THE TREATMENT OF ECLIPSES IN EARLY CHINESE ASTRAL SCIENCES

BY

YUZHEN GUAN

A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN THE DEPARTMENT OF EGYPTOLOGY AND ASSYRIOLOGY AT BROWN UNIVERSITY

PROVIDENCE, RHODE ISLAND

MAY 2015

This dissertation by Yuzhen Guan is accepted in its present form

by the Department of Egyptology and Assyriology as satisfying the

dissertation requirement for the degree of Doctor of Philosophy

Date____________ ________________________________

John Steele, Advisor

Recommended to the Graduate Council

Date____________ ________________________________

Matthew Rutz, Reader

Date____________ ________________________________

Yunli Shi, Reader

Approved by the Graduate Council

Date____________ ________________________________

Peter Weber, Dean of the Graduate School

Curriculum Vitae

Yuzhen Guan was born on June 16th, 1984 in Zhengzhou, People's Republic of China. He received a Bachelor of Engineering degree in 2007 at Northwestern Polytechnical University, Xi'an, China. From 2007 – 2009, he studied history of science at Shanghai Jiao Tong University, Shanghai, China. From 2009 -2010, he was a visiting student in the Department of Egyptology and Ancient Western Asian Studies in Brown University, Providence, United States. In 2010, He was admitted as a Doctor student in History of Exact Science in the Department of Egyptology and Ancient Western Asian Studies, later the Department of Egyptology and Assriology, in Brown University.

Yuzhen Guan received the Zhao Zhu Mu Lan Graduate Student Scholarship from Shanghai Jiao Tong University in 2009. From 2009 -2015, Yuzhen Guan has following publications:

Yuzhen Guan, (2015). "Eclipse theory in the *Jing chu li*: Part I. The adoption of lunar velocity." *Archive for the History of Exact Sciences* 69: 103–123.

Yuzhen Guan, (2015). "Excavated Documents Dealing with Chinese Astronomy." *Handbook of Archaeoastronomy and Ethnoastronomy*. Ed: Ruggles, Clive. New York: Springer. pp. 2079-2084.

Yuzhen Guan, (2010). "A new Interpretation of Shen Kuo's *Ying Biao Yi*." *Archive for History of Exact Sciences* 64: 707-719.

Yuzhen Guan, (2009). "*Zuozhuan Rishi Guannian Yanjiu.*" (On the Concept of Solar Eclipse in *Zuo Zhuan*). *Ziran bianzhengfa tongxun* (Journal of Dialectics of Nature) 31: 53-57.

Yuzhen Guan, (2009). "*Zhongguo Kexueshi Zhongde Moni Shiyan Fangfa tanxi*." (A Study of the Simulated Test Method Used in the Research of the History of Science in China). *Shanghai jiaotong daxue xuebao* (Journal of Shanghai Jiao Tong University) 17: 42-48.

Acknowledgments

It has been sixth years since I first arrived in Providence. The life of a Ph.D. is about meeting deadlines, setting goals and trying to meet everyone's expectations, especially my own. It is challenging and enjoyable, and sometimes difficult. There are things I feel comfortable dealing with and there are things I struggled in. However, at this very moment, I would like to thank all who have supported me in these years. Without the support from all of you, I would not be here.

The first person I would like to thank is my advisor Professor John Steele. He not only set an example in training me to think and work like a historian of science, but also in acting as a good person. The invaluable guidance from him has already, and will keep inspiring me to move forward in my research career. I am also truly grateful to Professor Matthew Rutz and Professor Yunli Shi, who have put in many efforts as members of my dissertation committee. They both have shown great carefulness and insights in dealing with my rough drafts, and have made many useful suggestions. Thanks also go to the faculty, staff, and students in the Department of Egyptology and Assyriology, and many other places in Brown.

I would like to gratefully acknowledge the financial support from China Scholarship Council for my study as a Ph.D. student in the United States, as well as the scholarships from the Department of Egyptology and Assyriology and the Graduate School in Brown University. The discussion on the general eclipse theory and the lunar velocity theory in the *Jing chu li* in chapter 4 is based upon my 2015 article "Eclipse theory in the *Jing chu li*: Part I. The adoption of lunar velocity." *Archive for the History of Exact Sciences* 69: 103–123. An earlier version of the discussion of eclipse divination in the *Zuo zhuan* in chapter 2 has been published as Yuzhen Guan, (2009). "*Zuozhuan Rishi Guannian Yanjiu.*" (On the Concept of Solar Eclipse in *Zuo Zhuan*). *Ziran bianzhengfa tongxun* (Journal of Dialectics of Nature) 31: 53-57. I would like to express my gratitude to all journals, publishers and editors who has contributed in these publications.

My final gratitude is to my family. I would like to thank the unconditional love and support from my parents. I know how difficult it is to watch me and keep caring me while I am on the other side of the earth. I am greatful to the love of my life, Wang Qin, who has always been a cheerleader of me and has shown great consideration and understanding. Without the love and support from all of you, there is no chance that this dissertation be presented at this moment.

Table of Contents

List of Tables

List of Illustrations

Chapter One Introduction

Eclipses are maybe the most astonishing astronomical phenomena everyone can see with their naked eyes. The change of the appearance of a heavenly body or variations in its movements held specific meanings in Chinese astrology. These meanings often related to politics. Even in the very first account of an eclipse observation in China, the event was regarded as ominous and was said to have caused a war between the central ruler and the local dukes. By the early imperial period, eclipses had come to hold great astrological significance. Unexpected or unpredicted astronomical phenomena were seen as signals sent by heaven to the governors of the country. Eclipses, especially solar eclipses, were recognized as a warning to the emperor that his governance was not satisfactory. Not surprisingly, therefore, astronomers were asked to pay particular attention to the interpretation and prediction of eclipses. Eclipse theory is one of the most important and difficult issues early Chinese astronomers faced in their astronomical and astrological practices. The complexity of solar and lunar motions and other technical issues relating to the prediction of eclipses made them a crucial test of an astronomical system.

In this dissertation I aim to investigate place of eclipses in early Chinese astral sciences. In particular I explore the significance of eclipses within divination and the development of eclipse theory in early China. In addition, because eclipses were an important part of the mathematical astronomy of the calendrical systems, I also explore the debate surrounding the reform of calendrical systems and the place of eclipses within these debates.

1.1 Scope

This dissertation deals with astronomical and astrological themes in early China. The title of this dissertation reads the treatment of eclipses in early Chinese astral sciences. Two terms require noting. First, by astral sciences, I mean first theoretical astronomy, calendrical systems and observational records, and second celestial divination and astrology. Closely related to this are the practitioners of astral sciences. I believe consideration of these three together give us a more complete picture of early forms of the astral sciences in China as they relate to eclipses. Second, by early China, I combine the usual terms of early China and early imperial China together. Given that the development of mathematical astronomy and astrology were not exactly at the same pace, there is a small discrepancy between the time periods covered in my discussion of these two parts of astral science. My discussion of the eclipse records and divination stretches from the 8th century BC onwards, but for mathematical astronomy I am concerned mainly with the early imperial period, by which I refer mainly to the Qin 秦 (221–207 BC), Han 漢 (206 BC – AD 220), Three Kingdoms 三國 (AD 220–265), although the discussion on calendrical reforms also covers examples from the Jin 晉 (AD 265–420) and Song 宋 (AD 420–479). In particular, I use a third century calendrical system, the *Jing chu li* as a case study of eclipse theory and the political influence of eclipse observations. This system, the most significant system in my discussion of mathematical astronomy, also plays an important part in my discussion of calendrical reforms. Astronomically, this system marks a significant stage in the development of early Chinese mathematical astronomy, as stated already by Zhu Wenxin (1935).

1.2 Sources

The texts of most Chinese *li* ("calendrical system") are recorded in the treatises of temperament and calendar 律曆志 in the dynastic histories (see section 1.5.1 for a discussion of the meaning of *li*). This tradition begins in the earliest dynastic history, the *Shi ji* (史記, the Book of History, compiled by Sima Qian 司馬遷, ?145 BC – ?86 BC), and is followed in subsequent histories including the *Han shu* (漢書, the Book of the Han dynasty, compiled by Ban Gu 班固, AD 32– 92), the *Hou Han shu* (後漢書, the Book of the Eastern Han dynasty, compiled by Fan Ye 範曄, AD 398–455), the *San guo zhi* (三國志, the History of the Three Kingdoms period, compiled by Chen Shou 陳壽, AD 233–297) and the *Jin shu* (晉書, the Book of the Jin dynasty, compiled by Fang Xuanling 房玄齡, AD 579–648). The *Shi ji* contains an early form of a Chinese *li*, the *Li shu jia zi pian* 曆術甲子篇. Early calendrical systems discussed in this dissertation include the *San tong li* (Triple Concordance System, adopted in 104 BC) in the *Han shu*, the *Si fen li* (Quarter Remainder System 四分曆, adopted in AD 85) in the *Hou Han shu*, the *Qian xiang li* (Supernal Emblem System 乾象曆, adopted in AD 206) and the *Jing chu li* (Luminous Inception System 景初曆, adopted in AD 237) in the *Jin shu* and *Song shu*. These preserved works of calendrical astronomy preserve most of our evidence for early Chinese mathematical astronomy; nonofficial treatises such as the *Zhou bi suan jing* which deal with other aspects of mathematical astronomy, especially the mathematics of the gnomon, provide some additional information, but do not deal with eclipses (Cullen 1996). Although other *li* from the Western Han to the Jin are mentioned in the histories, the texts of these systems themselves are not preserved. For example, Han Yi 韓翊 constructed the *Huang chu li* 黃初曆 around the time of the *Qian xiang li* and *Jing chu li* but it was not officially adopted by any government kingdom and no text of the system is preserved.

