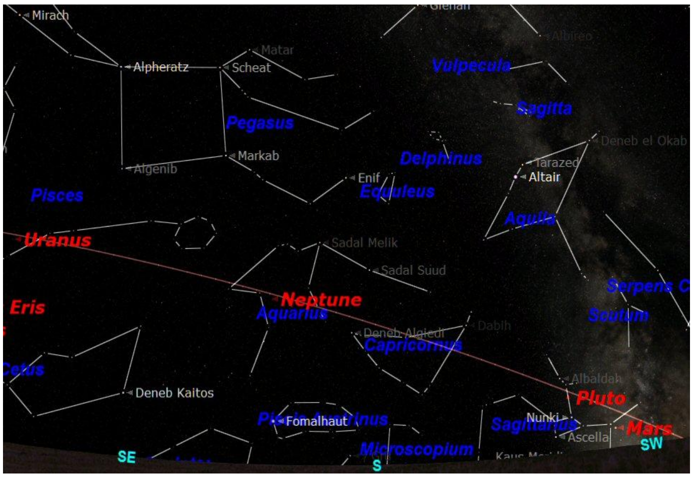


Chart showing Mars, Saturn and Venus on 5th October

JUPITER was in conjunction with the Sun on 26th September so will be close to the Sun and will not be visible this month. See the Mercury chart above.

SATURN will be in the south as the Sun is setting and the sky begins to darken. The Ringed Planet appears small at 15.5 arc-seconds in diameter but is quite bright at magnitude +0.5. Jupiter is quite low so will be in the turbulent air near the horizon. Unfortunately it will only rise to about 15º above the horizon so will be low and in quite dirty and turbulent air. See the chart above.

URANUS will be in a good observable position this month. It will be quite high in the south east as the sky darkens. It will be visible using a good pair of 10x50 binoculars as a slightly fuzzy blue, star like, object. A telescope at a magnification of 100x or higher will show it as a small blue/green disc.



Uranus and Neptune in the south at 22:00

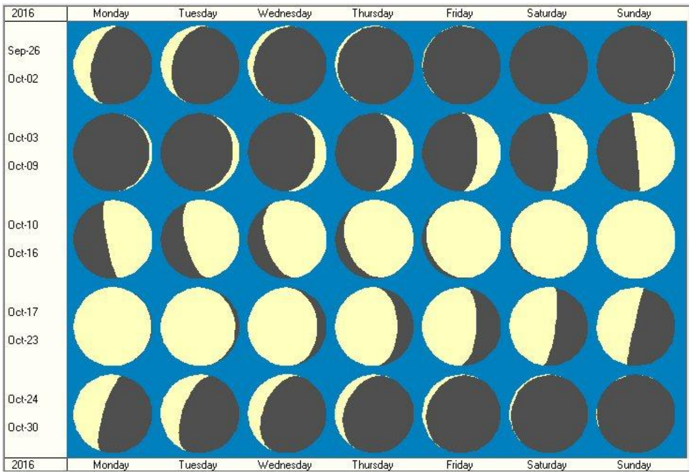
NEPTUNE will be visible in the south as soon as the sky is dark. It was at opposition (due south at midnight – 01:00 BST) on 2nd September and is still in a good position for observation. A telescope will be needed to show Neptune as a small blue/green disc using a magnification of 150x but it is small and difficult to find.

THE SUN

There are still some sunspots to see even though the active phase of the Solar Cycle is drawing to a close.

The Sun rises at 06:10 at the beginning of the month and at 07:00 by the end of the month. It will be setting at 17:40 at the beginning and 16:45 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 OCTOBER



