STAR OF BETHLEHEM

Biblical evidence

Matthew II, 1–2:

"Now when Jesus was born in Bethlehem of Judaea in the days of Herod the King behold, there came wise men from the east to Jerusalem, saying, where is He that is born King of the Jews? For we have seen His star in the east, and are come to worship Him."

Matthew II, 9–10:

"Then Herod, when he privily called the wise men, enquired of them diligently when the star appeared." [...] *"When they had heard the King, they departed; and lo, the star, which they saw in the east went before them, till it came and stood over where the young child was. When they saw the star, they rejoiced with exceeding great joy."*

What can we say from this?

- The wise men (Magi) were most likely priests and/or astrologers. They came presumably from Babylon, but possibly from Assyria or Chaldea.
- At about the sixth century tradition changed the Magi into Kings and their number was fixed at three because of the threefold nature of their gifts gold, frankincense and myrrh (but six Kings in the eastern tradition).
- The star was not very bright and obvious to everybody, but must have held astrological significance. Also it must have been a fairly long lasting phenomenon.
- It was only in medieval times that the star got to be depicted as very bright and with a tail, suggesting a comet or a meteorite.

- It remains possible that the story about the star is only fiction; part of a tale to amplify the significance of Jesus's birth and/or to fulfill the Old Testamental prophecy.
- Still we may wonder what has caused the story and what information on the dating of the birth of Christ it may contain.
- Or was it Divine intervention?
- Should we take it all (including the birth in a stable, the shepherds, etc.) literally or just as a tale to enhance the importance of the event?
- We can never be sure that what we arrive at is actually true, but it remains worhtwhile to explore what we can say.

Historical and other evidence

- Jesus was born during the reign of King Herod. Herod died sometime around a lunar eclipse seen from Jericho and around passover time, so probably eclips of March 12, 4 BC.
- Joseph and Maria travelled to Bethlehem from Nazareth to be taxed. This could be related to the census ordered by Ceasar Augustus in 8 BC.
- Cyrenius (Quirinius) was governor of Syria. This started about 6 AD, but he was a consul from 12 BC onwards.
- Sheep are not out on the fields in winter (much too cold) and shepherds are with their flock during the lambing season in March or April.

So the range is about 7 to 5 BC and the birth probably in the spring.

TRIPLE OR 'GREAT' CONJUNCTIONS

The synodic period of a planet P_{syn} is the time between two successive conjunctions or oppositions and follows from the sideric period P_{sid}. For an outer planet

$$\frac{1}{P_{syn}} = \frac{1}{P_{Earth}} - \frac{1}{P_{sid}}.$$

The time between successive conjunctions between two planets with synodic periods P_1 and P_2 ($P_2 < P_1$) is

$$\frac{1}{P} = \frac{1}{P_1} - \frac{1}{P2}.$$

Planet	P_{sid}	P_{syn}	Planets	P
Mars	1.88	2.14	Mars–Jupiter	2.24
Jupiter	11.86	1.09	Mars–Saturn	2.01
Saturn	29.46	1.04	Jupiter–Saturn	1.92

For a triple conjunction to occur, the oppositions of the planets have to occur within a period of a few days from each other. Ignoring excentricities these periods are

- 3.9 days for Mars–Jupiter
- 5.4 days for Mars–Saturn
- 1.7 days for Jupiter–Saturn

First we can calculate the periods between the times the opposition points of two planets "overtake". These are

- 47.8 years for Mars–Jupiter
- 43.2 years for Mars–Saturn
- 19.9 years for Jupiter–Saturn

These values show that e.g. every 48 years there is a chance for a triple conjunction between Mars and Jupiter. Whether it will actually occur depends on the precise times of opposition and the excentricities. The occurence of triple conjunctions between 25 BC and AD 2000 are found from calculations as follows.

