DELINEATING ASTERISM BOUNDARIES —— A WORK OF HERITAGE PRESERVATION FOR CHINESE ASTERISM SYSTEM

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Abstract: Around the asterisms (星官) of Chinese astronomical culture, linear-rectangular spherical polygons are delineated along celestial lines of right ascension and declination into 359 boundaries to establish, for the first time, a complete set of 321 Chinese constellations. The term "asterism" is coined from "star" and "bureaucrat" to describe an identifiable arrangement pattern of stars or asterisms in the night sky. All boundaries of the Chinese constellations seamlessly partition the celestial sphere into star regions, star fields, and star areas nested in a three-tier hierarchy. At the top level are six regions: two polar regions and four zodiac quadrant regions metaphorically represented by four cultural totems (四象). The middle layer subdivides these regions into 32 fields that epitomise ancient Chinese society, including the Three Enclosures (三垣), the Twenty-Eight Mansions (二十八宿), and the near-south-pole starry field. At the bottom level, the fields are further partitioned into 321 individual areas, each encompassing a unique asterism. The boundary of each area delineates an exclusive "star constituency" for the asterism, such that all points or stars within the star area unambiguously belong to the constituency, thereby establishing a Chinese constellation.

The delineation of the boundaries is based on 3,325 ascertained bright stars that compose all the asterisms in the hierarchy, most of which are catalogued in Yi Xiang Kao Cheng (仪象考成, 1752) and its continued edition Yi Xiang Kao Cheng Xu Bian (仪象考成续编, 1844). The astronomical information of these stars is cross-verified against modern star catalogues, and their positions are validated via the astronomical database systems SIMBAD and VizieR. The coordinates are converted into ICRS J2000.0 data. The boundary data is formatted in compliance with the Flexible Image Transport System (FITS) standards for legitimate data storage and network transmission in modern applications. The boundaries are tabulated using a smart computational algorithm pioneered by Nancy Grace Roman (1987) for indexing a boundary by celestial position. Parametric computations are also provided to determine the barycentres, areas (in square radians and square degrees), ranking ratios, and visibility of the Chinese constellations

With unambiguous boundaries, the Chinese constellations emerge as a modern digital infrastructure that facilitates high-resolution, rapid mapping of spheroidal pixelisation of the celestial sky, enables the integration of asterisms into modern astronomy, contributes to the preservation and protection of Chinese astronomical cultural heritage, and brings Chinese starry sky narratives into astronautical engineering and space technology.

Keywords: asterism; Chinese constellation; Constellation boundary; Nancy Roman table

1 INTRODUCTION

The term "asterism", coined from "star" and "bureaucrat" in this work, is used as an English equivalent of the term "asterism" in Chinese astronomical culture, as defined in the Glossary of Astronomical Terms (NADC, 2023), primarily to avoid confusion with the term "constellation". "Constellation" was formally recommended by the International Astronomical Union (IAU) in 1928 as the standard description of star areas bounding individual asterisms in Graeco-Roman astronomical culture. In contrast to IAU constellations, the asterism represents the most sophisticated and one of the oldest astronomical paradigms for depicting the Chinese architectural cosmos and its narrative of the starry sky in human history, with origins tracing back to the Shang Dynasty (circa 15th – 12th century BCE), as evidenced by oracle bone inscriptions (cf. Dong, 1948 – 1953; Feng, 2019; Xu et al., 1995). Unlike constellations in Western astronomical traditions, which evolved from star groups to defined sky regions culminating in the IAU boundaries of 1928 (cf. Gould, 1897; Thome, 1890; Delporte, 1930), asterisms in the Chinese astronomical tradition developed as a terrestrial hierarchy mapping celestial phenomena onto political and social organisations.

The foundational consolidation of the asterism system occurred around 270 CE, when Chen Zhuo (circa 270), the Grand Astrologer of the Wu Kingdom, synthesised the star catalogues of three schools (Gan De, Shi Shen, and Wu Xian), resulting in 283 asterisms containing 1,464 stars. This structure was later popularised through the "Song of Pacing the Heavens" (Bu Tian Ge, attributed to Dan Yuanzi of the Sui Dynasty, c. 600 – 700), which provided a mnemonic framework for learning star patterns.

The Qing Dynasty witnessed a significant expansion of the asterism system through *The Compendium of Astronomical Instrumentation and Star Catalogue* compiled by Kögler and Dai (1752) and its continued edition compiled by Aixinjueluo et al. (1844). These works, produced under the supervision of the Jesuit astronomers Ignaz Kögler and Augustin de Hallerstein and later by Chinese astronomers working independently, represent the most comprehensive traditional Chinese star catalogues. *The Compendium* recorded 3,083 stars organised into 300 asterisms, while the continued edition increased the total to 3,240 stars. Notably, the latter was compiled entirely by Chinese astronomers without Western missionary involvement, marking a significant achievement in indigenous Chinese astronomy.

1.1 Anatomy of asterism

Figure 1 presents a star map collated in the *Qinding Daqing Huidiantu* (Kun et al., 1899, The Illustrated Encyclopedia of the Great Qing Dynasty), which was perhaps the last official volume on Chinese asterisms and thus consigned to human history one of the earliest, longest-lasting, and most sophisticated astronomical systems in Chinese tradition

A asterism comprises one or more stars falling into two categories: primary stars and appendent stars (the latter serving as supplements to the former). In essence, it has at least one primary star and any number (including zero) of appendent stars. Primary stars are linked into identifiable arrangement patterns as symbolic representations on the celestial sphere. These patterns are constrained to the fixed background of stars with practical roles in Chinese cultural heritage, in which the line-charted figures were named from the visual perspective of folklore, legends, myths, and so on. They are rich in meaning and form a communication system analogous to characters in a written script (Miton and Morin, 2021).

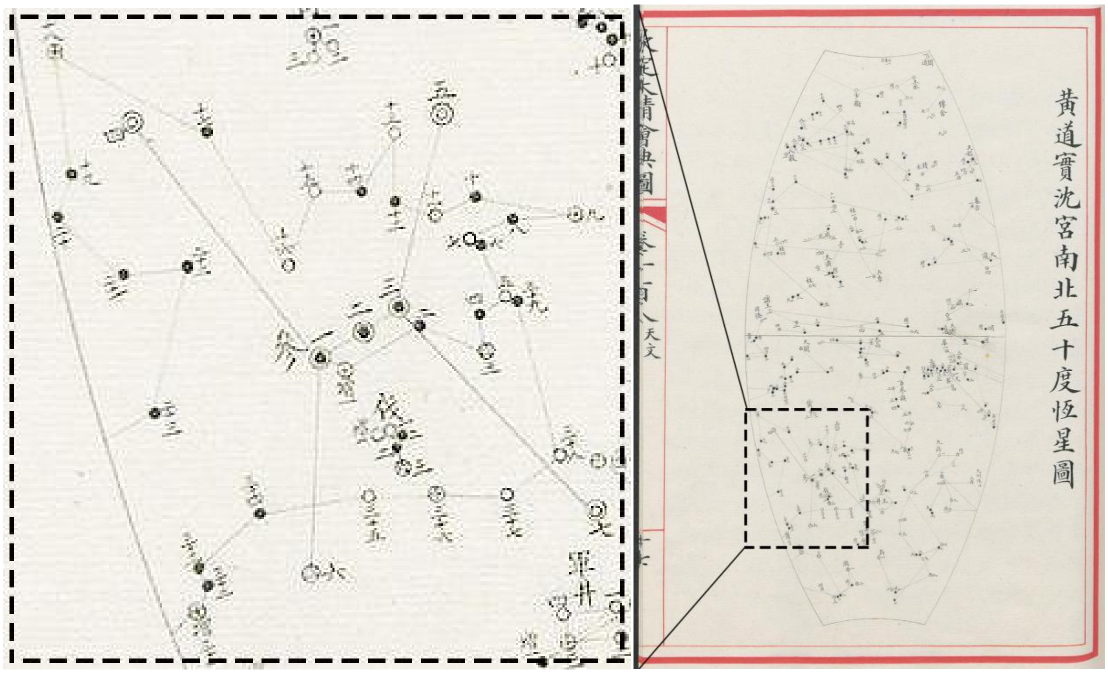


Figure 1: A star map made in the Great Qing Dynasty, 1899. On the right, it shows the asterisms within the star field between 50° and 90° ecliptic longitude and -90° to 90° ecliptic latitude; on the left, the enlarged chart exhibits the topology of the asterism Triads (Shenxiu). The chart almost overlaps the asterism of Orion (an IAU constellation). (Kun et al. 1899; Courtesy: The First Historical Archives of China, Beijing, China).

The appendent stars significantly affect the configuration of the asterism boundaries. They are unique in traditional astronomies across the world in history. For three thousand years in Chinese astronomy, only primary stars were recorded and charted. From 1752 to 1844, Chinese astronomers in the Imperial Observatory of the Qing Dynasty introduced appendent stars into 236 asterisms (the system has 321 asterisms in total; see Table 1 in Section 2.2). Appendent stars are traditionally not depicted in the line-charted figures, they are recorded by the asterisms orientations (east, west, south and north) and locations (interior and exterior). In its current formation, the asterism system consists of 1,523 primary stars and 1,802 appendent stars, bringing the total number of stars that compose all asterisms to 3,325.

Among the 321 asterisms, 85 have no appendent stars, and 56 have only one primary star. The asterism Xuan Yuan is the most populated asterism, comprising 75 stars (16 primary and 59 appendent); it also has the highest number of appendent stars. The asterism Palace Guard is composed of 45 primary stars, and its asterism chart is the most sophisticated among the asterisms in terms of the number of primary stars. Both primary stars and appendent stars are culture heritage of Chinese astronomy and are treasure of effective inheritance of wisdom and spirits of Chinese astronomical culture.

Another factor that essentially shapes the asterism is the topology of the asterisms or charts of asterism, which is defined by the primary stars. Legitimate charts must be plotted in strict observance of Chinese tradition and culture and often with respect to legends and myths.

This means that delineating boundaries around asterisms requires meticulous adjustment and modification, whether through arithmetic calculation or algorithmic computation processes.

Table 1: Hierarchical structure of the Chinese asterism system. There are 359 linear-rectangular spherical boundaries that delineate seamlessly the celestial sphere in three nesting layers, i.e. six star regions, 32 star fields and 321 star areas. There are 17 star areas nested in other star areas and five star areas overlap with other star areas. Every star area surrounds one and only one asterism or star group exclusively; every star field comprises of one or more star areas; every star region consists of one or more star fields.

<table>
<tr><th>Celestial sphere</th><th>Star regions</th><th>Star fields</th><th>Star areas</th><th colspan="2">Total Number</th></tr>
<tr><td rowspan="4">Near poles</td><td rowspan="3">Near north pole region
[bei tian qiu]
BTQ</td><td>Purple forbidden enclosure
[zi wei yuan] ZWY</td><td>39</td><td rowspan="3" colspan="2">80</td></tr>
<tr><td>Supreme subtlety enclosure
[tai wei yuan]] TWY</td><td>22</td></tr>
<tr><td>Celestial market enclosure
[tian shi yuan] TSY</td><td>19</td></tr>
<tr><td>Near south pole region
[nan tian qiu]
NTQ</td><td>Near south pole star field
[nan tian qiu xing yu] JNJ</td><td>23</td><td colspan="2">23</td></tr>
<tr><td rowspan="28">Near ecliptic</td><td rowspan="7">Azure dragon region
[qing long xiang]
QLX</td><td>Horn [jiao xiu] JAX</td><td>11</td><td rowspan="7">48</td><td rowspan="28">218</td></tr>
<tr><td>Neck [kang xiu] KAX</td><td>7</td></tr>
<tr><td>Root [di xiu] DIX</td><td>11</td></tr>
<tr><td>House [fang xiu] FNX</td><td>8</td></tr>
<tr><td>Heart [xin xiu] XIX</td><td>2</td></tr>
<tr><td>Tail [wei xiu] WWX</td><td>6</td></tr>
<tr><td>Dustpan [ji xiu] JIX</td><td>3</td></tr>
<tr><td rowspan="7">Black tortoise and snake region
[xuan wu xiang]
XWX</td><td>Dipper [dou xiu] DOX</td><td>10</td><td rowspan="7">67</td></tr>
<tr><td>Ox [niu xiu] NUX</td><td>11</td></tr>
<tr><td>Damsel [nv xiu] NVX</td><td>8</td></tr>
<tr><td>Void [xu xiu] XUX</td><td>10</td></tr>
<tr><td>Rooftop [wei xiu] WEX</td><td>11</td></tr>
<tr><td>Room [shi xiu] SIX</td><td>11</td></tr>
<tr><td>Wall [bi xiu] BIX</td><td>6</td></tr>
<tr><td rowspan="7">White tiger region
[bai hu xiang]
BHX</td><td>Legs [kui xiu] KUX</td><td>9</td><td rowspan="7">56</td></tr>
<tr><td>Bond [lou xiu] LOX</td><td>6</td></tr>
<tr><td>Stomach [wei xiu] WIX</td><td>7</td></tr>
<tr><td>Stopping-place [mao xiu] MOX</td><td>9</td></tr>
<tr><td>Net [bi xiu] BNX</td><td>15</td></tr>
<tr><td>Turtle-beak [zi xiu] ZIX</td><td>3</td></tr>
<tr><td>Triads [shen xiu] SNX</td><td>7</td></tr>
<tr><td rowspan="7">Vermilion bird region
[zhu que xiang]
ZQX</td><td>Well [jing xiu] JNX</td><td>20</td><td rowspan="7">47</td></tr>
<tr><td>Ghost [gui xiu] GIX</td><td>7</td></tr>
<tr><td>Willow [liu xiu] LUX</td><td>2</td></tr>
<tr><td>Seven-stars [xing xiu] XNX</td><td>5</td></tr>
<tr><td>Extension [zhang xiu] ZHX</td><td>2</td></tr>
<tr><td>Wings [yi xiu] YXX</td><td>2</td></tr>
<tr><td>Chariot-platform [zhen xiu] ZEX</td><td>9</td></tr>
<tr><td>Note</td><td colspan="5">English translations of the names of star regions and star fields are given together with Han Yu Pin Yin (in square brackets) according to ISO 7098 standards. The three-letter acronyms in red colour are labels of the star regions and star fields. Neither names nor labels of star areas are given in the table due to space constaints, only the number of the star areas nested in star fields and star regions are provided..</td></tr>
</table>

1.2 Conundrum of the asterism System

A fundamental distinction between Western constellations and Chinese asterisms lies in their respective approaches to celestial division. The IAU constellation boundaries, established in 1928 under the direction of the Belgian astronomer Eugène Delporte, partition the entire celestial sphere into 88 exclusive polygons aligned with lines of right ascension and declination. This system assigns every point and star in the sky to exactly one constellation, providing an unambiguous spatial indexing framework essential for modern astronomical research (Gorski et al., 2005; Bucur, 2022; IAU, 2023; Kemp et al., 2022; Harding, 2011).

More than half a century later, as human spacecraft have moved beyond Earth-centred reference frames and traditional monitoring networks have become ineffective, these seemingly "static" IAU constellation boundaries continue to serve as spatial references in critical applications such as autonomous navigation, link orientation, scientific observation, mission planning, and deep-space timekeeping. Consequently, the IAU constellations have evolved from cultural symbols in classical star maps into a digital infrastructure for modern applications. This transformation, however, has not been universal: while the Western system has achieved global standardisation, non-Western astronomical traditions—most notably the Chinese asterism system—remain marginalised in contemporary scientific practice (Zhao 2024, Roman, 1987; Szalay et al., 2005; Koposov et al., 2006; Górski et al., 2024).

1.2.1 Astronomy in Oral Tradition

The IAU constellation system has transformed the Western night sky into a precise celestial map and reference framework, while simultaneously pushing non-Western astronomical narratives—particularly the Chinese asterism system—to the fringes of "oral tradition”.

For example, when the Chinese space station passes over the asterism "Weaving Girl" (Zhi Nv), ground-based controllers can announce, "The external camera is pointing at the η region of the constellation Lyra”, yet they cannot announce, "The external camera is pointing 0.3° outside the southern boundary of Zhi Nv”, because Zhi Nv lacks a definitive boundary. This asymmetry reveals a deeper epistemological divide: Western constellations function as operational tools, whereas Chinese asterisms are relegated to cultural commentary (Zhao 2026, Ruggles, 2015; Selin, 2000).

1.2.2 Scientific Disconnection Caused by Uncertainty

The scientific disconnection stems from fundamental uncertainty. When Chinese space facilities such as *the Tiangong Space Station*, *Wukong-1*, and *the Einstein Probe* need to rapidly communicate the positions of variable stars and novae, they must use the format "RA = 17h30m, Dec = −29°30’, Sco”. However, switching to a Chinese asterism designation results in an inability to pinpoint the location precisely due to the lack of closed boundaries within the asterism system, thereby creating a disconnection between "cultural language" and "operational language”. This disconnection is not merely linguistic; it represents a structural barrier to integrating Chinese astronomical heritage into real-time space operations (Zhao 2026, Seth, 2009).

1.2.3 Embracing Diversity without Boundaries

Similar to the Western constellation system before 1928—more precisely, prior to the work of Thome (1890) and Gould (1897)—the Chinese constellation system historically identified only stars belonging to recognised asterisms or star groups. The system did not specify explicit boundaries between these star groups. Although *the Three Enclosures* are delineated by walls of stars, forming star-linked demarcations, and *the Twenty-Eight Mansions* provide a zonal division along the ecliptic, the system does not cover completely every observable point on the celestial sphere. Consequently, a star or object located outside the area of a given star group has no traditional "address" within the system—a limitation that prevents Chinese asterisms from being integrated into modern astronomical information systems and applications, whose data processing workflows rely on spatial indexing. Thus, the absence of boundaries is not a cultural preference but a technical constraint that excludes Chinese asterisms from digital astronomical infrastructure (Ho, 1966; Sun and Kistemaker, 1997; Pankenier, 2011).

