

Connecting Heaven and Man: The role of astronomy in ancient Chinese society and culture

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Abstract. This paper reviews the history of Chinese astronomy from the perspective of the rôle it played in establishing the Heaven-Man relationship in ancient China, which was politically and morally significant, and which in turn gave Chinese astronomy its most important characteristics.

Keywords. China, history, sociology, shamanism, astrology, politics

1. Introduction

Ancient Chinese astronomy, viewed from the scientific perspective, has a lot to be proud of (Needham 1959). It has maintained for continuous periods longer than any other civilisation accurate records of celestial phenomena such as eclipses, novae, comets, meteors, sunspots, etc. These records have found many applications in modern astronomy (Ho 1997). Over the course of history, China has produced more than 100 systems of mathematical astronomy, *li*, as it was called, that demonstrate highly sophisticated mathematical techniques for describing and predicting the solar, lunar and planetary motions. We find that the Chinese algebraic approach to celestial motions was not inferior to the Greek geometric one by any standard, only being more convenient for producing almanacs. There was continuous elaboration of astronomical instruments, ever since the Han astronomers invented the armillary spheres. In the 11th century, Song astronomers constructed a towered astronomical observatory combining instruments for measuring celestial motions, for demonstrating celestial movements, and for time-announcing. The whole system was powered by water flow from the clepsydra, and mechanical devices were used to keep the instruments running simultaneously with the heavens.

The purpose of this paper, however, is not to enumerate ancient China's astronomical achievements by the standards of modern astronomy. Such undertaking, while meaningful by providing us with facts and useful insight, could also misrepresent or even distort the picture of ancient Chinese astronomy by quoting it out of its social and cosmological context. To have a more precise picture of ancient Chinese astronomy, one must also ask what the purpose of astronomy was. What were the motivations, the methods, the systems, the cosmologies, the connections with philosophy, politics, religion, etc.? The main purpose of Chinese astronomy was to study the correlation between man and universe. In the words of the famous Han historian and astronomer Sima Qian from the first century BCE: "[...] it is to explore the boundaries between Heaven and Man, to comprehend changes old and new, and finally to form a total perspective (of the cosmos)" (Sima 1985). The universe was conceived not as an object independent of humans, but as a counterpart or mirror of human society. There is a certain harmony and proportion

between the heavens and humans, the order and pattern of the universe prevails in the world, and changes in the heavens are correlated with changes in the world. This cosmological view made Chinese astronomy the most highly regarded science by the state rulers. Astronomy in ancient China thus had a heavy political component in it.

In this paper I will look at ancient Chinese astronomy from the perspective of the relation between heaven and humans, focusing on its rôle in society and culture. I will examine three aspects of it: first, the relation between astronomy and worship of heaven; second, the role of calendar making in state politics; third, the political meaning of Chinese portent astrology.

2. From worshipping heaven to observing and following the heavens

Astronomy arose from worship of heaven in ancient China. Since the very beginning of Chinese civilisation, the Chinese had been worshippers of Heaven, or the Supreme High (*Shang Di*). This worshipping of Heaven was inextricably connected with astronomy. Archaeological studies reveal that shamanism was central to early Chinese culture. The universe was divided into separate realms of heaven and earth, or, gods and humans. Between the sacred and the mundane it was possible to communicate, but only through a privileged class of shamans or magicians. In this shamanistic society, heaven held the highest position in the world. Those who controlled the means of communicating with heaven had the power and knowledge of ruling the society.

Priests had many techniques and means to communicate between Heaven and Man. Among them were sacred mountains, trees, tortoise shells, counting rods, animals, dance, music, and medicine. Still, there was another particularly important means for communication. It was the observation of the sky. The determination of the seasons by observing the celestial movements symbolised the legitimacy and authority of ruling. It is recorded in the *Book of Documents* that the first priority for the legendary Emperor Yao was to send out astronomers to make astronomical observations in order to correctly determine the seasons. “He charged Xi and He with reverence to follow august Heaven and systematically observe the Sun, the Moon, and the other heavenly bodies, and respectfully to give the people the seasons”. The observation of the heavenly bodies was at the same time a ritual of worshipping Heaven. Issuing the calendar to the people was to claim authority over the people.

