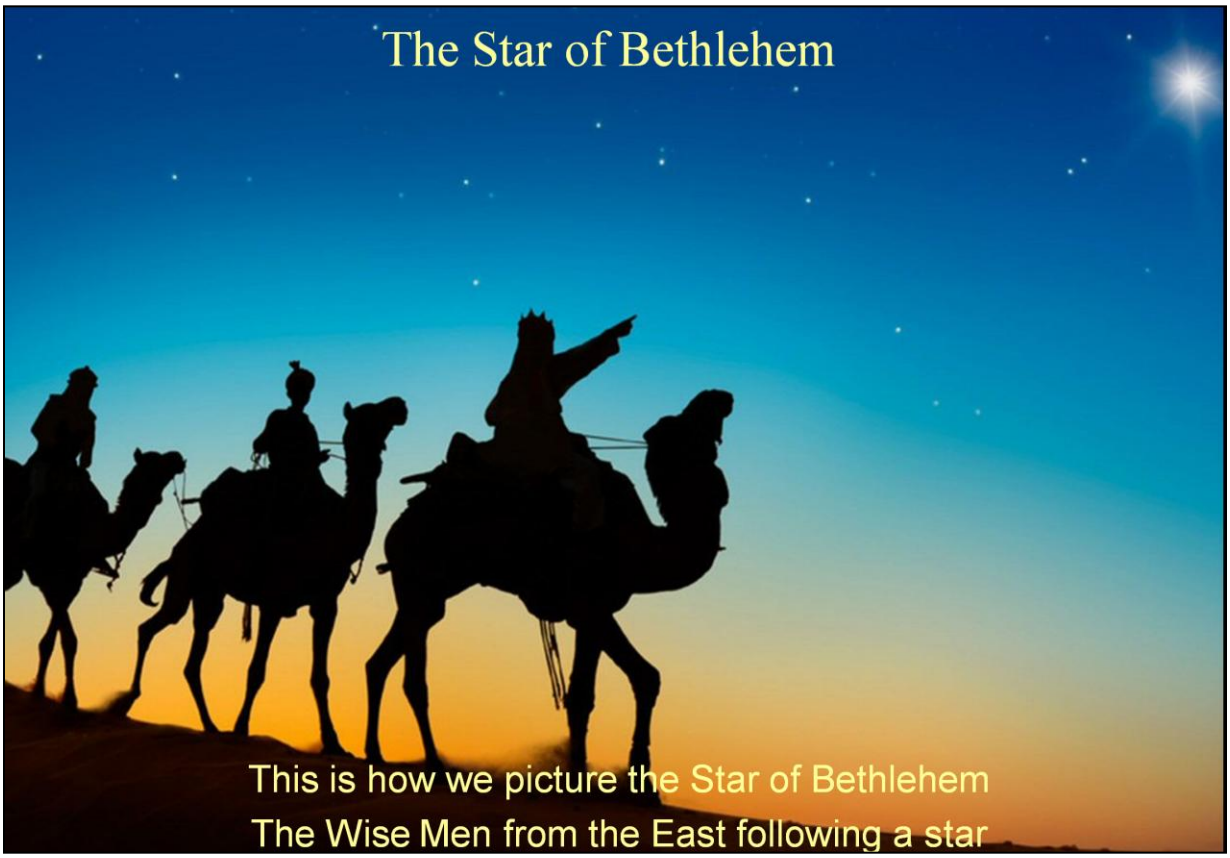
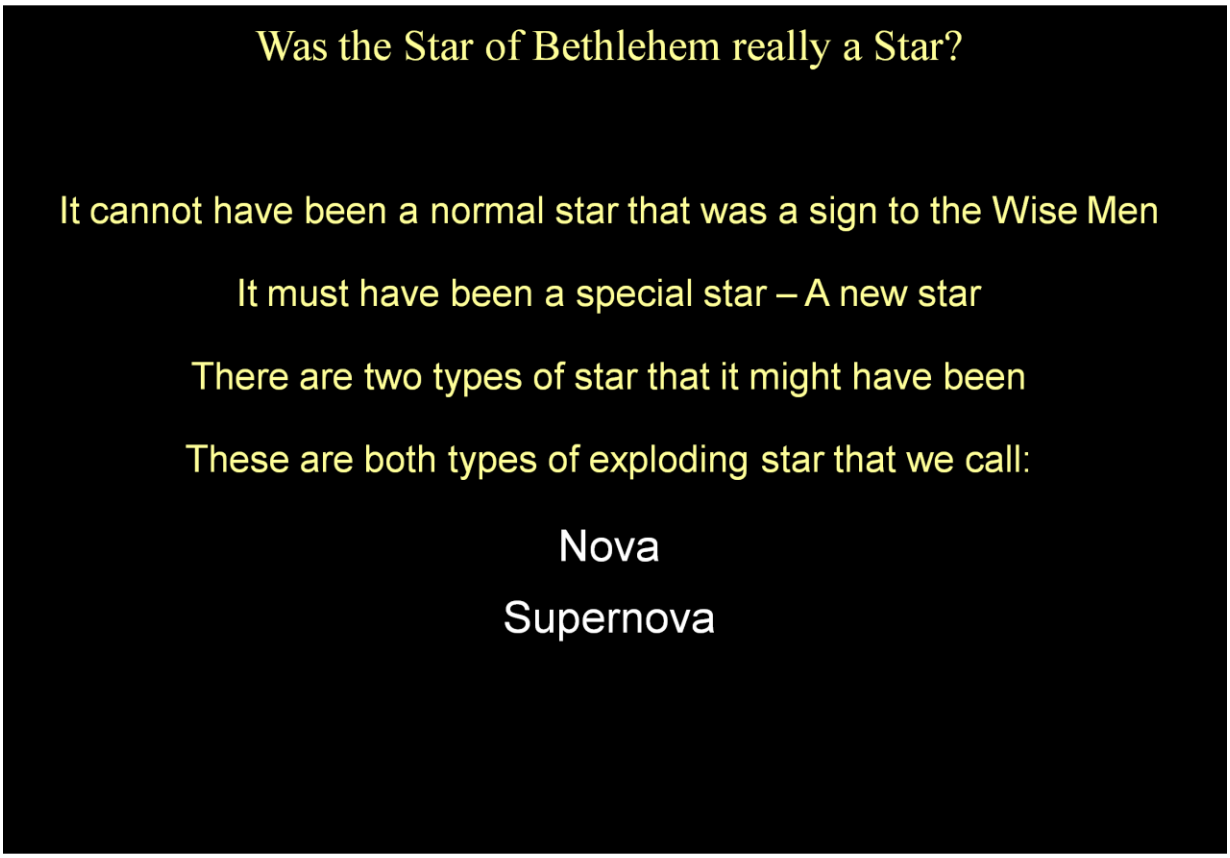


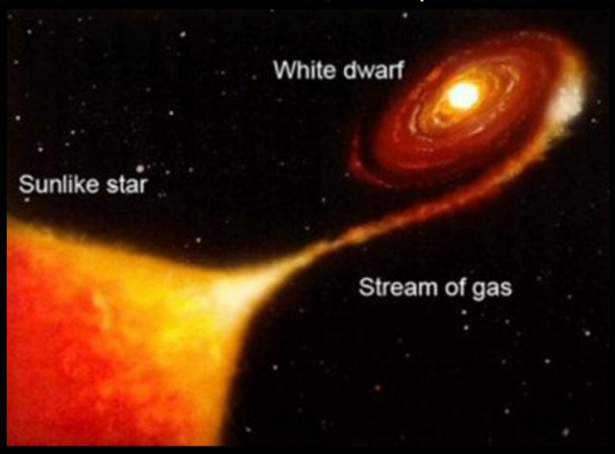
For nearly two thousand years scientifically minded people have wondered what was the ‘Sign in the Sky’ that the Wise Men saw?



