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The Guest Star of AD185 must have been a Supernova *

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Abstract The “guest star” of AD185, recorded in the ancient Chinese history the *Houhanshu*, has been widely regarded as a supernova. However, some authors have suggested that the guest star might have been a comet. It has also been proposed that the record is the concatenation of a nova with a comet made by an early compiler. We have checked the record of the guest star, comparing it with records of comets in the same history. We find that most descriptions of comets clearly indicate motion, whereas the record of the guest star does not. We further argue that the term “yan” used to describe the star’s “size” might be short for *yan-chuang* (seat bed), and “half a yan” would be simply as an imaginary figuration of the ancient observer. Moreover, we show that the term “hou-year” (*hou-nian*) most probably means the year after next. We argue that the asterism *Southern Gate* consisted of the stars α and β Cen. We conclude that the record describing the guest star of AD 185 is completely different from any comet record in the same history, and that it almost certainly was a supernova.

Key words: history of astronomy — guest star — stars: supernovae: individual (SN185)

1 INTRODUCTION

Studies of supernovae (SNe) have been regarded as important for modern astrophysics and cosmology because of their significance for stellar evolution, even with regard to the value of the Hubble constant. The “guest star” of AD 185 (hereafter GS185), recorded in the Chinese historical book *Houhanshu* (*History of the Later Han Dynasty*), has been regarded as an SN (SN185) since the middle of the last century (Xi 1955; Ho 1962; Xi & Bo 1965; Clark & Stephenson 1977; Stephenson & Green 2002). Stephenson & Green (2002), in a discussion of the most likely SN remnant (SNR) of SN185, identify RCW 86 (=G315.4–2.3, Cen XR-1) as the chief candidate. Other authors have suggested MSH15–52 as a possible candidate (e.g., Thorsett 1992), but its distance based on observations virtually excludes the possibility of it having been a naked-eye-SN (~ 4.2 kpc, cf. Strom 1994). Many authors have investigated RCW 86 in detail. Results derived by some modern measurements have shown that it may be a nearby SNR with a distance around 1 kpc (Ruiz 1981; Pisarski, Helfand & Kahn 1984; Nugent et al. 1984; Kaastra et al. 1992; Strom 1994; Bocchino et al. 2000). Such results logically support the view of Clark & Stephenson (1977) that when an SN burst, it had a very high brightness (as a type Ia SN). Some different measured results were also presented, however, which indicate that RCW 86 might be much farther than 1 kpc, that the age of the SNR might be not so young and that it was even derived from a type II SN outburst (Rosado et al. 1996). Rho (2002) showed a case of different origins of soft and hard X-rays of the SNR. So, the nature of RCW 86 is still open to investigation.

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On the other hand, from a different interpretation of the text in the *Houhanshu*, Chin & Huang (1994) argued that GS185 may have been a comet rather than an SN. Subsequently, Schaefer (1995) showed that this hypothesis also has problems, e.g., the comet had to twinkle, be extremely bright and move in a strange orbit. Schaefer advanced the hypothesis of a nova and a comet. He suggested that the record in the *Astrological Annals* of the *Houhanshu* is a concatenation introduced by an ancient compiler of the book, in which first a nova appeared in AD 185, December 7, and then a comet, which might have been P/Swift-Tuttle, was observed to disappear in the sixth month of AD 188, not far from the nova's position. Obviously, however, this hypothesis requires some very special circumstances.

Given that SNe have special importance for modern astrophysics and cosmology, and that in human history very few SNe have been found (no more than ten) before the advent of the telescope, in this paper we carry out a check, comparing the records of certain comets with those for GS185. All of these records are in the *Astrological Annals* and hence were written by the same authors. We also consider new evidence concerning “yan”, “hou nian” and “Southern Gate”.

2 ANCIENT RECORDS

Here we quote a translation of the record for GS185 in the *Astrological Annals* of the *Houhanshu*:

“In the second year of the *Zhongping* reign period, the tenth month, on a *Guihai* day (December 7, AD 185), a ‘guest star’ emerged within the *Southern Gate* (*Nanmen*, an ancient Chinese asterism, near α Cen). It seemed to be as large as half a *yan*, with scintillating, variegated colors, and it then grew smaller, until in the sixth month of the *hou-year* (*hou-nian*, 24 July to 23 August AD 187), it disappeared.”

Because there are different interpretations of the term “*hou-year*”, another choice for “24 July to 23 August AD 187” given above would be “5 July to 2 August AD 186”.

