The user wants me to translate a Chinese academic paper title and subtitle. Title: "Identification of Z Cam' s Historical Counterpart: The Quest for an Ancient Nova" Subtitle: "后印本" Let me break this down: - "Identification of Z Cam' s Historical Counterpart" - This seems to already be in English···.

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Date: 2025-01-07T00:00:00+00:00

Abstract

The user wants me to translate a Chinese academic text about astronomical research into English. Let me analyze the requirements:

1. **Critical Requirements**:
   - Preserve ALL LaTeX commands and placeholders exactly
   - Preserve ALL citation commands ([**?**], **??**, (**??**), etc.) exactly
   - **PRESERVE ALL ···paragraph wrapper tags EXACTLY**
   - Maintain academic tone and formal scientific writing style
   - Use precise technical terminology - obey the glossary strictly
   - Preserve section structure and paragraph organization
   - Translate all content completely - do not omit any information
2. **Output Rules**:
   - Return ONLY the translated text (no explanations, no quotes, no headings)
   - Keep one output paragraph per input paragraph
   - **Maintain exact count and IDs of ···tags**
   - Do NOT add Markdown formatting unless present in source
   - Preserve original line breaks within the paragraph when meaningful
3. **Formatting Guidelines**:
   - Keep mathematical expressions in original LaTeX format
   - Preserve equation numbers and references
   - Maintain proper academic paragraph structure

- Use formal scientific language

4. **Glossary**:
   - 机器学习 => machine learning
   - 深度学习 => deep learning

Looking at the input text, I see it' s about astronomical research linking the dwarf nova Z Cam to historical celestial events. The text mentions: - The "guest star" phenomenon reported in China in 77 BCE - Identification with Z Cam in AAVSO Variable Star Index and research papers - Reconstruction of the Purple Palace super-constellation in Han Dynasty - Finding that Z Cam is outside this enclosure - New text versions of the 77 BCE guest star - Analysis of divination text suggesting it was a comet - The guest star of 369 CE being a more plausible candidate for Z Cam

The input text appears to be a single paragraph without any tags, LaTeX commands, or mathematical formulas. However, the instructions are very specific about preserving these elements. Since there are no tags in the input, I need to consider whether I should add them or if this is a test case.

Wait, let me re-read the instructions carefully. The user says "Translate from Simplified Chinese to English" and provides the text. The text doesn' t contain any tags, LaTeX, or special markers. But the instructions say "PRESERVE ALL ···paragraph wrapper tags EXACTLY" and "if input has N paragraph tags, output must have exactly N paragraph tags with matching IDs" .

Since the input has NO tags, the output should also have NO tags. The

Full Text

Preamble

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Identification of Z Cam' s Historical Counterpart: The Quest for an Ancient Nova

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Abstract

In recent astronomical discussions, attempts have been made to link the known dwarf nova Z Cam to historical celestial events, particularly the "guest star" phenomenon reported in China in 77 BCE. Despite other suggestions and the problems with regard to the location of the event in 77 BCE, its identification with Z Cam is used in the Variable Star Index of the AAVSO and in several research papers that aim to derive knowledge on the evolution of cataclysmic variables. Through the reconstruction of the super-constellation of the Purple Palace in the Han Dynasty, we found that Z Cam is actually located outside this enclosure, contradicting the records of the 77 BCE guest star being "within the Purple Palace." With newly found text versions of the guest star in 77 BCE, we narrowed down the position given therein. Combining this with a new analysis of accompanying divination text leads to the conclusion that through meticulous examination and comparison, the guest star of 369 CE appears the most plausible candidate for Z Cam' s historical counterpart, aligning with both textual evidence and modern astronomical observations.

Key words: (stars:) novae -cataclysmic variables -history and philosophy of astronomy -stars: dwarf novae -stars: evolution

1. Introduction

Z Cam is a known dwarf nova and prototype of the class of Z Cam-type stars. In recent years, it has attracted considerable attention. Shara et al. (2007, 2012, 2024) captured the surrounding shell of Z Cam, demonstrating that it has permitted at least two classical nova eruptions in history. Consistent with the first age estimate of 240–2400 yr, Johansson (2007) linked the most recent eruption of Z Cam to the guest star of 77 BCE. Despite other suggestions (Nickiforov 2010; Warner 2016), astrophysics seems to favor this proposal because Shara et al. (2012, 2024) keep using this identification as the only one. Based on the reading of historical records, Hoffmann (2019) argued that neither Nickiforov' s suggestions nor the 77 BCE event match Z Cam' s location, and Hoffmann & Vogt (2021) provided a list of some other records that may match the position of Z Cam and had been suggested as potential historical novae by other scholars (although not all these suggestions are convincing). Currently, there are as many as 10 historical records suggested to relate to eruptions of the known dwarf nova Z Cam. With Shara et al. (2024) again referring to the record of 77 BCE which has already been rejected, we now use the most recent results of historical research in order to provide a more profound analysis of this identification and suggest what historical record may preserve the position of observations of the eruptions that caused the shells Shara et al. (2024) have found in the new data.

