Reports

A Revisit to the Guest Star of A.D. 185

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The guest star of A.D. 185 is possibly the earliest recorded supernova, and the radio source RCW 86 is believed to be its remnant. However, a restudy of ancient Chinese literature suggests that RCW 86 is unrelated to the guest star, which probably had a visible duration of only 7 months and appeared between β and ε Centauri, instead of the previously proposed 20-month duration and a location between α and β Centauri.

SECOND YEAR OF THE CHUNG-P'ING *reign period, the tenth month, day* kuei-hai *(December 7, 185), a guest star appeared within* Nan-men. *It was as large as half a mat and had fluctuating multiple colors. It decreased gradually in size and became invisible only until the sixth month of* hou-nien—in the astronomical treatise of *Hou-han-shu* (History of the Later Han Dynasty) (*1*).

This translation is of the only known record concerning the "guest star" (an ancient Chinese terminology for a new star) of A.D. 185 which was observed by Chinese imperial astronomers in Lo-yang (latitude 34.7°N).

Ancient astronomical records that were made with the unaided eye are undoubtedly of low precision, but there are several fields for which these records may be of special value to modern astronomy. The study of supernovae, the most spectacular stellar outbursts in the universe, is definitely one of these fields simply because not a single supernova has been seen in our galaxy since the telescope was invented at the beginning of the 17th century. Even though roughly 600 supernovae in other galaxies have been observed during the last 90 years, these supernovae are too distant to study the early evolution of their remnants in great detail. In order to understand how the remnant of a supernova evolves in the interstellar medium (for example, how its radio or x-ray surface brightness and diameter vary with age), historical supernovae in our galaxy serve as invaluable calibrators, because their physical properties are relatively well determined.

Many authors have made intensive studies of guest stars (*2–6*), and roughly eight such objects are now suggested as being associated with nonthermal radio sources, presumably the signature of the remnants of supernovae. However, some proposed remnants are not totally consistent with the information inferred from the ancient records (*7*). We propose a reinterpretation of the record concerning the visible duration and location of the guest star in A.D. 185.

Although Chinese astronomers marked the time the guest star appeared and disappeared, its visible duration, which is essential for estimating the magnitude at maximum light (the meaning of "as large as half a mat" in the treatise is obscure) (*8*), is not unambiguously known because of a controversy over the interpretation of *hou-nien*.

Ho (*3*) interprets *hou-nien* as "the following year," but Clark and Stephenson (*6*) prefer the meaning "the year after next" on the basis of the argument that, in the astronomical treatise of *Hou-han-shu*, there are 12 examples of *ming-nien* (next year) but only this single usage of *hou-nien*. This argument would be reasonable if no other word were used to express "the year after next." However, in the astronomical treatise, the year after next is frequently expressed by *hou-erh-nien* (2 years later; *erh* means "two").

Even though in modern Chinese *hou-nien* always means "the year after next," the same wording is used about a hundred years after the report of the guest star in *Chin-shu* where it clearly means "the following year" (*9*). The unusual usage of *hou-nien* in the *Hou-han-shu* record of the guest star may be relevant to its grammatical structure: *hou-nien* seems to be used within a sentence as part of a prepositional phrase, whereas *ming-nien* and *hou-erh-nien* are often used at the beginning of sentences as numerical adjectives. In fact, *hou-nien* may simply be an abbreviation of the term *hou-i-nien* (1 year later; *i* means "one"), which appeared four times in the astronomical treatise. The ancient usage of *hou-nien* strongly suggests that the guest star vanished sometime between 5 July and 2 August 186 and had a visible duration of 7 or 8 months instead of the previously proposed 20 months (*6*).

The location of the guest star was reported by the ancient observers to lie between the two member stars of *Nan-men* (*6*) ("Southern Gate"), a Chinese asterism in Centaurus. While the α-ε Cen pair has been proposed as the two members of this asterism (*10*), Clark and Stephenson (*6*) prefer the α-β Cen pair because these are the two brightest stars in this general area. Their interpretation also bases their identification of bright stars on an imprecise star chart in *Ku-chin-t'u-shu-chi-ch'eng* (*11*). Since both α and β Cen were no longer visible to imperial astronomers in the Chinese capitals after approximately A.D. 1000 because of the precessional motion of the earth, the value of the *Ku-chin-t'u-shu-chi-ch'eng* star chart in interpreting records from A.D. 185 remains unclear.

