

Tycho's Star and the supernov

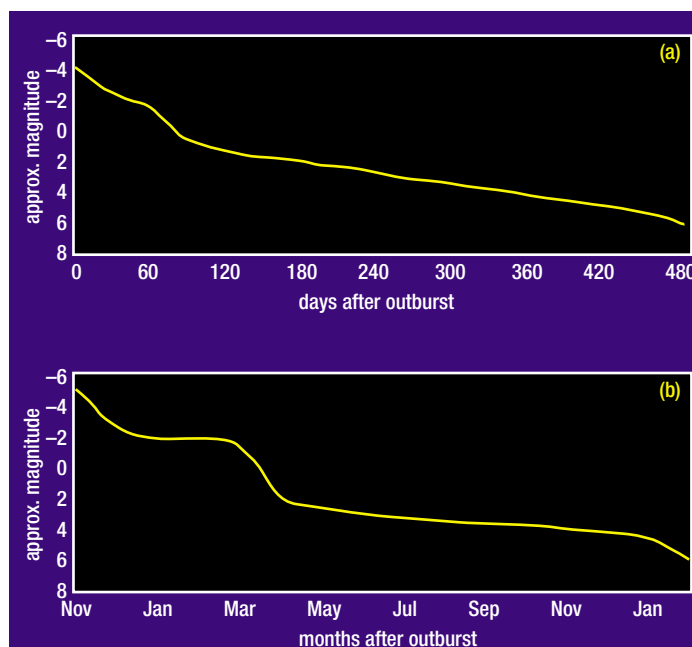
The discovery in the library of Manchester Astronomical Society of a first impression of John Bevis's *Uranographia Britannica* has led to a reappraisal of these early observations. In particular, his observations of Tycho's Star suggest a new interpretation of the supernovae responsible.

Kevin J Kilburn describes how a recently discovered 18th century star atlas can shed new light on old supernovae.

In November 1997, an old star atlas was found in the library of the Manchester Astronomical Society. With the help of the RAS librarian, Peter Hingley, it was identified as a rare copy of John Bevis's unpublished work, *Uranographia Britannica* (London, c.1750). Original imprints of the star charts, all that remained in October 1749 after the bankruptcy of John Neale (Bevis's bankroller and publisher), were sold at auction in 1785 after the death of Bevis's executor and fellow member of the Royal Society, James Horsfall. In 1786, the anonymous purchaser then sold bound sets of the star charts, some incomplete, as *Atlas Celeste*. Manchester's copy of *Atlas Celeste* is one of fewer than 20 copies and it is the most complete of these "ghost books".

After the discovery, the Manchester Astronomical Society bought a modern facsimile of *Atlas Celeste*, a compilation of several incomplete Bevis atlases. This atlas, probably one of only three almost complete atlases compiled before Neale's bankruptcy in 1749 and auctioned in 1785, contains one of only two surviving sets of catalogues and tables that Bevis intended to accompany his star charts – the other set is in an atlas owned by Cambridge University. Over the past three years, I have found that Bevis's work contains several points of interest that may be unfamiliar to the astronomical community, as seemed to be the case during the IAU General Assembly in Manchester last year. For example, one early line of investigation was that Bevis could have independently observed Uranus in 1738: there is circumstantial evidence – although no proof.

Here I present findings regarding Bevis's



1: Two light curves for Tycho's Star, observed in 1572. (a) Walter Baade's interpretation of Tycho's data, made in 1945 and cited in *The Historical Supernovae*, by Clark and Stephenson. (b) The new light curve based on Bevis's observations.

supernovae. Four historical supernovae and several novae are shown in *Uranographia* although Bevis did not know that these objects had a similar origin. To him they were either unresolved nebulae or "extinct stars"; what we would now call novae, or bright variables, no longer visible. Perhaps he included them in *Uranographia* in case they reappeared.