In addition to the unproven match of Z Cam and 77 BCE in the literature, the textual basis of this suggestion may be seen as critical: The text version that Johansson (2007) used for the suggestion is Ho (1962), who gives a medieval (Song Dynasty, see Table 1) rewriting of the original observation. Our reposi-

tioning of the guest star is based on the original version in combination with newly reconstructed historical star charts with a better epoch (Han Dynasty). Furthermore, the contextual reading of the record provides additional insight into the nature of the object that is described as a guest star.

2. Data Analysis

From the historical point of view, some new findings of recent years shed new light on both the record of 77 BCE and the possible identifications of historical records with Z Cam. First, we give our new reconstruction of the constellations that are used as the historical frame of reference; second, we provide new readings of the historical records.

2.1. Reconstructing Constellations: The Purple Palace in the Han Dynasty

In all Chinese versions of the recorded observations of the guest star in 77 BCE, it is consistently stated that this guest star was located within the superconstellation of Zigong (Purple Palace), which encloses many other smaller constellations. However, the definition of historical constellations has never been canonical but changed over the course of centuries (Hoffmann 2016, 2022; Yang 2023).

All previous astrophysical research utilized a random variety of historical maps. Due to the lack of a comprehensive study of this topic, Hoffmann (2019), Hoffmann et al. (2020), and Hoffmann & Vogt (2020) developed their new astrophysical data-mining method with the didactic reduction of a Chinese historical map provided by the Hong Kong Space Museum (mainly based upon star charts and maps in the middle Qing Dynasty, 18th century). This version of the Chinese star map placed Z Cam within the right wall of the Purple Palace, seemingly aligning with the description. In contrast, the latest research on the transformations of Chinese constellations (Yang 2023) reveals that the Purple Palace in 77 BCE (Han Dynasty) had been defined differently and Z Cam was actually located outside the Purple Palace.

During the early Western Han Dynasty (2nd century BCE), the official star system recorded in Sima Qian' s *Tianguan shu* (Book of Heaven Officials) had only 12 stars in the wall of the Purple Palace. However, at about 104–102 BCE, the Shi school asterism system replaced the old system and the wall of the new Purple Palace contained 15 stars. This new system continued to be transmitted to later generations. Therefore, we can reconstruct the Purple Palace in 77 BCE using star charts or other materials from later periods that are close in time.

The star map we use to reconstruct the early Purple Palace is the *Cheonsang Yeolcha Bunyajido*, which is kept in Korea. This star map was engraved on a stele in 1395, but its base map is a rubbing from a 7th-century star map stele (Stephenson 1976, 560–567). Therefore, the positions and shapes of the constellations preserved on this star map date back to before the 7th century.

Pan (2009, 489–495) found this star map to preserve the constellation forms of early Chinese celestial history during the first millennium. Nakamura (2021) calculated the coordinates of the stars on this map and dated them to around 53 BCE, plus or minus 100 yr. The constellations depicted on this star map differ significantly in shape and position from those on star maps created after the 11th century but align well with earlier textual descriptions. Recently, we discovered a new star catalog produced in the Han Dynasty, and upon comparison, we found it closely matches the *Cheonsang Yeolcha Bunyajido*.[3] Therefore, this star map is highly reliable for reconstructing the Purple Palace of the Han Dynasty.

Based on this star chart, we reconstructed the Purple Palace and its surrounding asterisms as shown in Figure 1 (top), which differs significantly from this region in the Song Dynasty (Figure 1, bottom). Sun & Kistemaker (1997) have also reconstructed the Han Dynasty sky, but some places in it could be improved. First, the *Shishi xingjing* (Shi School Star Canon) of the Han Dynasty described that "the Zigong has 15 stars, among which 7 are on the west (right) wall, 8 are on the east (left) wall" (Qutan 1980, 666). However, they put only six stars at the right wall and nine at the left. Second, this reconstruction does not align with early textual descriptions in the relative position between other asterisms and the wall of the Purple Palace. The original description said "the six stars of Tianchu (Celestial Kitchen) are located at the northeast outside the Purple Palace" (Qutan 1980, 681), but in their star maps, the positions became the east of the Palace wall, similar to the patterns on the Song star map (as shown in Figure 1). The positions of other asterisms, such as the Wudi neizuo (Interior Seats of Five Emperors), Nüshi (Female Protocol), and the Zhushi (Official of Royal Archives), also show significant discrepancies with the records in the Han Dynasty star canons. In contrast, the *Cheonsang Yeolcha Bunyajido* aligns well with the Han records.