The authorship of the *Astrological Annals* in the *Houhanshu* is rather complex. The author of the main body of the *Houhanshu* was Fan Ye (AD 398–445), but the work was not finished in his lifetime. Another author, Liu Zhao (who was active around AD 510), added the work of Sima Biao (AD? – 306) which includes the *Astrological Annals*, to accompany Fan Ye's text. However, a summary, which can be found in Fan Ye's part of the *Houhanshu*, shows that most astrological materials in Sima Biao's work were taken from texts written by Cai Yong (AD 132–192) and/or Qiao Zhou (AD 201–270). Therefore, the true authors of the *Astrological Annals* in the *Houhanshu* must have been Cai Yong and/or Qiao Zhou. In other words, the main body of the *Houhanshu* and its *Astrological Annals* were in fact written by different authors. However, in Fan Ye's contribution to the *Houhanshu*, the *Emperor Epochs* (records of reigns of emperors), there are also some astrological records, but the texts are much simplified compared with those in the *Astrological Annals*.

3 ANALYSES

3.1 Records of Comets and GS185

Examining the text carefully, we find the record does not indicate any evident motion for the guest star. However, Chin & Huang (1994) argued that the word *chu* (“emerged” in the above translation) could mean “leave”. Chin & Huang have further argued the word *chu* might mean “an object should not have left an asterism but did do so”, referring to examples in ancient Chinese literature. Moreover, it is true that in ancient Chinese records the term “guest star” (*Ke-Xing*) could be used for both SNe and comets. Hence Chin & Huang suggested that the guest star may, in fact, have been a comet, because it “left”.

However, the literature which Chin & Huang (1994) have cited was written more than 300 years after the *Astrological Annals* in the *Houhanshu*, and by other authors. In addition, according to our understanding of ancient Chinese, *chu* can mean “appearing” or “leaving”, depending on different idiographic case. Zhao & Shi (2001) have analyzed 14 entries of guest star records between AD 61–188 in the *Astrological Annals* of the *Houhanshu*, and argued that most of the records (10 entries) have showed motion for the objects by detailed descriptions, and that from the view of philology it is far from credible to define GS185 to be a moving object simply based on the meaning of the single character *chu*.

Since it is essential to know which of the above contradictory interpretations of the text is correct in order to judge whether GS185 was an SN or a comet, we have further examined all records which incontrovertibly refer to comets in the *Astrological Annals* of the *Houhanshu*, and compare them with the record for GS185, which was written by the same authors. We have found 37 such comet records (Beijing

Astronomical Observatory 1992) and list them together with that of GS185 in Table 1 (which can be found only in the web version of this paper at http://www.chjaa.org/2006_6_5.htm).

These 37 comet records span the period AD 22 to 218; therefore, on average, the ancient observers saw a comet every 5.3 years. In Table 1 most of the comet records give a fairly detailed description, indicating they were derived from scrupulous observations made by professionals. However, the 32nd, 35th and 36th entries in Table 1 (marked with “*”) were very brief, consisting of only six Chinese characters. Hence, they possess an evidently different style compared with other comet records. In fact, in another part of the *Houhanshu*, the *Emperor Epochs*, authored by Fan Ye, there are exactly the same brief records for these three comets, i.e. those in AD 200, 207 and 213. Therefore, we submit that these three pieces were not written by the authors of the *Astrological Annals*, but an ancient compiler may have copied them from the *Emperor Epochs* to the *Astrological Annals*. We will consequently exclude these three records from our statistics.

Among the remaining 34 records there is only one which does not explicitly mention motion for the comet, that of AD 191 (see Table 1), but the record calls the object a “*Chiyau* Banner”, which is certainly a name for a comet. All the other 33 clearly indicate that the comets moved. Therefore, summarizing, in the *Astrological Annals* of the *Houhanshu*, 97% of the comet records specifically describe motion, whether the word *chu* is used or not (had we not excluded the three very brief records, then the proportion would be 89%). Eighteen of the 33 records use the word *chu*, but with additional text to specify motion; the other 15 never use *chu*. It appears that the use of *chu* was neither necessary nor the usual way to indicate motion for comets. Conversely, for the record of GS185, they used the word *chu*, but they did not mention any motion for the guest star by additional descriptions, as they did for the 33 comet records.

We can also carry out a check by another approach. According to historical records, in AD 189 (the sixth year of the *Zhongping* reign period) in Luoyang, the capital of the Eastern Han, a bloody palace revolution took place, several thousand people were killed, and in the next year (AD190) the palace was burned and the capital was compelled to move to Chang-an. This serious event would inevitably shock the “normal work” of the royal observatory, which was located in the southern outskirts of Luoyang (Huang 1989). In this sense we suppose that after AD189 the royal astronomical observations became “abnormal”, so only the records before AD 189 were compiled under “normal” conditions by the professional observers in the observatory. We then note that in Table 1, of the 29 records of comets before AD 189, all (100%) describe motion, while that of GS185 does not.