1.2.4 Absent from Modern Star Catalogues

In modern star catalogues, approximately 120 million stars lack a "Chinese asterism" label, resulting in the absence of Chinese keywords, terms, or indices in international databases. This statistical void underscores the cumulative effect of the aforementioned barriers: without spatial boundaries, there can be no systematic labeling; without labeling, there can be no database integration; and without database integration, Chinese astronomical heritage remains invisible to the algorithms and workflows that define contemporary astronomy (Malkov et al., 2014; Calabretta and Roukema, 2007).

It is clear that the lack of closed boundaries — while historically consistent with the asterism-based architecture—has rendered the Chinese asterism system incompatible with the spatial indexing requirements of modern astronomy. This incompatibility manifests across multiple dimensions: operational (Section 1.2.1), communicative (Section 1.2.2), technical (Section 1.2.3), and statistical (Section 1.2.4). To bridge this gap, this work addresses whether and how the Chinese asterism system can be augmented with boundary definitions that preserve its cultural integrity while enabling its integration into global astronomical infrastructure.

1.3 Impetus for an Update

This study addresses the gap between Chinese asterisms and IAU constellations by defining spherical boundaries for Chinese asterisms to establish Chinese constellations. This aims to achieve two objectives:

- To update the Chinese asterism system into a digital infrastructure—for example, as a coordinate reference system that can be integrated into modern astronomy, astrophysics, and applications in other fields such as education and popular science (Zhao 2024).
- To preserve and protect cultural heritage, promoting the Chinese cultural narrative of the starry sky in, for instance, astronautical engineering and space technology (Zhao 2026).

The endeavour of providing asterisms with boundaries is not a return to the past but rather a forward-looking upgrade of Chinese astronomical culture. It will enable each star in the sky to possess potentially a Chinese identity, making every asterism a retrievable spherical polygon rather than a fragmentary manuscript in a museum. The scientific language of astronomy merges with the native language of culture. The Chinese constellation officially joins the shared cosmic operating system of humanity. This is the ultimate significance of delimiting the stars: to give the ancient concept a precise physical presence on an infinite sphere, so that future generations of humankind, wherever they go, can call out the names of every star in their familiar native tongue.

1.4 Implications

The implications of this work are both scientific and cultural. Scientifically, it enables the integration of Chinese asterisms into modern astronomical research, allowing tasks such as positional association (e.g., tracking and arc segment association) to be performed using Chinese constellation boundaries. Culturally, it establishes a formal digital infrastructure for the Chinese astronomical tradition spanning over three millennia, ensuring its preservation and accessibility both for cultural heritage applications and for future generations. The Chinese narrative of the asterisms combines ancient astronomical systems, mythological tales, and modern space exploration, resulting in a unique cultural expression in three dimensions.

Firstly, the asterisms correlate the night sky with the establishments of human society, such as the dynastic system and urban life, embodying the philosophy of "*The Unity of Humanity and Nature*" in the universe.

Secondly, there is the combination of mythology and celestial phenomena. Tales such as "*Chang'e Flying to the Moon*" (Chang'e, the wife of the celestial sovereign *Hou Yi* in remote antiquity) and "*Niulang and Zhi Nv*" infuse stars and asterisms across the Milky Way with emotional and moral significance, making the night sky a vehicle for collective national memories.

Thirdly, the names in these tales continue the legacy of modern space exploration. The Chinese lunar exploration program is named "*Chang'e*", the lunar rover "*Yutu*", the Mars rover "*Zhurong*", and the relay satellite "*Queqiao*" (a bridge across the Milky Way constructed by compassionate lovebirds). This narrative not only breathes new life into ancient myths in the era of advanced technology, creating dialogues between civilisations spanning thousands of years, but also embodies the wisdom of ancient sages in modern astronomical science and space technology through projects such as "*Mozi-1*", "*Xihe*", and "*Kua Fu*", thereby showcasing the perspective of Chinese asterisms on the exploration of multiple universes.

In addition, this work responds to a gap in international astronomical heritage research. A complete definition of asterism boundaries has not yet been undertaken in China or elsewhere worldwide. This study thus contributes to the growing field of cultural astronomy by providing the foundational data infrastructure for one of the world's major celestial mapping traditions. The work underlying the asterism boundaries is described in the subsequent sections.

2 HISTORICAL SOURCES AND DATA FOUNDATION

Preliminarily, this work began with a tedious and sometimes painstaking investigation into historically recorded star data dispersed throughout the Chinese asterism system among various and inconsistent sources spanning over three millennia. The most significant challenges arose from verifying and validating factual truth based on dispersed information. It was genuinely demanding to conduct dedicated "forensic" investigations into misleading information and time-consuming "excavations" of missing data. Nevertheless, the work over the past decade has gradually converged on sources from the period between 1634 and 1899.

When Chongzhen, the last emperor of the Ming Dynasty, promulgated and implemented *the Chongzhen Reign-period Treatise on Calendrical Science* (Xu et al., 1634), Chinese astronomical culture collapsed after the empire adopted European astronomy and calendrical science. The Chinese asterism system was subsequently abandoned ever since this setback. Over the next three centuries, China underwent chronic debility and stagnation, and the Chinese asterisms were lost in fragmentary manuscripts, with most dispersed around the world as cultural relics. This research has had no alternative but to rely primarily on two treasured books, *Yixiang Kaocheng* (1752) and *Yixiang Kaocheng Xubian* (1844), which are considered the definitive works of Chinese traditional astronomy.

2.1 Primary Sources

The delimitation of Chinese asterisms to define boundaries of Chinese constellations is primarily based on the star catalogues contained in *the Compendium of Astronomical Instrumentation and Star Catalogue* (1752) and its continued edition (1844). Although these memorial volumes have been dust-laden antiquities since their publication and have often served as ceremonial dossiers testifying to the long history of unique and distinctive Chinese astronomy, they represent the culmination of the Chinese asterism system, providing the most comprehensive and accurate positional data for stars from circa 15th century BCE to the *Chongzhen Reign* period.

2.1.1 *Yixiang Kaocheng* (1752)

Compiled by Dai *et al*. (1752) and later published by Liu (1757) with a preface by Emperor Qianlong of the Qing Dynasty, this work consists of 32 volumes. The first two volumes describe *the Armillary Clock Stabilizing the Polaris Instrument*, while the remaining 30 volumes contain star catalogues. Figure 2 shows a snapshot of a page of the star catalogues.

The work records 277 traditional asterisms containing 1,319 stars, supplemented by 1,614 appendent stars not previously catalogued, plus 23 asterisms with 150 stars in the south polar region, totaling 300 asterisms and 3,083 stars. The catalogues provide right ascension and declination coordinates measured with the newly constructed *Armillary Clock Stabilising the Polaris Instrument*. Figure 3 exhibits a full-sky star map from the volumes.

2.1.2 *Yixiang Kaocheng Xubian* (1844)

Compiled by Chinese astronomers (Aixinjueluo et al., 1844) during the Daoguang period after the departure of foreign missionaries from the Imperial Astronomical Bureau of the Qing Dynasty, this work represents the first major Chinese star catalogue produced without foreign involvement. It increased the total number of stars to 3,240 by adding 163 stars and removing six that could not be observed in the new measurements. The catalogue includes detailed positional data for each star, organised by asterisms within the Three Enclosures, the Twenty-Eight Mansions, and the south polar region.

Figure 4 shows example pages of the star catalogue, and Figure 5 is a snapshot of a full-sky star map from the volumes.

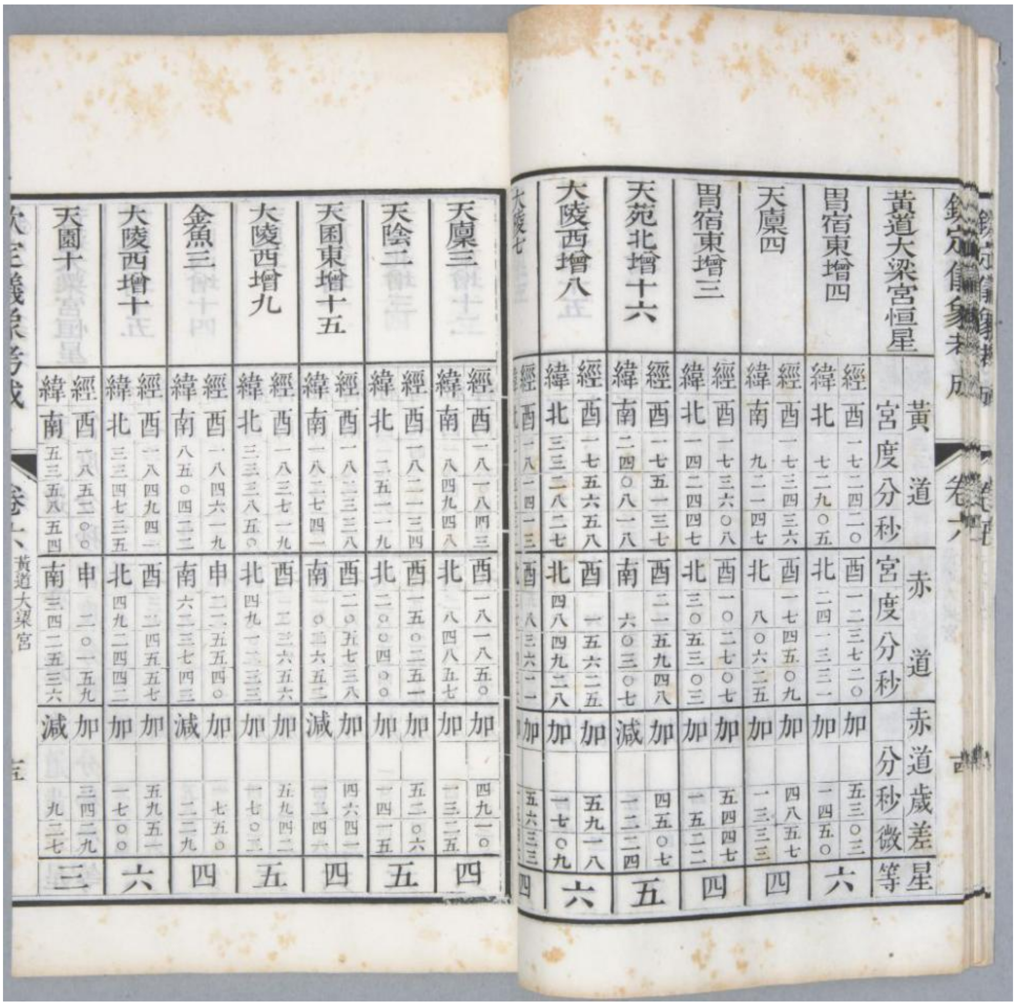


Figure 2: A page of the star catalogue in Yixiang Kaocheng, recording star positions in right ascension and declination. The coordinate values are written in Chinese numerals, which is self-explanatory regarding the difficulty of bringing the Chinese asterisms in their traditional form into compliance with modern applications. (Dai et al., 1752; Courtesy: National Museum of Classic Books, Beijing, China).

2.2 Hierarchical Nesting of asterisms

A comprehensive study of the primary sources reveals an exquisite hierarchy of the asterisms. This innate structure, which has long been obscured beneath the antiquity of the system, divides the celestial sky into three layers: six star regions, 32 star fields, and 321 star areas (see Table 1).

At the top layer, the celestial sphere is divided into six regions based on traditional Chinese cosmological concepts. These include the two polar regions (north polar and south polar) and four near-ecliptic regions metaphorised by colours, totems, spaces, and seasons: (1) Azure Dragon, East, Spring; (2) Black Tortoise and Snake, North, Winter; (3) White Tiger, West, Autumn; (4) Vermilion Bird, Summer, South.

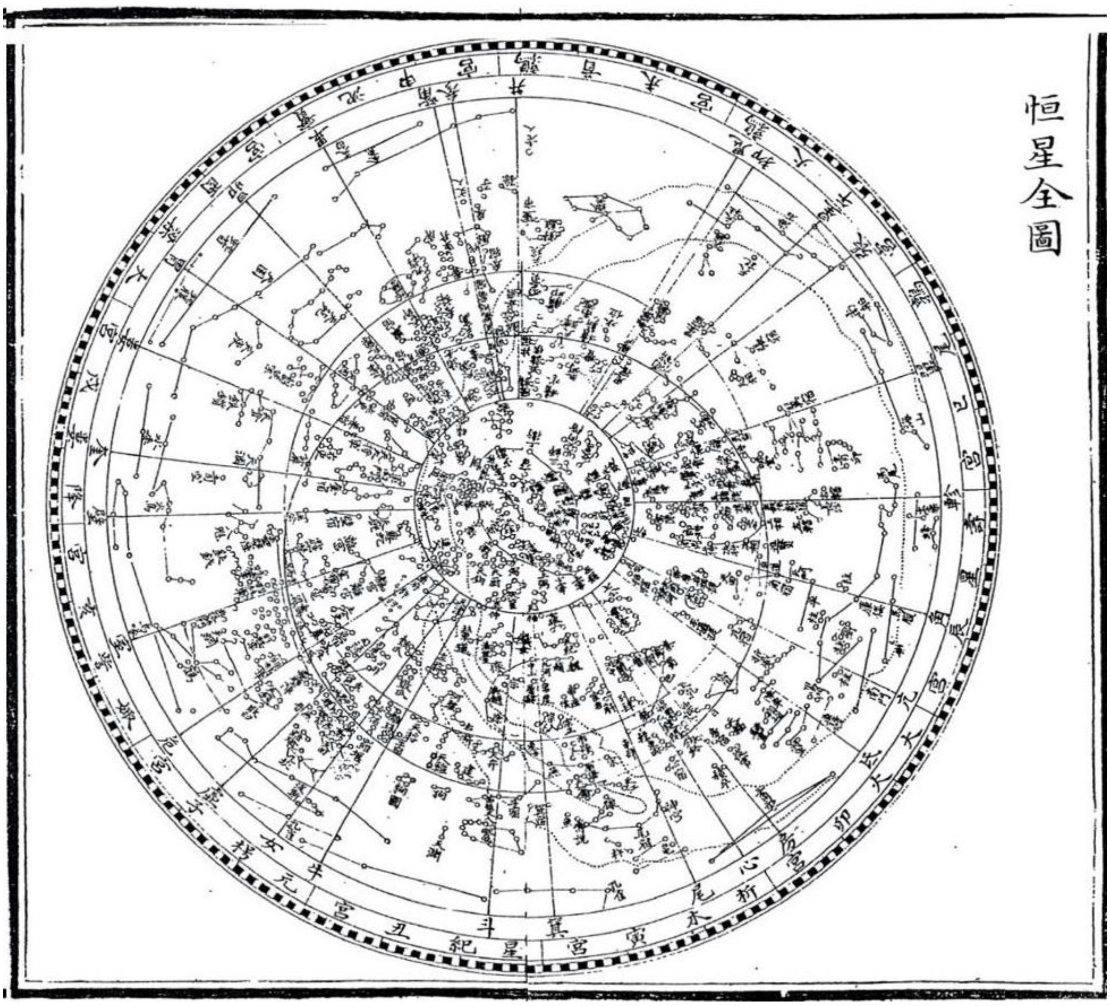


Figure 3: A full-sky star map of the Chinese asterism system from Yixiang Kaocheng. This is a typical Gaitian Map, a type of ancient Chinese cosmological map (Dai et al., 1752; Courtesy: National Museum of Classic Books, Beijing, China).

In the middle layer are 32 star fields. These consist of the Three Enclosures—(1) Purple Forbidden Enclosure, (2) Supreme Palace Enclosure, (3) Celestial Market Enclosure—the Twenty-Eight Mansions (i.e., four groups of seven mansions corresponding to the four near-ecliptic regions), and the near-south-pole star field, which is not covered by the Twenty-Eight Mansions and overlaps the south polar region.

At the bottom layer are 321 star areas, each surrounding a asterism. As described in Section 1.1, the individual asterisms of the asterisms in each star area consist of one or more stars. The star area allows to be exclusively delineated (see Section 3.2) as a seamlessly adjoining "celestial prefecture" within which every star or any other celestial body is subject to the asterism in cases such as positioning, naming, identifying, recording, and cataloguing.

2.3 Stellar Position Data

All stellar positions are provided in the International Celestial Reference System (ICRS) at the J2000.0 epoch.

Figure 4: A snapshot of a page from the star catalogue in Yixiang Kaocheng Xubian. The catalogue records star positions in right ascension and declination coordinates. The coordinate values are written in Chinese numerals, similar to Figure 2. (Aixinjueluo et al., 1844; Courtesy: National Museum of Classic Books, Beijing, China).

