The Historical Supernovae

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Abstract. The available historical records of supernovae occurring in our own Galaxy over the past two thousand years are reviewed. These accounts include the well-recorded supernovae of AD 1604 (Kepler’s SN), 1572 (Tycho’s SN), 1181, 1054 (which produced the Crab Nebula) and 1006, together with less certain events dating back to AD 185. In the case of the supernovae of AD 1604 and 1572 it is European records that provide the most accurate information available, whereas for earlier supernovae records are principally from East Asian sources. Also discussed briefly are several spurious supernova candidates, and the future prospects for studies of historical supernovae.

1 Introduction

The investigation of observations of Galactic supernovae is very much an interdisciplinary exercise, far removed from the usual course of scientific endeavour. It seems well established that no supernova has been observed in our own Galaxy since AD 1604. Hence for reports of Galactic supernovae it is necessary to rely entirely on observations made with the unaided eye. It is fortunate that early astronomers recorded several of these events – along with many other temporary ‘stars’, such as comets and novae. As might be expected the quality of these early observations is very variable. In the case of the two most recent Galactic supernovae, in AD 1604 and 1572, European astronomers measured the positions with remarkable precision – to within about 1 arcmin – and the changing brightness was carefully recorded. However, in earlier centuries the available observations are of lesser quality. Nevertheless, sightings of three supernovae have been confidently identified from medieval East Asian records, while three more ancient supernovae have also been proposed.

Here we review the available historical records of supernovae occurring in our own Galaxy over the past two thousand years or so. Studies of potential supernovae from the various historical records will be concentrated on those new stars which were said to be visible for at least three months. This restriction eliminates most novae and also considerably diminishes the possibility of the object being a comet. More detailed discussions of these historical supernovae are presented in [1,2].

In Sect. 2 the available historical records – from East Asian, Europe and the Arab Dominions – of the well-recorded supernovae of AD 1604, 1572, 1181, 1054 and 1006 are discussed. Other probable supernovae occurring before AD 1000, from Chinese records, are discussed in Sect. 3, with less convincing possible, and spurious historical supernova discussed in Sect. 4 (including the suggestion that the supernova that produced the young SNR Cas A was seen by Flamsteed in AD 1680). Table 1 presents a summary of the well-recorded and probable historical supernovae seen in our Galaxy,
including the sources of historical records. Finally, the future prospects for studies of historical supernovae are briefly discussed in Sect. 5.

Table 1. Summary of the historical supernovae, and the source of their records

| date     | length of visibility | remnant       | Historical Records |
|----------|----------------------|---------------|-------------------|
|          |                      |               | Chinese | Japanese | Korean | Arabic | European |
| AD1604   | 12 months            | G4 5+ 6 8    | few     | –        | many       | –     | many   |
| AD1572   | 18 months            | G120 1+2 1   | few     | –        | two        | –     | many   |
| AD1181   | 6 months             | 3C58          | few     | few      | –          | –     | –      |
| AD1054   | 21 months            | Crab Nebula   | many    | few      | –          | one   | –      |
| AD1006   | 3 years              | SNR327.6+14.6| many    | many     | –          | few   | two    |
| AD393    | 8 months             | –             | one     | –        | –          | –     | –      |
| AD386?   | 3 months             | –             | one     | –        | –          | –     | –      |
| AD369?   | 5 months             | –             | one     | –        | –          | –     | –      |
| AD185    | 8 or 20 months       | –             | one     | –        | –          | –     | –      |

2 Well-defined historical Supernovae

2.1 Kepler’s SN of AD 1604

The new star which appeared in the autumn of AD 1604 was discovered in Europe on Oct 9, and first noticed only a day later in China, and by Korean astronomers on Oct 13. The supernova, which remained visible for a whole year, was extensively observed by European astronomers, including Johannes Kepler, and this SN is often referred to as Kepler’s SN. Chinese and Korean astronomers kept a regular watch on it, and valuable systematic Korean reports over many months are still preserved, as well as occasional Chinese records. There are no known Japanese or Arab accounts of this star. The European positional measurements are far superior to those from East Asia (approximately 1 arcmin precision as compared with 1 degree). Favourable circumstances assisted the discovery of the supernova, as it was only about 3 degrees to the north-west of the planets Mars and Jupiter, which were then in conjunction. This conjunction was carefully watched by European astronomers in early October of AD 1604, and was also recorded in China. The peak brightness of the supernova probably did not occur until late October, so that the supernova was detected well before maximum.

