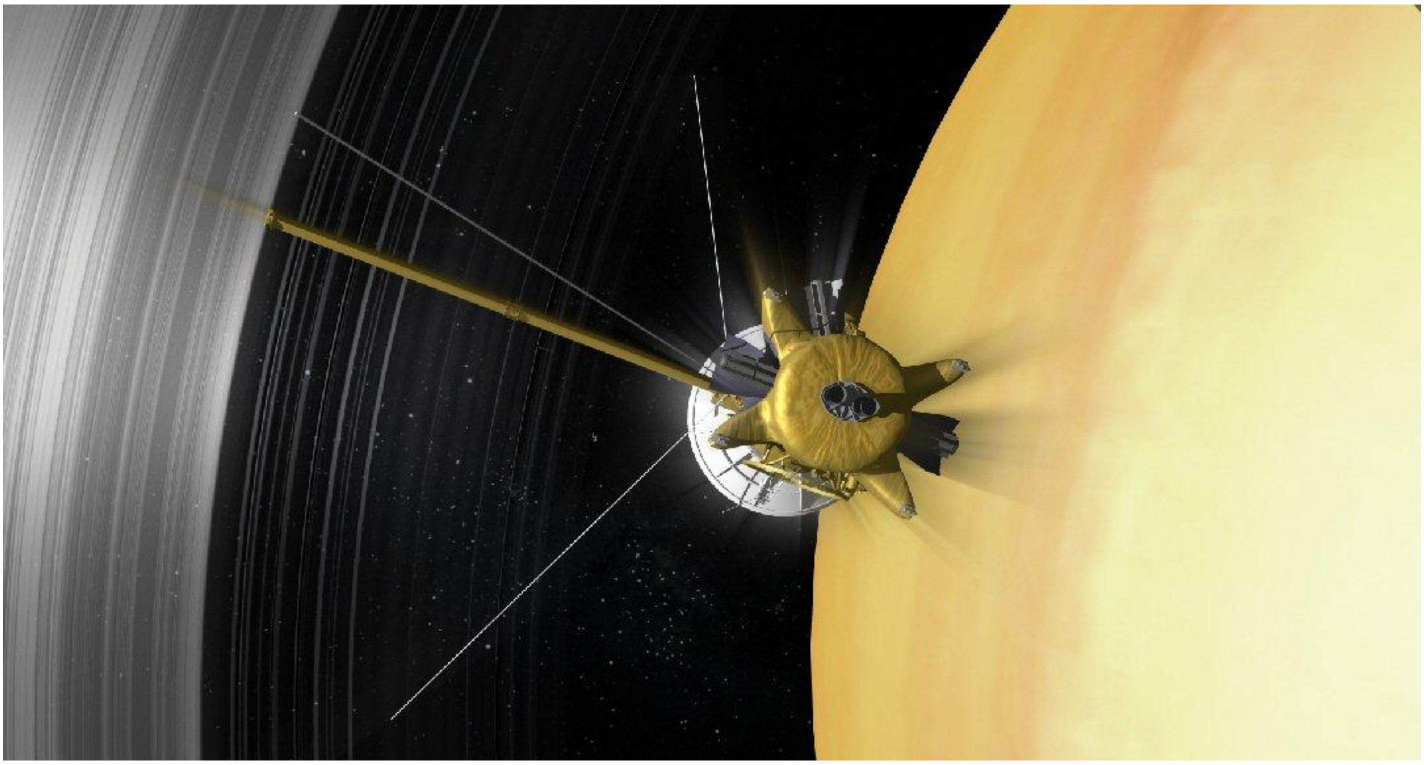
NEWBURY ASTRONOMICAL SOCIETY

MONTHLY MAGAZINE - APRIL 2017

CASSINI BEGINS ITS FINAL MISSION



An artist impression of Cassini diving under Jupiter's ring system

Scientists are bracing themselves for a blitz of discoveries in the last six months of Cassini's mission at Saturn. The plutonium-powered robot is about to dash through the unexplored gap in the planet's famous rings then make a destructive plunge into the atmosphere in September.

The dramatic last act has been in the flight plan since 2010, when NASA formally approved the plan. It will use flybys of Saturn's moon Titan and periodic thruster burns to reshape Cassini's orbit around the ringed planet.

Cassini's mission will end on 15th September with a suicidal dive into Saturn's Hydrogen and Helium atmosphere after a series of 22 close-in week-long orbits passing between the planet's innermost icy ring and the cloud tops on the planet. The robotic spacecraft will set up for the mission's last phase, named the 'Grand Finale', with a fly-by of Saturn's moon Titan on 22nd April. This will be followed by the first dip through the ring gap around four days later.

The spacecraft will then make its first passage through the 2,400 kilometre gap between Saturn's rings and cloud tops. It will turn its dish-shaped high-gain antenna to point forward to use as a shield to protect the orbiter's sensitive electronics, computer and scientific sensors from collisions with ice and dust that may populate the region.

No spacecraft has ever passed through the gap and although images do not show any signs of dust or ice in Cassini's path, officials cannot be sure of the threat. Cassini will be moving so fast that any contact with even a tiny grain could cause catastrophic damage.

If there are any microscopic ring particles in Cassini's flight path, the spacecraft's Cosmic Dust Analyzer will scoop up ice grains and directly measure their composition. The rings are 99% water ice but what the other 1% is will be the important question. Cassini will get a chance to investigate that directly.

During the mission's last five passes in August and September, Cassini will be low enough to skim through the top of the atmosphere. This will tell the ground team about the molecules that make up the outer rarefied layers of Saturn itself. On the very final orbit Cassini will be deep enough into the atmosphere that it will need to have the high-gain antenna pointed towards Earth so it can transmit directly right up until the moment it is destroyed.

Cassini's mass spectrometer will be gathering data on the conditions inside the atmosphere and sending the readings back to Earth live. With a nearly 90 minute lag due to Saturn's distance any stored data would be lost as Cassini breaks up and is destroyed. Watch out for the latest news and pictures on the NASA website.

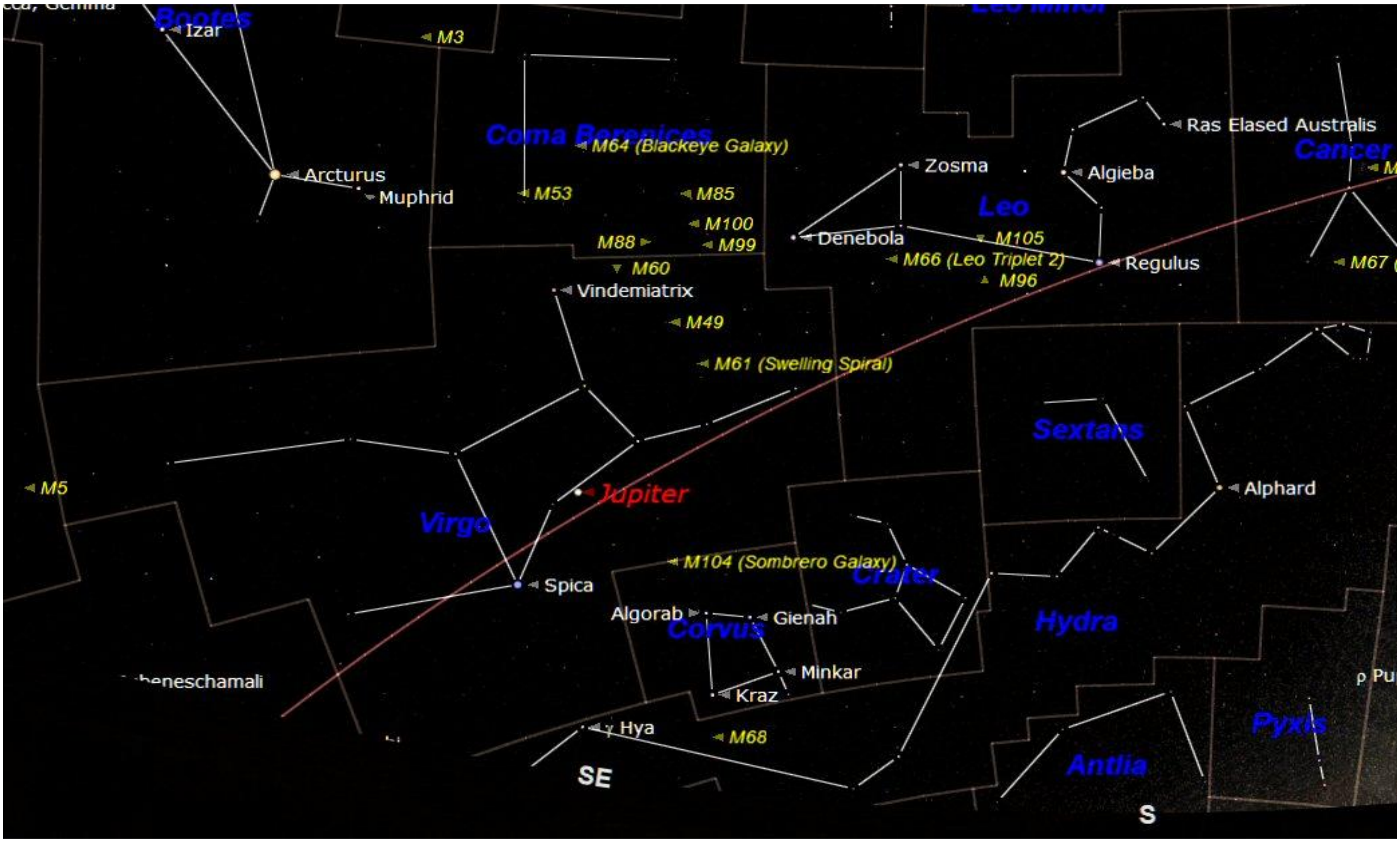
NEWBURY ASTRONOMICAL SOCIETY MEETINGS

31st March	Kew Observatory – Dr. Lee Mcdonald
Website:	www.newburyastro.org.uk

NEXT NEWBURY BEGINNERS MEETING

19th April	Rings Around the Solar System
Website:	www.naasbeginners.co.uk

CONSTELLATION OF THE MONTH – VIRGO (the Virgin)



