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Was there a (Super)nova in 1408?

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Abstract

The 1408 CE "guest star" recorded in Chinese historical texts presents a compelling case for identifying a historical stellar transient. While previous studies debated its nature as a meteor, comet, or nova, we reevaluate the event using original Ming Dynasty records, including a newly found memorial from the imperial court. The object, described as stationary for over 10 days, yellow, and luminous (resembling a "Zhou Bo virtue star"), is inconsistent with cometary behavior. Positional analysis locates it near the *Niandao* asterism (modern Cygnus–Vulpecula region) within the Milky Way, with a derived brightness of −4 to 0 mag. Lightcurve stability over 10 days and color descriptions align with a slow nova or a supernova. We cross-correlated the historical coordinates with modern catalogs and found a few possible counterparts. Among them, CK Vul—a luminous red nova remnant from 1670 to 1672—is the most interesting candidate. Could its progenitor system have experienced a precursor classical nova eruption circa 1408 prior to the merger ∼200 yr later? We also examine cataclysmic variables and planetary nebulae within the 100 square-degree search field, though most lack sufficient brightness or age characteristics. This study emphasizes the value of integrating detailed historical records with contemporary astrophysical data to resolve long-standing controversies over ancient transients. The 1408 event likely represents a rare, well-documented nova, offering insights into premodern stellar phenomena and their modern counterparts.

Unified Astronomy Thesaurus concepts: Classical novae (251); Ultraviolet astronomy (1736); History of astronomy (1868); Interdisciplinary astronomy (804)

1. Introduction

Within the past ∼90 yr, several supernovae have been successfully discovered among Chinese observations of "guest stars." N. U. Mayall & J. H. Oort (1942) suggested the identification of the Crab Nebula (M1) with a guest star in 1054 CE, Tycho's and Kepler's Supernovae (1572 and 1604) were matched with their counterpart remnants, and the guest star 1181 observed in Korea, China, and Japan was recently interpreted as a supernova of a rather special type (A. Ritter et al. 2021). Historical novae, however, are much more controversial, as the well-known examples of identifications of stars and nebulae with guest stars in 101 CE (K. Hertzog 1986), 438 CE (B. Miszalski et al. 2016), and 77 BCE (G. H. Johansson 2007) turned out as probable comets.

A very interesting case of a decade-long discussion is given by the guest star 1181 observed in China, Korea, and Japan. F. R. Stephenson (1976) and his subsequent work have suggested the pulsar wind nebula (PWN) 3C58 for the identification. However, M. F. Bietenholz (2006) and M. F. Bietenholz et al. (2013) have argued that (a) the nebula is too old, and (b) in 1181, the pulsar would not have been in the center of the nebula. Despite these strong arguments, scholars kept using Stephenson's identification (R. Kothes 2010, 2013) until A. Ritter et al. (2021) suggested a new identification, and it turned out to be a rather special type of supernova.

A similarly controversial and yet undecided debate has been carried out concerning a guest star in the 15th century. The debate is summarized by G. Wang & X. Sun (2016) and Q.-B. Li (1978) had proposed the case by connecting records of guest stars in 1408 September and October and identifying them as one and the same object in the sky. K. Imaeda & T. Kiang (1980) additionally provided two brief records from Japan in July of the same year regarding the "guest star," arguing that they referred to the same guest star as the ones recorded in September and October in China. F. R. Stephenson & K. K. Yau (1986) provided a detailed argument that the guest stars observed in September and October were actually meteors or comets, and that the Japanese records were unrelated to the two Chinese accounts (F. R. Stephenson & D. A. Green 2005). G. Wang & X. Sun (2016) examined the evidence presented by both parties, endorsing Stephenson's conclusions regarding the Japanese records and the nature of the September guest star in the Chinese records. However, they insist that the possibility of the October guest star being a nova or supernova could not be excluded, although there were several meteors and comets reported in the same year.

In this contribution, we discuss the remaining record from 1408 October, which cannot be refuted, as a nova candidate. F. R. Stephenson & K. K. Yau (1986) argued that the absence of a given duration may suggest that it was visible for only a single night. In such a short time frame, a comet could also appear stationary, but comets are typically visible for more than one night. Hence, we looked for more observational records of this celestial guest.

2. Analysis of the Phenomenon Reported in 1408 October (China)

2.1. Original Records

Up to now, only the short version of the record has been used. For instance, in Z. Xu et al. (2000), it reads:

"Emperor Chengzu of Ming, 6th year of the Yongle reign period, 10th month, day *gengchen* [17]. In the night, at the zenith, southeast of *Niandao*, there was a star like an oil-cup of a lamp. It was yellow and shiny bright. It emerged but did not move. It was said to probably be a ZHOU BO, a star of virtue."

Ming Taizong shilu, ch. 84; Guo que, ch. 14.

The translation "shiny bright" had alternatives in G. Wang & X. Sun (2016), but the explicit statement that the object did not move may point to any sort of nova. The previous entry in Z. Xu et al.'s (2000) list of "guest stars" is a similar record dating to 1404. It reads, "There was a star like a shallow cup southeast of *Niandao*. It was yellow and shiny bright, but did not move," and is quoted from another source *Ming shi*, *Tianwen zhi*, ch. 27. Although the wording is the same, another date (1404 instead of 1408) is given. Z. Xu et al. (2000) seem to suggest that there were two "shiny bright" guest stars within four years. Yet, the record given in the second year (instead of the sixth) of this reign period could be a writing error by the historical scribe. Thus, there are several problems with these two quotations from Z. Xu et al. (2000): (1) the date, (2) the translation, and (3) the source; we first discuss these historical questions before deriving the astrophysical consequences.

2.1.1. The Sources

The *Ming shi* is a chronicle written after the end of the dynasty and published in 1739. It primarily draws its historical materials from the *Ming Taizong shilu* (Veritable Records of Emperor Taizong of the Ming), completed in 1430 and compiled based on original archives from the Yongle reign. Consequently, the *Ming Taizong shilu* (which gives the date 1408) preserved more authentic and accurate information than the *Ming shi*. The *Ming shi*, in turn, was subject to editorial revisions by court historians, leading to the loss of significant information from the original records. However, this had even happened to the *Ming Taizong shilu*. Its substantial editorial revisions resulted in the loss of the original observational data.

This confusion can be addressed by examining the collected works of individuals who might have personally witnessed the event during the Yongle reign. We found more detailed reports from the Qintianjian (Imperial Astronomical Bureau) included in an original archive: Hu Guang (1370–1418) was one of the contemporary witnesses of the event. Serving as a Hanlin Academy scholar, he was responsible for composing congratulatory memorials and laudatory poems addressed to the emperor following the occurrence of auspicious phenomena, which were often attributed to the emperor's personal virtue. After the Astronomical Bureau observed the "Zhou Bo Virtue Star," Hu Guang presented a congratulatory memorial to the emperor on behalf of the court officials. To provide readers with a more comprehensive understanding of this star, as well as the circumstances and thoughts of its observers, we translate the content in its entirety rather than extracting some "key" information because this has frequently been part of the interpretation problem in astrophysics. Still, we highlight the passages that are more relevant to our discussion (G. Hu 1997):

"*Memorial of Congratulations on the Auspicious Star*

The Qintianjian reported: In the sixth year of the Yongle era, on the sixth day (1408.10.24) of the tenth month at early dusk, a star was observed in the southern region of the *Niandao* in the middle of the sky, appearing as large as a *Zhan* (cup), with pure yellow color, smooth and bright. The star remained stationary and calm over 10 days of measurement and observation. According to the divination texts, this is an auspicious star, known also as the Virtue Star, whose appearance signifies peace throughout the realm. It is said that such a Virtue Star manifests when a ruler governs with propriety, harmonizes rituals and music, and ensures internal and external order while himself enjoying longevity and enduring health. The star was located within the celestial division of the lodge Dou (eighth lodge), precisely corresponding to the imperial domain (according to "field allocation" astrology).

