2.4 THE CHARACTERISTICS OF ANCIENT CHINA'S ASTRONOMY

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What are the characteristics of ancient China's astronomy? Many scholars have discussed the problem. In 1939 Herbert Chatley summed up fifteen points. Joseph Needham(1959) in his great work *Science and civilisation in China* concentrated it into seven points.

1. the elaboration of a polar and equatorial system strikingly different from that of the Hellenistic peoples;

2. the early conception of an infinite universe, with the stars as bodies floating in empty space;

3. the development of quantitative positional astronomy and star catalogues two centuries before any other civilisation of which comparable works have come down to us;

4. the use in these catalogues of equatorial coordinates, and a faithfulness to them extending over two millennia;

5. the elaboration, in steadily increasing complexity, of astronomical instruments, culminating in the 13th century invention of the equatorial mounting, as an 'adapted torquetum' or 'dissected' armillary sphere;

6. the invention of the clock drive for that forerunner of the telescope, the sighting tube, and a number of ingenious mechanical devices ancillary to astronomical instruments;

7. the maintenance, for longer continuous periods than any other civilisation, of accurate records of celestial phenomena, such as eclipses, comets, Sunspots, etc.

Needham also pointed out that the most obvious absences from such a list are just those elements in which occidental astronomy was strongest: the Greek geometrical formulations of the motions of the celestial bodies, the Arabic use of geometry in stereographic projections, and the physical astronomy of the Renaissance.

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Liu Jinyi (1984) also put forward ten points which are similar to those of Herbert Chatley. Their viewpoints, I think, describe its contributions rather than characteristics. As regards the fundamental characteristics, they were not clarified. Zhu Kezhen (1951) considered that there were two fundamental characteristics, i.e. practical application and protracted nature; but he did not mention it in detail. I suppose the former is more important than the latter and shall discuss it here.

At the present time astronomy is a pure science and belongs to fundamental sciences, but the early period of a science in its development is always different from the late period. Thomas S. Kuhn (1979) pointed out that "Early in the development of a new field, social needs and values are a major determinant of the problems on which its practitioners concentrate. Also during this period, the concepts they deploy in solving problems are extensively conditioned by contemporary common sense, by a prevailing philosophical tradition, or by the most prestigious contemporary sciences." In China, astronomy originated in the need of agriculture and astrology, and due to the influence of Chinese social conditions and traditional culture, developed in a way quite different from that of Greek astronomy. From the school of Pythagoras (C 582-500 B.C.), Greek astronomy intended to set up a model of the universe, while Plato (427-347 B.C.) further saw that any philosophy with a claim to generality must include a theory as to the nature of our universe. But in so doing, just as S.A.Mason (1953) pointed out, he did not wish to stimulate the observation of the heavens; on the contrary, he desired only to make astronomy a branch of mathematics. This ideological line determined the rationalism of European astronomy; though later astronomers took to the observation of the heavens to obtain data for calculation, test and improvement of their models of the universe.

On the contrary, natural philosophy in China did not develop to the full and occupied no distinguished position (cf. Ye Xiaoqing, 1984). Chinese sages only wanted astronomers "to observe the heavens so as to investigate the change of human affairs on the earth" (The Classic of Changes, *Yi Jing*) as well as "to observe the Sun, Moon and stars in order to issue the official calendar" (the Yao Canon of the *Shu Jing* Historical Classic). This ideological line determined the pragmatism of Chinese astronomy.

On the other hand, since the calendar reform directed by Julius Caesar in the middle of the first century B.C. the calendar used in Europe is a solar one, and which developed into the Gregorian calendar, and only requires the accuracy of tropical year in order to coordinate the relation between the days and the months, regardless of the motion of the Moon and the planets, so the calendar making occupies a very small position in the western astronomy. In contrast with that, as far back as the 14th century B.C. China had an embryonic form of a lunisolar calendar, and from the second century B.C. Chinese calendar contained the fundamental contents of modern astronomical almanac, including the calculation and observation of the positions of the Sun, Moon, planets and stars and of solar and lunar eclipses, so Chinese astronomy developed by the way of calendar making and had a character of applied science.