The location of Jupiter in the constellation of Virgo this month

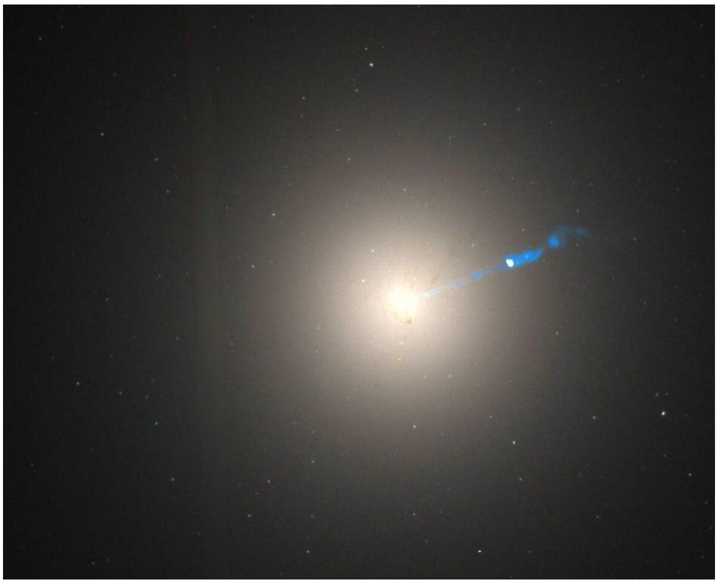
Virgo is not a very distinctive constellation but it is easy to locate this year because it is host the planet Jupiter. With Jupiter as a guide the bright star Spica can be located to the south. The recognised shape of Virgo may be difficult to identify from a light polluted area because most the stars are not very bright.

Virgo is one of the twelve constellations of the Zodiac therefore it sits on the Ecliptic (the imaginary line along which the Sun, Moon and planets appear to move across the sky). It is preceded to the west along the ecliptic by Leo (the Lion) and followed by Libra (the Scales) to the east. The virgin most commonly associated with Virgo is Erigone, the daughter of Icarius of Athens. Icarius, was killed by his drunken shepherds and Erigone hanged herself in grief. In the middle ages the Virgin was often associated with the Virgin Mary.

Spica is the brightest star in the constellation of Virgo and the 16th brightest star in the night sky. Analysis of its parallax shows that it is located 250 light years from the Sun. It is a spectroscopic binary and rotating ellipsoidal variable; a system whose two main stars are so close together they are egg-shaped rather than spherical and can only be separated by their spectra. The primary is a blue giant and a variable star of the Beta Cephei type. As Spica is always low it appears to sparkle due to air turbulence.

The main interest in Virgo is the presence of a famous cluster of galaxies. Although it is known as the Virgo Cluster it does spill over into the neighbouring constellation of Coma Berenices. The Virgo Cluster is comprised of approximately 1300 (possibly up to 2000) member galaxies and the cluster forms the heart of the larger Virgo Super-cluster. Our galaxy and our Local Group are members and controlled by the combined gravity of the Virgo cluster.

Messier 87 (also known as M87 or NGC 4486) is a supergiant elliptical galaxy at the centre of Virgo. It is one of the most massive galaxies in our local universe and contains more than a trillion stars. It is also notable for its large population of globular clusters. M87 contains about 12,000 compared to the 150–200 orbiting the Milky Way.

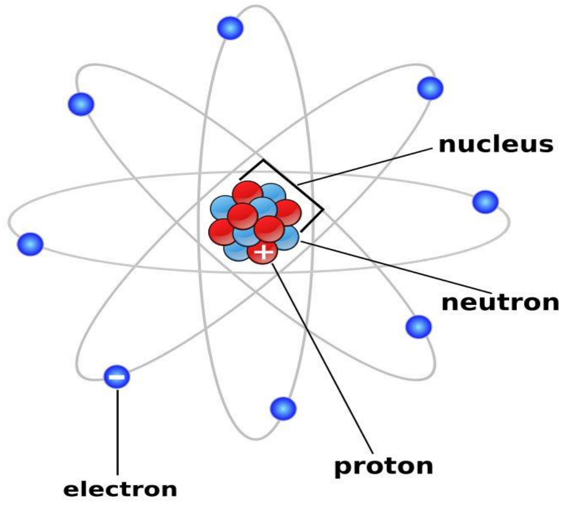


Messier 87 (M87) A super Giant Elliptical Galaxy

M87 has one of the largest black holes that has been found and may be as massive as 3.5 trillion times the mass of our Sun. See page 6 for more about Super Massive Black Holes. M87 also has a huge powerful jet of energetic plasma that originates at the galaxy core (the Super Massive Black Hole) and extends outward at least 4,900 light-years and is travelling at very high speed.

COMPACT OBJECTS

Compact or Super Massive objects are those objects whose atomic structure has been compressed beyond the natural limits of normal Baryonic elements. Normal atoms are made of a Nucleus (comprised of Protons and Neutrons) and orbiting electrons.



The construction of a typical atom

Each element is defined by the number of Protons present in its Nucleus. Protons have a positive electrical charge and there will always be an equal number of negatively charged electrons orbiting the Nucleus. The nucleus can also contain a number of Neutrons that have no electrical charge and are therefore electrically neutral. The atoms of each element can accommodate various numbers of Neutrons but there will be certain numbers that will allow the atom to be stable but some numbers will cause the atom to be unstable. The different numbers of Neutrons that a specific element can accommodate produce variants of that element called isotopes.

A specific element will always have the same number of Protons in its nucleus and an equal number of Electrons in orbits around that nucleus. A normal atom of Oxygen will have eight Protons with eight Neutrons in its nucleus. It will also have eight electrons orbiting the Nucleus. All atoms have two electrons in the first orbit position and up to eight in the second orbital shell. The heaviest atoms can have up to seven shells. The heaviest naturally occurring element (Uranium) has: 2, 8, 18, 32, 21, 9, 2 electrons.

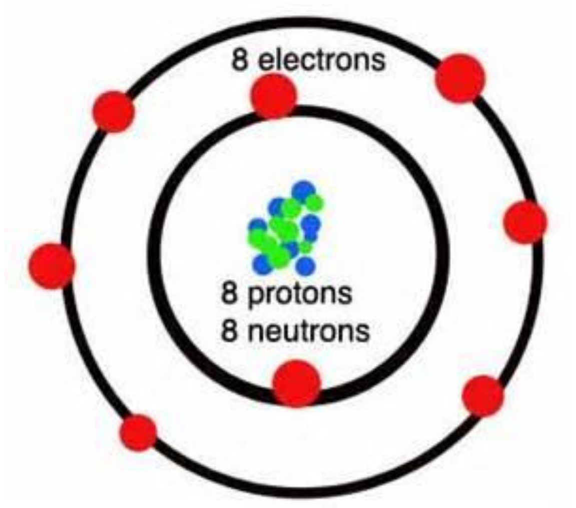


Diagram of a normal Oxygen Atom

Atoms in normal space which also applies on our planet have their electrons orbiting in shells that are at a specific distance from the Nucleus. The electron shells are located at enormous distances compared to the size of the Nucleus. Therefore the vast majority of a normal atom is just empty space and the sizes of the particles that make up the atom are incredibly small in comparison.

In an ordinary gas (known as Fermion Gas), in which thermal effects dominate, most of the available electron energy levels are unfilled so free electrons are able to move into these vacant positions. When a material is subjected to extreme compression the particle density is increased. Free electrons progressively fill the vacant lower energy shells and additional electrons are forced to occupy higher energy shells even at low temperatures. Eventually what is known as a Degenerate Gas is formed.

In the core of a star that has reached the end of its Hydrogen fuel supply, nuclear fusion reactions stop. The star becomes a collection of positively charged ions, largely Helium and Carbon nuclei, floating in a sea of electrons which have been stripped from the nuclei. Without the radiation pressure produced from the nuclear fusion that had pushed outwards, gravity begins to compress the remains of the star. As the volume of the star decreases the internal pressure increases. Free electrons are forced into the vacant shell positions around the atom nuclei.