A valuable piece of information may be inferred from an entry in *Hsia-hsiao-cheng* (*12*) which says, "In the fourth month, *Nan-men* is upright shortly after sunset." A calculation of the positions of α, β, and ε Cen (the brightest stars in this area) reveals that only β and ε Cen could have been located at the same azimuth (that is, "upright") at the beginning of the fourth month when viewed from a latitude of 35° (where most of the Chinese capitals at that time were located) roughly 1 hour after sunset. The excellent agreement with the ancient description in the *Hsia-hsiao-cheng* strongly suggests the identification of β and ε Cen for *Nan-men*, at least through the period of the Later Han Dynasty (A.D. 23 to 220).

The reason ancient people chose ε Cen (2.3 mag) instead of α Cen (0.1 mag) as a member of *Nan-men* may be astrological. The two stars of *Nan-men* were chosen to symbolize the southern gate of *K'u-lou* ("Armory"), an asterism whose shape has a wide opening facing toward *Nan-men* (*13*). The choice of the β-ε Cen pair as *Nan-men* may have resulted from their suitable locations that made them the gate of *K'u-lou* (the α-β Cen pair seems to be too far away to be the gate).

According to this interpretation of the ancient record, we can narrow the location of the guest star to somewhere between β and ε Cen, which, however, spans approximately 8° of the sky. In order for the guest star to have been seen on the reported dates of discovery and disappearance, the guest star would likely have been located closer to ε Cen than to β Cen, and have lain at a right ascension greater than that of ε Cen. In Fig. 1, we plot the preferred search area for the

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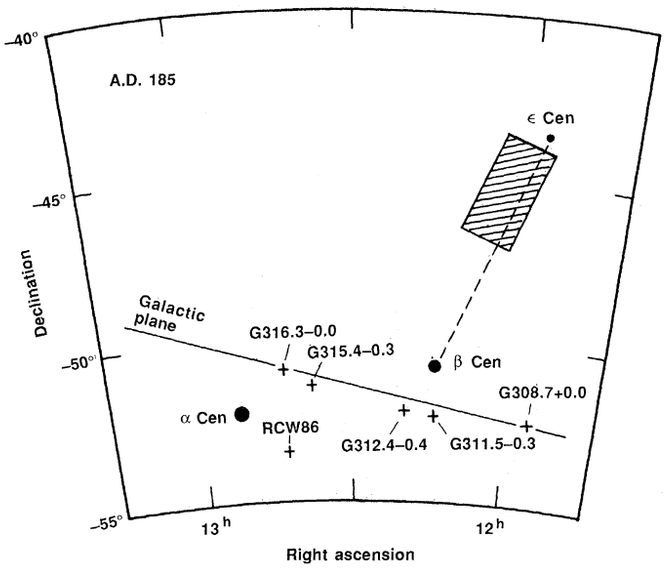

Fig. 1. Locations of α, β, and ϵ Centauri and known galactic supernova remnants in epoch 185. Proper motions of the stars, but not the remnants, have been considered. Preferred search area (the hatched rectangle) for the guest star of A.D. 185 is also given.

guest star. This rough location helps us further narrow the visible duration of the guest star to 7 months because the effect of twilight would be too serious to see the star at a disappearance date other than 5 July 186 or shortly after.

The supernova remnant RCW 86 has been proposed as the remnant of the guest star (*6, 14*), but it is far from the location given by the ancient record. In addition, the position of RCW 86 at the date of disappearance of the guest star was in twilight (Fig. 2), and it was, therefore, invisible to observers. Clark and Stephenson (*6*) recognize this difficulty but simply attribute it to an error in date. Although errors occasionally do occur in the ancient astronomical records, the dates of most observations at that time have been proven to be correct (*6*). RCW 86, which has a radio surface brightness fainter than 70% of all known galactic supernova remnants (*15*), may just be an old remnant unrelated to the guest star.

