Identification of the Guest Star of AD 185 as a comet rather than a supernova

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Very few nearby supernovae have been bright enough to see with the naked eye. The only such case this century was Supernova 1987A. Matching historical records of such events with presently observable remnants allow accurate estimates to be made of the age and incidence rate of supernovae; ancient Chinese astronomical records are a particularly valuable resource for this purpose. In the *Houhanshu*[1] of the Later Han dynasty is recorded the appearance of a 'guest star' in AD 185. This is widely regarded as the oldest supernova recorded historically, and several candidate remnants have been suggested[2,3], in particular the object RCW86[2]. Here we show that a reinterpretation of the relevant passage in the *Houhanshu* is inconsistent with the supernova interpretation, but suggests instead that the guest star was a comet. Our findings indicate that some of the keywords used by Chinese astronomers in historical records must be interpreted with caution.

On 7 December AD 185, astronomers at the imperial observatory of Lo-Yang in central China reported the appearance of a 'guest star' in the southern sky. This event was recorded originally in *Houhanshu*[1], the official history of the Later Han Dynasty (AD 23-220). Here we translate the original record :

中平二年十月癸亥客星出南門中大如半筵五色喜怒稍小至後年六月消占曰為兵至六年司隸校尉袁紹誅滅中官大將軍部曲將吳匡攻殺車騎將軍何苗死者數千人

"In the second year of the *Zhongping* reign period, the 10th month, on the day *Guihai* [7 December, AD 185], a 'guest star' emerged from the middle of the asterism *Nanmen* [Southern Gate]. It seemed to be as large as half a *yan* [bamboo mat]. It displayed the five colors, and *xi* [pleasure] and *nu* [anger]. It decreased gradually in size and in brightness. In the sixth month of the next year [5 July to 2 August 186] it disappeared. According to the standard prognostication this means military action. In the sixth year of the same reign period [AD 189] Metropolitan Commandant *Yuan Shao* wiped out the eunuchs; an officer *Wu Kuang* of the General-in-Chief attacked and killed *He Miao*, the Chariot and Horse General, and several thousand people were killed."

On several points, our translation differs from that given by other authors[2–4]. In contrast to previous articles, the description of the astrological forecast has also been translated, because it will be relevant for the following discussion.

The asterism (group of stars) *Nanme* was the southernmost constellation visible in AD 185 from Lo-Yang (34.7°), the capital of the Later Han Dynasty. The asterism, which is no longer visible from this latitude, is widely believed to consist of the two bright stars β and α Centauri[2,3], although a few authors have suggested ε and β Cen[4,5] or ε and α Cen[6]. As we show below, it probably consists instead of ξ and α Cen. The coordinates of the west star of *Nanmen* are given in a description of this asterism which appeared in *Lingtai miyuan*[7], which was originally written about AD 600, and rewritten and corrected between AD 1049 and AD 1054. It was 137 *du* from the North Pole and 11 *du* east of γ Corvi (a circle was defined to be $365\frac{1}{4}$ Chinese angular unit *du*). These coordinates are consistent with those of ξ Cen in the eleventh century. A similar description was also collected in *Kaiyuan zhanjing*[8]. It was 130 *du* from the North Pole and 14 *du* east of γ Crv, which is consistent with the coordinates at about 70 BC, when the original measurement was done. In a late reference[9] (eighteenth century), the coordinates and magnitudes of these two stars were found to be: *Nanmen* west; right ascension (RA) 197°27′, declination (dec.) −52°20′, magnitude 4. *Nanmen* east; RA 221°42′, dec. −59°30′, magnitude 1. This is consistent with ξ and α Cen.

In previous work, the words *chu* and *zhong* were translated respectively as "appear", and "middle" or "within", according to the usage of modern Mandarin Chinese. However in both *Lingtai miyuan*[10] and *Kaiyuan zhanjing*[11] there are lists of the ancient definitions of some keywords used by Chinese astronomers. According to these definitions, *chu* was used to describe *wei dang qu er qu*,

未當去而去，

which means "an object should not have left an asterism but did leave". *Zhong* meant that an object went through an east-west asterism almost in the middle, and was not near the stars in this asterism within ~ 0.7°. The two words can thus be translated literally "emerge from" and "through the middle". With these definitions we cannot translate the original record in terms of a guest star that stayed within the asterism *Nanmen*. Instead, it must have been an object changing its position on the sky.

From the last argument, it seems to be clear that the guest star was a comet, and not a supernova. We can, however, still study the remaining part of the text to get more information. In the next two sentences the size and brightness of the object were mentioned. First, it seemed to be as large as half a *yan*, where the word *yan*, (as in the translation used in other references[2–4]) means a bamboo mat. On the other hand, *yan* could also be an ancient unit of length which was defined as 9 *chi* (old Chinese length scale)[12]. Because *du* and *chi* are used interchangeably in ancient Chinese astronomical texts for the angular unit, the size of this guest star could be ~ 4 or 5°. The colour and brightness of this guest star was described with *wuse xi nu*. *Wuse* (five colours) might happen because of the low elevation of *Nanmen* and its guest star. *Xi nu*, because of its original meaning "pleasure and anger", was translated to be "scintillated"[2] or "fluctuating"[4]. *Xi* and *nu*, along with *mang* and *jiao*, were actually used by the Chinese astronomers to describe the brightness of stars[10,11]. Analyzing some descriptions of the planets which contain these four words allows an estimate of the magnitude of the new object: this guest star was probably not brighter than the five planets visible with the naked eye. Considering the low elevation it could have been about magnitude 3 to 4. This guest star decreased gradually in size and in brightness until it disappeared, as recorded in the next sentence.