In conclusion, we argue that GS185 was most probably not a moving object, but stationary, and hence not a comet.

3.2 The Description “Half a Yan”

In the record of GS185, “as large as half a *yan*” is used to describe the scale of the object. *Yan* has been understood as “bamboo mat”, which might have a size of about 2 meters, so “as large as half a *yan*” would, Chin & Huang (1994) has argued, indicate an extended object (a comet) rather than an SN. Zhao & Shi (2001) examined the meaning of *yan*, and emphasized that *yan* means “bamboo mat” in general, but “as large as half a *yan*” would be simply an imaginary figuration of the ancient individual observer. As is widely known, in the Eastern Han Dynasty (AD 25–220) Chinese people never made use of chairs or stools. We propose here that *yan* can be a shortened form of *yan-chuang* (“seat bed”), namely a *zuo-ta* which was like a very low stool. Some evidence shows that *yan-chuang* had long been in use before AD 185. Figure 1 shows a fresco found in a tomb in Wangdu County, Hebei Province, China, dating from the late Eastern Han dynasty (which would include AD 185). In this rare ancient painting we can see two officers sitting on a *yan-chuang*. The term has been defined as, a “*yan-chuang* was a *zuo-ta* laid with a mat” (Luo 1986) and it was a popular piece of indoor furniture, made of wood and for personal daily use. The seat of a *yan-chuang* is almost square, and the length of the sides ranged from 60 to 100 cm, according to archaeological research (<http://www.gg-art.com/dictionary/>), therefore, the scale of “as large as half a *yan*” would be in fact no larger than 30–50 cm. However, we do still agree with that “as large as half a *yan*” is only an imaginary figuration of the ancient observer, as Zhao & Shi (2001) have argued.

When SN 185 first appeared in the sky it was very bright (perhaps -7.0 ± 2 – -8.8 ± 2 mag.) (Schaefer 1996) and was very near the apparent horizon (at very low altitude) (Clark & Stephenson 1977). So, the effect of intense refraction and dispersion by the air can deform and blur the very bright stellar image into a



Fig. 1 A fresco found in a tomb in Wangdu County, Hebei Province, China, which dates from the late Eastern Han (AD 25–220) period. In this rare painting two officers sit on a *yan-chuang* (“seat bed”, i.e., a mat laid on a *zuo-ta*). Referring to archaeological research, the side length of the approximately square surface of a *yan-chuang* ranges 60–100 cm.

seriously extended object, and the differential refraction and dispersion in the low-altitude atmosphere may even cause the star image to appear coloured and elongated. Moreover, in our experience, for a light source in or beyond the atmosphere, we have “the brighter the light source, the larger it looks”. Hence, we can understand how ancient observers might have perceived the extended image of GS185.

It is also noticeable that none of the 34 records of comets in the *Astrological Annals* of the *Houhanshu* listed in Table 1 uses “as large as half a *yan*” as a description. So, it seems that to the authors, “as large as half a *yan*” was not a usual and proper description for comets.

3.3 The Interpretation of “*Hou-Nian*”

In contemporary Chinese, “*hou-year*” (*hou-nian*; in Chinese *hou* means “after...” or “later”) means “year after next”, while “*ming-year*” (*ming-nian*) means “next year” (“in a year” could also be used, while “in two years” is the near-equivalent of “year after next”; similarly in Chinese we can use “*hou-yi-nian*” – *hou-one-year* – for “in a year”, “*hou-er-nian*” for “in two years”, etc.). However, Huang (1989) quotes several texts which use “*hou-year*” to mean “next year”, leading him to suggest that GS185 might have disappeared in the following year, i.e. in the sixth month of AD 186. Then the visible period of GS185 would have been only 8 months, which might be short enough to accommodate a nova or comet as well as an SN. We note, however, that the texts quoted were not written by the authors of the *Astrological Annals*, but by others, and at a very different time. Since a word may imply various meanings to different authors, it makes more sense to carry out a survey on the same text in the *Astrological Annals* of the *Houhanshu*, written by the same authors.

We have examined the full text of the *Houhanshu*’s *Astrological Annals* and find that the authors used “*ming-year*” (*ming-nian*) to mean “next year” 15 times, they used “*hou-one-year*” (*hou-yi-nian*) to mean “after one year” (equivalent to “next year”) four times, and “*hou-two-year*” (*hou-er-nian*) to mean “after two years” (“year after next”) three times; yet they used “*hou-year*” (*hou-nian*) only once, i.e. for GS185. Therefore, if “*hou-year*” really meant “next year”, it would have to be short for “*hou-one-year*”.