What sign could have been so important that they would have started a very dangerous journey covering over a thousand kilometres to witness what the sign had foretold? We tend to accept that the Star of Bethlehem was a star but was it a star and if it was is there any evidence of it in the sky today? The stars do not normally change they are fixed in the sky so do not move. Some do vary slightly in their brightness but most of these variations are slight so any variations in all but the very brightest stars will go unnoticed. Most variable stars have fairly regular variation cycles so would not be regarded as a special event. So what could have attracted the attention of these ancient scientists.

What is a Nova?

A Nova is one component star of a double star system
The two stars have always been a pair but one was bigger than the other
The larger star was brighter so used up its Hydrogen fuel faster
At the end of its life as a normal star, it collapsed to become a White Dwarf

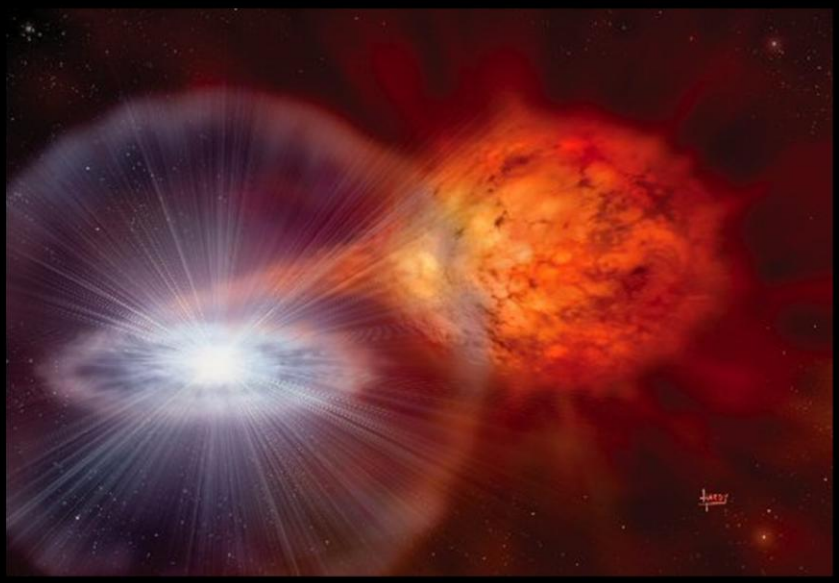


The two stars were very close together and rotating around their Centre of Gravity
The stars were so close that the gravity of the super dense White Dwarf
pulled Hydrogen gas off the surface of the other expanding Red Giant

If it had been a 'New Star' then it would have been either a Nova or a Supernova in our vicinity. A Nova is a star that is one component of a double star system that has exploded. It would have been the larger of the pair that had reached the end of its time as a normal star and became a small but very dense White Dwarf.

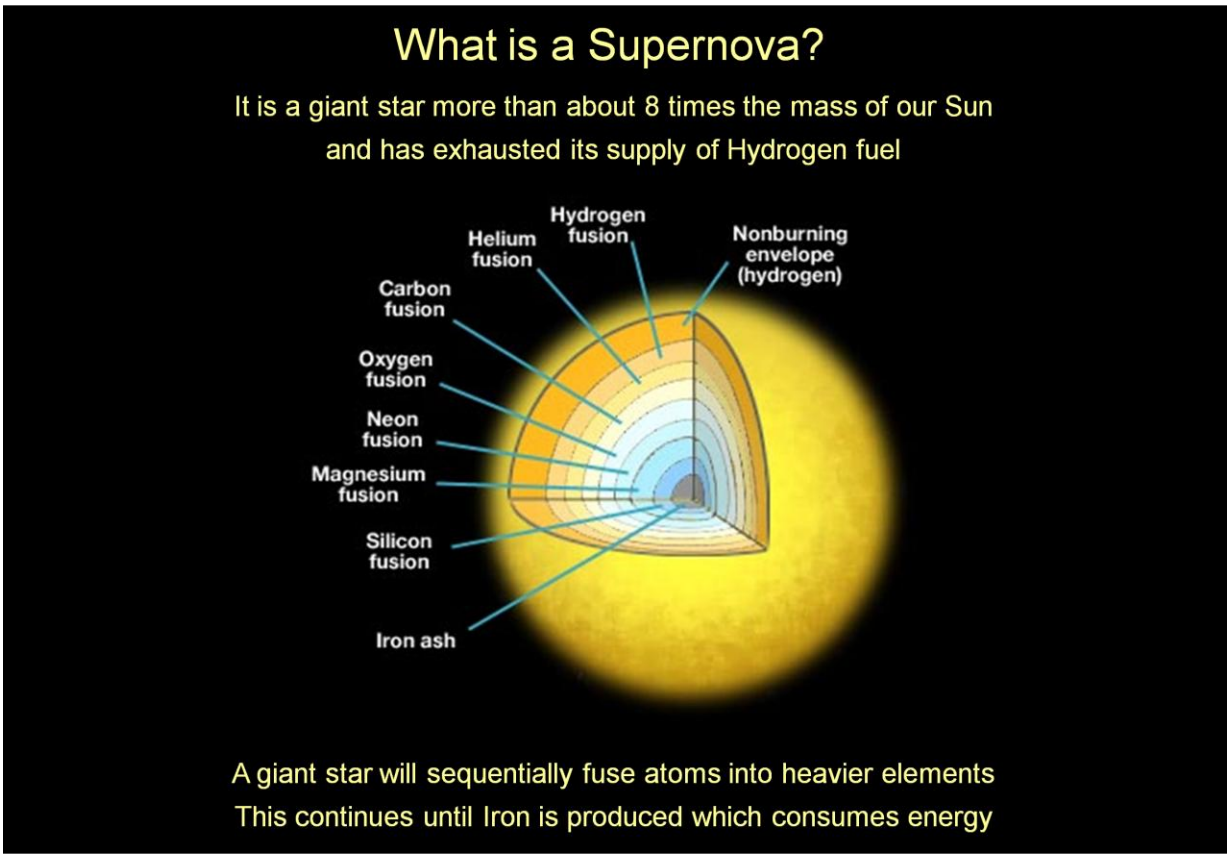
What is a Nova?

The Hydrogen built up on the surface of the White Dwarf
Eventually the layer of Hydrogen exploded in a Nuclear Fusion Explosion