When gas becomes super-compressed, particles are position right up against each other to produce degenerate gas that behaves more like a solid. Pressure is only increased by the mass of the particles which increases the gravitational force pulling the particles closer together. Therefore, the phenomenon is the opposite of that normally found in matter where if the mass of the matter is increased, the object becomes bigger. In degenerate gas when the mass is increased the pressure is increased and the particles become spaced closer together so the object becomes smaller. Degenerate gas can be compressed to very high densities, typical values being in the range of 10,000 kilograms per cubic centimeter.

Degenerate Gases strongly resist further compression because the electrons cannot move to already filled lower energy levels due to what is known as: the Pauli Exclusion Principle. Since electrons cannot give up energy by moving to lower energy states, no thermal energy can be extracted.

There is an upper limit to the mass of an electron-degenerate object called the 'Chandrasekhar Limit'. Beyond this limit electron degeneracy pressure cannot support the object against further collapse. The limit is approximately 1.44 solar masses for objects with typical compositions expected for white dwarf stars (carbon and oxygen with 2 baryons per electron). The limit may change with the chemical composition of the object, as this affects the ratio of mass to number of electrons present.

Stellar objects below this limit are known as White Dwarf Stars. These are formed by the gradual shrinking of the cores of stars, about the mass of our Sun, when they have exhausted their supply of Hydrogen fuel. During this shrinking, the electron-degenerate gas forms a core up to 1.44 times the mass of our Sun. On reaching this mass further collapse of the star prevented.

WHITE DWARF STARS

A white dwarf is also called a degenerate dwarf and is a stellar core remnant composed mostly of electron-degenerate matter. A white dwarf is very dense, its mass is about that of the Sun while its volume is similar to Earth.

The size of a White Dwarf compared to Earth

The nearest known white dwarf is Sirius B at just 8.6 light years. It is the smaller component of the Sirius binary star. There are currently thought to be eight white dwarfs among the hundred star systems nearest the Sun. The existence of white dwarfs was first recognised in 1910.

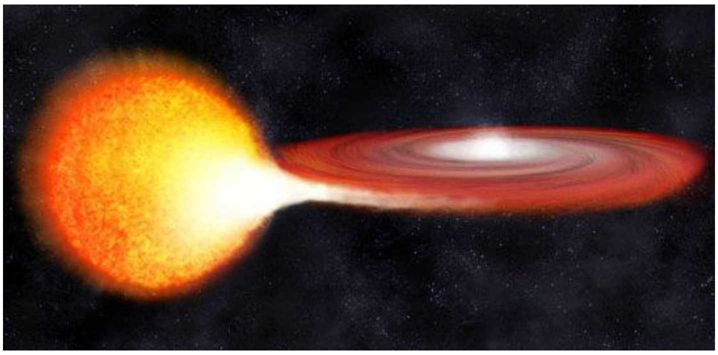
White dwarfs are the final evolutionary state of stars whose mass is not high enough to become a neutron star this would include the Sun and over 97% of the other stars in the Milky Way. When a main-sequence star similar to our Sun has used up its supply of Hydrogen fuel it will expand to become a red giant. During this phase it fuses helium to carbon and oxygen in its core by the triple-alpha process. After such a star sheds its outer layers and forms a planetary nebula, it will leave behind a collapsed dense core which is the remnant white dwarf. Usually, white dwarfs are composed of carbon and oxygen atoms.

The material in a white dwarf no longer undergoes fusion reactions so the star has no internal source of energy. As a result, it cannot support itself by the radiation generated by fusion against gravitational collapse. It will therefore gently collapse until it is stopped from further collapse by electron degeneracy pressure. It will then be extremely dense. The physics of degeneracy dictates there will be a maximum mass for a white dwarf referred to as the Chandrasekhar limit. This maximum mass is approximately 1.44 times the mass of our Sun (written as: $M_\odot$) beyond which it cannot be supported by electron degeneracy pressure.

A white dwarf is very hot when it forms but because it has no internal source of energy, it will gradually radiate its energy away and cool. This means that it is initially bright white high temperature colour that will lessen and redden with time. Over a very long time, a white dwarf will cool and its material will begin to crystallize (starting at its core). The star's lower temperature means it will no longer emit significant heat or light and it will become a cold Black Dwarf. The universe has not existed long enough for any white dwarf to release all of its heat energy as it will take many billions of years before it becomes a 'cold' Black Dwarf Star. The very oldest white dwarfs still radiate at temperatures of a few thousand Kelvin.

Some interesting things can happen to White Dwarf Stars and one interesting thing is they can produce powerful explosions known as Novae (*singular* Nova). A Nova occurs when a white dwarf is a component in a close binary system. This is where there is a pair of stars that are orbiting each other and they are very close together. One star of the pair is likely to be larger than the other. The larger star will be much brighter and consume its supply of hydrogen fuel faster than its smaller twin. It will age quicker to become a Red Giant then a White Dwarf while its smaller twin will still be in its normal main sequence phase.

As the second star begins to age it naturally develops into a Red Giant. As this star becomes larger its outer region begins to be attracted by the powerful gravity of the White Dwarf companion. Hydrogen is pulled off the red giant and spirals inwards towards the white dwarf and forms a rotating disc. The Hydrogen gas eventually falls on to the surface of the white dwarf and is compressed by the enormous gravity into a shallow but very dense layer on the surface.



A white dwarf stealing Hydrogen for its companion

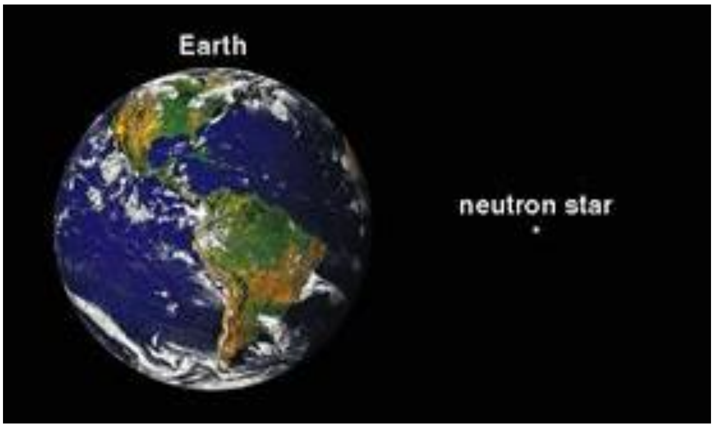
As the Hydrogen builds up on the surface it becomes very hot and very highly compressed. The layer of hydrogen eventually reaches a point when the atoms spontaneously fuse together and trigger a run-away Nuclear Fusion detonation. The whole Hydrogen layer explodes in a massive Nova explosion. The white dwarf normally survives this event as does the red giant although the giant star may be damaged by the event. This whole process may repeat a number of times with the Hydrogen detonating every time it reaches that critical mass, density and temperature.

This process is very useful for astronomers because it always occurs at the same point in the process and always produces the same magnitude of explosion. These explosions are very powerful and can be seen over vast distances of space so they can be easily detected in distant galaxies with large telescopes. As the explosion always produces the same sized flash of light the nova can be used to give an accurate estimate of how far it is away by judging how bright this 'standard candle' appears. The nova can be used to estimate the distance to the host galaxy.

There is a second type of nova called a Double Degenerate. These are produced by two white dwarf stars merging. Many white dwarfs are expected to be in binary systems. It starts with two Sun like stars of similar size, separated by about one astronomical unit (the distance between Earth and the Sun). The two stars may transfer mass between them reducing the white dwarf's angular momentum and cause them to begin spiralling toward each other. The white dwarfs can either be torn apart by the gravitational tidal forces or the two can collide and merge completely. Either way, the result is a huge and catastrophic explosion.

NEUTRON STARS

A Neutron Star is the collapsed core of a large star with a mass greater than 3 times the mass of our Sun. Neutron stars are the smallest and densest stars known to exist. Neutron Stars have a radius in the order of 10 km but they can have masses of about twice that of the Sun.



The size of a White Dwarf compared to Earth

They result from the supernova explosion of a massive star, combined with gravitational collapse that compresses the core past the white dwarf star density to that of atomic nuclei. Most of the basic models for these objects imply that neutron stars are composed almost entirely of neutrons which are subatomic particles with no net electrical charge and with slightly larger mass than protons. Neutron Stars are supported against further collapse by Neutron Degeneracy Pressure. This is a phenomenon described by the Pauli Exclusion Principle.

Any main-sequence star with an initial mass of up to 8 times the mass of the sun (8 $M_{\odot}$) has the potential to produce a neutron star. As the star evolves away from the main sequence, subsequent nuclear fusion produces an iron-rich core. When all nuclear fuel in the core has been exhausted, the core must be supported by electron degeneracy pressure alone. Further deposits of mass from the shell fusion burning causes the core to exceed the Chandrasekhar limit where a White Dwarf would be formed.

Electron-degeneracy pressure is overcome and the core collapses further, sending temperatures soaring to over 5×10^9 K. At these temperatures, photodisintegration (the breaking up of iron nuclei into alpha particles by high-energy gamma rays) occurs. As the temperature climbs even higher, electrons and protons combine to form neutrons via electron capture, releasing a flood of neutrinos. When densities reach the nuclear density of 4×10^{17} kg/m^3, neutron degeneracy pressure halts further contraction.