The connection between worship of heaven and astronomy is proved by archaeological findings in China. On the archaeological site of Liangzhu Culture from around 5,000 years ago, archaeologists in 1980s discovered two altars for worshipping Heaven. The layout of the Yaoshan Altar, for instance, shows that its central axis was exactly in the North-Southern direction, and that its four corners, seeing from the center of the Altar, were in alignment with the four points on the horizon where the Sun rose and set on days of Winter and Summer solstices. In building the altar, the constructor had already taken into consideration the Sun (Liu 2007) The observation of the sunrise and the sunset was part of the rituals of Sun worshipping.

Another important piece of evidence is provided by the recent discovery of the base of semi-circular wall structure in the prehistoric site of Taosi Culture from around 2400 BCE. On-spot observations and preliminary analyses suggest this site could be the remains of the earliest astronomical observatory in ancient China. The semi-circular wall has 12 slits in it. These slits, in combination with the central observation post and the remote mountains on the eastern horizon, formed a system of alignments that presumably was used for determining the seasons by observing sunrises (Wu *et al.* 2009). the Taosi Culture is closely associated with Emperor Yao mentioned above. The place is

historically known as Capital of Yao. Therefore, this discovery provides strong evidence for what was recorded in the *Book of Documents* about Emperor Yao's astronomical mission.

Rulers from the Shang dynasty (17th–11th century BCE) were much indulged in divination. Whatever decisions they made on state affairs, they did it by asking about the will of Heaven or ancestors through divination. Astronomical observation was one of the means of divination. In oracle-bone inscriptions of divination, we can find a lot of entries on celestial phenomena: sunrise and sunset, solar and lunar eclipses, sunspots, stars, planets, novae and comets, etc. These astronomical observations constituted part of the worship of Heaven. For example, towards the Sun, we can find more than ten forms of sacrificing. That means the sun held a high position in the mind of the Shang people. It also explains why the Sun was carefully observed. Among many methods of divination, the astronomical one came to be seen as more predictable and reliable than others. No wonder we find so many astronomical records in the oracle-bone divination texts. It shows that from the shamanistic religion of heaven-worshiping emerged the art of celestial observations. Astronomy provided an effective means of communicating with Heaven.

From worship of Heaven the Zhou people derived the concept of *Mandate of Heaven*. Heaven was the highest, the most powerful, and the most benevolent god. It gave blessings only to those were virtuous. The ruler received the *Mandate of Heaven* because he deserved it. Heaven, therefore, determined the succession of the dynasties. The question was how to determine the *Mandate of Heaven*. Divination and sacrifice certainly remained the paths to Heaven. From the 5th century BCE on, however, the Chinese developed a more or less naturalistic approach to the problem of mandate of Heaven. It was based on the concepts of *yin*, *yang* and five phases. Zou Yan from the third century BCE put forward a theory of *cycle of five phases* (*wu de zhong shi*) to assign the mandate of heaven. His idea presupposes a dynamic cycle of water, earth, wood, metal and fire which corresponds to cycles of human history. Each phase wins an *ascendancy* over its predecessor. When the Qin state wiped out the other states and replaced the Zhou dynasty, its ruler took up water as its new cosmic dispensation according to the theory of the *cycle of five phases*. In the meantime, much progress was made in astronomy during the period. Based on the discovery of the *rule cycle* –19 years contain 235 lunations– the Quarter Day system for calendar making was established. The knowledge about the planetary motions became more sophisticated than before. The system of the twenty-eight lunar lodges was formed to provide the necessary reference points in the sky for measuring the movements of celestial bodies. People were more confident than ever in astronomical observations and predictions. Mencius claimed: “*High as the sky, far away as the stars, if we study the reasons behind them, we can easily determine the winter solstice of one thousand years.*” (Yang 1960)

This confidence in predicting celestial movements brought about a new explanation of the mandate of Heaven. The mandate of Heaven was in fact the *Way of Heaven*. To respect Heaven was to act in accordance with the *Way of Heaven*. The *Way of Heaven* was most obviously exemplified in the sequence of the seasons which were given in the astronomical calendar. So long as the seasons were followed, the society would be orderly and harmonious. This idea of seasonality was expressively the main theme of Master Lü's *Spring and Autumn Annals* compiled under leadership of Lü Buwei, the prime minister of the First Emperor of the Qin. The book was meant to provide a comprehensive principle for the governance of the state. The main point was to follow the *monthly ordinances* of Heaven that could be determined through astronomical observations. For example, the book says “*in the first month of spring, the Sun is located in Encampment. At dusk*

the constellation Triad culminates, and at dawn the constellation Tail culminates". As the celestial position was determined, so was everything else: from weather to phenology, from harmonics to calendrics, from animals to deities, from rituals to sacrifices, etc. What the Son of Heaven was expected to do was to perform specified rituals and ceremonies at predetermined time and place. In this way he was ruling in accordance with the *Mandate of Heaven*. What his subjects were expected to do was just to follow the example of the emperor in conducting their productive and social and religious activities. This was the way to attain peace and order in the empire. Violation of the monthly ordinances would cause flood, epidemics, and all kinds of calamities (Chen 1984).