Chinese observations of the supernova are found in two approximately contemporary sources: three records in the annalistic Ming Shenzong Shilu, and a single record in the dynastic history the Mingshi. The guest star was first detected in China on AD 1604 Oct 9 and was finally lost to sight on AD 1605 Oct 7. Although the guest star was not sighted in Korea until Oct 13 it attracted considerable attention there. An almost day-to-day record of the Korean observations of the star over the first six months of visibility is available, and the regular estimates of brightness parallel the European observations – see Fig. 1. Nearly one hundred separate observations of the guest star are reported in the Sonjo Sillok. Several brief accounts of the new star are also to be found in the Chungbo Munhon Pigo, a compendium dating from AD 1770.
The most important contemporary European work on the supernova is Johannes Kepler’s *De Stella Nova in Pede Serpentarii* which was published in AD 1606 (the more familiar name for *Serpentarius* is Ophiuchus). Other European accounts of the star are to be found in a wide variety of sources (see [3]). The most important aspects of the European observations are the accurate position of the star measured by Kepler and its changing brightness over the twelve months of observation.

We can be fairly confident that AD 1604 Oct 9 was the date of discovery because several European astronomers, observed the conjunction of Mars and Jupiter on Oct 8 and did not notice anything remarkable. Due to poor weather, Kepler did not start observing the supernova until Oct 17. He measured the angular distance between the new star and several planets and reference stars using a sextant. Several European astronomers estimated the brightness of the supernova in the days leading up to maximum. It can probably only be concluded that the brightness considerably exceeded that of Jupiter, with peak magnitude close to $3.0$. Although Kepler’s SN has been identified as type I in the past – on the basis of its light curve from the historical observations – this classification cannot be justified, as the light curves of some type I and type II SN can be quite similar (see also [4]). With an estimated date of peak brightness of approximately Oct 28 in AD 1604, the supernova was detected nearly twenty days before maximum. Using the calculated position for the new star from Kepler’s observations, Baade [3] was able to locate the remnant as a patch of optical nebulosity with the 100-inch reflector at Mount Wilson. Subsequently the remnant – G4 5+6 8 – has been revealed as a limb-brightened ‘shell’ supernova remnant at radio and X-ray wavelengths.
2.2 Tycho’s SN of AD 1572

The supernova which appeared in the constellation of Cassiopeia during the late autumn of AD 1572 was compared by observers in both Europe and East Asia with Venus, and was visible in daylight. Since the most detailed observations of the supernova in Europe were made by Tycho Brahe, this supernova is often referred to as Tycho’s SN.

Five Chinese records of this supernova are preserved, two in the same sources as the observations of the supernova of AD 1604: the Ming Shenzong Shilu and in the astronomical section of the Mingshi. Further brief mentions occur in the biographical section of the Mingshi and also the Ming Shiwa, the draft version of the Mingshi. A fifth account is in the Yifeng Xianzhi, a provincial history. Only two brief Korean reports of the AD 1572 star are available. The guest star of AD 1572 was discovered in Korea on Nov 6 and sighted two days later in China. Noticeably fading by AD 1573 March, the star finally disappeared from sight some time between Apr 21 and May 19 in AD 1574. The duration of visibility was thus about 18 months. Chinese records assert that the star was visible in daylight, while in Korea its brightness was compared with Venus. The position of the supernova is not defined very precisely by the East Asian records, but it is notable that its position is marked on at least two independent Chinese star charts.