The *Jin shu* and *Song shu* both recorded the *Jing chu li*, the calendrical system which I discuss extensively in this dissertation. Table 1.1 shows the differences in the text of the *Jing chu li* as found in these two sources. There are only minor differences between the texts from the *Jin shu* and the *Song shu*. The *Jin shu* provides a few more characters in its text than the *Song shu* did, including a statement of Yang Wei's official title at the beginning and a couple adverbial modifiers. But generally speaking, there are not too many differences. In my discussions of this system I have generally relied upon the *Zhong hua shu ju* edition of the *Jin shu*.

Unless specifically stated, all translations of classical texts presented in this dissertation and my own. There are primary texts which have been translated into English before, such as parts of the *Han shu* (Dubs 1938). However, in such cases I have only adopted translations made by

Jin shu	Gentleman of the Masters of Writing in the Wei Yang Wei stated in his memorial
晉書	魏尚書郎楊偉表曰
Song shu	Yang Wei stated in his memorial
宋書	楊偉表曰
Jin shu	even constructed the *Tai chu li*
晉書	更造《太初曆》
Song shu	constructed the *Tai chu li*
宋書	造《太初曆》
Jin shu	it has been always frequently reformed with no stop.
晉書	常改革不已
Song shu	it has been frequently reformed with no stop.
宋書	改革不已

Table 1.1 Differences in the preface to the *Jing chu li* found in the *Jin shu* and the *Song shu*.

historians of science rather than general historians of China because of difficulties in understanding the technical terminology found in scientific texts. It should also be noted the original text of the calendrical systems comes with no punctuation marks nor sections. They have been inserted by the editors of the *Zhong hua shu ju* editions. For the materials without previous studies, I have marked the texts and divided them into sections.

1.3 Previous scholarship

Many fields of the subject this dissertation have been touched upon by previous researchers. For details on Chinese astrological divination, see Pankenier (2013), Sun, Xiaochun (2009) and Loewe (1994). For studies on eclipse records, see Liu Ciyuan (2003), (2009), Xu, Yau & Stephenson (1989), Xu, Pankenier & Jiang (1995), Stephenson(1997) and Steele (2000). For translations of astrological treatises, see Ho Peng Yoke (1966) and Major (1993). On mathematical astronomy, for a general history of Chinese astronomy, see Chen Meidong (2003); for a history of calendrical astronomy, see Qu Anjing (1994a), (2005), (2008), Zhang Peiyu (2002), Martzloff (1997); for case studies on calendrical systems, see Sivin (2009), Cullen (2007), Morgan (2013), and Liu Hongtao (2003). Cullen also has a translation of the *San tong li*, the *Si fen li* and the *Qian xiang li* in the process of publication. This is only an extremely brief account of related scholarship, see detailed information of previous researches in the appropriate chapters.

1.4 Contents

This dissertation is arranged following both chronological and thematic order. Chronologically, it focuses on the development of the astral sciences from the late period of early China to the early medieval period. Chapter two and three focus on the late part of early China, from the *Chun qiu* ("Spring and Autumn") period to the end of Han. Chapters four and five focus on the early part of medieval china, roughly from the end of the Han to the Song in the Southern and Northern Dynasties. I refer the chronological definition on early China and early medieval China to the timeline recognized by the journals *Early China* and *Early Medieval China*. Thematically, chapter 2 focuses on the divination of eclipses, chapter 3 and 4 study the theoretical astronomy related to eclipses, and chapter 5 looks at the bigger picture including astronomers, politics and calendrical reforms.

Chapter 2–5 contain analyses built upon case studies of particular texts. In Chapter 2 I discuss solar eclipses record from the *Chun qiu* and the commentaries from the *Zuo zhuan*, as well as the Han eclipse divination and its impact on state politics. I first give a detailed examination on Chinese eclipse records in the pre-Qin period from primary sources, and second discuss the development of eclipse divination in that period. By comparing with earlier eclipse records, I will show why the *Chun qiu* eclipse records are the beginning of a long tradition of recording eclipses. The *Zuo zhuan* not only records the results of these divination attempts, but also explains the reason and theories astrologers used in great detail. By looking at the commentaries in the *Zho zhuan* I try to reconstruct the ways in which Pre-Qin astrologers interpreted eclipses. In the second part of chapter 2, which concerns eclipse divination during the Han, I expand my research on the astrological meaning of eclipses from the pre-Qin period to the Han in order to address questions such as: What and how many records do we have in the Han? Are these records reliable? How does the development of eclipse divination change in the Han? What examples of divination and predictions do we have in historical treatises? How do the developments in eclipse theories affect the divination of eclipses? Is eclipse theory the result of desire to make astronomical predictions or purpose to apply judicial astrology better in the state? By studying the examples of divination in the Han and comparing them with the Pre-Qin records, I have attempted to reveal the patterns early Chinese diviners used to make astrological predictions.

Chapter 3 focuses on eclipse theories in the Han calendrical systems. In particular, I discuss the development of eclipse theory in the different systems, by means of translating and commenting on the texts of the *San tong li* and the *Si fen li*. Theses earliest eclipse theories are also meaningful to show the original form of calendrical astronomy in China. I then compare the early theories with the methods in the *Qian xiang li*.

Chapter 4 presents a case study of the eclipse theories in the *Jing chu li*, in order to show the form of an eclipse theory in a fully developed calendrical system. This system is important for its innovations. For example, I show how Yang Wei combined lunar velocity theory with the traditional method of predicting eclipses using cycles in order to determine the time of the eclipse. He also developed methods of predicting the magnitude of the eclipse and the direction of impact of the shadow.

Chapter 5 is an exploration of the bigger picture of the complexity of cultural traditions and technical developments in early imperial China, with case studies on the *Huang chu* and *Yuan jia* debates over calendrical reform. The transition from the Han to the Jin dynasty led to dramatic changes in politics and daily life in China; this certainly effected the life and work of astronomers such as Liu Hong, Yang Wei and He Chengtian. When astronomers improved the official calendrical system, they made efforts, for example, a test of the accuracy of system, to convince the emperor to adopt their system as the official one. The debate between Liu Hong, Han Yu and Yang Wei on the adoption of a calendrical system and the test of the *Yuan jia li* are particularly interesting. I use excerpts from the *Hou han shu,* the *Jin shu* and *the Song shu*, to study how astronomy is practiced and how non-astronomical factors affect the adoption of a calendrical system. A calendrical system not only contains methods and data which are used in the reforms to make predictions, but also a preface to better illuminate its advantages. A translation and comments on the Preface of the *Jing chu li* is included in chapter 5.

1.5 Notes

1.5.1 The translation of Chinese *li*

All *li* have a similar structure. They always begin with a preface explaining why the system is built and how good it is. The second section is usually a list of constants used in the calculation. This is followed by a series of procedures to calculate astronomical phenomena, including, for example in the *Jing chu li*, solar theory, lunar theory, intercalation, eclipse theory and planetary theory. Earlier systems sometimes have fewer sections and simpler methods but their structure and, more importantly, the function of the systems are similar.

Translations and commentaries are seen everywhere in this dissertation. There is always the concern over how to recover the ancient thoughts from the writing. I believe what the ancient texts presented us are more than just what were written. The historical context could serve as aids in understanding the texts themselves.[1] On the question of translations, for example, many people have discussed the the meaning and translation of the Chinese character *li* 曆. In his article "Mathematical astronomy and the Chinese calendar", Sivin (2011) discussed the distinct meanings of the word *li* and explained why he uses "astronomical system" as the translation to the word *li*. The traditional translation "calendar" only represents the use of *li* as ephemerides in almanacs. However, other meanings include a system for predicting astronomical phenomena, a treatise on this system and a method of computing an ephemeris for the following year. In Sivin's view, simply using the word "calendar" as a translation of the Chinese *li* is partial and misleading. The difficulty in translating the Chinese word *li* lies in

[1] See Cullen (2005) and (2011a) for more discussions on the methods and principles in translating Chinese calendrical systems. Cullen translated sections of the *Si fen li* (he calls '*Han li*') in a series of Microsoft Excel spreadsheets. The excel file can be downloaded from http://www.nri.org.uk/lifa.html. He explained the reasons of translating with Microsoft Excel in Cullen(2005). His translations of full texts of the *San tong li*, the *Si fen li* and the *Qian xiang li* is in press.

finding one English word or term which corresponds to all these distinctive meanings. I therefore suggest using the word *li* as the English translation of Chinese *li*. This is similar to the use of the term *zij* directly in English as the translation of Islamic astronomical handbooks. Historians either straightforwardly call it *zij* in English context or use the word "table" as a representative. Similarly, I also call Chinese *li* "system" in short for "calendrical systems". I prefer "calendrical system" rather than "calendar" or "astronomical system" as the representative of the word *li* because "Calendrical system" is closer to the literal meaning of the Chinese word *li*. Both "Astronomical system" and "Calendrical system" are clear enough to indicate the complexity, function and the systematic structure of the Chinese *li* and show the most important similarity between Chinese, Islamic and western theoretical astronomy in that they all attempt to study and make predictions of significant astronomical phenomena. I agree that the official systems are all astronomical systems. However, there are other systems in China which are astronomical systems but not related to the calendar. For example, the system in the *Zhou bi suan jing* is an astronomical system, but it is not a calendrical system and cannot be used as an official calendar. The structure of the system in the *Zhou bi suan jing* is unlike other Chinese official *li*. I also use the original Chinese word *li* in the name of a system rather than attempting to translate it. For example, I use *Jing chu li* rather than *Jing chu* system. In this dissertation, I use calendar to refer to the Velocity Calendar.

