NEWBURY ASTRONOMICAL SOCIETY
MONTHLY MAGAZINE – APRIL 2021

FIREBALL LIGHTS UP THE SKY

The Fireball Meteor seen on 28th February at 21:54 image from Richard Fleet

Richard Fleet who is an active member of the Newbury Astronomical Society has a rather unusual astronomical observatory at his home in Pusey, Wiltshire. It has no telescopes but it does have an array of night vision cameras. The observatory is one of a number across Europe dedicated to continually watching out for meteors. The cameras run continuously and if a movement is detected in the sky it will save the previous 10 seconds of video to memory on a laptop Hard Disk Drive.

Reports of a very bright meteor were posted of Twitter, Facebook and other social media sites during the late evening of 28th February 2021. Many video clips from dash-cams, security cameras and even front door bell cameras captured the very bright trail of the meteor. When Richard examined his video, recorded through the night, he found he had captured the meteor's trail.

Specialised cameras across the country were able to recreate the flight path, allowing scientists to determine exactly where in the solar system it came from and predict where any meteorite fragments fell. The original space rock was travelling at nearly 14km per second before hitting the Earth's atmosphere.

Almost 300g of a very rare type of meteorite, known as a Carbonaceous Chondrite, survived its fiery passage through the Earth's atmosphere. Some landed on a driveway in the small Cotswold town of Winchcombe. Other pieces of this exceptional meteorite have now been recovered in the local area. The meteorite fragments were retrieved in such a good condition and so quickly after its fall that it is comparable to the samples returned from space missions, both in quality and quantity.

The meteorite is a Carbonaceous Chondrite which is a class that comprises some of the most primitive space rocks known. These rocks formed in the very earliest days of the Solar System and have remained largely unchanged in the billions of years since and so provide a pristine window into our cosmic past.

Studying such rocks can provide unique information on where water and the building blocks of life were formed and what planets are made from. It is also fascinating that much of pieces that fell to Earth broke into bits as dust. This shows how these weak asteroids behave and explains why thousands of tonnes of dust from these objects continually fall through our atmosphere.

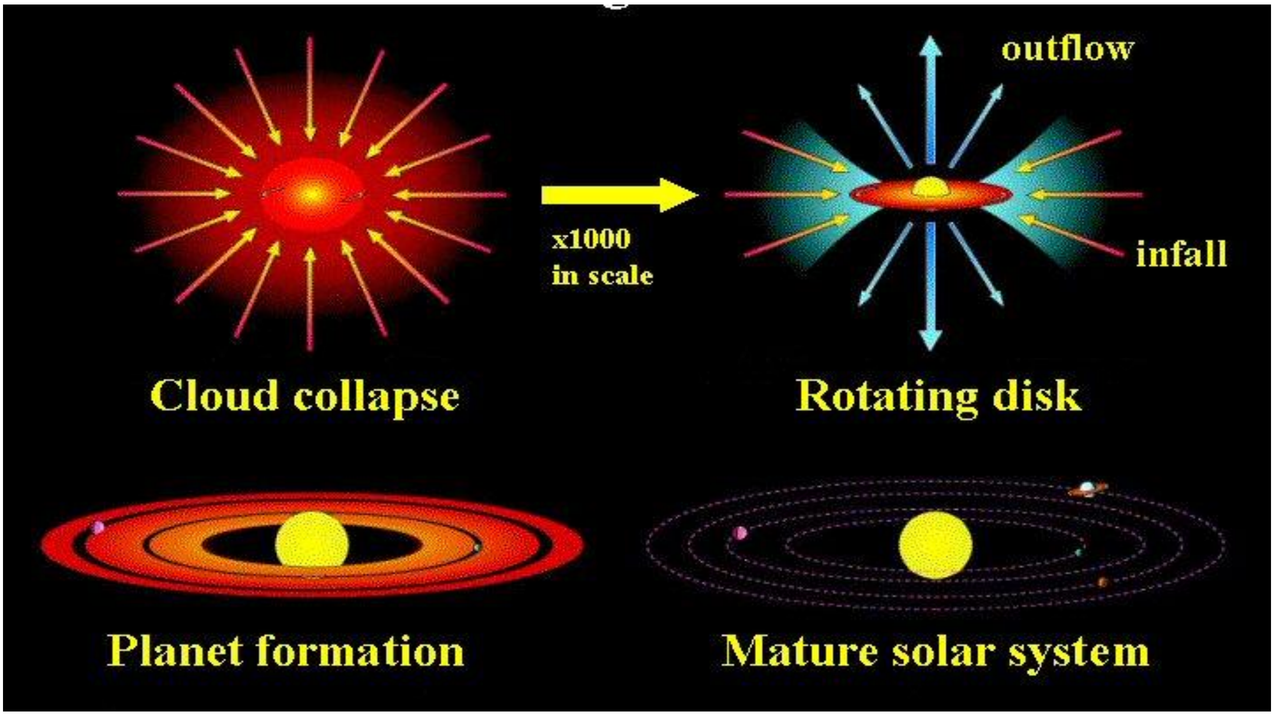
NEWBURY ASTRONOMICAL SOCIETY MEETING

9th April	White Dwarf Stars
Website:	www.newburyastro.org.uk

NEXT NEWBURY BEGINNERS MEETING

21st April	Observing the Sun 'SAFELY'
Website:	www.naasbeginners.co.uk

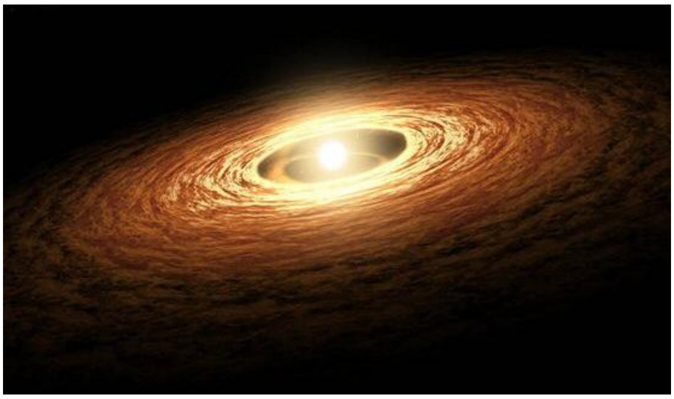
OUR STAR – THE SUN



Stars from in vast clouds of Hydrogen Gas

Starting with the absolute basics we have to say our Sun is a Star so perhaps we should just consider what a star really is. At the fundamental level we could say a star is just a cloud of gas and that is exactly what it is. All stars are created in vast clouds of Hydrogen gas called Nebulae (*single* Nebula) that constitute a large proportion of what Galaxies are made of. Hydrogen gas is drawn into a flat disc as the galaxy rotates and more material is pulled in by gravity.