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The differences of Chinese lunisolar calendar from that of Babylon and Greece are (1) to take "shuo" (the moment when the Sun and the Moon are at the same longitude) as the beginning of a month; (2) to think of the winter solstice point as starting one for measurement of solar apparent position as well as star positions; (3) to fix the moment of the Sun at the winter solstice point in the eleventh month, and to take this moment as the beginning of a year, and from which to divide a tropical year into 24 periods (12 "jie" and 12 "qi", solar terms). Of these 20 names are connected with season, air temperature or precipitation, such as "lichun" (the beginning of spring), "dashu" (great heat), "xiaoxue" (slight snow). They directly show the change of seasons, and make agricultural things very convenient. The system so far helps farmers to know what kind of weather to expect in each period.

The 24 solar terms are directly determined by the apparent position of the Sun and belong to the category of the solar calendar. For coordinating the relation between them and the synodic months it is necessary to arrange the intercalary month ("run"), therefore qi (12 solar terms), shuo and run make up the three elements of Chinese calendar, around which Chinese astronomy developed. The solar terms can be measured by Gnomon, because the solar shadow of gnomon is longest at winter solstice and shortest at summer solstice. At the moment when the Sun and the Moon have the same longitude, the Moon cannot be seen. Only when a solar eclipse takes place,it can be proved that the Sun and the Moon have same longitude and same latitude, so observation and calculation of eclipses became an inseparable part of Chinese calendar-making . On the one hand, for raising the accuracy of prediction of the solar terms, the beginning of a month, the intercalary month and eclipses, it was necessary to improve the calculation method; on the other hand, for raising the precision of their observation, new instruments had to be made and new observational methods had to be invented. And both sides complement each other. According to study by Chen Meidong (1983), the evolution of Chinese calendar can be shown in Table 1.

TABLE 1

Error of / Time	qi	shuo	eclipse	planetary position
B.C.206-A.D.220	3-2 days	1 day	1 day	8^0
220-589	2-1/5 day		15-4ke*	$8-4^0$
581-1127	20-10ke		4-2ke	$4-2^0$
1127-1368	10-1ke		2-0.5ke	$2-0.5^0$

* 1ke = 14^m4

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Calendar making in China not only served agricultural production, but also formed a part of the superstructure. To promulgate the calendar was a symbol of dominion and only the court should have it in hand. To use the calendar promulgated by an emperor meant recognition of his political power. In the calendrical Chapter of *Shiji* (Historical Records) Sima Qian said: "When a new dynasty was established, the emperor must change his surname, alter the calendar, transform the colour of ceremonial dress and calculate the position of vigour in order to undertake the mandate of heaven". After the emperors You and Li, the Zhou dynasty declined and the emperor did not promulgate the shuo, so the calendar of the Lu dukedom, which used the shuo promulgated by the Zhou emperor, was not corrected either. In the sixth year of Wengong of the Lu dukedom (621 B.C.) the Duke did not promulgate the shuo of the intercalary month. About this matter the classics *Zuozhuan* (Master Zuoqiu's Enlargement of the *Spring and Autumn Annals*) wrote critical remarks as follows:

"Not to inaugurate solemnly the first day of the intercalary month was an infringement of the proper rule. The intercalary month is intended to adjust the seasons. The observance of the seasons is necessary for the performance of the labours of the year. It is those labours by which provision is made for the necessities of life. Herein then lies caring for the lives of the people. Not to inaugurate properly the intercalary month was to set aside the regulation of the seasons; --- what government of the people could there be in such a case?" (English translation by Legge 1872).

By the end of the period of Spring and Autumn, Zigong, a student of Confucius, wanted to cancel the system of offering a sheep for promulgating the shuo. Confucius opposed it and said "You love the sheep but I love the rite". Right up to the seventeenth century, when the Qing Court appointed Adam Schall (a German Jesuit, 1591-1666) to calculate the official ephemeris, because of the five Chinese characters "Yi Xi Yang Xin Fa" (Based on the New Western Method) printed on the front cover of the ephemeris, Yang Guangxian, a scholar from Anhui province, accused him of usurping state power and of stealing secret information under the cover of compiling the calendar, thus causing consternation in the Qing Court. Consequently, on the 1st day of the 4th month of 1655, the ministries of Rites and Punishments drew up a proposal, according to which Adam Schall should be put to death by dismemberment. On the next day while the Regents were holding a meeting to ratify the proposal, they had to flee in alarm from a sudden earthquake. Thereafter earth quakes continued from time to time and a comet appeared in the sky. According to traditional Chinese astrology, the Qing court regarded these phenomena as manifestations of the anger and discontent of Heaven, and offenders must have their penalties reduced. Hence Adam Schall and his assistant Ferdinand Verbiest (1623-1688) were released from prison and then took charge the Royal Bureau of Astronomy again (cf. Xi Zezong 1982).