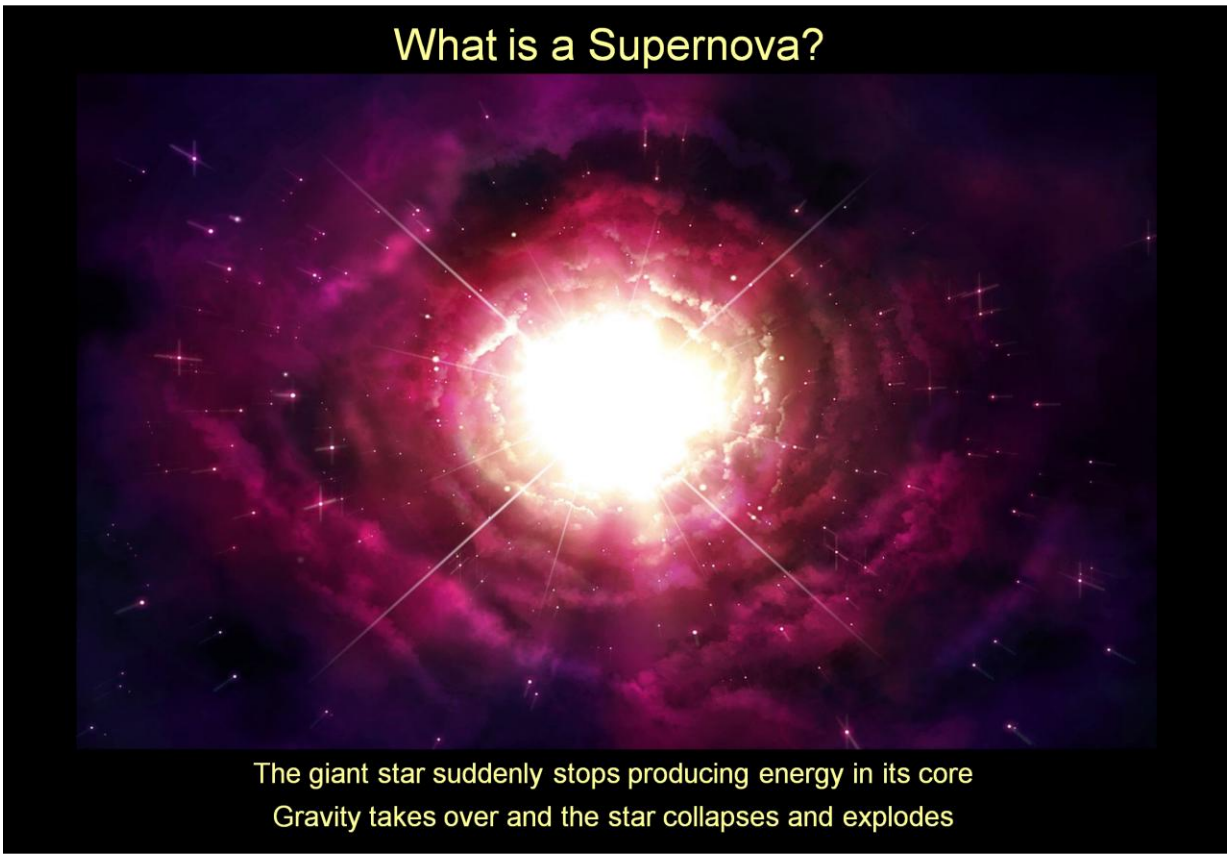


The White Dwarf briefly shone millions of times brighter
After a few months the bright 'new star' faded away

The Hydrogen would build up a very dense layer of atmosphere on the surface of the White Dwarf until the pressure and temperature on the surface created a run-away Nuclear Fusion explosion. The huge explosion (Nova) would cause the star to increase in brightness by millions of times. The two stars would normally survive this enormous explosion and repeat the whole process in tens to hundreds of year cycles.



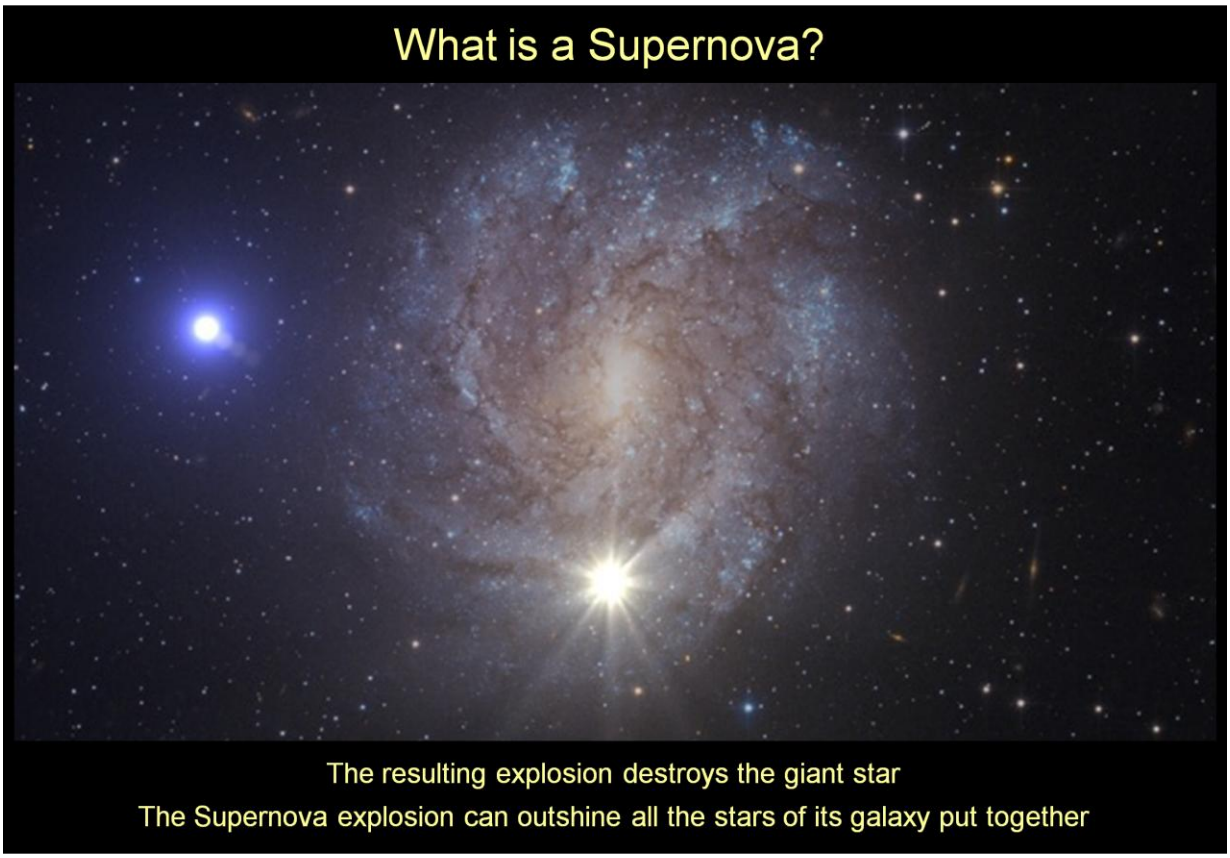
The diagram above shows the structure of a supergiant star just prior to its eventual collapse as a Supernova. Shells of increasingly complex and heavier atoms are formed around the core of the star through the nuclear fusion process. Nuclear fusion continues at the boundary of each shell causing the 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 sequential 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. The accumulation of the central Iron core is created in a very short time in fact just a few Earth days.

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 collapsing in on the core, it exceeds the limits for a White Dwarf and then the limits of a Neutron star and (if massive enough) may form a Stellar Black Hole.

In the process of the core collapse it produces an enormous burst of Neutrinos. This huge burst of energy impacts with the outer regions of the star that are collapsing towards the core at tremendous speed. The impact causes an enormous nuclear explosion the destroys the star and blows away the outer layers as a supernova explosion. The remaining core remnant 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 in diameter.



A Super Nova explosion produces an enormous flash of light that can shine brighter than the whole galaxy where the star was located. This flash and subsequent fireball will be seen over great distances for a few months and then slowly fade away.

Are there any Supernova Remnants in our vicinity?

A giant star exploded 7000 years ago and was recorded in 1054
The Supernova remnant can still be seen in the constellation of Taurus

The supernova that created what we call Messier 1 (M01) the Crab Nebula occurred 7000 years ago when a giant star exploded. The light from the explosion took 6000 years to reach Earth so the explosion occurred 6000 light years away from us. 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. When imaged with a large telescope it can be seen as shown above. However no Nova or Supernova remnants that could have been the Star of Bethlehem have been found.

In the earliest period after our Solar System formed, millions of comets rained in towards the Sun from the outer reaches of the young Solar System. This is known as the Late Heavy Bombardment and finished about 3.8 million years ago but we still have occasional visits by comets. These are a tiny fraction of the activity during the LHB. It is likely that there are still close encounters and even collisions of the Dwarf Planets in the Oort Cloud and the Kuiper Belt beyond the orbits of the outer planets where proto-comets reside. Any close encounters are likely to disturb the fragile orbits of these icy bodies. The effect of the gravity of the Sun is extremely week at these vast distances. Just a tiny change to the path of one of the objects could send it on a course towards the Sun and its planets. These journeys in towards the Sun may take many thousands or even millions of years.