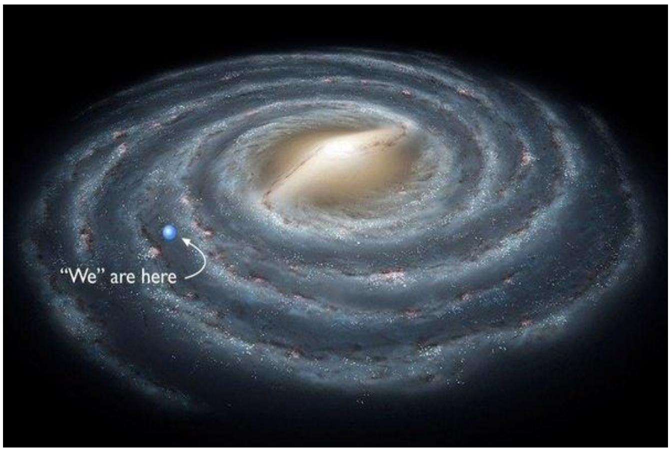
Denser clumps of gas form in the disc as the gas is pulled in by the increasing gravity and this process increases as the clumps accumulate more mass. Eventually gravity compresses the clumps of gas into the smallest possible volume and they became a sphere.



The formation of our Sun from a Nebula

Ever more gas is pulled in as the mass and gravity of the sphere increases. Enormous pressure in the core of the sphere causes the temperature to increase to millions of degrees. The pressure and heat force the Hydrogen atoms together and they combine (fuse) to create larger and heavier atoms of Helium gas. In the process of this Nuclear Fusion, a vast amount of energy is produced in the form of X-Rays. All this additional energy heats the sphere of gas so it begins to shine and a star is 'born'.

All stars have been created by this process in galaxies throughout the Universe. So our Star (that we call the Sun) is just one of over 200 billion stars in our Giant Spiral Galaxy that we call the Milky Way.



The location of our Sun in the Milky Way Galaxy

All stars begin as described above and all stars are made basically the same. However they develop differently depending how big (massive) they are. Larger stars use up their Hydrogen faster and shine very much brighter. Big stars use their fuel up very quickly and consequently will have a shorter life. Small stars use less fuel and survive for much longer with the smallest lasting for hundreds of billions of years.

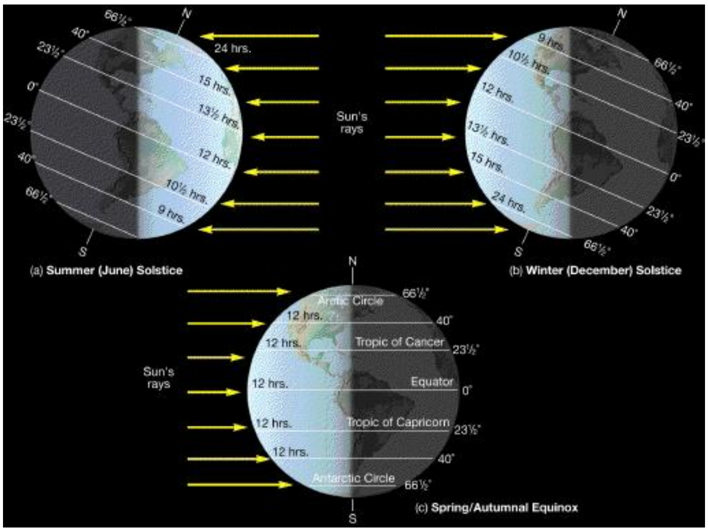
The most common stars are the small and very small ones because they survive much longer (some for trillions of years). Larger stars consume their Hydrogen fuel very fast and may survive for only around a billion years. The very largest stars use up their fuel so fast that they may survive for only a few million years then they explode as a Supernova and destroy themselves.

Our Sun is classed as a Yellow Dwarf and will last for about 10 billion years. It is already 4.3 billion years old so it has about 4 to 5 billion years of fuel left.

The Sun changes position in our sky in two ways. First it appears to move across the sky every day due to the rotation of Earth. The Sun appears to rise in the east in the morning and set in the west in the evening. It appears to follow an arc across the sky so if we trace an imaginary line along its path the arc becomes apparent. We call this arc of the Sun's path 'the Ecliptic'. This arc is caused by Earth being tilted over at 23.4º compared the plane of the Solar System. The planets have their orbits on this plane which is the Equator of the Solar System. The Moon's orbit around Earth is on this same plane despite Earth's tilt. Therefore all the planets, the Moon and the Sun appear to move alone this imaginary Ecliptic arc.

Our seasons are caused by the 23.4º tilt of Earth's axis of rotation. As Earth orbits the Sun (once per year) the axis of rotation remains pointing at the same angle and direction. This has the effect of the poles being tilted towards the Sun for half of the year and tilted away for the other half of the year. When the North Pole is tilted towards the Sun the Ecliptic and the Sun appear higher in the sky during the day so it will be summer. During the summer nights the Ecliptic will be lower in the sky so the Moon and planets appear lower and closer to the horizon.

The Sun rises at about 04:45 on Midsummer Day (the Summer Solstice) and this will occur on 21st June. This is the time when the Sun appears to reach its maximum height above the southern horizon, it will actually occur at on 21st June. Until this day the Sun will appear to be getting higher in the sky then it will appear to get lower every day as we begin to head back towards winter.



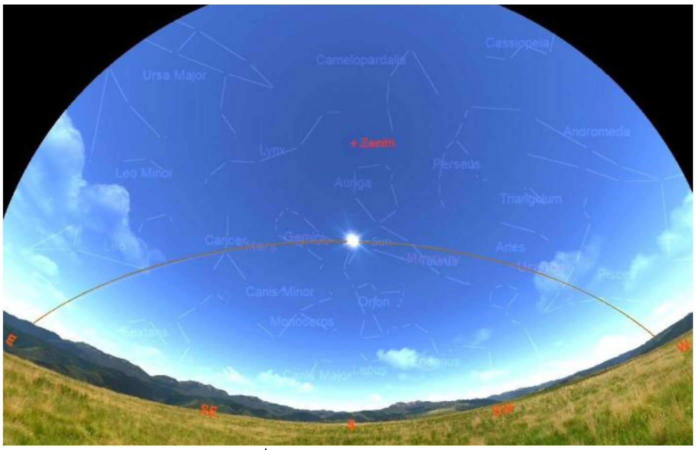
The diagram above shows how the length of the day changes due to the tilt of Earth's axis of rotation. The top left diagram shows how the North Pole is tilted towards the Sun in summer and the days are longer (up to 16 hours long for us). During the winter the North Pole is tilted away from the Sun (top right diagram) so the days are shorter. Days can be as short as 8 hours for us in the UK on midwinter day 21st December (UT/GMT).