Moreover, their reconstruction of the Purple Palace and surrounding constellations seems to rely much on Song Dynasty star maps, so the walls of the Purple Palace are much longer compared to the *Cheonsang Yeolcha Bunyajido*, making the asterism Huagai (Canopy of the Emperor), which is located at the northern gate of the Purple Palace, move dramatically from its original location. A meteor record from the early 6th century suggests that Sun and Kistemaker' s reconstruction does not accurately represent the location of Huagai in the early Purple Palace area. According to the *Weishu* (Book of Wei): "In the first year of the Yanchang era, the third month, on the day yiwei (April 6, 512), a meteor appeared near the Taiyangshou (Guard of the Sun), passed through the Beidou, entered the Purple Palace, reached the Beiji, and extinguished at Huagai" (Wei 1974, 2036). The trajectory of this meteor passed through many asterisms including the Taiyangshou, Beidou, Beiji, and Huagai. In Sun and Kistemaker' s reconstruction, these asterisms are not aligned in a straight line, which contradicts the record. In contrast, the Purple Palace reconstruction based on *Cheonsang Yeolcha Bunyajido* shows that these asterisms are aligned in nearly a straight line, closely matching the meteor record. Additionally, the shape of Huagai in this reconstruction also closely resembles the canopy used

by the royal family in earlier times.

Based on the clues above, it is evident that the configuration of the Purple Palace depicted in the Korean *Cheonsang Yeolcha Bunyajido* is generally reliable for reconstructing Chinese constellations. However, due to errors introduced during the processes of drawing, transcription, and being engraved on the stone, the star chart is not exact and can only reflect approximate positions and shapes of the asterisms. Further evidence is required to carefully determine the specific stars corresponding to the walls of the Purple Palace.

First, the most reliable records from the Han Dynasty are the star catalogs. During the transition between the 2nd and 1st century BCE, most probably from 104 to 102 BCE (Ahn 2020; Yang 2023), astronomers of the Western Han Dynasty measured the coordinates of the Shi asterisms, including the Right Star of the Southern Gate of the Purple Palace and its adjacent stars, Tianyi (Celestial One) and Taiyi (Supreme One), which are indicated with triangles in Figure 1. The Shi school in the Han Dynasty gave a brief description of their relative positions: "Tianyi is outside the gate of Purple Palace, south of the right star, at the same degree (in R.A.)" and "Taiyi is at the south of Tianyi and close to it," so the three stars should be in the same line and close to each other (Qutan 1980, 667–668). They also mentioned that "When the star Tianyi shines brightly and radiantly (which should be its normal state), yin and yang are harmonized, and all things come into being," from which we know that Tianyi should be a relatively bright star compared to Taiyi. Based on these data and descriptions, we can identify the three stars respectively as right star of southern gate (6 Dra, $m = 4.95$ mag), Tianyi (κ Dra, $m = 3.85$ mag) and Taiyi (CQ Dra, $m = 5$ mag), which are the same with the identification of Maeyama (2002). The locations and alignment of these stars are consistent with the *Cheonsang Yeolcha Bunyajido*.

Apart from the right gate star, currently, there are no observational data from the Han Dynasty regarding the other 14 stars of the Purple Palace wall. However, observers from the early 8th century mentioned an old star chart, on which the seven stars of the Purple Palace' s right wall were located within the lunar mansions (LM) of Lou (Bond), Mao (Hairy Head), Bi (Net), Jing (Well), Liu (Willow), Zhang (Extended Net), and Zhen (Chariot) (Qutan 1980, 957). The records from ancient star maps inherently contain certain inaccuracies, so the coordinates provided cannot be treated as strictly but should allow for a margin of error. However, it is surprising that five of the seven stars match the positions we reconstructed. The other two stars that do not align precisely are either near the boundary or in an adjacent mansion. This discrepancy is likely due to observational errors. For instance, the right star of the Southern Gate was originally in the Yi mansion, but due to errors, Han Dynasty observers recorded it as being "ten du into Zhen." [4] As a result, the star map based on this catalog also places the star in the Zhen mansion. The boundaries of these mansions are shown in Figure 1.

The second and third stars of the right wall of the Purple Palace can be relatively

easily identified based on the star maps. However, the fourth star requires careful analysis, as its identification is closely related to the position of Z Cam. Z Cam is located between the fourth and fifth stars from the southern gate of the right wall of the Purple Palace, regardless of whether we consider the version of this constellation from the Han Dynasty or the Song/Qing Dynasty. In the Song Dynasty, the fourth star is d UMa (Sun & Kistemaker (1997) chose it as the third star), and the fifth star is HIP 33827 also called BLL 18 (in the Qing Dynasty, it was 43 Cam; Sun & Kistemaker (1997) also chose 43 Cam as the fourth star) which places Z Cam inside the wall. In the Han Dynasty, d UMa is a member of the constellation of Neijie (Inner Steps), which also differs from its Song/Qing Dynasty counterpart.

Neijie consists of six stars,[5] which form a slanted stair-like shape on *Cheonsang Yeolcha Bunyajido* and another early star map. In the early 8th century, Tang Dynasty astronomers measured this asterism and noted "Now we measured that it is north of Wenchang, spanning from the Jing to the Liu Mansions, narrow and long, its stars close to each other in pairs (three pairs)···" (Qutan 1980, 960). Based on star charts and these descriptions, we can confidently identify the member stars of the Inner Steps: A UMa, π^2 UMa, ρ UMa, σ^2 UMa, d UMa, and HIP 47594. Due to the precession of the equinoxes, the LMs where these stars are located had shifted by the early 8th century compared to the Han Dynasty: the first four stars were in the Jing Mansion, d UMa was in the Gui Mansion, and HIP 47594 was in the Liu Mansion, which perfectly align with the measurements of Tang Dynasty astronomers.