1.5.2 Chronology

1	*jia zi*	甲子	21	*jia shen*	甲申	41	*jia chen*	甲辰
2	*yi chou*	乙丑	22	*yi you*	乙酉	42	*yi si*	乙巳
3	*bing yin*	丙寅	23	*bing xu*	丙戌	43	*bing wu*	丙午
4	*ding mao*	丁卯	24	*ding hai*	丁亥	44	*ding wei*	丁未
5	*wu chen*	戊辰	25	*wu zi*	戊子	45	*wu shen*	戊申
6	*ji si*	己巳	26	*ji chou*	己丑	46	*ji you*	己酉
7	*geng wu*	庚午	27	*geng yin*	庚寅	47	*geng xu*	庚戌
8	*xin wei*	辛未	28	*xin mao*	辛卯	48	*xin hai*	辛亥
9	*ren shen*	壬申	29	*ren chen*	壬辰	49	*ren zi*	壬子
10	*gui you*	癸酉	30	*gui si*	癸巳	50	*gui chou*	癸丑
11	*jia xu*	甲戌	31	*jia wu*	甲午	51	*jia yin*	甲寅
12	*yi hai*	乙亥	32	*yi wei*	乙未	52	*yi mao*	乙卯
13	*bing zi*	丙子	33	*bing shen*	丙申	53	*bing chen*	丙辰
14	*ding chou*	丁丑	34	*ding you*	丁酉	54	*ding si*	丁巳
15	*wu yin*	戊寅	35	*wu xu*	戊戌	55	*wu wu*	戊午
16	*ji mao*	己卯	36	*ji hai*	己亥	56	*ji wei*	己未
17	*geng chen*	庚辰	37	*geng zi*	庚子	57	*geng shen*	庚申
18	*xin si*	辛巳	38	*xin chou*	辛丑	58	*xin you*	辛酉
19	*ren wu*	壬午	39	*ren yin*	壬寅	59	*ren xu*	壬戌
20	*gui wei*	癸未	40	*gui mao*	癸卯	60	*gui hai*	癸亥

Table 1.2 the *ganzhi* cycle.

The *Ganzhi* system (干支 sometimes translated "Sexagenary Cycle") is a cycle with sixty terms used to mark year, month, day and hours. There are 12 *tiangan* (heavenly stems) and 12 *dizhi* (earthly branches). It has been used in China since the Zhou dynasty without being interrupted. [2]

Table 1.2 contains a listing of all 60 *ganzhi* terms. The 12 earthly branches were also used for directions: *zi* 子 represents north, *mao* 卯 represents west, *wu* 午 represents south, *you* 酉 represents west. The 12 earthly branches were also used to represent the twelve Double-Hours in a day.

1.5.3 Specific systems in Chinese astronomy

Here I briefly introduce the preliminaries related to Chinese mathematical astronomy. In chapter 3 and 4, I will discuss the detailed eclipse theory in the calendrical systems in early imperial China. However, the basic ideas these system used in calculating astronomical phenomena is by using cycles. It is to find periods of astronomical phenomena, construct cycles based on it and make predictions based on the time when last astronomical event occured. These cycles are periodic repetitions of celestial bodies, usually reflecting the mean motion of the sun, the moon and the planets. Here is a simple example showing the use of cycles, imagine there is a 12 year cycle for a planet. If we start in year 1, after 13 years, we would

[2] See Smith (2011) for the use of *ganzhi* cycles in Chinese calendars.

be in the 2nd year of the 2nd cycle, rather than year 14. If we start in year 1, after 100 years, we would be in the 5th year of the 8th cycle, as shown by the following mathematics:

$$(1+100) / 12 = 8 + 5 / 12$$

The remainder is used to determine where it is in a cycle. It allows us to know after 100 years, how far we are away from the beginning of the next cycle, which probably indicates the happening of a particular astronomical phenomenon. Although this example is much simpler than the ones been actually used in calendrical systems it reflects the basic idea.

Table 1.3 lists the 24 solar terms which divide a solar year. Table 1.4 lists the 28 lunar lodges for reckoning positions of heavenly bodies.[3] The widths of each lunar lodge changes over time, see Cullen (2002) for a list of the lunar lodge positions according to ecliptic and equater and an example of Zhang Heng's celestial measuring system in the Eastern Han. These positions were given in the unit of *du*. Solar path was divided into 365 1/4 parts, each part is named a *du*, See Guan Zengjian (1989) for the astronomical meaning of *du*.

There is also a traditional 12 *ci* system for measuring the sky in traditional Chinese astronomy. 1 *ci* equals 30 degrees. It comes from the 11.86 years period of Jupiter. The 12 *ci* are *Xingji* 星紀, *Xuanxiao* 玄枵, *Zouzi* 娵訾, *Jianglou* 降婁, *Daliang* 大梁, *Shichen* 實沈, *Chunshou* 鶉首, *Chunhuo* 鶉火, *Chunwei* 鶉尾, *Shouxing* 壽星, *Dahuo* 大火, *Ximu* 析木.

3 See discussions on lunar loges in Chinese astronomy in Liu Zhaonan (1979) and Stephenson (2008).

1	*Lichun* 立春	Enthronement of Spring	13	*Liqiu* 立秋	Enthronement of Autumn
2	*Yushui* 雨水	Rainwater	14	*Chushu* 處暑	Abiding heat
3	*Jingzhe* 驚蟄	Excited insects	15	*Bailu* 白露	White dew
4	*Chunfen* 春分	Vernal division	16	*Qiufen* 秋分	Autumnal division
5	*Qingming* 清明	Clear and bright	17	*Hanlu* 寒露	Cold dew
6	*Guyu* 穀雨	Grain rains	18	*Shuangjiang* 霜降	Frost settles
7	*Lixia* 立夏	Enthronement of summer	19	*Lidong* 立冬	Enthronement of Winter
8	*Xiaoman* 小滿	Small but full	20	*Xiaoxue* 小雪	Lesser snow
9	*Mangzhong* 芒種	Bearded grain	21	*Daxue* 大雪	Greater snow
10	*Xiazhi* 夏至	Summer solstice	22	*Dongzhi* 冬至	Winter solstice
11	*Xiaoshu* 小暑	Lesser heat	23	*Xiaohan* 小寒	Lesser cold
12	*Dashu* 大暑	Greater heat	24	*Dahan* 大寒	Greater cold

Table 1.3. The 24 solar terms.

1	*Jiao*	角	Horn	15	*kui*	奎	Crotch
2	*Kang*	亢	Neck	16	*Lou*	婁	Pasture
3	*Di*	氐	Root	17	*Wei*	胃	Stomach
4	*Fang*	房	Chamber	18	*Mao*	昴	Hairy Head
5	*Xin*	心	Heart	19	*Bi*	畢	Net
6	*Wei*	尾	Tail	20	*zi*	觜	Beak
7	*Ji*	箕	Basket	21	*Shen*	參	Triad
8	*Dou*	斗	Dipper	22	*Jing*	井	Well
9	*Niu*	牛	Ox	23	*Gui*	鬼	Ghost
10	*nü*	女	Maid	24	*Liu*	柳	Willow
11	*Xu*	虚	Tumulus	25	*Xing*	星	Stars
12	*Wei*	危	Rooftop	26	*Zhang*	張	Bow
13	*Shi*	室	Hall	27	*Yi*	翼	Wings
14	*Bi*	壁	Wall	28	*zhen*	軫	Chariot

Table 1.4. The 28 lunar lodges.

Chapter Two Eclipse records and divination in early China

The systematic recording of eclipses was essential for astronomers to develop eclipse theories. In imperial China, astronomers paid much attention to the observation of eclipses and left us a total of more than 1,500 eclipse records in various treatises over a period of more than 2,000 years.[4] Eclipses also played a significant part in the development of techniques of celestial divination. The tradition of systematically recording eclipses in Chinese history begins in the *Chun qiu*, which contains accounts of 37 eclipses dating from the 8th to the 5th centuries BC. In this chapter I will first examine the development of eclipse divination in the pre-Qin period and then focus on the influence of the *Chun qiu* eclipses on later Han treatises. I discuss questions such as what early primary sources do we have to study eclipses? How were eclipses used in divination in the Pre-Qin period? What theories did ancient diviners use to interpret astronomical phenomena? Eclipses eventually became the most important celestial phenomena in ancient China. What caused this change? What happened during the change?