The idea of monthly ordinances based on astronomy was the rationalisation of the religion of heaven worshiping and the shamanism. Its ultimate purpose was to establish the legitimacy of ruling. In such a process astronomy played a very important rôle. If the shamanistic mediation between Heaven and man was the key to power, then astronomy provided one of the most important technical means to realise such mediation – so important that it came to replace magic to become the major means of connecting Heaven and Man.

3. Astronomical reform and state politics

Ancient Chinese astronomy consisted of two major aspects: *li* or *lifa* and *tianwen*. The word *li* is often translated as “calendar”, but a Chinese *li* was in fact a mathematical system for computing and predicting celestial phenomena, such as solar and lunar eclipses. Technically speaking, if an astronomical system was used for a long time period, its discrepancies would accumulate to an extent that it would fail to predict some important celestial phenomena, the solar eclipses for instance. Then a change was expected.

But, since the astronomical system symbolized the *Mandate of Heaven*, its change implied political change. Sima Qian, the Grand Astrologer serving Emperor Wu of the Former Han around 100 BCE, claimed that, “when the receiver of the *Mandate of Heaven* comes from a different family, he must carefully consider the beginnings of things; he must adopt a different civil calendar, change the colors of ceremonial costumes, and examine the epochs of his computational system. This is to comply with the Will of Heaven” (Sima 1985). So the change of the astronomical system was not only a technical matter, but also a political one. I will illustrate this by the astronomical reform of the Former Han in the first century BCE, known as the *Great Inception* reform (see Cullen 1993, for a detailed study of the political and religious aspects of this astronomical reform).

Now according to the theory of *cycle of five phases*, the Han dynasty should have earth as its cosmic dispensation to replace water of the Qin dynasty. It should have its own astronomical system to demonstrate this ascendancy of power. But in the beginning of the new dynasty, the Han ruler just took over what the Qin had of the astronomical system. This situation became unacceptable as people realised it was not in accordance with the change of *Mandate of Heaven*. An official of younger generation, Jia Yi (201–168 BCE), was among the first to propose an astronomical reform. He said: “It has been more than twenty years since the founding of the Han. Now that all under heaven is in peace and harmony, it is high time to reform the calendar, to change the color of ceremonial costumes, to rectify laws, to establish official ranks, and to set up rituals and music”. Obviously it was a proposal not simply for changing the calendar, but also for major political reform, which would certainly changed the status quo enjoyed by those who had served the state in its founding. It was on this account that the old generation of officials strongly objected his proposal. They denounced him as “being inexperienced, imprudent,

and presumptive, would only disrupt the established order". The emperor had to reject his proposal.

In the years that followed, many proposed to reform the astronomical system, but each time the proposal failed to pass because of various unfavorable political events. When the young and ambitious Emperor Wu came to the throne, he was enthusiastic about establishing the cosmic order for the Han. Responding to this his advisors proposed to change the calendar once again. But this time they met with unexpected objection from Empress Dowager Dou, who as a regent to the young emperor was more interested in the policy of non-action than in the theories about cosmic dispensation by scholars. And this time she dealt heavy-handedly: those who made the proposal were put in jail and finally committed suicide. The proposal for astronomical reform was once again tabled.

It was only after 135 BCE when Empress Dowager Dou died that the issue of cosmic power was raised again. After many years of preparation, in the year 110 BCE, Emperor Wu at last performed the feng sacrificial ceremony at Mount Tai and the shan ceremony to Mother Earth. These were two most prestigious ceremonies that only really great and virtuous rulers were entitled to performing them. They loudly demonstrated that the Han had received a new cosmic power to rule. A grand new era began. In 104 BCE the Court Gentlemen Gongsun Qing and Hu Shui, and the Grand Scriber Sima Qian submitted a proposal for calendar reform (Gu & Zhao 1962). The proposal was promptly accepted by Emperor Wu. Many officials and astronomers were called to carry out the reform.