The supernova was probably detected in Europe by Maurolycus, abbot of Messina, on AD 1572 Nov 6 (if not a day or two earlier). It was first observed by Tycho on Nov 11 (although he remained sceptical of the star’s existence until he had questioned both the servants who were with him and passers by). Tycho immediately realised this was a new star, and “began to measure its situation and distance from the neighbouring stars of Cassiopeia and to note extremely diligently those things which were visible to the eye concerning its apparent size, form, colour and other aspects”. Over the following year he was to make many measurements of the angular distances of the star from the nearby stars of Cassiopeia, and also determined its distance from Polaris. The accurate observations by Tycho Brahe and others, which established the fixed nature of the star, have proved of great importance to modern astronomers in a different guise: fixing the precise location of the supernova to within a few arcminutes. Tycho concluded that the new star was situated far beyond the Moon and among the fixed stars. Hence the supernova contravened the widely accepted Aristotelian doctrine that change could only occur in the sub-lunar region. Virtually all the important European observations of the supernova are contained in Tycho’s Astronomiae instaurate progynasmata (‘Essays on the new of astronomy’), published in AD 1602. From Korean and European comparisons of the supernova with Venus, it seems that the peak magnitude of the supernova was around \(4^m\). Tycho was evidently the only astronomer to carefully watch the decline in brightness of the new star. In the months after discovery he successively compared it with Jupiter, then stars of fainter magnitudes.

The remnant of Tycho’s SN was first tentatively identified in 1952 [5], when a radio source was found near the then available position for the SN. This was subsequently confirmed by later radio observations, which also led to the identification of the faint optical nebulosity associated with the radio source (Minkowski, private communication in [6]). At radio and X-ray wavelengths this remnant – often called either 3C10 or G120 1+2 1 – shows a limb-brightened shell \(8\) arcmin in diameter.
Fig. 2. Detailed account of the supernova of AD 1181 from the Wenxian Tongkao, which was compiled about a century after the supernova

2.3 The SN of AD 1181

The new star of AD 1181, which was extensively observed in both China and Japan, was seen for fully six months. Such a lengthy duration of visibility in the various historical records is indicative of a supernova. There are three Chinese records of the new star of AD 1181, from both the North (Jin) and South (Song) Chinese empires in existence at that time, and five Japanese accounts. None of these sources report any motion of the star. The most detailed surviving Chinese account of the guest star is found in the Wenxian Tongkao (‘Comprehensive study of civilisation’), an extensive work compiled around AD 1280 – see Fig. 2. This account clearly states that the star was first seen on AD 1181 Aug 6, and was visible for 185 days in total. There is also some valuable positional information in the record, giving the approximate location of the guest star, and describing it as guarding the fifth star of the Chuanshe asterism. The Japanese records of this guest star come from a variety of sources, including a retrospective account of the star (and also the new stars of AD 1054 and AD 1006) written in AD 1230. The date of discovery of the guest star in Japan is one day after its discovery in South China. Other Japanese accounts of the star occur in various histories, and in diaries of imperial courtiers. Unlike the Chinese accounts, there are no estimates of the
full duration of visibility of the guest star in the available Japanese accounts, although one states it was still visible two months after discovery.

The guest star was said to ‘invade’ the Chuanshe asterism, and to guard the fifth star of that asterism. The identification of the fifth star with SAO 12076 was proposed by Liu Jinyu [7], in which case the position of the SN can be deduced as within about 1 degree of SAO 12076: equivalent galactic coordinates are $l = 130^\circ$, $b = +3^\circ$. This position is close to the radio source 3C58 (G130 $^\circ$ 7 + $^\circ$ 3), which was first proposed as the remnant of this guest star in 1971 [8]. 3C58 is a ‘filled-centre’ supernova remnant, in which a pulsar with a period of $65.58$ ms has recently been identified (see [9]).

2.4 The SN of AD 1054 that produced the Crab Nebula

The Crab Nebula, which has been known optically since the early 18th century, was first suggested as the remains of the Chinese guest star of AD 1054 in the 1920s (see [10,11]). A substantial number of records of the guest star, from both China and Japan, were later assembled by the Dutch sinologue Duyvendak in 1942 [12], since when the Crab Nebula has generally been recognised as the remnant of the oriental guest star of AD 1054. The Crab Nebula is one of few Galactic SNRs which are known to contain a pulsar – which is extremely important for explaining the energetics and structure of the whole SNR – and is the prototype of the class of ‘filled-centre’ SNRs. The nebula was first identified as a source of radio waves in 1963 and in X-rays in 1964, while the discovery of a pulsar within it in 1968 attracted huge interest internationally. No other supernova remnant has achieved such notoriety, or been the subject of so many research papers.