In 1731, Bevis discovered the Crab Nebula, perhaps the most famous supernova remnant. Charles Messier did not make his own independent discovery until 1758, giving it the now-familiar designation of M1. The precedence was brought to Messier's attention: Bevis sent him a proof copy of *Uranographia* some time before Messier published his first list (*Mémoires de l'Académie* 1771). Although not published in or around 1750 as intended, *Uranographia* was the first major star atlas to depict the Crab Nebula.

Kepler's Star of 1604 was not included in the final version of the atlas, nor is it referred to in the star catalogue, but it is spectacularly shown on the one remaining proof copy of the Scorpis plate, now in the map collection of the British Library (ref. C.21. e.8). Cassiopeia A is also there. There is a 6th magnitude star on the Cassiopeia plate where no star now exists. Flamsteed, on whose star positions much of Bevis's *Uranographia* is based, apparently catalogued this object and it is listed in Bevis's accompanying catalogue.

The star is shown slightly north of, but very close to, the present position of Cassiopeia A. Little is known about the outburst that created the radio emitting Cass A supernova remnant. It is thought that its light was attenuated by

interstellar dust and that the supernova reached only 5th or 6th magnitude. Perhaps this is what Flamsteed recorded, in which case the outburst may have occurred between about 1685 and 1715, when he was compiling his observations. This is consistent with modern theory that suggests an explosion approximately 300–350 years ago.

Tycho's Star

Tycho's Star is depicted as a large, brilliant object in a large-scale plate of Cassiopeia, but what is particularly intriguing is a half page of the Bevis star tables, facing the Cassiopeia plate, with a remarkably detailed description of the 1572 outburst (given in the box, above right). Using Bevis's notes and modern astronomy software, it is easy to draw a light curve of Tycho's Star throughout the 16 months that the supernova was visible. Magnitude comparisons described in his text could indeed have been made directly against planets and stars visible at the times stated. Bevis's text also suggests a potentially different interpretation of the physics of this supernova.

In 1945, Walter Baade at Mt Wilson Observatory used Tycho Brahe's observations to draw a SNI light curve for the supernova. This is still regarded as its standard interpretation. However, according to Bevis, the light curve went through a distinct plateau during the initial decline, before a steady and shallow descent into obscurity. This is more characteristic of Type II-P supernovae, the collapse of the iron core of a super-massive star. The colours, initially brilliant white and changing to the rosy hue of a dying star, may also be

ae of *Uranographia Britannica*

Tycho's Star according to Bevis

In the year 1572, a phaenomenon arose in this constellation [Cassiopeia], so very extraordinary, as greatly to excite the curiosity of the astronomers, and the amazement of all beholders. It was a star, which seemed to have blazed out all at once with prodigious splendour. Wolfgangus Schulerus was perhaps the first among the astronomical Literati, who happened to cast his eye upon it, the 6th of November, about 6 o'clock in the morning, at Wittenburg, and believed it to be a comet. He attempted to find its position in the heavens, but his observations were very inaccurate. It was seen by Paulus Hainzelius at Ausberg, on the 7th, and Cornelius Gemma saw it at Lovain on the 9th, Tycho Brahe saw it not before the 11th of November, in the evening, after sunset, at Copenhagen, not far from the zenith, and was so surprised at the sight, that he could hardly believe his eyes.

Hieronymus Munosius, according to Gemma's translation of his book, which was written in Spanish, says, he was very certain, that it was not yet visible on the 2nd of November, both from the answers of several shepherds whom he interrogated about it, and because himself that very night shewed the stars of the Chair to his pupils at Valentia, where he was professor of mathematics, without perceiving any such thing. The same Gemma elsewhere, 'tis true, endeavours to prove, that some people saw it about the end of October; but his argument rests upon vague popular rumour only, in contradiction to Munosius, and also to himself; for, in his first account, he asserts, that it had never been seen by any before the 9th, when he saw it himself, as above. Tycho conjectures that it might begin with the new Moon on the 5th: But it is uncertain if anyone saw it at the instant of its first effulSION.

It continued for the space of 16 months, in the same point of the heavens, and formed a rhombus with the stars α , β and γ of this constellation.