After the core has collapsed the outer layers of the star fall in on the core. The in-falling of the outer layers is halted and blown outwards by the extremely powerful blast of neutrinos produced in the creation of the neutrons. The outer part of the star explodes as a supernova. The core remnant left behind is a Neutron Star.

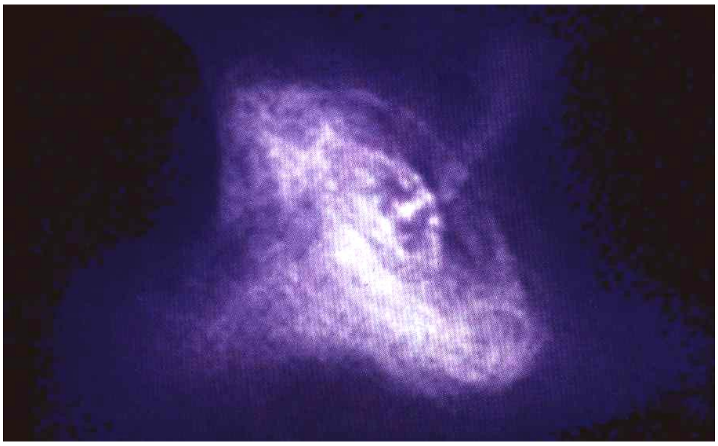
As the star's core collapses, its rotation rate increases as a result of conservation of its angular momentum. Newly formed neutron stars rotate at up to many thousand times per second. Some neutron stars emit beams of electromagnetic radiation that make them detectable as pulsars that produce pulses of radiation.

Neutron stars are far too small and faint to be observed directly but their presence can be detected by their effect on the space surrounding them. The best known neutron star is the one at the centre of the Crab Nebula (Messier 01) in the constellation of Taurus.

The Crab Nebula Messier 01 (M1) in Taurus

The supernova occurred 7000 years ago when a giant star exploded. The light from the explosion took 6000 years to reach Earth. It was seen by astronomers in the year 1054 and recorded by Chinese astronomers at the time. The supernova appeared as a ‘new’ (nova) star that was bright enough to be seen in daylight for about three months. Since 1054 the supernova remnant has expanded and faded but can still be seen as ‘fuzzy’ patch of light using a modest sized telescope, as shown above.

The region around the Neutron Star was found to be a strong source of radio waves in 1949 and X-rays in 1963. It was identified as one of the brightest objects emitting gamma rays in 1967. In 1968 the star was found to be emitting its radiation in rapid pulses and becoming one of the first pulsars to be discovered.



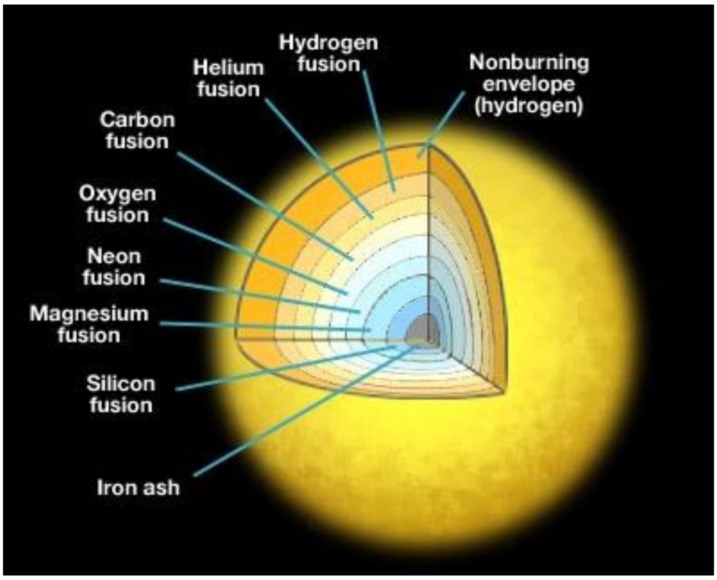
The Neutron Star (Pulsar) at the centre of M01

Pulsars are sources of powerful electromagnetic radiation, emitted in short and extremely regular pulses many times a second. Pulsars are rapidly rotating neutron stars, whose powerful magnetic field concentrates radiation emissions into narrow beams at the poles. The Crab Pulsar is believed to be about 28km in diameter and rotating 33,000 times per second. Pulses are emitted at all wavelengths from radio waves to X-rays. The dynamic feature in the inner part of the nebula is the point where the pulsar's equatorial wind interacts with the nebula, as shown above. The shape and position of this feature shifts rapidly.

BLACK HOLES

Black holes are the ultimate type of compact objects that we know about. There are two main types that we call Stellar Black Holes and Super Massive Black Holes.

Stellar Black Holes are created during the collapse of a large star between 10 and 30 times the mass of our Sun or even larger. Like Neutron Stars these massive stars are able to process the heavier atoms they create through the nuclear fusion process to create even heavier atoms.



The structure of a super giant star

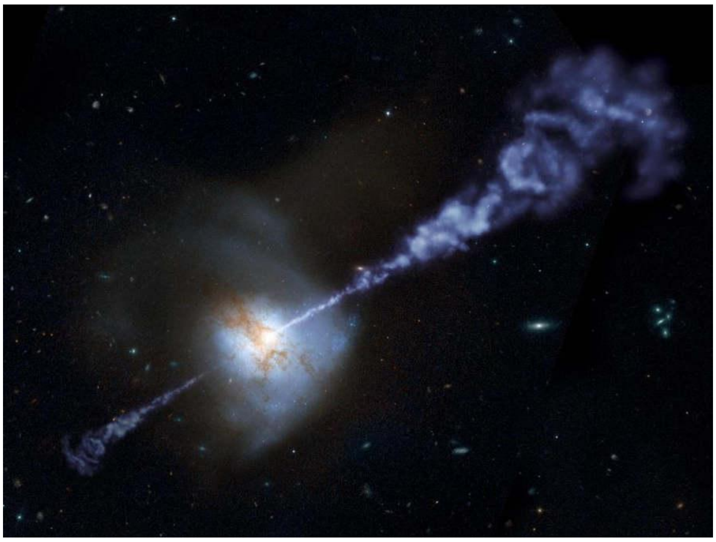
The diagram above shows the structure of a supergiant star just prior to its eventual collapse as a supernova. Shells of increasingly complex and heavier atoms are formed around the core of the star through the nuclear fusion process. The nuclear fusion continues at the boundary of each shell causing the lighter atoms to fuse into the heavier atoms. The heaviest atoms migrate to the centre due to their greater mass. Atoms of other elements are also formed in the process but these decay or combine into the main constituents shown. The sequence of atom production from the original Hydrogen is: Helium, Carbon, Oxygen, Neon, Magnesium, Silicon and finally Iron.

Each process stage contributes additional energy to heat the star and the star is forced to expand in volume. The increase in volume causes the ratio of surface area to volume to increase so the available heat is distributed over an ever increasing area. Consequently the outer surface receives less heat per unit of area and appears cooler. This causes the star to radiate with lower radiation energy and the star becomes yellow, orange and finally a Red Giant.

The Iron at the centre of the core does not contribute any additional energy and the atom production fusion process cannot continue on to even heavier atoms. When the mass of the Iron core reaches 1.44 times the mass of our Sun it collapses to momentarily form a White Dwarf. With additional matter falling in on the core it exceeds the limits for a White Dwarf and then the limits of a Neutron star to form a Black Hole. In the process of collapse it produces an enormous burst of Neutrinos that blows away the outer layers as a supernova explosion. The remaining Black Hole will have a mass of more than 3 solar masses and can grow by consuming additional matter to eventually become tens or even hundreds of solar masses but still incredibly small.

SUPER MASSIVE BLACK HOLES

Super massive Black Holes are found at the centre of galaxies and as their name suggests are super massive. They are typically hundreds of thousands of solar masses and up to millions of solar masses. The very largest may be trillions of solar masses.