We, your ministers, have encountered this auspicious sign and respectfully offer our congratulations. We humbly thought: the heavenly vault reveals its blessings, with the Virtue Star's glittering brilliance in the middle of the sky; the Silver River (Milky Way) unfolds its splendor, its luminous beauty interwoven along the *Niandao*. This splendid omen is truly a sign of an enlightened era. We respectfully recognize His Majesty, the Emperor, possesses virtues that reach the heavens and divine accomplishments that surpass all under heaven. With benevolence akin to the heavens and the earth, His Majesty nurtures all beings, bringing perpetual spring; with wisdom that illuminates the farthest corners, His Majesty's light extends across the four directions. His magnificent governance has refined rituals and music to their height, and his teaching and transformation have brought prosperity and blessings to all. Distant peoples hasten to pay tribute, harvests are abundant, and the years are fruitful. Thus, auspicious signs appear in abundance, and the Virtue Star shines brightly. This is, indeed, the result of harmony among the people below and the response of the heavenly way above. Witnessing such an exalted sign, we, your ministers, cannot contain our joy. To encounter such peace and prosperity as in ancient times is our great fortune, and we celebrate this era of unparalleled governance. Beholding Your Majesty's countenance at such close distance, we humbly offer wishes for your boundless longevity."

Hu wenmugong quanji, ch. 9.

This memorial includes (1) a more comprehensive and detailed report from the Astronomical Bureau and (2) a laudatory ode that proves authenticity. The record is written only weeks or months after the observation, probably by an eyewitness. While only the first paragraph has the original observation, the rest of the text emphasizes the great impression it had on the observers.

According to L. Chu & B. Yang (2022), during this period, Liu Zhe, the Deputy Director of the Imperial Astronomical Bureau, was tasked with compiling a large volume of comprehensive astrological books. Thus, celestial omens are assumed to have been highly important; we can consider the information reliable.

2.1.2. (Our) Interpretation

This memorial addressed to the emperor significantly reinforces the authenticity of this guest star record, effectively eliminating the possibility of fabricated astronomical records often found in official histories.

Instead of "shiny bright" in Z. Xu et al.'s (2000) translation, we stick to the original Chinese term "guang-run", where "run" refers to a smooth, polished, and lustrous state. The term is typically used to describe white jade, and it is associated with a gentle quality and without sharp edges. It does not exactly mean "shiny," but it is clearly distinct from stars described as having "points" or "spikes" (máng jiǎo). Rays and edges are often associated with dangerous or ominous phenomena.

Note that the supernova of 1006 was recorded with "rays" in Europe, where it was close to the horizon. In contrast, the Imperial Astronomical Bureau of China avoided such a description when they identified the guest star as the Zhou Bo star. Instead, they called it "yellow in color, lustrous" (run-ze), because yellow is a positive color and lustrous does not imply any negative omens. This exemplifies the choice of wording with regard to the divination and the narrative in the chronicle rather than accurate descriptions in the standardized language of astronomical observers.

2.2. What Astrophysics Can We Derive?

The object is reported stationary for (at least) 10 days. Thus, the hypothesis of a comet can be excluded; a stellar transient is highly likely. Also, the object is reported as "calm" for over 10 days, which probably means that it did not flicker and they did not observe a significant dimming or change of color. With regard to typical nova lightcurves (R. Strope et al. 2010; M. Kato & I. Hachisu 2023), this rarely happens, and it is characteristic for specific types of progenitor stars: plateaus were observed at T Pyx-type recurrent novae and DQ Her-type novae, some of them even with very long plateaus in the order of years.

2.2.1. Color

Color terms are not highly reliable in historical texts. First, because color terms, in general (until today), are not well defined in colloquial language, color perception strongly depends on the environment. Second, there were fewer terms for color in all historical languages (e.g., R. MacLaury et al. 2007), e.g., many languages had only one term for green and blue together, and the shades of orange between yellow and red were typically unnamed. Third, the color yellow was auspicious in ancient China, implying that its mention in the omen stresses the positive meaning of the apparition. Again, the 1006 supernova was recorded as whitish-blue in Japan, but in China, it was described as yellow in color to stress its connection to a flourishing period in Chinese history (for both, see Z. Xu et al. 2000).

So, the phenomenon of 1408 may have had a bright color, but pure white or bluish would have been interpreted as a bad omen. A reddening due to extinction can be excluded, as the constellation Niandou was "in the middle of the sky." A large height, close to the zenith, can be confirmed with Stellarium. However, a humid or dusty atmosphere due to common weather conditions may additionally blur and colorize the star. From the description, we only know that the color was not reddish; everything else is possible.

Although the bright (2 mag) Nova Persei 1901 was described as deeply red by naked eye observers (F. S. Archenhold 1901), most of the novae and the supernovae seem to match this finding. Recent surveys (P. Craig et al. 2025) reveal that the optical color of novae seems to be rather white $(B - V)_0 = -0.2 \pm 0.3$ at peak and slightly reddens (by 0.2) during t_2, the decline by 2 mag. Thus, they appear bluish-white or white during the initial observation.

2.2.2. Peak Brightness

The ode also contains essential information. In addition to the Qintianjian report, Hu Guang claimed that many of the court officials had observed the star, which suggests that the literati at the time might have discussed the star. Hu Guang used what he knew to craft a beautiful portrayal of the night sky. In the memorial, Hu Guang mentioned not only the guest star and the *Niandao* but also the Milky Way, a detail that was not included in the Qintianjian report: astronomers know that the constellation *Niandao* is in the Milky Way, but for an untrained court official, this might stress the beauty of the observation. This suggests that Hu Guang, or individuals within his circle, had really observed the star. They saw the star with the unaided eye in front of the bright background of the Milky Way in the Cygnus–Vulpecula area. Together with the mentioned color, this information points us to the first brightness estimate: the object must have had at least the brightness of the modern pole star, as colors are only visible for stars brighter than 2 mag. Furthermore, the term "Zhou Bo star" that they use in the divination was only used for extraordinarily bright phenomena, such as the supernova in 1006 at an estimated apparent magnitude of −9.5 mag (D. H. Clark & F. R. Stephenson 1977). The description as a Zhou Bo Star of "glittering brilliance," therefore, suggests a phenomenon as bright as planets (roughly: Venus −4 mag, Jupiter −3 mag, and Mars and Mercury −2 mag).

