Galileo and the new star

In the spring of 1604, strange signs were seen in the heavens. Planets lined up repeatedly whilst an entirely new star burst forth into the skies, foxing the sky watchers of the time. What did it all mean? ***Nick Kollerstrom*** *has the answer.*

The new star of 1604 marked the beginning of Galileo's astronomical career. Image: Royal Astronomical Society Library

In the year 1604, Galileo was the mathematics lecturer at Padua in Venice. He had yet to make any public pronouncements on whether the Earth moved or that it might not be the centre of the cosmos. Every day, he had to teach his students that all the stars of heaven revolved around Earth.

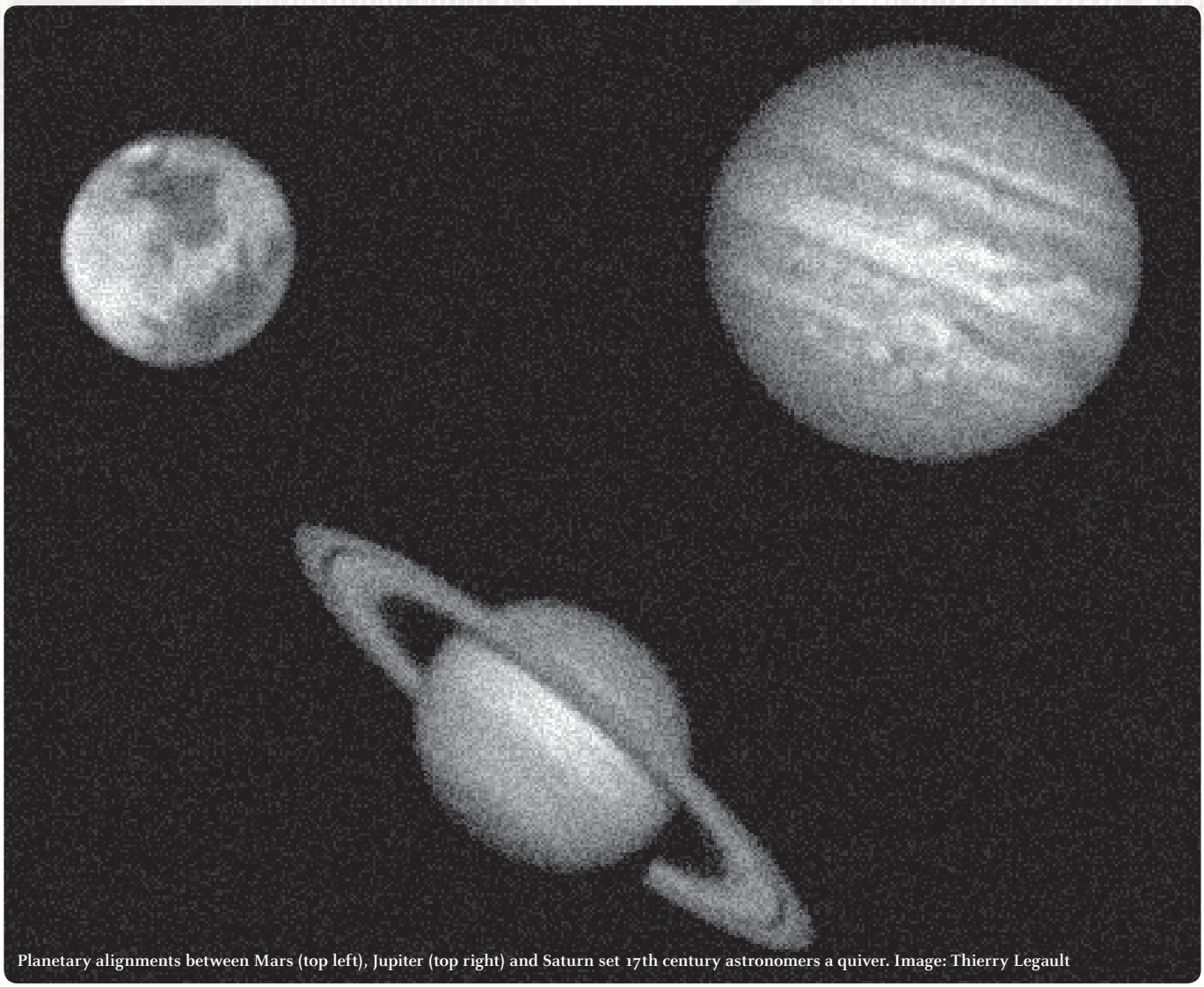
Also this year, Jupiter and Saturn met in the heavens as they do every twenty years, only this time they had done so thrice owing to Jupiter's retrograde motion (caused by Earth overtaking Jupiter, thus making it appear as if the giant planet spun in a little loop in the sky). This convergence of phenomena happens only once per century. Then, in the autumn, while the planets were separating, with Jupiter sidling into a meeting with Mars, a brand new star lit up. It did so in the constellation of Ophiuchus, and was just three degrees away from the ecliptic, adjacent to the spot where Mars and Jupiter had just met. Had the conjunction somehow engendered this new apparition?