In fact, the Neijie was likely modeled after another asterism, Santai (Three Steps). In the Han Dynasty, Santai is also called Tianjie (Celestial Steps) or Taijie (Supreme Steps) among imperial astronomers, described as "Taiyi ascending and descending treading on it." The name "Inner Steps" also implies a staircase, referred to as "the steps of the Heavenly Emperor" (Wei 1974, 532-534). With both constellations resembling stairs, one represents the emperor' s passage from Taiwei (Supreme Court) to the Wenchang (Administrative Center) palace, while the other symbolizes the path from the Wenchang palace to the Purple Palace.

As a result, the right wall of the Purple Palace during the Han Dynasty can only be between d UMa and the pole, and the fourth star should be chosen as 27 UMa. No matter whether the fifth star is chosen as HIP 40793 or HIP 39117, Z Cam ends up outside the wall of the Purple Palace in the Han Dynasty, which clearly does not match the record of 77 BCE that reports the guest star "within Zigong."

2.2. Revisiting the Position of the Guest Star in 77 BCE

Up to now, research on this guest star primarily relies on records from Chinese-English translations of excerpts of chronicles. There, the original record of 77 BCE reads: "Emperor Zhao of Han, 4th year of Yuanfeng reign period, 9th

month. A guest star was situated within Zigong between Doushu and [Bei-]Ji (North Pole (Asterism))." This passage was excerpted by Xu et al. (2000, 129) from the Chinese official historical text *Tianwenzhi* (Astronomical Treatise) in the *Han shu* (Book of Han). Zigong (The Purple Palace) is the circumpolar region, and Doushu was regarded to be α UMa (Xu et al. 2000, 422), the first star of the Beidou (Northern Dipper), which is usually called Tianshu (Celestial Pivot). However, this positional description is peculiar: the guest star is located within the Purple Palace, while the reference star "Doushu" is outside the Purple Palace. The stars of the western (right) wall of the Purple Palace separate the North Pole Asterism (Beiji) from the reference star α UMa. Why would a star outside the Purple Palace be used as a reference for celestial phenomena inside it?

At the 2023 Chinese Conference of the History of Science and Technology, Zhao Shuaijun proved that there is a textual corruption in the record for 77 BCE because the "Dou" is actually an extra word added by mistake that probably emerged at least in the Song Dynasty, as several printed versions of the *Book of Han* all preserved this error after the Song Dynasty (Zhao 2023). He found that the printed edition of the *Book of Han* after the Song Dynasty differs from the earlier Tang Dynasty manuscript. Therefore, the correct record of 77 BCE needs to be sought in books before the Song Dynasty. The *Kaiyuan zhanjing* (Divination Canon of Kaiyuan Reign, KYZJ), compiled during the early Kaiyuan reign period (713–741) of the Tang Dynasty, happens to quote the record of the 77 BCE guest star from the *Book of Han* and another book. The quotation from the *Book of Han*, Astronomical Treatise reads: "In the 4th year of Yuanfeng, in the 9th month, the guest star 'qu' (departed from) 'Jian' (middle or surrounding space) of Shu-Ji of Zigong. The divination said: 'It indicates war.' In the sixth month of the fifth year, young men were sent from the capital area and other counties/sub-kingdoms to assist northern army." (Qutan 1980, 781) Another book called *Hongfan tianwen xingchen bian zhan* (The Divination of Star Anomalies in Heavenly Patterns Chapters of Hongfan, HFTWXCBZ) records (Qutan 1980, 781): "Emperor Zhao of Han, 4th year of Yuanfeng reign period, the 9th month. A guest star 'zai' (was in/at) 'Jian' of Shu-Ji of Zigong. Three years later, Emperor Zhao died."

The two early records are consistent in describing the position of the guest star, without the word "Dou" and by only using "Shu." The term "Shu" has several meanings. Excluding the first star of the Big Dipper, Tianshu (which is outside the Purple Palace), the stars named Zuoshu (left door hinge) and Youshu (right door hinge) in the southern gate of the Purple Palace and the fifth star of the North Pole Asterism, Shuxing (pivot star), are known as "Shu" within the Purple Palace; furthermore, the equatorial pole itself could also be called so. The term "Ji" (pole) has two meanings: one meaning is the equatorial pole, and the other is the asterism called the North Pole consisting of five stars. The term "Jian" can be interpreted as "middle/in between" or "surrounding space of something."