When did this guest star disappear? For this event no definite date is given. Instead, the term *hounian liuyue* is used. *Liuyue*, as translated before, denotes the sixth month of the Chinese calendar. *Hounian*, after the usage of modern Mandarin Chinese, means the year after next. According to this translation the guest star disappeared between 24 June and 23 July 187. Clark and Stephenson[2] excluded the possibility that this guest star could have been a comet from this point, because a comet could not be observed that long (~ 19 months). This contrasts with our investigation of the usage in *Houhanshu* which suggests that *hounian* was used for the next year, whereas the year after next would be *houernian*, which means 'the next second year'. Therefore *hounian liuyue* was probably used to mean the sixth month of the Chinese calendar (5 July to 2

August) in AD 186. The asterism *Nanmen* could not be seen, however, from Lo-Yang until after the sixth month. If this guest star were a supernova, it would have stayed at the same position and could therefore be observed only after the sixth month, but if it were a comet, it could have been observed both before and after this time, because it would not have stayed in *Nanmen*.

The second half of the historical text is an astrological forecast with its associated events. In ancient China the main task of astrology was to forecast the future from the astronomical events. Predictions recorded in the official history had to be consistent with the omens. In official astrology[7] the forecast based on a guest star staying in *Nanmen* was totally different from that of a guest star leaving *Nanmen*. The first interpretation implied war waged by foreign countries wherreas the second predicted war inside China. Here the text refers to fighting between generals in China, and is thus consistent only with a guest star that moved out from *Nanmen*.

Our discussion gives a clear version of events. On 7 December AD 185, in the morning before sunrise, a comet of magnitude 3–4 appeared in the southern horizon between the stars ξ and α Cen. Its tail pointed northwest and was ~ 4–5° long. In the following days it moved north out of this region and decreased in size and in brightness. By July of the succeeding year, it was no longer visible.

One further point must still be clarified. Why was the event recorded with the words *kexing*, guest star, instead of *huixing*, which specified cometary events? In the beginning we assumed this guest star was a comet without a visible tail, but this is contradicted by the size of this guest star. After our detailed study of the whole section of astronomy in *Houhanshu*, we found other descriptions of comets with the name *kexing*, along with descriptions of the lengths of their tails[13]. Furthermore, one event was recorded initially as a *kexing* and after several days as a *huixing*[14]. This word *huixing* used as the translation of 'comet' in astronomical writing, is actually only a usage of modern Mandarin Chinese. Astrologers had special terms for comets with visible tails, but did not always feel the need to use them. Guest star was the common term for transient events such as comets and supernovae, where the meaning of the omen stressed its transience. It is not sufficient to identify a guest star by the word used for it; the context is also highly important.

Because only very few Galactic supernovae have been observed in the last two millennia, the identification of an historical supernova with an associated remnant is important for our understanding of supernova: Each individual case can be used to study the evolution of a supernova remnant after its formation; the supernova rate can be calculated only with these observed data. As we mentioned before, RCW86 (alias MSH14−63, G315.4−2.3, PKS1439−62, Cen XR-1 and 1H 1438−623) is widely taken to be the remnant of SN185 (ref. 2). Thorsett[3], however, proposed that the counterpart of this supernova is PSR1509−58 in the supernova remnant RCW89 (alias MSH15−52 and G320.4−1.2), and it would be then only the second pulsar, after PSR0531+21 in the Crab nebula as the counterpart of SN1054[15–17], to have a known age. There are, however, further problems associated with this identification: Schaefer[18] argued that such an identification would require too high a luminosity. A low value for the Hubble constant might also be required from the visibility constraints. Strom[19] discussed the physical parameters (for example, distance, luminosity and visual magnitude) of these two remnants, and concluded that RCW86 must remain the preferred candidate for SN185. Nevertheless this identification with RCW86 remains disputed. For instance, it does not resemble a young supernova remnant of age 1,800 yr; 10^4 yr is more likely[3]. Furthermore, there is an additional problem with the supernova rate: From Poisson statistics and a Scalo initial mass function[20], van den Bergh and Tammann[21] determined the probability that one or more core-collapse supernovae have occurred within 1 kpc of the sun (where RCW86 is located[22]). The probability is only 0.06 for $M_{\rm min} = 8M_{\odot}$, or 0.14 for $M_{\rm min} = 5M_{\odot}$, during the last 2,000 yr. These problems disappear, however, if there were no supernova in AD 185. On the other hand, Strom[23] discussed the local supernova rate with all of the historical records along with observed young supernova remnants. Although one event less might not change substantially the observed supernova rate, our discussion shows that a more careful investigation of other historical records is necessary for a reliable determination of the local supernova rate.

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ACKNOWLEDGMENT We thank C. Henkel, S. van den Bergh, and an anonymous referee for their thoughtful and kindly comments and suggestion. Y.-N. Chin is a scholar of DAAD (German Academic Exchange Service).