An active Super Massive Black Hole in a galaxy

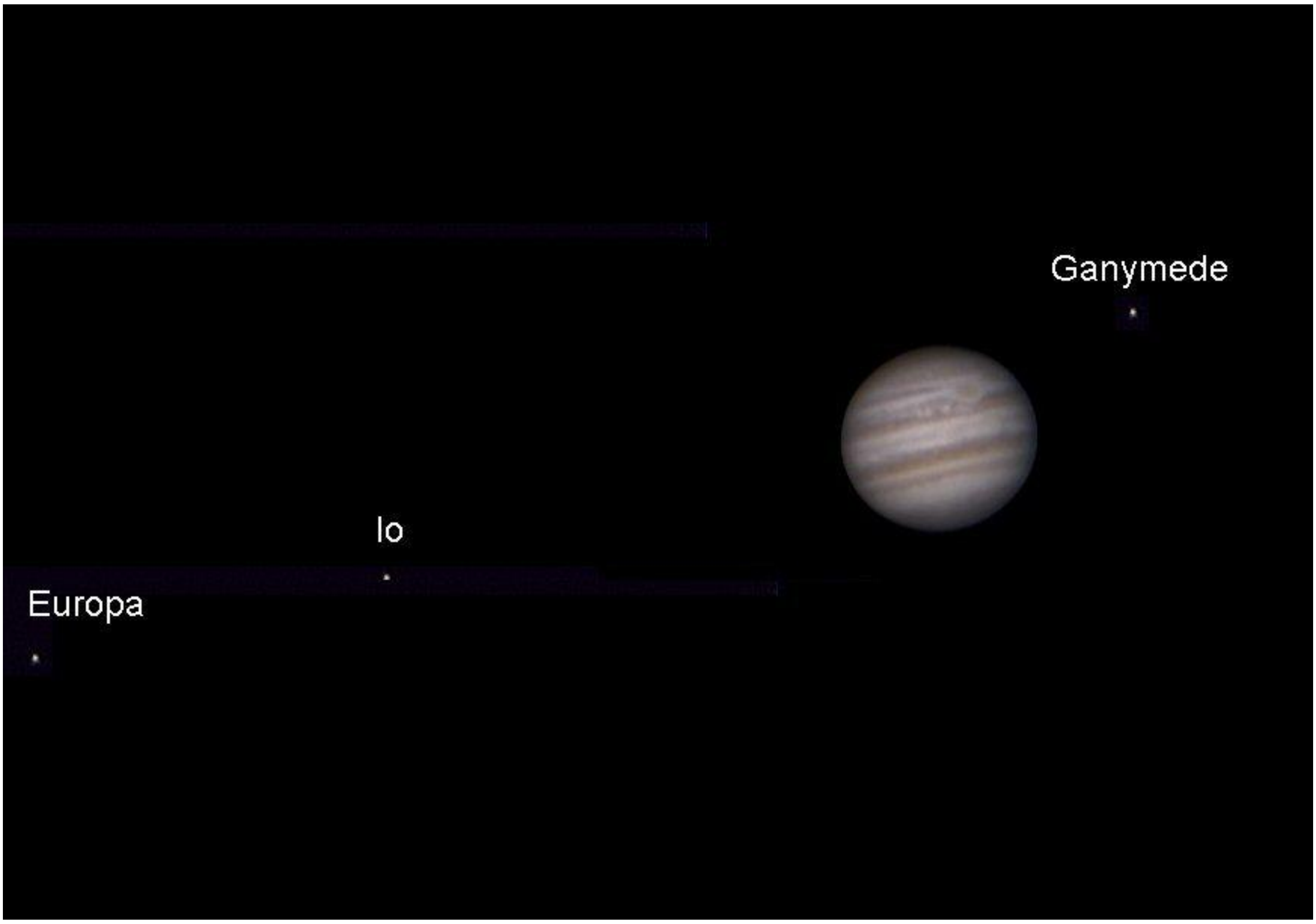
Black holes themselves are invisible because their gravity is so strong that even light cannot exceed the required escape velocity to escape from their influence. However black holes are greedy and will consume anything that comes too close. Around all black holes is a zone of extreme gravity bounded by what is known as its Event Horizon. This is the point where if crossed there is no way back. The gravity of the black hole will pull everything in and even light cannot escape its deadly grasp.

Although black holes are invisible they can be detected by their gravitational influence. They can also give their location away as they devour gas, dust and even whole stars. As matter is pulled into a black hole it is drawn into a disc that forms around it. The material is accelerated to enormous speeds and becomes heated so that it emits light. At the point that it is destroyed it emits a flash of X rays that can be detected and shows the location of the black hole.

Some black holes (and Neutron Stars) can over indulge and cannot consume all the in-falling material. This excess interacts with the incredibly powerful magnetic fields around the object and is directed towards the magnetic poles. On reaching the poles the now highly energised particles are formed into powerful jets that blast out from the poles. These can be seen in the image above as they travel for millions of light years across space and in the image on the previous page showing the Crab Pulsar (Neutron Star).

Super Massive Black Holes are only found at the centre of galaxies so it appears that they are associated with the formation of galaxies. There seems to be a general rule that big galaxies have big black holes. There is however a great mystery around how Super Massive Black Holes can grow so massive. Calculations show that there has not been anywhere near enough time for the largest of them to have grown as big as they appear. In fact we can see very large ones even in galaxies that formed in the very early universe. One theory is that the mysterious Dark Matter may have played a part in their formation.

JUPITER AND ITS AMAZING MOONS



Jupiter and three of its moons imaged by Steve Harris (Newbury Astronomical Society)

In the March issue of this magazine we were thinking about observing Jupiter and the beautiful detail that is visible using a larger telescope but Jupiter's larger moons are also very interesting. A small telescope or even a good pair of 9 x 50 binoculars will show the four brightest moons known as the Galilean Moons. These four bright moons are called the 'Galilean Moons' after Galileo Galilei who first recorded seeing them.

The moons are too small to see any detail using a small telescope but their positions can be observed using a basic small but reasonably good quality telescope. A good pair of 9 x 50 binoculars may just about show the moons but a pair of 15 x 70 binoculars will show them well. The larger binoculars will need to be supported using a tripod or some other device to enable them to be held steady. The moons can be observed to have moved noticeably over the course of an evening's viewing.

A computer planetarium application can be downloaded free from the internet to predict the events happening around Jupiter and then followed using a telescope. One of the best and most popular computer planetarium applications to download is 'Stellarium'. This and other applications can be used to identify the moons and predict what is going to happen to Jupiter and its moons during any clear night before observing is started.

It can be fun to make simple sketches perhaps once every hour showing the actual positions of the moons. With three or four simple sketches in a book the movements of the moons around their orbits can be monitored and can be followed from night to night.

Sometimes it is possible to see the moons pass in front or behind Jupiter or pass above or below the planet. This makes observing Jupiter very interesting. We can watch the moons approach the planet to disappear behind or in front of Jupiter and then watch them reappear an hour or two later. We can also see their shadows as they pass in front and project their shadow on to the planet. These events can be predicted using a planetarium application and the events can then be followed and timed using a fairly modest telescope. These special events can be timed and recorded with sketches as they happen and can then be checked against the predictions.

Eclipses occur when a moon casts its shadow on to Jupiter. It is quite easy to see because the eclipse shadow looks like a black full stop on the planet. Moons can also be eclipsed as they pass through the very large shadow cast by Jupiter.

Transits occur when a moon passes in front of Jupiter. The moon is actually very difficult to see while it is in front of the planet as it is lost in the glare from the surface.

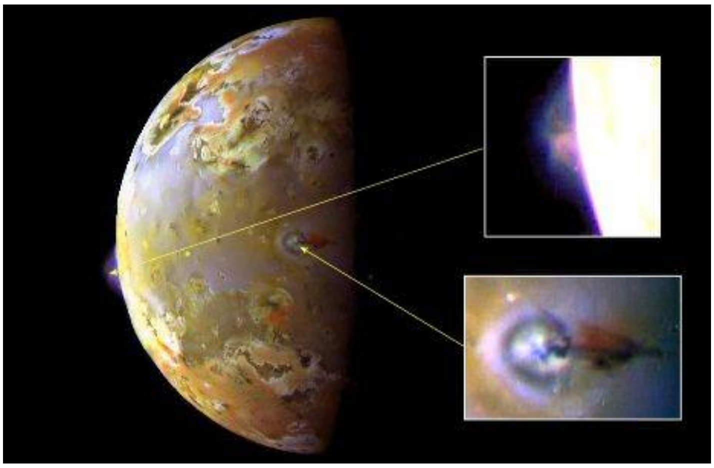
Occultations occur when a moon passes behind the planet. Occultations and Transits are easy to follow with a telescope as the moon approaches Jupiter.

Using an accurate clock (a radio controlled clock is best) the actual times of the event can be annotated to the sketches to make them more interesting and scientific. The times can also be compared to the times predicted by the planetarium programme.

Jupiter's four largest moons Io, Europa, Ganymede and Callisto

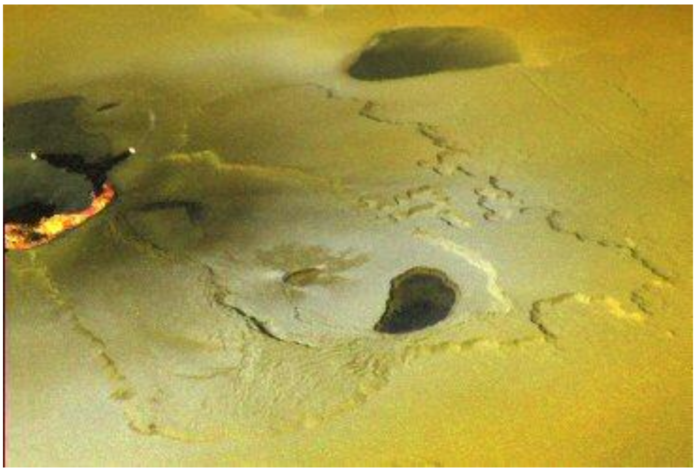
Our earth bound telescopes cannot see detail on the surface of Jupiter's moons but robotic probes have given us an insight into the amazing nature of these alien moons. With a telescope we can see these moons for ourselves but visiting probes have helped us to appreciate what these mysterious, distant moons are really like.