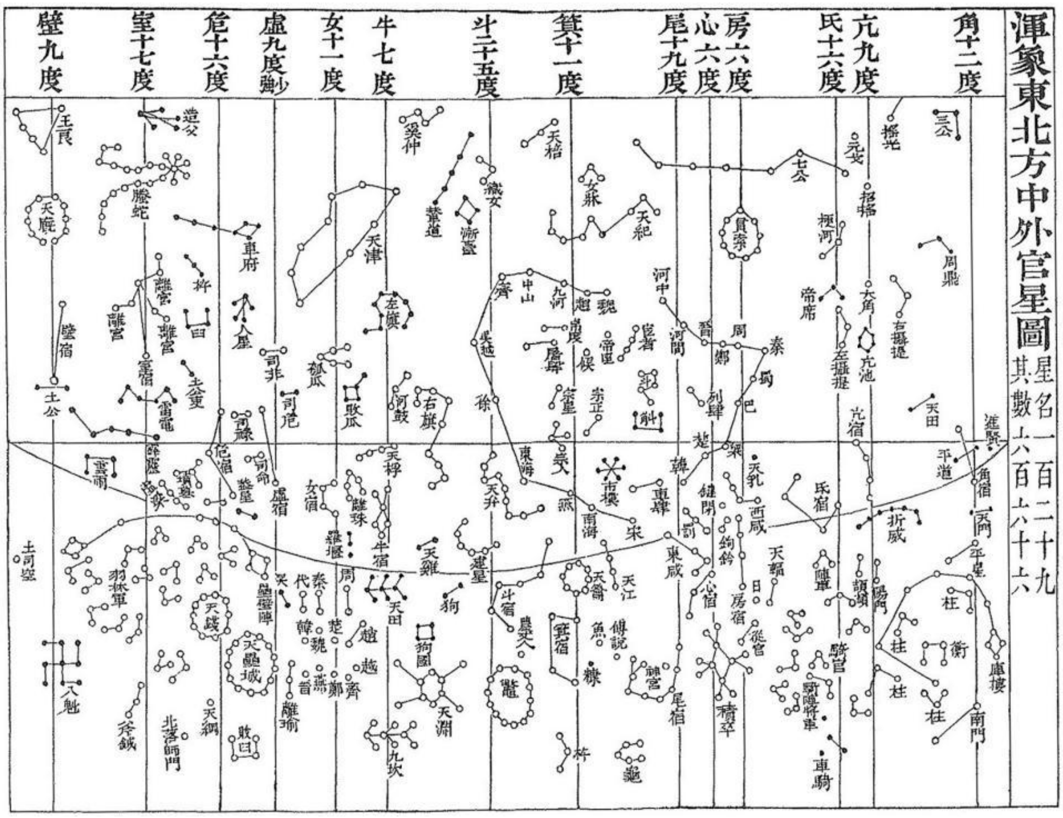


Figure 5: A Chinese asterisms in Chinese star map similar to the Plate Carrée projection (Aixinjueluo et al., 1844; Courtesy: National Museum of Classic Books, Beijing, China).

The coordinates from *Yixiang Kaocheng* and *Yixiang Kaocheng Xubian*, originally measured in the contemporary equatorial coordinate system of the Qing era, have been rigorously transformed to the J2000.0 reference frame using established precession models. The transformation accounts for the epoch difference (mean epoch approximately 1744 for *Yixiang Kaocheng* and 1842 for *Yixiang Kaocheng Xubian*) and incorporates corrections for proper motion where available. This facilitates the verification and validation of the 3,325 stars mentioned in Section 1.1.

The information for these stars is first cross-verified by their names, locations, and chart figures against five catalogues listed in Table 2. The verification confirms that all stars in the asterisms are found in 2MASS; one star is absent from HD, two from SAO, nine from HIP (HIP2 and XHIP), 190 from Gaia (R1, R2, and R3), and 1,680 from FK5. Although individual stars in the asterisms may be absent from a given catalogue, cross-verification against multiple catalogues guarantees that every star is indexed in at least two modern catalogues and that its information is up-to-date and trustworthy.

Table 2: Number of bright stars in the Chinese asterisms system verified and validated against star catalogues 2MASS, HD, SAO, HIP, Gaia and FK5. A small-sized star database is built that stores more than two and a half million (precisely 2,500,628) bright stars. This database is used to cross-index among catalogues HIP, HD, SAO, 2MASS, Gaia and FK5 data and to support the visualisation of star regions, star fields and star areas in this work.

Catalogues	Reference citations	Number of verified and validated stars
2MASS	(IRSA., 1997-2001)	3325
HD	(Nesterov, 1995)	3324
SAO	(SAO Telescope Data Center, 2019)	3323
HIP2, XHIP	(Perryman, 1997; Francis, 2012)	3316
Gaia R1 Gaia R2 Gaia R3	(Van Leeuwen, 2017; ESA and DPAC, 2019) (Gaia Collaboration, et al., 2016b) (Gaia Collaboration, et al., 2023j)	3135
FK5	(Fricke, 1988)	1645

Next, the star catalogues in Table 2 are set as benchmarks for cross-validating the astronomical data of the stars in the asterisms. The validation is carried out in the well-known astronomical information systems SIMBAD (*Set of Identifications, Measurements, and Bibliography for Astronomical Data*; Wenger, 2000) and VizieR (*Astronomical Catalogues and Tables Adopted Standards Version 2.0*; Ochsenbein, 2000). The validation also transforms the coordinates of star positions into ICRS values at Epoch J2000.0.

The outcomes of the validation comprise a star database that stores star positions, proper motions, star types, magnitudes, and distances—basic parameters for defining the asterism boundaries. The data in the database can be exported in data file of FITS (Flexible Image Transport System) format. The FITS file that stores the data is listed under the filename "star_basics.fits" in Table 4..

The star database stores more than two and a half million (precisely 2,500,628) bright stars cross-indexed among the HIP, HD, SAO, and 2MASS catalogues. This small-sized database includes every star in the Chinese asterism system and is dedicated to providing a "starry background" to demarcate (see Figures 7, 9, and 11 in Section 3.2) the celestial sphere into the hierarchically nested starry skies tabulated in Table 1. This database is used to cross-index among catalogues HIP, HD, SAO, 2MASS, Gaia, and FK5 data and to support the visualisation of star regions, star fields, and star areas in this work.

3 METHODOLOGY FOR BOUNDARY DEFINITION

3.1 Principles of Boundary Assignment

The construction of Chinese constellations based on the Chinese asterism system involves the definition of boundaries. It follows three guiding principles:

3.1.1 Intrinsic Principle
This refers to the concept of "*The Unity of Humanity and Nature*", the very basis of ancient Chinese philosophy and metaphysics. For boundary assignment, it pins this concept down to cultural protection and inheritance, which essentially shapes the constellation boundaries. Both the primary and appendent stars of the asterisms and their chart topology must be legitimate and plotted in strict observance of Chinese tradition and culture, often with respect to legends and myths. This means that the delimitation of asterisms requires meticulous adjustment and modification, even when arithmetic or algorithmic approaches to the processes are applicable.

3.1.2 Geometric Principle
Boundaries are defined along lines of right ascension and declination, following the precedent of the IAU constellation boundaries and complying with the computation of linear-rectangular spherical polygons. This ensures compatibility with modern spherical indexing systems such as HEALPix (Hierarchical Equal Area iso-Latitude Pixelation of a sphere; Górski, 2024) and facilitates computational applications including positional association and spatial queries.

3.1.3 Semantic Principle
Boundaries respect traditional relationships among asterisms. The walls of *the Three Enclosures*, formed by designated delimiting stars, are preserved as explicit demarcation; the fields of *the Twenty-Eight Mansions* are maintained as fundamental divisions, with borders following the "lodge" divisions established in traditional astronomy; asterisms associated with particular mansions are contained within those mansion fields; proximity assigns stars to the asterism to which they are nearest, with boundaries falling midway between stars belonging to different asterisms (this is realised by using Voronoi-based approach).

3.2 Delimitation of asterisms

The boundary definition proceeds hierarchically on the celestial sphere in a bottom-up approach that starts from the boundaries of the star areas, then the star fields, and finally the star regions. All boundaries are delineated as linear-rectangular spherical polygons with steps and turns as illustrated in Figure 6.

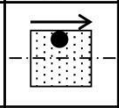
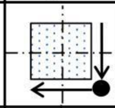
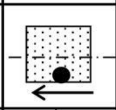
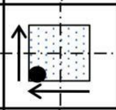
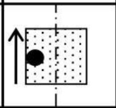
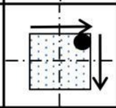
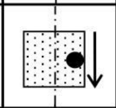
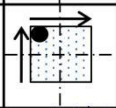
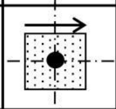
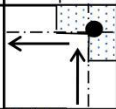
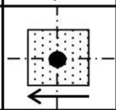
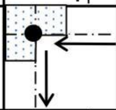
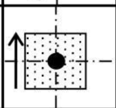
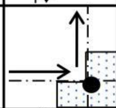
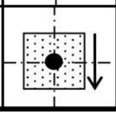
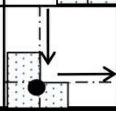
STEP			TURN		
Labels	**Diagrams**	**Stepping Directions**	**Labels**	**Diagrams**	**Turnings**
E		Eastward	SW		Stepping south Turning west Stepping west
W		Westward	WN		Stepping west Turning north Stepping north
N		Northward	ES		Stepping east Turning south Stepping south
S		Southward	NE		Stepping north Turning east Stepping east
CE		Cross the prime meridian to east	NW		Stepping north Turning west Stepping west
CW		Cross the Prime Meridian to west	WS		Stepping west Turning south Stepping south
CN		Cross the Equator to north	EN		Stepping east Turning north Stepping north
CS		Cross the Equator to south	SE		Stepping south Turning east Stepping east

Figure 6: Illustrations of steps and turns in process of delineating the boundaries of the Chinese constellation along parallel and meridian grids of the celestial sphere.

3.2.1 Steppings along Parallels and Meridians

Geometrically, the boundary of a Chinese constellation is delineated step by step along parallels and meridians in either a clockwise or counterclockwise direction. This work takes all steps for every Chinese constellation in the clockwise direction.

There are eight types of "steps" used in delineating the boundaries of the Chinese constellations. The labels serve as indicators toward the next position along the boundary. The iconic diagrams depict the way in which each step is carried out: the square in the iconic diagram symbolises the boundary, the arrow represents the step direction, the horizontal and vertical dash-dot lines epitomise the parallels and meridians, respectively, and the solid black dot indicates the interior of the boundary. Four special steps are devised: two for crossing the prime meridian and two for crossing the equator, for cases of transition handling of longitudes and latitudes.

3.2.2 Turnings around a asterism between Parallels and Meridians

A colloquial term for vertices of linear-rectangular spherical polygons is "turnings"; these refer to the changing points in boundaries where steps along meridians turn onto parallels and vice versa. Figure 6 illustrates eight types of turnings defined for contouring the star regions, star fields, and star areas. The labels and iconic diagrams of stepping and turnings follow the clockwise direction.

3.2.3 Spherical Partition

With the database mentioned in Section 2.3, the maximum and minimum dimensions of every asterism can be calculated.

Take the Three Stars or Triads (Shenxiu; see Figure 1) as an example: its limit sizes for right ascension range from 5.15 h to 6.6395 h, and for declination from −14.5° to 9.795°, as shown in the red dashed-line spherical box in Figure 7. Meanwhile, the limit sizes of Four River Systems (Sidu), one of Triads' neighbouring asterisms, range from 6.25 h to 7.15 h in right ascension and from −2.25° to 11.815° in declination, as shown in the blue dashed-line spherical box.

The parallel ***A-B*** and meridian ***B-C*** delineate clockwise around Triads; the meridian ***a-b*** and parallel ***b-c*** delineate clockwise around Four River Systems. ***A-B-C*** and ***a-b-c*** are the same border lines that demarcate the two star areas by negotiation between the two asterisms. The border lines are either perpendicular or parallel to the dashed-line spherical boxes, but do not coincide with them. Although, by stepping and turning, the border lines can maintain a Voronoi-based spherical partition between asterisms, a asterism boundary should be constructed with as few turnings as possible (the *de facto* minimum number of turnings in a boundary is 4). For Triads (Shenxiu), 20 turnings were used.

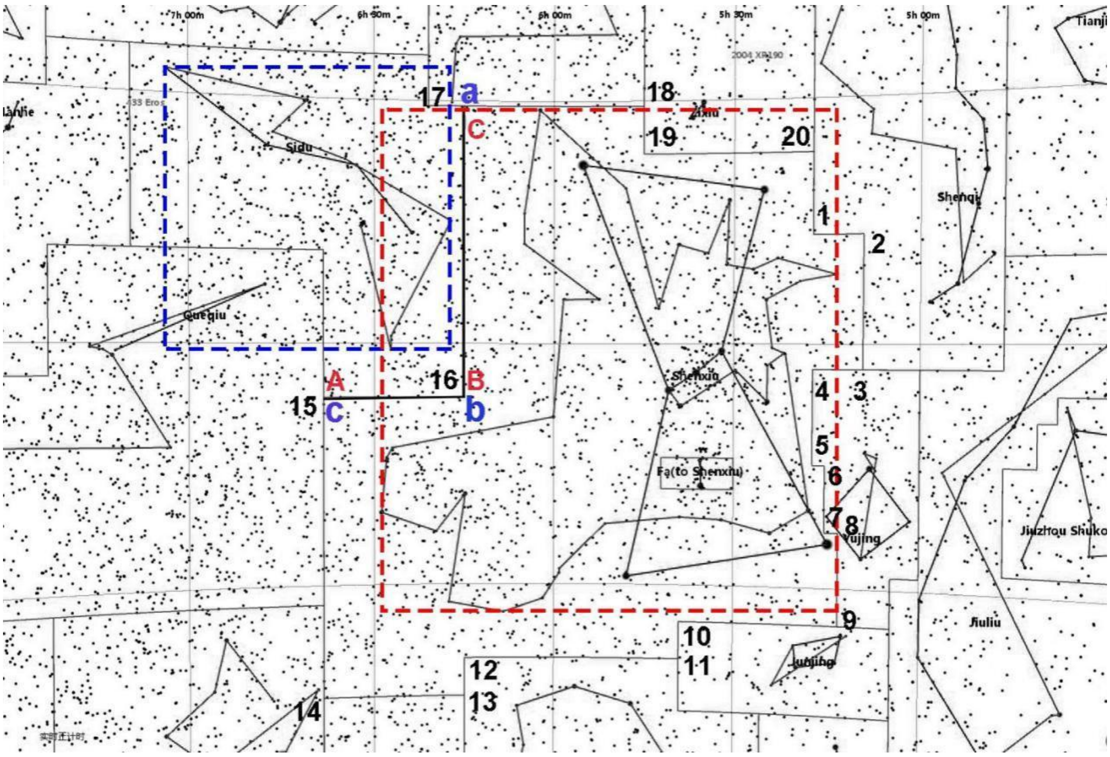


Figure 7: Demarcation of the star area of Triads (Shenxiu) by marking the turnings from parallels to meridians (and vice versa) for delineating border lines between adjacent star areas. The red dashed-line box indicates the limit size of Triads, and the blue dashed-line box indicates that of the neighboring asterism named Four River Systems (Sidu). ***A-B-C*** illustrates stepping along a parallel and turning to another stepping along a meridian around Triads, and ***a-b-c*** reverses the order for a turning around Four River Systems. As a result, 20 turnings are numbered in clockwise sequence for the boundary of the star area that surrounds Triads

3.2.4 Rules of Spherical Partition

The fundamental work in boundary construction is to ascertain the turnings around a asterism in its surrounding star area. It entails the formation of the asterism boundary to abide by the following rules:

(1) Turnings do not coincide with the positions of any primary stars or appendent stars. Ideally, they do not occupy the positions of bright stars or any other stars in the catalogues listed in Table 2.

(2) Boundary lines (parallels and meridians) between every two adjacent turnings do not intersect or coincide with the star charts of any asterisms. Ideally, no bright stars or stars from the catalogues in Table 2 sit on the boundary lines.

(3) A boundary does not intersect with other boundaries. Nevertheless, it is permitted that two or more boundaries coincide with each other. In particular, one or more can be nested within another boundary. As explained in Section 2.2, boundary nesting not only forms part of the hierarchy but also manifests the beauty and agility of the Chinese asterism system.

(4) Turnings and steps that guide boundaries through Chinese constellations or between stars allow for the implementation of hand-shaking spherical partitioning.

(5) The direction of a step is determined by the second letter in the label of the current turning; the magnitude of the step is measured in angle and should be less than or equal to 0.75°.

Once the turnings around every constellation are identified and set up, seamless delineation in appropriate steps (see Section 3.3 below) can traverse the borderlines of the entire asterism hierarchy to complete the boundaries around the 321 Chinese constellations.

3.3 Delineation of Boundaries

This section continues with the Triads (Shenxiu) example. The right ascension (RA in hours) and declination (Dec in degrees) of the turning points marked in Figure 6 are listed in Table 3. The turning points are numbered clockwise from 1 to 20. Each turning point is assigned a label specified in Figure 6. RA steps and Dec steps are made along parallels and meridians of the celestial sphere, respectively, as follows.

The delineation starts at turning point 1, where the label **SE** stands for "along the 5.285 h meridian make 0 steps **South**; turn **East**; along the 4.5° parallel, make 27 steps **East** to approach turning point 2 at meridian 5.15 h".

At turning point 2, the label **ES** stands for "turn from stepping **East** to stepping **South** along the 5.15 h meridian, 74 steps to approach turning point 3 at parallel −1.05° ".

At turning point 3, the label **SW** stands for "turn from stepping **South** to stepping **West** along the −1.05° parallel, 27 steps to approach turning point 4 at meridian 5.285 h".

The delineation iterates the turnings and steps until it reaches turning point 20 to complete the whole boundary of the star area surrounding the asterism Triads (Shenxiu). It must be stressed that the steps in the above iteration require fine-tuning in the increments of right ascension in each RA step and of declination in each Dec step for delineating smooth and accurate constellation boundaries. This is necessary to ensure the compatibility of constellation boundaries with modern indexing schemes, which demand smooth boundaries that follow great circle arcs along lines of constant right ascension or declination. In this work, the increments of right ascension and declination are roughly calibrated as 0.005 h and 0.075°, respectively.

Table 3: The right ascension (RA in hours) and declination (Dec in degrees) of the turning points in the boundary of the Triads constellation. The turning points are numbered clockwise from 1 to 20. Each turning point is assigned a label specified in Figure 6. RA steps and Dec steps are made along parallels and meridians of the celestial sphere, respectively. The "RA Steps" and "Dec Steps" columns are number of steps made along parallels and meridians with step increments as 0.005 h and 0.075°, respectively.

