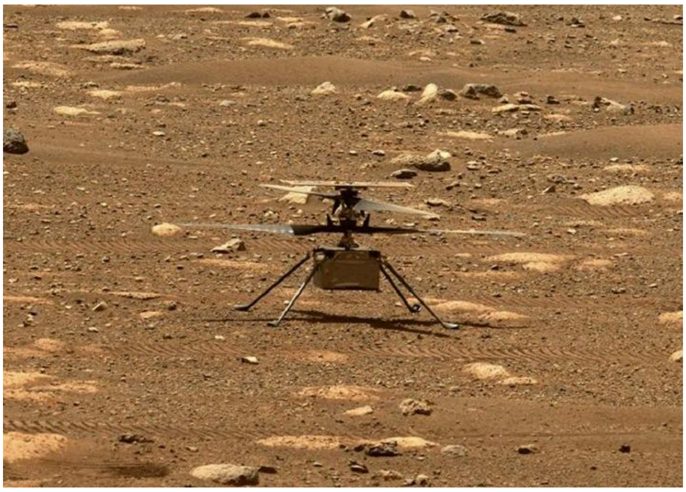
NEWBURY ASTRONOMICAL SOCIETY
MONTHLY MAGAZINE – MAY 2021

INGENUITY PASSES FIRST TEST FLIGHTS ON MARS

NASA's Ingenuity helicopter flying through the atmosphere of Mars

NASA's mini helicopter Ingenuity successfully completed its third flight from the surface of Mars on Sunday 25th May. It travelled even farther and hitting a peak speed of 7.2 km/h four times faster than its two earlier flights. During this third flight it hovered at nearly 5m before moving sideways 50m for a flight that lasted 80 seconds.

Ingenuity's flights are challenging because the conditions are vastly different from Earth's. Foremost among the problems is the rarefied atmosphere that has less than one percent the density on Earth. This means that Ingenuity's rotors that span 1.2m have to spin at 2,400 revolutions per minute to achieve lift. This is about five times faster than a similar helicopter on Earth.



Ingenuity on the surface of Mars imaged by Perseverance

NASA announced it is now preparing for a fourth flight. Each flight is planned to be of increasing difficulty in order to push Ingenuity to its limits. The Ingenuity test phase will end after about one month in order to let Perseverance return to its main task of searching for signs of past microbial life on Mars.

Ingenuity faces the challenge of flying in the Martian atmosphere that is about 100 times thinner than Earth's. On Earth Ingenuity weighs 1.8kg but is just 0.68kg on Mars because of the planet's lower gravity (roughly one third of Earth's). The Ingenuity helicopter is a technology demonstration so does not have any scientific instruments onboard. However, it does have a couple of grams of fabric from the Wright brothers' first plane called 'the Flyer' attached to it as a good luck charm.

Ingenuity is a technology experiment that will push space exploration forward by a giant leap. It will add a new dimension to the way we explore other worlds in the future. According to NASA one of Ingenuity's key objectives is to survive the low temperatures on Mars where nights can be as cold as -90ºC.

NEWBURY ASTRONOMICAL SOCIETY MEETING

7th May	Taking pictures of Exoplanets
Website:	**www.newburyastro.org.uk**

NEXT NEWBURY BEGINNERS MEETING

19th May	Our Universe and the 'Big Bang'
Website:	**www.naasbeginners.co.uk**

OUR UNIVERSE AND WHERE DID IT COME FROM?

Our Universe was created in the 'Big Bang'

This month we are going to think about our Universe and how it was created. First of all we need to clarify what we mean by 'Our Universe'. It is the largest structure we can conceive of and contains everything we know about space. This covers everything from our world (Earth) right out as far as we can see using our most powerful telescopes. So we will discuss what we know about the Universe and how it came into being from an event we know as the 'Big Bang'.

The Big Bang does not really describe how the Universe formed because the creation event was not big (in fact it was very small) and there was no bang (because there was nothing to transmit sound).

Before we consider what happened in the 'Big Bang' we need to acquaint ourselves with a couple of basic scientific theories. We may think this will be difficult but they are actually quite easy to understand. The first is Albert Einstein's famous equation $E = mc^2$.

So looking at Albert's equation, E represents energy, m represents mass and c^2 is the speed of light squared. So 'E' is the amount of nuclear energy that is contained in a mass of matter 'm' multiplied by the speed of light twice 'c^2'. What is evident from this equation is that the speed of light is a large number and anything multiplied by the speed of light twice would become a very large number. This means the amount of energy (E) concentrated in even a small mass is enormous.

For those of us that think they don't understand maths here is a very quick and simple guide to how equations work in maths. First the terms on each side must remain equal. For example: $3 \times 4 = 12$. We can however rearrange the equation into another form as long as both sides remain equal, for example if we divide both sides of the equation by 4 we get:$3 \times 4\ (\div 4) = 12\ (\div 4)$ so dividing we obtain $3 = 12 \div 4$ and if we carry this forward we can see $3 = 3\ (12 \div 4)$.

We call this branch of maths algebra and we can use it to calculate an unknown term. For example $E = 3 \times 4$ so this means the unknown term E is equal to 3×4 so $E = 12$. Similarly in the equation $12 = 3 \times E$ we can divide both sides by 3 to obtain $12\ (\div 3) = 3 \times E\ (\div 3)$ so x3 and ÷3 cancel out to 0 so $4 = E$.

Now let us apply this simple maths to Albert Einstein's famous equation $E = mc^2$. We have seen that this equation represents Energy = mass x (speed of light x 2) but we can use the equation to find an unknown term if we do know the value of other two terms. So if we know the mass and speed of light we can solve the equation for the unknown term 'E'.

If the Energy contained in 1gram of matter is multiplied by the speed of light x 2. We can write this as:

$E = 1 \times 300{,}000{,}000^2$ or $E = 90{,}000{,}000{,}000{,}000{,}000$ we can see this is a very large number so if we could extract 'all' the energy from a small 1g piece of matter it would be an enormous amount of energy.

One other thing to gain from this equation is mass can be converted into energy. The equation also tells us that energy can be converted into mass. The equation can be transposed to calculate the other terms:

$E = mc^2$ to show how much energy is in matter

$E \div c^2 = m$ to show how much mass is in energy

$E \div m = c^2$ to show how fast light travels

Significantly we can see from the transposition of the equation to $E \div c^2 = m$ shows us that energy can be converted into matter. We will use this in the following pages when we consider the Big Bang.

The other basic scientific theory we need to consider is the speed and nature of light. We have already seen that the speed of light is used in Albert Einstein's very important equation $E = mc^2$ that shows that Energy and Mass is interchangeable.

Now we must consider the properties of light. It needs to be said that the exact nature of light is still not fully understood. Some things we do know are: light travels at a finite speed of 300,000 kilometres per second in a vacuum. Light has carried nearly all the information that we have about our universe. Now here is the odd thing light appears to travel as a wave of electro-magnetic energy through space so has no mass. However in some ways it has the characteristics of a particle that we call a Photon.

The wave length of light is dependent on its energy with the most energetic having the shortest wavelength (Blue) and the least energetic is longest (Red).

WHAT WAS THE BIG BANG AND WHEN DID IT HAPPEN?