So the summer days are good for observing the Sun during the warm days. The summer nights are short and the sky does not get completely dark from mid May to mid August so observing faint deep sky objects is quite difficult. Summer nights might be short but they are warmer so night time observing can be more comfortable and some observing can still be done.

In midsummer the Ecliptic appears low in the south at midnight and appears high during the day. This can be seen by the Moon and planets being close to the horizon at night and the Sun being high in the sky during the day. The first chart below shows the night sky in midsummer. The second chart shows how the Sun is high in the south, on the Ecliptic, on the same day at 12:00 (GMT).

Midnight on 21st June 20201 Midsummer Day

It can be seen on the midnight chart (above) the planets are located on or near the Ecliptic so they are in the more turbulent and contaminated air close the horizon. Therefore they will be difficult to observe due to movement of the air and its poorer quality. We would also be looking at them through much more thick air close to the horizon (about 300 km) compared to the relatively shallow thickness of the atmosphere directly overhead (our Zenith) marked in red on the charts.



Midday on 21st June 2021 Midsummer Day

The Midsummer Day chart above shows the location of the Sun at Midday 12:00 GMT (13:00 BST) on Tuesday 21st June 2021 when the Sun will be at its highest point in the summer sky. If we compare the height of the Ecliptic (the brown curved line) is much higher than at midnight as shown in the upper chart. On the charts above the point directly overhead is marked and labelled 'Zenith' in red. This shows that the Sun is closer to the Zenith than it is to the horizon on Midsummer Day.

As the Sun is overhead it is seen through less of our atmosphere than if we were looking at it close to the horizon. This means the image of the Sun seen through a suitably filtered telescope will be much clearer and steadier. So any sunspots will be clearer and more detail will be seen. The following pages are intended to provide some guidance for observing the Sun safely.

OBSERVING THE SUN 'SAFELY'

The ideal thing to observe during the summer is the Sun. Of course we must take great care in how we observe the Sun as it can be very dangerous if not done correctly. A telescope or binocular must never be used to look directly at the Sun. The instrument is designed to gather as much light as possible from faint objects and direct that light into our eyes. However the Sun produces a lot of light and heat so directing this light and heat into the eye will cause permanent damage and blindness.

There are two ways to observe the Sun safely these are to use a special Solar Filter or to project an image of the Sun on to a screen. If we do have a telescope or binoculars we can use a piece of white card as a screen and project the light from the Sun on to the card.

If binoculars are to be used, cover one of the lenses with the dust cap. Place the card in a suitable supported position so its flat surface is facing the Sun. Hold the binoculars about 300mm above the card in the direction of the Sun. Move the binoculars around until the projected image can be seen on the card. The process can be improved by supporting the binoculars using an improvised stand to support the binoculars and screen.

A simple rig can be assembled to support a screen and attach it to a telescope to allow the image of the Sun to be projected on to a screen. The picture below shows such a homemade rig fitted to a refracting telescope.

A Solar Observing Screen attached to a telescope

There will probably be too much light so the Dust Cover can be fitted over the lens of the telescope and the small light reducing cap removed. This will reduce the glare on the screen and help protect the eyepiece from overheating damage.

Venus Transit 8th June 2004 imaged using the rig above

For those who are fortunate to have access to a telescope, observing the Sun can be taken a step further. The telescope can be used 'safely' to observe the Sun in more detail. The telescope must be fitted with a fail-proof Solar Filter. This can be bought ready made from an astronomy shop or can be made at home using a sheet of special Mylar Solar Film.

Mylar Solar Filter fitted to a Reflecting telescope

The 'Solar' filtered telescope shown above will allow just a tiny amount of sunlight over the full aperture to enter the telescope. It will be the full spectrum (all wavelengths of light) so it will be white light. This will allow any sunspots to be seen in very good detail. It will also show the 'mottled' surface of the Sun, looking like the texture of orange peel.

A WORD OF WARNING! If the telescope has a finder fitted, it must be securely covered or the finder completely removed to avoid accidental burns.

A more advanced type of filter can be bought that will show the activity on the surface and in the atmosphere of the Sun. These are called Hydrogen Alpha filters. They will allow just one very narrow wavelength of light to pass through. This is the red light emitted by excited Hydrogen gas on the Sun.

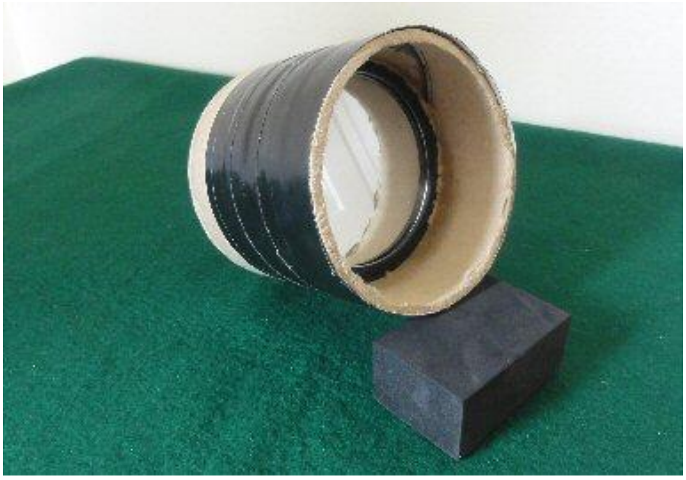
The Hydrogen atoms are able to absorb photons (mainly Ultraviolet light) but this causes the electron in the atom to jump out of its orbit into a higher orbit. The electron will quickly jump back to its natural orbit but to do this it must release the energy from the photon. It does this by releasing a flash of light that is at a discrete wavelength and is always deep red in colour. This is called Hydrogen Alpha (Hα) light.

A Personal Solar Telescope (PST) Hα telescope
Approximate purchase price £800.

ADAPTING A TELESCOPE TO OBSERVE THE SUN

The author's 102mm by 400mm *fl* Skywatcher refractor adapted for solar observing

Most telescopes can be simply adapted for use as a solar telescope. The author's 102mm Skywatcher refracting telescope is shown above with the additions required for observing the Sun directly and above all 'SAFELY'. The most important adaption is the fitting of a genuine Solar Filter. These come in two basic types: a specially coated glass filter or a special Solar Film Filter. The one fitted above is a glass type mounted in a cardboard tube.