A comet is a lump of ice mainly comprised of water ice with Carbon Dioxide (CO^2) as the second largest constituent. It will also have traces of many other frozen gases and dust particles from the nebula (cloud of gas and dust) in which the Sun formed.

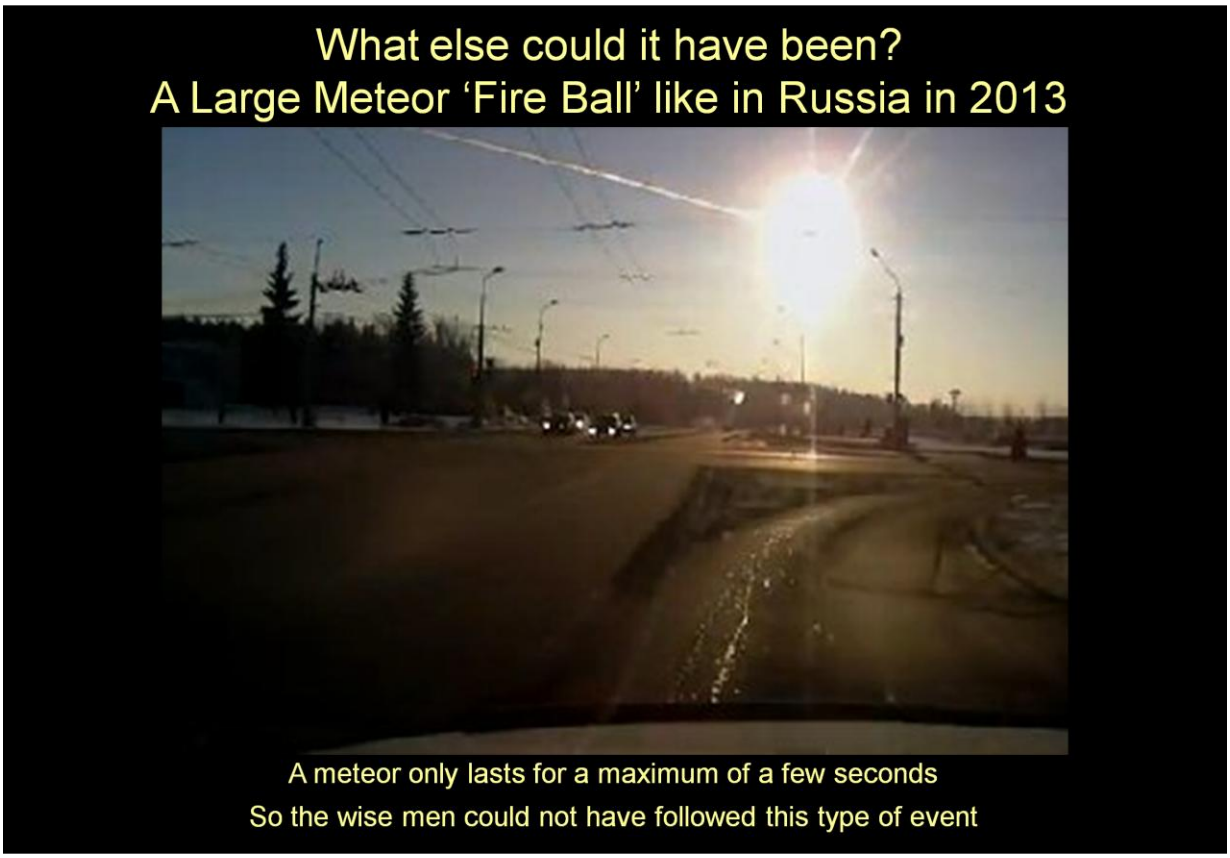
But no Comet were recorded

Comet Hale – Bopp Imaged by Lee Mcdonald in 1995

No bright 'naked eye' comets were recorded around 7BC

When the comet has looped around the Sun and is moving back to the outer Solar System the tail will still point away from the Sun (in front of the nucleus/coma) As a comet nucleus approaches the Sun the frozen gases begin to sublime (melt directly into gas) and form a cloud around the nucleus called the 'Coma'. Between the orbits of Jupiter and Mars is the point when the Carbon Dioxide (CO^2) on the surface begins to sublime. As a comet approaches the orbit of Mars the radiation from the Sun will begin to sweep the material of the coma into a long tail that trails away from the Sun.

The coma of a comet is extremely tenuous but may be very large, often over 100,000 kilometres in diameter. In 1996 a very bright and beautiful comet graced our sky for about two months this was Comet Hale-Bopp, named after the two astronomers who discovered it. It was easily visible and impressive to the naked eye with the tail stretching about 10^o across the sky.



At 9 o'clock in the morning of 15th February 2013 a huge meteor fireball was seen in the sky over the town of Yekaterinburg in Russia. The meteor streaked across the sky and exploded over central Russia raining fireballs over a vast area and causing a shock wave that smashed windows, damaged buildings and injured 1,200 people.

People heading to work in Chelyabinsk heard what sounded like an explosion, saw a bright light and then felt the shock wave, in the industrial city 1,500 km (950 miles) east of Moscow.

The fireball, travelling at a speed of 30 km (19 miles) per second blazed across the horizon, leaving a long white trail that could be seen as far as 200 km (125 miles) away.

Car alarms were set off and thousands of windows shattered and mobile phone networks were disrupted. The Interior Ministry said the meteorite explosion, a very rare spectacle, also unleashed a sonic boom.

So if this was not a stellar event
this really only leaves a planetary event

How can we find out what planetary events happened 2000 years ago?

We can use our computer planetarium applications

We can programme the planetarium to show the sky 2000 years ago

But do we know what year was Jesus born?

Our only clue is:

We know it was in the reign of Herod the Great ~74 BC to ~4 BC

So Jesus must have been born before 4 BC

So when was this planetary event?

Our calendar is based on a calendar created by the monk Dionysius

in the 6th century, he used the reigns of the Roman Emperors

But Dionysius made two BIG mistakes:

1. Augustus ruled from 27 BC to 14 AD but he also ruled as Octavius from 31 BC to 27 BC but Dionysius forgot to add in these 4 years
2. The Romans had no concept of the number 0 (Zero) so the dates went from 1 BC to 1 AD with no year 0 so Dionysius missed a year