2.1 The records

2.1.1 Eclipse records and divination in the Pre-Qin period

The *Chun qiu* eclipses were not the earliest records of their kind in China. Unfortunately,

[4] According to Liu Ciyuan (2009), there are 961 solar eclipse records in Chinese treatises before AD 1500, 545 lunar eclipse records before AD 1500. For more researches on Chinese eclipse records, see for example Stephenson (2007) and Steele (2000).

however, only a small amount of evidence survives from the earlier period in primary sources and we may therefore only touch on our topic by means of a few examples.[5] The earliest relevant eclipse is the *Zhong Kang* 仲康 eclipse, which is recorded in the *Shang shu* 尚書 (the *Book of Documents*), a book of pre-Qin history, as well as in the *Shi ji* 史記 and the *Zuo zhuan* 左傳. Although the *Shang shu* record does not seem to be sufficiently reliable to confirm that this is an accurate records of a second millennium BC eclipse, the accounts in the *Shi ji* and the *Zuo zhuan* suggest that this eclipse was indeed observed and was significant to the early Chinese ruler.[6] Unfortunately, we do not know the exact date of this event. Scholars have proposed more than ten possible dates ranging from 22nd century BC to 20th century BC. Recently the Xia-Shang-Zhou chronology project provided has proposed four most likely dates: including October 3, 2043 BC, December 6, 2019 BC, November 5, 1970 BC and October 26, 1961 BC.[7]

The accounts of the eclipse are much more detailed than a simple eclipse record: The ruler *Zhong Kang* sent out troops and killed Xi 羲 and He 和, local officers with astronomical and astrological duties, after they failed in their predictions of the eclipse. Yin was ordered by the ruler to campaign and announced to the public:

---

5 See Liu Ciyuan (2003) for a review on early Chinese solar eclipse records. See Mucke, H., & Meeus, J. (1983a) and Meeus, J., and Mucke, H., (1983b) for canons of solar and lunar eclipses.

6 Zhong Kang 仲康 (ruled 21st??-20th?? century BC) is said to be the fourth king of the Xia 夏 dynasty. See Wu Shouxian (2000) for a historiographical study on the authenticity and possible dates of this solar eclipse. See Loewe (1993) for introductions to the primary sources in early China.

7 Liu Ciyuan (2002). For more details on the Xia-Shang-Zhou chronology project, see Xia-Shang-Zhou duandai gongcheng (2000).

> 惟時羲和，顛覆厥德，沈亂于酒，畔官離次，俶擾天紀，遐棄厥司。乃季秋月朔，辰弗集于房，瞽奏鼓，嗇夫馳，庶人走。……《政典》曰：「先時者殺無赦，不及時者殺無赦。」
>
> On the first day of the last month of Autumn, the *chen* did not gather in *fang*; the blind played their drums, the junior officials galloped, people ran around.[8] … *Zheng Dian* notes: “if the eclipse occurs earlier than the prediction time, the predictor will be killed. If the eclipse occurs later than the prediction time, the predictor will also be killed.”
> (*Shangshu* ·*Yinzheng*)

Although the text suggests that astronomers at the time were able to predict solar eclipses, based on my analysis of the early Chinese eclipse theories in chapters 3 and 4, it does not seem reasonable to assume that astronomers at that time were able to make accurate predictions on solar eclipses.

Solar and lunar eclipses were interpreted differently in China. Solar eclipses were generally considered much more ominous than lunar eclipses. As a result, most early eclipse records are of solar eclipses. However, there are at least five early lunar eclipse records found on oracle bones, texts inscribed on animal bones and turtle shells.[9] Scholars have proposed different dates for these records,[10] but all that can be said with certainty is that they date to between the 14th and the 11th century BC. Based upon these sources, however, we know at least that a

---

[8] *Chen*, the sun; *fang, its own position.* the *chen* did not gather in *fang* 辰弗集于房 means the sun did not appear at the position where it should be. See Wang Jiaxin (2008) for explanations on the characters.

[9] Xu, Yau & Stephenson (1989), Xu, Stephenson & Jiang (1995). There are as well possible but not reliable records of solar eclipses, see Zhang Peiyu, (1999).

[10] See Zhang Peiyu (2009) pp. 26-37 for a summary of these different arguments.

lunar eclipse was an ominous phenomenon for the Shang people.[11]

Further evidence for the interpretation of a solar eclipse as ominous is provided by a record from the *Shi Jing* 詩經:

> 十月之交，朔日辛卯，日有食之，亦孔之醜。
>
> On the joining of the tenth month, the first day, the day of *xinmao*, there was a solar eclipse, how ominous it is!
> (*Shi* · Xiaoya)

This eclipse dates to a xinmao day, the first day of the tenth month in the sixth year of the King You in Zhou dynasty 周幽王. There has been considerble discussion of the date of this eclipse. One date that has often been suggested is September 6, 776 BC.[12] According to Zhang Peiyu's calculation, however, the eclipse in 776 BC can not be seen in the capital of Zhou and he therefore proposes a different date, November 30, 735 BC which seems more reasonable.[13] On this date, an eclipse of magnitude 0.80 could have been seen in the capital of Zhou.

In the Shang dynasty, the interaction between people and heaven within religious and divinatory practice was not as clear as in the Chun qiu period. In the *Shang shu*, Duke Zhou 周公 said "what the people wanted, heaven will have its response. 民之所欲，天必從之". The Chun qiu period scholar Fan Li 範蠡 said "heaven responds to the people, important figures

---

[11] See Chen Meidong (2003), pp. 28-30 and Zhang Peiyu (1999) for details of these eclipse records.
[12] See Zhang Peiyu (2006) for a historiographical discussion on the researches in favor of this date.
[13] Zhang Peiyu (1984).

respond to heaven. 天因人，聖人因天".[14] In the *Zuo zhuan* and *Guo yu*, the phrase "the fate of a country is due to Heaven 国之存亡，天命也" appears several times.[15] The example in the *Shi jing* clearly indicates that ancient Chinese diviners believed the meaning of eclipse in astrology was ominous before the *Chun qiu*. However, there is no evidence in these early examples of any more specific interpretation of an eclipse rather than just the general statement that it is ominous. The differences between these early examples and the records in *Chun qiu* may be helpful for us to see the development of celestial divination in this period. The following section will show how the idea of interaction between people and heaven was linked up in the Pre-Qin period, and similarly, how the political meaning was given to eclipses divination in the same period.

2.1.2 *Chun qiu* solar eclipses records

As the earliest extant chronicle book in Chinese history, the *Chun qiu* 春秋(Spring and Autumn Annals) covers the historical events from 722 BC to 481 BC from the perspective of the state of Lu 魯.[16] The *Zuo zhuan* 左傳, also called *Chun qiu zuo zhuan* 春秋左傳, is the *zhuan* of the *Chun qiu*. A *zhuan* is a book with commentary. Thus, the *Zuo zhuan* is the commentary on the *Chun qiu*. After the Eastern Han Dynasty, the book was renamed *Chun qiu zuo shi zhuan* 春秋左氏傳, or *Zuo zhuan* for short. According to *Han shu·Yi wen zhi* 漢書·

---

[14] *Guo yu*, chapter 21, *yueyu* 2. *Guo yu*, a treatise based on the history of various countries from 990BC to 453 BC. Fan Li, politician and scholar around 6th century BC in the Chun Qiu period.
[15] *Guo yu*, chapter 12, *jinyu 6*.
[16] Lu, a state in northern China, lasted from the 10th century BC - 256 BC.

藝文志, there are five annotated editions of the *Chun qiu*: *Zuo shi zhuan* 左氏傳, *Gong yang zhuan* 公羊傳, *Gu liang zhuan* 谷梁傳, *Zou shi zhuan* 鄒氏傳, *Jia shi zhuan* 夾氏傳.[17] Among those, only the first three editions have been preserved until today. *Gong yang zhuan* and *Gu liang zhuan* were written during the Western Han, with a focus on the interpretation of Confucianism rather than on historical facts. The *Zuo zhuan* is broader in scope and is not only concerned with important affairs in politics and the military, but also other topics in all areas in daily life, including social customs, the system of etiquette, moral values as well as astronomical knowledge. As a historical chronicle, in accordance with the style of the *Chun qiu*, the *Zuo zhuan* recorded the history from the first year of Duke Yin of Lu (722 BC) to the fourth year of Duke Dao of Lu (464 BC).