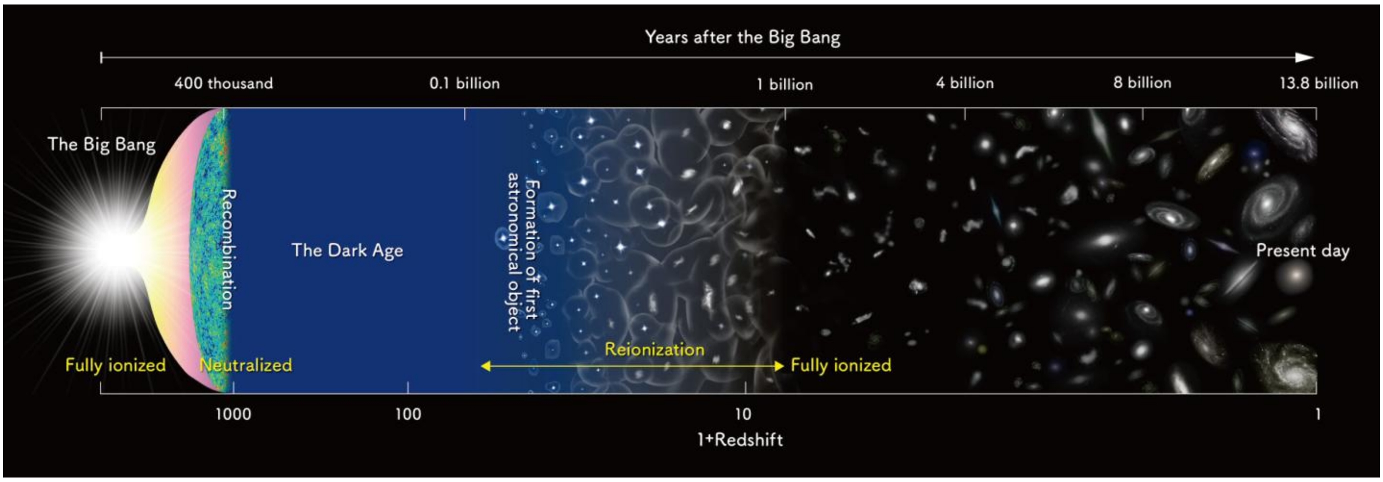


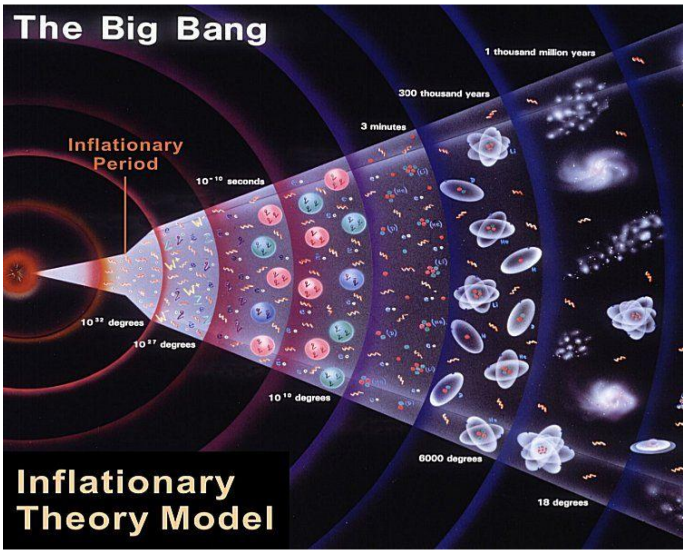
Diagram showing the developement of the Universe

The event we call the 'Big Bang' occurred 13.8 billion Earth years ago. This is when time began for us and everything in our Universe was created. For us anything that happened or was there before the Big Bang has no meaning to us because we can never see out beyond our Universe, it is too far for us to see the edge.

We cannot know what caused the Big Bang but we can speculate for ourselves as to what happened in the beginning. What we can say is there was an enormous release of energy and it occurred at a very small point.

We can see that the Universe, as we see it today, is expanding. If we look at the light coming from the galaxies around us we can see, by examining the light, that they are all moving away from each other (with a few exceptions). So if we work out the directions that the galaxies are travelling and we project their path back, they all appear to have come from the same place.

This means that in the past the Universe was much smaller and everything was much closer together. If we continue this thought back far enough then the whole universe appears to have started out from the same place. The trajectories of everything show that it all would have been in the same place about 13.8 billion years ago. So the 'Big Bang' could have occurred at an infinitely small point known as a 'Singularity'.



The phases of the very early Universe

We don't know what caused the Big Bang but we do know that when it formed it was very small, very dense and very hot. In fact it was so dense and hot that it could not exist as any form of matter that we can conceive of today so with think of it being a ball of pure energy. In the first second it expanded so fast that light could not escape from it, see the diagram in the previous column.

The diagram above shows the whole process of the creation of the Universe and the diagram in the previous column shows the early phases directly after the 'Big Bang'. In this diagram time is marked along the top of the cone shape and temperature along the bottom of the cone. The term 10^{-18} represents a very small number preceded by a decimal point and 18 decimal places such as: 0.000,000,000,000,000,001 of 1 second of time. The temperature shown as 10^{32} is a huge number represented by 10 followed by 32 zeros. This is a very high temperature and beyond our comprehension.

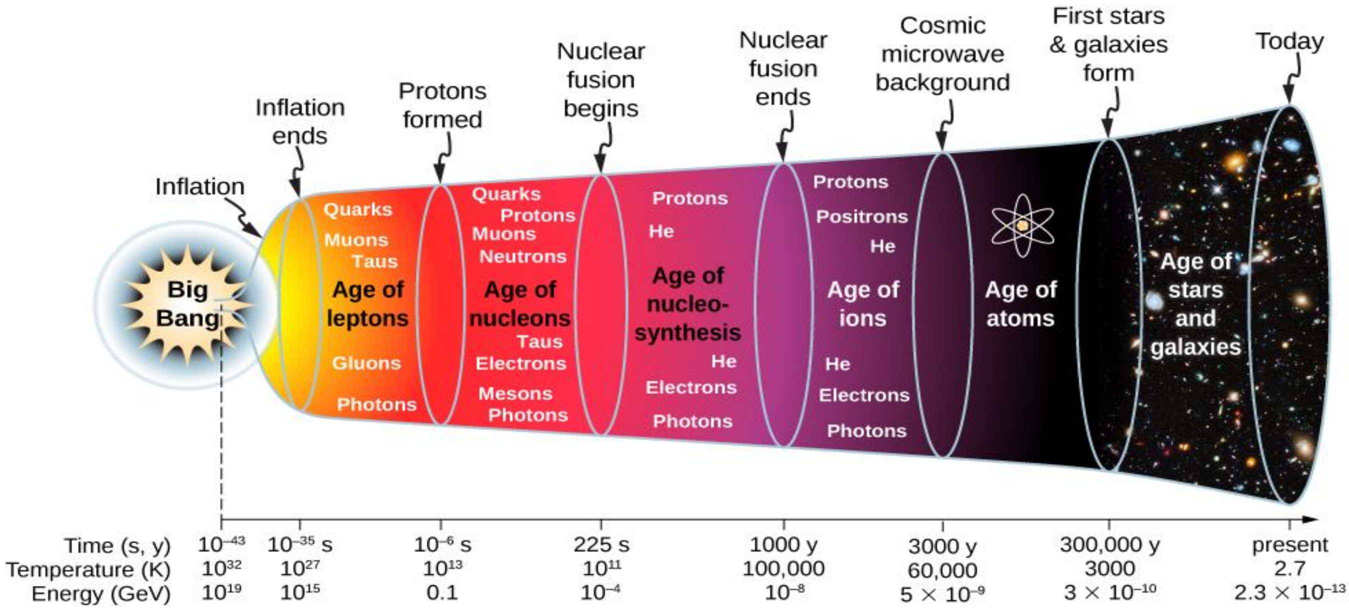
In the first 10^{-100} of a second the Singularity expanded exponentially (this is like growing 2x, 4x, 8x, 16x, 32x, 64x, 128x per unit of time). This caused the universe to inflate with unbelievable speed. After a very short time the super inflation phased stopped but the Universe still carried on expanding and cooling at fast rate.

After it had expanded for 10^{-10} of a second the universe had cooled from 10^{32} degrees to 10^{27} degrees and sub atomic particles began to form. After 3 minutes the sub atomic particles began to create atoms. Over the next 300,000 years as atoms formed most formed and the free sub atomic particles were consumed by the forming atoms. The Universe became transparent and a flash of electromagnetic radiation (light) was released.

After this point the atoms began to be attracted to each other by their gravitational force. As the atoms moved closer to each other their combined gravitation pulled in more atoms to create denser regions within the expanding universe. On the largest scale the atoms were drawn into vast filaments like a spider webs. This left voids (of nothing) between the filaments. See page 5.

On a smaller scale within the filaments and particularly at the junctions of the filaments, large clouds formed and became galaxies. At the smallest scale, within these developing galaxies, stars formed. This star and galaxy formation began within the first 500million years.

HOW THE UNIVERSE DEVELOPED



A diagram showing the development of the Universe

We have already seen how the Universe began with the 'Big Bang' 13.8 billion years ago. Now we can consider how the unbelievably small, dense and hot fireball expanded and cooled into the complex Universe we can observe today.

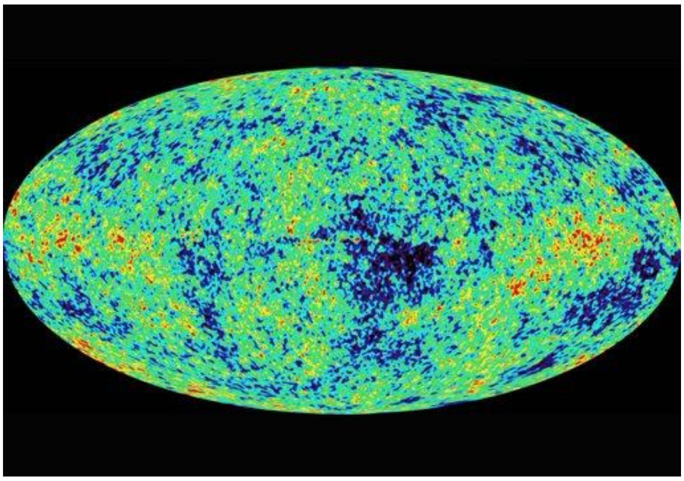
Things began to develop very fast immediately after the Big Bang. If we look at the horizontal scales at the bottom of the diagram above the time scale begins on the left using decimal fractions of a second. In fact it starts with tiny divisions of a second shown as 10^{-43} this, as we saw on page 3, represents a division of a second with a decimal point followed with 42 zeros and a number. The Super Inflation period lasted 10^{-43} to 10^{-35} of a second.