There are many Chinese records of the guest star of AD 1054. It was first sighted in China at daybreak in the eastern sky on AD 1054 Jul 4 and remained visible until AD 1056 Apr 6. Three records of the guest star from Japan are known, apparently from two independent sources. As noted above, one Japanese record, from AD 1230, also includes discussions of the guest stars of AD 1006 and 1181. Both Chinese and Japanese sources agree that the guest star appeared close to Tianguan, which is identified with $\zeta$ Tau. There is no hint of any motion; on the available evidence, the guest star remained fixed for the whole of the very long period of visibility. In noting that the star was visible in daylight (probably for 23 days), Chinese astronomers compared it with Venus. Japanese observers compared the brightness with Jupiter, again implying a brilliant object.

It is also likely that this supernova was recorded in Constantinople. Ibn Butlân, a Christian physician, provides a brief record of a new star seen at this time. Although there have been some suggestions that there are European records of the supernova of AD 1054, there appears to be no definite report of it from Europe. It has also been suggested that this supernova, which was close to the ecliptic, is recorded in cave paintings in the American south-west which depict a crescent close to a circle or star symbol. However, only a very approximate date range can be deduced for the paintings (tenth to twelfth centuries AD), while only one of the pictures shows the correct orientation of the crescent relative to the new star. If the paintings are indeed astronomical, which is open to speculation, they might possibly represent one or more close approaches of the Moon to Venus over the estimated date range of some two centuries.
2.5 The bright SN of AD 1006

The new star which appeared in AD 1006 was extensively observed in China and Japan, and was also recorded in Europe and the Arab dominions. The various records indicate that the star was of extreme brilliance and had an exceptionally long duration of visibility – several years.

The reports from China are by far the most detailed, giving not only a fairly accurate position, but also demonstrating that the new star was certainly seen for at least three years. Chinese observations are preserved in a wide variety of sources, including dynastic histories, chronicles and biographies. The new star was independently sighted in Japan, where it was consistently described as a *kexing* or ‘guest star’ in several independent reports. Discovery in both China and Japan took place on AD 1006 May 1. Chinese records indicate that the star remained visible until some time during the lunar month between Aug 27 and Sep 24, when it set heliacally. However, Japanese reports may imply visibility to Sep 21. After recovery in China on AD 1006 Nov 26, the star was seen until the following autumn (between Sep 14 and Oct 13 in AD 1007), when it was lost to view in the evening twilight. The star was evidently sighted again at dawn some time toward the end of AD 1007, or the beginning of AD 1008, and – after a further conjunction with the Sun near the end of AD 1008 – was apparently still visible well into the year AD 1009. In China, the extreme brilliance of the star was emphasised in several ways: it was “huge like a golden disk”, “its appearance was like the half Moon and it had pointed rays”; “it was so brilliant that one could really see things clearly (by its light)”.

In Japan, the only direct brightness comparison was with the planet Mars, although the fact that the new star made such a profound impression on the imperial court suggests that it was a remarkable sight.

Brief Arab reports of the new star are preserved in chronicles from several regions: Egypt, Iraq, north-west Africa or Spain, and Yemen. The most likely date for the discovery of the new star in the Arab dominions is AD 1006 Apr 30, one day earlier than in China and Japan. Furthermore several Arab records suggest that the star disappeared around Sep 1, a few weeks before it ceased to be reported in Japan. Two accounts from Europe – in the chronicles of the monasteries at St Gallen in Switzerland and at Benevento in Italy – clearly refer to the new star, the former source indicating that it was visible for three months. Several other annals note the occurrence of a ‘comet’ in or around AD 1006. Since there is no notice of a comet in Chinese history around this time, it may be presumed that the European chroniclers also referred to the new star but had no separate term to describe a brilliant star-like object. The St Gallen record mentions frequent interruptions in visibility, which imply that the star no more than skimmed the southern horizon; this provides a valuable declination limit for the position of the supernova.

The identification of the likely remnant of this SN was made in 1965 [13], when a search was made of radio catalogues covering part of the region for the SN from the historical observations. The radio source PKS 1459 51 – also known as MSH 14 4/5, or G327 4+14 6 from its Galactic coordinates. Subsequent improved observations confirmed this as the remnant, when its structure was revealed to be a limb-brightened ‘shell’ supernova remnant about half a degree in diameter.
3 Probable historical Supernovae before AD 1000

Other long duration guest stars recorded before AD 1000 in China that are possibly records of supernovae are from AD 393, 386, 369 and 185, which are briefly discussed here.