The glass solar filter mounted in a cardboard tube

The Solar Filter shown above is the one used in the solar telescope shown above. The glass solar filter is a special filter supplied by Meade for use with a Meade ETX90 telescope. It is usually screwed into a special thread on the ETX90 but has been mounted into a cardboard tube to fit into the Dew Shield of the telescope shown above. The telescope is usually fitted with a 12.5mm eyepiece to provide a magnification of 400 ÷ 12.5 = 35 times, this gives a good overview of the Sun.

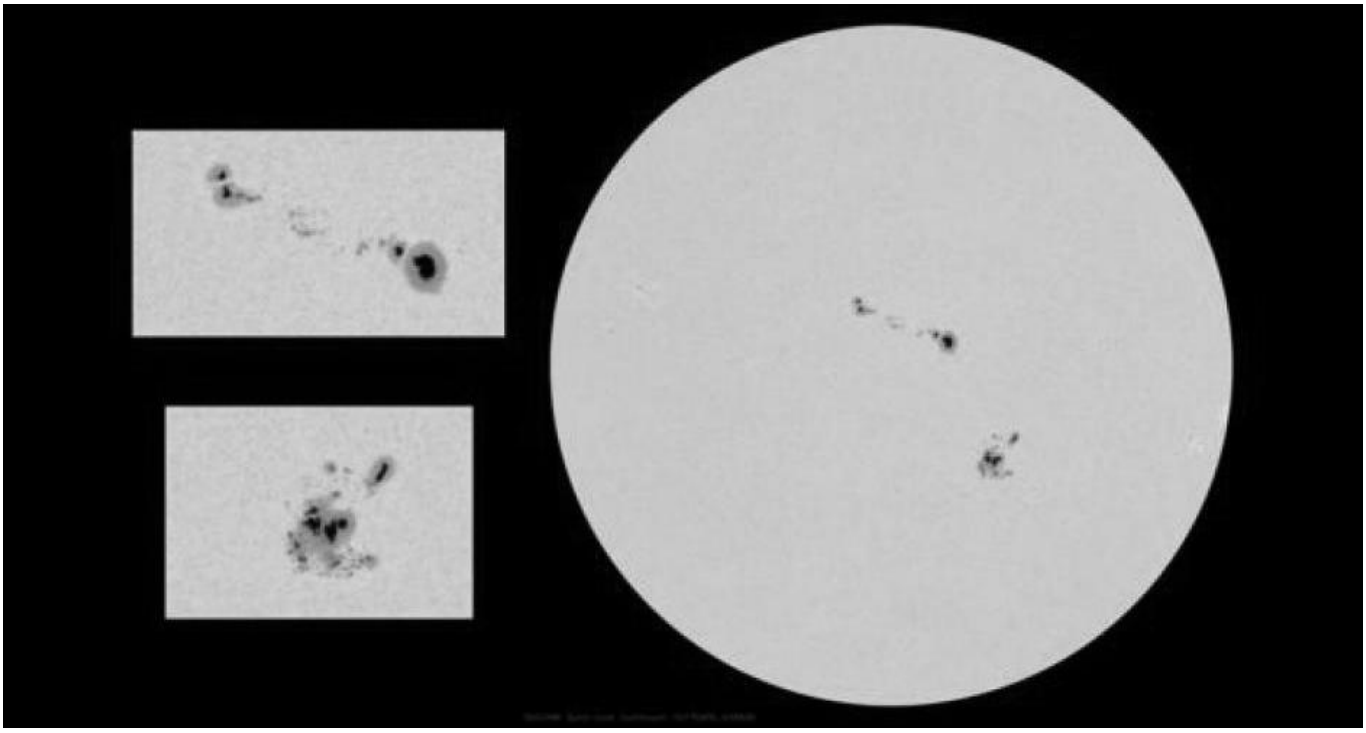
This type of filter removes the vast majority of the light from the Sun to a safe level that will not damage the eye of the observer. The light available is the same 'white' light that is naturally emitted by the Sun but vastly reduced in intensity. So what is seen is the view we would see if we could look directly at the Sun. This set up is the best for observing sunspots that occur on the surface of the Sun. It is also possible to see the granular structure of the overall surface of the Sun.

It will be noticed that the finder cap is in place to prevent the entry of sunshine that could cause a burn to any skin that is exposed. If the telescope is to be used in public the finder scope would be removed from the assembly.

The solar projection finder

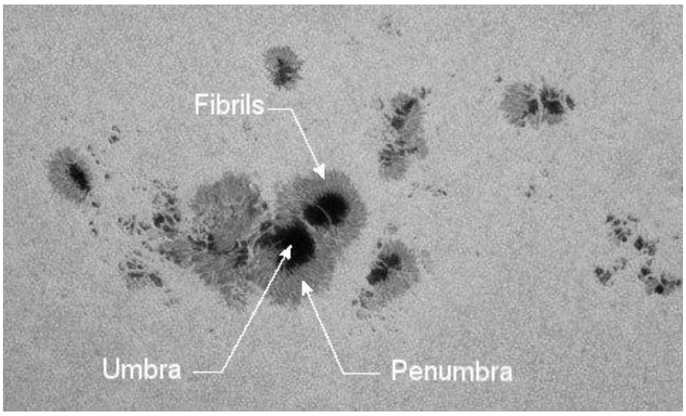
A special Solar Finder has been made and fitted to the telescope to help locate the Sun. This is done by projecting the light of the Sun through a pinhole in the front (black) screen on to the white rear screen. The telescope is adjusted until spot of sunlight is located in a small circle drawn on the white screen. The Sun will then be in the centre of view and ready for observing.

WHAT IS THERE TO SEE ON THE SUN?



The sort of view that can be achieved using a small telescope

Sunspots are cooler, relatively dark areas on the Sun's bright surface (the *photosphere*). Most have a central dark 'Umbra' and a lighter gray 'Penumbra'. At high resolution the penumbra is seen to have thin 'Fibrils' radiating from the umbra. The smallest sunspots do not have penumbras so these are known as 'Pores'.



A large group of sunspots

Spots tend to form in pairs, marking the "feet" of magnetic-field loops that arch above the surface. A Pore appearing in a clear area is a sign that a spot group may soon develop. Pores often die out in a day or two but sometimes one grows and develops a penumbra. More spots may appear nearby and within about ten days a complex 'active region' may develop between two major spots lined up east-west.

The eastern spot is usually the first to die out; the western one becomes round and smaller, sometimes persisting alone for weeks. The end of a sunspot is often signalled by a large light bridge, a finger of the photosphere that intrudes into the spot and appears to split it apart.

The Sun's rotation quickly becomes evident with several sunspot drawings, allowing two weeks for a group to travel across the disk. Different regions of the Sun rotate at different rates. The Synodic rotation period (apparent period as seen from the moving Earth) is 27¼ days at the Sun's equator but about 30 days at solar latitude 40°.