In the next sub-second phase on the diagram the pure energy expanded and cooled enabling sub-atomic particles (proto-matter) to form. It seems very strange that matter can be created from energy but we have seen on page 3 that Albert Einstein's famous equation $E = mc^2$ shows us it is possible. If we mathematically transpose ($E = mc^2$) into ($m = E \div c^2$) then we have Mass (matter) created from Energy (E) divided by the speed of light squared (c x c). The sub-atomic particles are listed on the diagram (these are the building blocks of atoms).

In the next 1000 years the sub-atomic particles are forced together by the pressure and heat and start to create Protons (the positive (+) nucleus of an atom) and Electrons (the negative (-) particle orbiting an atom). As a Proton and Electron fuse together they create an atom of Hydrogen gas. There were some fusion events that joined two Protons and two Electrons together to create an atom of Helium gas. Some sub atomic particles called Neutrons (similar to Protons but with no electrical charge neither + or -) were able to be combined into the forming atoms to create stable isotopes of these atoms.

The Nuclear Fusion process also produced sub-atomic energy packets called photons that are the carrier of what will become light. However these photons could not leave the expanding fireball because it was too dense and opaque. After 3000 years most of the subatomic particles had been converted into atoms and the photons could be released as electromagnetic waves (light).

This release of the electromagnetic waves was at the most energetic end of the scale. They were in the form of highly energetic and short waves of Gamma Rays and X-Rays but now appear as Microwaves. See page 7.



The remnant of the Big Bang flash

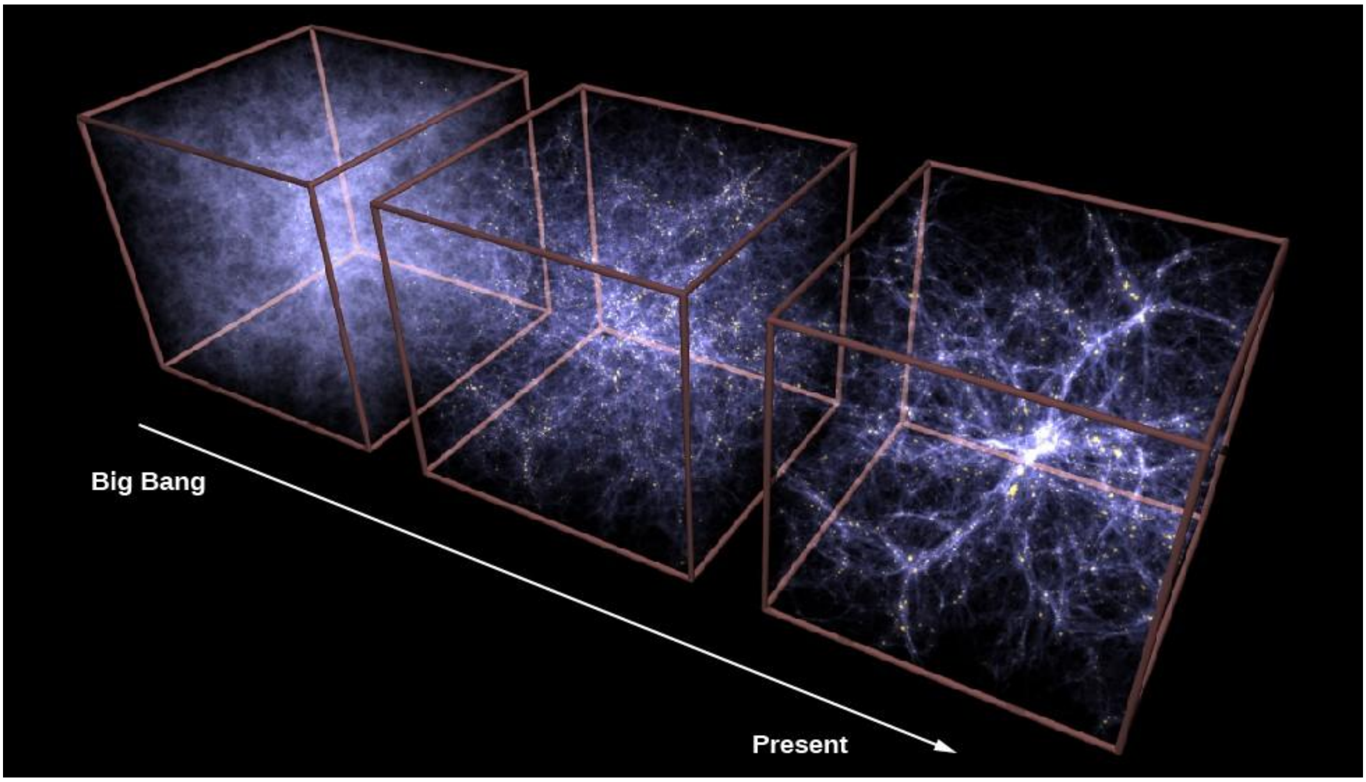
The image above shows the Cosmic Microwave background (CMB) which is the remnant of the flash from the Big Bang. (More about the CMB later in this article.)

After about 300,000 years the Universe was transparent so the flash could travel through space. Gravity started to exert its effect on the matter that had been created. Atoms that were already moving due to the Big Bang were drawn together by their mutual gravity. As more atoms were drawn together their mutual gravity increased and pulled even more atoms together.

At the largest scales the atoms of Hydrogen and about 11% Helium were drawn into vast filaments stretching across the expanding Universe. At a smaller scale the atoms by virtue of their velocity (movement through space) began to form into great swirling clouds and eventually created spinning Spiral Galaxies.

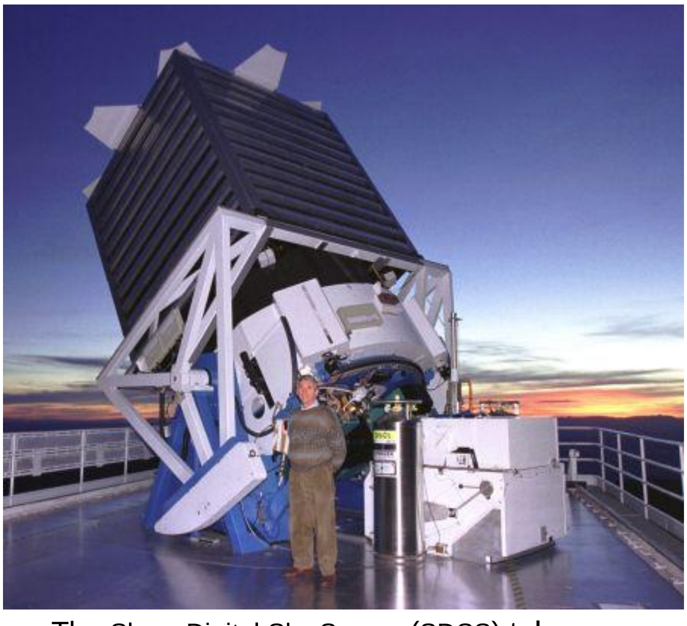
As the Galaxies formed the gas was drawn into a thin disc around the central core of the galaxy. The movement in the disc caused denser clouds to form in to smaller spinning discs that contracted to create stars.

THE UNIVERSE AS WE SEE IT TODAY?