No	Labels	RA (hours)	RA Steps	Dec (degrees)	Dec Steps
1	SE	5.2850000	0	+04.5000000	0
2	ES	5.1500000	-27	+04.5000000	0
3	SW	5.1500000	0	-01.0500000	-74
4	WS	5.2850000	27	-01.0500000	0
5	SE	5.2850000	0	-05.0000000	-52.67
6	ES	5.2515000	-6.7	-05.0000000	0
7	SE	5.2515000	0	-07.7500000	-36.67
8	ES	5.2150000	-7.3	-07.7500000	0
9	SW	5.2150000	0	-11.4975000	-49.97
10	WS	5.6500000	87	-11.4975000	0
11	SW	5.6500000	0	-13.0000000	-20.04
12	WS	6.2500000	120	-13.0000000	0
13	SW	6.2500000	0	-14.5000000	-20
14	WN	6.6395000	77.9	-14.5000000	0
15	NE	6.6395000	0	-02.2500000	163.34
16	EN	6.2500000	-77.9	-02.2500000	0
17	NE	6.2500000	0	+09.7950000	160.6
18	ES	5.7500000	-100	+09.7950000	0
19	SE	5.7500000	0	+07.8500000	-25.94
20	ES	5.2850000	-93	+07.8500000	0

3.4 Boundaries of Star Areas

In the hierarchical structure of the Chinese asterism system, star areas are at the bottom level. Each star area surrounds one and only one asterism, and thus there are 321 star area boundaries delineated following a similar approach to that used in delineating the boundary of Triads (Shenxiu). These boundaries are plotted in an all-sky map in Plate Carrée (or equirectangular or simple cylindrical) projection, as shown in Figure 8.

3.5 Boundaries of Star Fields

There are 32 star fields located at the middle level of the Chinese asterism hierarchical structure. As an example, Figure 9 demonstrates the delineation of the boundary of the Triads star field, using a similar approach to delineating a star area boundary. The star field boundary is plotted with stepping along parallels and meridians through the marked turnings, and it can be verified by seamlessly splicing the boundaries of the star areas nested within the star field.

3.6 Boundaries of Star Regions

At the top level of the Chinese asterism hierarchy, there are six star regions: two near the north and south celestial poles, and four near the ecliptic that are metaphorised by traditional Chinese totems. Figure 11 illustrates the delineation of the boundary of the star region metaphorised as the White Tiger.

In fact, the Triads star field consists of seven asterisms (see the number of star areas of Triads (Shenxiu) in Table 1), namely Shenxiu, Fa (to Shenxiu), Yujing, Junjing, Ce (Shenxiu), Ping (Shenxiu), and Shi (Shenxiu). Splicing the boundaries of these star areas in which the seven asterisms reside individually yields exactly the same boundary as that of the Triads star field demonstrated in Figure 10.

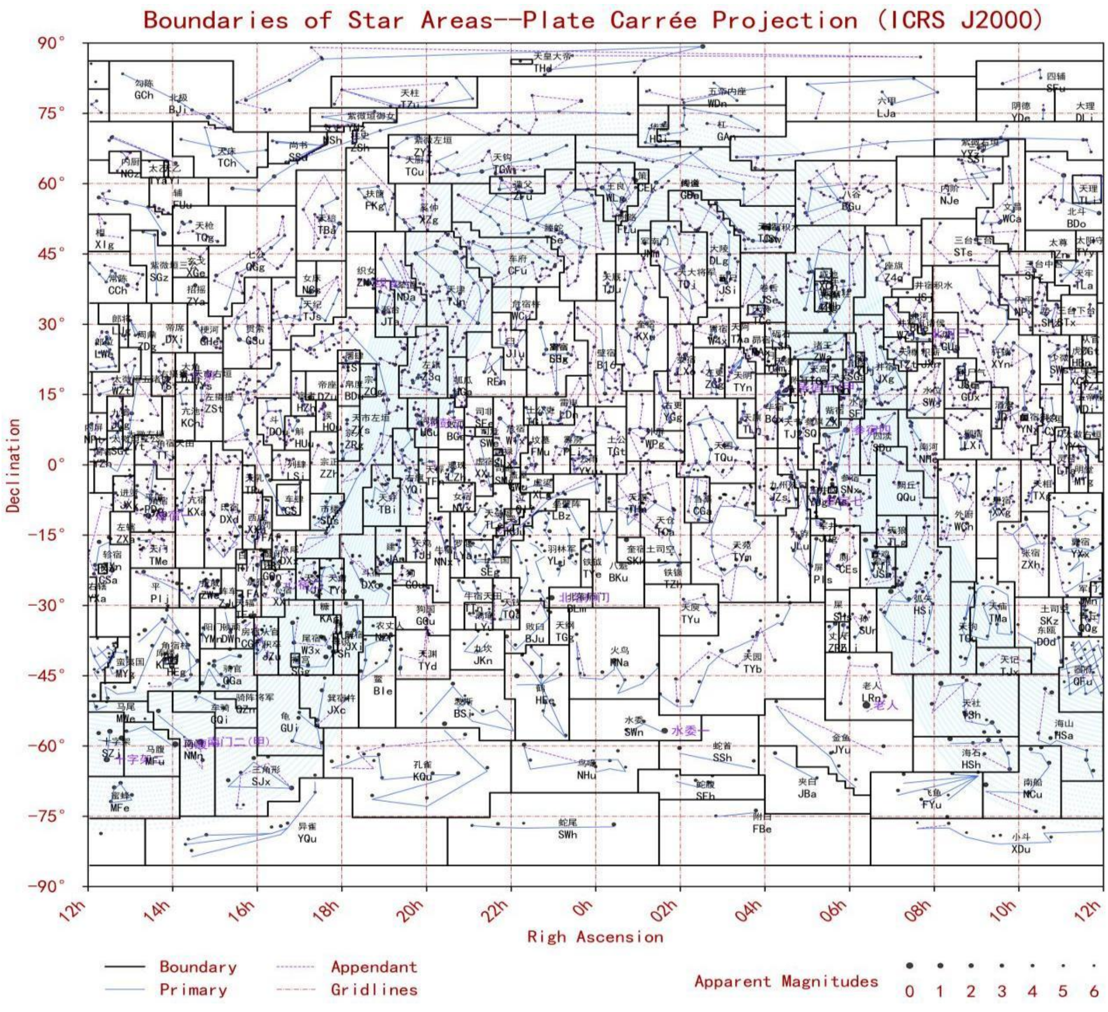


Figure 8: All-sky map of star area boundaries in Plate Carrée projection. The map shows 3,325 bright stars, including 1,523 primary stars and 1,802 appendent stars; 321 asterism boundaries; 556 star charts of primary stars; and 235 charts of appendent stars. The boundaries are labelled with both traditional Chinese asterism names and proposed tentative 3-letter labels. Complete list of names and labels of star area boundaries is provided in FITS data. The data file is listed under file name “Chinese_constellation_names.fits” in Table 4.

Table 4: The FITS data files generated in this work. They are listed as supplementary materials, but the data contents are not necessarily the parts of this paper to publish. The data in these files are freely available after the permanent repository is allocated to host these files.

FITS Data Files Listed by File Names	File Descriptions
Chinese_constellation_map.fits	Data of spherical pixels mapped to the Chinese constellations (NSIDE = 256, ORDER = Ring)
asterism_pmultiHDU.fits	Data of the Chinese starcratia, asterism charts of the primary stars
asterism_amultiHDU.fits	Data of the Chinese starcratia, asterism charts of the appendent stars
boundary_computation.fits	Computational data of boundary parameters of the Chinese constellations
Chinese_constellation_names.fits	FITS format of the names of Chinese constellations (pin yin, English translations, Chinese names and labels)
Chinese_constellation_boundary_points_multiHDU.fits	Data of Chinese constellation boundaries for star regions, star fields and star areas
Chinese_constellation_boundary_roman_data_excl.fits Chinese_constellation_roman_data_j2000_excl.dat	Roman data in FITS format and Roman table in ASCII text format of the Chinese constellations, exclusive of overlapped and nested boundaries
Chinese_constellation_boundary_roman_data_incl.fits	Roman data in FITS format of the Chinese constellations, inclusive of overlapped and nested
star_basics.fits	Star data of the Chinese starcratia system consisting of 3325 bright stars

The boundary of this region is plotted using a similar approach to that for a star field—that is, stepping along parallels and meridians through 60 marked turnings. Similar to the delineation of star fields, a star region can also be delineated by seamlessly splicing the boundaries of the seven star fields or the boundaries of the 56 star areas nested within the star region. Splicing the boundaries of the seven star fields by the approach demonstrated in Figure 9 yields exactly the same boundary as by the approach demonstrated in Figure 11, as does splicing the boundaries of the 56 star areas by the approach demonstrated in Figure 7.

3.7 Computation of asterism Boundaries

With the boundary, the asterism together with all the stars and points within the bounded star area establishes a Chinese constellation named after the asterism. The established constellation, being equipped with spherical geometry, becomes parametric and computational. The computed parameters include spherical area (measured in square radians or square degrees), area ratio to a hemisphere, spherical barycentre coordinates, and constellation visibility (latitude range of observable locations).

The spherical area $\boldsymbol{S}$ of a spherical linear rectangle is solved by the double integral formula:

$$\boldsymbol{S} = \iint \cos(\boldsymbol{\delta})\, d\boldsymbol{\alpha} d\boldsymbol{\delta} = (\boldsymbol{\alpha_1} - \boldsymbol{\alpha_0})(\sin \boldsymbol{\delta_1} - \sin \boldsymbol{\delta_0}) \tag{1}$$

where $\boldsymbol{\alpha}$ and $\boldsymbol{\delta}$ denote right ascension and declination, respectively; $\boldsymbol{\alpha_0}$ and $\boldsymbol{\alpha_1}$ are the minimum and maximum right ascension; and $\boldsymbol{\delta_0}$ and $\boldsymbol{\delta_1}$ are the minimum and maximum declination. The constellation area ratio $\boldsymbol{\rho}$ is calculated with the constant $\boldsymbol{\pi}$ taking the value 3.1415926 by formula (2):

$$\boldsymbol{\rho} = \frac{\boldsymbol{S}}{2\boldsymbol{\pi}(\sin(\boldsymbol{\pi}/2))} \tag{2}$$

The spherical barycentre coordinates $\boldsymbol{\alpha_c}$ and $\boldsymbol{\delta_c}$ of Chinese constellation boundary are solved by the double integral formulas (3) and (4):

$$\boldsymbol{\alpha}_c = \frac{\iint \boldsymbol{\alpha} \cos \boldsymbol{\delta}\, d\boldsymbol{\alpha} d\boldsymbol{\delta}}{\iint \cos \boldsymbol{\delta}\, d\boldsymbol{\alpha} d\boldsymbol{\delta}} = \frac{\boldsymbol{\alpha_0} + \boldsymbol{\alpha_1}}{2} \tag{3}$$

$$\boldsymbol{\delta}_c = \frac{\iint \boldsymbol{\delta} \cos \boldsymbol{\delta}\, d\boldsymbol{\alpha} d\boldsymbol{\delta}}{\iint \cos \boldsymbol{\delta}\, d\boldsymbol{\alpha} d\boldsymbol{\delta}} = \frac{\boldsymbol{\delta_1} \sin \boldsymbol{\delta_1} - \boldsymbol{\delta_0} \sin \boldsymbol{\delta_0} + \cos \boldsymbol{\delta_1} - \cos \boldsymbol{\delta_0}}{\sin \boldsymbol{\delta_1} - \sin \boldsymbol{\delta_0}} \tag{4}$$

where $(\boldsymbol{\alpha}, \boldsymbol{\delta}) \in [\boldsymbol{\alpha_0}, \boldsymbol{\alpha_1}] \times [\boldsymbol{\delta_0}, \boldsymbol{\delta_1}]$.

Right ascension $\boldsymbol{\alpha}$ remains within a single branch of the angular coordinate, avoiding the discontinuity at 0°/360°, i.e. it does not cross the limit 0hr/24hr.

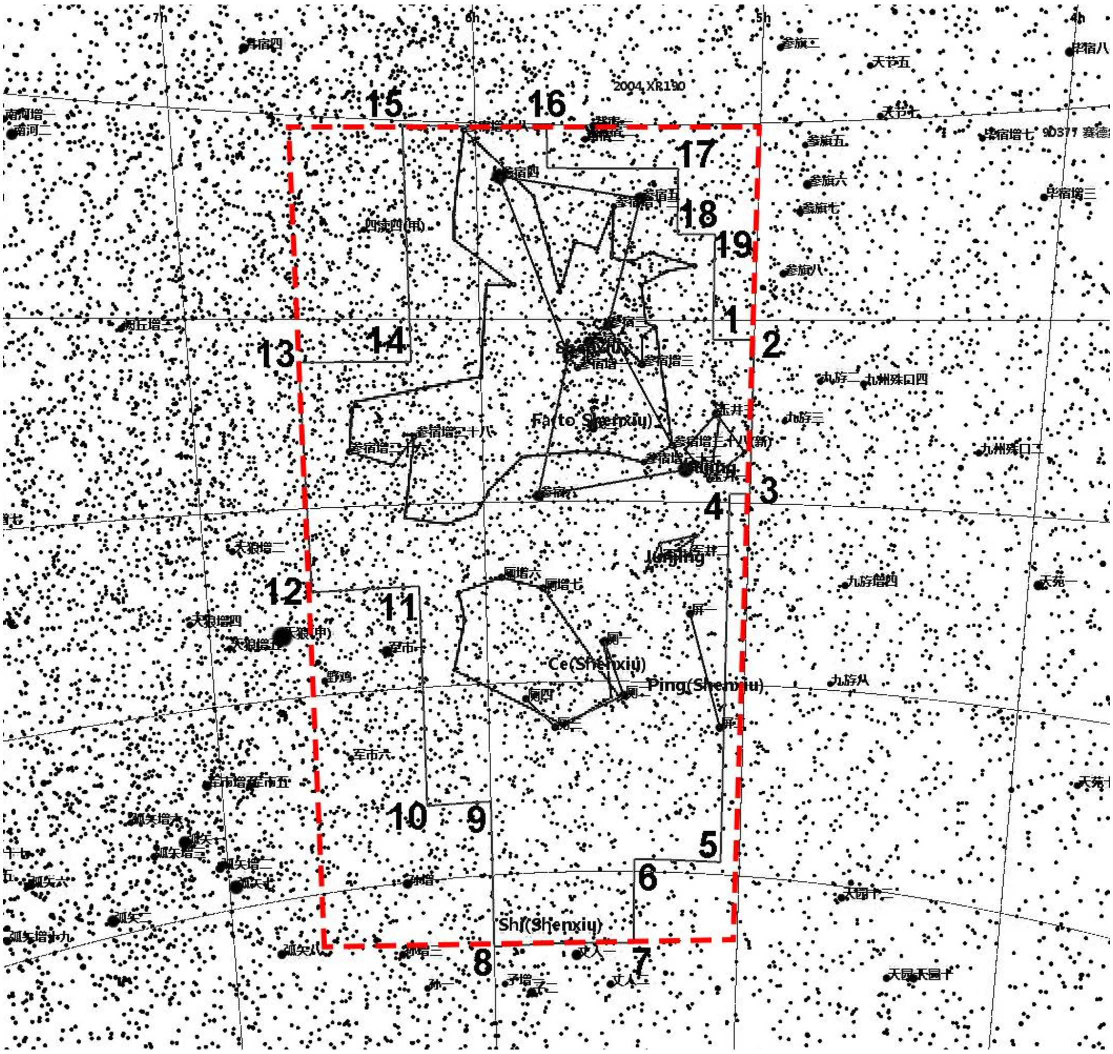


Figure 9: Demarcation of the Triads (Shenxiu) star field using a similar approach to that for a star area. The boundary of the Triads star field is delineated by marking 19 turnings from parallels to meridians and vice versa. The red dashed-line box indicates the limit size of the Triads star field, which consists of seven asterisms: Shenxiu, Fa, Yujing, Junjing, Ce, Ping, and Shi.

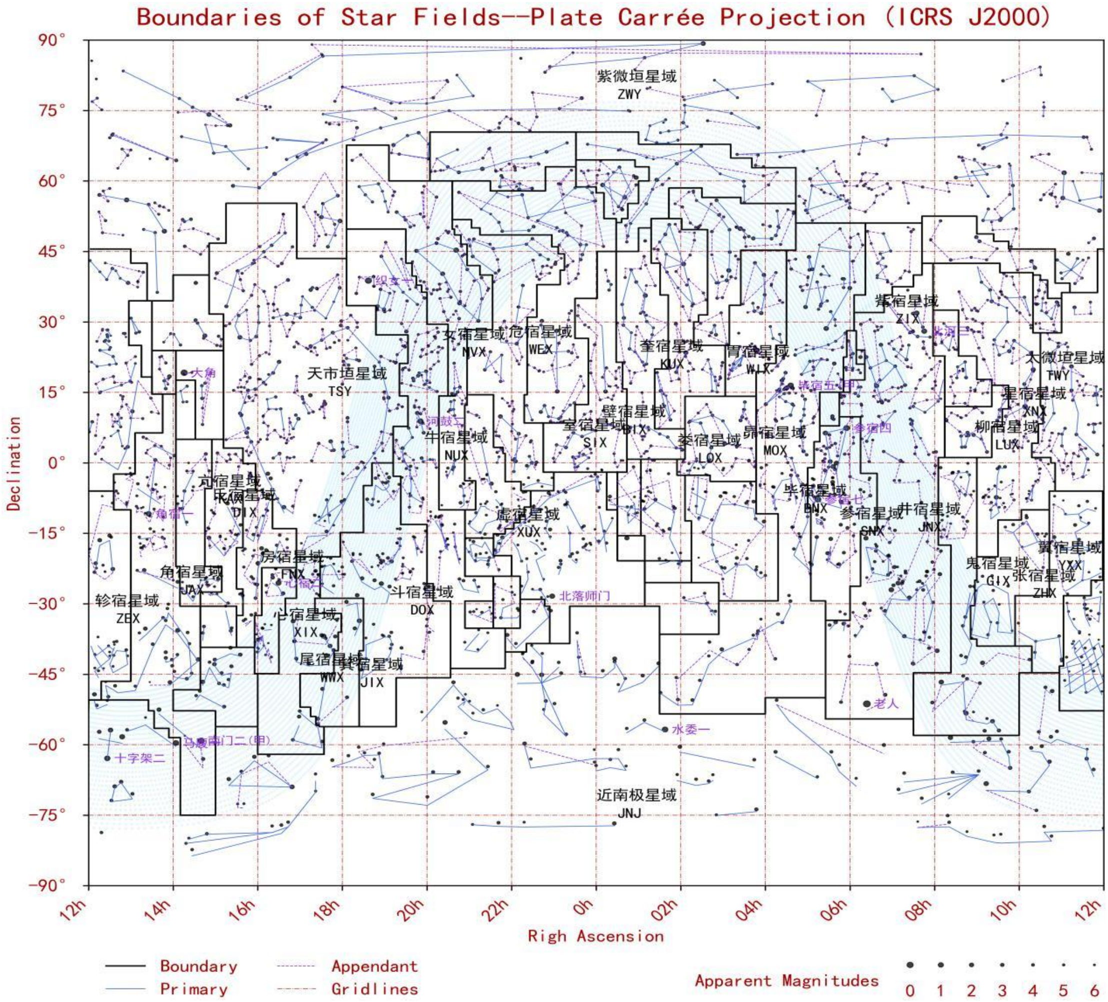


Figure 10: All-sky map of star field boundaries in Plate Carrée projection. The map shows the boundaries of the 32 star fields in the Chinese asterism system. The boundaries are labelled with both traditional Chinese star field names and proposed tentative labels in three uppercase letters.