Jesus was most likely born between 7 BC and 4 BC

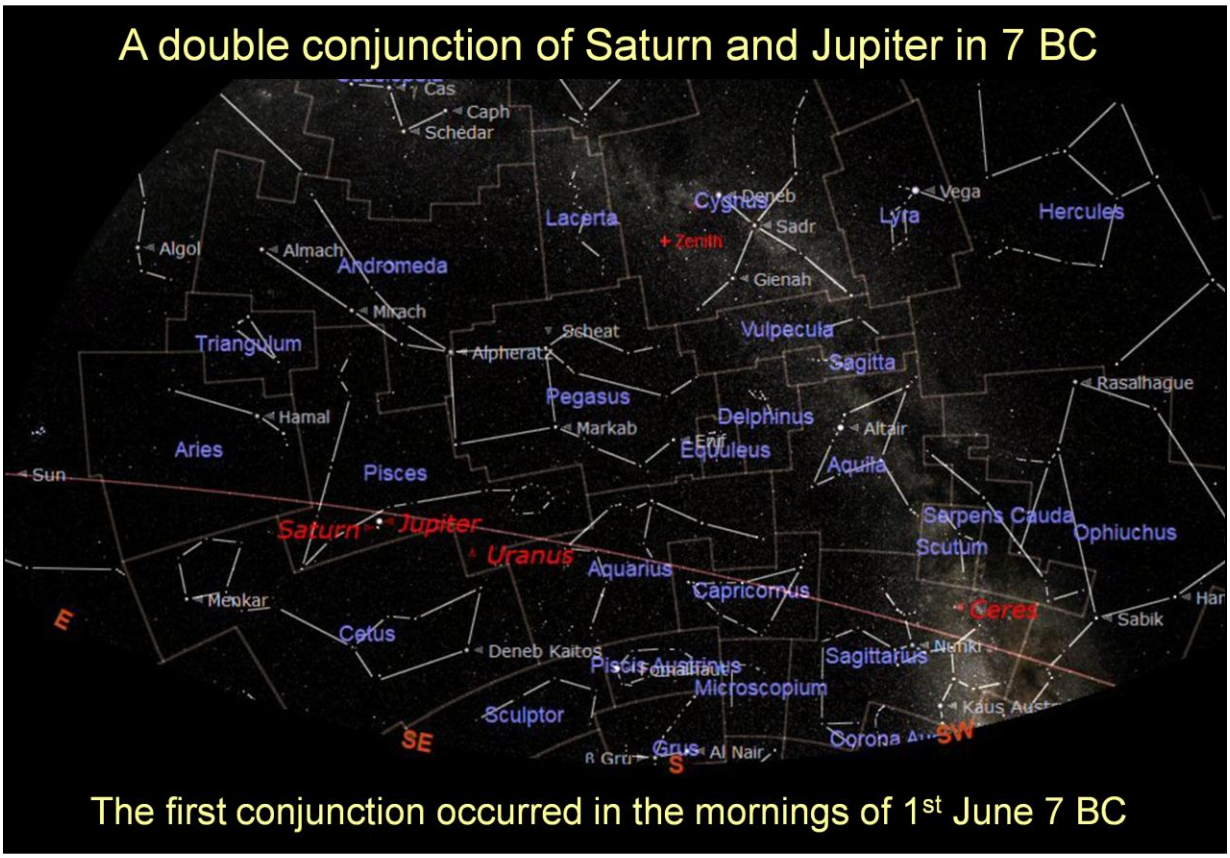
So was there anything unusual in this period?

There were three interesting events in this time frame:

A double conjunction of Jupiter and Saturn in 7 BC

An alignment of all the known planets in 6 BC

A conjunction of Jupiter and Venus in May 6 BC



The first of these conjunctions occurred in the early morning sky on 1st June 7BC. The second was on 1st December 7BC in the evening sky. The chart below shows the sky as it appeared from Bagdad at 04:00 (before sunrise) on 1st June 7BC. This first conjunction and the second occurred in the constellation of Pisces, the constellation next to Aries.

Jupiter appeared to approach Saturn from the west (right) and was at its closest at the beginning of June 7BC. Jupiter then moved away from Saturn to the east (left) until September 7BC when it began to move back westward and returned to Saturn. Through October and November Jupiter moved closer and closer to Saturn.

So what was the significance of this event?

There were three points of interest:

Jupiter was associated with Kings and Saturn with stability
The constellation of Aries was associated with Judea
The First Point of Aries was about to move into Pisces

THE FIRST POINT OF ARIES

This is the point in the sky marking the Vernal Equinox
It is where the Sun crosses the Equator in Spring
So Hipparchus set this as the zero point in 130BC
Due to Precession it moved from Aries into Pisces in 1AD
(It moves 1º every 72 years and will move into Aquarius in 2150)
So the Wise Men knew this was going to happen

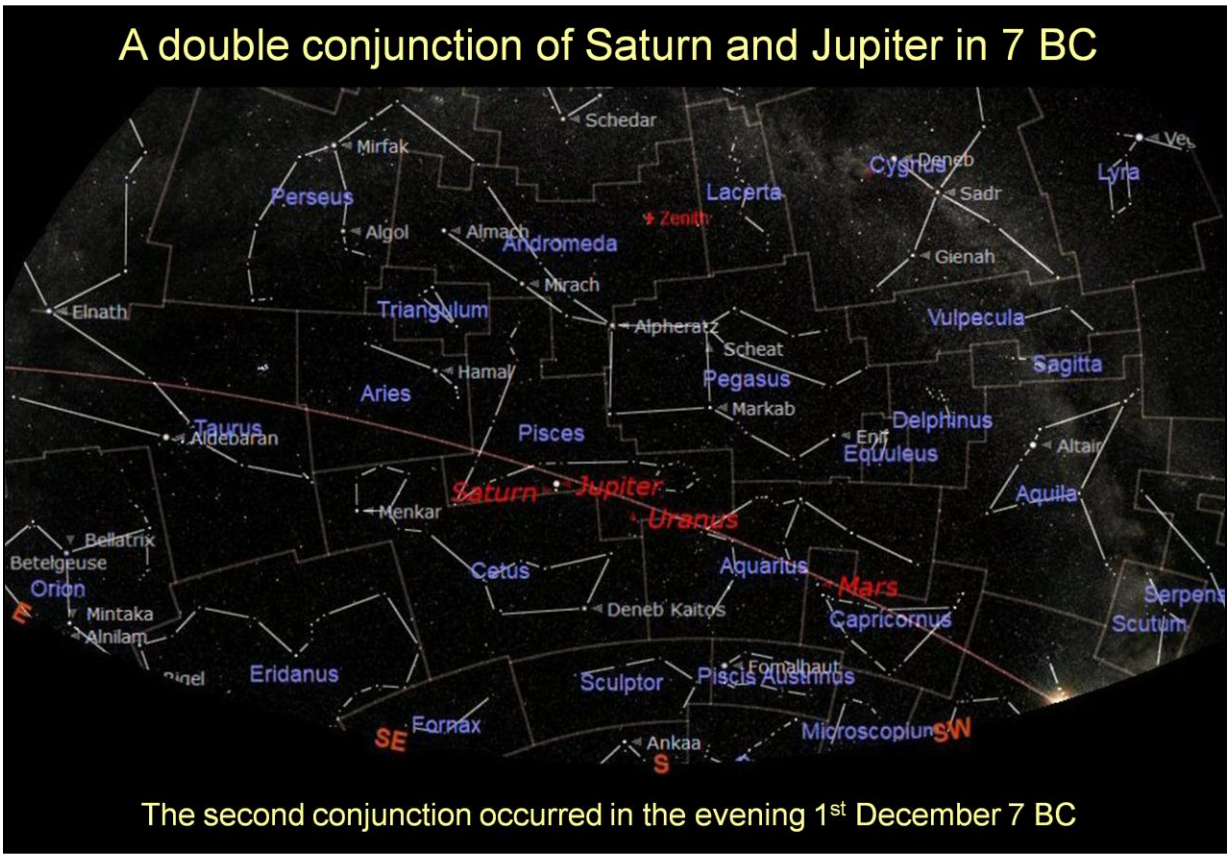
Jupiter was associated with Kings by the ancient astrologers so anything happening to Jupiter in the sky could be important. The planet is associated with Kings and good luck, wealth and power.

In astrology, Saturn is associated with restriction and limitation. Where Jupiter expands, Saturn constricts. Although the themes of Saturn seem depressing, Saturn brings structure and meaning to our world.