The *Chun qiu* contains 37 eclipses records, among which at least 33 have been shown by Liyan Guan (1998, 2000) to be reliable accounts of actual eclipses. As far as we can tell, *Zuo zhuan* was the beginning of the tradition of regularly recording solar eclipses and other significant astronomical phenomena. A list of the solar eclipse records in the *Chun qiu* is presented in Table 2.1. Columns 2 to 5 summarize the information found in the *Chun qiu* records. Notes are made by modern scholars to supplement and revise the information given by the records in the *Chun qiu*.[18]

---

[17] *Han Shu·Yi Wen Zhi* refers to the volume of art and literature in the *Han shu* (dynastic history of Han). See Cheng A., (1993) for an introduction to the commentaries of the *Chun qiu*.

[18] Zhang Peiyu (2002). pp. 166-171

No.	*Chun qiu* solar eclipse records				Date(BC)	Notes
1	Duke *Yin*	Year 3, month 2	*Jisi*		720.02.22	
2	Duke	Year 3, month 7, *shuo*	*Renchen*	*Ji*	709.07.17	
3	*Huan*	Year 17, month 10, *shuo*			695.10.10	*Gengwu*
4	Duke	Year 18, month 3			676.4.15	*Renzi*
5	*Zhuang*	Year 25, month 6, *shuo*	*Xinwei*	*Gu*	669.5.27	
6		Year 26, month 12, *shuo*	*Guihai*		668.11.10	
7		Year 30, month 9, *shuo*	*Gengwu*	*Gu*	664.8.28	
8	Duke *Xi*	Year 5, month 9, *shuo*	*Wushen*		655.8.19	
9		Year 12, month 3	*Gengwu*		648.4.6	
10		Year 15, month 5			645.5.2	*Renzi*, no solar eclipse
11	Duke	Year 1, month 2	*Guihai*		626.2.3	
12	*Wen*	Year 15, month 6, *shuo*	*Xinchou*	*Gu*	612.4.28	
13	Duke *Xuan*	Year 8, month 7	*Jiazi*	*Ji*	601.9.20	Month 10, *Jiazi*
14		Year 10, month 4	*Bingchen*		599.3.6	
15		Year 17, month 6	*Guimao*		592.5.8	Year 7, month 6, *Guimao*
16	Duke	Year 16, month 6, *shuo*	*Bingyin*		575.5.9	
17	*Cheng*	Year 17, month 12, *shuo*	*Dingsi*		574.10.22	
18	Duke	Year 14, month 2, *shuo*	*Yiwei*		559.1.14	
19	*Xiang*	Year 15, month 5	*Dingsi*		558.5.31	Month 7, *Dingsi*
20		Year 20, month 10, *shuo*	*Bingchen*		553.8.31	Not visible in

						Qufu
21		Year 21, month 9, *shuo*	*Gengxu*		552.8.20	
22		Year 21, month 10, *shuo*	*Gengchen*		552.9.19	No solar eclipse
23		Year 23, month 2, *shuo*	*Guiyou*		550.1.5	
24		Year 24, month 7, *shuo*	*Jiazi*	*Ji*	549.6.19	
25		Year 24, month 8, *shuo*	*Guisi*		549.7.18	No solar eclipse
26		Year 27, month 12, *shuo*	*Yihai*		546.10.13	
27	Duke *Zhao*	Year 7, month 4, *shuo*	*Jiachen*		535.3.18	
28		Year 15, month 6, *shuo*	*Dingsi*		527.4.18	
29		Year 17, month 6, *shuo*	*Jiaxu*		525.8.21	Month 9, *hui*, *Gengyou*
30		Year 21, month 7, *shuo*	*Renwu*		521.6.10	
31		Year 22, month 12, *shuo*	*Guiyou*		520.11.23	
32		Year 24, month 5, *shuo*	*Yiwei*		518.4.9	
33		Year 31, month 12, *shuo*	*Xinhai*		511.11.14	
34	Duke *Ding*	Year 5, month 3, *shuo*	*Xinhai*		505.2.16	
35		Year 12, month 11, *shuo*	*Bingyin*		498.9.22	
36		Year 15, month 8, *shuo*	*Gengchen*		495.7.22	
37		Year 14, month 5, *shuo*	*Gengshen*		481.4.19	

Table 2.1 Solar eclipse records in the *Chun qiu*.

The recorded eclipses in the *Chun qiu* date from 722 BC to 481 BC. Previous researchers (e.g. Liyan Guan 2000, Zhang Peiyu 2002), have made the following three points about the records:

1) Three eclipses were not visible at the capital of Lu: Year 15, month 5 of Duke *Xi*; Year 15, month 5 of Duke *Xiang*; and Year 21, month 10 of Duke *Xiang*.
2) Later eclipse records are more frequent; later eclipse records are more accurate.
3) Not all visible eclipses from Qufu were recorded in the *Chun qiu*. The text usually records eclipses with large magnitudes.[19]

2.2 Celestial divination from eclipses in the *Zuo Zhuan*

2.2.1 The political meaning of solar eclipses

The *Chun qiu* only contains brief descriptions of solar eclipses, usually giving only the date and *ganzhi*. By contrast, the *Zuo zhuan* records the interpretation of the eclipses as omens, and explains the reasons and theories that the astrologers used in constructing their interpretation. It has been argued by Pines (1997) that the *Zuo zhuan* speeches are reliable sources to reconstruct the intellectual history in pre-Qin China. In any event, they are the only sources we have and so provide our only way of accessing this information.[20]

In the earlier texts discussed above, the occurrence of a solar eclipse is clearly stated to be a bad omen, but there is no discussion of why it was bad or how bad it was. In the *Zuo Zhuan,*

[19] See Zhang Peiyu (2002) for a list of the unrecorded eclipses.
[20] See also Stephenson (1992) and Zhang Peiyu (2009).

however, eclipse omens became more descriptive and detailed. The influence of eclipses on politics was highly emphasized. Here is an example from the 7th year of King Zhao:

> 夏，四月，甲辰，朔，日有食之，晉侯問於士文伯曰，誰將當日食，對曰，魯衛惡之，衛大魯小，公曰，何故，對曰，去衛地，如魯地，於是有災，魯實受之，其大咎，其衛君乎，魯將上卿，
>
> A solar eclipse occurred on a jiachen day, the first day of the fourth month. The Duke of Jin asked Shiwenbo: "which country does the eclipse aim at?" Boxia answered: "Lu and Wei, mostly Lu." The ruler: "Why?" Boxia answered: "the eclipse is from the area of Wei to the area of Lu, if there is incoming danger, Wei will suffer most of the danger, and its ruler will be punished; Lu will suffer a smaller part of the danger, and the officer will be punished."
> (*Zuo zhuan*· the 7th year of King Zhao)

When the Duke of Jin asked his officer Boxia to interpret the observation of a solar eclipse in Lu, it is noteworthy here that Boxia used a theory to explain the impact of eclipse, namely field allocation theory.[21] This account is the earliest attested use of the field allocation theory in explaining a solar eclipse. The text continues by answering a doubt many readers, as well as the Duke of Jin himself, would have: why are eclipses bad omens?

> 公曰，詩所謂彼日而食，于何不臧者，何也，對曰，不善政之謂也，國無政，不用善，則自取謫于日月之災，故政不可不慎也，務三而已，一曰擇人，二曰因民，三曰從時。
>
> The Duke asked: "the *Shi* said if the sun is eclipsed, bad things would happen. Why?" Boxia answered: "it is the country's poor political operation. (If the ruler) ruled the country badly, does not apply virtue, he would be punished by the suffering of the sun and the moon, thus ruling can not be not cautious. There are three missions, the first is selecting officers, the second is following the

[21] Shiwenbo is Boxia's political position. Field allocation theory is a theory in Chinese astrology, which related different countries or places on earth to specific areas on heaven. See Li Yong 李勇 (1992) Zhou Liang and Li Yong.(2013) for detailed studies on the field allocation theory in China.

people, the third is obeying Heaven.
(*Zuo zhuan·* Year 7 of the Duke Zhao)

Boxia extended the ominous meaning of eclipse to politics. He argued the solar eclipse was a bad omen in the *Shi* because it symbolized the country's poor political operation. Eclipses were the warnings given to rulers by Heaven. The happening of a solar eclipse was linked to the poor government of the country, since the first to be responsible was the ruler, thus it is possible that the solar eclipse is because of a particular ruler.