The visibility of the constellation is obtained according to the maximum and minimum latitudes of the star area by the following computation procedure (pseudo code):

```
LET mindec = minimum latitude of constellation
LET maxdec = maximum latitude of constellation
LET outStr = output string
IF min dec >= 0 THEN
    outStr = "90°N~"
ELSE
    outStr = FORMAT("%d°N~", 90 + FLOOR(min dec))
END
IF max dec >= 0 THEN
   outStr = outStr + FORMAT( "%d°S\n", 90 - CEIL(datadb[3] ))
ELSE
   outStr = outStr + FORMAT( "90°S\n")
END
PRINT(outStr)
```

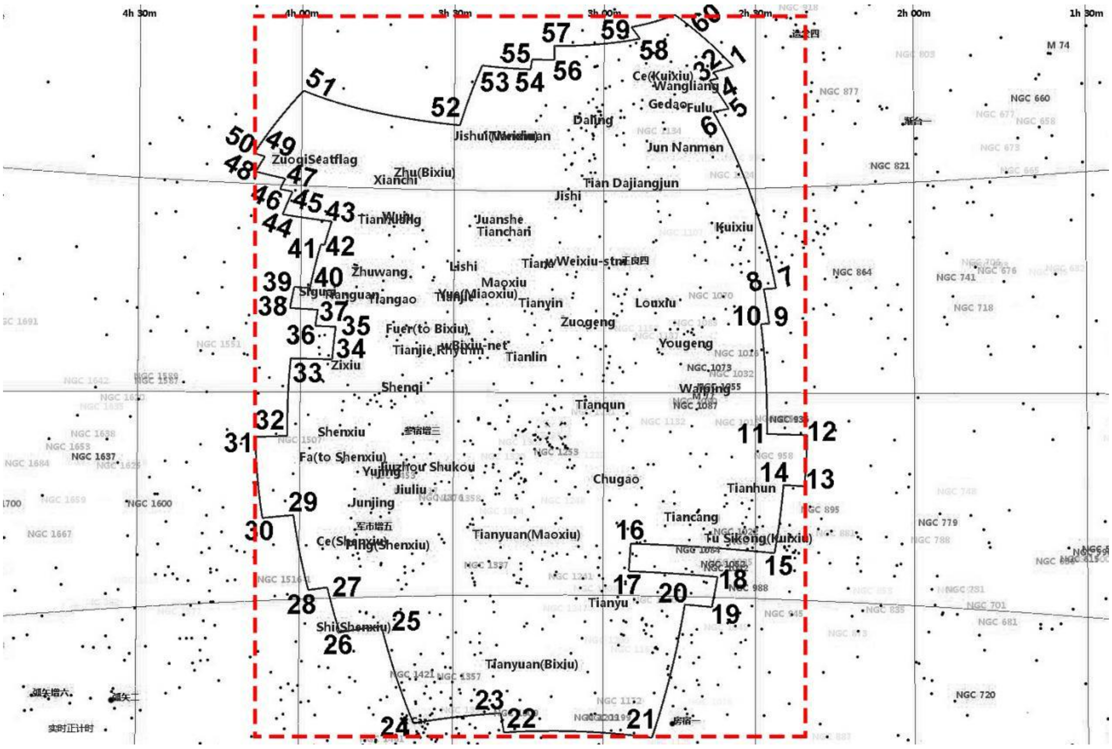


Figure 11: Demarcation of the White Tiger star region using a similar approach to that for a star field. The boundary of the White Tiger star region is delineated by marking 60 turnings from parallels to meridians (and vice versa). The red dashed-line box indicates the limit size of the White Tiger star region, which consists of seven star fields, which in turn comprise 56 star areas.

4 FITS FORMAT COMPLIANCE

The data generated in this work are formatted according to the Flexible Image Transport System (FITS) standard and then stored in FITS files. These files are collectively listed in Table 4 for reference. The FITS format is the international standard for astronomical data storage and is designed to be machine-readable and network-transmissible, supporting integration with existing astronomical software packages that handle celestial coordinate data. These listed files do not necessarily form a part of this work to publish, but are provided as supplementary materials attached to this work to assist readers who might attempt to carry out related research and development work in the following areas:

- To upgrade the Chinese constellations or refine the constellation boundaries.
- To map the spheroidal pixels to the Chinese constellations by carrying out similar work to that exhibited in Figure 13.
- To use the data in a constellation map like the data in Chinese_constellation_map.fits in the applications of astronautical engineering and space technology.
- To index the constellation boundaries in Roman table and search the Chinese constellation by celestial positions.
- To develop star catalogues with reference to the boundaries of the Chinese constellations.

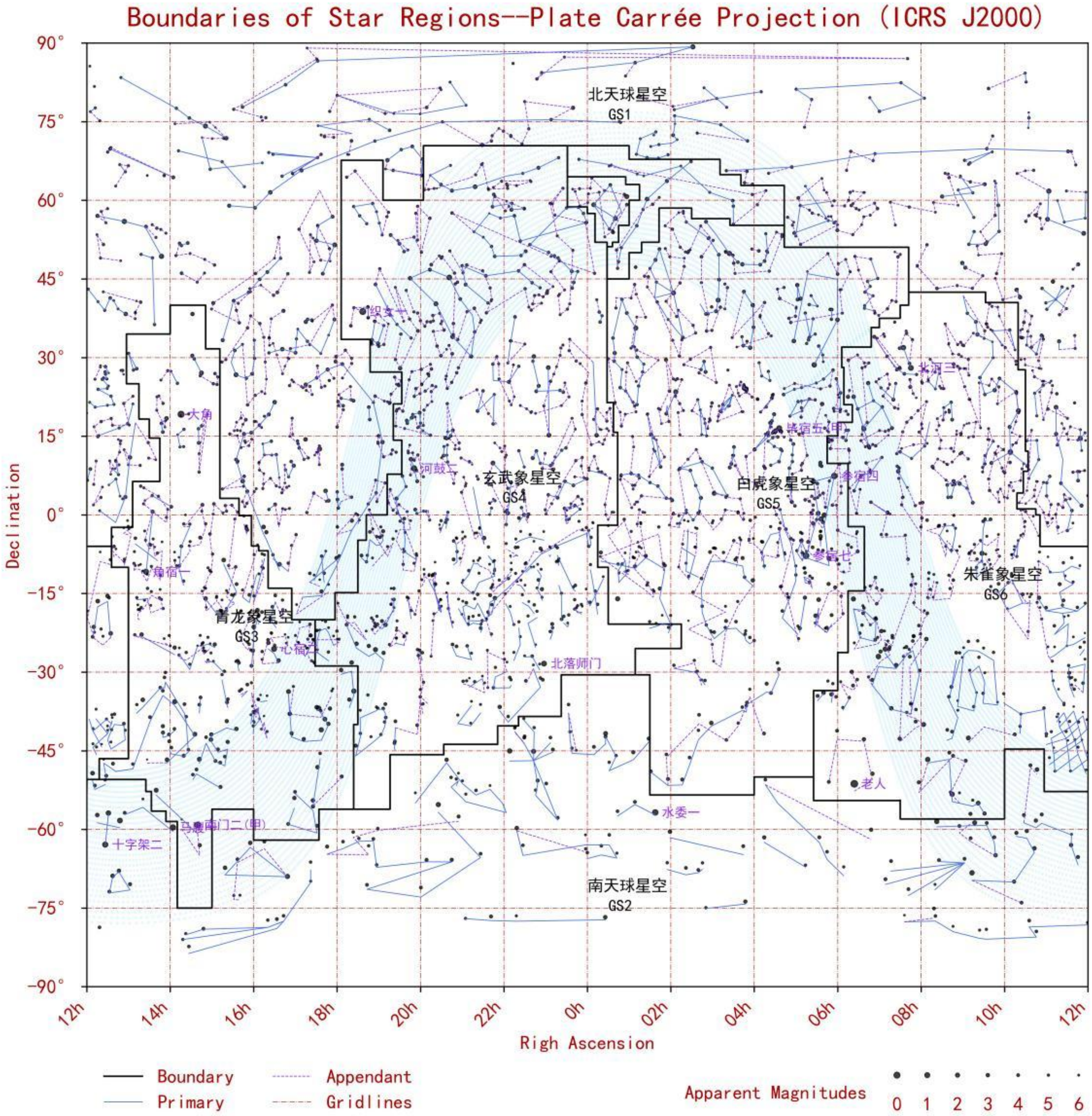


Figure 12: All-sky map of star region boundaries in Plate Carrée projection. The map exhibits the boundaries of the six star regions in the Chinese asterism system. The boundaries are labelled with both traditional Chinese star region names and proposed tentative labels in three uppercase letters

4.1 Proposed Names of the Chinese Constellations

One of the most important aspects of the standardisation that the IAU imposed on IAU constellations is the normalised names and labels (abbreviations of names). The normalisation of constellation names facilitates the integration of IAU constellations in modern applications.

Although the names of Chinese asterisms have remained unchanged throughout history, these names are not broadly recognised due to cultural background and language tradition. Even with the Romanisation of Modern Mandarin Chinese Pinyin standards ISO 7098:2015 or formal translations into English or other languages, it remains a trivial but challenging task to assign exclusively meaningful yet brief labels for individual asterisms, as it does for Chinese constellations. This becomes particularly awkward in maps, illustrations, and other visual presentations where names must be spelled or written in alphabetic letters. A more practical form than Mandarin Chinese Pinyin and translated English names is to use three-letter labels that closely align with the naming conventions followed by the IAU constellations. The file "*Chinese_constellation_names.fits*" listed in Table 4 contains a complete list of labels for the boundaries of six star regions, 32 star fields, and 321 star areas, including the full names of asterisms in traditional Chinese, Mandarin Chinese Pinyin, and English translations.

With all the labels specified, Table 1 can be represented into a complete hierarchy with all the star areas being labelled as shown in Figure 13.

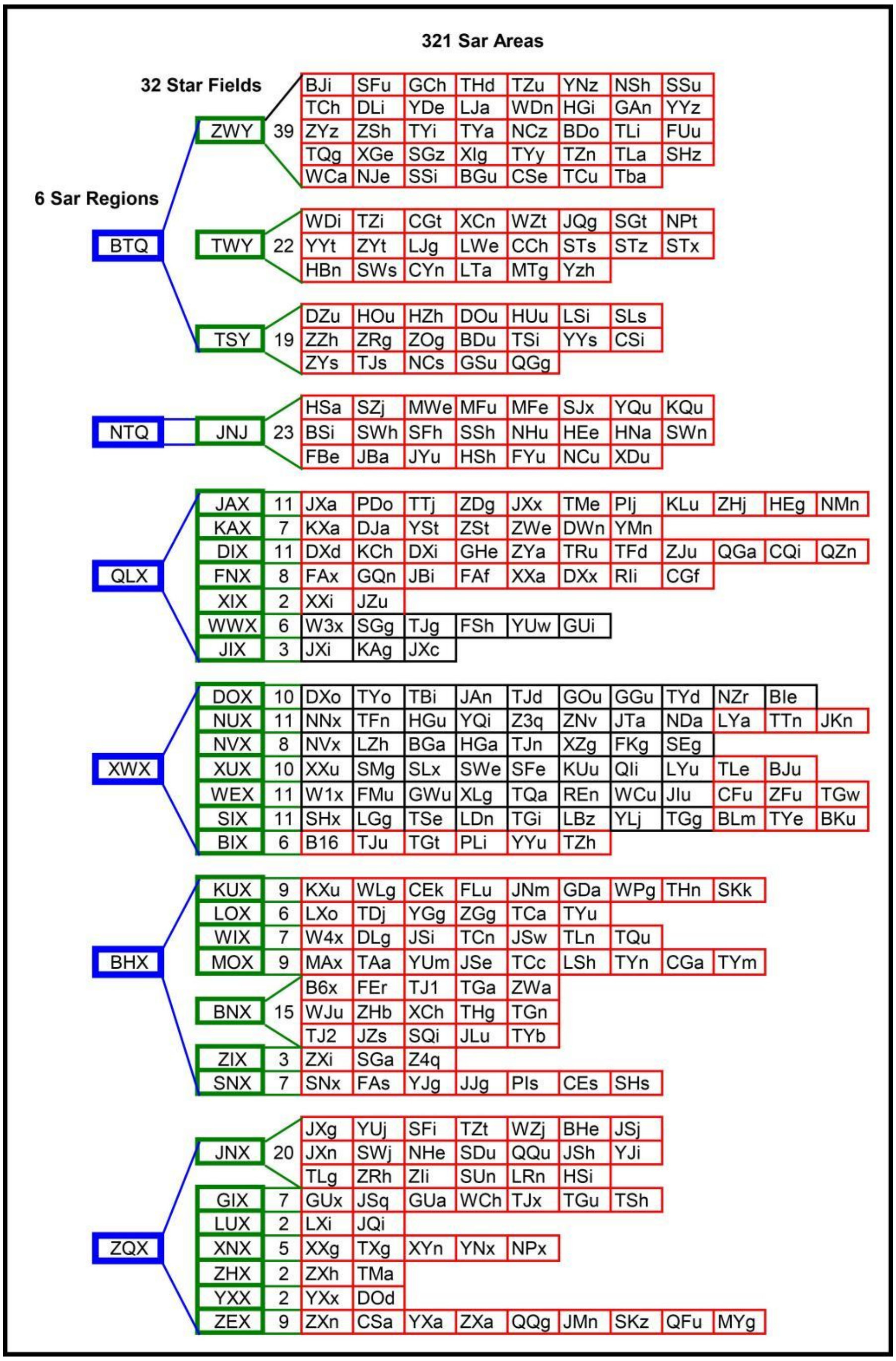


Figure 13: Hierarchical labeling of the Chinese constellation boundaries. Labels of star region boundaries in blue colour boxes, labels of star field boundaries in green colour boxes and labels of the star area boundaries, i.e., the Chinese constellations boundaries in red colour boxes.

Table 5: Nancy Grace Roman data set of Chinese constellation boundaries. Data entries highlighted in red-line boxes are overlapped by other boundaries; data entries highlighted in blue dash-line boxes are nested in other boundaries. The data in an arrangement which is easy to use for finding a constellation from a position(Roman, 1987).