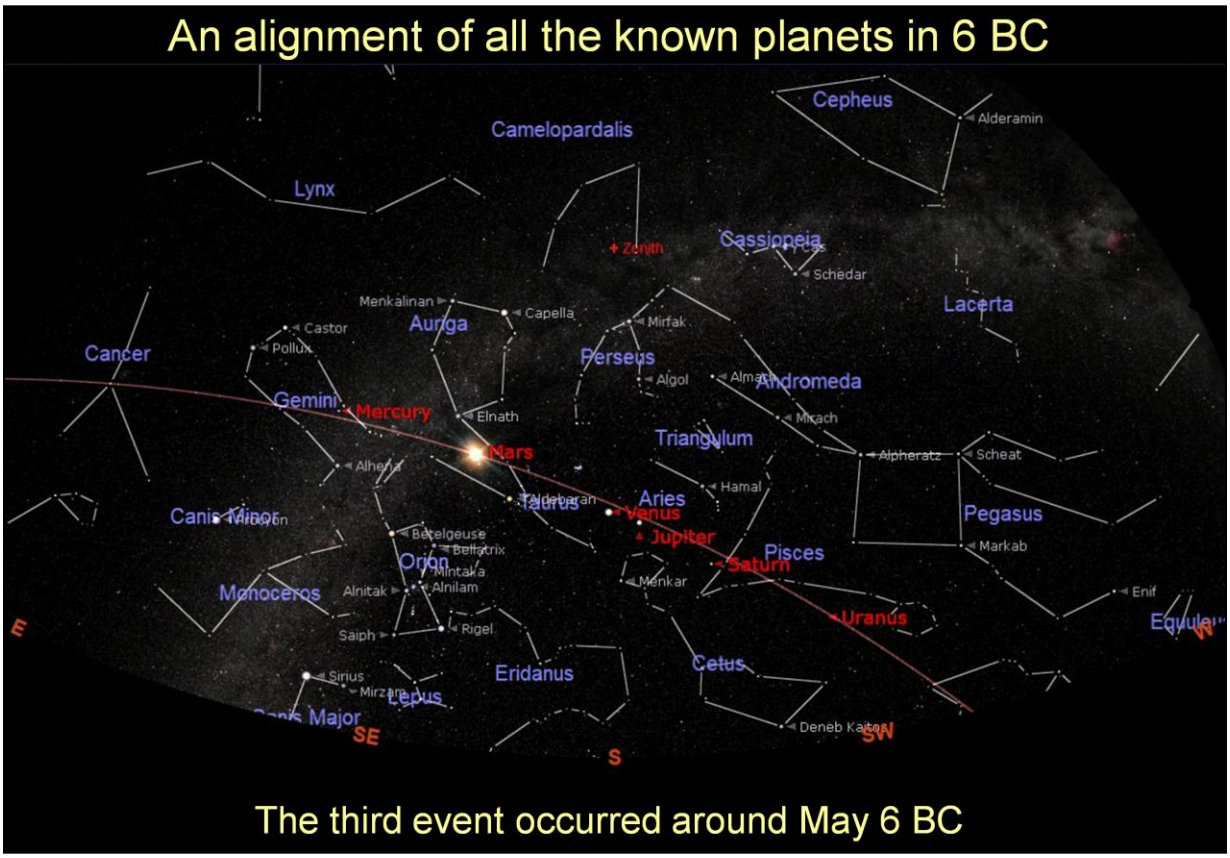
The constellation of Aries has many meanings in astrology but it is thought by some scholars to have had an association with the area around Jerusalem by the ancient Babylonians.

The first point of Aries was the point chosen by Hipparchus in 130BC as the starting point in the sky for measuring longitude east and west. It is the point where the Sun crosses the Ecliptic (Earth Equator) projected on to the sky. This is the Vernal Equinox (or Spring Equinox).

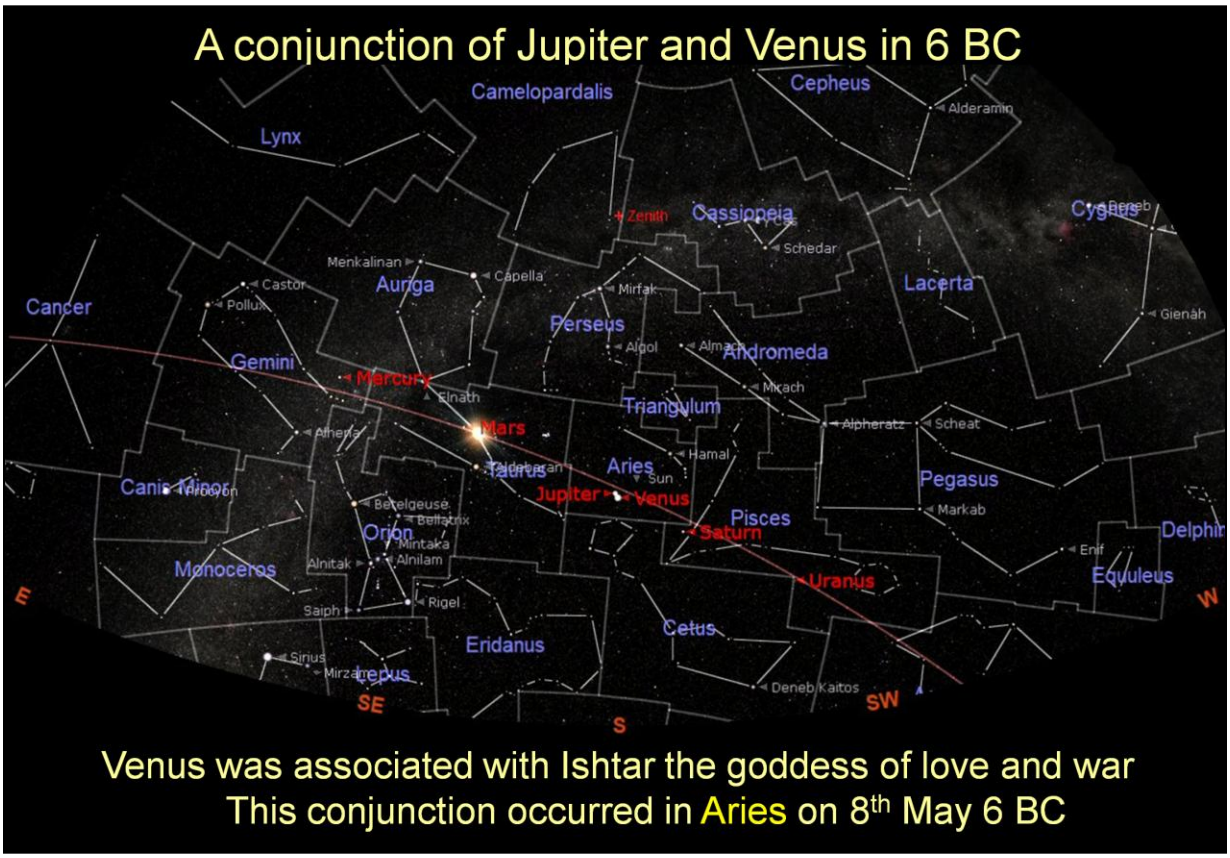
Due to the wobble of Earth the axis of rotation moves in a circle every 25,772 years, this is called Precession. Consequently Vernal Equinox gradually moves westwards at a rate of about one degree every 72 years. This means that, since the time of Hipparchus, it has shifted across the sky by about 30°, and is currently located within Pisces. It will move into Aquarius in the year 2150. We still use this point (First Point of Aries) as zero RA when using an equatorial mounted telescope.



Jupiter made another loop around Saturn towards the end of 7BC and into early 6BC. Jupiter then moved eastwards (to the left) again. In late March 6BC Jupiter moved out of Pisces and into Aries.



The Jupiter/Saturn conjunctions were followed by the alignment of all the known planets that were assembled along the Ecliptic in May 6BC when Jupiter was in Aries.



Then there was the final special event when Jupiter and Venus moved into conjunction on 8th May 6BC. This occurred when the planets were all assembled and the conjunction of Jupiter and Venus occurred in the constellation of Aries.

Venus was know as the god Ishtar by the Babylonians. She had a dual role as a goddess of both love and war thereby representing a deity that presided over birth and death. This would have had a very important meanings for the king that the Wise Men made their important journey to see.

Aries is the constellation that was thought to be associated with the area around Jerusalem and Bethlehem by the Magi.

Why are these event interesting?

The wise men were Magi from the area around Iraq

They were Astronomers and Astrologers

They would have been able to predict all these events

The constellations had special meanings for places

The constellation of Aires was special to the area of Judea

The planet Jupiter had a special association with Kings

Saturn would bring structure and meaning to our world

Why were these events so important?