Triple conjunctions

Mars–Jup	Mars–Sat	Jup–Sat	Mars–Jup	Mars–Sat	Jup–Sat
	–24				
		–6			
21-22					1007-1008
	77		1027		
164-165				1061-1062	
	177-178			1063-1064	
	179-180			1100	
	216		1170-1171		
307-308				1198	
		332-333		1264-1265	
354-355				1302-1303	
	380-381				1305-1306
		411-412	1313-1314		
	418-419				1425
		452	1456-1457		
497-498			1503-1504	1503-1504	
	519			1505-1506	
	619-620			1542	
	621-622			1640	
641			1646-1647		
	658				1682-1683
		709-710		1706-1707	
	756			1742-1743	
784				1745	
	822-823			1779	
	860-861		1789-1790		
884			1836-1837		
927				1877	
929					1940-1941
		967-968		1945-1946	
			1979-1980		
					1981

- The triple (or "great") conjunctions appear to occur at *mean* intervals of
  - 110 years for Mars–Jupiter
  - 70 years for Mars–Saturn
  - 170 years for Jupiter–Saturn
- The next Jupiter–Saturn great conjunction will occur in 2238-2239!
- During triple conjunctions Mars and Jupiter or Mars and Saturn remain within 10° for 6 to 7 months and Jupiter and Saturn within 3° for 9 months.
- The relevant triple conjunction would the one between Jupiter and Saturn of the year –6 (= 7 BC).
- Kepler observed the conjunction of Jupiter and Saturn in 1603-04, which caused him to calculate back in time and to suggest that the one in 7 BC was the star of Bethlehem.

MUTUAL OCCULTATIONS AND COMPACT TWO-PLANET CONFIGURATIONS

Most fascinating is the possibility of a mutual occultation. For some time two planets will approach each other and finally merge. This will last only hours (and the total brightness will decrease during the occultation). But it would have profound astrological significance. These occultations are very rare; between 1570 and 2230 there are only 23 (including the outer planets Uranus, etc.).

There is none such an occultation in our lifetime, nor around the time of the birth of Christ. The most recent one occured in 1818 (Venus–Jupiter) and the next one will be in 2065 (also Venus–Jupiter). Both though occur close to the Sun on the sky.

The most interesting one in historic times to note is that of Neptune by Jupiter in 1613. Neptune wasn't known at the time, but Galileo was then observing Jupiter quite regularly. Indeed Neptune appeared in his drawings at least twice! But he failed to notice it as a new planet.

There is also the possibility of a close configuration (a close miss rather then an occultation). If the distance on the sky is only a few arcmin then the two planets may appear as one brighter object. This also will last only hours and is rather rare.

The following ones occured around the time of Christ's birth (12 BC to AD 7, visible from the Near East, separation $< 12'$, solar elongation $\leq 15°$).

Date	Planets	sep. ($'$)	elon. ($°$)	Time
Aug 12, 3 BC	Jupiter–Venus	12	21	Morning
Jun 17, 2 BC	Jupiter–Venus	3	45	Evening
Jun 3, AD 5	Mars–Saturn	11	57	Evening
Jun 16, AD 5	Mercury–Venus	9	21	Evening
Aug 11, AD 5	Mars–Venus	9	35	Evening
Mar 29, AD 6	Mars–Jupiter	12	23	Morning

CLOSE PLANETARY CONFIGURATIONS

These are important and noteworthy configurations, where three or more planets come together within a circle of only a few degrees. Again these last for only hours to a day at most and are relatively rare.

The following ones occured around the time of Christ's birth (12 BC to AD 7, visible from the Near East, within circle of diameter 3°, solar elongation $\leq$15°).

Date	Planets	diam. °	Elon. °
Jan 22, 12 BC	Mars–Saturn–Venus	0.8	18
Nov 5, AD 1	Jupiter–Mars–Mercury–Venus	2.7	17
Feb 14, AD 4	Jupiter–Mars–Mercury	1.4	25
Mar 29, AD 6	Jupiter–Mars–Mercury	3.0	24

A less spectacular case, which does have also astrological significance is a "massing" of planets. This is usually reserved to cases where the three naked–eye, outer planets (Mars, Jupiter and Saturn) are visible during the night in roughly the same constellation.

After the great conjunction of Jupiter and Saturn of 7 BC, the following year Jupiter, Saturn and Mars massed in the constellation Pisces.

LUNAR OCCULTATIONS OF PLANETS

These are not very unusual, but do have astrological significance. The planets disappears for a period up to a few hours behind the Moon.