ROMAN TABLE				ROMAN TABLE (Continued)			
RAl (hr.)	RAu (hr.)	Decl (deg.)	Con	RAl (hr.)	RAu (hr.)	Decl (deg.)	Con
15.43449	15.43449	+89.85000	GCh	04.72000	07.10991	+64.89000	YYz
09.00000	15.43449	+86.15000	GCh	16.75000	16.95000	+64.85000	SSu
22.00000	22.50000	+85.50000	THd	00.00000	00.92050	+64.50000	CSe
09.00000	17.75000	+82.85000	GCh	00.00000	00.92050	+64.50000	GDa
09.00000	12.50000	+80.15000	SFu	23.52000	24.00000	+64.50000	CSe
01.00000	04.50000	+76.71500	WDn	23.52000	24.00000	+64.50000	GDa
17.25000	17.75000	+76.15000	GCh	16.25000	16.75000	+64.25000	SSu
17.75000	21.20000	+76.15000	TZu	16.00000	16.25000	+63.50000	TCh
04.50000	09.00000	+73.25000	LJa	00.92050	01.25000	+63.00000	CSe
09.00000	10.85000	+73.25000	YDe	00.92050	01.25000	+63.00000	GDa
10.85000	12.50000	+73.25000	DLi	22.80000	23.52000	+63.00000	TGw
12.50000	14.85000	+73.25000	BJi	16.92500	18.10000	+62.87500	ZYz
18.50000	19.30000	+73.00000	YNz	03.68200	04.72000	+62.82500	YYz
14.85000	15.00000	+72.50000	BJi	12.50000	13.25000	+62.25000	NCz
17.25000	18.50000	+72.25000	YNz	21.50000	22.80000	+61.50000	TGw
15.00000	15.30000	+71.88000	BJi	13.25000	13.80000	+61.25000	TYa
01.45000	01.72000	+71.65000	HGi	13.80000	13.90000	+61.25000	TYi
15.30000	15.43449	+71.55000	BJi	13.80000	14.50000	+61.25000	YYz
15.43449	17.25000	+71.00000	GCh	14.50000	16.00000	+61.25000	TCh
17.25000	18.05000	+71.00000	NSh	00.92050	01.25000	+60.00000	CEk
00.00000	01.00000	+70.42500	ZYz	09.40000	09.62500	+60.00000	NJe
19.10000	24.00000	+70.42500	ZYz	19.10000	20.06976	+60.00000	TCu
03.18200	04.50000	+70.00000	GAn	20.06976	21.50000	+60.00000	TGw
08.00000	10.15000	+69.45000	YYz	23.52000	24.00000	+58.73000	WLg
01.45000	02.00000	+69.05000	GAn	01.72000	02.50000	+58.50000	CSe
18.25476	18.34595	+68.74104	ZSh	01.72000	02.50000	+58.50000	GDa
17.60000	17.65000	+68.30000	SSu	21.50000	22.80000	+57.90000	ZFu
17.55000	17.60000	+68.10000	SSu	00.00000	00.18500	+57.50000	WLg
17.50000	17.55000	+67.90000	SSu	02.50000	03.42000	+56.50000	CSe
01.00000	02.00000	+67.80680	HGi	02.50000	03.42000	+56.50000	GDa
02.00000	03.18200	+67.80680	GAn	11.27193	11.94810	+55.85066	TLi
18.10000	19.10000	+67.65000	ZYz	02.67000	02.87000	+55.50000	TCn
17.45000	17.50000	+67.60000	SSu	14.00000	14.85000	+55.25000	FUu
17.40000	17.45000	+67.40000	SSu	14.85000	16.92500	+55.25000	ZYz
17.35000	17.40000	+67.20000	SSu	00.75000	01.00000	+55.20000	WLg
17.30000	17.35000	+66.90000	SSu	03.42000	04.72000	+55.20000	CSe
10.15000	11.15000	+66.85000	YYz	03.42000	04.72000	+55.20000	GDa
12.50000	13.25000	+66.85000	YYz	13.45000	13.58500	+54.98784	FUu
17.22500	17.30000	+66.60000	SSu	09.00000	09.40000	+54.85000	NJe
17.17500	17.22500	+66.30000	SSu	00.60000	00.75000	+54.00000	WLg
17.12500	17.17500	+66.00000	SSu	02.87000	03.02000	+54.00000	TCn
07.10991	08.00000	+65.80000	YYz	13.58500	13.75000	+54.00000	FUu
08.00000	09.75000	+65.80000	SSi	12.00000	13.00000	+53.45000	BDo
14.00000	14.50000	+65.80000	TCh	13.75000	14.00000	+53.45000	FUu
17.05000	17.12500	+65.70000	SSu	00.47206	00.60000	+53.15000	FLu
17.00000	17.05000	+65.35000	SSu	00.47206	00.60000	+53.15000	WLg
16.97500	17.00000	+65.20000	SSu	03.02000	03.17000	+52.50000	TCn
11.15000	12.50000	+65.00000	YYz	07.70352	09.00000	+52.50000	NJe
16.95000	16.97500	+65.00000	SSu	00.00000	00.25000	+52.00000	WLg
13.25000	13.80000	+64.95000	YYz	00.18500	00.47206	+52.00000	WLg
03.18200	03.68200	+64.89000	YYz	00.60000	00.75000	+52.00000	FLu

ROMAN TABLE (Continued)

RAl (hr.)	RAu (hr.)	Decl (deg.)	Con
01.30000	01.72000	+52.00000	CSe
01.30000	01.72000	+52.00000	GDa
01.72000	02.02000	+52.00000	DLg
20.60000	21.05351	+51.77000	TSe
00.47206	00.60000	+51.15000	FLu
04.72000	07.10991	+51.05000	BGu
07.10991	07.70352	+51.05000	NJe
03.17000	03.27000	+51.00000	TCn
03.94352	04.10973	+50.35111	JSw
01.00000	01.30000	+50.00000	CSe
01.00000	01.30000	+50.00000	GDa
10.15000	12.00000	+50.00000	BDo
13.00000	13.65000	+50.00000	BDo
21.05351	21.25351	+50.00000	TSe
18.10000	19.25852	+49.77000	FKg
19.25852	20.60000	+49.77000	XZg
20.60000	20.65000	+49.77000	CFu
02.02000	02.63500	+49.65000	DLg
03.27000	03.42000	+49.00000	TCn
09.00000	09.40000	+48.75000	WCa
20.65000	20.80000	+48.52000	CFu
21.25351	22.95351	+48.50000	TSe
09.40000	09.75000	+47.15000	WCa
13.65000	14.00000	+46.75000	BDo
14.00000	15.25000	+46.75000	TQg
20.80000	20.95000	+46.55000	CFu
22.95351	23.10351	+46.00000	TSe
09.54500	09.75000	+45.50000	STs
09.75000	10.15000	+45.50000	WCa
10.15000	10.85000	+45.50000	TZn
11.35000	12.00000	+45.50000	TYy
12.00000	13.00000	+45.50000	XIg
03.42000	04.72000	+45.25000	TCn
00.02500	00.47206	+45.00000	TSe
00.47206	01.00000	+45.00000	CSe
00.47206	01.00000	+45.00000	GDa
01.00000	01.30000	+45.00000	JNm
23.10351	23.25000	+44.50000	TSe
10.85000	11.35000	+43.62528	TZn
16.92500	18.10000	+43.50000	TBa
01.30000	01.51000	+42.50000	TDj
13.00000	13.38500	+42.50000	SGz
19.50000	19.65000	+42.50000	TJn
07.70352	09.54500	+42.48500	STs
20.95000	21.25000	+42.00000	CFu
23.15000	23.25000	+41.00000	CFu
09.54500	10.32787	+40.50000	STz
07.50000	07.70352	+40.00000	Z4q
10.32787	10.50000	+40.00000	STz
14.00000	14.85000	+40.00000	XGe
15.70000	16.92500	+40.00000	QGg
21.25000	21.55000	+40.00000	CFu
19.65000	19.75000	+39.75000	TJn
02.95000	03.05000	+39.25000	JSi
18.79500	19.15000	+39.25000	NDa

ROMAN TABLE (Continued)

RAl (hr.)	RAu (hr.)	Decl (deg.)	Con
05.17500	05.57500	+39.15500	XCh
10.50000	10.85000	+38.93500	STz
10.85000	11.20000	+38.25000	TLa
21.55000	23.15000	+37.95000	CFu
19.75000	19.87500	+37.82500	TJn
07.00000	07.50000	+37.50000	Z4q
19.15000	19.25000	+37.35000	NDa
19.87500	20.00000	+36.31500	TJn
11.20000	11.85000	+36.25000	TLa
16.92500	17.39469	+36.00000	NCs
01.51000	01.70491	+35.75000	TDj
06.10000	06.36700	+35.75000	WJu
06.10000	06.36700	+35.75000	ZHb
06.36700	07.00000	+35.75000	Z4q
07.00000	07.96500	+35.75000	JSj
00.00000	00.02500	+35.00000	TSe
00.02500	00.47206	+35.00000	TJu
10.67000	11.00000	+35.00000	STx
23.15000	24.00000	+35.00000	TSe
11.85000	13.38500	+34.50000	CCh
13.38500	14.00000	+34.50000	SGz
14.00000	14.85000	+34.50000	ZYa
15.40000	15.70000	+34.45000	QGg
09.54500	09.75000	+34.09500	NPx
02.63500	03.42000	+33.55000	DLg
18.10000	18.79500	+33.45000	ZNv
05.17500	05.57500	+32.68765	THg
07.15000	07.41500	+32.55000	BHe
07.96500	08.56500	+32.50000	XYn
21.55000	22.00000	+32.50000	WCu
03.60000	04.00000	+32.09140	TCc
14.85000	15.40000	+31.68500	QGg
02.42235	02.63500	+31.50000	TDj
17.80000	18.10000	+31.50000	TJs
06.10000	06.80500	+31.11500	WZj
09.75000	10.00000	+31.05000	NPx
22.37000	22.60000	+31.00000	WCu
03.42000	04.50000	+30.35000	JSe
01.70491	02.42235	+30.00000	TDj
07.41500	07.61500	+30.00000	BHe
12.25000	12.73500	+30.00000	LJg
17.35000	17.80000	+30.00000	TJs
19.75000	20.00000	+29.50000	NDa
20.00000	20.50000	+29.50000	TJn
22.00000	22.37000	+28.75000	WCu
20.95000	21.55000	+28.35000	TJn
04.50000	06.10000	+28.10950	WJu
04.50000	06.10000	+28.10950	ZHb
06.10000	06.24750	+28.10950	JXg
07.61500	07.96500	+28.00000	BHe
10.00000	10.32787	+27.69529	NPx
10.32787	11.00000	+27.69529	SHz
11.00000	11.85000	+27.69529	STx
16.80000	17.35000	+27.50000	TJs
18.79500	19.25000	+27.25000	JTa

ROMAN TABLE (Continued)

RAl (hr.)	RAu (hr.)	Decl (deg.)	Con
19.25000	19.75000	+27.25000	**NDa**
06.80500	07.32500	+27.22500	**WZj**
23.50000	23.81590	+26.50000	**B16**
07.32500	07.96500	+26.27095	**WZj**
02.30896	03.30000	+25.00000	**W4X**
03.30000	03.42000	+25.00000	**TAa**
03.42000	03.50000	+25.00000	**MAx**
04.00000	04.50000	+25.00000	**LSh**
04.50000	04.60000	+25.00000	**ZWa**
12.73500	12.95000	+25.00000	**LJg**
12.95000	13.50000	+25.00000	**ZDg**
21.55000	21.82000	+25.00000	**JIu**
06.80500	06.90000	+24.65000	**TZt**
16.33741	16.80000	+24.50000	**TJs**
17.90000	18.42500	+24.45000	**ZYs**
06.15000	06.24750	+23.95000	**SGa**
06.24750	06.35000	+23.95000	**JXg**
13.50000	14.35000	+23.90000	**DXi**
14.35000	15.19068	+23.90000	**GHe**
03.50000	03.55000	+23.75000	**MAx**
20.50000	20.95000	+23.00000	**TJn**
07.96500	08.56500	+22.75000	**GUa**
08.56500	09.00000	+22.75000	**XYn**
03.55000	03.60000	+22.65000	**MAx**
04.60000	05.92500	+22.51500	**ZWa**
06.90000	07.05000	+22.50000	**TZt**
06.15000	06.35000	+22.15000	**YUj**
03.60000	03.78000	+22.00000	**MAx**
17.90000	18.42500	+21.68250	**TSi**
18.42500	18.81500	+21.55000	**ZYs**
07.60000	07.96500	+21.45000	**JXn**
00.47206	00.62500	+21.40000	**KXu**
07.05000	07.15885	+21.25000	**TZt**
04.00000	04.25000	+21.15000	**YUm**
19.35000	19.55000	+21.15000	**ZYs**
11.03500	11.20000	+20.65000	**SWs**
11.20000	11.50000	+20.65000	**HBn**
11.50000	11.85000	+20.65000	**CGt**
15.19068	16.33741	+20.50000	**GSu**
21.82000	22.37000	+20.25000	**JIu**
01.38500	01.70491	+20.00000	**KXu**
07.15885	07.60000	+20.00000	**TZt**
16.80000	17.90000	+20.00000	**ZYs**
11.85000	12.73500	+19.85000	**LWe**
03.78000	04.00000	+19.39468	**MAx**
04.00000	04.60000	+19.39468	**TJ1**
23.30000	23.81590	+19.00000	**SHx**
23.30000	23.81590	+19.00000	**LGo**
13.06500	13.50000	+18.25000	**WZt**
08.56500	08.72500	+18.00000	**JSg**
04.78500	05.50000	+17.92500	**TGa**
09.00000	09.35000	+17.75000	**XYn**
05.84500	06.35000	+17.65000	**SGa**
14.06540	14.52500	+17.60950	**DJa**
11.47500	11.58500	+17.50000	**YYt**

ROMAN TABLE (Continued)

RAl (hr.)	RAu (hr.)	Decl (deg.)	Con
11.58500	11.85000	+17.50000	**TZi**
11.85000	12.09500	+17.50000	**XCn**
10.50000	11.03500	+17.15000	**SWs**
09.35000	09.74500	+16.51171	**XYn**
00.62500	01.38500	+15.75000	**KXu**
01.70491	02.00000	+15.75000	**LXo**
05.28500	05.35000	+15.05500	**SQi**
05.35000	05.84500	+15.05500	**TGn**
04.30000	04.60000	+14.92500	**B6x**
12.45000	13.06500	+14.63500	**WZt**
13.50000	14.06540	+14.63500	**YSt**
18.42500	18.81500	+14.50000	**ZOg**
20.95000	22.37000	+14.50000	**REn**
22.37000	23.30000	+14.50000	**SHx**
22.37000	23.30000	+14.50000	**LGo**
16.00000	16.80000	+14.25000	**YYs**
19.35000	20.50000	+14.25000	**Z3q**
20.50000	20.67500	+14.25000	**HGa**
02.00000	02.30896	+14.15000	**LXo**
02.30896	03.05000	+14.15000	**ZGg**
03.05000	03.78000	+14.15000	**TYn**
17.15000	17.90000	+13.85000	**DZu**
04.60000	04.78500	+13.25000	**FEr**
17.90000	18.42500	+12.50000	**BDu**
00.00000	00.72500	+12.40000	**B16**
23.50000	23.81590	+12.40000	**LDn**
23.81590	24.00000	+12.40000	**B16**
20.67500	20.95000	+12.27500	**HGa**
10.50000	10.56500	+12.15000	**CYn**
08.23950	09.35000	+11.98350	**GUx**
06.35000	07.35885	+11.81500	**JXg**
09.60000	09.74500	+11.50000	**JQi**
11.47500	12.09500	+11.05550	**WDi**
12.09500	12.45000	+11.05550	**WZt**
16.65000	16.80000	+10.37500	**DOu**
16.80000	17.38500	+10.37500	**HZh**
07.35885	08.23950	+10.00000	**SWj**
05.75000	06.35000	+09.79500	**SFi**
10.05000	10.20000	+09.50000	**YNx**
22.30000	22.60000	+08.50000	**TGi**
22.60000	23.50000	+08.50000	**LDn**
10.45000	10.56500	+08.31500	**XYn**
10.85000	11.03500	+08.02500	**CYn**
11.03500	11.19150	+08.02500	**YYt**
20.89500	21.57500	+08.00000	**SFe**
05.28500	05.75000	+07.85000	**ZXi**
19.20000	19.55000	+07.76500	**ZYs**
19.55000	19.72500	+07.76500	**HGu**
09.35000	09.60000	+07.71500	**JQi**
12.45000	12.82500	+07.23950	**JQg**
01.38500	02.10000	+07.23500	**YGg**
17.25000	17.38500	+07.05000	**HUu**
17.38500	17.90000	+07.05000	**HOu**
16.00000	16.15000	+06.45000	**DOu**
13.10000	14.06540	+06.35000	**ZYt**

ROMAN TABLE (Continued)

RAl (hr.)	RAu (hr.)	Decl (deg.)	Con
21.15000	21.57500	+06.00000	SWe
03.35000	03.78000	+05.70500	TLn
11.55000	11.89500	+05.50000	NPt
12.20000	12.45000	+05.50000	NPt
14.06540	14.52500	+05.00000	KCh
14.52500	15.19068	+05.00000	ZSt
10.75000	10.85000	+04.95000	CYn
05.15000	05.28500	+04.50000	SQi
16.15000	16.35000	+04.25000	DOu
23.40000	24.00000	+04.20000	PLi
10.30000	10.45000	+04.15000	XYn
11.19150	11.58500	+03.86500	YYt
06.63950	07.15000	+03.85000	SDu
07.15000	07.35885	+03.85000	NHe
19.72500	20.28000	+03.70500	HGu
03.78000	04.30000	+03.50000	B6x
04.30000	04.78500	+03.50000	TJ2
12.45000	12.82500	+03.35000	SGt
21.57500	21.80000	+03.30000	W1X
11.89500	12.20000	+03.25000	NPt
20.28000	20.89500	+03.25000	BGa
15.19068	15.65000	+03.15000	YYs
16.35000	16.65000	+03.10150	DOu
16.65000	17.25000	+03.10150	HUu
22.22000	22.40000	+02.50000	W1X
11.58500	11.64000	+02.05000	YYt
21.57500	21.80000	+02.00000	SLx
21.80000	21.85000	+02.00000	W1X
08.09050	08.23950	+01.12500	NHe
08.23950	09.35000	+01.12500	LXi
09.35000	10.30000	+01.12500	XYn
10.30000	10.75000	+01.12500	CYn
17.90000	18.42500	+00.78500	ZRg
00.72500	02.10000	+00.75000	WPg
11.89500	12.45000	+00.65000	YZh
10.75000	10.85000	+00.00000	LTa
13.10000	13.62500	+00.00000	TTj
18.70000	19.20000	+00.00000	ZYs
15.65000	15.95000	-00.15000	YYs
21.85000	22.22000	-00.60000	W1X
04.78500	05.15000	-01.05000	SQi
05.15000	05.28500	-01.05000	SNx
07.35885	07.75000	-01.33150	NHe
00.00000	00.72500	-02.00000	TGt
22.22000	22.75000	-02.00000	FMu
22.75000	23.40000	-02.00000	PLi
23.40000	24.00000	-02.00000	YYu
04.30000	04.65000	-02.10000	JLu
06.25000	06.63950	-02.25000	SDu
12.59500	13.10000	-02.40500	ZYt
01.91000	02.69500	-02.65950	TQu
19.20000	19.38000	-02.85000	YQi
13.62500	14.06540	-03.05000	TTj
04.65000	04.70000	-03.15000	JLu
16.35000	17.25000	-03.27750	LSi

ROMAN TABLE (Continued)