Even more information can be deduced, as ancient Chinese astronomers commonly used objects from daily life to describe the brightness of unusual celestial bodies. The term *zhan* was used in this record, a word frequently employed in the Ming dynasty astronomical records. Y. Wang (2008) provided numerous convincing examples to demonstrate that observers assumed a radius of 13 m for the celestial sphere when they used length rather than angular units for celestial measurements. While the angular size of a (super)nova itself is small (a dot for the eye), atmospheric conditions and the optical limitations of the human eye may lead to an "apparent enlargement effect," namely, a cognition of a small disk. The brighter the star, the larger its apparent size. Therefore, descriptions of the size of supernovae, meteors, and other similar phenomena essentially translate to descriptions of their brightness.

The term *zhan* has been overinterpreted as "lamp" (Q.-B. Li 1978), but in ancient China, it referred to a cup used for tea or wine or a vessel for lamp oil. Y. Wang (2008) provided the *zhan* diameter of 6–10 centimeters, corresponding to an angular diameter of $0^\circ\!.26 - 0^\circ\!.42$ at a distance of 13 m. The corresponding brightness would be −5 to −7 mag. However, traditional Chinese tea or wine cups generally have a larger top and a narrower bottom. The diameter he described refers to the upper opening. In contrast, the actual diameter of the cup's base usually ranged from 2 to 4 centimetres, corresponding to an angular diameter of $0^\circ\!.09 - 0^\circ\!.17$ and a brightness of magnitude 0 to −3 mag. Therefore, judging from the term *zhan*, the brightness of the 1408 (super)nova should have been between 0 and −7 mag.

2.2.3. Lightcurve

The Qintianjian report explicitly states that it remained "calm" for (at least) 10 days. We interpret this description as referring to brightness.

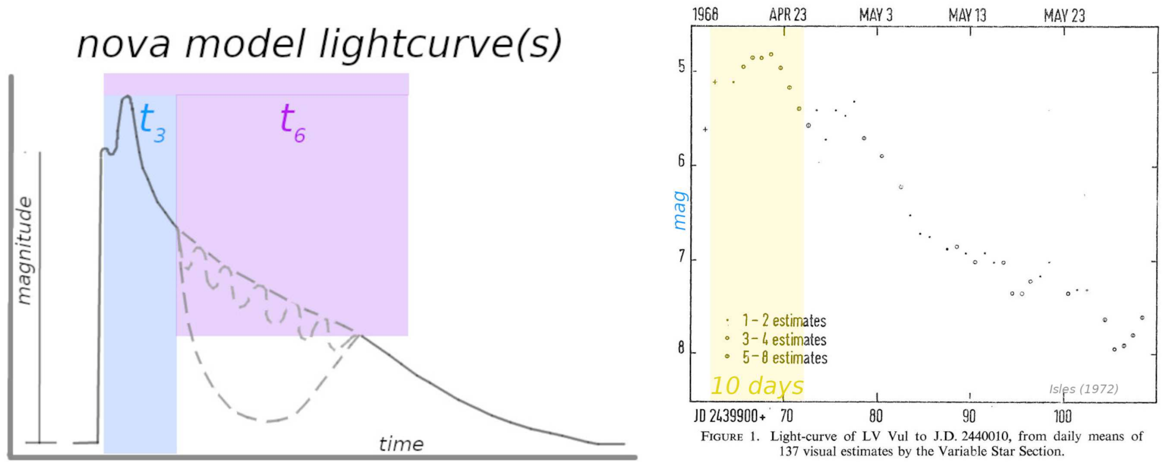

Figure 1. Model lightcurves for typical novae (left) and the specific Nova Vulpeculae 1968 after J. E. Isles (1972; right) with our highlighting of the first 10 days: the slight variability ($4.9^{+0.2}_{-0.3}$ mag) would not be recognized by naked eye observers. The t_3 time would still be $\sim$100 days for a fast nova (N_a-type).

This indicates that its visible duration might be much longer than the 10 days recorded.

After 10 days of observations of Qintianjian, the officials with no expertize in astronomy were still able to easily recognize the star, indicating that its brightness was still brighter than +2 mag (to recognize the color) and probably even of negative magnitude to fit the description "calm." The position given in the text is in the middle between the bright stars Vega, Deneb, and Altair, so that Vega's brightness (0 mag) was visually comparable. Novae typically start to decline quickly after their appearance. Assuming that the initial brightness was (at least) −4 mag, the interpretation of negative magnitudes for (at least) 10 days suggests that the time t_3 of decline by 3 mag was longer than 10 days (as the brightnesses of Venus and Saturn can be clearly distinguished and such a difference would unlikely be described as "calm"). Very fast novae are, thus, almost excluded (but not all N_a-type novae, see Figure 1), but all other types of stellar transients are possible.

2.2.4. Position and Search Field

The position is described relative to the constellation *Niandao* and within the lunar lodge *Dou*. The lunar lodge (or mansion) is the section of right ascensions from ϕ Sgr (272° R.A.$_{1408}$, today 305° R.A.) to β Cap (297° R.A.$_{1408}$, today 281° R.A.). The detailed information on a lunar lodge and the word "measurement" suggest that the observers at the time used instruments to observe the star. According to L. Chu & B. Yang (2022), the Qintianjian in early Ming consisted of many astronomers and a huge variety of sophisticated instruments, with an average observational error of about 5′. With this accuracy of the position measurement, the statement of a nonmoving object can be taken seriously, even in modern terms.

The asterism of *Niandao* in the Ming Dynasty is considered to consist of the stars 13 Lyr, η Lyr, ϑ Lyr, 4 Cyg, and 8 Cyg. Previous researchers used the Qing dynasty star map as a reference, identifying 17 Cyg as the "Southern Star of the Niandao." However, based on the star catalog observed at around 1363 CE (calculated by B.-S. Yang 2023, 75–80, 220), it is clear that the Southern Star should be the 4.7 mag star 8 Cyg (HIP 96052; see Figure 2, with observational data marked by crosses). Southeast of it is the Milky Way.

Figure 2 displays the historical and modern map, and the derived search field: it lies in the middle of a huge, constellation-free space of 115 square degrees, bordered by the constellations *Tianjin* and *Zuoqi*, cut by the boundary of the lodge *Dou*. The remaining space is still 50 square degrees wide and in the Milky Way.

Remark: Both the *Ming Tai zong shilu* and the *Ming shi* record the guest star's position as "southeast of the *Niandao*." Still, the Memorial of Congratulations suggests it was located south of the *Niandao*. Therefore, the actual position may be slightly to the south–southeast of *Niandao*.

To be cautious, we will search the southeastern and southern regions of the *Niandao* within the boundaries of the lodge *Dou* (as indicated by the dashed rectangle in the figure). The upper boundary corresponds to the decl. of 8 Cyg in 1408, while the left edge of the lodge *dou* marks the left (east) boundary. The right and bottom boundaries are slightly closer to the constellations *Zuoqi* and *Jiantai* to allow for a sufficient margin of error. This area encompasses approximately 100 square degrees within the Milky Way, and it is anticipated that many objects will be found within this region. Thus, we expect to find many objects in this area.