Similar to the case of Babylonia, Chinese astrology belongs to the judicial or portent system (cf. Nakayama S. 1966), which by the observa-

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tion of celestial phenomena (especialy abnormal) divines important events, such as victory or defeat in a war, the rise and fall of a nation, success or failure of the year's crop, and the actions of emperor, empress, concubines, princes, feudal lords and court officials. Here astronomy played a check on the ruler, and astronomers were regarded as interpreters of celestial signs (cf. Eberhard D. 1957). For the former case, we can take an example from the astronomical Chapter of *Shiji*: "When Mercury appears in company with Venus to the east, and when they are both red and shoot forth rays, then foreign kingdoms will be vanquished and the soldiers of China will be victorious. When they are to the west, it is favourable to a foreign country". For the latter, we can take another example from the "Five Elements" Chapter of *Hanshu* (History of the Han Dynasty): On the First day (Wushen) of the 12th month of the third year of the Jianshi era of the reign of Emperor Cheng (January 5, 29 B.C.) a solar eclipse took place in the sky and in that night an earthquake occurred in the Weiyang palace. Astrologer Gu Yong reported to the Emperor: "Solar eclipse at 9^0 of Wunu (the 10th lunar lodge) means that something will be wrong with the empress, while an earthquake within the screen wall lays the blame on a noble concubine. Now both of them take place at the same time, portending that Yin will make attack upon Yang. I think, the empress and the concubine will together do the prince harm." When the Emperor asked another astrologer Du Qin, Du also said: "The solar eclipse happened at Wei (13^h-15^h) on Wu Shen day. Wu and Wei represent earth (one of the Five Elements) which corresponds to the central region. Combining it with the fact that the earthquake occurred within the palace, I suppose the close concubines will do harm each other so as to contend for the love of the Emperor, and when affairs go wrong on Earth, abnormal phenomena appear in the Heaven. If the emperor undertakes moral conduct, the disaster can be eliminated by itself. If he neglects the warning of the Heaven and does not care it, the disaster will come".

The sayings of Gu and Du represent the difference between Chinese and Babylonian astrology in that the theoretical foundation of Chinese astrology is the Yin-yang theory, the Five Elements theory and the heaven mandate theory. The Yin-yang theory explains all the phenomena in the universe in terms of a fundamental dichotomy which corresponds to that between heaven and earth, male and female, and so on. The five elements theory was used to systematize the relations of things by placing them in the constellation of natural agents - wood, fire, earth, metal and water. The heaven mandate theory considers that the monarch is a man of transcendent virtue, whose title to the throne is bestowed by heaven, in other words, he is the agent of the natural order and he rules under its auspices. If, then, his conduct is contrary to the natural order, he is no longer qualified for the throne. In this respect, the royal astronomers were emperor's advisors, and celestial phenomena were matters of great concern to the throne, implying grave political consequences. For example, please read the proclamation of the Emperor Wen of the Han dynasty in 178 B.C. for a solar eclipse: "We have heard that when heaven gave birth to the common people, it established princes for them to take care of and govern them. When the lord of men is not virtuous

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and his dispositions in his government are not equable, Heaven then informs him by a calamitous visitation, in order to forewarn him that he is not governing rightly. Now on the last day of the eleventh month there was an eclipse of the Sun—a reproach visible in the sky—what visitation could be greater?...Below Us, we have not been able to govern well and nurture the multitude of beings; above Us, we have thereby affected the brilliance of the three luminaries (i.e., the Sun, the Moon, and the stars). This lack of virtue has been great indeed. Wherever this order arrives, let all think what are Our faults and errors together with the inadequacies of our knowledge and discernment. We beg that you will inform and tell Us of it and also present to Us those capable and good persons who are foursquare and upright and are able to speak frankly and unflinchingly admonish Us, so as to correct Our inadequacies. Let everyone be therefore diligent in his office and duties. Take care to lessen the amount of forced service and expense in order to benefit the people." (English translation by Dubs H.H. 1938). This is the beginning of a new system of selecting talented persons for government, which lasted many centuries.