The immutable heavens stood in contrast to the ever-changing realm of Earth. So, what did it *mean*, did it portend some great event? That was the urgent question, but Galileo was in no hurry to answer it. Was it God's angry eye, an omen of disaster? At last, Galileo gave a series of three public lectures on the subject at 'Il Bo' where more than three hundred packed into a hall to hear him. This was his public debut as an astronomer, with the lectures given in Latin. He gave a somewhat pagan twist to the event, by describing it as the offspring of Mars and Jupiter. A fragment of his lecture-notes remain:

"On the 10th October 1604 a certain strange light was first observed in the heavens. At first it was quite small, but soon it was visible even by daylight, surpassing in brightness all fixed and wandering stars with the exception of Venus. It was red as well as sparkling. It gave off waves of light, which seem both to kill and set aflame, more than any of fixed stars and the dog star itself [i.e., Sirius]. It had the splendid brilliance of Jupiter and the redness of Mars, which is like fire. The contractive quality of these terrible rays announced destruction, as if from the boiling redness of Mars, whilst the expansive quality of these rays gave forth Jupiter's bright lightning. It came forth as the due fruit generated by the intercourse of Mars and Jupiter. In almost the same position as the conjunction had been predicted the new star appeared to be born ... The star was located where previously no conspicuous star had been observed, except those three already mentioned [i.e. the three planets]."

These three planets, Mars Jupiter and Saturn, were the very outermost then known, beyond which was the sphere of the fixed stars. Galileo is describing the astrological-type qualities of the new star's radiance, as being both Martial (it announces 'destruction') and Jovial ('their expansive quality'), alluding to classical attributes of these two planets: 'Jupiter's bright lightning' alluded to the classical image of Jove as wielder of thunderbolts.

People were wondering, he explained, whether the new star existed as a true constellation of stars in the heavens, or whether it had merely been generated by 'vapour near the Earth?' He was far from confident of being able to resolve this weighty matter: 'By Hercules! That splendid desire of yours is worthy of the most superior intellects! Ah, would that my slight intellect could serve



Planetary alignments between Mars (top left), Jupiter (top right) and Saturn set 17th century astronomers a quiver. Image: Thierry Legault

the magnitude of the question and of your expectations! I despair of doing do.' These lectures were given two months after the New Star's appearance, as its brightness was gradually dimming. Could this be because it was moving away, or was Earth itself moving? These lectures were a triumph and cemented his unique position in Padua.

"It has no parallax for us on Earth
By reason of the sky's enormous girth"

He wrote later on, in a poem to the nova: it was a long way away.

Earlier new stars

Galileo's correspondent Ottavio Brenzoni pointed out to him that two earlier new stars had appeared in their lifetimes. 'Tycho's Star' of 1572 had lit up in Cassiopeia, and astronomers had agreed that that was not 'under the circle of the Moon' owing to its lack of any parallax detectable, but it was 'in the 8th heavenly sphere,' i.e. beyond all the planets. Brenzoni pointed out that only once in nine centuries did such a meeting of Mars, Saturn and Jupiter take place. He also alluded to the much weaker nova that appeared in Cygnus three years earlier. (This 1601 nova in Cygnus was merely 3rd magnitude).

Nowadays, many astronomers would happily sell close members of their family for the chance to study two supernovae in our own Galaxy (see *When is the next one due?*)

People were wondering... whether the new star existed as a true constellation of stars in the heavens, or whether it had merely been generated by 'vapour near the Earth?'

Jargon buster: parallax

This is the shift in the apparent position of a nearby celestial object with reference to the 'fixed' backdrop of stars, when measured at different times of the year. The Earth moving through its orbit and therefore looking at the celestial objects from a different angle causes the difference. The closer the object, the larger the parallax, which is why the nearer object appears to move further than the background stars. For a good example of parallax hold a finger up at arm's length and close one eye. Take a note of where the finger lies in relation to distant objects. Now swap eyes and notice how your finger seems to jump position: that's parallax!

More to explore:

Galileo, Supernova lecture Dec 1604, *Works*, Vol 2 pp275-85.
Galileo, Brenzoni letter, *Works*, 15 Jan 1605 No 115
James Reston *Galileo A Life* 1994 p64-71.
Barry Hetherington *A Chronicle of Pre-Telescopic Astronomy* Wiley 1996. (includes the nova in Cygnus in 1601, as well as the 1572 and 1604 novae).