A computer generated diagram of how the filament structure of the Universe formed

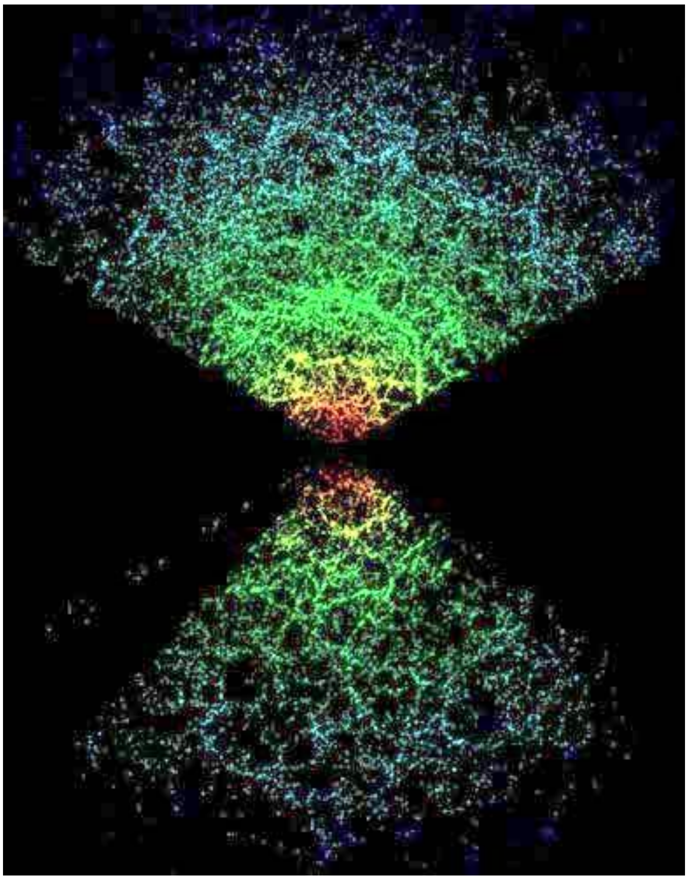
The most detailed view we have of the structure of the Universe has been taken by the Sloan Digital Sky Survey (SDSS) telescope. The SDSS has mapped the structure of the universe, in great detail and as far out as it can see. A three dimensional map has been created from the data that enables us to look at millions of galaxies.



The Sloan Digital Sky Survey (SDSS) telescope

The Sloane Survey accurately recorded the positions of all the galaxies it could see. This gave us a two dimensional map of those galaxies. Every galaxy was then measured for its Red Shift to determine its distance and its speed away or towards us (see page 7). The map opposite shows the vast area surveyed by SDSS in the two directions it could see (where our galaxy didn't get in the way). Red colours are closest and the Blue furthest away and we can see the filaments and voids.

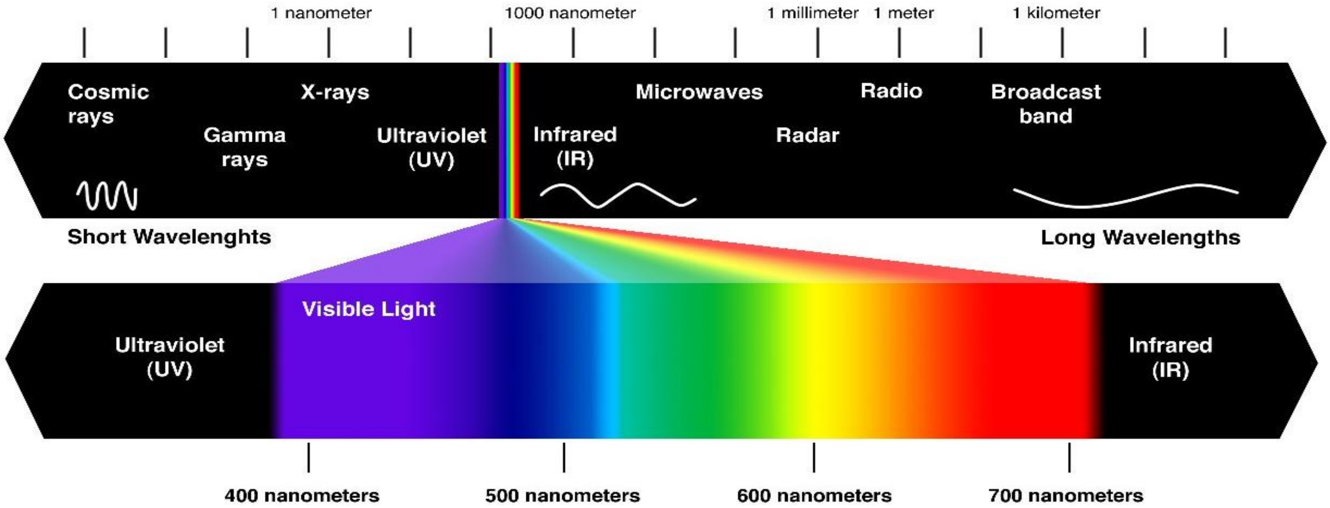
The very interesting thing about this map is the filament structure of galaxies that was plotted and how it closely resembled the theoretical structure predicted by computer simulations as shown in the picture above.



The structure found by the Sloane Survey

A three dimensional (3D) map was then produced by adding the Red Shift measurements. This allowed us to virtually travel through the filaments of galaxies.

HOW BIG IS OUR UNIVERSE TODAY



The Electromagnetic Spectrum – Wavelengths of light

Light is our only messenger from deep space so everything we know about the Universe has come to us on waves of light. So to understand the Universe we must have a basic knowledge of light and how we can retrieve all the information the light is carrying.

When we talk about light we initially think of the wavelengths of light that we can detect with our eyes. However the visible light is a very small part of the entire Electromagnetic Spectrum which includes all the different wavelengths of energy waves that can travel through space. The diagram above shows whole range of wavelengths of the Electromagnetic Spectrum and the small amount that we can detect with our eyes.

Waves of the Electromagnetic Spectrum have different amounts of energy that affects the wave length of the wave. If the event that has created the wave was very powerful like the explosion of a star or the heating of atoms as they are pulled into a black hole then the wave length will be shorter. So the rule is the more energetic the Electromagnetic wave is the shorter the wave length.

We measure Electromagnetic waves either by the length between each wave in metres or by the number of waves received per second (frequency) using a unit that we call Hertz (Hz). The shortest waves at less than a nanometre (trillionth of a metre) and most energetic are called Gamma Rays and they are shown to the left of the diagram above. The longest are Radio waves that can be hundreds of kilometres in length shown to the right.

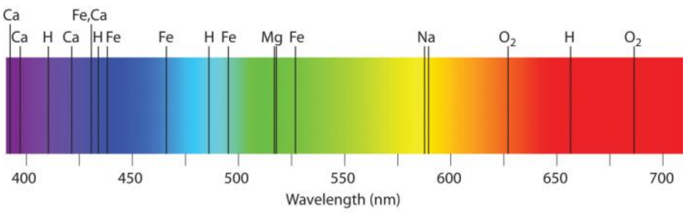
Another important thing is the speed of light is closely related to us thinking about the structure of Universe and our place in it. Distances in space are so vast that we cannot use conventional units for measuring distance so we need a much larger unit of distance. This is where the speed of light comes in. The speed of light is constant in space and all waves of the Electromagnetic Spectrum travel at the same speed that is about 300,000 km/sec (186,000 miles/sec).

So we can use the amount of time it takes light to travel a certain distance and because we need it to be a large unit we use the light-year. This is the DISTANCE travelled by light in one Earth year so this is a unit of distance not speed. One light-year is 9.4607304725808 trillion kilometres ($9.4607304725808 \times 10^{12}$ km) or 5.88 trillion miles (5.88×10^{12} miles). As defined by the International Astronomical Union (IAU)

We can get some idea how far objects are away from us using light speed units by considering familiar objects:

The Moon	1.3 (light) seconds
The Sun	500 seconds or 8.3 minutes
Jupiter	2000 seconds or 33.3 minutes
Neptune	245 minutes or 4 hours 5 minutes
Star Sirius	8.6 light years
Across our Galaxy	100,000 light years
Andromeda Galaxy	2.4 million light years
Most distant Galaxy	about 13.4 billion light years

So we have a sufficiently large unit to measure the vast distances across space as the 'light-year'. We can also extract other information from light waves that come to us from the distant stars. One of the most important fields of information is 'what are the stars and other objects made of?' We can get very detailed information about the materials present in space by looking at the spectrum of star light or glowing gas.