The increasing political significance of eclipses also resulted in the performance of sacrificial rituals. For example, a ritual was held after an eclipse in year 17 of Duke Zhao:

夏，六月，甲戌，朔，日有食之，祝史請所用幣，昭子曰，日有食之，天子不舉，伐鼓於社，諸侯用幣於社，伐鼓於朝，禮也，平子禦之，曰，止也，唯正月朔，慝未作，日有食之，於是乎有伐鼓用幣，禮也，其餘則否，大史曰，在此月也，日過分而未至，三辰有災，於是乎百官降物，君不舉辟，移時樂奏鼓，祝用幣，史用辭，故夏書曰，辰不集于房，瞽奏鼓，嗇夫馳，庶人走，此月朔之謂也，當夏四月，是謂孟夏，平子弗從，昭子退曰，夫子將有異志，不君君矣。

On *jiaxu*, the first day of the sixth month of summer, the sun was eclipsed. The invocators and scribes asked to use offerings of silk. Zhaozi said, "When the sun is eclipsed, the rites require the Son of Heaven not to spread (his table) but to beat the drum in the temple, and require the many lords to offer silk in the temple and beat the drums in the court." Pingzi opposed this, saying: "Stop. It is (only) on the first day of the first month, when the evil has not yet acted and the sun has been eclipsed that to beat the drums and to offer silk is according to the rites; otherwise it is not." The Grand Scribe said, "It is in this month; the sun has passed the equinox but is not yet at the solstice. When the three chen have disaster, the hundred officers send down presents and the lord does not spread (his table), retiring until the time (i.e., the eclipse) has passed. The musicians play the drums, the invocators offer silk, and the scribes use their words. Therefore the Book of Xia says, 'The chen did not gather in Fang; the blind ones played their drums, the lower officials galloped and the

> multitudes ran about.' This refers to the first day of the month; it was in the fourth month of Xia, what we call the first month of summer."
> (*Zuo zhuan*, Duke Zhao, Year 17, translated by Zhang Peiyu, 1990)

These rituals were performed as a response to the criticism implied by the observed eclipse.

2.2.2 The modeling of eclipse divination

The interpretation of eclipses presented in the *Zuo zhuan* evolved over centuries. In the following sections, I use the term "modeling" not to refer to a unified model in eclipse divination in the Chun qiu period but rather to applying various theories of eclipse divination. Among the various astronomical phenomena mentioned in ancient Chinese treatises, solar eclipses were considered to be the most significant one. In the *Chun Qiu* period, people started to wonder about the causes of eclipses. As one of the most recognizable astrologers in the *Chun qiu*, Zishen made the argument reflecting the belief that solar phenomena will not cause disaster when they are running as usual:

> 秋七月壬午朔，日有食之。公問於梓慎曰：「是何物也？禍福何為？」
>
> 對曰：「二至二分，日有食之，不為災。日月之行也，分，同道也；至,相過也。其他月則為災。」
>
> A solar eclipse occurred on a *renwu* day, the first day of the seventh month in Autumn. The Duke asked Zishen: "what exactly is it, is it a good or bad omen?" Zishen answered: "(in the month of) equinoxes or solstices, when the sun eclipsed, there is no disaster. The movement of the sun and the moon, on equinoxes, (they are) in parallel; on solstices, (they) pass each other. In the other months there will be disasters.
> (*Zuo zhuan*·Year 21 of the Duke Zhao)

How to understand warnings from Heaven? Where does the warning aim at? In order to develop an effective eclipse divination method, astrologers in the Chun qiu period began to make predictions using modeling methods. In the above-mentioned example of the eclipse on the seventh year of the Duke Zhao, Boxia clearly pointed out that Lu and Wei will be the objects of the prediction. The eclipse will mostly be aimed at Wei since the eclipse was seen from the area of Wei to the area of Lu. His prediction was correct: four months later, the Duke of Wei died. After another three months, the chief officer Jiwuzi 季武子 passed away. The Duke of Jin was amazed by Boxia's successful prediction and asked Boxia to develop a theory to predict eclipses:

> 十一月，季武子卒。晉侯謂伯瑕曰：「吾所問日食，從矣，可常乎？」對曰：「不可。六物不同，民心不一，事序不類，官職不則，同始異終，胡可常也？《詩》曰：‘或燕燕居息，或憔悴事國。’其異終也如是。」公曰：「何謂六物？」對曰：「歲、時、日、月、星、辰，是謂也。」公曰：「多語寡人辰，而莫同。何謂辰？」對曰：「日月之會是謂辰，故以配日。」
>
> In the eleventh month, Jiwuzi passed away. The Duke of Jin asked Boxia; “the solar eclipse I asked, from now on, can you make regular (predictions)?” (He) replied: “I can not. The six factors are different, people are not in harmony, the sequence of matters are not the same, the political position differs. The beginnings are alike while the endings differ. How to make regular (predictions)? Shi said: ‘either rest with pleasure, or exhaustingly serve the country.’ The varied endings are like these.” The Duke of Jin asked: “what are the six factors?” Boxia answered: “The year, the time, the sun, the moon, the planets, and the Chen.” The Duke of Jin said: “Many have mentioned the Chen to me, but not quite the same. What is the Chen? (He) answered: “The conjunction of the sun and the moon is called the Chen, thus it accompanies the sun.”
> (*Zuo zhuan*·Year 7 of the Duke Zhao)

In Boxia's opinion, too many factors could affect the prediction of eclipses. Even though he was successful in the earlier prediction, it is still not quite possible to use one single theory to make all the future predictions. Diviners were only starting to use theories on eclipse divination at that time, thus Boxia's caution was quite wise. However, as long as eclipses are related to political affairs there will naturally be a will to produce a divinatory theory.

The field allocation theory is not the only theory used in eclipse divination in the *Zuo zhuan*. For example, the interpretation of an eclipse in year 31 of the Duke Zhao mentioned the *wuxing* theory:

> 十二月辛亥朔，日有食之。是夜也，赵简子梦童子羸而转以歌。旦占诸史墨，曰：「吾梦如是，今而日食，何也？」对曰：「六年及此月也，吴其入郢乎！终亦弗克。入郢，必以庚辰，日月在辰尾。庚午之日，日始有谪。火胜金，故弗克。」
>
> On a *xinhai* day, the first day of the twelfth month, the sun eclipsed. On that night, Zhaojianzi dreamed of a weak child, who danced and sang. On the next day, he asked scribe Mo to divine (and)said: "Thus it is my dream, and the sun eclipsed today, why?" Mo answered, "after six years, in this month, Wu will enter Ying! At last (Wu) will not conquer it. The entrance to Ying must be on the day of *gengchen*, the Sun meets the Moon on the last part of Chen. On the day of *gengwu*, the sun will be eclipsed. Fire overcomes Metal, thus (Wu) cannot defeat. "
> (*Zuo zhuan*·Year 31 of the Duke Zhao)

Instead of Boxia's Field Allocation theory, Shi Mo used the *wuxing* theory, along with the *ganzhi* cycles to interpret the dream.[22] He predicts the Kingdom Wu may enter Ying, the capital of the kingdom Chu on the day of *gengchen*. This is because the Sun meets the Moon

[22] See Graham (1986) and Nylan (2010) for explationations on the Yin yang and wu xing theories.

on the last part of Chen on that day and there was a solar eclipse on the day of *gengwu*. According to the *wuxing* theory, geng represents metal and Chu represents fire. Fire overcomes metal, thus the ganzhi of this day implies the kingdom Wu cannot completely defeat the kingdom Chu. Based on these examples, we can see that different eclipse divination theories co-existed in the Chun qiu Period. At this time, there was not a dominant theory. Here is another example of yet another model of eclipse divination:

> 夏五月乙未朔，日有食之。梓慎曰：「将水。」昭子曰：「旱也。日过分而阳犹不克，克必甚，能无旱乎？阳不克莫，将积聚也。」……秋八月，大雩，旱也."
>
> On a *yiwei* day, the first day of the fifth month in the summer, the sun was eclipsed. Zishen said: "there will be a flood." Zhaozi said: "it is a drought.[23] The sun has passed the vernal equinox and Yang still did not overcome Yin. (When) it overcomes there must be lot of (yang), how could be no drought? The Yang has not yet overcome, it will accumulate."... In the eighth month in Autumn, a grand *yu* ritual (was held), a drought (happened)."
> (*Zuo zhuan*·Year 24 of the Duke Zhao)

The predictions by Zishen and Zhaozi were quite different. The general view was that the solar eclipse was caused by Yang overcoming Yin. Water is associated with Yin and this is the reason Zi Shen predicted a flood. The sun eclipsed, Yang is shadowed by Yin, thus there should be plenty of water and there will be a flood. Zhaozi did not agree with his opinion, he argued that when Yang rises, it should overcome Yin, but it did not. Thus Yang will be accumulated to overcome Yin. If it succeeded, there will be too much Yang and there will be a

[23] Zi shen and Zhao zi are both officer in the Lu.

drought. Thus the eclipse was the precursor of the drought. The two diviners were making predictions based on the same eclipse but they came to opposite results.

These examples show that it was common to use the model method to perform eclipse divination but there was not a unified model in eclipse divination. Rather different astrologers used different models (for example field allocation theory, *wuxing* theory, and *yinyang* theory) in order to interpret an eclipse.

2.2.3 Summary

In this section I discussed the astrological meaning of eclipse records in *Zuo zhuan* as well as their impact on later periods. First, I argued that the *Zuo zhuan* was the first treatise in ancient China to give clear political meanings to solar eclipses. The system in the *Zuo zhuan* modeled a method of eclipse divination and created a direct relationship between rulers and astronomical phenomena. This eventually made eclipses the most important celestial phenomena in ancient China. Secondly, I discussed the models of eclipse divination in China that were formed in *Zuo zhuan*. There was no single way to interpret a solar eclipse in the pre-Qin period, rather several models were being tried and recorded in the *Zuo zhuan*.