Kepler sees the new star also

Galileo was not alone in seeing the new star. Johannes Kepler also observed the striking celestial event and, as ***Nick Kollerstrom*** *explains, it is Kepler that is more closely associated with the supernova.*

The new star was a supernova, lighting up close to the centre of our Galaxy. Kepler's fine diagram of Ophiuchus shows the mythic figure with his foot just above the Galactic centre – though of course no one knew that at the time. Obviously one for a challenge, Ophiuchus is grappling with a huge serpent – and stepping onto the Scorpion! The New Star was, in Kepler's words *in pede Serpentaris*' – in the right foot of the Serpent-Bearer.

The sky-map Kepler used represents the ecliptic as a straight line, and the latitude-lines become progressively more curved as they move away from that. Both feet of Ophiuchus are on the ecliptic, with the New Star in the right foot. Kepler used the new diagram of Johann Bayer from his Uranometria of 1604, but mysteriously turned the figure of Ophiuchus around. Indeed, there is some disagreement between star-maps over whether the back or front of Ophiuchus should be facing us. It is also interesting to note that, although Ophiuchus has never been a traditional zodiacal constellation, the planets do move through his feet, passing from Scorpius to Sagittarius.

Johannes Kepler, after whom the 1604 supernova is named. Image: Royal Astronomical Society.

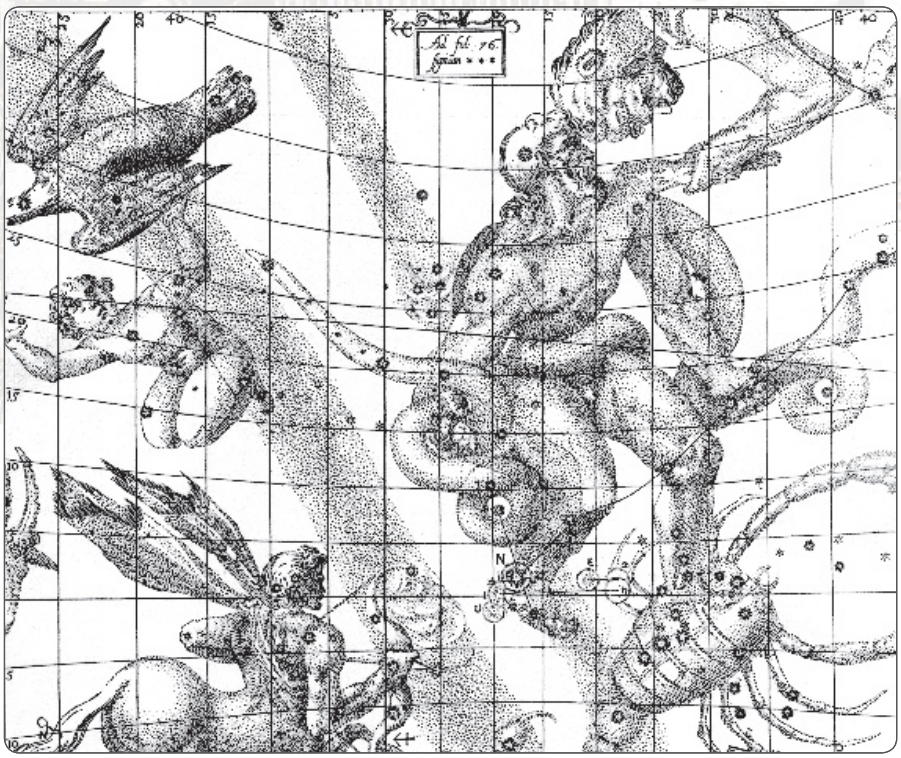
Siting the supernova

Kepler's diagram shows the supernova located within the Milky Way and a few degrees due North of the ecliptic. Next to it are ringed positions where Jupiter, Saturn and Mars had been, at the time of its appearance. But, as Galileo had noted as well, this particular Jupiter-Saturn meeting was especially important. The two planets meet every twenty years, at positions that move around the zodiac to make a triangle.

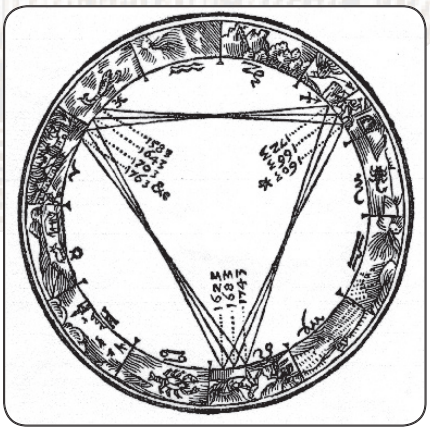
Such a triangle tends to remain within one 'element' of the zodiac. The three 'fire-element' signs were Aries, Sagittarius and Leo and they form a triangle in the zodiac. It happened that, as the triangle of Jupiter-Saturn conjunctions slowly moves round the zodiac, it transitions once per two hundred years into a new element. There was an Arab tradition that its entry into the fire-element triplicity, as happened once per eight hundred years, was especially important.