RAl (hr.)	RAu (hr.)	Decl (deg.)	Con
19.81500	20.00000	-03.80750	TFn
20.28000	20.89500	-03.80750	LZh
20.89500	21.15000	-03.80750	XXu
02.69500	03.78000	-03.97685	TQu
21.57500	21.85000	-04.00000	SMg
21.85000	22.22000	-04.00000	GWu
18.50000	18.70000	-04.82500	ZYs
04.70000	04.78500	-04.95000	JLu
05.25150	05.28500	-05.00000	YJg
14.75000	14.91500	-05.45000	KXa
15.65000	15.95000	-05.95000	TRu
15.95000	16.12500	-05.95000	YYs
22.22000	23.00000	-05.95500	XLg
10.71205	10.85000	-06.00000	TXg
10.85000	11.19150	-06.00000	LTa
11.19150	11.64000	-06.00000	MTg
11.64000	12.15000	-06.00000	YYt
12.15000	12.59500	-06.00000	ZYt
05.50000	05.70000	-06.05000	FAs
17.25000	17.90000	-06.15000	ZZh
17.90000	18.05450	-06.15000	ZYs
21.15000	21.57500	-06.69350	XXu
16.12500	16.35000	-06.85000	YYs
07.75000	08.09050	-07.05000	NHe
20.00000	20.28000	-07.15000	TFn
23.00000	23.85000	-07.39500	LBz
05.21500	05.25150	-07.75000	YJg
18.03500	18.05450	-08.35000	SLs
18.00000	18.03500	-08.65000	SLs
04.50000	04.78500	-09.25000	JZs
17.95000	18.00000	-09.25000	SLs
21.83500	22.00000	-09.41950	TLe
22.00000	22.45000	-09.41950	QIi
05.00000	05.07500	-09.50000	YJg
17.90000	17.95000	-09.75000	SLs
22.62500	23.00000	-09.85000	LBz
00.00000	00.25000	-10.00000	LBz
00.25000	00.50000	-10.00000	TCa
10.05000	10.71205	-10.00000	TXg
12.52500	12.59500	-10.00000	ZXn
12.59500	13.10000	-10.00000	JXx
20.28000	21.15000	-10.00000	NVx
23.85000	24.00000	-10.00000	LBz
22.60000	22.62500	-10.05000	LBz
22.57500	22.60000	-10.25000	LBz
17.85000	17.90000	-10.35000	SLs
22.55000	22.57500	-10.45000	LBz
22.52500	22.55000	-10.65000	LBz
16.46335	17.01766	-10.78343	CSi
06.63950	08.09050	-10.79500	QQu
03.78000	04.50000	-10.85000	JZs
22.50000	22.52500	-10.85000	LBz
17.80000	17.85000	-10.95000	SLs
22.20000	22.30000	-11.15000	KUu
05.07500	05.21500	-11.49750	YJg

ROMAN TABLE (Continued)

RAl (hr.)	RAu (hr.)	Decl (deg.)	Con
17.75000	17.80000	-11.55000	**SLs**
16.07500	16.12500	-11.80000	**XXa**
09.50000	10.05000	-12.16462	**XXg**
02.10000	02.69500	-12.35000	**CGa**
17.70000	17.75000	-12.65000	**SLs**
22.05000	22.20000	-12.75000	**KUu**
00.50000	01.05500	-12.88169	**THn**
22.29500	22.50000	-13.06750	**LBz**
18.50000	19.38000	-13.12750	**TBi**
19.38000	20.00000	-13.12750	**YQi**
17.65000	17.70000	-13.35000	**SLs**
21.65000	21.83500	-13.45000	**TLe**
16.01000	16.07500	-13.80000	**XXa**
16.35000	17.25000	-14.00000	**YYs**
17.25000	17.65000	-14.00000	**SLs**
21.85000	22.05000	-14.05000	**KUu**
13.00000	14.06540	-14.35000	**JXa**
13.00000	14.06540	-14.35000	**PDa**
06.25000	06.63950	-14.50000	**SNx**
17.95000	18.50000	-14.82500	**ZYs**
05.07500	05.65000	-15.06650	**JJg**
21.57500	21.65000	-15.15000	**TLe**
21.65000	21.85000	-15.15000	**KUu**
00.50000	01.15000	-15.50000	**TCa**
15.95000	16.01000	-15.85000	**XXa**
23.65000	23.85000	-15.85000	**YLj**
23.85000	23.92500	-15.85000	**BKu**
20.90000	21.57500	-16.00500	**TLe**
22.00000	22.29500	-16.15000	**LBz**
12.52500	13.00000	-17.00000	**ZXa**
06.63950	07.35000	-17.50000	**TLg**
08.09050	08.38895	-17.50000	**WCh**
15.50000	15.65000	-18.05000	**DXd**
15.65000	15.95000	-18.05000	**XXa**
15.95000	16.35000	-18.05000	**FAf**
06.55000	06.65000	-19.75000	**YJi**
21.57500	22.00000	-19.75000	**LBz**
09.00000	09.50000	-20.00000	**XXg**
16.91450	17.95000	-20.00000	**ZYs**
17.95000	18.05000	-20.00000	**DXo**
16.09500	16.15000	-20.45000	**FAx**
16.15000	16.35000	-20.45000	**JBi**
19.20000	19.52150	-20.76915	**JAn**
19.52150	20.00000	-20.76915	**TJd**
01.15000	02.25000	-20.83500	**TCa**
15.50000	15.75000	-21.25000	**RIi**
13.00000	14.06540	-22.05000	**TMe**
14.06540	14.75000	-22.05000	**KXa**
14.75000	15.50000	-22.05000	**DXd**
16.09500	16.35000	-22.32500	**GQn**
16.35000	16.91450	-22.32500	**DXx**
12.25000	12.45000	-23.21500	**CSa**
18.80000	19.20000	-23.25000	**JAn**
11.97500	12.20000	-24.00000	**ZXn**
20.56000	20.90000	-24.13500	**LYa**

ROMAN TABLE (Continued)

RAl (hr.)	RAu (hr.)	Decl (deg.)	Con
20.90000	22.00000	-24.13500	**SEg**
22.00000	22.20385	-24.13500	**YLj**
08.38895	09.00000	-25.00000	**WCh**
09.50000	09.90500	-25.00000	**ZXh**
11.70000	11.97500	-25.00000	**YXx**
01.15000	02.25000	-25.50000	**TZh**
02.25000	02.90000	-25.50000	**TYm**
19.20000	20.00000	-25.72500	**GOu**
20.00000	20.15000	-25.72500	**NNx**
22.90350	23.65000	-26.15000	**YLj**
23.65000	23.92500	-26.15000	**TYe**
06.00000	06.25000	-26.25000	**CEs**
06.25000	07.08500	-26.25000	**JSh**
05.42500	06.00000	-26.71500	**CEs**
15.50000	15.65000	-26.85000	**FAx**
14.64500	15.50000	-27.50000	**ZWe**
10.71205	11.70000	-28.27899	**YXx**
11.70000	11.97500	-28.27899	**JMn**
11.97500	12.20000	-28.27899	**YXa**
16.65000	16.91450	-28.82950	**XXi**
16.91450	17.47500	-28.82950	**TJg**
17.47500	18.05000	-28.82950	**TYo**
18.05000	18.50000	-28.82950	**DXo**
22.20385	22.78098	-29.05000	**YLj**
02.90000	04.30000	-29.37500	**TYm**
04.30000	05.07500	-29.37500	**JLu**
05.07500	05.42500	-29.37500	**PIs**
20.15000	20.56000	-29.42500	**NNx**
20.56000	21.57050	-29.42500	**TTn**
08.85000	08.95000	-30.41500	**TGn**
00.50000	00.00000	-30.50000	**BKu**
00.50000	01.15000	-30.50000	**SKk**
01.15000	01.49650	-30.50000	**TYu**
13.00000	14.15950	-30.50000	**PIj**
14.15950	14.64500	-30.50000	**ZWe**
22.78098	22.90350	-30.50000	**YLj**
22.90350	23.92500	-30.50000	**BLm**
23.92500	24.00000	-30.50000	**BKu**
14.64500	15.50000	-30.83350	**ZJu**
17.35000	17.80000	-32.05000	**KAg**
17.80000	17.97500	-32.05000	**JXi**
09.90500	10.71205	-32.50000	**ZXh**
10.71205	11.05000	-32.50000	**SKz**
15.50000	15.65000	-32.50000	**TFd**
15.65000	16.09500	-32.50000	**FAx**
16.09500	16.65000	-32.50000	**XXi**
18.50000	19.20000	-32.50000	**DXo**
19.20000	19.27250	-32.50000	**GGu**
05.42500	06.00000	-33.50000	**SHs**
19.27250	20.03500	-35.18500	**GGu**
20.56000	21.57050	-35.18500	**LYu**
21.57050	22.20385	-35.18500	**TQa**
17.80000	17.87216	-36.05000	**W3X**
17.87216	17.97500	-36.05000	**YUw**
18.50000	19.27250	-36.45000	**NZr**

ROMAN TABLE (Continued)

RAl (hr.)	RAu (hr.)	Decl (deg.)	Con
20.03500	20.56000	-36.45000	GGu
01.49650	02.90000	-36.50000	TYu
11.05000	11.48135	-36.74735	SKz
11.48135	12.20000	-36.74735	QQg
12.20000	13.00000	-36.74735	ZXn
08.85000	09.00000	-37.50000	TMa
22.35000	22.90350	-38.45000	BJu
22.90350	23.37715	-38.45000	TGg
09.00000	09.90500	-39.00000	TMa
09.90500	10.30000	-39.00000	DOd
12.65000	12.70000	-39.00000	QFu
14.64500	15.00000	-39.25000	YMn
15.00000	15.50000	-39.25000	DWn
15.50000	15.92500	-39.25000	CGf
12.60000	12.65000	-40.00000	QFu
17.80000	17.90000	-40.00000	FSh
18.40000	18.50000	-40.00000	JXi
05.42500	05.75000	-40.05000	ZRh
05.75000	06.00000	-40.05000	ZIi
06.00000	06.63950	-40.05000	SUn
06.63950	07.00000	-40.05000	HSi
21.85000	22.35000	-40.25000	BJu
16.80000	17.00000	-40.30000	SGg
12.55000	12.60000	-40.85000	QFu
12.52150	12.55000	-41.50000	QFu
13.82507	14.10076	-42.47381	HEg
10.95000	11.05000	-43.25000	DOd
12.40000	12.47500	-43.25000	QFu
12.47500	12.52150	-42.25000	QFu
20.56000	21.85000	-43.78050	JKn
07.00000	08.38895	-44.67105	HSi
08.38895	09.00000	-44.67105	TGn
09.00000	10.30000	-44.67105	TJx
10.30000	10.95000	-44.67105	DOd
15.92500	16.50000	-44.87350	JZu
16.50000	17.80000	-44.87350	W3X
17.80000	18.40000	-44.87350	JXi
19.27250	20.56000	-45.75000	TYd
12.30000	12.40000	-46.50000	QFu
12.40000	13.00000	-46.50000	MYg
13.41500	14.64500	-48.30500	KLu
13.41500	14.64500	-48.30500	ZHj
14.64500	16.00000	-48.30500	QGa
00.00000	01.49650	-50.00000	HNa
04.00000	05.42500	-50.00000	TYb
15.00000	15.50000	-50.00000	QZn
21.85000	22.09605	-50.00000	HEe
23.37715	24.00000	-50.00000	HNa
12.00000	12.30000	-50.47650	QFu
12.30000	13.41500	-50.47650	KLu
12.30000	13.41500	-50.47650	ZHj
15.50000	17.00000	-52.00000	QZn
17.00000	17.25000	-52.00000	JXc
10.95000	12.00000	-52.78500	QFu
12.00000	12.85000	-52.78500	MWe

ROMAN TABLE (Continued)

RAl (hr.)	RAu (hr.)	Decl (deg.)	Con
13.41500	15.00000	-52.78500	CQi
01.49650	04.00000	-53.42500	TYb
17.25000	17.37500	-54.00000	JXc
05.42500	07.50000	-54.50000	LRn
12.85000	13.55000	-54.95000	MWe
17.37500	17.45000	-55.89500	JXc
17.45000	18.40000	-56.13250	JXc
18.40000	19.27250	-56.13250	BIe
19.27250	21.25000	-56.13250	BSi
15.00000	16.00000	-56.15000	CQi
13.55000	13.90000	-56.50000	NMn
07.50000	10.00000	-58.00000	TSh
13.90000	14.16950	-58.50000	NMn
00.00000	02.50000	-58.85000	SWn
21.25000	22.09605	-58.85000	BSi
22.09605	23.37715	-58.85000	HEe
23.37715	24.00000	-58.85000	SWn
03.85000	04.75000	-60.00000	JYu
10.00000	11.00000	-60.00000	HSa
16.00000	17.56500	-62.05835	GUi
04.75000	05.50000	-64.50000	JYu
01.00000	01.50000	-65.00000	NHu
01.50000	02.00000	-65.00000	SSh
06.50000	07.50000	-65.60475	JYu
07.50000	10.00000	-65.60475	HSh
05.50000	05.70000	-66.00000	JYu
02.00000	03.85000	-66.21150	SSh
03.85000	04.00000	-66.21150	JBa
12.00000	12.85000	-66.50000	SZj
12.85000	14.16950	-66.50000	MFu
17.00000	17.56500	-66.85000	SJx
17.56500	18.25000	-66.85000	KQu
05.70000	05.90000	-67.50000	JYu
11.00000	12.00000	-67.50000	HSa
05.90000	06.10000	-69.00000	JYu
00.00000	01.00000	-70.00000	NHu
01.00000	01.50000	-70.00000	SFh
21.50000	22.00000	-70.00000	KQu
22.00000	24.00000	-70.00000	NHu
06.10000	06.50000	-70.50000	JYu
01.50000	04.00000	-71.45000	SFh
16.25000	17.00000	-71.85000	SJx
04.00000	06.50000	-74.50000	JBa
14.16950	15.00000	-75.00000	NMn
15.00000	16.25000	-75.00000	SJx
18.25000	21.50000	-75.25000	KQu
06.50000	09.15000	-75.47500	FYu
09.15000	11.00000	-75.47500	NCu
11.00000	14.16950	-75.47500	MFe
01.50000	06.50000	-80.00000	FBe
00.00000	01.50000	-85.50000	SWh
06.50000	13.35000	-85.50000	XDu
13.35000	20.50000	-85.50000	YQu
20.50000	24.00000	-85.50000	SWh
00.00000	24.00000	-90.00000	NJq

4.2 Computational Parameters of the Chinese Constellations

The file "boundary_computation.fits" contains the values of the computational parameters for all the Chinese constellations established in this work. As a demonstration, the computational parameters for the Triads (Shenxiu) constellation are given as follows:

- Number of primary stars: 7
- Number of appendent stars: 39
- Area in square radians: 0.1198266
- Area in square degrees: 6.8655594
- Area ratio to hemisphere: 1.907%
- Coordinates of spherical barycentre: RA 5.8812790 h, Dec −2.9342684°
- Minimum RA: 5.1500000 h
- Maximum RA: 6.6395000 h
- Minimum Dec: −14.5000000°
- Maximum Dec: 9.7950000°
- Visibility latitudes: between −80° and 75°

The coordinates of the spherical barycentre also provide the locations for constellation labels in the maps exhibited in Figures 8, 10, and 12.

4.3 Nancy Grace Roman Data Set

Following the precedent established by Roman (1987) for the IAU constellation boundaries, the Chinese constellation boundaries are presented in two formalised tabular data sets that transcribe the listing into machine-readable form. This makes it convenient to manipulate the Chinese constellations into an indexing arrangement that is easy to use for finding a boundary from a position specified in right ascension and declination. The two data sets are provided in the form of FITS binary tables named as (see Table 4):

- "*Chinese_constellation_boundary_roman_data_excl.fits*"
- "*Chinese_constellation_boundary_roman_data_incl.fits*"

These two FITS files serve the same purpose but differ in that "*Chinese_constellation_boundary_roman_data_excl.fits*" contains exclusively the boundary data for 299 Chinese constellations whose boundaries are neither overlapped by nor nested in other boundaries. The "*Chinese_constellation_boundary_roman_data_incl.fits*" file contains the boundary data for all 321 Chinese constellations, of which five are overlapped (as explained below in Section 4.3.1) by and 17 are nested (see below Section 4.3.2) in others.

The Roman table (Roman, 1987) of the IAU constellation boundaries is a meticulous work that laid the cornerstone for mapping pixelated celestial sphere to the IAU constellations. Within the Python's "ecosystem" for astronomy, two computer programming libraries and tool sets, *Astropy* (the Astropy Developers, 2025) and *Healpy* (Górski et al., 2005), bind with Roman table to make the IAU constellations from a humble beginnings to extraordinary advancements in space technology. To catch up with the Roman table of IAU constellations, this research strives for two tables with Roman data sets to make the Chinese constellations compatible with the Python utilities of *Healpy* and *Astropy*. Table 5 is the complete Roman data set of the Chinese constellation boundaries transcribed from the

"*Chinese_constellation_boundary_roman_data_incl.fits*" file. Due to space constraints, the Roman data set derived from the "*Chinese_constellation_boundary_roman_data_excl.fits*" file is listed "*Chinese_constellation_roman_data_j2000_excl.dat*" in Table 4 as supplementary materials, which transcribes 299 exclusive constellation boundaries with neither overlapping nor nesting data set.

4.3.1 Overlapped Chinese Constellations

As two overlapping constellation boundaries are geometrically identical, the overlapping boundary blocks the overlapped one in pixelation mapping and visualisation display. This is the reason for 316 instead of 321 Chinese constellation boundaries accountable during the spheroidal pixelisation HEALPix mapping (see Figure 13 in Section 5.2), because five overlapped boundaries being blocked. The overlapped constellation boundaries are highlighted in red-line boxes in the Roman data set listed in Table 5.