Sunspot numbers range from zero on some days near the time of minimum activity to more than 200 near solar maximum (may be seen using a larger telescope).

Solar limb darkening is where the edge of the Sun's disk is darker than the centre, is another feature readily observed. Here is proof that the Sun has an atmosphere. At the centre of the disk our vision extends straight down into a deeper, hotter layer of the photosphere, while near the limb our line of sight enters obliquely and penetrates only to a higher, cooler layer.

Faculae Often seen near the limb are large bright patches near to active areas. Faculae in an unspotted region mean either that spots will break out within about a day or more likely, that a spot group has died there sometime in the past few weeks. Keep an eye especially on the eastern limb. Faculae rotating into view often mean sunspots will follow.

Granulation is visible only in excellent seeing with high power and at least a 100mm aperture. Sometimes called rice grain or lemon peel, this textured appearance is due to hot gas continually boiling up to the Sun's surface, cooling, and sinking down again. Each granule is a convection cell of upwelling gas about an arc second (700 kilometres) across and persisting 5 or 10 minutes.

White-light flares are very rare but dramatic events that are small but brilliantly incandescent eruptions that last just a few minutes. Flares are believed to result from a sudden release of energy in the tangled magnetic fields above a sunspot group.

Other rare sightings include **Dark Faculae** which are occasionally reported toward the middle of the Sun's disk.

IMAGING THE MOON FOR FUN

The 'Old Moon' and Venus at sunrise in the east

It can be good fun to take pictures of the Moon and you do not need an expensive camera to do it. The picture above was taken using a hand held mobile phone camera. It was taken at 06:55 in the morning on 15th October 2020. This is an interesting picture because it shows the old Moon, as opposed to the New Moon that we are very familiar with. We see the New Moon every month as it emerges from behind the Sun and into the evening sky. In the image above the Moon is illuminated on the opposite side as it is moving towards the Sun in the early morning eastern sky.

So we don't need a camera but if we do have one, we can take many different images of the Moon.

The new Moon using a DSLR

The image above was taken using a DSLR camera mounted on a tripod at sunset. It is very useful to use a remote shutter button to reduce movement when taking a picture. These can be bought from a photography shop for as little as £7. It is essential if longer exposure night images are going to be attempted.

A zoom lens fitted to the DSLR camera can enable close up views of the Moon to be imaged. Quite artistic pictures can be produced when scenery is included.

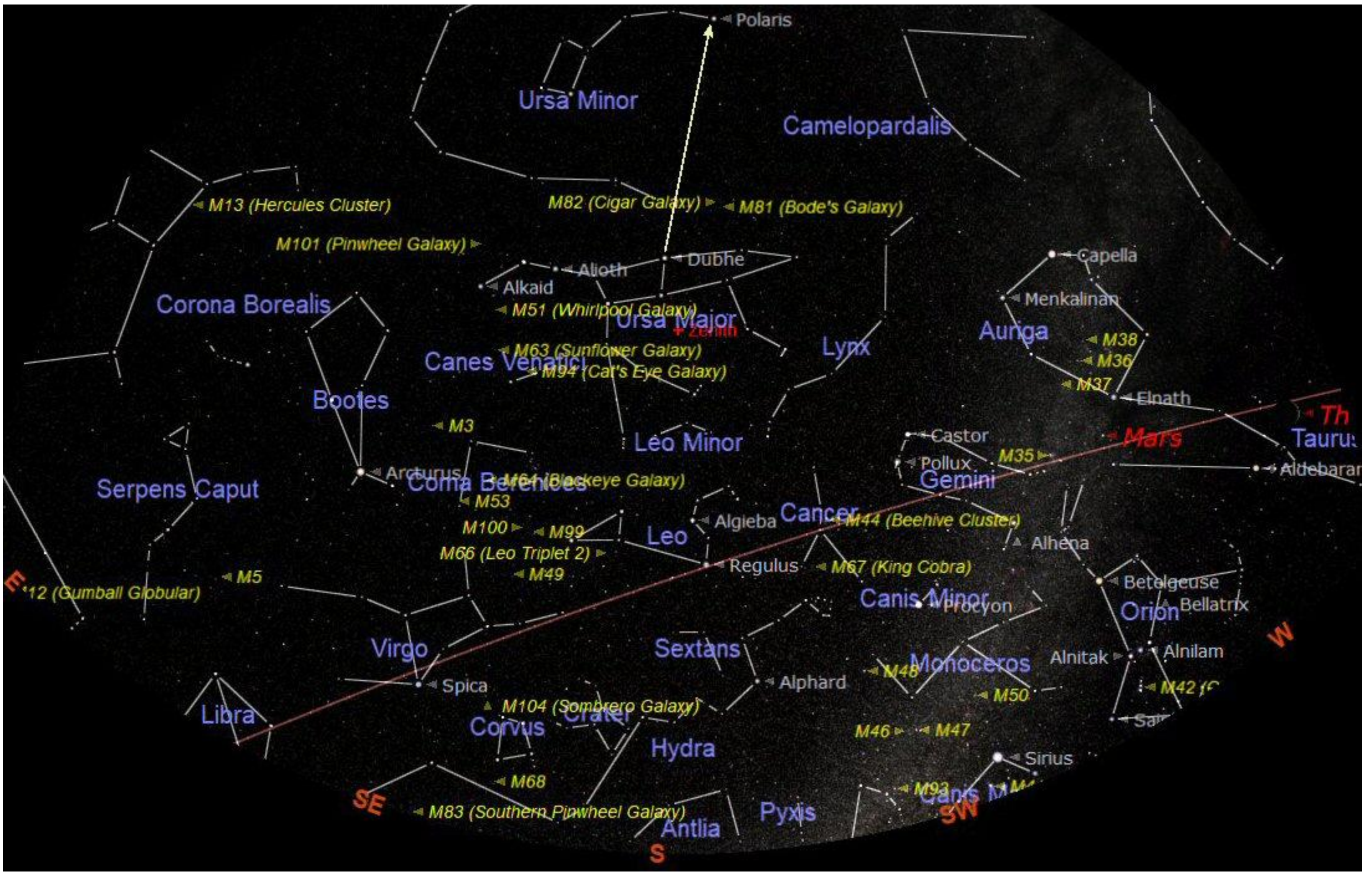
The Moon imaged using a DSLR using full zoom

It is also good to take pictures of the Moon when a special event is occurring such as a lunar eclipse (when Earth's shadow is crossing the Moon surface).