2.3. Astrophysics of the Area

We performed a query in SIMBAD using the coordinates given in Table 1 and obtained an expectedly large number of objects of all types. In total, there are 32 supernova remnants (SNRs) in both fields, 53 potentially interesting stars (cataclysmic variables (CVs), X-ray binaries, Wolf–Rayet (WR) stars), and 146 nebulae classified as "planetary nebulae" (PNe) or "PN candidates." The latter is a "default category" for unknown objects; some might be SNRs or nova remnants, which need to be investigated by spectroscopy and the measurement of expansion rates. As a popular example, the SNR of Kepler's Supernova had been classified as a potential "PN" prior to D. J. Frew et al. (2013). Spectroscopy easily distinguishes SNRs, but only tediously, the spectra of PNe can be distinguished from that of a nova remnant as they show the same forbidden line (S. Kwok 2007). The line ratios of the forbidden oxygen, nitrogen and sulfur lines [O III], [N II], and [S II] to hydrogen lines are not always convincing ([O III] 5007/Hβ should be larger for PNe (>3–10) than (<1–3) for nova remnants, while in contrast, [N II] 6583/Hα should be

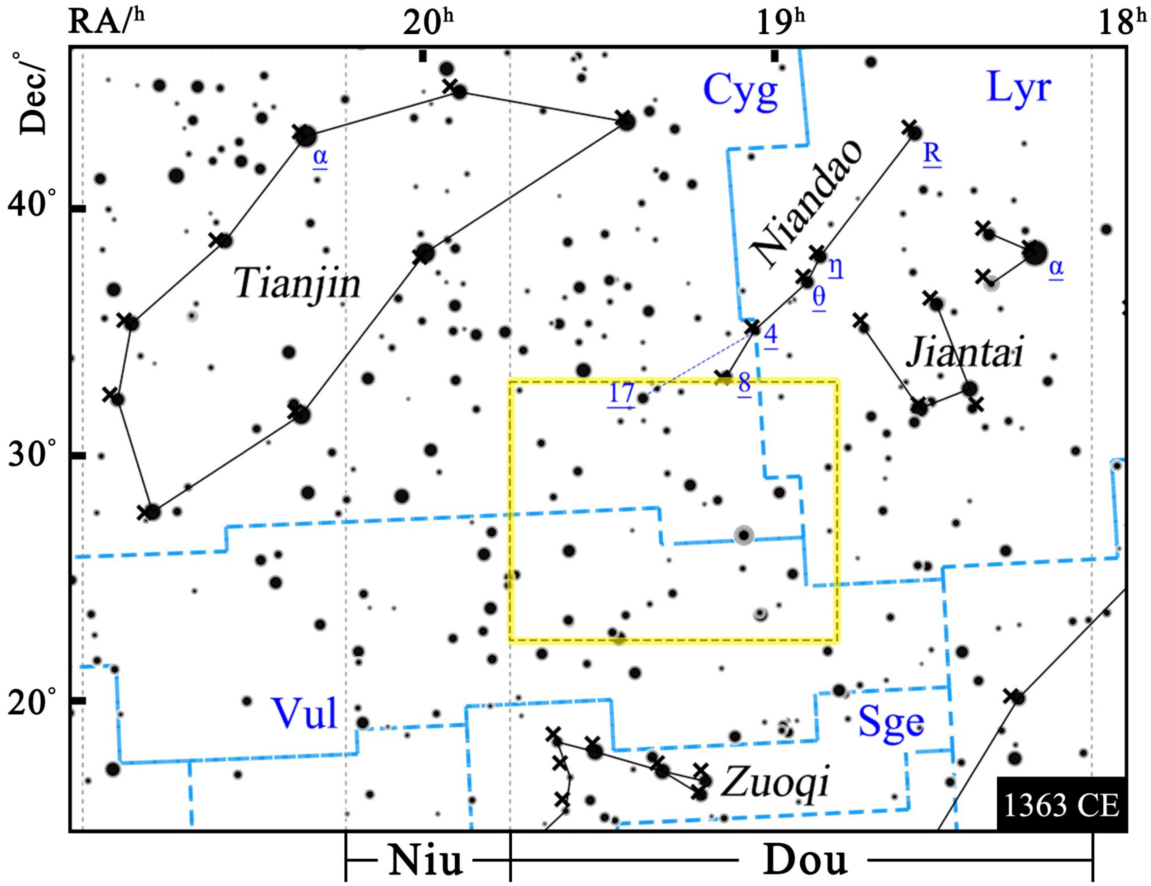

Figure 2. Search field of the 1408 (super)nova. The vertical dashed lines represent the boundaries between different lodges. We used coordinates (R.A./decl.)$_{1363}$ as we want to show the constellations in their view of this epoch. The modern coordinates of our field (R.A./decl.)$_{2000}$ are given in Table 1.

Table 1
Search Field and (SIMBAD) Search Results of Possible Objects

		South		Southeast	
		Max.	Min.	Max.	Min.
Search coordinates	R.A.$_{2000}$/deg	305.3	289	302	292
	Decl.$_{2000}$/deg	34.5	21.5	39	24
Results by object types	SNRs	32		21	
	CVs	27		33	
	XBs	3		3	
	WR	6		7	
	PN?	62		36	
	PN	119		84	

much smaller 0.3–1.5 for PNe versus >1 or even >3 for novae; [S II] 6716+6731/Hα is typically small <0.4 for PNe and large >0.5–1 for novae). However, the ranges are not always sharp, which sometimes led to misidentifications (B. Miszalski et al. 2016; M. M. Shara et al. 2017; F. Göttgens et al. 2019), see D. J. Frew et al. (2013). A stronger distinction criterion is the much higher speed of gas in nova remnants (20–40 km s^{-1}, as opposed to 100–1000 km s^{-1} and more), which can be determined with the line widths (FWHM). Another option would be the distinction by expansion rates (differing by factors of 10–30) due to the different initial momentum of thermonuclear runaway eruptions and red giant pulsation-driven ejecta (S. M. Hoffmann & N. Vogt 2020). Yet, some exceptionally fast PNe and the slowest nova shells could also be mixed up, which may contribute to the number of misclassifications.

Real PNe are irrelevant to our research interest, except for some rare phenomena of so-called rebirth (T. Blöcker 2003; F. Herwig et al. 2006; M. M. Miller Bertolami et al. 2011b; H. Todt et al. 2015) with much longer durations than observed here, or diffusion-induced novae (M. M. Miller Bertolami et al. 2011a). Therefore, we need to check the catalog for misclassified objects.

Some PNe and so-called "PN candidates" are also found in this area in the Milky Way: PN Ra 13, TYC 2674-1567-1, 2MASS J19595642+3048238, G068.2+00.9, G066.4-00-0, HIILBN 070.13+01.71, PN G070.4+00.7, G064.9+00.7, G064.1+00.7, G062.2+01.1, G061.8+00.8, G062.1+00.1, and G065.8+05.1 are rather certainly not nova remnants. The nebulae G070.9+02.2 and RAS 20032+3212 are close to the described position but in the wrong lunar mansion, so we exclude them.