- LGo (Mandarin Chinese Pinyin: li gong; English Translation: Resting Palace) overlapped by SHx (Mandarin Chinese Pinyin: shi xiu; English Translation: Encampment) within star field SIX (Mandarin Chinese Pinyin: shi xiu xing yu; English Translation: Room).
- PDa (Mandarin Chinese Pinyin: ping dao; English Translation: Flat Road) overlapped by JXa (Mandarin Chinese Pinyin: jiao xiu; English Translation: Horn) within star field JAX (Mandarin Chinese Pinyin: jiao xiu xing yu; English Translation: Horn).
- GDa (Mandarin Chinese Pinyin: ge dao; English Translation: Flying Corridor) attached to KXu (Mandarin Chinese Pinyin: kui xiu; English Translation: Legs) overlapped by CSe (Mandarin Chinese Pinyin: chuan she; English Translation: Guest House) within star field ZWY (Mandarin Chinese Pinyin: zi wei yuan xing yu; English Translation: Purple Forbidden Enclosure).
- ZHj (Mandarin Chinese Pinyin: jiao xiu zhu; English Translation: Pillars in Horn) overlapped by KLu (Mandarin Chinese Pinyin: ku lou; English Translation: Arsenal) within star field JAX (Mandarin Chinese Pinyin: jiao xiu xing yu; English Translation: Horn)..
- ZHb (Mandarin Chinese Pinyin: bi xiu zhu; English Translation: Pillars in Net) overlapped by WJu (Mandarin Chinese Pinyin: wu ju; English Translation: Five Chariots) within star field BNX (Mandarin Chinese Pinyin: bi xiu xing yu; English Translation: Net)..

4.3.2 Nested Chinese Constellations

There are 17 Chinese constellation boundaries in the Roman data set in Table 5 that are nested in another constellation boundaries. The nested boundaries are highlighted in Table 5 in blue dash-line boxes while the nesting boundaries are not highlighted in red solid-line boxes.

- THd (Mandarin Chinese Pinyin: tian huang da di; English Translation: Emperor The Great Heaven) nested in GCh (Mandarin Chinese Pinyin: gou chen; English Translation: Curved Array).
- TLi (Mandarin Chinese Pinyin: tian li; English Translation: Judge for Nobility) nested in BDo (Mandarin Chinese Pinyin: bei dou; English Translation: Northern Dipper).
- JSw (Mandarin Chinese Pinyin: wei xiu ji shui; English Translation: Accumulated Water) nested in TCn (Mandarin Chinese Pinyin: tian chuan; English Translation: Celestial Boat).
- THg (Mandarin Chinese Pinyin: tian huang; English Translation: Celestial Pier) nested in WJu (Mandarin Chinese Pinyin: wu ju; English Translation: Five Chariots).

- XCh (Mandarin Chinese Pinyin: xian chi; English Translation: Pool of Harmony) nested in WJu (Mandarin Chinese Pinyin: wu ju; English Translation: Five Chariots).
- ZSh (Mandarin Chinese Pinyin: zhu shi; English Translation: Royal Archive Officer) nested in ZYz (Mandarin Chinese Pinyin: zi wei zuo yuan; English Translation: Left Wall of Purple Forbidden Enclosure).
- CSi (Mandarin Chinese Pinyin: che si; English Translation: Commodity Market) nested in YYs (Mandarin Chinese Pinyin: tian shi you yuan; English Translation: Right Wall of Celestial Market).
- CSa (Mandarin Chinese Pinyin: chang sha; English Translation: City of Entertainment) nested in ZXn (Mandarin Chinese Pinyin: zhen xiu; English Translation: Chariot).
- HEg (Mandarin Chinese Pinyin: heng; English Translation: Railings) nested in KLu (Mandarin Chinese Pinyin: ku lou; English Translation: Arsenal); HEg is also nested in ZHj (Mandarin Chinese Pinyin: jiao xiu zhu; English Translation: Pillars in Horn).
- YJi (Mandarin Chinese Pinyin: ye ji; English Translation: Wild Cockerel) nested in JSh (Mandarin Chinese Pinyin: jun shi; English Translation: Soldiers Market).
- JSi (Mandarin Chinese Pinyin: ji shi; English Translation: Piling Corpses) nested in DLg (Mandarin Chinese Pinyin: da ling; English Translation: Mausoleum).
- SGg (Mandarin Chinese Pinyin: shen gong; English Translation: Spirit Palace) nested in W3x (Mandarin Chinese Pinyin: wei3 xiu; English Translation: Tail).
- THn (Mandarin Chinese Pinyin: tian hun; English Translation: Celestial Pigsty) nested in TCa (Mandarin Chinese Pinyin: tian cang; English Translation: Celestial Square Granary).
- TCc (Mandarin Chinese Pinyin: tian chan; English Translation: Celestial Slander) nested in JSe (Mandarin Chinese Pinyin: juan she; English Translation: Rolled Tongue).
- FAs (Mandarin Chinese Pinyin: shen xiu fa; English Translation: Suppress) nested in SNx (Mandarin Chinese Pinyin: shen xiu; English Translation: Three Stars or Triads).
- JSq (Mandarin Chinese Pinyin: ji shi qi; English Translation: Corpse Pile Gas) nested in GUx (Mandarin Chinese Pinyin: gui xiu; English Translation: Ghosts).
- YNx (Mandarin Chinese Pinyin: xing xiu yu nv; English Translation: Maids-in-Waiting) nested in XYn (Mandarin Chinese Pinyin: xuan yuan; English Translation: The Yellow Emperor).

In fact, due to the inherent hierarchical structure of the Chinese asterisms, the 321 Chinese constellations are all nested within the 32 the star fields, which are in turn all nested within the six star regions, as exhibited in Figure 13. Such an exquisite structure of the Chinese constellations provides multiple resolutions of boundaries in 6, 32, and 321 (compared to 88 in IAU constellations) for spheroidal pixelisation mapping.

5 DISCUSSION

5.1 Comparison with IAU Constellation Boundaries

The Chinese constellations defined in this study differ from the IAU constellations in both conceptual foundation and practical implementation. Table 6 lists the comparative features of the two boundary systems.

The larger number of celestial divisions in the Chinese constellation system (359 vs. 88) reflects a different philosophy: the Chinese system focused on named star groups, resulting in a finer-grained division of the sky. The boundaries presented in this study preserve this granularity while providing the spatial coverage necessary for modern applications.

Table 6: The comparative features of the IAU constellations formalised in 1928 and the Chinese constellation formalised in this work.

Features	IAU Constellation Boundaries	Chinese Constellation Boundaries
Historical Basis	Greco-Roman tradition formalised in 1928	Chinese tradition formalised in this study
Structure	Single level 88 constellations	Three hierarchical levels 6 regions, 32 fields, 321 areas
Delineation Logic	Primarily RA/Dec lines	Primarily RA/Dec lines allowing overlapping and nesting
Number of Divisions	88 in one level	359 in a three levels hierarchy
Spacial Indexing	Designed for modern astronomy	Compatible with modern astronomy
Data reference frame	B1875	J2000

5.2 Implications for Spherical Indexing

The definition of exclusive spherical boundaries for Chinese constellations enables their integration with modern spherical indexing systems such as HEALPix (Górski et al., 2024), HTM (Szalay et al., 2005), and Q3C (Koposov and Bartunov, 2006).

Figure 14 shows the spheroidal pixelisation implemented in this work with the HEALPix system. It indexes 786,432 spherical pixels (each being 0.052456 square degrees in area) from the whole celestial sphere into the complete set of 316 Chinese constellations (not including the five overlapped ones; see Section 4.3.1). The coordinates of the centres of the spherical pixels are stored in the FITS file "constellation_map.fits."

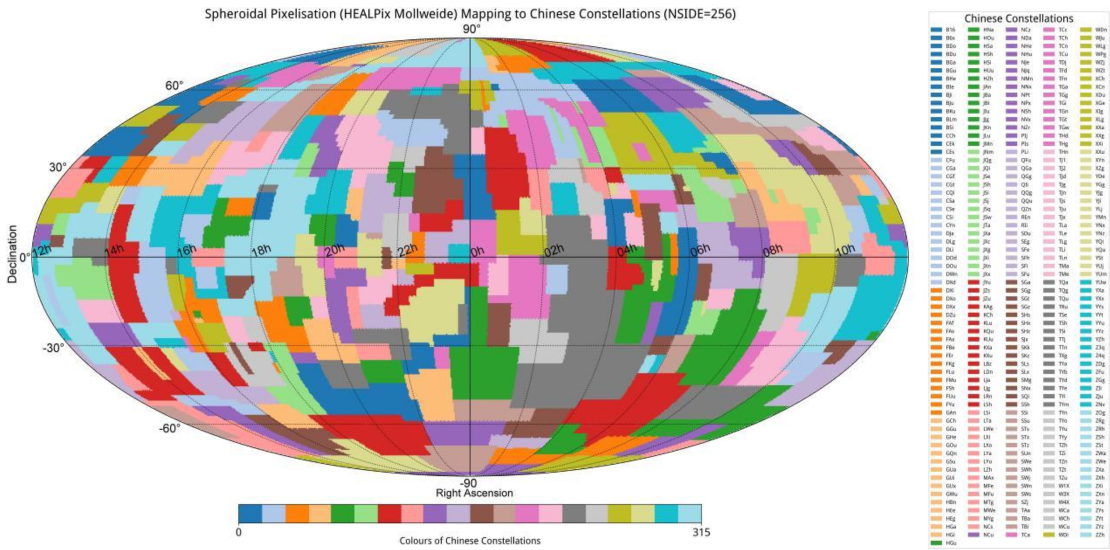


Figure 14: Spheroidal pixelisation (HEALPix) mapping to 316 Chinese constellations HEALPix parameters: NSIDE = 256, ORDER = Ring

The Chinese constellations are labelled with colour indexes. The labels are marked within individual boundaries of the constellations in Figure 15. The boundaries of star areas (red), star fields (green), and star regions (blue) are plotted and labelled in different colours. The top 10 constellations indexed by the most spherical pixels and with the highest area percentages are as follows:

- TYb: Bi xiu tian yuan (Celestial Orchard); 16,842 pixels, 883.46 square degrees (2.14%)
- ZYs: Tian shi zuo yuan (Left Wall); 15,374 pixels, 806.46 square degrees (1.95%)
- XYn: Xuan yuan (The Yellow Emperor); 13,401 pixels, 702.96 square degrees (1.70%)
- HNa: Huo niao (Firebird); 11,702 pixels, 613.84 square degrees (1.49%)
- HSi: Hu shi (Bow and Arrow); 11,533 pixels, 604.97 square degrees (1.47%)
- TYm: Mao xiu tian yuan (Celestial Meadows); 11,455 pixels, 600.88 square degrees (1.46%)
- TSe: Teng she (Flying Serpent); 9,137 pixels, 479.29 square degrees (1.16%)
- YYs: Tian shi you yuan (Right Wall); 8,875 pixels, 465.55 square degrees (1.13%)
- KQu: Kong que (Peacock); 8,856 pixels, 464.55 square degrees (1.13%)
- YLj: Yu lin jun (Palace Guard); 7,969 pixels, 418.02 square degrees (1.01%)

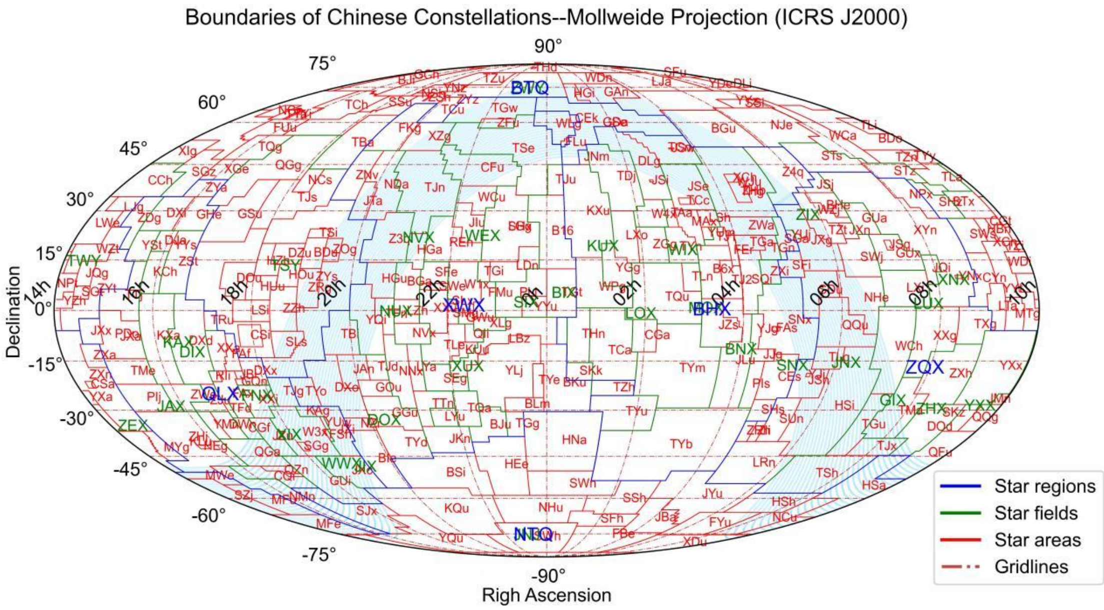


Figure 15: Boundaries of star areas, star fields and star regions of the Chinese constellation system

The bottom 10 constellations indexed by the fewest spherical pixels and with the lowest area percentages are as follows:

- CEk: Kui xiu ce (Whip); 135 pixels, 7.08 square degrees (0.02%)
- TYi: Tian yi (Celestial Great One); 128 pixels, 6.71 square degrees (0.02%)
- GQn: Gou qian (Lock); 121 pixels, 6.35 square degrees (0.02%)
- FSh: Fu shui (Fu Yue); 95 pixels, 4.98 square degrees (0.01%)
- NSh: Nv shi (Female Protocol); 94 pixels, 4.93 square degrees (0.01%)
- YUj: Jing xiu yue (Battle Axe); 93 pixels, 4.88 square degrees (0.01%)
- YUw: Yu (Fish); 88 pixels, 4.62 square degrees (0.01%)
- SLx: Si lu (Deified Rank Judge); 85 pixels, 4.46 square degrees (0.01%)

- ZSh: Zhu shi (Royal Archive Officer); 31 pixels, 1.63 square degrees (<0.01%)
- THd: Tian huang da di (Emperor The Great Heaven); 28 pixels, 1.47 square degrees (<0.00%)

The integration of the boundaries of the Chinese constellation with systems like HEALPix supports applications including:

- **Positional Association**: Astronomical objects can now be assigned a "traditional Chinese address" by performing point-in-polygon tests against the boundaries of the Chinese constellations, enabling cultural context to be attached to modern astronomical observations and space missions.
- **Arc Segment Association**: For moving objects such as asteroids or satellites, their trajectories across the sky can be analysed in terms of which asterisms they traverse, supporting applications in cultural astronomy and historical astronomy.
- **Multi-Level Spatial Queries**: The hierarchical structure enables queries at different granularities—from major regions to star fields to individual asterisms in star areas—supporting flexible analysis of spatial relationships.

5.3 Cultural and Historical Significance

This work represents the first complete spatial definition of the traditional Chinese celestial system. While the system has been studied extensively from historical and philological perspectives, it has lacked the spatial infrastructure necessary for integration with modern computational methods. This study provides that infrastructure, enabling:

- **Digital Humanities and Applications:** The boundary data support the creation of digital maps, interactive educational tools, and virtual observatories featuring the traditional Chinese sky.
- **Preservation of Astronomical Heritage:** The data sets provide a permanent, machine-readable record of the traditional astronomical system, ensuring its preservation for future scholarship.
- **Cross-Cultural Comparison:** Researchers can now perform quantitative comparisons between Chinese, Greek, Arabic, and other celestial mapping traditions using common spatial methodologies.

5.4 Limitations and Future Work

Several limitations of this study should be acknowledged:

- **Historical Ambiguity:** For some asterisms, traditional descriptions provide insufficient information to determine exact boundaries, requiring decisions based on proximity and symmetry. Future research may refine these definitions based on additional historical sources, particularly the archives of asterisms, star maps, and catalogues before 1620.
- **Epoch Differences:** The *Yixiang Kaocheng* and *Xubian catalogues* represent observations separated by nearly a century. Proper motion corrections have been applied, but for stars without accurate modern proper motion data, some positional uncertainty remains.
- **Hierarchical Consistency:** In a small number of cases, the requirement for exclusive

coverage forced boundaries that cross traditional associations. For example, GDa, which belongs to KXu, is located within star field ZWY and the boundary of CSe (see Section 4.3.1). These cases are documented in the full data set "*star_basics.fits*" in the supplementary materials.

Future work will focus on:

- **Extending** the data sets to include proper motion predictions, enabling boundaries to be computed for arbitrary epochs.
- **Developing** interactive visualisation tools for further exploring the asterism system and the Chinese constellation boundaries.
- **Integrating** the data sets with the HEALPix spherical indexing system to enable high-performance spatial queries.
- **Submitting** the data sets to the International Astronomical Union's Working Group on Cultural Astronomy for consideration as a formal reference or standard.

6 CONCLUSION

This study has presented the first complete definition of spherical boundaries for the traditional Chinese asterism system, based on the star catalogues of Yixiang Kaocheng (1757) and Yixiang Kaocheng Xubian (1845). This work defines exclusive boundary polygons for 321 asterisms organised into a three-tier hierarchical structure of star regions, star fields, and star areas around individual asterisms. All boundary data and associated stellar positions are provided in the ICRS J2000.0 coordinate system, formatted according to FITS standards for storage and transmission. Following the indexing methodological precedent established by Nancy Grace Roman for the IAU constellation boundaries, indexing Roman tables are established for the Chinese constellation boundaries and are implemented in success with spheroidal pixelisation (HEALPix) mapping.

This work establishes a digital infrastructure that enables the ancient Chinese celestial culture and traditional Chinese astronomical system to be integrated into modern astronomical research, education, and cultural heritage applications. It addresses a long-standing gap in the documentation of one of the world's major astronomical traditions and provides a foundation for future research in cultural astronomy, digital humanities, and cross-cultural celestial cartography.

The data sets are made freely available to the research community upon the publication of this work, in the hope that they will facilitate scholarship, education, and appreciation of the rich astronomical heritage of China and its contributions to humanity's understanding of unity with the nature.

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