We find that in the *Astrological Annals*, after a record in AD 132 when the authors used “*hou-one-year*” to mean “next year”, the term “*hou-one-year*” never again appears. Until the end of the full text (a record in AD 218), the term “*ming-year*” alone is used (10 times) to express “next year”. AD 185 occurs in this 86 year span (AD 132–218). This indicates that in the record for GS185, “*hou-year*” most probably does not mean “next year”, i.e., it is not short for “*hou-one-year*”, for if it was, the authors surely would have used “*ming-year*”, as they did with monotonous regularity. Therefore, most probably, “*hou-year*” here is short for “*hou-two-year*”, i.e. it denotes AD 187.

In conclusion, GS185 most probably disappeared in the sixth month of AD 187, so its visible period was about 20 months. This result is consistent with Clark & Stephenson (1977), and it further argues strongly in favor of an SN interpretation (see also Stephenson & Green 2002).

3.4 Concerning the *Southern Gate Nanmen*

Clark & Stephenson (1977) and Stephenson & Green (2002) have argued that the asterism *Southern Gate* mentioned in the record of GS185 most probably consisted of two stars, i.e., α and β Cen. However, there have been differing opinions about this asterism, and the stars should be identified with throughout the long course of Chinese history. Huang (1989) and Chin & Huang (1994) preferred α and ξ_2 Cen, but there are also other views, e.g., α and ε Cen (Yi 1981), or ε and ξ_2 Cen (Pan 1989), according to diverse historical material which has been uncovered since the Tang Dynasty (AD 618–907). Here we present additional clues which strongly support the identification with α and β Cen.

The earliest record to mention the *Southern Gate* which we have found is an extremely ancient literary source, *Xia-xiao-zheng*, which describes ancient astronomical phenomena during the 12 months of a year. In the text, *Southern Gate* is mentioned at least twice, together with other bright and conspicuous stars, e.g., α Lyr, α and β Ori, α Sco, the Big Dipper, etc. (Hu 2000). The time of writing, according to an analysis by Hu, was no later than the Zhou Dynasty (BC 1046–221) and most probably during the period of the Xia Dynasty (BC 2070–1600) (Hu 2000). Hence the *Southern Gate* is a very old asterism from the remote past of China. It is notable that in the period BC 2000–1000, the stars α , β Cen would have been very striking and easily visible (at a declination of about -40° – -45°) in the southern sky for people living in Northern China. However, later the stars could only be seen close to the southern horizon because of the effect of precession on their declinations. It seems that precession has also contributed to the confusion of just what the two stars of the *Southern Gate* were.

Concerning what a “gate” (*men*) looked like to ancient Chinese people, we have checked the oldest written forms of the Chinese character *men*, including forms come from oracle bones (very ancient Chinese characters carved on tortoise shells or animal bones for divination) dating from the Shang Dynasty (BC 1600–1046), roughly the period when the name *Southern Gate* first appears, and forms from bronzes made in the Western Zhou Dynasty (BC 1046–771) (see Fig. 2 at <http://www.chjaa.org/2006.6.5.htm>. The Editorial Committee of the Big Dictionary of Chinese 1986). We see that the characters graphically always consisted of two “pillars” equal in height. In a different vein, according to Chinese tradition a “southern gate” (in most cases for city walls) normally faces due south. Therefore, we deduce that the two stars of the asterism *Southern Gate* must be: (1) evidently brighter than the neighboring stars (α Cen is 0.1^m ; β Cen, 0.9^m ; ε Cen, 2.6^m ; and ξ_2 Cen, 4.4^m); (2) visually not far apart; (3) not very different in brightness; (4) when seen due south, the two stars should have similar elevations. The only pair of stars to satisfy all these conditions is α and β Cen, and we conclude that they most probably comprised the asterism *Southern Gate*.

4 SUMMARY

We have scrutinized the historical Chinese record of GS185. We note that differences between records of comets and that of GS185 in the *Astrological Annals* of the *Houhanshu* should not be ignored, and that results derived from an analysis which uses the same text by the same authors will be more reliable for understanding the exact meaning of ancient records. With the crucial distinction between the comet and GS185 records, and the most probable visibility period for the guest star of more than 20 months, we conclude that GS185 must have been an SN, not a comet and/or nova. Furthermore, we have also presented additional evidence that the asterism *Southern Gate* mentioned in the record of GS185 most likely consisted of α and β Cen.

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