The lunar eclipse on 16th July 2019

So if you do have a camera, go out and try taking some pictures of the Moon. The Moon can even be imaged in the daytime sky.

A TOUR OF THE NIGHT SKY - APRIL 2021



The chart above shows the night sky looking south at about 22:00 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 (in red) at the upper centre of the chart. The curved brown line across the sky at the bottom is the Ecliptic or Zodiac. This is the imaginary line along which the Sun, Moon and planets appear to move across the sky. The brightest stars often appear to form a group or recognisable pattern; we call these 'Constellations'.

Constellations through which the ecliptic passes this month are Aries (the Ram), Taurus (the Bull), Gemini (the Twins), Cancer (the Crab), Leo (the Lion), Virgo (the Virgin) and Libra (the Scales).

Moving towards the south western horizon is the constellation of Taurus (the Bull). The most obvious star in Taurus is the lovely Red Giant Star called Aldebaran. It appears slightly orange to the 'naked eye' but it is very obviously orange when seen using binoculars or a telescope. Aldebaran is located at the centre of the 'flattened' X shape formed by the brightest stars in Taurus. Aldebaran appears to be in a cluster of stars known as the Hyades but it is not a true member and is much closer to us than the other stars. The bright orange planet Mars is in Taurus so we must make sure we do not confuse Mars with Aldebaran.

At the end of the top right (upper west) arm of the 'X' of Taurus is the beautiful 'naked eye' Open Star Cluster Messier 45 (M45) known as the Pleiades (or the Seven Sisters). It really does look magnificent using binoculars. Just above the star at the end of the lower left arm of the 'X' is the faint Supernova Remnant Messier 1 (M1) the Crab Nebula. This exploding star was seen as a bright new star in 1054 and can still be seen as a faint patch of light using a medium telescope but a really dark and clear sky is required.

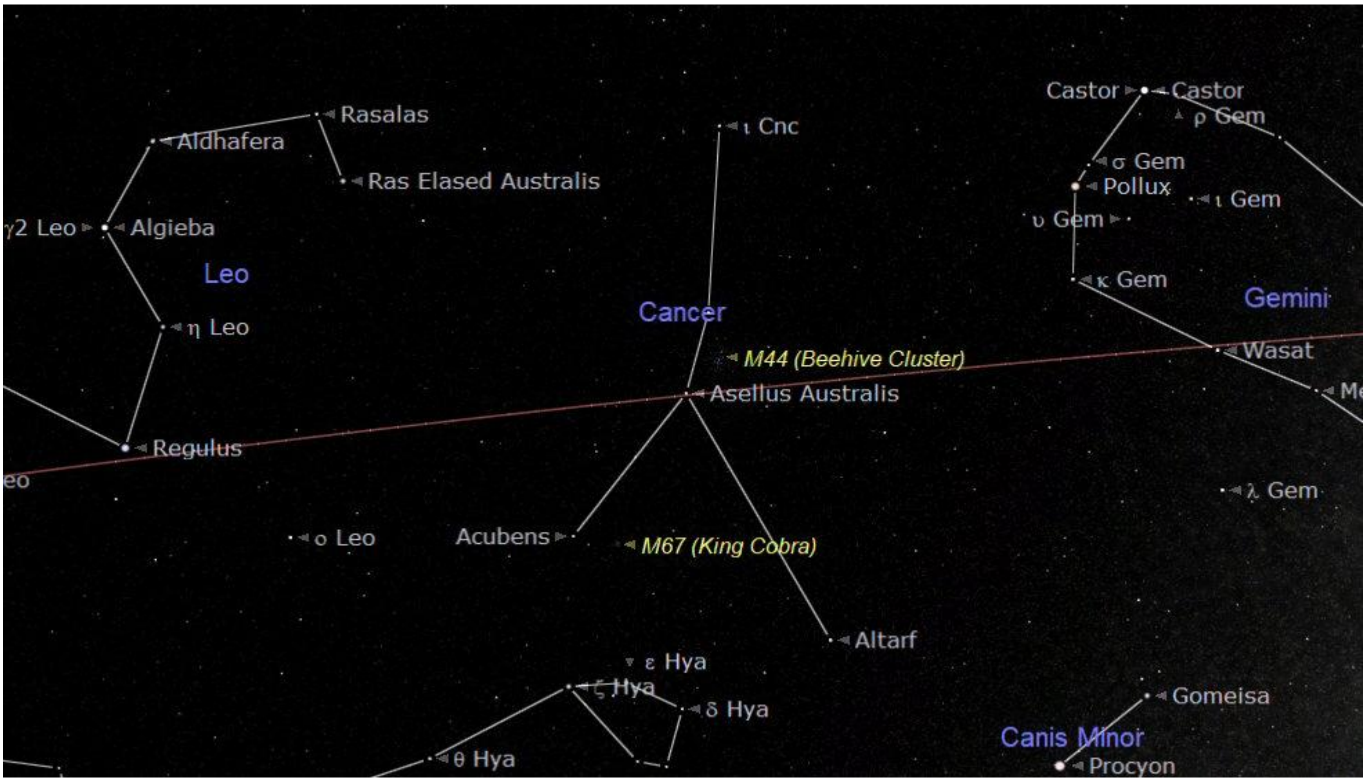
Following Taurus is the constellation of Gemini (the Twins). The two brightest stars in Gemini are Castor and Pollux that are named after mythological twins. To the north of Taurus is the odd pentagon shape of Auriga (the Charioteer). Dominating Auriga is the brilliant white star Capella which is almost overhead in the early evening. For those with a telescope there is a line of lovely open clusters to search out in Taurus and Auriga. These are M35 in Taurus and M36, M37 and M38 in Auriga.

To the east (left) of Gemini is the rather indistinct constellation of Cancer (the Crab). The stars of Cancer are quite faint and can be difficult to discern especially in a light polluted sky. It is worth searching out Cancer using binoculars or a telescope to see the Open Cluster M44 Praesepe (the Beehive Cluster). M44 is older and further away than M45 (the Seven Sisters) so is fainter but still looks lovely. It has a group of stars that resemble an old straw Beehive with bees around it. See page 8.

To the south of Taurus and Gemini is the spectacular constellation of Orion (the Hunter). Orion is one of the best known constellations and hosts some of the most interesting objects for us amateur astronomers to seek out. Orion was the February constellation of the month.

The constellation of Leo (the Lion) follows Cancer along the Ecliptic and will be the constellation of the month next month. It does actually look a little like a lion or the Sphinx in Egypt. Around and between Leo and the neighboring constellation of Virgo is a cluster of galaxies. Our Milky Way galaxy and our local group of galaxies are members of this larger group of galaxies called the Virgo Cluster. A medium sized telescope (150mm to 200mm) and a dark sky is required to see these faint objects.