2.3 Eclipse records and divination in the Han

2.3.1 Han eclipse records

As one of the most important Confucian Classics, the *Zuo zhuan* was highly valued and followed by ancient Chinese historians. The eclipse records in *Zuo zhuan* were representative of the pattern of recording solar eclipses in ancient China. It is the beginning of the tradition that later Chinese historians regularly recorded eclipse in the dynastic histories. After the *Zuo zhuan*, Chinese historians started to provide more details in their eclipse records, such as the time of the eclipse, the magnitude, and the position of the contact. For example,

> 七月癸未，日有食之……日中时，食从东北，过半，哺时复。
>
> On a *guiwei* day of the seventh month, the sun was eclipsed…… at noon, the eclipse started from northeast, (the magnitude) was over half, it recovered in the hour of *bu*.[24]
> (*Han shu*, chapter 37)

The recording of solar eclipses became more systematic with records of most, although not all, of the visible solar eclipses preserved after the Western Han dynasty.[25] Records of 59 solar eclipses are preserved from the Western Han and 78 from the Eastern Han. It is worth noting that not all eclipse records are reliable. Scholars have shown that (1) in certain years almost all visible eclipses were reported, and in other periods many were neglected (Dubs 1938-1955), and (2) there are false eclipse records preserved.[26] Bielenstein (1950) and Eberhard (1957; 1970) argued that the records of eclipses preserved in the dynastic histories were manipulated under political considerations, and hence faked eclipse records were indirect

[24] Bu-shi, the hour of *bu*, 3pm-5pm.
[25] For lists of East Asian eclipse records, see Zhu Wenxin (1934), Zhuang Wei-feng & Wang Li-xing (1988), Stephenson (1997) and Zhang Peiyu (2006).
[26] Stephenson (1997).

evidence of their political significance.[27]

Lunar eclipses had much less political significance than solar eclipses. As a result, observations of lunar eclipses were only rarely recorded in the Han (it was not until the southern and northern dynasties that lunar eclipses were regularly recorded in the dynastic histories). In part this is because they are easier to predict astronomically than solar eclipses. When observations of lunar eclipses were recorded in this period it is generally because they were used in astronomy rather than for their astrological interpretation. For example, in the example of the *Yuan jia li* reform tests discussed in chapter 5, five lunar eclipses are recorded and are used to determine the position of the sun. They are recorded in the *lü li zhi*, treatise of temperament and calendar, rather than the *tian wen zhi*, treatise of astrology. The only astrological use of lunar eclipses in the Han appears in the *Houhanshu* where we have two cased where it is reported that "the lunar eclipse was not at its month 月食非其月," but in neither case was any interpretation of the meaning of the eclipse made.[28] By contrast, most solar eclipse records are accompanied not only by interpretations, but also activities such as rituals or punishing high officials.

2.3.2 The treatment of eclipses in the Han

As discussed in section 2.2, in the pre-Qin period, Chinese began to give significant political

[27] However, Pankenier (2012) has recently reviewed the researches on the reliability of Han Dynasty solar eclipse records and argued most erroneous were scribal errors rather than been faked.

[28] Hou han shu, p.3946.

meaning to observed astronomical phenomena. This bond between astronomy and state politics became even closer during the Han. As I will discuss in chapter 5, during the Han, Dong Zhongshu 董仲舒 developed a political philosophy based upon the idea of the Mandate of Heaven (*tian ming* 天命) in which the emperor only ruled with Heaven's permission and that Heaven could show either good or bad signs based on actions of the ruler. As a result, more or less any unexpected astronomical phenomena such as a comet or a guest star became important within state politics, although eclipses, especially total solar eclipses, were the most significant omens. [29]

Eclipses could be either a warning to the emperor of incoming danger or a criticism of his mistakes. On the occasion of a solar eclipse in 178 BC, the Han Wen emperor interpreted the eclipses as a criticism of his governance and issued an edict to blaming himself (z*uijizhao* 罪己詔):

> 十一月癸卯晦，日有食之。詔曰：「朕聞之，天生民，為之置君以養治之。人主不德，布政不均，則天示之災以戒不治。乃十一月晦，日有食之，適見於天，災孰大焉！朕獲保宗廟，以微眇之身託於士民君王之上，天下治亂，在予一人，唯二三執政猶吾股肱也。朕下不能治育羣生，上以累三光之明，其不德大矣。令至，其悉思朕之過失，及知見之所不及，匄以啟告朕。及舉賢良方正能直言極諫者，以匡朕之不逮。因各敕以職任，務省徭費以便民。朕既不能遠德，故憪然念外人之有非，是以設備未息。今縱不能罷邊屯戍，又飭兵厚衛，其罷衛將軍軍。太僕見馬遺財足，餘皆以給傳置。」
>
> On the last day *gengwu* of the eleventh month, the sun eclipsed. (He issued) an edict

[29] See Lagerwey and Kalinowski (2009) for a general discussion on early Chinese religion, see Bielenstein (1950), Eberhad, (1957), De Respigny (1976), Bielenstein and Sivin (1977), Kern (2000) and Chemla, Harper and Kalinowski, eds. (1999) for discussions on the political use of omens and portents. See Xiong (2007) for a later example during the Tang.

saying; "I heard it, Heaven brought people, set the ruler for them to nourish and govern them. If the human ruler is short of virtue, the governing is not balancing, then Heaven brought a bad omen to warn about the bad governing. The last day of the eleventh month, the sun eclipsed, accused by Heaven, no warning is more serious than this. I am responsible to conserve the ancestral temple, to the tiny body on behalf of people and dukes, the governing of the whole country, is on me myself, only two or three chancellors are like the limbs of my bodies. Downward I cannot rule and govern the people, upward I diminish the brightness of the sun, the moon and stars, the guilt is huge. When the edict arrives, all need to think carefully about my erroneous deeds, and the shortcoming of mysightedness, I sincerely ask to tell me. Recommend *xianliang fangzheng*, who speaks straightforwardly, to correct my flaws.[30] Thus the officials need to do their own jobs, save corvée and expenses for people's convenience. I cannot reform what is distant with virtue, that is why I am not at ease, worrying the other clans would rebel. Thus the defense and preparations cannot cease. Even if now cannot stop the frontiers and to exploit land, should not order forces to strictly guard me, dismiss the troops led by the general of guards. Keep to a sufficient number the horses administered by the Grand Coachman, the othershould all be used for posts."
(*Han shu*, chapter 4)

Other emperors used high officials as scapegoats, as in the following example concerning Wang Mang, the emperor of the short-lived Xin dynasty between the western and the eastern Han:

三月壬申晦，日有食之。大赦天下。策大司馬逯並曰：「日食無光，干戈不戢，其上大司馬印韍，就侯氏朝位。太傅平晏勿領尚書事，省侍中諸曹兼官者。以利苗男訢為大司馬。」

戊子晦，日有食之。大赦天下。復令公卿大夫諸侯二千石舉四行各一人。大司馬陳茂以日食免，武建伯嚴尤為大司馬。

On the last day of *renshen* of the third month, the sun eclipsed. The country was amnestied. (The emperor) relieved the Commander in chief Lu Bing and said, "the sun was eclipsed and lost light, the arms would not cease, let him submit the seal of the Commander in chief, (and let him) take (his own) *hou*-duke position. Don't let

[30] *Xianliang fangzheng* 賢良方正, literally means virtuous and expostulate. It later became a way the Han ruler select people as officials.

the Grand tutor Ping Yan perform the affair of the Master of Writing, relieve the palace attendants and bureau officials who serves concurrently, and appoint Miao Xin of *Limiao nan*-Duke to be the Commander in chief."

On the last day of *wuzi* of a month, the sun eclipsed. The country was amnestied. And ask the ministers, grandees and dukes who earns 2000 *shi* to recommend man with one of the four virtues. The commander in chief Chen Mao was relieved for the solar eclipse, appointed *Wujian bo*-duke Yan You as the commander in chief.
(*Han shu*, chapter 99)

Another response to an eclipse was to hold a ritual sacrifice. As discussed in section 2.2.1, this tradition is already described in the *Zuo zhuan*. In the Han, the rituals became even more complicated. The *Shiji* explained the reasons why the emperor and high officials were targeted by an omen and why rituals need to be held:

日變修德，月變省刑，星變結和。凡天變，過度乃占。國君彊大，有德者昌；弱小，飾詐者亡。太上脩德，其次脩政，其次脩救，其次脩禳，正下無之。夫常星之變希見，而三光之占亟用。日月暈適，雲風，此天之客氣，其發見亦有大運。然其與政事俯仰，最近（大）［天］人之符。此五者，天之感動。為天數者，必通三五。終始古今，深觀時變，察其精粗，則天官備矣。

If there is a solar anomaly, practice virtue; if there is a lunar anomaly, reduce punishments; if there is a planetary anomaly, join in harmony. In all cases of celestial anomalies, if the [regular] measures are overstepped, then prognosticate. If the lord of the state is strong and great, the virtuous will prosper, and the weak and small, fawning and false will perish. The ultimate superior cultivates virtue, the next level practices [good] government, the next level carries out relief efforts, the next level conducts expiatory rites, directly below that there is nothing [to be done]. Now, changes in the constant stars are rarely seen, but prognostications concerning the Three Luminaries are frequently applied. The Sun and Moon, with their halos and blemishes, clouds and winds, these are the transient [effects] of celestial *materia vitalis*, and their production and appearance also have their major cycles. Moreover, with regard to the vicissitudes of governmental affairs, they are the most proximate tallies of [the interaction] between Heaven and Man. These Five are the responsive movements of Heaven. Those who deal with the Regularities of Heaven must comprehend the Three and the Five. [Having explored events] from beginning to end, from ancient times to the present, [we have] looked deeply into the vicissitudes of