Io is the innermost of the four large moons that Galileo discovered and is the second smallest at 3,630km in diameter which is slightly larger than Earth's Moon which is 3,476km. Io orbits Jupiter every 1.77 Earth days at a distance of 421,000km from Jupiter. When seen up close the surface resembles a pizza. Io is the most volcanically active body in the Solar System. It is so close to Jupiter that it is nearly torn apart by the gravitational forces of Jupiter and the larger moons orbiting outside it. Gravitational forces stretch and squash Io, producing tides that cause the rocky surface to rise and fall by about 100m every 9 hours. This produces enormous pressure and friction forces that generate heat inside the moon. This internal heat causes continuous volcanic action on the surface. The volcanic activity was not known about until the Galileo probe took close up images in 1995. Huge plumes from volcanoes were seen on the edge of the moon.



Images of Io taken by Galileo in 1995

Io was expected to have similar features to our own Moon so the scientists were amazed at what they could see in the first images returned. When it was realised that there were volcanoes on Io the Galileo probe was programmed to make special close fly-by encounters with the moons including Io. One of the big questions was 'are the volcanoes like those on Earth?' or 'are they more like geysers just venting gas from a frozen surface?' Galileo was ordered to make a very close fly-by to enable it to take close up high resolution images of the surface. These images revealed truly amazing pictures of molten rock lava flowing across the surface of Io.



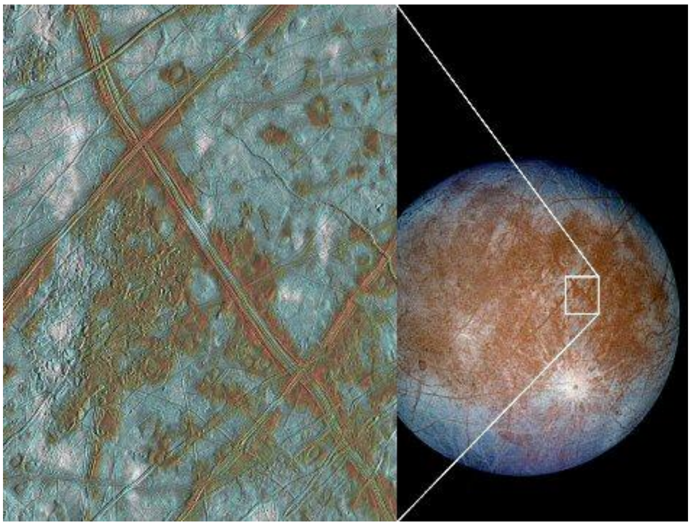
Galileo's image of molten lava on the surface of Io

The volcanic eruptions on Io not only cover the surface of the moon with multi-coloured deposits of Sulphur but also send gas and particles out of Io's gravitational grip and into orbit around Jupiter. This adds to the fine ring structure found around Jupiter by the visiting probes.

Europa is the second large moon out from Jupiter and is the smallest of the four at 3,138km in diameter (slightly smaller than our Moon). The ice on the surface reflects 10 times more sunlight than the surface of our moon, making its surface the brightest of Jupiter's moons.

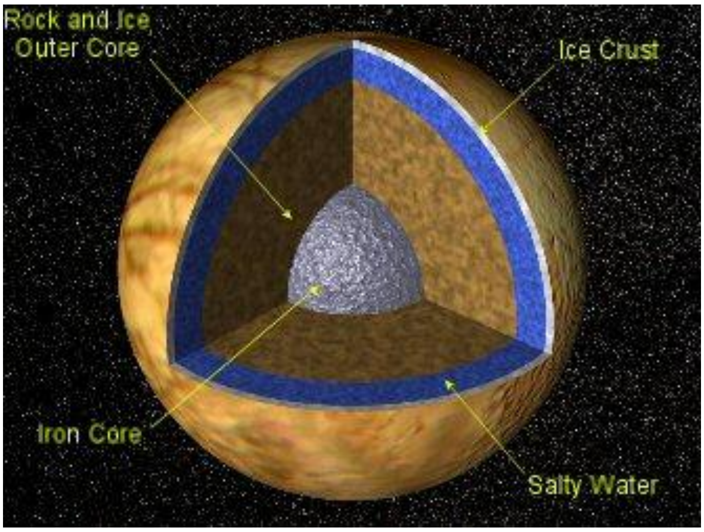
The moon is thought to be comprised mainly of water ice and is believed to have a 70 to 100km thick layer of water and ice that covers the surface of this, the smoothest moon in the solar system. The surface is criss-crossed with huge cracks probably caused by powerful tidal forces produced by the gravity of Jupiter. Radar scans have indicated that there may be a liquid salty water ocean beneath the 20km to 30km thick water ice crust.

The image on the following page shows the surface is cracked, with the cracks coloured on either side. This effect is seen on Earth where pack ice cracks and the sea wells up through the crack and freezes on the surface leaving a stain caused [on Earth] by bacteria in the sea. It may be possible that there is some kind of life in the salty ocean below the ice so there is a lot of interest to send a probe there to find out.



A close-up image of the surface cracks on Europa

Europa appears to have a metallic (Iron) core surrounded by an outer core of frozen water. The liquid salty water sea appears to be about 80km deep and covered by a 20km thick crust of frozen water. This means Europa may have up to three times the amount of water we have on Earth.



A diagram showing the interior of Europa

Ganymede is the largest moon in the solar system (5,263km in diameter). It orbits Jupiter in about 7.16 (Earth) days at just over 1 million km from Jupiter. Ganymede is the only moon known to have a magnetosphere and that indicates it may have a hot (<1500°K) liquid Iron core. Polar ice caps have been detected that may be formed by water molecules migrating along the magnetic force lines and being deposited at the poles. There may be a multilayered water and ice surface layer up to 800km deep. It is suspected that there may be a deep liquid layer of water at the ice / rock interface.

The surface has many fault lines, resembling a ploughed field. These strange 'furrow' like features are 100m high and 10km wide and caused by ice movements on the surface. From a distance it resembles our Moon with large dark areas and smaller lighter patches. However its density is much less and appears to have a large proportion of its mass made of water ice. Radar probes have revealed that there may be large pieces of rock suspended in the ice layers. This indicates that much of the water is frozen solid but there may some liquid water layers.

The 'furrow' like features on the surface of Ganymede

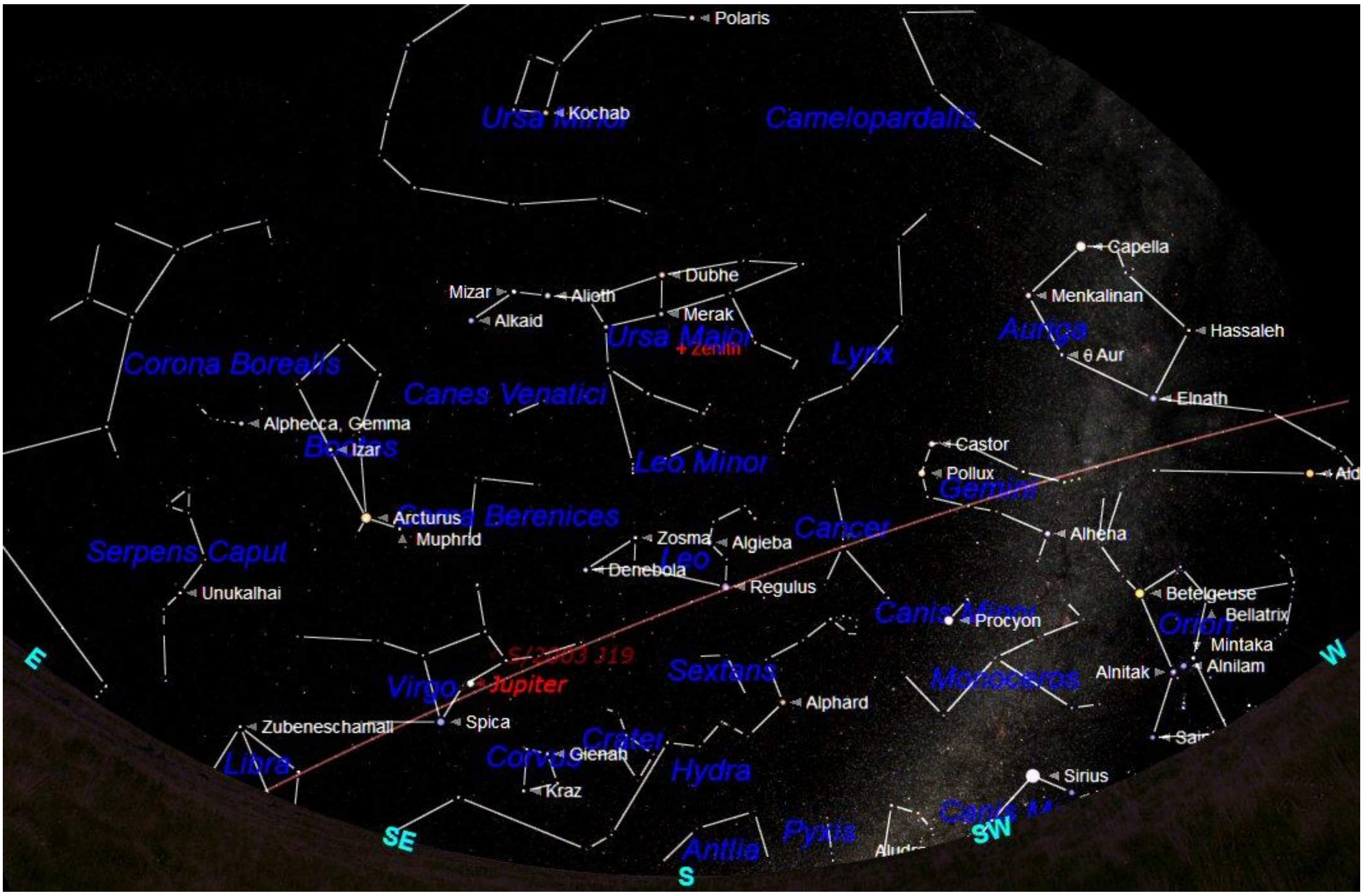
The 'furrows' have few craters compared to the rest of the surface indicating that they have been formed more recently. This leads scientists to conclude that there must have been activity in the interior of Ganymede long after it was formed. There is no evidence that the sub surface activity is currently active.