![Diagram](image)

**Fig. 3.** The region of the Nanmen asterism, near which the SN of AD 185 occurred. The positions of the bright stars α and β Cen which are thought to comprise Nanmen are shown, along with the fainter ε Cen. The circles indicate the centroids of catalogued Galactic SNRs, some with additional crosses and labels. The solid line shows the Galactic equator.

The new stars of AD 393, 386 and 369 appeared towards the end of the Jin dynasty in China. All three objects are recorded in the astronomical treatises of histories of both the Song and Jin dynasties (the Songshu and Jinshu). However, the two records of each of these stars clearly show a common origin. The guest star of AD 393 was visible for some 8 months, and so is likely to have been a supernova. The position of this star is within the Wei asterism, which lies near the Galactic equator. There are several SNRs within this region, and it is not possible to identify the remnant of this SN unambiguously. The new star of AD 386 was visible for anything from about 60 to 115 days. Since the duration of visibility may have been rather short, the possibility that this was a nova cannot be ruled out. Nevertheless, a supernova interpretation is also plausible. The position of the guest star is not well defined – it could have appeared near the star group Nandou (which lay close to the Galactic equator), or was merely somewhere in the range of RA defined by Nandou. In the latter case, although the RA would be fairly well defined, the declination would not. In the former case there are several possible identifications for the remnant of this guest star, with G11 2 0 3 perhaps being the prime candidate. The guest star of AD 369 is described with only limited details. It was reported to be visible for 5 months, but only poorly localised.
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position is reported. If the star was near the galactic equator a supernova interpretation would be plausible, but if it were far from the galactic plane it is more likely a slow nova.

The earliest new star which merits investigation as a possible supernova was seen in China in AD 185. This event is reported only in a single early source, the *Hou Hanshu*, which was composed towards the end of the third century AD. The new star was recorded as being visible for at least 8 months, or possibly even 20 months (depending on interpretation of part of the record to mean ‘next year’ or ‘year after next’). The star was reported to be within the *Nanmen* asterism. Although some authors have questioned the identification of this asterism, comparison with contemporary records and star charts supports the usual identification of α and β Cen with *Nanmen*, which lies close to the Galactic equator. G315 4 2 3 is the prime candidate for the remnant of the SN of AD 185 among the SNRs in the present catalogue of Galactic SNRs between α and β Cen – see Fig. 3 – although it should be noted that there are other remnants in this region which have not yet been studied in great detail.

4 Other possible and spurious Supernovae

4.1 Did Flamsteed see the Cas A supernova in AD 1680?

Cassiopeia A (Cas A) is an obviously young and relatively nearby SNR, which is a bright source at radio and X-ray wavelengths, showing a clumpy shell of emission. Optically Cas A shows a patchy ring of many expanding knots. The date at which the knots would converge, assuming no deceleration, is AD 1671 (see [14] for a recent review). These observations are consistent with Cas A being produced by a SN in AD 1671 or shortly afterwards, provided these optical knots have undergone only a very small deceleration subsequently, which is expected if these optical knots are very dense ejecta from the SN. The distance to Cas A can be found trigonometrically to be 3.4±0.2 kpc, by combining the proper motion of the optical filaments in the plane of the sky with their radial velocities measured spectroscopically. Given the likely date and proximity of the supernova that produced the Cas A SNR, it has been a puzzle that no historical observations of it are available. In 1980 Ashworth suggested [15] that the supernova that produced Cas A was indeed recorded by Flamsteed in AD 1680, as he catalogued a 6th magnitude star ‘3 Cas’, to the west of τ Cas, fairly close to the present site of Cas A, where there is no known star today. However, the discrepancy in the positions of 3 Cas and Cas A – about 10 arcmin – is very much larger than Flamsteed’s typical measurement error. Alternatively – as proposed by Broughton [16] and by Kamper [17] – Flamsteed did not observe the supernova, but instead accidentally compounded his measurements of two separate stars (AR Cas and SAO 35386), neither of which he actually catalogued. Since it is possible to identify the other faint stars that would have produced the erroneous 3 Cas position – see Fig. 4 – with measurement uncertainties that are plausible for Flamsteed’s typical precision, it seems most unlikely that Flamsteed observed the supernova which produced Cas A.
4.2 The Korean guest stars of AD 1592