2.3.1. Are There Supernova Candidates?

Most of the SNRs are undetermined in age or, with age estimates of some 10^4 yr, yet too old. This is in particular also true for CTB 80 which was proposed in the 1980s (cf. U Manitoba Catalog of SNRs). Three of the SNRs have a pulsar in or near their center. Two cases may be interesting to study further regarding the event in 1408 (roughly 600 yr ago). Both of them are too old at first glance, but may perhaps get into the age range if the age estimate is changed.

1. The SNR G063.7+01.1 (filled center SNR, >8000 yr, PWN but no pulsar (PSR) known: perhaps 3XMM J194753.4+274357 (CXO J194753.3+274351) driving the PWN; ManitobaCat).
2. The SNR G067.7+01.8 is even more interesting because it is much younger, differing from the event only by a factor of 2, as the youngest possible age is 1500 yr. Still, the upper age limit of 13,000 yr also excludes it as a candidate. There is no PSR known in this nebula with a radio-bright center.

2.3.2. Cataclysmic and Other Contact Binaries

Additionally, there are roughly 20 bright CVs, plus eight bright symbiotic and X-ray binaries (XBs). The list of the brightest and most interesting objects in the search field is given in Table 2.

2.3.3. X-Ray Binaries

No case is known in which a low-mass or high-mass X-ray binary has ever erupted as a nova. Yet, X-ray binaries are possible sources of eruptions, e.g., tidal disruption events (TDEs) or other high-energy emission (that may or may not also flare up the system in visible light).

X-ray binaries are contact binaries whose compact companion might be a white dwarf (like in novae), a neutron star, or a black hole. Thus, the X-ray emission may originate from a variety of different physical effects. Likewise, any sort of eruption from these systems may have different causes.

TDEs were first observed in high-energy astrophysics (ROSAT data), but recently, optical surveys like Zwicky Transient Facility and ASAS-SN have also detected several of them (Y. Yao et al. 2023). Typical known cases still originate from systems with black holes, even supermassive black holes in the centers of galaxies (S. Gezari 2021; Y. Yao et al. 2023). Yet, occasionally stellar binaries with a black hole companion are also discussed, although frequently rejected (J. Bodensteiner et al. 2020; T. Rivinius et al. 2020; M. Safarzadeh et al. 2020). As lightcurves of TDEs show a characteristic (observable) incline of brightness (in contrast to novae and supernovae where the process of flaring up is typically received as immediate), we consider them less likely options for historical observations, yet, not automatically excludable. The duration of the visibility of TDEs in the known systems ranges from months to years, and lightcurves in S. Gezari (2021, Figure 4) and Y. Yao et al. (2023, Figure 8) suggest stability over the first 10 days after peak. Still, the long phase of rising to peak brightness would have been noticed and probably described as the appearance or growing of the object.

For completeness, we mention the X-ray binaries, although we consider such a scenario rather unlikely for our historical observation.

2.3.4. Nova Candidates

A few known novae are in this Milky Way area. The known novae QV Vul (Nova Vul 1987) and NQ Vul (Nova Vul 1976) are slightly too far west, and with historical eruption peaks fainter than 6 mag, they are also not bright enough to produce a phenomenon as described in the Ming Dynasty. QU Vul (Nova Vul 1984b) could match the position, but with 5.3 mag in peak, this N_a-type nova would also be too faint (S. M. Hoffmann & N. Vogt 2021, 260). The only potential candidate would be LV Vul, the Nova Vulpeculae 1968, see Figure 1 (J. E. Isles 1972). The lightcurve of this fast nova (N_a-type) appeared stable for the first 10 days, and R. A. Downes & H. W. Duerbeck (2000) and I. Hachisu & M. Kato (2019) give the time of decline by 3 mag $t_3 \sim 43$ days. However, the peak brightness was estimated to be roughly 4.5 mag in V band. Based on the known variability of peak brightness of recurrent novae (± 2 to 4 mag; see S. M. Hoffmann & N. Vogt 2022, Figure 3), we would not expect it to achieve negative magnitudes. So, this object is highly unlikely to cause the 1408 observation. Still, novae with recurrence periods of more than a century (in this case, it would be 1968–1408 = 560 yr) are unknown (M. J. Darnley 2021; S. M. Hoffmann & N. Vogt 2022), and the behavior of objects like this may differ from the known cases. We denote this for future research.

With typical amplitudes of 11–13 mag and maximum amplitudes of 16 mag for classical novae (N. Vogt et al. 2019; A. Rosenbush 2020), smaller amplitudes for symbiotic novae (U. Munari 2019), and the given stability of the visual appearance in the first 10 days, here we consider identifications either with a Z And-type star, a dwarf nova (UG-type), or a DQ Her-type intermediate polar as candidates. DQ Her-type systems permit novae whose lightcurve is rather stable at the beginning (R. Strope et al. 2010, Figure 2), but the stability might last even longer than 10 days.

Z And-type stars are symbiotic. They could be a combination of a red giant and a white dwarf, like all slow (N_c-type) novae and some observed recurrent novae. Their orbital periods are also similar to those of N_c-type novae. CVs of dwarf nova-type (UG) could permit a classical nova, and DQ Her-type contact binaries have lightcurves with a plateau at the beginning (R. Strope et al. 2010). In total, we found nine candidates within these main groups (see Table 2, uppermost section). In the case of the CVs, the range of their orbital periods coincides with the range of those of known N_b-type novae.

With typical amplitudes (N. Vogt et al. 2019, Figure 1), the quiescence of a CV should be 8 ± 4 to reach −4 ± 3 mag in eruption. Assuming maximum amplitude (16 mag), the progenitor system should have at least 13 mag in quiescence. None of the stars in Table 2 qualify for a typical case, and the extreme amplitude yields only four candidates: the dwarf novae EM Cyg and V923 Cyg, and the symbiotic systems BF Cyg and CI Cyg. As novae from symbiotic systems have smaller amplitudes, none of these is likely.

Furthermore, assuming typical absolute magnitudes of novae, most objects in Table 2 would be ruled out: H. W. Duerbeck (1981) assumed $M_V = -6 \ldots -7$ mag for slow novae and $M_V = -8 \ldots -11$ mag for fast ones. More recent studies seem to calculate with a value of $M_V = -8.5$ mag (R. Gilmozzi & M. Della Valle 2003; Y. Kok 2010; A. Rosenbush 2020; J. G. Clark et al. 2024). It has even been proposed to use classical novae as standard candles (R. Gilmozzi & M. Della Valle 2003) as their absolute magnitudes in peak, and even 15 days after peak, seem to be always the same, as the same physical processes cause them. The very detailed study by N. G. Kantharia (2017) concludes for novae in our Galaxy, M31, and M87 $M_V = (-8 \pm 2)$ mag (or −6 to −10), again,

Table 2
Nova Candidates within the Search Field: VSX Data and Gaia DR3 Parallaxes (Gaia Collaboration et al. 2023)