The wise men could have predicted all these events

They could have seen the first Jupiter conjunction from Iraq

They would have had six months to journey to Bethlehem

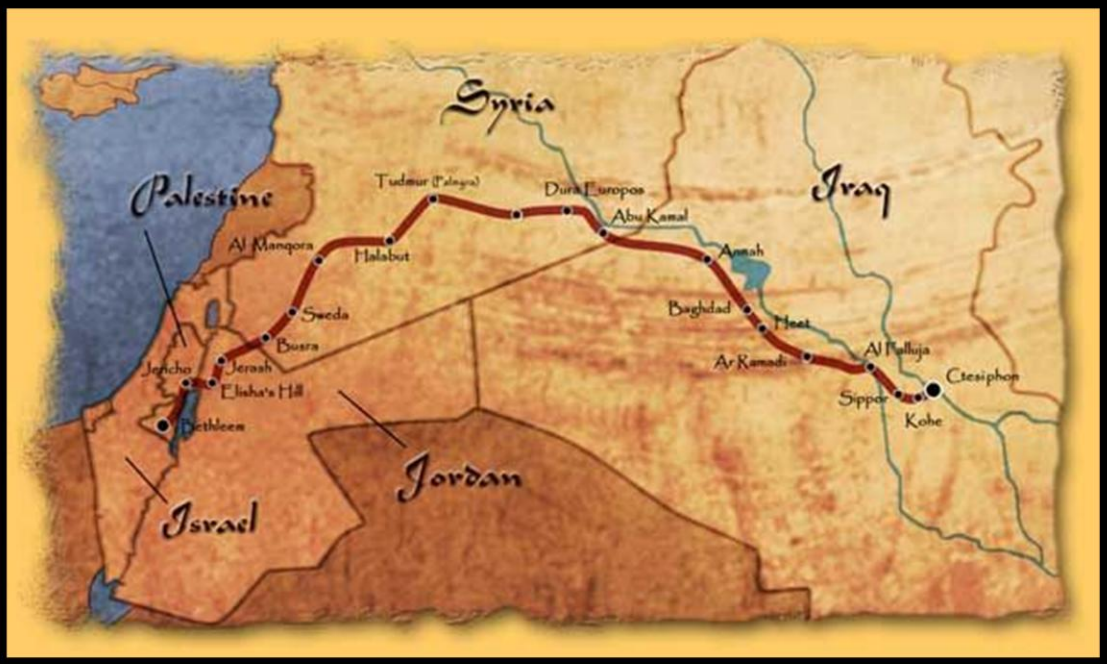
They would have known about the alignment of the planets

They would have known about the Jupiter / Venus conjunction

It could have indicated that a great King was to be born in Judea

So how can we link all this together?

What would have been the route taken by the Magi?



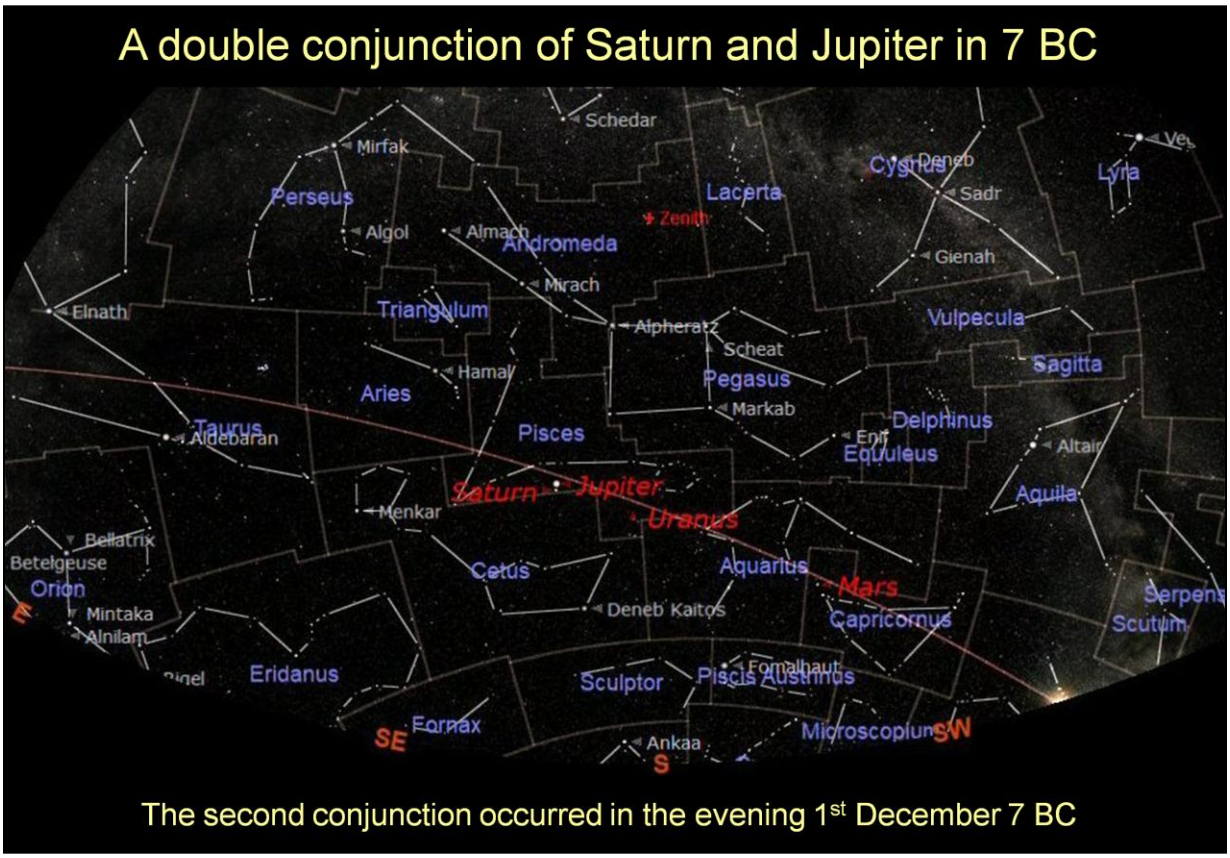
They would have to travel around the dessert

The Wise Men would have travelled north from Iraq then west and south to take them around the dangerous desert on the only safe route. See the chart above. The highly educated Magi could easily have predicted all these very important astrological events and made the decision to travel to see the new king.

The June conjunction could have predicted the birth of a king and would have been seen from Iraq.