During a period of about one month in AD 1592, four separate guest stars were reported in Korea in the Sonjo Sillok, the official annals of the King Sonjo who reigned in Korea from AD 1567 to 1608. The first of these appeared in Cetus and was observed for 15 months. Two more guest stars (both in Cassiopeia) were seen for periods of at least three and four months, while a fourth (in Andromeda) was visible for more than a month. In each case the position remained unchanged; small refinements in the recorded locations of the three stars of longest duration only serve to emphasise their fixed nature. Surprisingly, none of these objects was reported in China or Europe, which suggests that all were by no means brilliant: probably of 2nd magnitude or fainter. The various records have been investigated in detail [18]. In summary, it would appear that as many as four novae may have occurred in AD 1592, but in no instance is a supernova interpretation tenable.

4.3 The spurious supernovae of AD 1408, 1230 and 837

In 1979 Li Qibin [19] assembled several Chinese records of two temporary stars observed in AD 1408. Six of these accounts were from Szechuan province and described a bright star which appeared in the east, most probably on Sep 10. Three further reports were in official histories of China and related to a star which appeared on Oct 24 and ‘did not move’. Li Qibin regarded the two objects as identical and proposed a supernova identification. Subsequently Imaeda & Kiang [20] found two further Japanese records mentioning a guest star on a date equivalent to AD 1408 Jul 14. Although no position was recorded for this object, it was inferred that the observation represented an earlier sighting of the stars seen in China on Sep 10 and Oct 24. They further concluded that the star “was quite likely to be a supernova explosion”. The publications by Li Qibin and Imaeda & Kiang led to consideration of G69 -0+2 7 (CTB 80) as the remnant of the star by various authors. However, it has been shown [21] that the ‘star’ of Sep 10
was merely a meteor, and also there are insufficient grounds for linking the guest star of Jul 14 seen in Japan with the star appearing on Oct 24 as reported in China.

Wang Zhenru in 1987 suggested [22] that a ‘bushy star’ seen for more than three months in AD 1230 was a supernova, and further proposed a $\gamma$-ray source 2CG 054+01 as its remnant. (Wang Zhenru also proposed an association between a purported 14th century BC supernova record with another $\gamma$-ray source, but this is highly speculative.) The object was, in fact, a comet. Ho Peng Yoke [23] had already drawn attention to the motion of the same object as described in the astronomical treatise of the Jinshu – which contained records from North China.

Two guest stars appeared in AD 837, which were discovered soon after Halley’s Comet had been detected in that year. Various authors have interpreted the records of one of these guest stars as evidence of a supernova, which they associate with the SNR G189 1+ 3 0 (IC443). Although the first star was fairly close to the galactic equator, the duration of visibility (22 days) was very short. Further, the star disappeared while still some 7 hours in RA to the east of the Sun, so that its visibility would not be impaired by the twilight glow. A supernova interpretation can thus be rejected; the star was most likely a fast nova. The second star, visible for 75 days in high galactic latitude was evidently also a nova.

5 Future Prospects

Looking to the future, it seems unlikely that records of additional supernovae – other than those discussed above – will come to light. Most of the accessible historical sources, especially those of East Asia, have been fairly thoroughly examined. Many medieval Arab and European chronicles are still unpublished, but even to access a small proportion of this material, which is scattered in numerous archives, would be extremely time-consuming. Furthermore, chroniclers were mainly interested in reporting only the most spectacular events. Hence although it would seem likely that further accounts of the brilliant supernova of AD 1006 might well emerge, the prospects for fainter objects – including the supernova of AD 1054 – would appear to be far from promising. In particular, caution should be exercised in assessing the viability of further potential records of historical supernovae.

The remnants of the supernovae observed since AD 1000 are well-established. However, improved distance measurements for the suggested remnants of the proposed supernovae of AD 393, 386 and 185 would be valuable. These results would lead to better estimates of the physical size and hence age, which might help distinguish between individual candidate remnants.

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