Name	Type	P_{orb}/ d	Mag Range	px/mas	Remark
Bright Enough					
V2306 Cyg	DQ	0.1821454	15.3–15.7 Rc	0.7708 ± 0.0277	
V792 Cyg	UGSS	0.29717	14.1–17.0 p	0.7715 ± 0.0437	
EZ Vul	UGZ/IW	⋯	13.2–15.8 V	7.0676 ± 0.0171	Far south and wrong lunar mansion(LM): unlikely
V923 Cyg	UGZ	⋯	12.4–14.1 V	1.6946 ± 0.0169	
EM Cyg	UGZ+E	0.290909	11.9–14.4 p	2.8263 ± 0.1942	
EY Cyg	UGSS	0.459324	11.4–15.5 V	1.5627 ± 0.0155	
BF Cyg	ZAND	755	9.1–13.5 V	0.1944 ± 0.019	Rather south than southeast: unlikely
CI Cyg	ZAND+E	852.98	9.0–12.3 V	0.4755 ± 0.025	
CK Vul = N Vul 1670	V838MON	⋯	2.6 V–<23 r	0.066 ± 0.1858	Exceptional, Gaia DR3 parallax may refer to the wrong star
X-ray Binaries					
V1357 Cyg	HMXB/ BHXB+ELL	5.599824	8.72–8.93 V	0.4439 ± 0.0149	Around 9 mag quiescence, red brighter than blue: possible
4U 1954+31	ZAND+LMXB/XP	⋯	10.01 (0.1) V	0.2575 ± 0.0245	Symbiotic X-ray binary
SWIFT J195509 +261406	LMXB/XN	⋯	14.2–24.4 Ic	?	
NSV 24903(?)	HMXB/XP	40.415	14.17–14.27 V	?	
QZ Vul	LMXB/BHXB/XN	0.34583	17.5 B–21.4 r	?	Bit far south and too faint
In the Field, but Too Faint					
V1505 Cyg	UGZ	⋯	15.7–19.7 g	?	
V1449 Cyg	UGSS	⋯	15.5–<17.7 p	?	
V1452 Cyg	UGSS	⋯	15.4–<17.0 p	?	
MGAB-V830	UG	⋯	15.1–18.0 g	?	
ASASSN-17dd	UGSU	⋯	15.0–20.5 g	?	
V550 Cyg	UGSU	0.0675	14.8–21.0 r	0.3667 ± 0.0526	With nebula, wrong LM
NSV 12270	ZAND	⋯	14 –? V	0.4983 ± 0.1518	With nebula (“PN”) but rather unknown
V795 Cyg	UGSS	0.181299	13.4–<17.9 p	1.5206 ± 0.0806	
LV Vul	NA	⋯	4.5–18.4 V	?	Too faint

roughly the range given by H. W. Duerbeck (1981). The distance modulus would then lead to an estimated distance of the classical nova between 63 and 630 pc, and a parallax between 1.6 and 160 mas. The Gaia parallaxes displayed in Table 2 would then only allow EM Cyg, V923 Cyg, and EZ Vul as candidates (plus the nine objects for which no Gaia data are available).

2.3.5. The Peculiar Object: CK Vul

Despite all of the above facts that may rule it out, we consider the special case CK Vul worth some consideration: it has been suggested as a nova by M. M. Shara & A. F. J. Moffat (1982), usually considered as counterpart of Nova Vulpeculae 1670 observed by M. Hevelius (1670) and his contemporaries. This event exhibited rather unusual behavior, as it was reported with three separated maxima in the years 1670, 1671, and 1672 (see the lightcurve reconstructed by M. M. Shara et al. 1985, our Figure 3, also M. M. Shara & A. F. J. Moffat 1982, and M. Hajduk et al. 2007).

M. M. Miller Bertolami et al. (2011a) suggested that the simulated scenario for a “diffusion-induced nova” offers an explanation for CK Vul and explains the observed properties of WR-central stars of PNe (typically of subtypes WN or WC). They seem to imply that the event in 1670–1672 was a rebirth scenario of a CSPN, already suggested by A. Evans et al. (2002). However, M. Hajduk et al. (2013) with optical observations, and A. Evans et al. (2016), based on new Spitzer infrared observations, reject the possibility that CK Vul is a remnant of any type of nova: neither could it be a classical nova remnant in hibernation, a very late thermal pulse, a luminous red variable, such as V838 Mon, nor a diffusion-induced nova. In their view, “the true nature of CK Vul remains a mystery.” The same conclusion is reached by D. P. K. Banerjee et al. (2020), who derive an absolute magnitude of $M_v = -12.4^{+1.3}_{-2.4}$ of the event in 1670 and a distance of $3.2^{+0.9}_{-0.6}$ kpc for CK Vul (the apparent contradiction to Gaia DR3 data can be explained with a misidentification, the Gaia data may belong to a different star; cf. S. P. S. Eyres et al. 2018; “star 1” in their Figure 2). They speculate if CK Vul forms part of a peculiar group of intermediate-luminosity optical transients that bridge the luminosity gap between novae and supernovae. Summarizing, infrared data do not support any nova hypothesis for CK Vul; the object and event remain peculiar.

The explanation as a “luminous red nova” (LRN) or V838MON, a stellar collision in a contact binary, had been proposed by T. Kato (2003), T. Kamiński et al. (2015), and supported by M. Hajduk et al. (2013) who stressed that one of the components must have been a white dwarf. More recent research (R. Tylenda et al. 2019; T. Kamiński et al. 2023; R. Tylenda et al. 2024) considers the novae 1670–1672 as a merger of a red giant with a helium white dwarf. Yet, this hypothesis appears brave as helium white dwarfs are extraordinarily rare; only two are known (J. Liebert et al. 2004;

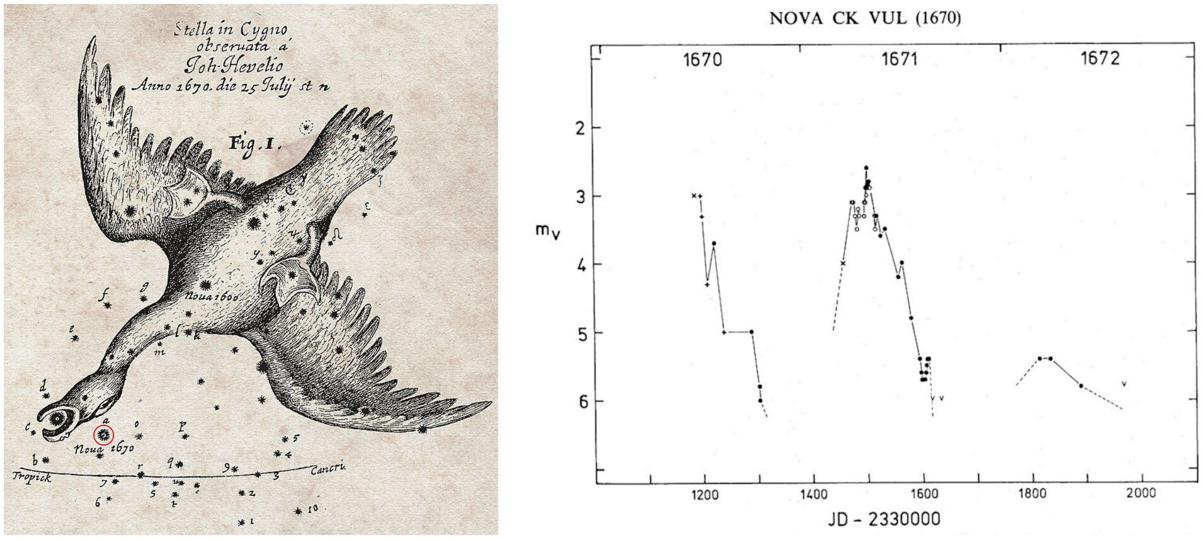

Figure 3. Observation drawn by M. Hevelius (1670; left) and lightcurve (right) of the Nova Vul 1670–1672 by (M. M. Shara et al. 1985) from observations of Anthelme, Cassini, Hevelius, and various anonymous members of the Académie des Sciences, Paris.