They determined cardinal directions, set up instruments and water clock, and measured the coordinates of the Twenty-eight lunar lodges. They further measured and determined the Winter solstice, positions of the Sun and the Moon, and the Moon phases. Based on these initial observations, they determined the epoch for the calendar being the first day of the eleventh month of the seventh year of Yuanfeng (103 BCE), when it was exactly the moment of Winter solstice, the first day of the Hexadecimal cycle, and the New Moon (Gu & Zhao 1962). This was an ideal moment for the epoch of the calendar.

The making of calendar was more than the determination of the epoch; it involved more mathematical computations and celestial observations. To accomplish this, a nation-wide search for talented and competent scholars was made. More than twenty scholars from all over the country were recruited to the task, including scholars who had already had official ranks and scholars of common origin. Among them Dang Du, Luoxia Hong, and Deng Ping stood out as remarkable. Tang Du was a technical master. He divided and organised constellations in the sky. Sima Qian claimed that he followed Tang Du's system when he wrote his *Monograph on Constellations* (*Tianguan shu*). Luoxia Hong was the one who was said to have invented the armillary sphere to measure the positions of stars. He at least measured the positions of the Twenty-eight lunar lodges, because they served as the basic coordinate system for astronomical measurements and calendrical computations. Deng Ping, whose official title was *Calendar Advisor* (*Zhi li*), was responsible for the actual compilation of the mathematical system. Finally the new astronomical system was made. It was named the *Grand Inception* system to symbolise the beginning of a new era.

The *Grand Inception* astronomical reform indeed solved the technical problem of large discrepancies in predictions by the old Zhuanxu system took over from the Qin. Most importantly, it solved the problem about the legitimacy of the Han rule. It was simply unacceptable that a triumphant new dynasty should not have its own astronomical system to prove its *Mandate of Heaven*. The change of the astronomical system was a matter of state importance, so the activity itself had political implications. On the one hand, the Han did not immediately change the astronomical system because it adopted sort of *laissez-faire* policy in governing the state that had been newly founded. On the

other hand, any political reform that was implied in astronomical reform would compromise the interest of senior officials. That is why senior officials of the first generation always objected the reform. When Empress Dowager Dou died, the last stronghold of the first generation finally disappeared. Now Emperor Wu could carry out his own political agenda. Up to the middle of his reign, the Han was strong in military and expanded in territory. It was time for him to perform all kinds of religious ceremonies to demonstrate his mandate of Heaven. The astronomical reform was part of his undertaking. It solved the problem of why the Han rulers were authorised with power; the mandate was from the heaven, and it was determined by the cosmic order. The calendar was a symbol of the mandate of heaven; it was a part of the ritual paraphernalia of the ruling dynasty.

4. Astrology and politics

Portent astrology constituted the other major aspect of ancient Chinese astronomy. The Chinese used the term *tianwen* to indicate what we nowadays would call astrology. *Tianwen* literally means *patterns in the sky*. It studied patterns in the sky—constellations and all kinds of celestial phenomena—and interpreted them in connection with society. Chinese astrology was essentially portent astrology (Nakayama 1969). Celestial phenomena (and some meteorological phenomena which ancient people could not distinguish) were taken as portents or omens to reveal the will of Heaven and to foretell the welfare of the state. Chinese astrology was mainly concerned with extraordinary or abnormal celestial events that could not be predicted or explained with established systems and accepted knowledge. Calendrics revealed the order, regularity, and cyclic rhythms of the universe, with the ultimate goal that all celestial phenomena could be computed and predicted. This was of course impossible, thus what could not be predicted was naturally left to the realm of astrology. But “abnormal” phenomena can only be said to be so with regard to “normal” phenomena. So the development of astrology could never be independent of the development of calendrical astronomy. Every solution to a problem of astronomical prediction meant removal of one or more sources of portents. For instance, the retrograde motions of planets had been regarded as abnormal and thus had astrological implications before the Han. But in the Han time, astronomers came to realise that these retrograde motions were normal movements of the planets after all, and they could be predicted with astronomical ephemerides, so Sima Qian suggested in his *Tianguan shu* that this phenomenon be removed from astrological considerations.