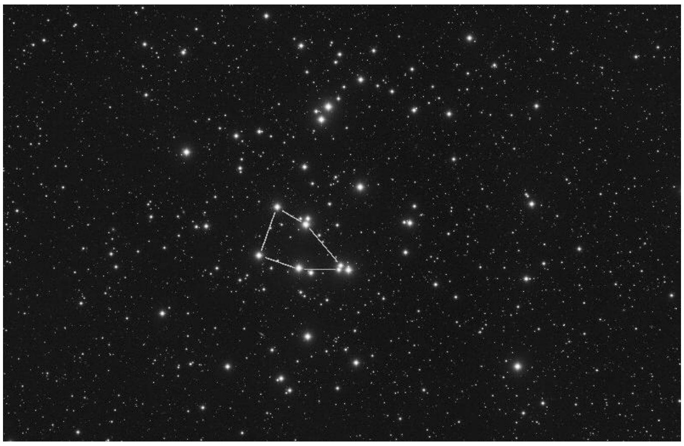
CONSTELLATION OF THE MONTH - CANCER (THE CRAB)



The constellation of Cancer (the Crab)

Between the two prominent constellations of Gemini and Leo is the rather indistinct constellation of Cancer (the Crab). The stars of Cancer are quite faint and so the recognisable shape of the constellation can be difficult to identify especially in a light polluted sky. The recognised 'stick figure' shape of Cancer is an upside down 'Y' (⅄).

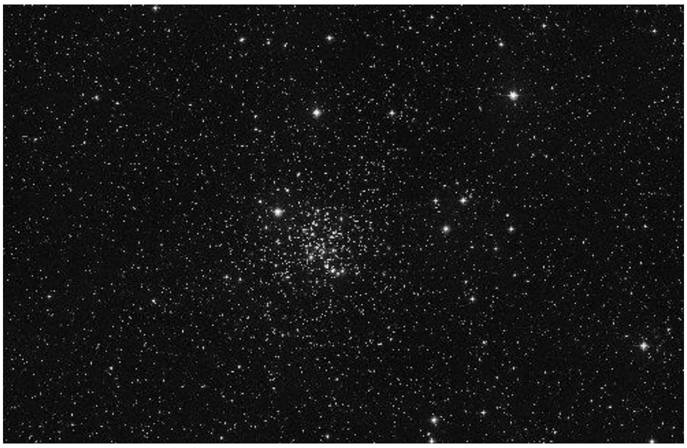
However it is well worth searching out Cancer using binoculars or a small telescope to see the Open Cluster Messier 44 (M44) known as Praesepe (or the Beehive Cluster). M44 is older and further away than M45 (the Seven Sisters) so is fainter than M45 but still looks lovely. It has a group of stars that resemble an old straw Beehive with bees around it.



The shape of the old style beehive

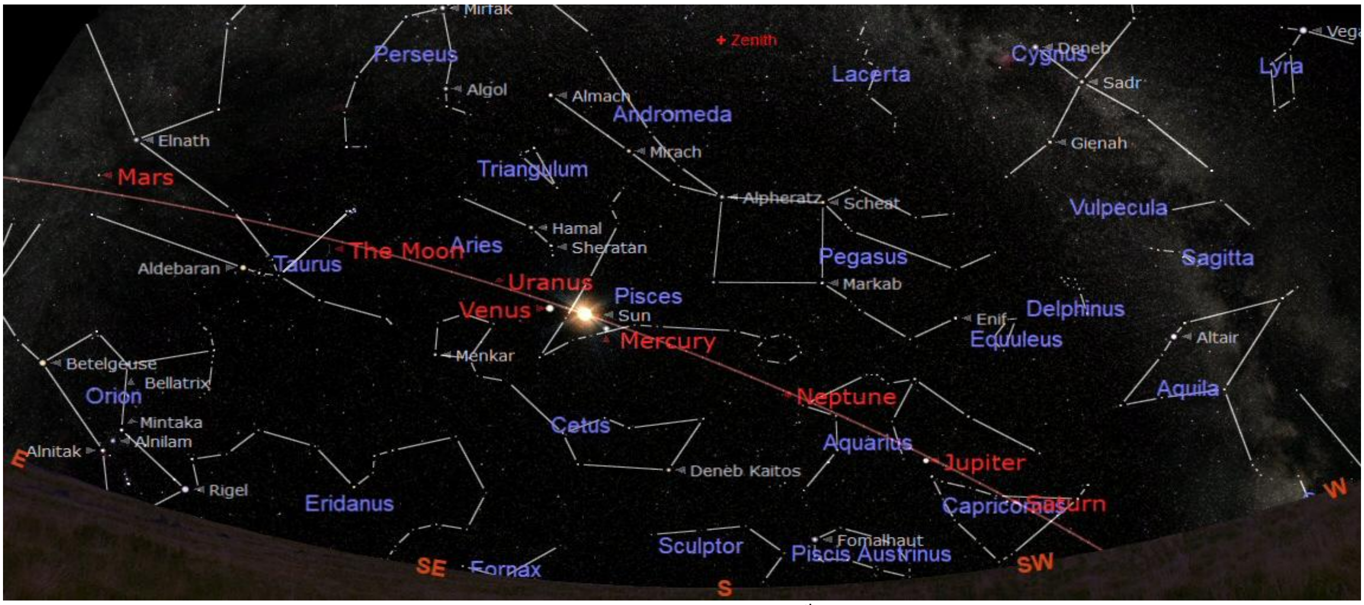
Messier 44 (M44) Praesepe the Beehive cluster

M44 is one of the few deep sky objects that look best using binoculars or a small telescope at low power. The image below has been marked to show the old style pyramid shaped straw Beehive with bees around it old straw Beehive with bees around it.



Messier 67 (M67 also called NGC 2682) is an open cluster in the southern half of Cancer. It is thought to be one of the oldest Open Clusters in our galaxy with estimates of its age ranging between 3.2 and 5 billion years. Distance estimates are also varied and typically are 2,600–2,900 light years away.

THE SOLAR SYSTEM - APRIL 2021



The planets at 11:00 on 15th April

All the planets except Mars will be difficult to see this month as they are close to the Sun or in daylight.

MERCURY will be rising just before the Sun low in the east this month and will not be visible. The smallest planet will be close to Jupiter and Saturn as they rise in the bright dawn sky later in the month.

VENUS is now too close to the Sun and will not be visible. It was in Superior Conjunction (behind the Sun) on 25th March 2021. It will emerge into the early evening sky in the west over the next few months.