There are two of interest:

- **March 20, 6 BC**. The Moon occulted Jupiter at about sunset with Moon–Jupiter still well above the horizon as seen from the Near East. It ended about half an hour later on the horizon.
- **April 17, 6 BC**. The Moon again occulted Jupiter, but now around local noon in the Near East, so it was invisible. But astrologers would know that it happened from calculations (Many reported astrological events of the time now appear to be calculations rather than observations). Furthermore, that same day was Jupiter's heliacal rising (Jupiter rose in the east just as twilight sets in; so the earliest visibility, astrologically in those times set as 12° from the sun). Moreover, the calculated occultation was located just above Bethlehem as seen from Jerusalem.

COMETS, NOVAE AND SUPERNOVAE

These are here lumped together because these cannot be predicted (or postdicted) for periods that far in the past. And all information comes from records of those days, mainly from China and some other Far Eastern countries.

- **Comets** are remains from the formation of the Solar System that reside in a spherical shell (the Oort Cloud) around the Sun at a distance of the order of 100 Astronomical Units (1 AU = the mean distance of the Earth from the Sun) and that are sometimes directed by gravitational disturbances from stars in the neighbourhood towards the Sun. They may be captured by the pull from the planets (mainly Jupiter) into periodic orbits for up to centuries. Eventually they will evaporate. New ones develop near the Sun a tail due to the radiation pressure of the Sun's photons, which is always roughly pointing away from the Sun.
- **Novae**. These are stars of moderate mass that in their late stages blow away parts of their outer parts. During this they increase their luminosity significantly for periods up to months. Some are recurrent, but with irregular intervals.

- **Supernovae**. This is the final stage of a massive star, when as a result of the multiplicity of nuclear reactions a run-away effect occurs that disrupts the star in a gigantic explosion that blows the outer parts into the interstellar medium. A supernova is a rare occurance in the Galaxy that may be visible to the naked eye only once every few centuries or so.

From ancient records the following ones are candidates in the period 20 BC – AD 10 (Ho Peng–Yoke catalogue):

- **Nr. 61**. This one was first visible on August 26, **12 BC** and remainded visible for 56 days. It can be traced as being Halley's comet.
- **Nr. 63**. This one was first seen in **5 BC** (exact date unknown, but between March 10 and April 7) and remained visible for over 70 days. It is described as a "sweeping star", so probably a comet. However, there is no mention of motion, so a nova is still a possibility. It was seen in Aquila.
- **Nr. 64**. First seen in April, **4 BC** and described as a comet.

SOLAR AND LUNAR OCCULTATIONS

Solar occultations occur when the Moon is on the line between the Earth and the Sun and when the Moon therefore blocks (part of) our view of the Sun. It is only visible from those selected places where the Moon casts its shadow on the Earth. It occurs during New Moon.

Lunar occultations occur when the Moon is in the shadow on the Earth. It is visible from any position on the Earth where at the time of the occultation the Moon is above the horizon. It occurs during New Moon.

Every year there are between 2 and 5 (average 2.5) solar eclipses visible from selected places on Earth and 0 to 3 (average 1.5) lunar occultations visible from many more places; in a year there are never more than 7 eclipses and never less than 3. A solar eclipse is *at a particular position* a rather unusual phenomenon due to the limited visibility, but a lunar eclipse is more usual from any place on Earth.

The next table lists the eclipses between 1990 and 2000; the visibility applies to Groningen.

Occultations or eclipses have long played a major role in astrology or as omens of bad or good happenings.

visible			not visible		
			26–01–1990	solar	part
09–02–1990	lunar	total			
			22–07–1990	solar	total
			06–08–1990	lunar	part
			15–01–1991	solar	total
			11–07–1991	solar	total
			21–12–1991	lunar	part
			04–01–1992	solar	total
			15–06–1992	lunar	part
10–12–1992	lunar	total			
			24–12–1992	solar	part
			21–05–1993	solar	part
			04–06–1993	lunar	total
			13–11–1993	solar	part
29–11–1993	lunar	total			
			13–12–1993	solar	part
10–05–1994	solar	part(0.47)			
25–05–1994	lunar	part			
			03–11–1994	solar	total
			15–04–1995	lunar	part
			29–04–1995	solar	total
			24–10–1995	solar	total
04–04–1996	lunar	total			
			17–04–1996	solar	part
27–09–1996	lunar	total			
12–10–1996	solar	part(0.63)			
			09–03–1997	solar	total
24–03–1997	lunar	part			
			02–09–1997	solar	part
16–09–1997	lunar	total			
			26–02–1998	solar	total
			22–08–1998	solar	total
			16–02–1999	solar	total
			18–07–1999	lunar	part
11–08–1999	solar	part(0.89)	11–08–1999	solar	total
21–01–2000	lunar	total			
			05–02–2000	solar	part
			16–07–2000	lunar	total
			31–07–2000	solar	part
			25–12–2000	solar	part