Chinese astrology was mainly concerned with state affairs, such as war, famine, epidemics, flood, drought, and court politics. According to the theory of interaction between heaven and man proposed by Dong Zhongshu of the Former Han, astrology became an important part of political discourse on disastrous occurrences. Dong Zhongshu put forward the theory like this: “*The interaction between Heaven and Man is awesome. If the ruler governs the country inappropriately, heaven will issue disastrous events to warn him. If he does not amend his behavior, heaven will again issue strange events to terrify him. If he still does not change his way, calamity will come.*” (Gu & Zhao 1962). This theory of ‘*heavenly warning*’ put some constraint on the ruler’s behaviour. The ruler must govern the state in a moral and benevolent way. Otherwise heaven would use disastrous events to warn him. Abnormal celestial events were considered as such disasters. For instance, a solar eclipse was considered as a serious warning to the emperor. When it occurred, the emperor must show his awe towards heaven by *shunning from the main hall, reducing the courses of imperial dinner, and cancelling court meeting*. Solar and lunar eclipses, comets, meteors, “guest stars”, and planetary conjunctions, all

could count as such “disastrous events”. Portent astrology thus acquired its political significance.

In order to interpret the meaning of celestial events in terms of their relevance to affairs in human society, there must be a correlation framework in which celestial events were to be related to human affairs. This was done in Chinese astrology through the configuration of stars. If we look at the star names in the Chinese sky, we see an entire culture. The star names include royal court and clan, imperial officialdom and administration, palaces and temples, tombs and shrines, shops and markets, farmers and fields, armies and weapons, hunting and harvesting, traffic and transportation, ritual and ceremonies, philosophical and religious concepts, myths and legends, states and provinces. Almost all aspects of the imperial society were reflected in the sky. All these things are projected with order and harmony. The royal family and imperial officials are put in the North polar area, which is the most dignified place in the sky, while peasants, garrison troops are put in the far southern area, very low above the horizon. Constellations are organised into groups representing pictures of daily and social life, associated with each other in the sequence of the seasons. For instance, in the autumn sky one sees harvesting and hunting in the winter sky (Sun & Kistemaker 1997).

The Chinese sky was a counterpart to the Chinese imperial society. This system of correspondence became a basic mode of astrological predictions. A star or constellation, with its name, shape and location, presented a certain *xiang* (correspondence, symbol or counterpart) in the sky. The astrological meaning of the star or constellation was determined by that *xiang*. For instance, when the *Tianguan shu* says, “*Beidou is the chariot of the emperor*”, it means that the constellation *Beidou* symbolises the chariot of the emperor, and its moving around the center symbolizes the control of the empire by the emperor. Thus in astrology *Beidou* is always connected to the ruling of the emperor and to the central court and government; any abnormal happenings in the *Beidou*—change of brightness or color of its stars, comets or meteors entering into it, supernovae appearing inside it, etc—will definitely have astrological applications related to the emperor or the central court and government. Astrological predictions were made easy and straightforward using the *xiang* system of stars. This mode of stellar astrology lay at the foundation of Chinese astrology. The Chinese sky was in itself an astrological system.

The Chinese constellations set up a backdrop for interpreting the astrological meanings of all other celestial events. Each constellation had its *corresponding subject*. A celestial event happened in a particular constellation was interpreted in a way that combined the character of the celestial event with the corresponding subject of the constellation. For example, Mars is characterized as fighting. If Mars entered the constellation *Heart* (Scorpion) which corresponds to the Imperial Court, then this event foretells very bad things for the emperor. The astrological prognostication was thus stipulated as in a code of law. So the Chinese astrology was a type of judicial astrology: the warning from heaven was determined by a set of rules. A comprehensive astrological system must be able to interpret all celestial events. Astrological treatises thus provided a huge number of protases in the form of “*if so and so happened, it means ...*”. Many mentioned in the protases were imaginary events that could never happen at all. Because of the political relevance of portent astrology, the Chinese were on constant lookout for abnormal celestial phenomena. This explains why the Chinese have diligently watched the sky and have maintained detailed records of all kinds of celestial phenomena.

Portent astrology as one form of reading *heavenly warnings* played an important rôle in state politics. In many cases, the strange phenomena recorded were not meant to forecast future events; rather, they were seen as responses to past events. This particular function of omens was rooted in the *Mandate of Heaven* theory. Heaven did not cease

to intervene in human political affairs after providing the founder of a dynasty with the tablets of mandate. It responded to the everyday acts of all rulers through omens. Heaven sent down auspicious omens to express its confirmation of a just ruler's mandate; evil portents appeared in response to ruler's misbehaviour. To maintain support for his own authority, the emperor was required to modify his behaviour and policies accordingly.