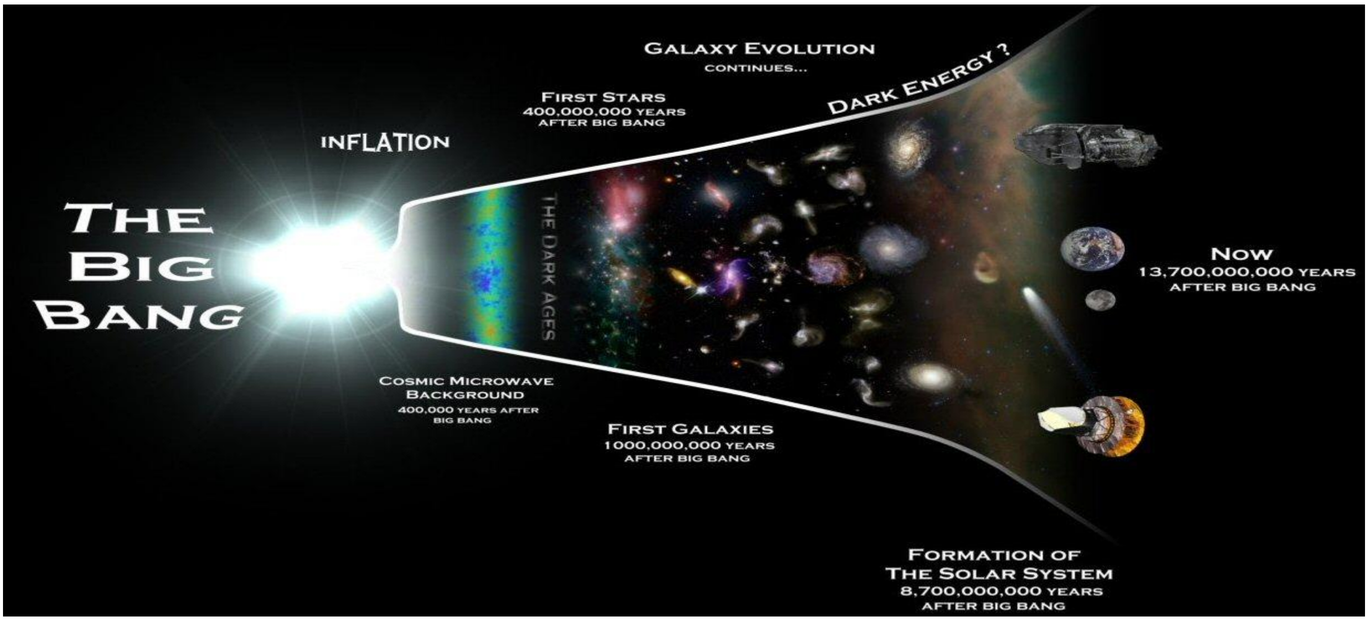


The light spectrum with absorption lines

The diagram above shows the light from a star that has been split into its different colours using a spectrograph. This is like using a prism to split sunlight into a rainbow. On this spectrum some of the wave lengths have been absorbed by elements the light has encountered on its journey to us. Every kind of atom leaves a different pattern of absorption lines on the spectrum so we can identify these specific elements by their patterns.

Elements that the light encounters leave a shadow on the overall continuum of the spectrum. However if an element emits light itself it will produce unique light bands of the same pattern, position and colour as the absorption lines but no other colours in its spectrum.

WHAT IS HAPPENING TO THE UNIVERSE NOW?

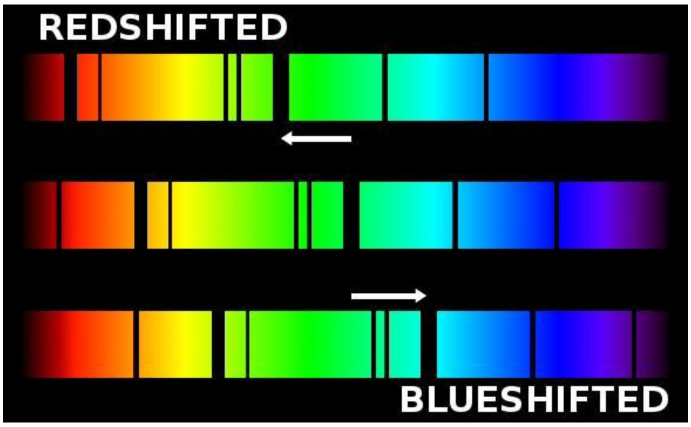


The expansion of the Universe

We have seen that the Universe went through a super inflation phase in the first second after its creation. It then continued to expand over the last 13.7 billion years. There have been a number of theories relating to the eventual fate of the Universe.

Much depended on the amount of stuff that the Universe is made of. If there was a certain amount of stuff, its gravity would halt the expansion and the gravity would pull it back and it would collapse back into a Singularity in a Great Crash. If there was less stuff the expansion would continue forever. However recent discoveries have changed those theories.

The rate of expansion has been measure using a method called Red Shift. Edwin Hubble studied the spectra of objects in all directions and at all distances that could be measured. He found that the absorption lines on the spectra of objects had moved further towards the red end the further they were away from us. He called this 'Red Shift'.



The absorption lines 'Red Shifted' towards red end

Another thing Hubble deduced was the further away an object was the older it was. This is because the light had taken longer to reach us than closer objects. He also found that when he compared the Red Shifts through time he found about 5 billion years ago the expansion of the Universe appeared to start accelerating. Something had started overpowering the force of gravity.

Initially this could not be explained because gravity should have slowed the expansion. It would require some unknown additional force to push against gravity to cause the expansion to speed up (accelerate).

It now appears there could be something in the universe that we cannot see or detect that has been called Dark Energy and it may constitute up to 69% of the stuff in the Universe. The already postulated Dark Matter appears to contribute 26% of the mass so that leaves just 5% of the Universe as Baryonic Matter. The stuff that we can see and feel and what we are made of.

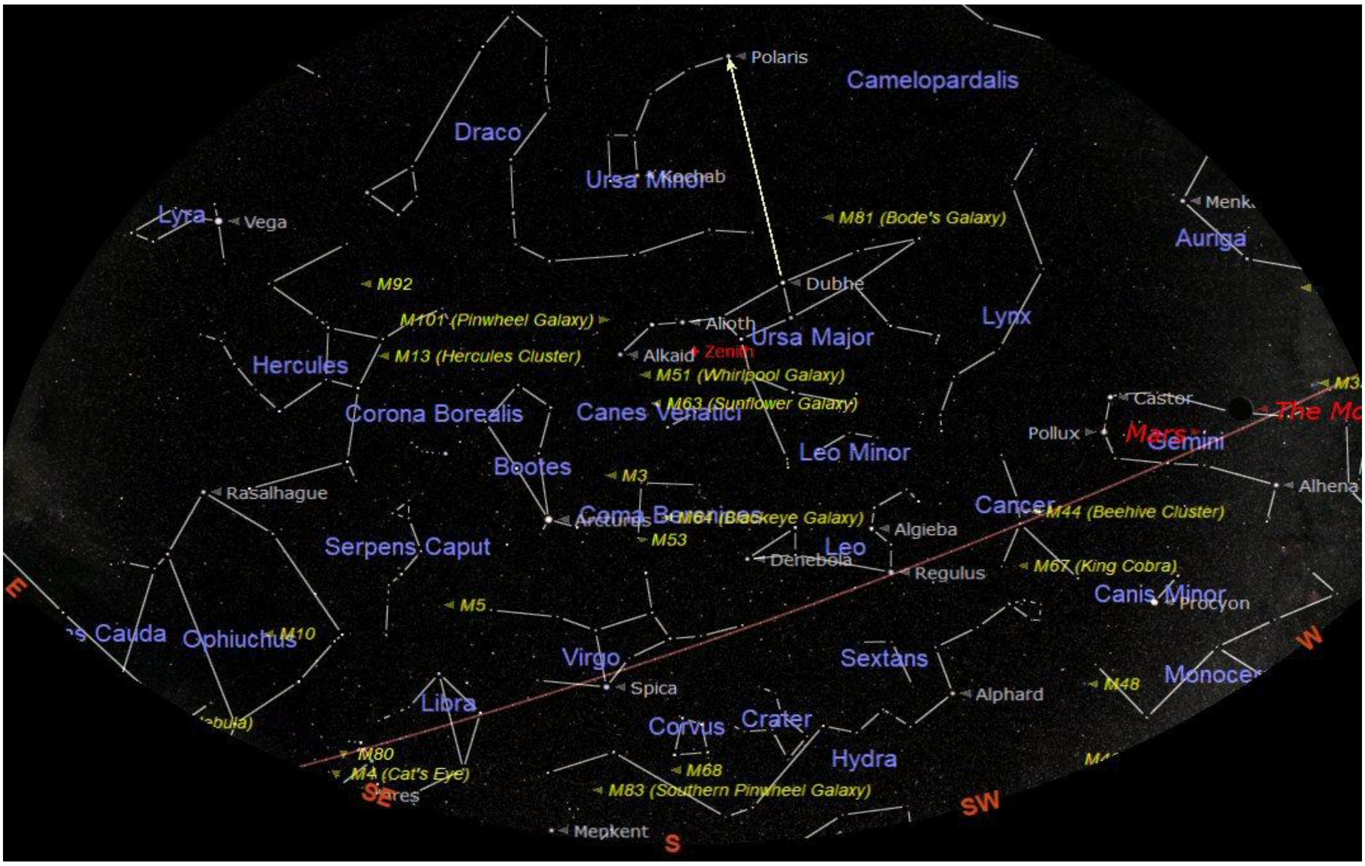
It appears that when all the stuff of the Universe was close together gravity was the overall dominating force. As the Universe expanded after the Big Bang all the parts of the Universe moved further apart and should start to slow down. The gravitational force has less effect over greater distance so it had less influence to slow down the expansion of the Universe. If gravity was the only effect the expansion of the Universe would have just slowed down but Edwin Hubble found this was not the case the expansion was speeding up.