No known supernova remnant has been found between β and ϵ Cen (Fig. 1). Although the long duration of the ancient observation tends to imply a supernova event as the guest star, the possibility that it was a nearby, slow nova (*16*) cannot be completely ruled out on the basis of the record in *Hou-han-shu* alone. The absolute magnitude (and its estimated total error) of the guest star at disappearance can be given as

$$(-10.5 \pm 2) - 5\log r - (0.5 \pm 0.5)r$$

where r is the distance (in kiloparsec) to the guest star. In deducing this, we have assumed a foreground interstellar extinction of 0.5 ± 0.5 magnitude per kiloparsec (the guest star was possibly several degrees above the galactic plane), an atmospheric extinction of about 3 ± 1 mag (the expected elevation at disappearance was about 1°), and a limit of about 2.5 ± 1 mag for naked eye detection at disappearance (the sun was then roughly 10° below the skyline and 100° away from the guest star in azimuth).

If the guest star is a supernova, a comparison of its visible duration with the average light curves of most extragalactic supernovae (*17*) suggests a decrease of 5.5 ± 1 mag in absolute magnitude from discovery to disappearance. An attempt can be made to estimate the distance to the guest star by assigning it an absolute magnitude typical of a supernova (say, between −21 and −18 mag). However, no useful distance information can be inferred here because of the large uncertainties involved.

A successful search for the possible radio remnant of the guest star should greatly improve our understanding of how the remnant of a supernova evolves in the interstellar medium, because its well-determined age is at least 800 years older than any other known historical supernovae.

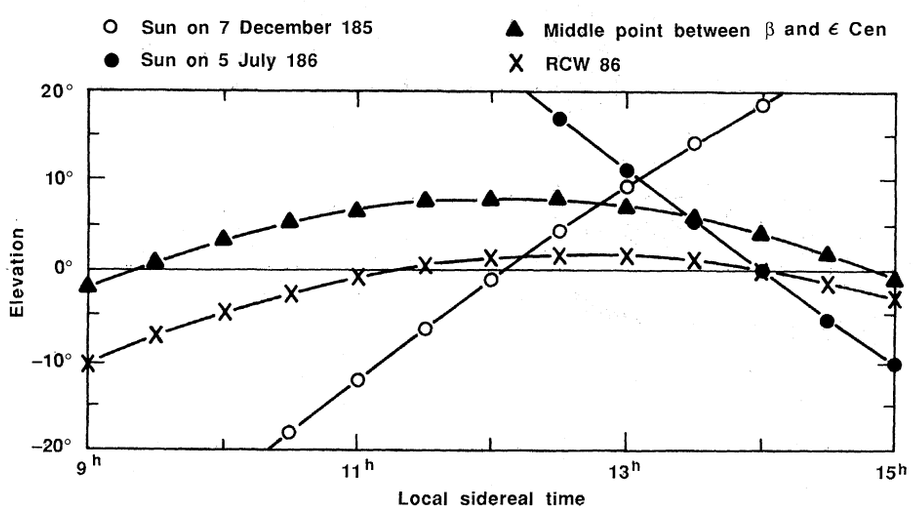

Fig. 2. Elevation versus local sidereal time. The effect of diffraction at the horizon is not considered here. The supernova remnant RCW 86 was invisible on the approximate date (5 July 186) of disappearance of the guest star of A.D. 185.

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8. See (*4*) for another interpretation of "mat."
9. Both *ming-nien* and *hou-nien* were used in the biography of Tu-Yü in *Chin-shu* (History of the Chin Dynasty) to describe the same date. Fuang-Hsüan-Lin *et al.*, *Chin-shu* (Chung-hua, Peking, 1974 reprint), vol. 2, pp. 1028–1029.
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14. The first suggestion of an association between RCW 86 and the guest star is given by B. E. Westerlund [in *Symposium on Radio and Optical Studies of the Galaxy*, J. V. Hindman and B. E. Westerlund, Eds. (Mount Stromlo Observatory, Canberra, 1966), p. 78]. The guest star is also suspected to be related to the peculiar planetary nebula He 2-111 [B. L. Webster, *Mon. Not. R. Astrol. Soc. 185* (1978)], but which is not located between β and ϵ Cen.
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