MARS is still well positioned in the evening sky moving through Taurus and will be in the south as the sky darkens. It is getting smaller at about 5.0 arc-seconds as Earth pulls further away. Mars will be around until May but will be moving closer to the south western horizon and appearing smaller. After it has moved over the horizon we will not see it again for two years.

JUPITER will be rising in the South East from about 04:30 and will be visible in the west just before sunrise. Jupiter and Saturn will move further away from the Sun during the year and will be at their best for observing in August. Jupiter will be at opposition on 20th August.

SATURN will be even more difficult to see than Jupiter in the bright early morning sky. The ringed planet rises just before Jupiter in the South West at about 04:00. Saturn will be at its best this year on 2nd August when it will be at opposition and will be due south at midnight.

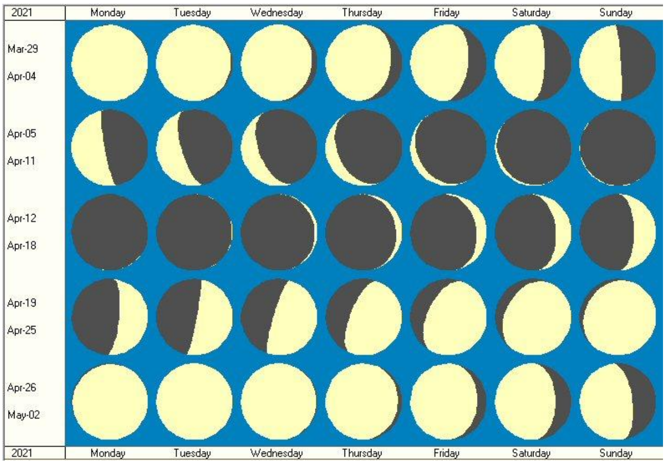
URANUS will be more difficult to find and will need a telescope. This month it will be in the south west and sets at about 21:00.

NEPTUNE will not be visible this month as it was in conjunction with the Sun on 11th March. It will reappear in the east in the morning sky later in the year.

THE SUN

The Sun rises at about 06:25 at the beginning of the month and 05:40 at the end. It sets at 19:40 at the beginning of the month and 18:15 at the end. There have been very few Sunspots recently.

THE MOON PHASES DURING APRIL



Last Quarter will be on 4th April

New Moon will be on 12th April

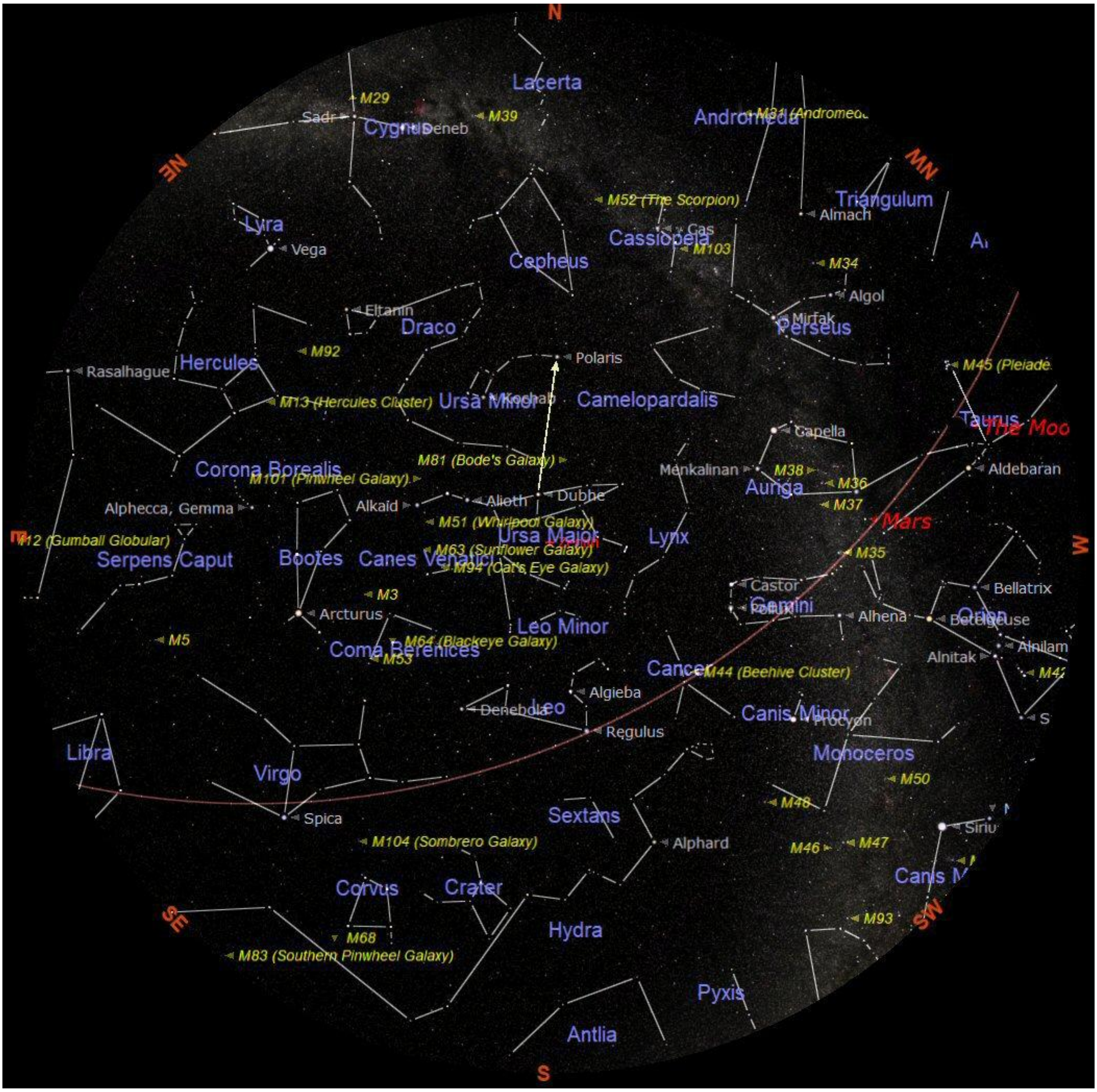
First Quarter will be on 20th April

Full Moon will be on 27th April

There will be what we have got used to referring to as a 'Super Moon' this month. This occurs when the Moon's closest approach to Earth (on its orbit) coincides with Full Moon. The Moon will appear a larger because it is closer to us. This will occur on 27th April.

How the Super Moon will appear in the east

THE NIGHT SKY – APRIL 2021



The chart above shows the whole night sky as it appears on 15th April at 22:00 (10 o'clock) 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 9 o'clock BST at the beginning of the month and at 11 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 over head. 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: Mars.