For the expansion to speed up it would need an additional force to push outwards but there is now know force that can do this. So a new name was invented to give some explanation and a name to this unknown force it was called 'Dark Energy'. At the moment we have no idea what it is but it certainly appears to be there.

So we can understand the Universe is expanding from the Big Bang but the expansion is a bit more complicated to understand. This expansion doesn't just mean the galaxies are moving further apart it means space itself is expanding. We know this because light waves travelling through space become stretched.

The effect of stretching the light waves is that the waves become longer. This can be demonstrated if we put two marks on an elastic band and the stretch it. If we imagine the marks are the crests of two waves they move apart as we stretch the rubber band and the wave becomes longer. The flash from the Big Bang were X-Rays but they are now detected as longer (stretched) Microwaves. See the section about the CMB on page 4.

A TOUR OF THE NIGHT SKY - MAY 2021



The chart above shows the night sky looking south at about 22:00 BST on 15th May. 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 Taurus (the Bull), Gemini (the Twins), Cancer (the Crab), Leo (the Lion), Virgo (the Virgin) and Libra (the Scales) just coming into view in the east.

Taurus is just moving over the western horizon soon after the Sun sets so it will be difficult to see this month. 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 high in the west in 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 small 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.

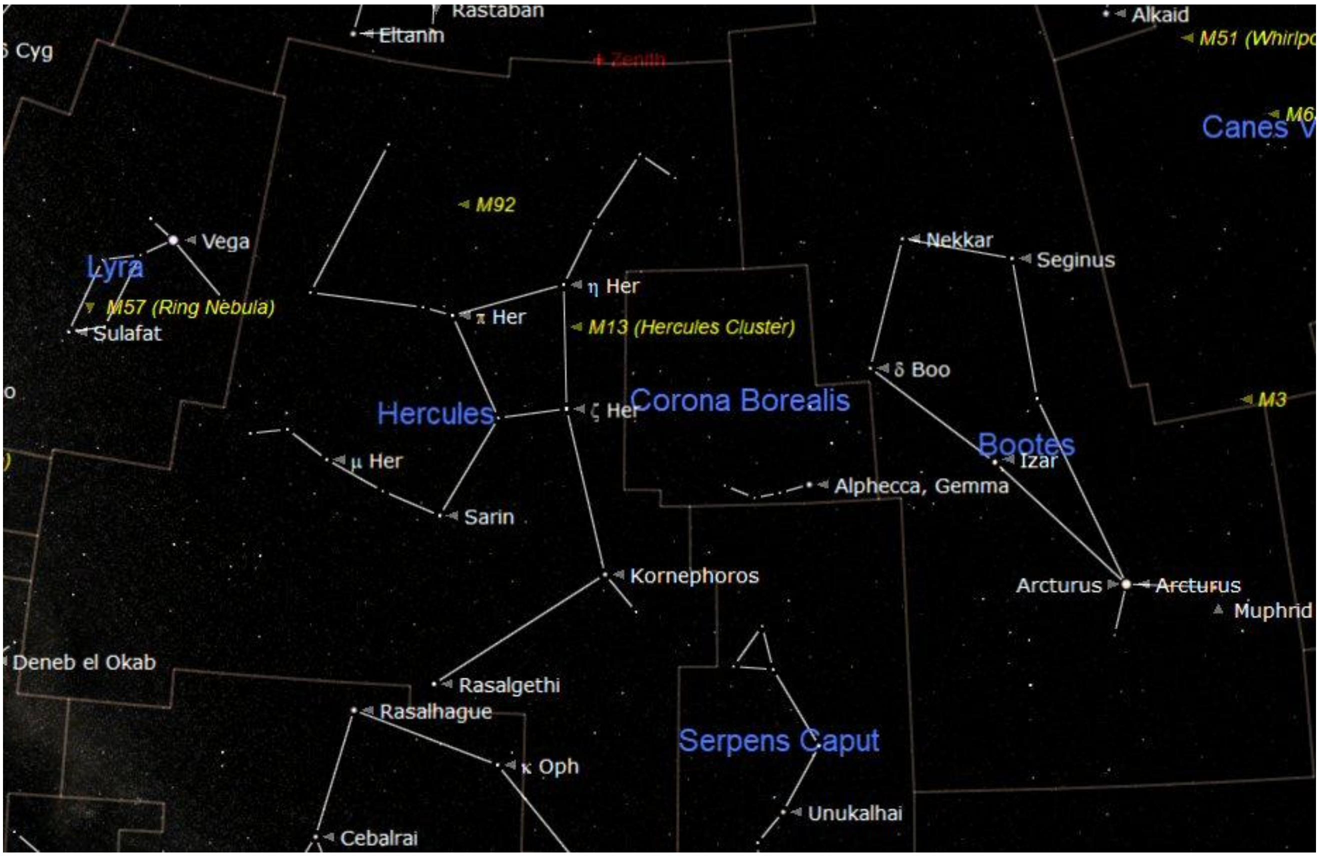
The constellation of Leo (the Lion) follows Cancer along the Ecliptic and is a very interesting constellation. It does actually look a little like a lion or the Sphinx in Egypt. Around and between Leo and the neighboring constellation of Virgo is a cluster of galaxies. Our Milky Way galaxy and our local 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.

Following Leo is the less obvious constellation of Virgo but it does have one fairly bright star called Spica. Virgo gives its name to a large cluster of Galaxies that is also spread over into the neighbouring constellations of Coma Berenices (Berenices' Hair) and into Leo.

To the north of Virgo is the bright orange coloured star called Arcturus in the constellation of Boötes. Arctaurus is a Red Giant star that is nearing the end of its 'life' as a normal star. It has used almost all of its Hydrogen fuel and has expanded to become a Red Giant, 25 times the diameter of our Sun. At the moment it shines 115 times brighter than our Sun but it is destined to collapse and become a White Dwarf.

Higher in the south east is the constellation of Hercules (the Strong Man). Hercules has a rather distinctive distorted square shape, at its centre, called the 'Keystone'. This is due to its resemblance to the centre stone of an arch or bridge. The jewel of Hercules is without doubt is the Great Globular Cluster, Messier 13 (M13). M13 can be found in the western (right) vertical imaginary line of the 'Keystone'. It is just visible using a good pair of 9 x 50 binoculars. The spherical cluster, of about a million stars that can be seen using a 90mm *f*10 telescope but will look even more impressive when using a larger telescope. See page 9.

THE CONSTELLATIONS OF HERCULES AND BOÖTES



The constellations of Hercules and Boötes

The chart above shows the constellation of Hercules and its location to the west (right) of the bright star Vega in the Summer Triangle. Hercules is the great strongman from Greek mythology. He is usually illustrated in the sky (usually up-side-down) as the strong man 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.

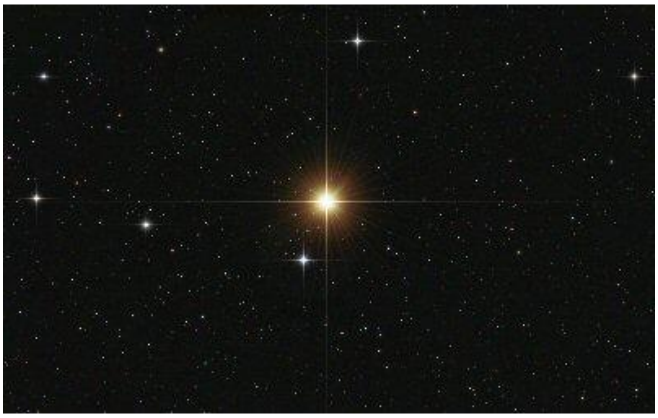
The jewel of Hercules is without doubt is the Great Globular Cluster, Messier 13 (M13). M13 can be found in the western (right) vertical imaginary line of the 'Keystone'. It is just visible using a good pair of 9 x 50 binoculars. The spherical cluster, of about a million stars, can be seen using a 90mm *f*10 telescope but will look even more 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 a Giant Spiral Galaxy like our Milky Way. The outer stars of these smaller galaxies have been stripped away, by the gravity of the giant spiral. This process has left the dense cores as clusters of between 100,000 and a million stars. There are about 100 Globular Clusters in a halo around our Milky Way. There is another Globular Cluster in Hercules called M92 but it is further away and needs a telescope to see.