In the first place, the appearance of abnormal celestial phenomena was often good excuse for court officials to criticize the emperor on current policies. Without such heavenly excuse, critics might be seen as offence to the emperor. This also limited the emperor's power to some extent. No matter how powerful the emperor was, he must stand in awe of heaven. When some major celestial events such as solar eclipses occurred, the emperor would issue edicts calling for perusing and criticising his governing behaviour. During the Han, Confucian scholars increasingly used omens to express their political ideas and criticisms (Powers 1983).

Secondly, abnormal celestial events were also exploited by officials in partisan politics in imperial China. One well known case is about Wang Anshi's *New Policies* reform in the 11th century China. As Prime Minister Wang started an unprecedented comprehensive social and economic reform. Conservatives opposed fiercely the reform. But since Wang had the support of the Emperor, they could not stop him. But the appearance of a comet tipped the balance of power. Conservatives claimed such disastrous events were caused by Wang's new policies. They eventually persuaded the Emperor to dismiss Wang from his office (Sun 2004).

5. Conclusions

Like in other ancient civilisations, astronomy played an important rôle in Chinese civilisation. The ancient Chinese civilisation was largely based on an agricultural society. The determination of the season was essential for agriculture. To complete successfully the cycle of production, one must follow the cyclic change of the season that was determined by observing celestial movements. This obvious connection between the heavens and humans is not a trivial one. Based on this, the Chinese cultures developed a cosmological understanding that emphasised the correlation and interaction between heaven and humans, and that had foremost implications in the Chinese religion and statecraft. Since the very beginning of Chinese civilisation, the Chinese had been worshippers of Heaven, or the Supreme High (*Shang Di*). This worshipping of Heaven was inextricably connected with astronomy. To interpret the will of Heaven, it involved the observation of many kinds of celestial phenomena, as, for instance, shown in oracle bone inscriptions from the 13th century. The place to worship Heaven was likely also the place to observe the sky. The ruler considered himself *Son of Heaven* who received his mandate from Heaven to govern the people. This mandate of heaven was symbolised by the astronomical calendar that told people the seasons. The production and distribution of the calendar therefore became the top priority for the ruler. It was also an imperial prerogative to be guarded jealously. To change the calendar would indicate the change of the mandate of heaven. Therefore the astronomical calendar acquired political significance. The making of the calendar and the changing of it were frequently occasions of political controversy.

Chinese Astrology was basically portent astrology based on the theory of the correlation and interaction between Heaven and man. It was judicial astrology that was mainly concerned with the welfare of the state. Abnormal astronomical phenomena being considered as omens that were warnings to rulers in their governance of the state. Astrology thus played a very important rôle in politics and religion in ancient China.

References

- Chen, Q. (ed) 1984, *Lü shi chun jiu jiao she, Lü shi chun jiu (Master Lü's Spring and Autumn Annals), by Lü Buwei, ca. 239 BCE* (Shanghai: Xuelin chubanshe)
- Cullen, C. 1993, *Journal for the History of Astronomy*, 24, 185
- Gu, B. & Zhao, B. (eds) 1962, *Han Shu (History of the Former Han Dynasty)* (Beijing: Zhonghua Shuju)
- Ho, P. Y. 1997, in *Encyclopaedia of the History of Science, Technology, and Medicine in Non-Western Cultures*, H. Selin (ed) (Dordrecht: Kluwer). p. 108
- Liu, B. 2007, *Shen wu de shi jie: Liangzhu wen hua zong lun (The World of Shamans: A Outline of the Liangzhu Culture)* (Hangzhou: Zhejiang sheying chubanshe)
- Nakayama, S. 1969, *History of Japanese Astronomy with Chinese Background and Western Impact* (Cambridge: Harvard University Press)
- Needham, J. 1959, *Science and Civilisation in China*, Volume III (Cambridge: Cambridge University Press)
- Powers, M. 1983, *Bulletin of the Museum of Far Eastern Antiquities*, 55, 1
- Sima, Q. 1985, *Shi ji [Records of the Grand Scribe]*, completed ca 90 BCE, Rev. ed. 10 vols. (Beijing: Zhonghua shuju)
- Sun X. 2004, *Ziran Kezueshi Yanjiu (Studies in the History of Natural Science)*, 23, 218
- Sun, X. & Kistemaker, J. 1997, *The Chinese Sky during the Han - Constellating Stars and Society* (Leiden: Brill)
- Yang, B. 1960, *Menzi (Mencius) yizhu*, Annotated and translated into modern Chinese (Beijing: Zhonghua shuju)
- Wu J., Chen M., & Liu C. 2009, *Science in China, Series G: Physics, Mechanics and Astronomy*, 52, 151