First, we can exclude Zuoshu and Youshu, for we find that these names did not

appear before the famous astronomical poem *Butian ge* (Song of Pacing the Heaven), which was believed to originate from the 7th or 8th century (Chen 1992; Pan 2009). Prior to this, the names of the stars of the wall of Purple Palace were different: among them, the left and right stars of the southern gate were called Touguan and Xingui respectively from the Han Dynasty to the late 7th century (Li 1993, 265–268). The fifth star of the North Pole Asterism was named Shuxing, which was very close to the equatorial north pole and at that time had the same function that our pole star (Polaris) has today. Thus, many people did not distinguish between the Shuxing and the equatorial pole. The pole star in the Song Dynasty was identified to be HIP 62572 (a 5 mag-star between Kochab and Polaris) due to contemporary star catalogs (Pan 2009, 299), but in 77 BCE, it was about 5° away from the real north pole and cannot be considered the Han pole star. Based on its relatively small separation from the pole in the 1st to the 5th century, Huang (1992) believed that the pole star in that time was HIP 62170 (HD 111112), but at the beginning of Han in 77 BCE, the visible star closest to the true north pole was HIP 65595, and this star is not only brighter than HIP 62170 but also closer to the other four known stars of the North Pole Asterism, so we can regard it as the pole star in 77 BCE, although it is only 5.7 mag bright: it will be recognized near the North Pole Asterism.

The first interpretation of the above records is that this guest star was located between the pole star Shuxing (HIP 65595) and the equatorial pole, which is an angular distance of $ $2° (our Search Field 1, Figure 3). Alternatively, we could interpret "Shu" as the equatorial pole, then "Ji" should refer to the five stars of the North Pole Asterism. In this case, the interpretation of the record is that this guest star was located between the North Pole Asterism and the equatorial pole. However, if we consider "Shu-Ji" as a term, which also makes sense, it will refer to the asterism or the pole star or the pole itself. In this reading, "Jian" is no longer "middle/in between" but refers to the space around a specific object, that is, the space adjacent to the North Pole Asterism or the northern pole.

2.3. Search for SNRs and Nova Candidates at the New Position

The map in Figure 3 contains all supernova remnants (SNRs) and pulsars (PSRs) in the area, which makes it clear that none of them is within any of our search fields. The cataclysmic variables (CVs) are only plotted in a circle of 15° around the equatorial pole in 77 BCE. Among them, roughly eight objects in our search field(s) have the potential to flare up to naked eye visibility. None of them is in the small search field between the North Pole Asterism Beiji and the north pole, but the dwarf nova DDE 75 is close to this position. It is of Z Cam-type with dwarf nova peak brightness of 13.8 mag and a quiescence fainter than 18 mag (still, likely too faint). The brightest of all candidates is the dwarf nova SS UMi with a peak brightness of 12.6 mag. In case of a classical nova with typical amplitudes of 11–13 mag but possible amplitudes up to 16 mag (Vogt et al. 2019, Figure 1), this object could theoretically flare up to naked eye visibility

and reach 4–1 mag.

2.4. Is the Record 77 BCE Really a Possible Nova?

This record has a long tradition in nova candidate lists. It can be traced to the 19th century and is copied by all authors of the 20th century (Hsi 1957; P. Ho 1962; Stephenson 1976; Clark & Stephenson 1977; Xu et al. 2000). In the 19th century, the term "nova" was used for all kinds of transients that were not understood in those days: Stellar evolution has been described from the 1920s onwards, the definition of "supernovae" in astrophysics started in the 1930s (Trimble 1982, 1983), and "novae" as surface eruptions in cataclysmic or symbiotic binaries were understood as late as the 1960s. Thus, Hsi (1957) and Ho (1962) refer to the suggestions of Williams (1871) and Biot (1843), who wrote when it was not even clear what the energy source of stars is, let alone the life cycle of stars or what distinguishes novae from supernovae. Stephenson (1976) copied their suggestion and, since then, the record is regarded as a potential (super)nova candidate.

New data from studies of Chinese history challenge this suggestion of the event with regard to the modern definitions of "novae" and "supernovae" in astrophysics. Among the guest stars mentioned in ancient China, many are comets, and some may even be meteors or aurorae. Xu et al. (2000) attempt to sort out the categories and treat them in different chapters of their two volumes, and Stephenson (1976) and his subsequent studies also aim to judge the astrophysical nature by reading records. As they all consider the terminology in chronicles not perfectly reliable, Hoffmann et al. (2020) and Hoffmann & Vogt (2020, 2021) recommended probing the search fields derived from the records for all kinds of variable stars and letting astrophysics decide upon the nature of the appearance they saw. Without any supernova remnant in the area, the record would rather be considered a nova than a supernova (or anything else that may or may not be stellar).

However, the inconsistencies of the two records in 77 BCE quoted from the Astronomical Treatise and HFTWXCBZ in the KYZJ are suspicious: The former used the verb "qu"(departing) while the latter used "zai"(being in/at). Are these two records contradictory or is one of them wrong? The solution requires an understanding of historical writing: both records are correct, but the problem is modern extraction of sentences disregarding the context.

The selection criteria for "possible novae" in Chinese records from the 19th century onwards were based on modern standards, aiming to produce lists of potential variable stars and stellar transients of all types, while ignoring the seemingly irrelevant background information. In contrast, ancient Chinese astral science was largely astrology, so abnormal celestial phenomena indicated significant events in human society. This idea often governed the historiography of early historians: for each recorded celestial phenomenon, they would strive to find the corresponding social event. Although there was no actual connection

between the two, ancient historians often established a correspondence between celestial phenomena and human affairs based on a certain logic such as formal similarity. Therefore, conversely, we can uncover information about primitive celestial phenomena from corresponding social events.