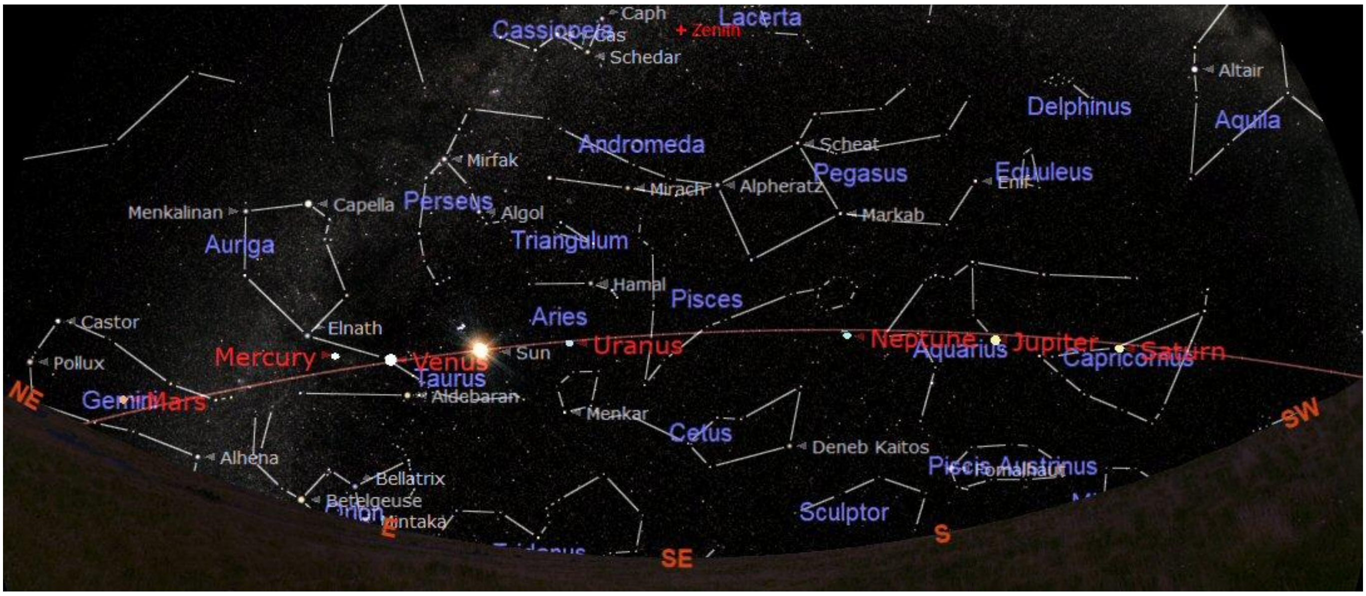
To the west of Hercules is the bright orange coloured star called Arctaurus in the constellation of Boötes the Herdsman. Arctaurus is the only bright star in Boötes, the other stars are fainter and form the shape of an old fashioned diamond shaped kite with Arctaurus located where the string of the tail would be attached.

Arctaurus is a Red Giant star that is slightly larger than our Sun and more advanced. It has used almost all of its Hydrogen fuel and has expanded in diameter to around 25 times that of our Sun. At the moment it shines 115 times brighter than our Sun but it is destined to collapse to become a White Dwarf and a Planetary Nebula.



The beautiful red star Arctaurus in Boötes

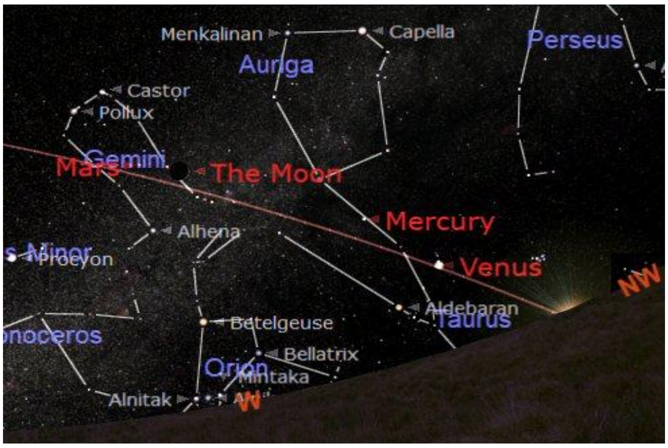
THE SOLAR SYSTEM - MAY 2021



The planets at 08:00 on 18th May

The chart above shows the location of the planets relative to the Sun. The sky has been darkened to make the planets visible. The planets to the west of the Sun (right) will be visible in the early morning sky before sunrise. The planets to the east of the Sun (left) will be visible in the early evening sky after sunset.

MERCURY will be visible in the early evening sky as soon as possible after sunset. It will be quite difficult to find in the bright sky and will require a clear view west.



Mars, Mercury and Venus in the early evening sky

VENUS will also be visible in the early evening sky as soon as possible after sunset. It will be easier to find than Mercury but will require a clear western horizon.

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 4.0 arc-seconds as Earth pulls further away. Mars will be around until the end of May but will be moving closer to the south western horizon. After it has moved over the horizon we will not see it again for nearly two years.

JUPITER will be rising in the South East from about 02:30 and will be visible in the east 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. See page 11 for Special Mutual Events on Jupiter.

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 east at about 02:00. Saturn will be at its best this year on 2nd August when it will be at opposition and will be due south at midnight.

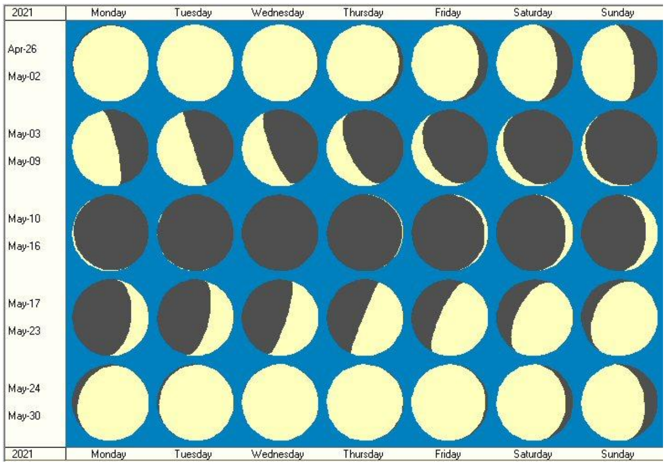
URANUS will be very difficult to find in the brightening early morning sky and will need a telescope. This month it will rise in the south west at about 04:45.

NEPTUNE will be just visible this month to the east of Jupiter. It will be difficult to see in the brightening morning sky as it is only magnitude +7.8.

THE SUN

The Sun rises at about 05:25 at the beginning of the month and 04:50 at the end. It sets at 20:30 at the beginning of the month and 21:00 at the end. It will reach its highest point in the sky on 21st June the Summer Solstice. There have been few small Sunspots during April.