S. R. Kulkarni & M. H. van Kerkwijk 2010; W. R. Brown et al. 2013), and they typically are not created in binary systems.

In their articles, they do not give an accurate date for the merging during the sequence of three maxima in 3 yr. Yet, it is known that the duration of the visibility of all nova and supernova eruptions depends on the surrounding nebulae of gas and dust that reflect the light. The red giant or supergiant in symbiotic binaries like CK Vul always produces an embedding of gas and dust clouds (see the prototype of V838Mon-type stars). Today, the stellar remnant is not directly visible because of opaque molecule clouds, and it can be assumed that the emission of the nebula from the symbiotic system had been ongoing for a long time when the merger happened in the 1670s. It is well possible that parts of one or more of the peaks in the 17th century originate from reflections of the energy released by the merger in some nearby cloud filaments.

Before merging, the binary would have orbited closely, perhaps permitting a transfer of hydrogen-rich gas from the giant's atmosphere toward the white dwarf for a long time. It was also suggested that the event in 1670 was a merger of a CV system (B. D. Metzger et al. 2021; K. J. Shen 2015). So, it is not excluded that about 200 yr prior to the merging event, a classical nova outburst had occurred in CK Vul, observed by Chinese astronomers (S. M. Hoffmann & N. Vogt 2021). In DQ Her-type intermediate polars (which we preferred as candidates due to their broad peak; R. Strope et al. 2010), the magnetic field disrupts the accretion disk and a dust belt, which may align with CK Vul's bipolar nebula structure (M. Hajduk et al. 2013; D. P. K. Banerjee et al. 2020). A classical nova of the system may, thus, show similar behavior and match the Chinese observation in 1408.

During this hypothetical nova eruption, most of the outer hydrogen layer of the white dwarf (accumulated during the previous ∼100,000 yr) was transformed into helium, and this way, causing the combination between a giant and a helium white dwarf that finally merged according to R. Tylenda et al. (2019). Thus, our hypothetical scenario would explain the presence of a (rare) helium white dwarf in the CK Vul system. O. Yaron et al. (2005) estimate the time between outbursts within the same system based on mass transfer rates onto a white dwarf of 0.4 $M_\odot$ to the order of 10^6 yr, which would exclude a recurrence after only ∼250 yr. However, in our scenario, the second event would be of a different nature and different physics than the first one. The first event would be a thermonuclear runaway on the surface of an ordinary white dwarf, turning it into a helium white dwarf, and the second one a merger of this with its contact companion.

Although the spatial distance of CK Vul derived from most recent Gaia data seems to contradict its potential to become visible as a classical nova of typical absolute magnitudes, the preliminary idea of a nova of CK Vul in 1408 should be investigated, as everything about it seems to be exotic: the merger, the helium white dwarf, and the facts that (a) the nova prior to the merger would have been brighter than the merger, and that (b) only eight members of the V838MON class are registered in the VSX, three of them uncertain. Given that five stars of this type are distributed over the entire sky ($41,253^{\circ 2}$), an accidental coincidence of CK Vul with a historical observation within a field of only $\sim 100^{\circ 2}$ is rather improbable (0.2%). Furthermore, our new finding of an observational record from 1408 confirms the hypothesis of a stellar transient in the area.

3. Conclusion

The 1408 CE "guest star," documented in Chinese historical records, is reevaluated as a probable classical nova based on critical analysis of original Ming Dynasty sources and modern astrophysical data. Key features of the observation (stationary position over 10 days, stable lightcurve, and luminous appearance) align with characteristics of stellar transients rather than cometary phenomena. Positional constraints localize the event in the Cygnus–Vulpecula region, where we identify CK Vul, an LRN remnant from 1670 to 1672, as a possible candidate. The symbiotic progenitor system could have permitted a classical nova eruption in 1408, preceding its later merger event (T. Kato 2003; T. Kamiński et al. 2015; B. D. Metzger et al. 2021). While other supernovae, CVs, and PNe within the search field were examined, most lack the required age, brightness, or lightcurve stability to match the historical account. Further observations of all discussed objects (EM Cyg, V923 Cyg, EZ Vul, and CK Vul) are needed to verify the hypotheses proposed in this paper. If these stars are not the counterpart of the 1408 transient event, then the counterpart may still remain undiscovered.

This study highlights the synergy between meticulous historical scholarship and modern astrophysical techniques in resolving ambiguities surrounding ancient transients. The 1408 event stands as one of the earliest well-documented nova candidates, offering a rare opportunity to probe pretelescopic stellar phenomena and their modern counterparts. Future high-resolution observations of CK Vul's remnant and spectroscopic studies of its circumstellar environment could test the hypothesized connection to the 1408 eruption. Such interdisciplinary efforts underscore the enduring value of historical records in constructing a comprehensive timeline of Galactic transient activity.

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Authors' Contributions

Yang and Hoffmann performed the research together. Hoffmann initiated the research due to open questions from earlier projects. Yang discovered the 1408 observational report and together with Hoffmann analyzed the color, brightness, position, and related information. Hoffmann had searched for possible (super)nova counterparts of the event in 1408 in earlier publications. Thus, when she designed this paper, she consulted her former coauthor, the expert on cataclysmic variables and novae, Nikolaus Vogt, for a closer discussion of the candidates.