The authors of the two books chose different social events corresponding to the celestial phenomena. In the Astronomical Treatise, the guest star left the North Pole region, and the government ordered some young men to go to the northern border to assist the army in the following year. We found a record of the same event in the Annals of Emperor Zhao of the *Book of Han*: "In the sixth month, unruly youths from the capital area and other counties/sub-kingdoms, and those who had been officially reported deserters were dispatched to garrison the Liaodong (in northeast Han territory)" (Ban 1964, 231). Therefore, these young men were actually social nuisances, and sending them from the capital to the border corresponds precisely to the guest star leaving the celestial north pole region of the Purple Palace. Therefore, this guest star should be a moving comet rather than a stationary nova.

In the second book, the author chose the death of the emperor three years later as the corresponding event for this phenomenon. Therefore, the author only needed to emphasize that this guest star (a comet) had once been in the northern polar region of the Purple Palace, indicating disaster for the emperor, without mentioning its subsequent whereabouts.

The record in 85 CE provides a similar case. The Astronomical Treatise in the *Book of Later Han* states: "2nd year of Yuanhe reign period, the 4th month, day dingsi (CE 85 May 20). A guest star appeared in the morning at the east at 8 du within mansion Wei (Stomach) measuring three feet in length, and passed by the Gedao (Flying Corridor) into the Purple Palace, staying there for forty days before extinguishing. The Gedao and Purple Palace are the places of the emperor. A guest star that invades and stays for a long time signifies a great mourning. Four years later, Emperor Xiao Zhang died" (Fan 1965, 3232). There is no doubt that this was a comet, and because it eventually stayed in the Purple Palace for a long time, it was believed to have caused the emperor' s death four years later.

Another chapter in *Book of Later Han*, Annals of Emperor Zhang, also mentioned this comet: "Emperor Zhang of Han, 2nd year of Yuanhe reign period, in summer, the 4th month, day yisi[dingsi, May 20].[6] A guest star entered the Purple Palace. On the day of yimao (May 18), the emperor' s carriage returned to the palace" (Fan 1965, 150). In this record, the comet is not considered a disaster but symbolizes the emperor' s carriage, entering the Purple Palace area as the emperor returns from his inspection tour. Here, the historians only recorded the moment of the comet' s entry into the Purple Palace and disregarded the movements before and after, as these pieces of information were irrelevant for the correspondence of a celestial event and human affairs they aimed to establish. Through this interesting case, we see the choices ancient historians made regarding the information of primitive celestial phenomena.

With regard to the event in 77 BCE, we can understand why there are records of both "departing" and "being in/at." If the text explicitly mentions movement, it undoubtedly refers to a comet; however, if it only mentions the star being in the Purple Palace, it could be either a moving object or a stationary one. In this case, when the 77 BCE comet was associated with the emperor' s death, the compiler emphasized its presence in the Purple Palace while omitting any reference to its movement. However, another book, which linked this comet to a different event involving population migration, retained the term "qu" (depart from), providing us with clear evidence that this was indeed a comet.

Conclusion 1. Z Cam does not relate to the guest star of 77 BCE. Actually, even if we consider the wrong text version that dates after the Song Dynasty and places the event of 77 BCE between α UMa and the North Pole Asterism, Z Cam still does not match the position but is 4 or 5 R.A.-hours away.

2.6. Are There Alternative Candidates for a Nova Event in 369 CE?

Hoffmann & Vogt (2020) mentioned that possible eruptions of CQ Dra and BZ Cam may also match the guest star in 369 CE. CQ Dra is a symbiotic star which is visible to the naked eye (5 mag) and if it permits a classical nova eruption, this will increase its brightness more than Venus' and it will decline slowly so that a visibility of a couple of months could easily be given. However, from the Han Dynasty to the Tang Dynasty, CQ Dra has always been referred to by astronomers as Taiyi (Supreme One). Assuming that they would have noticed that this star had flared up in 369 CE, they would not have called it a "guest star" (because a guest is necessarily new and only stays for limited time). So, with regard to the phrasing and framing of the observation in 369 CE, an eruption of CQ Dra is unlikely to have been considered as a guest star.

BZ Cam is a nova-like with an impressive multiple shell structure around it. The first photographs from Kitt Peak published in Miszalski et al. (2016) may suggest recurrent nova eruptions on the timescale of centuries or millennia as referred to by Hoffmann & Vogt (2020). However, Balman et al. (2022) with new measurements of the hot flows of this nova-like system (X-ray spectroscopy) suggest that a jet-like outflow mimics an eruption structure that resembles nova shells and their interaction with the interstellar medium (ISM) even with regard to the ejecta mass. From the historian' s point of view, the new studies of the transformations of ancient Chinese constellations that provide better time-resolution suggest that BZ Cam may be considered too far away from the "western wall of the Purple Palace" that is described in the guest star record of 369 CE (see Figure 5 [Figure 5: see original paper]).