THE MOON PHASES DURING MAY



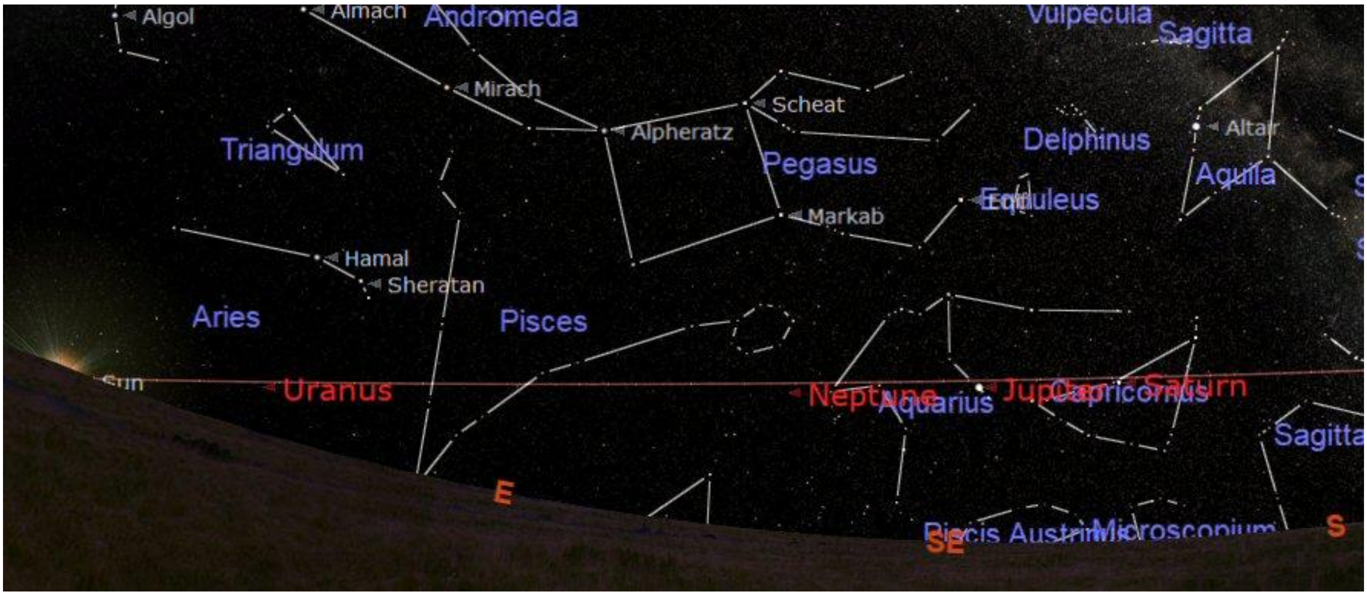
Last Quarter will be on 3rd May

New Moon will be on 11th May

First Quarter will be on 19th May

Full Moon will be on 26th May

THE POSITION OF JUPITER DURING MAY 2021



Jupiter in the early morning in May 2021

There is something interesting happening that makes it very worthwhile getting up to observe Jupiter in the early morning before sunrise. Every six years the orbital plane of the four Galilean moons is edge-on with the Sun and Earth so we enter the season of Mutual Phenomena. This is when the moons pass in front or pass behind Jupiter. Even more significant is the moons can Eclipse or Occult each other.

The season began on 3rd January when Europa partially eclipsed Io and will finish on 16th November with a Ganymede-Io occultation. Although Jupiter is still low at dawn it will still be possible to follow the events.

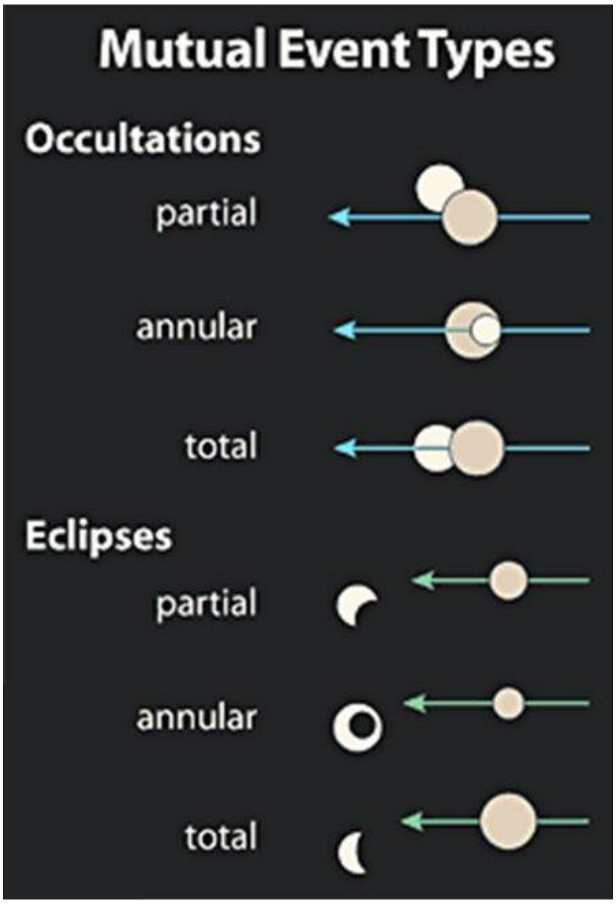


Diagram showing types of Mutual Events

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. A moon can also pass behind the planet in what is called an Occultation.

The moons can also pass in front of or behind another moon when we see Jupiter with its equator edge on to us producing a ‘Mutual Event’.

Occultations occur can when a moon passes behind another moon. These events can be Partial, when one moon partially obscures the other. Annular is where a smaller moon passes in front of a larger moon. A Total Occultation occurs when a larger moon completely obscures another moon. See the diagram opposite.

Eclipses occur when a moon casts its shadow on to another moon. It is quite easy to see because as the shadow crosses the surface of the moon it will be seen to darken. These events can be Partial when the shadow of one moon falls on to another moon but does not completely cover it. An Annular Eclipse occurs when the shadow of a smaller moon is projected on to a larger moon. A Total Eclipse occurs when the shadow of a larger moon completely covers a smaller moon.

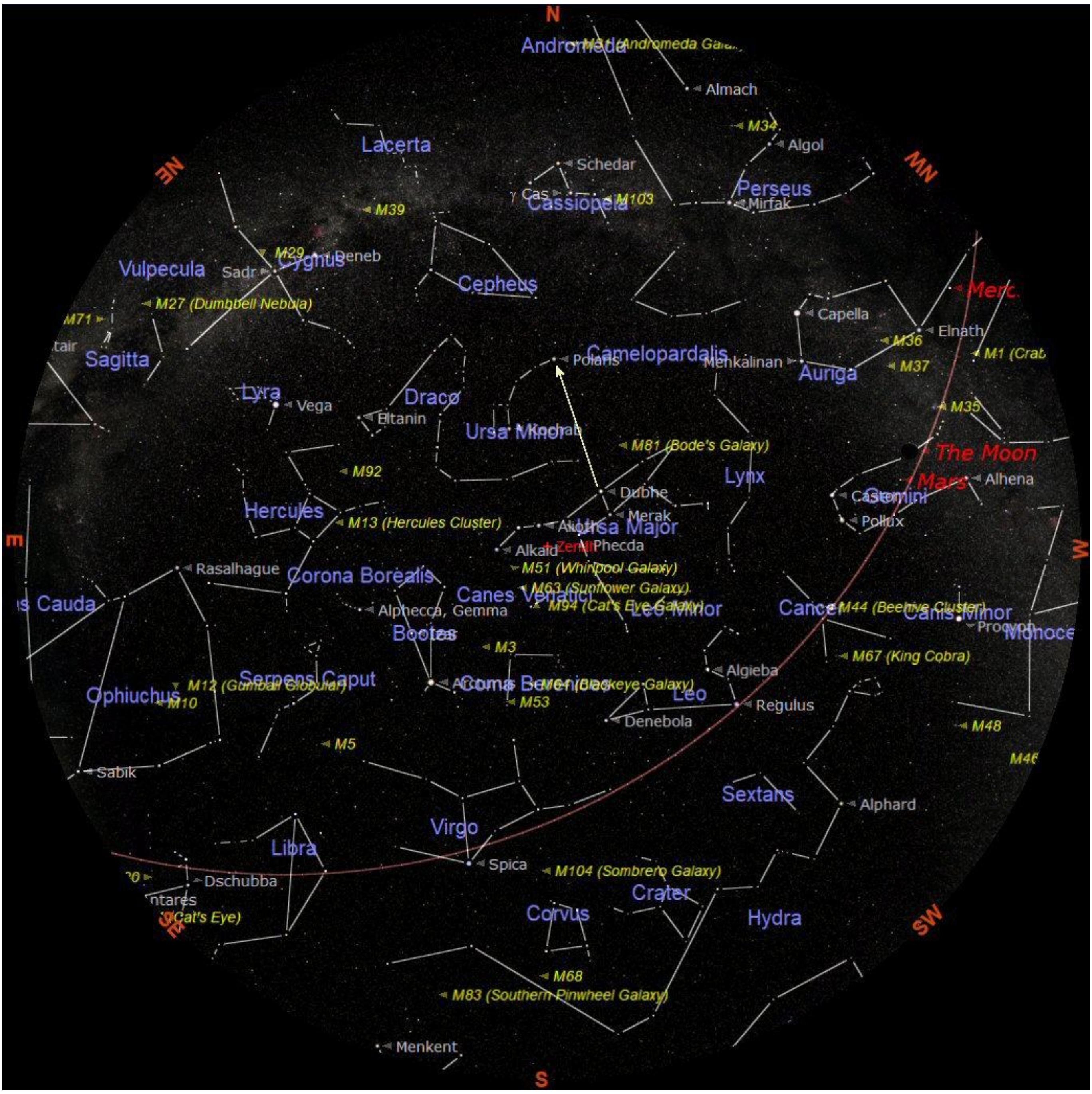
A Planetarium Application is needed to predict when these events are due to occur. The larger screen on a PC or laptop will make it easier to see the events when using a Planetarium Application.

Always check the weather forecast before setting the alarm for early the morning ‘wake up’ in case Jupiter cannot be seen due to clouds.

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

There is still time to see a few of these interesting events because they will continue until November but in reducing numbers. If we miss this series of Mutual Events we will have to wait another six years before the next series of the events occur in 2027.

THE NIGHT SKY – MAY 2021



The chart above shows the whole night sky as it appears on 15th May 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.