Astronomical phenomena; Candidates for the Star of Bethlehem

- *Triple conjunction of Jupiter and Saturn* in **7 BC** in Pisces. Closest approaches were on May 27, October 6 and December 1 with separations of very close to 1°. Kepler, after having witnessed the conjunction between these planets in 1603/04 was the first as far as we know to suggest this phenomenon as a an explanation of the star of Bethlehem.
- *"Massing" of Mars, Jupiter and Saturn* in **6 BC**, still in Pisces. Between February 18 and March 7 the distance between each two of these planets was less than 10°. The closest grouping was around February 25, when Jupiter and Saturn were just over 7° apart and Mars 4° further away. The triple could be seen after sunset.
- A *Lunar occultation of Jupiter* occured twice in **6 BC**, on March 20 and on April 17. The latter occured during daytime and coincided with Jupiter's heliacal rising.

- A *comet* appeared, according to Chinese records, in March, **5 BC** and was visible for over 70 days. It appeared in Capricornus and was first seen in the east before sunrise. Then it moved south.
- There was a *conjunction of Jupiter and Venus* on June 17, **2 BC**, which was very close. After sunset the two planets approached each other and came to $3'$ angular distance (only just separable to the naked eye) just before setting. A similar event of August 12, **3 BC** was less striking, but is still a candidate. Both events though are after the likely date of Herod's death.

Possible sequence of events

- **7 BC**. Magi (wise men, who must have been astrologers) in Persia (Babylon) saw the great conjunction in Pisces (astrologically associated with Israel).
  "A Messiah-King will be born in Israel".
- **6 BC**. Then followed the massing of the planets in the same constellation, while there were Lunar occultations of Jupiter. The planets were visible from Babylon in the western sky after sunset.
  "It will be a mighty King".
- **5 BC**. The comet in Capricornus confirms that the King has been born. Capricornus signifies the rebirth of the Sun (Tropic of Capricorn). Magi decide to travel to Jerusalem.
- **5 BC**. Travel form Babylon to Jerusalem will take one to two months. In Jerusalem Herod's advisors told them that the King should be born in Bethlehem according to Micah's biblical prophecy.
- **5 BC**. The comet was by then seen in the south before sunrise (the direction of Bethlehem from Jerusalem). Magi travel to Bethlehem. After returning to Herod they answered his question of the date of the star's appearance, which could be anything up to 2 years prior to that, so Herod decides to have boys under the age of 2 stain.

Chronology

- Birth of Jesus in the period March–April, 5 BC.
- Visit by shepherds in same period.
- Up to 2 months later visit by the Magi.
- Soon after flight to Egypt.
- Return to Nazareth after Herod's death (March, 4 BC).

DATE OF CRUCIFIXTION

Evidence

- Pontius Pilate was procurator of Judea between AD 26 and 36.
- Baptism by John occured in the 15^{th} year of Tiberius Ceasar (Luke); thus around AD 29.
- From events that can be dated and his own descriptions of time intervals Paul's conversion can be dated to probably AD 34.
- Last Supper was probably a Passover meal and Passover is on the day of full moon in the month Nissan. So the Jewish date must have been 14 Nissan. It could have been held 1 or 2 days earlier because of expected imminent arrest.
- Crucifixtion occured before the beginning of Sabbath, thus on a Friday. So 14 Nissan must have been a Friday.

- This leaves Friday **April 7, AD 30** and Friday **April 3, AD 33**. There is a (unlikely) possibility that due to introduction of "leap-months" Nissan occured a month later. The only viable date then is Friday April 23, AD 34.
- These arguments were essentially put forward first by Newton in 1733. He concluded on April 23, AD 34.
- The Bible reports that the Moon *"turned to blood"* after the crucifixtion. On **April 3, AD 33** there was a partial lunar eclipse, which was ongoing while the Moon was rising in Jerusalem.

Our best guess is that Jesus was born in the spring of 5 BC and died on April 3, AD 33.

Jesus then was around his 37^{th} birthday when he was crucified.