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References

Archenhold, F. S. 1901, Das Weltall, Vol. 11 (Germany: Mitwirkung zahlreicher Fachgenossen), 93
Banerjee, D. P. K., Geballe, T. R., Evans, A., et al. 2020, ApJL, 904, L23
Bietenholz, M. F. 2006, ApJ, 645, 1180
Bietenholz, M. F., Kondratiev, V., Ransom, S., et al. 2013, MNRAS, 431, 2590
Blöcker, T. 2003, in IAU Symp. 209, Planetary Nebulae: Their Evolution and Role in the Universe, ed. S. Kwok, M. Dopita, & R. Sutherland (Cambridge: Cambridge Univ. Press), 101
Bodensteiner, J., Shenar, T., Mahy, L., et al. 2020, A&A, 641, A43
Brown, W. R., Kilic, M., Allende Prieto, C., Gianninas, A., & Kenyon, S. J. 2013, ApJ, 769, 66
Chu, L., & Yang, B. 2022, AcASn, 63, 15
Clark, D. H., & Stephenson, F. R. 1977, The Historical Supernovae (Oxford: Pergamon)
Clark, J. G., Hornoch, K., Shafter, A. W., et al. 2024, ApJS, 272, 28
Craig, P., Aydi, E., Chomiuk, L., et al. 2025, MNRAS, 538, 2339
Darnley, M. J. 2021, The Golden Age of Cataclysmic Variables and Related Objects (Trieste: Sissa), 44
Downes, R. A., & Duerbeck, H. W. 2000, AJ, 120, 2007
Duerbeck, H. W. 1981, PASP, 93, 165
Evans, A., Gehrz, R. D., Woodward, C. E., et al. 2016, MNRAS, 457, 2871
Evans, A., van Loon, J. T., Zijlstra, A. A., et al. 2002, MNRAS, 332, L35
Eyres, S. P. S., Evans, A., Zijlstra, A., et al. 2018, MNRAS, 481, 4931
Ferrand, G., & Safi-Harb, S. 2012, AdSpR, 49, 1313
Frew, D. J., Bojičić, I. S., & Parker, Q. A. 2013, MNRAS, 431, 2
Gaia Collaboration, Vallenari, A., Brown, A. G. A., et al. 2023, A&A, 674, A1
Gezari, S. 2021, ARA&A, 59, 21
Gilmozzi, R., & Della Valle, M. 2003, in Stellar Candles for the Extragalactic Distance Scale, ed. D. Alloin & W. Gieren (Berlin: Springer), 229
Göttgens, F., Weilbacher, P. M., Roth, M. M., et al. 2019, AAp, 626, A69
Hachisu, I., & Kato, M. 2019, ApJS, 242, 18
Hajduk, M., van Hoof, P. A. M., & Zijlstra, A. A. 2013, MNRAS, 432, 167
Hajduk, M., Zijsktra, A. A., Evans, A., et al. 2007, in ASP Conf. Ser. 378, Why Galaxies Care About AGB Stars: Their Importance as Actors and Probes, ed. F. Kerschbaum, C. Charbonnel, & R. F. Wing (San Francisco, CA: ASP), 301
Hertzog, K. 1986, Obs, 106, 38
Herwig, F., Freytag, B., & Werner, K. 2006, in IAU Symp. 234, Planetary Nebulae in our Galaxy and Beyond, ed. M. J. Barlow & R. H. Méndez (Cambridge: Cambridge Univ. Press), 103
Hevelius, M. 1670, RSPT, 5, 2087
Hoffmann, S. M., & Vogt, N. 2020, MNRAS, 496, 4488
Hoffmann, S. M., & Vogt, N. 2021, Nuncius Hamburgensis, Applied and Computational Historical Astronomy (tredition), Vol. 55 (Hamburg: Trediton), 238
Hoffmann, S. M., & Vogt, N. 2022, NewA, 92, 101722
Hu, G. 1997, Siku Quanshu Cunmu Congkan (Jinan: Qilu Shushe)
Imaeda, K., & Kiang, T. 1980, JHA, 11, 77
Isles, J. E. 1972, JBAA, 83, 44
Johansson, G. H. 2007, Natur, 448, 251
Kamiński, T., Mason, E., Tylenda, R., & Schmidt, M. R. 2015, A&A, 580, A34
Kamiński, T., Schmidt, M., Hajduk, M., et al. 2023, A&A, 672, A196
Kantharia, N. G. 2017, arXiv:1703.04087
Kato, M., & Hachisu, I. 2023, ApJ, 951, 128
Kato, T. 2003, A&A, 399, 695
Kok, Y. 2010, JAVSO, 38, 193
Kothes, R. 2010, in The Dynamic Interstellar Medium: A Celebration of the Canadian Galactic Plane Survey (San Francisco, CA: ASP), 347
Kothes, R. 2013, A&A, 560, A18
Kulkarni, S. R., & van Kerkwijk, M. H. 2010, ApJ, 719, 1123
Kwok, S. 2007, The Origin and Evolution of Planetary Nebulae (Cambridge: Cambridge Univ. Press),
Li, Q.-B. 1978, AcASn, 19, 210
Liebert, J., Bergeron, P., Eisenstein, D., et al. 2004, ApJL, 606, L147
MacLaury, R., Paramei, G., & Dedrick, D. 2007, Anthropology of Color: Interdisciplinary Multilevel Modeling (Amsterdam: John Benjamins Publishing Company)
Mayall, N. U., & Oort, J. H. 1942, PASP, 54, 95
Metzger, B. D., Zenati, Y., Chomiuk, L., Shen, K. J., & Strader, J. 2021, ApJ, 923, 100
Miller Bertolami, M. M., Althaus, L. G., Olano, C., & Jiménez, N. 2011a, MNRAS, 415, 1396
Miller Bertolami, M. M., Rohrmann, R. D., Granada, A., & Althaus, L. G. 2011b, ApJL, 743, L33
Miszalski, B., Woudt, P. A., Littlefair, S. P., et al. 2016, MNRAS, 456, 633
Munari, U. 2019, arXiv:1909.01389
Ritter, A., Parker, Q. A., Lykou, F., et al. 2021, ApJL, 918, L33
Rivinius, T., Baade, D., Hadrava, P., Heida, M., & Klement, R. 2020, A&A, 637, L3
Rosenbush, A. 2020, arXiv:2007.11025
Safarzadeh, M., Toonen, S., & Loeb, A. 2020, ApJL, 897, L29
Shara, M. M., Ilkiewicz, K., Mikolajewska, J., et al. 2017, Natur, 548, 558
Shara, M. M., & Moffat, A. F. J. 1982, ApJL, 258, L41
Shara, M. M., Moffat, A. F. J., & Webbink, R. F. 1985, ApJ, 294, 271
Shen, K. J. 2015, ApJ, 805, L6
Stephenson, F. R. 1976, QJRAS, 17, 121

Stephenson, F. R., & Green, D. A. 2005, JHA, 36, 217
Stephenson, F. R., & Yau, K. K. 1986, QJRAS, 27, 559
Strope, R., Schaefer, B., & Henden, A. 2010, AJ, 140, 34
Todt, H., Guerrero, M. A., Fang, X., et al. 2015, in ASP Conf. Ser. 493, 19th European Workshop on White Dwarfs, ed. P. Dufour, P. Bergeron, & G. Fontaine (San Francisco, CA: ASP), 141
Tylenda, R., Kamiński, T., & Mehner, A. 2019, A&A, 628, A124
Tylenda, R., Kamiński, T., & Smolec, R. 2024, A&A, 685, A49
Vogt, N., Hoffmann, S. M., & Tappert, C. 2019, AN, 340, 752
Wang, G., & Sun, X. 2016, JHA, 47, 416
Wang, Y. 2008, To Measure the Sky with Rulers: the Quantification and Reduction of the Records of Astronomical Phenomena Observed with Naked Eyes in the Scale System in Chinese Annals (Jinan: Shandong Education Press)
Watson, C., Henden, A. A., & Price, A. 2006, SASS, 25, 47
Wenger, M., Ochsenbein, F., Egret, D., et al. 2000, A&AS, 143, 9
Xu, Z., Pankenier, D. W., & Jiang, Y. 2000, East Asian Archaeoastronomy (Amsterdam: Gordon and Breach Science Publishers)
Yang, B.-S. 2023, PhD thesis, USTC Hefei
Yao, Y., Ravi, V., Gezari, S., et al. 2023, ApJL, 955, L6
Yaron, O., Prialnik, D., Shara, M. M., & Kovetz, A. 2005, ApJ, 623, 398