This transition was taking place in Kepler's time: the 1604 conjunction had been in the fire-sign of Sagittarius, whereas the previous one, twenty years earlier, had been in the watery sign of Pisces.

But, hang on! Kepler didn't believe in the zodiac. He said so: it was just superstition and not part of nature. He was a minimalist astrologer who thought he could throw out a whole lot of its traditional superstition. What makes his work on the supernova so interesting is that this was the one time when he did demonstrate some belief in the zodiac, at least in terms of the measuring out of these long cycles of time. Perhaps this was motivated out of his deep respect for Tycho Brahe in whose steps he was following as the Imperial Mathematician.



The large constellation of Ophiuchus represented the figure of Asclepios the demi-god healer of Cos, according to the Greek myth. But the serpent he holds is a bit too large to represent the snakes that were used in Greek healing-temples. Kepler turned round the figure (compared to the earlier image by Bayer) so that the new star appeared in the right foot not the left: the picture of Ophiuchus published by Flamsteed a century later was quite similar to Kepler's. Image: Royal Astronomical Society.



The two slowest-moving planets were Jupiter and Saturn. Their meetings in the sky were known as chronocrators and taken to measure out cycles of time in history. This diagram shows their sixty-year pattern (comprising three conjunction every twenty years or so, which forms a triangle). Kepler has re-designed the traditional images for the zodiac signs in this diagram, relating them to the seasons of the year and to the elements that were traditionally associated with them.
Image: Royal Astronomical Society.

A dim new star appeared in the neck of Cygnus in 1601, discussed in Kepler's *De Stella Nova* of 1606. In modern terms it was a nova not a supernova. Image: Royal Astronomical Society.

Brahe boldness

Brahe had prophesied that this motion of the 'chronocrators' as they were called (the twenty-year pattern of conjunctions) into the fire-trigon in the coming new century, meant some great new restoration of things.

Using this eight-hundred-year cycle, Kepler wove out an argument that linked his time to that of the birth of Jesus, by two steps of this cycle. A new star had appeared then, and maybe its date had been near to that of the Jupiter-Saturn conjunction of 7 BC? That conjunction was triple, i.e. Jupiter and Saturn had passed by each other thrice on the ecliptic, as happens once a century on average. Kepler assumed that the Star of Bethlehem was a new star somewhat as he had seen. The cycle is slightly less than eight centuries and would have brought him to the AD 14 conjunction; but Mars, too, was close and he found out that this happened every eight centuries and had also happened in 6 BC, i.e. the three planets were then close together as they were in 1604.

Kepler saw the hand of Divine Providence in all these things and urged his readers to examine their sins and repent.

Far, far away

The new star was very far away, indeed it belonged in the heavenly sphere of fixed stars. Kepler wrote about the event in his influential work *De Stella Nova* of 1606.

But what did it mean? Like Galileo, Kepler was hesitant about giving an answer to this question that everyone expected from him, as the Imperial Mathematician to Rudolf II, Holy Roman Emperor. Tycho Brahe, his great predecessor, had looked forward with great optimism to this event, the start of a new eight-century cycle, as the start of a new age in history, this being only the sixth time this had happened. He, too, had seen a new star lighting up in the sky in 1572 to prophesy about, and so had given people cause to look forward to the new century. But, as the new century arrived, the storm clouds of what was to be the Thirty Years' war were brewing, and it was rather harder for Kepler to be optimistic about things.

Part of his *De Stella Nova* concerned another new star that had lit up in the neck of Cygnus (the Swan) in 1601. It was 3rd magnitude, i.e. not nearly so bright as the nova of 1604 and now known to have been a nova rather than a supernova.

There is a lot in this section of Kepler's work about his eschatology, i.e. how providence worked through history, via Jesus and Charlemagne (the next stop in the 800-year cycle) up to his own time. So, to a large extent, his approach to astrology involved renouncing prognostication, i.e. the claim of a privileged access to knowledge of the future, and instead he looked at the cycles of time whereby history was unfolding.

Soon, the supernova of 1604 became known as 'Kepler's Star'.

Jargon buster: The heavenly spheres

To each planet belonged a 'sphere', which was concentric upon Earth and possessed of several motions. As well as all revolving once per day, they also had specific motions in the other direction e.g. Saturn's sphere as the outermost of the planets moved round once in thirty years. The Sun and Moon each had their own sphere, and that of the Moon was the closest to Earth. The speed of rotation of the spheres decreased with their distance from Earth, from the Moon as the fastest moving to that of Saturn the slowest. Beyond these was an immutable sphere where all the fixed stars were located. Poets sometimes described them as crystal spheres but no astronomers did; in Dante for example they are made of fine Ether, some kind of heavenly substance that was immutable. Kepler located the new star on this final, fixed sphere.