Callisto, unlike the other three large moons, appears not to have any noticeable internal activity or source of heat. Consequently the surface is old and has one of the most heavily cratered surfaces in the Solar System. Callisto is a large moon with a diameter of 4,800km orbiting Jupiter at 1.8 million km and takes 16.69 (Earth) days to complete each orbit.

Callisto showing the heavily cratered surface

Callisto would be very interesting to visit because it appears to have what may be the oldest undisturbed surface in our Solar System. Samples of this surface may be able to tell us about the original constitution of the nebula that our Sun and the planets formed in.

THE NIGHT SKY - APRIL 2017



The Southern Night Sky during April 2017 at 21:00 BST (9:00 pm)

The chart above shows the night sky looking south at about 21:00 BST on 15th April. 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: Aries (the Ram), Taurus (the Bull), Gemini (the Twins), Cancer (the Crab), Leo (the Lion), Virgo (the Virgin) and Libra (the Scales) just appearing over the eastern horizon.

The Milky Way (our Galaxy) appears to rise up from the south western horizon. It continues up through the constellations of Monoceros, Orion, Gemini, Auriga, Perseus and into Cassiopeia off the top right of the chart.

The winter constellation of Orion is moving closer to the western horizon. Along with Taurus and Gemini. To the north west and sitting astride the ecliptic is the constellation of Taurus (the Bull). The Taurus asterism (shape) looks like a squashed cross 'X'. The winter constellations are still visible soon after the Sun sets.

The constellation of Gemini (the Twins) is easy to find by looking for the twin stars Pollux and Castor. There is a lovely Messier Open Cluster M35 in Gemini just off the end of the line of stars emanating from the bright star Castor. Castor is a double star when seen in a telescope with a third more distant companion nearby.

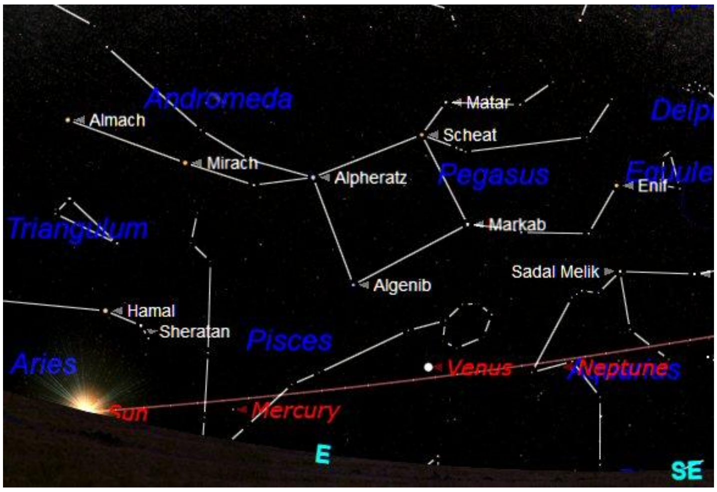
To the east of Gemini is the faint and rather indistinct constellation of Cancer (the Crab). The asterism (shape) of Cancer looks quite uninteresting but the Open Cluster Messier 44 (M44) Praesepe or the Beehive Cluster looks beautiful and like a swarm of bees around an old style hive when seen using binoculars. Following Cancer is Leo (the Lion) with is distinctive 'hook' shaped asterism looking like a sickle or a back to front question mark (?).

Following Leo to the east along the ecliptic is the constellation of Virgo (the Virgin). The constellation shape is comprised of mainly fairly faint stars except Spica which is easy to find. Jupiter is located in Virgo just above Spica so the bright planet can be used to locate Virgo. The constellation of Virgo is the Constellation of the month on page 2 this month. Just rising over the eastern horizon is the constellation of Libra (the Scales).

Directly overhead this month is the best known of all the constellations Ursa Major (the Great Bear) also known as the Plough or the Big Dipper to the Americans. The main asterism (shape) actually looks most like a saucepan. The star half way along the saucepan handle is called Mizar and is a naked eye double star. The companion star to Mizar is called Alcor and is just visible to most people but can be easily seen using binoculars. Mizar is also a double star itself but needs a telescope to separate the pair. Amazingly each of the stars of the Mizar pair are also very close double stars that are too close together to be separated using a telescope. This makes the Mizar and Alcor system a five star associated system.

THE SOLAR SYSTEM APRIL 2017

MERCURY will be visible in the west at the beginning of the month and will move into inferior conjunction (between us and the Sun) on 20th April. It will rise just before the Sun at the end of the month but will not be visible as it will be too close to the eastern horizon and in the brightening sky.



Mercury, Venus and Neptune in the east at sunrise

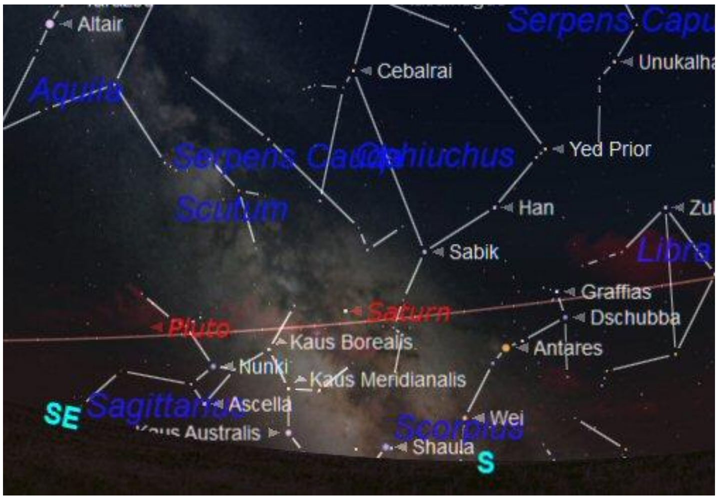
VENUS has disappeared out of the evening sky but is now making its appearance in the early morning sky before sunrise in the east at about 03:30. See the chart above.

Venus imaged by Steve Knight on 15th March

MARS will be in the south west as the Sun is setting and the sky begins to darken. The Red Planet appears small at just 4.1 arc-seconds in diameter and is fading to magnitude +1.5. Mars is getting low in the turbulent air near the horizon and will set at 21:50. The red planet is now getting difficult to see as it moves closer to the western horizon and into the bright dusk sky. See the chart on page 12.

JUPITER is now a good late evening object. It rises over the eastern horizon at 18:30 and will be observable by mid evening towards the end of the month. A pair of binoculars will reveal the four brightest of Jupiter's moons, Io, Europa, Ganymede and Callisto. Even a small telescope will allow the moons to be seen very clearly. See pages 2 & 7 to 9.

SATURN will be visible in the brightening dawn sky close to the south eastern horizon. The ringed planet rises at about 00:00 this month, this about 4 hours before the Sun. The view of Saturn will not be good as it is still quite close to the Sun and rather low. It is observable in the south east from 02:00 until the sky begins to brighten before sunrise. It will also be close to the south eastern horizon in turbulent and dirty air. Saturn will remain low in the sky this year so the views will not be perfect but the rings are nearly wide open so should still look very impressive. A medium sized telescope (100 to 150mm aperture and 150x magnification) will be required to see the rings well.



Saturn in the south at 04:00

URANUS rises just after the Sun so will be in daylight and not observable. It will set before the Sun in the west at 18:46 but will still be too close to the Sun to be seen.

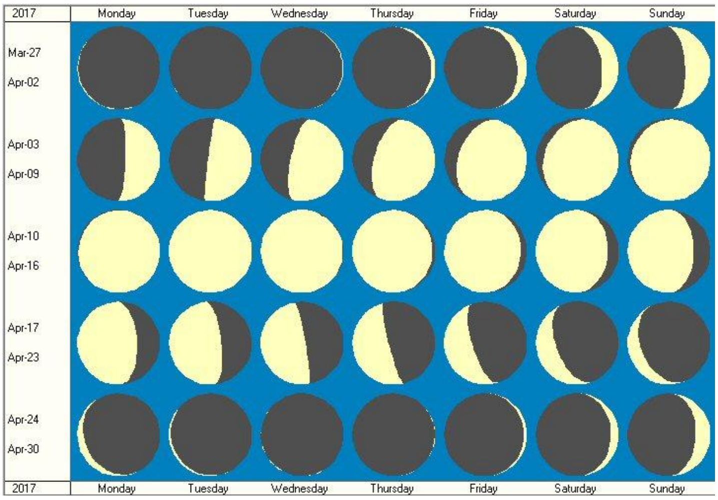
NEPTUNE rises in the east at 04:00 so will, in theory, be observable before the Sun rises. However it will be close to the south eastern horizon and very difficult to see.