Since celestial phenomena were so important to the state affairs, astronomical work was of course given much attention and became a part of government work. From about 2000 years B.C. an observatory was established. During the regime of Qin Shihuang (259-210 B.C.), the first emperor of China, there were over 300 persons engaged in astronomical observations in court. According to *Jiu Tang shu* (The Old History of Tang Dynasty), at that time (618-907 A.D.) as a bureau, the royal observatory worked under the direction of the Department for the Imperial Archives and Library and consisted of the following 4 parts:

1. calendar making: 63 persons
2. astronomical observations: 147 persons
3. time-keeping (managers of clepsydras): 90 persons
4. time-service(reporting time by bell and drum):200 persons

It is a characteristic of ancient Chinese astronomy that there were so many astronomical workers in a government and their heads had positions of such high rank. This characteristic was at first sight noted by the Jesuit Matteo Ricci of Italy (1552-1610), who used it to do missionary work. He never ceases saying that "astrology" was generally practised by the Chinese society of his time, and it would have been an error not to see in this somewhat inappropriate term all the social importance and philosophical elevation with which it was clothed in the Far East (Cf. Bernard,H., 1935). Matteo Ricci wrote on May 12, 1605 to a correspondent in Europe:

"I address to Your Reverence urgent prayers for a thing which I have for long requested and to which I have never received any reply: it is to send from Europe a Father or even a Brother who is a good astronomer. In China the king maintains, I believe, more than 200 people at great expense to calculate the ephemerides each year. If this astronomer were to come to China, after we had translated our table into Chinese, we

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would undertake the task of correcting the calendar, and, thanks to that, our reputation would go on increasing, our entry into China would be facilitated, our sojourn there would be more assured and we would enjoy great liberty". At the invitation of Matteo Ricci, missionaries who had a good command of astronomy arrived in China in 1620 and European astronomy began to be widely introduced into China.

In Europe national observatories were built only from the end of the seventeenth century. In the Islamic world no observatory existed for more than 30 years, and it always declined with the death of a king. Only in China did the royal observatory last thousands of years, in spite of the changes of dynasties.

Not only the royal observatory but also the astronomical records lasted thousands of years. The Chinese term "tian wen" is now used simply to mean "astronomy", but this is a decided shift in connotation; in classical writings it is ordinarily used in the sense of portent astrology. The major part of the Tianwenzhi (astronomical chapter) in the official histories is devoted to the observational records of celestial abnormal phenomena and their connection with political events. As a result, the 24 Histories preserve voluminous and detailed collection of such observations - a collection which has so far attracted the attention of scholars both in China and abroad, and some remarkable results have been achieved when it is related to modern astronomical problems such as the remnants of supernovae, solar activity and so on (cf. Xi Zezong, 1983).

Apart from the astronomical chapters in the 24 Histories, there are Lizhi (calendrical chapters) in which there is described how to compute the motion of the Sun, Moon and planets, how to predict eclipses and how to observe these phenomena and stellar positions.

In summary we can say, ancient Chinese astronomy mainly comprised two parts: calendar making and celestial phenomena observation, instrument making was in the service of these two tasks. These tasks were considered a part of political affairs, the royal observatory was one of government departments, and the heads of astronomical profession were royal advisors, men of high rank and position. They were not interested in pure science for science's sake, and they did not spend enough time in developing abstract laws. So the development of astronomy in China was closely connected with the feudal society and could not be expected to transform into modern astronomy.

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DISCUSSION

S.S.Lishk : Were angular distance of heavenly bodies measured in terms of earth distances 'Li' ?

Xi Zezong : No.

L.C.Jain : In Chinese calendrical calculations two words, Phing Chhao (floating difference) and Ting Chhao (fixed difference) were in use. Could you kindly comment on whether any other Asiatic nation made use of these words during the contemporary period or earlier periods ?

Xi Zezong : These were the developments of later period in China.

S.Nakayama : Does ten days difference make really a success or failure of crops ?

Xi Zezong : Difference of one unit value in astronomical system will lead it into crisis.

S.D.Sharma : Yuga of 60 year cycle has been used both in Indian and Chinese tradition. Could you kindly explain how the same was used in Chinese Calendar ?

Xi Zezong : I think that the two 60 year cycles have no common origin.

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