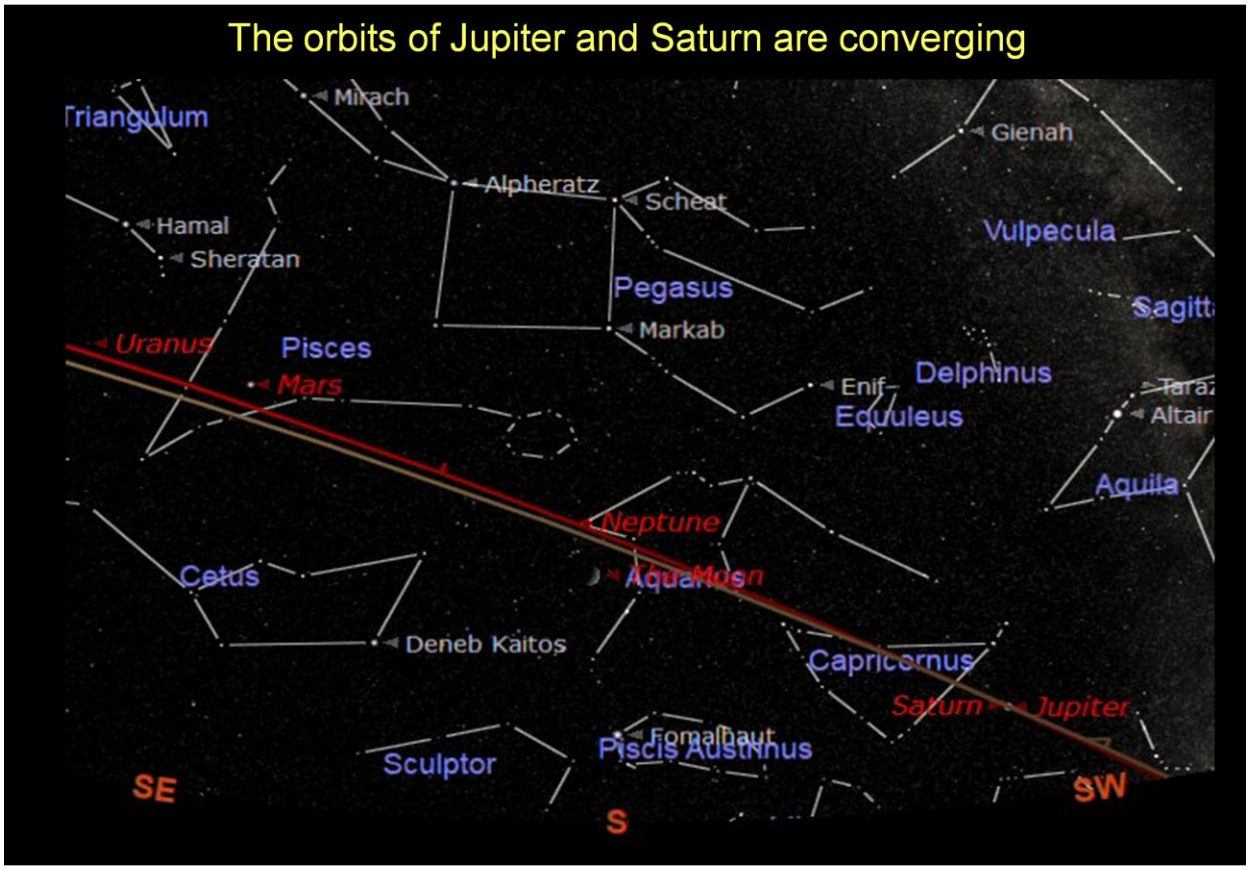
The December conjunction might have heralded the birth of the king.

They would have seen the conjunction and above the town as they approached Bethlehem from the north. Interestingly this means they would have seen it occur in the south and above Bethlehem as they approached from the north.



The sky as it appeared over Bethlehem on 1st December 7 BC looking to the South.

Herod's palace was about 12 kilometers south of Jerusalem so the wise men would have travelled south to Bethlehem after visiting Herod. They would have seen the Jupiter /Saturn conjunction as they arrived from the northerly direction so they would have seen it in the south above the town of Bethlehem.

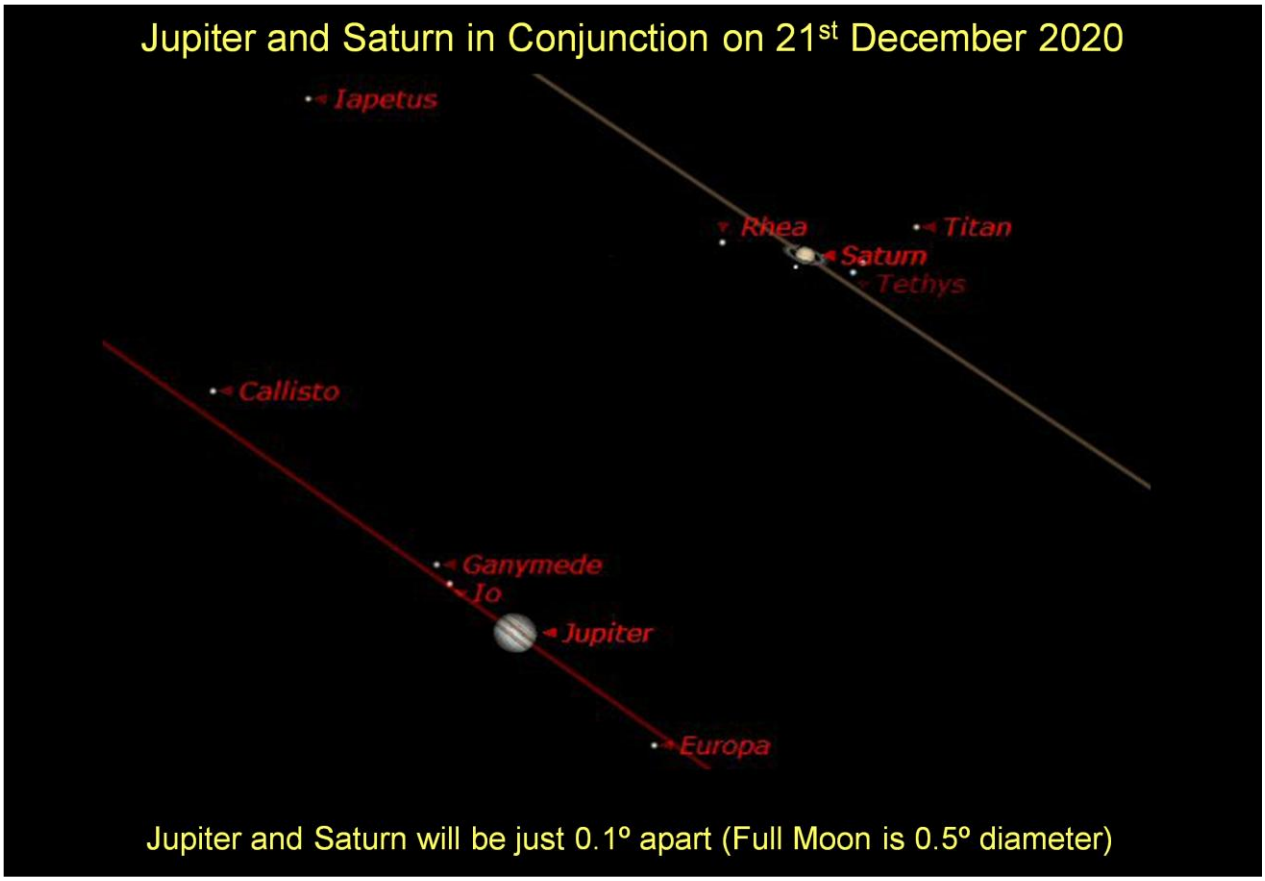


The two Gas Giant Planets have appeared close together in the sky all summer and will continue to move even closer together until the end of the year.

The converging orbital paths of the planets are shown on the chart above.

The orbital paths of the planets are show as red for Jupiter and brown for Saturn.

It can be seen on the chart above that the orbital paths are converging and towards the end of the year will cross as the planets move further to the west.



The chart above shows how the two planets and their moons will appear using a telescope around the 21st December.

They should fit into the field of view of most telescopes and even some larger telescopes using a low power eyepiece.

Jupiter and Saturn will not be any closer to each other than they normally are and will still be moving around their established orbits. This conjunction is just a 'line of sight' effect from our point of view on Earth. The two planets will actually be as far apart from each other as Earth is from Jupiter (about 750 million kilometres). Jupiter is approaching Saturn because it is moving faster than Saturn along its orbital path and will overtake Saturn on 21st December. From our point of view they will appear very close together so at this time the two planets will be at their closest conjunction. The planets will be just 0.1º or 6 arc-minutes (6') apart in the sky.

To put this in prospective the Full Moon is ½ of 1º (one degree) ~30 arc-minutes in diameter. The distance between Jupiter and Saturn will be 1/5 of the Moon diameter.

This presentation is available on the

Newbury Astronomical Society Website:

www.naasbeginners.co.uk