During several days of its first apparition it was exceedingly brilliant, surpassing Jupiter, and even Venus, almost when brightest; so that it was many times visible, during the month of November, in

broad day. In December its lustre began to abate a little, and it looked pretty like Jupiter. In January 1573 it was discernibly less than Jupiter, but still more conspicuous than the stars of the first magnitude, even than Sirius, to which it seemed equal in February and March. In the next two months it exceeded not the stars of the second magnitude, and kept daily diminishing. In June, July and August, it was of the size of the larger stars of Cassiopeia, reckoned then not to exceed the third magnitude. In September, October and November, it looked as of the fourth magnitude. In the beginning of December it was esteemed to be rather less than the star near it, marked κ in Bayer. The latter end of this year, and the beginning of the next, it still a little exceeded the stars of the fifth magnitude. It remained just visible to the latter end of February, 1574. In March it was entirely extinct.

Its light, for many days after it first appeared, was white and sparkling; then it inclined a little to the yellow; and in the Spring of 1573 it was a copper red, like that of Mars, the right shoulder of Orion, or Aldebaran. In the month of May it became of a pale white, much like that of Saturn, which complexion this phaenomenon retained as long as it afterwards continued visible, except that a few days before it quite vanished, it had something of a muddy intermixture; but it had a plain scintillation to the very last.

Above twenty astronomers employed their pens about this extraordinary star, and particularly Tycho, in an excellent work, entitled De Nova Stella Anni 1572; wherein, from accurate observations, he has determined its place in the Ecliptic as [longitude] 6° 54', with 53° 45' north latitude. Its distance from the north pole being little more than 13 degrees, it was inocciduous [circumpolar] throughout Europe; and Tycho often took its meridian altitude, both above and below the pole, with very nice instruments. He found it, in all positions, to keep the same distance from the Pole Star, and several others; whence he justly concluded it to be absolutely exempt from parallax, and that it was placed beyond any of the planets, in the region of the fixed stars.

consistent with the HII-rich shell of an expanding and slowly fading SNa II-P outburst.

Here is my summary and interpretation of what Bevis says of Tycho's Star. At its first appearance, the star was brighter than Jupiter and as bright as Venus. On the morning of 6 November 1572, Venus was shining at magnitude -4.6 , opposite Cassiopeia in the sky and at the same altitude as the supernova. Through November the star was visible in daylight. It faded a little in December, to match Jupiter, which was then at magnitude -2.3 . The star was losing its brilliance and becoming cream-coloured. In January 1573 it became less bright than Jupiter, but brighter than Sirius, and it matched Sirius for February and March. Jupiter was still well placed in the evening, shining at -2.2 during January. Sirius and the stars of Orion and Taurus were also available for comparison. Even allowing for atmospheric extinction, Sirius had an apparent magnitude in negative figures during February and March. The nova maintained comparability

with Sirius during this time. It was also deepening in colour through yellowish to red.

From April to May the star became around second magnitude and faded daily. There fading must have been very rapid if it was discernable on a day-to-day basis. As its brightness faded through June, July and August, the star lost its red colour and became dirty white.

September, October and November saw it as a 4th magnitude star and at the start of December, Bevis put its magnitude at the same as κ Cass, magnitude 4.2. It then faded to around 5th magnitude and vanished in March 1574.

The new light curve is shown alongside Walter Baade's interpretation cited in *The Historical Supernovae*, by David Clark and F Richard Stephenson. Stephenson (pers. comm.) concurred that it is not known from where Bevis obtained all his information, although it is possible that it was another section of Tycho's *Astronomiae Instauratae Progymsmata*. Stephenson agrees that the Sirius comparisons cited by Bevis are important and ought to be

included in future study of the light curve.

At the time of his death on 6 November 1771, 199 years to the day since the discovery of Tycho's Star, Bevis's remarkable star atlas was still unknown except to a very few. Even in 1786, with the sale of the enigmatic "ghost books", few astronomers would have access to his magnificent work, whose obscurity has continued to the present. Only 300 years later can we begin to appreciate its importance. ●

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