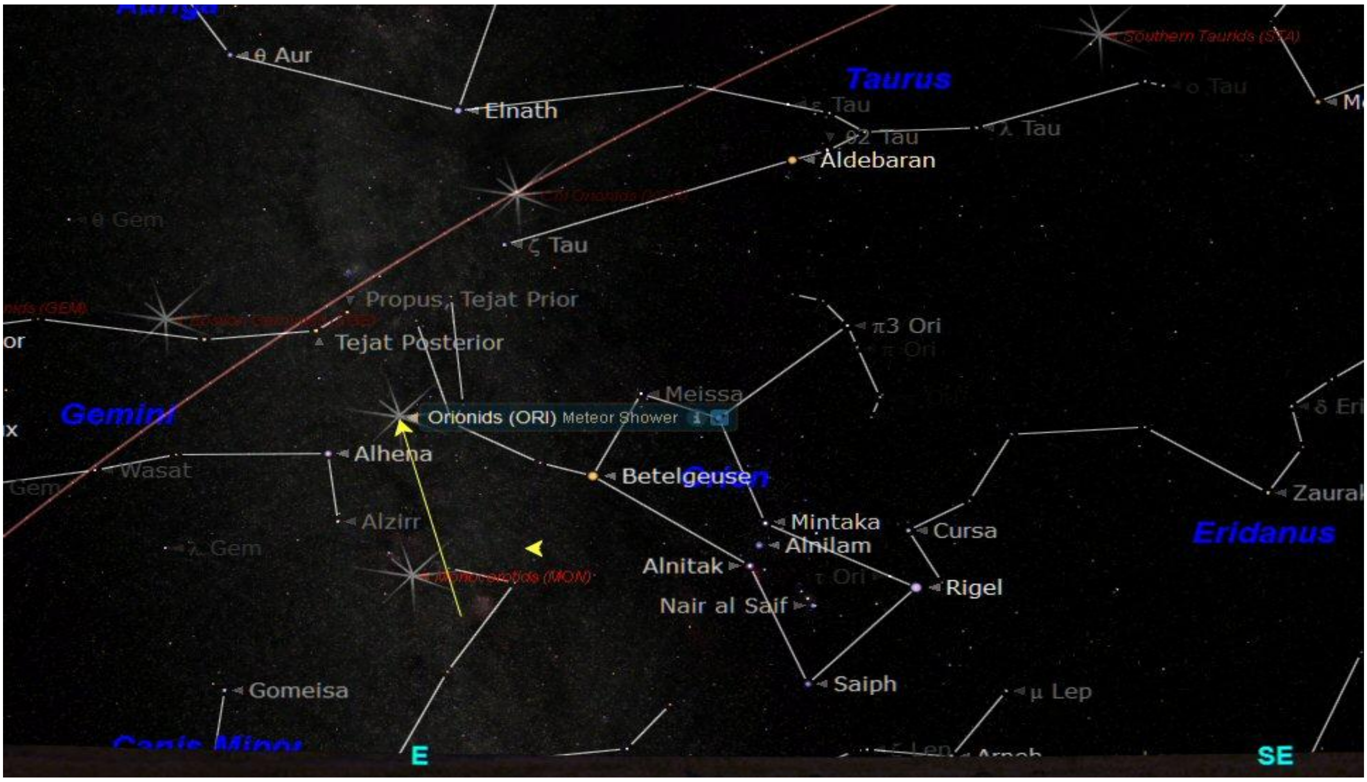
New Moon will be on the 1st October

First Quarter will be on 9th October

Full Moon will be on 16th October

Last Quarter will be on 23rd October

THE ORIONID METEOR SHOWER



The radiant of the Orionids at 01:00 BST

The Orionid Meteor shower occurs between 16th and 30th October but peaking between 21st and 24th.

The chart above shows the night sky looking towards the eastern horizon at about 01:00 BST on 22nd October. The constellation of Orion is just rising over the eastern horizon and the radiant point of the Orionid Meteor Shower is shown arrowed. The paths of the meteors will appear to be emanating from the direction of the radiant point. The radiant point of the Orionid Meteor Shower is located to the east (left) of Orion's club as it is held above his head. See the chart above. Earlier in the evening any meteors will appear to originate from below the horizon. This means all the meteors will be moving up from the eastern horizon and in a 'fan' shape across the sky.

To start viewing allow about five minutes for your eyes to become adapted to the dark. This period can be used to familiarise yourself with the sky and work out where everything is. Try to turn off all lights around you. If there is a street light bothering you, it may be possible to erect a screen around yourself using garden canes, step ladders, washing poles, string and old sheets, curtains, towels or even newspapers. Even lights which appeared dim when you first began your session seem to get very bright when your eyes are fully adjusted to the dark.

It is useful if you can observe from your own back garden because you can quickly get used to the positions of stars from one night to the next. It is not always possible to use your own garden due to the dazzling effect of street lights or perhaps trees or buildings blocking the view. It may be necessary therefore to go to a darker area away from lights. If this is the case it is much better to go with a friend, if possible, as it will be safer and more enjoyable.

A remote observing site also has the disadvantage of having to transport any equipment. If it is decided to try a remote site, always check the weather forecast first - this might save a lot of travelling and anguish when the sky clouds over shortly after all has been set up.