THE SUN

There are still occasional sunspots to see even though the active phase of the Solar Cycle is all but over.

The Sun rises at 05:30 at the beginning of the month and at 04:40 by the end of the month. It will be setting at 18:35 at the beginning and 19:30 at 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 APRIL



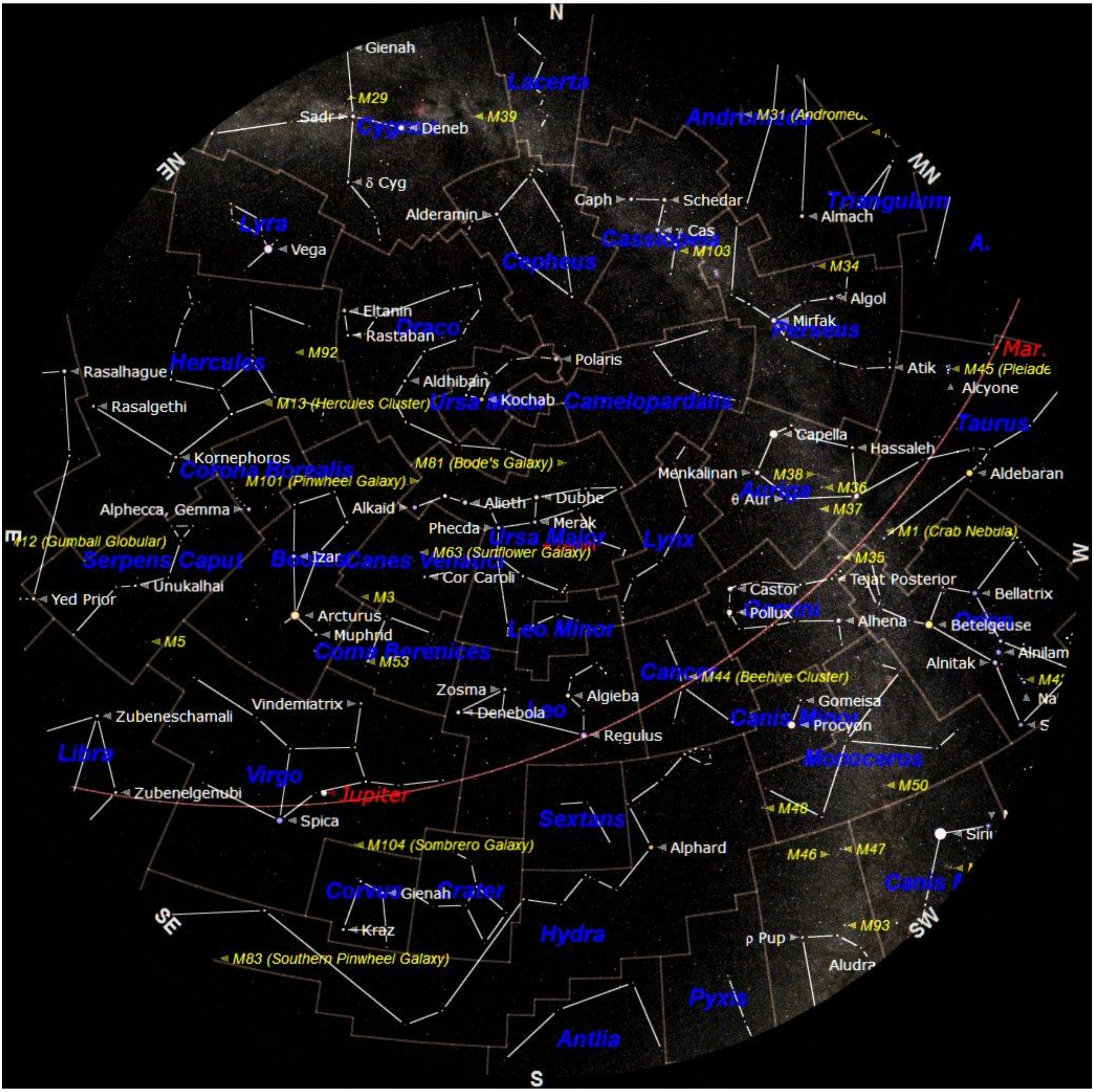
First Quarter will be on 3rd April

Full Moon will be on 11th April

Last Quarter will be on 19th April

New Moon will be on 26th April

THE NIGHT SKY THIS MONTH



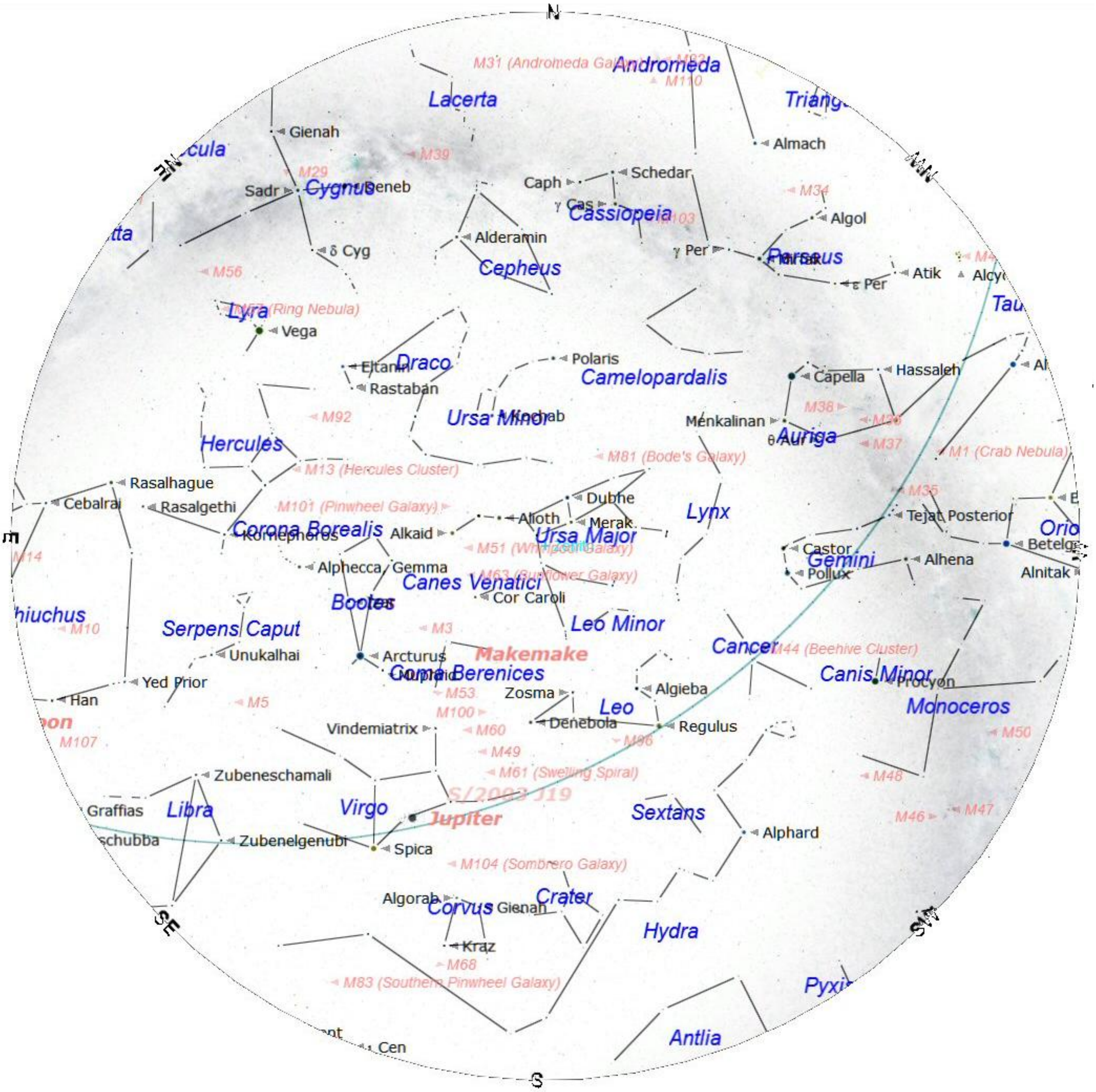
The chart above shows the whole night sky as it appears on 15th April at 21:00 (9 o'clock) in the evening British Summer Time (BST). As the Earth orbits the Sun and we look out into space each night the stars will appear to have moved across the sky by a small amount. Every month Earth moves one twelfth 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 quite easy to find. This month it is directly overhead. 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 in the evening sky: Mercury and Jupiter. Saturn and Venus are visible in the morning before dawn.

THE NIGHT SKY THIS MONTH

This chart below is included for printing off and use outdoors



Position yourself looking south and hold the chart above your eyes with south at the bottom.
The chart shows the sky at 22:00 on 15th April 2017