The object located directly at the asterism line in Figure 5 is MGAB-V1226 and has been newly discovered in 2020. It passed our brightness filter because it varies around 18 mag (from 17.45 to 18.4). Presuming a hypothetical eruption amplitude of 13 mag or more (cases up to 16 mag were occasionally observed in some systems during the past 250 yr, see Vogt et al. (2019, Figure 1)), it

is not excluded to flare up to naked eye visibility, but is somehow unlikely to be a historical nova (small chance). The new definition of the "west wall" of Zigong rather suggests the dwarf nova CI UMa close to this asterism line as a candidate for observations by historical astronomers. This dwarf nova varies normally between 14 and 15 mag (with eclipses to lower brightness) and may therefore become visible to naked eye observers in case of a classical nova eruption with typical amplitudes of 11–13 mag; it will likely become roughly as bright as Polaris.

Despite other possibilities that always exist, the inner shell of Z Cam should now be considered the most likely match for this event. The description of the position in this record fits the historical frame of reference better than used in the specific time.

Conclusion 3. Only the guest star in CE 369 can be considered as a nova candidate. Apart from the already known information that it lasted for five months, we found the wording "guard" in the following divination text, which indicates that this guest star remains stationary. Its reported position next to the "west wall" is consistent with the position of Z Cam. This event' s eruption 1655 yr ago is consistent with the observation results presented in Shara et al. (2007) with an age estimate for the shell between 240 and 2400 yr, and with an inter-eruption time of more than 1300 yr (Shara et al. 2012). Shara et al. (2024) 's new approximate age of the inner shell between 1855 and 4774 yr does not perfectly match the only reported date: the astrophysical dating leads to an eruption between 2749 BCE and 169 CE, and not 369 (which relates to an age of 1655 yr), if we take it accurately to a year, but the uncertainties in astrophysics are usually larger. With typical nova amplitudes of 11–13 mag, an eruption of Z Cam with a quiescence brightness of roughly 11.8 mag would flare up the star to Sirius' brightness, and it will be visible for the time of decline by t_3 to t_6. According to Strope et al. (2010), even t_3 of roughly 150 days (5 months) is not frequent but occasionally happens, see Hoffmann et al. (2020, Figure 2). Decline times by 6 mag of $t_6 \approx 5$ months would be shorter than currently observed (as t_6 typically lasts longer than seven months) but are not totally excluded. As t_4 and t_5 (which are not used as index) necessarily lay in between t_3 and t_6, the reported five months in 369 CE do not help to exclude or support the identification with Z Cam. Summarizing, the guest star in 369 CE is the only nova candidate that matches Z Cam in position, although it does not match perfectly in age. If the current astrophysical age estimate again turns out to favor an earlier date, it is well possible that the classical nova eruption of Z Cam in history remained unobserved or that the records are lost, as already suggested by Shara et al. (2007).

3. Conclusions

As already pointed out by Hoffmann (2019), the position of Z Cam does not match the position of the guest star in 77 BCE. The most recent comprehensive dissertation by Yang (2023) concerning the transfer and transformation of

Chinese constellations as the historical frame of reference for most "guest stars" yielded a much better time-resolution of the definition of them. With this new knowledge, we have to emphasize the rejection of this identification. Furthermore, our profound new reading of the record within its context suggests that the "guest star" in 77 BCE was a comet rather than a stellar transient.

Looking for alternative historical records that could be identified with Z Cam, we support the earlier suggestion by Hoffmann & Vogt (2021) that the "guest star"in 369 CE, which is reported to have lasted for 5 months, could be the counterpart of the innermost shell of Z Cam. This record fits earlier age estimates but is 200 yr younger than the youngest possible age in the most recent age estimate by Shara et al. (2024), as long as they do not change their (asymmetric) upper error bar. Thus, it is well possible that the most recent classical nova eruption of Z Cam remained unobserved by historical stargazers or that their record on this is lost—as already suggested by Shara et al. (2007).

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Data Availability: The dissertation by Yang (2023) is currently only available at USTC Hefei and written in Chinese. We are looking forward to a future publication. In addition, we used data from the above-mentioned databases.

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References

Ahn, S.-H. 2020, PASJ, 72, 87
Balman, Ş., Schlegel, E. M., & Godon, P. 2022, ApJ, 932, 33
Ban, G. 1964, *Han shu* (The Book of Han) (Beijing: Zhonghua Book Company)
Biot, E. 1843, *Des Etoiles extraordinaires observées en Chine depuis les temps anciens jusqu' à l' An 1203 de notre ère* (Paris: Bureau des Longitudes), 60
Chen, M.-D. 1992, *Chenzhuo Xingguan de Lishi Shanbian* (The Historical Change of Chenzhuo' s Asterisms), Anthology of History of Science and Technology 1 (Shanghai: Science and Technology Press), 77
Clark, D. H., & Stephenson, F. R. 1977, *The Historical Supernovae* (New York:

Pergamon Press)
Fan, Y. 1965, *Houhan Shu* (The Book of Later Han) (Beijing: Zhonghua Book Company)
Gongyang, S. 1999, *Gongyang Chunqiu Zhuan Zhu Shu* (Exegesis of the Gongyang Commentary on the Spring and Autumn Annals), *Shisan Jing Zhu Shu* (Beijing: Beijing Univ. Press)
Ho, P. Y. 1962, VA, 5, 127
Hoffmann, S. M. 2016, Orbis Terrarum, Vol. 14, 33
Hoffmann, S. M. 2019, MNRAS, 490, 4194
Hoffmann, S. M. 2022, in *Astronomy in Culture–Cultures of Astronomy: Proc. of the Splinter Meeting in the Annual Meeting of the Astronomische Gesellschaft* (Hamburg: Tredition), 491
Hoffmann, S. M., & Vogt, N. 2020, MNRAS, 496, 4488
Hoffmann, S. M., & Vogt, N. 2021, in *Applied and Computational History of Astronomy: Proc. of the Splinter Meeting in the Astronomische Gesellschaft*, ed. G. Wolfschmidt (Hamburg: Tredition), 238
Hoffmann, S. M., Vogt, N., & Protte, P. 2020, AN, 341, 79
Hsi, T.-T. 1957, CoA, 2, 109
Huang, Y.-L. 1992, TsHUJ, 15, 93
Johansson, G. H. I. 2007, Natur, 448, 251
Li, F. 1993, *Zhongguo Kexue Jishu Dianji Tong Hui* (General Collection of Chinese Science and Technology Classics): Astronomical Parts, *Tianwen Yao Lu*, Vol. 4 (Kaifeng: Henan Educational Press)
Maeyama, Y. 2002, in *The Two Supreme Stars, Thien-i and Thai-i, and the Foundation of the Purple Palace*, ed. S. M. R. Ansari (Dordrecht: Springer), 3
Manchester, R. N., Hobbs, G. B., Teoh, A., & Hobbs, M. 2005, AJ, 129, 1993
Miszalski, B., Woudt, P. A., Littlefair, S. P., et al. 2016, MNRAS, 456, 633
Nakamura, T. 2021, JAHH, 24, 440
Nickiforov, M. G. 2010, BlgAJ, 13, 116
Pan, N. 2009, *Zhongguo Hengxing Guance Shi* (A History of Chinese Star Observation) (Shanghai: Xuelin Press)
Qutan, X.-D. 1980, *Yingyin Wenyuange Siku Quanshu, Kaiyuan Zhanjing*, Vol. 807 (Taibei: The Commercial Press (Taiwan, China))
Shara, M. M., Lanzetta, K. M., Garland, J. T., et al. 2024, MNRAS, 529, 212
Shara, M. M., Martin, C. D., Seibert, M., et al. 2007, Natur, 446, 159
Shara, M. M., Mizusawa, T., Zurek, D., et al. 2012, ApJ, 756, 107
Stephenson, F. R. 1976, QJRAS, 17, 121
Strope, R. J., Schaefer, B. E., & Henden, A. A. 2010, AJ, 140, 34
Sun, X., & Kistemaker, J. 1997, *The Chinese Sky during the Han: Constellating Stars and Society* (New York and Köln: Brill)
Trimble, V. 1982, RvMP, 54, 1183
Trimble, V. 1983, RvMP, 55, 511
Vogt, N., Hoffmann, S. M., & Tappert, C. 2019, AN, 340, 752
Warner, B. 2016, in *3rd Annual Conf. on High Energy Astrophysics in Southern Africa* (Trieste: SISSA)
Wei, S. 1974, *Wei shu* (The Book of Wei) (Beijing: Zhonghua Book Company)

Wenger, M., Ochsenbein, F., Egret, D., et al. 2000, A&AS, 143, 9
Williams, J. 1871, *Observations of Comets from BC 611 to AD 1640*, ed. (Cambridge: Cambridge Univ. Press)
Xu, Z., Pankenier, D. W., & Jiang, Y. 2000, *East Asian Archaeoastronomy: Historical Records of Astronomical Observations of China, Japan, and Korea* (Amsterdam: Gordon and Breach)
Yang, B.-S. 2023, PhD thesis, USTC Hefei
Zhao, S.-J. 2023, Annual Meeting of the Chin. Soc. History of Science and Technology: *BC 77 Kexing Weizhi Zaitan* (Revisiting the Location of 77 BC Guest Star)
Zhu, G.-C. 1425, *Tianyuanyuli xiangyi fu* (Beijing: Manuscript of Ming dynasty)
Zotti, G., Hoffmann, S. M., Wolf, A., Chéreau, F., & Chéreau, G. 2020, JSA, 6, 221

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[3] This article is accepted and will be published in 2025 in *The Chinese Journal for the History of Science and Technology* (in Chinese).

[4] The offset of the triangles from the real position of the identified stars (6 Dra, κ Dra and CQ Dra) in Figure 1 is preserved in the above "old star charts" and in text as "ten degrees into Zhen" (referring to 10° R.A., in this case 2° separation); it can be explained by measurement errors with armillary spheres (Yang 2023, 85–108). 365.25 du equals 360°.

[5] Sun & Kistemaker' s reconstruction of this asterism contains only four stars, which is incorrect.

[6] In the 4th month, there is no day yisi. This is a corruption and should be corrected to dingsi.

Note: Figure translations are in progress. See original paper for figures.