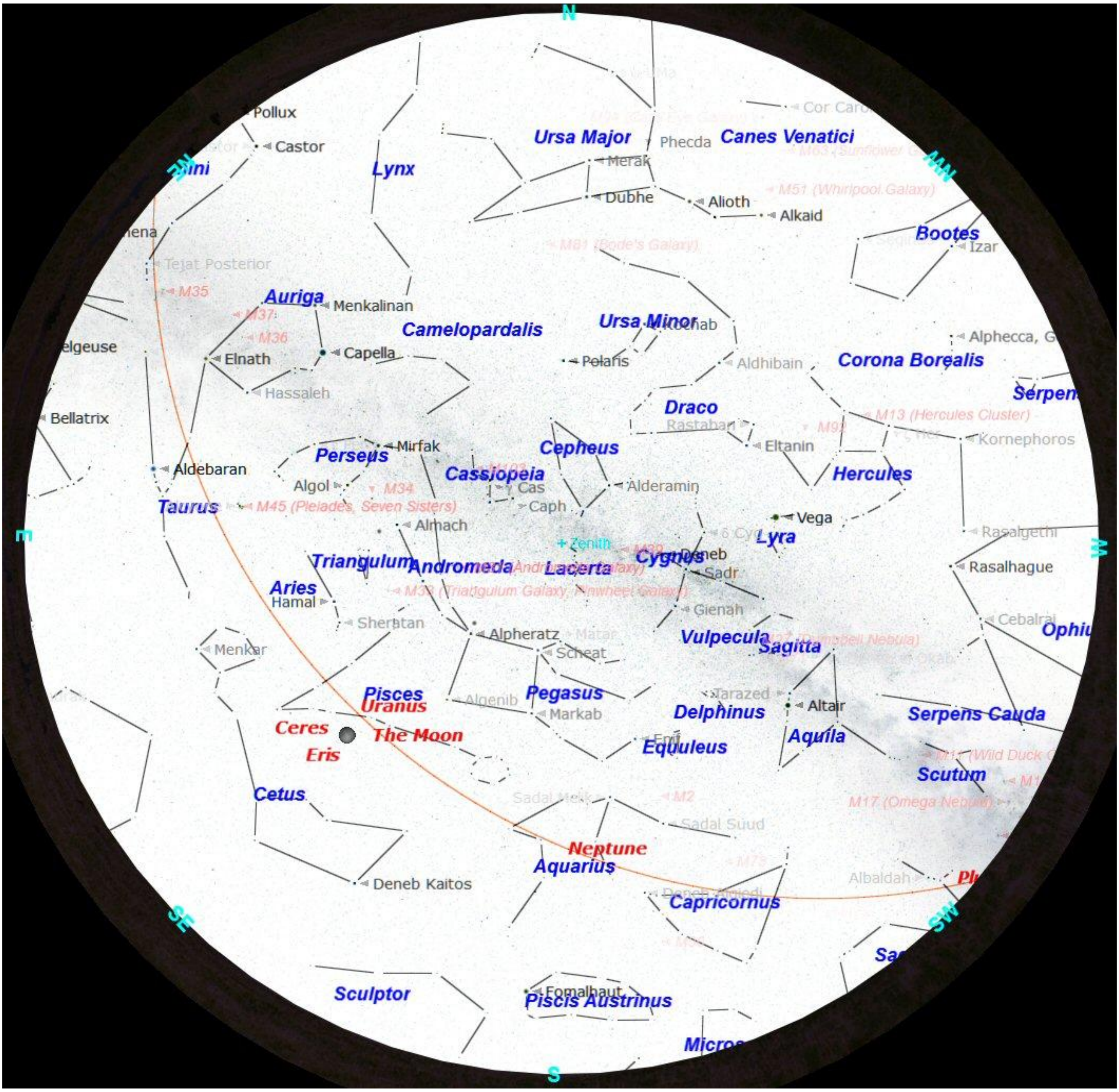
A garden 'lounger' chair is an excellent piece of equipment especially the type that can be reclined into a near horizontal position. This will help avoid neck and back ache when looking up.

After making yourself warm and comfortable and allowing enough time for your eyes to become adapted to the dark it is time to start observing. The first thing to do is to look around the sky to find familiar objects. The most common thing used is the constellation of Ursa Major also called the Plough. Use the instructions on the back page to align the chart. Now position your star chart just above your eyes ensuring that the south position on the map is at the bottom. What you see represented on the chart should be what you see in the sky. Once the orientation is complete the chart can be lowered into a convenient reading position.

Observing can start before midnight but there will most likely be fewer meteors at this time. There are two reasons for this, first the radiant of the Orionid shower will be below the eastern horizon until just before midnight so fewer meteors will appear above the horizon. Secondly, after midnight Earth will be ploughing head on into the main meteor stream. It is normally best to look up at an angle of around 45° above the horizon and 30° to 90° right or left from the radiant point. It will also be useful to familiarise yourself with the positions of the constellations in the direction you are looking while you are waiting for the meteors.

The meteors are fragments of dust left by Halley's Comet when is melted as it passed close to the Sun.

THE NIGHT SKY THIS MONTH



The chart above shows the night sky as it appears on 15th October at 21:00 (9 o'clock) in the evening British Summer Time (BST). 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 BST at the beginning of the month and at 8 o'clock BST 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. 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: Mars and Saturn (early evening) with Uranus and Neptune all night.