> the times, examining the minute and the large scale, [so that exposition of] the Celestial Offices is now complete.
> (*Shiji*, translated by Pankenier 2014)

From the Western Han dynasty on, examples of using the modeling theories to explain eclipses appear again and again. For example, the *Ganshi xingjing*, a treatise on astrology by Gande and Shishen which is preserved in the *Kaiyuan zhanjing*, an astrological work from the Tang dynasty, describes eclipse divination based on seasons, the month of the year, the times of day and the shadow direction.[31] Examples from the *Ganshi xingjing* include the following:

> 甘氏曰：日出至早食时蚀，为齐。
>
> Gande stated: If the sun rises and is eclipsed at the time of breakfast, it is aimed at Qi[32].
>
> 甘氏曰：日蚀从旁起，失于令，相当之。
>
> Gande stated: If a solar eclipse started from one side, (it is because) governing policies fails, the minister should bear it.
> (*Kaiyuan zhanjing*, chapter 9)
>
> 石氏曰：三月日蚀不见光，水大出。
>
> Shishen stated: If there is a total solar eclipse occurring in the third month, there will be serious flood.
> (*Kaiyuan zhanjing*, chapter 10)

2.4 Summary

---

[31] Gande and Shenshenfu were astronomers in the Warring States period. Their works were only preserved in other treatises such as the *Kaiyuan zhanjing*. Yabuuchi, (1937), Qian Baocong,(1937) Maeyama Yasukatsu, (1977) and Hu Weijia 胡維佳 (1998) all studied the date of the *Ganshixingjing* . Most recently, Sun Xiaochun and Kistemaker (1997) have argued the star positions recorded in the Kaiyuanzhanjing date from 70 BC.

[32] Qi, 齐. A country in east China in the Chun Qiu period.

This chapter has discussed the history of eclipse divination from the Pre-Qin period to the Han. Up to the period of Qin, eclipses were of importance only for their ominous meaning. By the Han, eclipses had become an important subject within mathematical astronomy (see chapters 3 and 4), but they remained just as important for their role in celestial divination. The interpretation of a solar eclipse was usually linked to the behavior of the ruler: it was either a warning of potential danger or a criticism of a ruler's mistake.

Eclipses were regarded as just one of the important factors in divination before the *Chun qiu* period. Then patterns were constructed to interpret eclipses in divination as astrological omens. Based on the examples chosen from *Zuo zhuan* as well as other Pre-Qin eclipse records, I have argued that the *Zuo zhuan* is the first treatise in ancient China to give clear political meanings to solar eclipses. The system in *Zuo zhuan* modeled a method of eclipse divination and created a direct relationship between rulers and astronomical phenomena. This eventually made eclipses the most important celestial phenomena in ancient China.

Chapter Three The Development of Eclipse Theory in the Han

In chapter two, two major questions were investigated: for the diviners, how to interpret a solar eclipse, and for the ruler, what needs to be done after observing a solar eclipse? From the pre-Qin period to the Han, as eclipses gradually became more significant, naturally people would think about the possibility to predict the occurrence of a solar eclipse in advance. This chapter focuses on the theoretical development of methods of predicting eclipses during the Han.[33] During this same period, Chinese astronomers were able to develop theories to predict eclipses. In order to examine the early forms of eclipse theories, in this chapter I analyze the development of eclipse theories in different systems. Two main questions will be addressed in this chapter: first, how did Chinese astronomers use cycles to predict solar and lunar eclipses? Second, how did astronomers during the Han further develop the methods of eclipse prediction?

3.1 The use of cycles in eclipse prediction in the *San tong li*

The earliest evidence of an eclipse theory in a calendrical system is found in the *San tong li* adopted in 7 BC towards the end of the Western Han.[34] Refinements to this theory were

---

[33] For previous researches on eclipse theories and prediction in China, see Steele (2008), Li Guangshen (1963), Chen Jiujin (1983), Foley. (1989), Chen Meidong (1991), Chen Meidong (1992), Li Jiancheng (1994), Stephenson and Fatoohi (1995), Hu Tiezhu (2001), Qu Anjing and Tang Quan (2008).

[34] Liu Xin 劉歆(53 BC – AD 23) constructed the *San tong li* and develop reformed astronomical

introduced in subsequent calendar systems of the Eastern Han. It is unclear whether the eclipse period in the *San tong li* is intended to be used for both solar and lunar eclipses or only for lunar eclipse. Shi Yunli and Xing Gang used the *San tong li* method to calculate lunar and solar eclipses and compared it to modern calculation and ancient eclipse records such as the *Chun qiu* eclipses, and found that the lunar eclipses results are much better than solar ones. Also, both the *San tong li* and the *Si fen li* texts only explicitly mention the calculation of lunar eclipses rather than solar eclipses or both. Therefore, Shi and Xing argued that the *San tong li* was only used in lunar eclipse prediction.[35]

In the *San tong li*, units such as the *yuan, tong, zhang*, year, month and day are used to describe time intervals. Beyond these units, the Ultimate Epoch (*shang yuan* 上元) is a combination of all cycles in the system. One problem in using cycles to represent astronomical periods is that the values of fundamental astronomical parameters often contain fractions rather than only whole numbers. In order to simplify calculations using different cycles, denominators are used in fractions with the name 'factor' (*fa* 法), for example, the Day Factor (*ri fa* 日法), the Rule Factor (*zhang fa* 章法), the Era Factor (*ji fa* 紀法), the Concordance Factor (*tong fa* 統法) and the Ultimate Factor (*yuan fa* 元法).[36] After a certain

---

theories on the basis of the *Tai chu li*. Cullen (2001) discusses Liu Xin 劉歆, his system and his writing, the *Canon of the Ages* (*Shi jing* 世經).

35 Shi Yunli and Xing Gang (2002) and (2005).

36 Scholars translate *fa* 法 as either "factor" (Cullen 1996, Morgan 2013), "divisor" (Sivin 2009), "rule" (Sivin 1969) or "denominator" (Sivin 2008). In this dissertation I translate *fa* 法 as "factor". In most cases, *fa* works as the devisor or denominator in a fraction that corresponds to an astronomical period. But there are also examples of the use of *fa* as a numerator. For example, in the *San tong li*, the length

period, usually a periodic cycle, when fractions accumulate to produce a whole number, the factor will be eliminated. For example, the length of a solar year in the *San tong li* is 365 385/1539 days, where 1539 is known as the Concordance Factor. The system set the cycle of Tong as 1539 years, which makes a total of 562120 (365×1539 + 385) days, a whole number rather than a number with a fraction of days.[37]

The *San tong li* eclipse theory is described in only in a brief account of the eclipse period and the steps to calculate the month of eclipse:

> 推月食，置會餘歲積月，以二十三乘之，盈百三十五，除之。不盈者，加二十三得一月。盈百三十五，數所得，起其正，算外，則食月也。加時，在望日沖辰。
>
> To calculate the lunar eclipses, use the remainder (after taking out) the Meeting Year, multiply the total number of months by 23. If it is over 135, divide it (by 135). If it is not enough, add 23 to reach a month. If it is over 135, take the whole number out of the result. Count out (the last month), it is the month of the eclipse. This time is on the full moon's day, the sun is on the opposite of the synodic point.
> (*Han shu*, chapter 93)

In the *San tong li*, the Meeting Year (*hui sui* 會歲) is a period of 513 years, which equals 6345 months. Liu Xin uses this large number for a numerical reason: 6345 is the least common multiple of 135, the number of months in one eclipse period and 235, the number of months in one Rule cycle (the 19 years intercalary period). This means there are 47 135-month eclipse periods in one Meeting Year. After 6345 months, the cycle of the eclipse period and the cycle

of the synodic month is 2392 / 81, which is *yue fa* (month factor) / *ri fa* (day factor).

[37] For a more detailed introduction on the use of cycles in early Chinese mathematical astronomy, see Sivin (1969).

of intercalation meet again in the same place. The total number of months is calculated from the epoch, when all astronomical periods in the calendrical system have a uniform starting point. The method uses the remainder after taking whole numbers of the Meeting Year out of the months from the epoch to the year we are calculating. According to the *San tong li*, there are 23 eclipses in 135 months. After each month, the eclipse period has passed 23 / 135 eclipses to the next whole number, when there is another eclipse (the text reads simply "to calculate the lunar eclipses", but it is clear that it is referring to eclipse possibilities). We therefore multiply the total number of months by 23 and divide it by 135, which means dividing the number by 135 / 23, the time between two eclipses. The fraction in the result shows where we are within that 135-month eclipse period. The number of months away from the end of this eclipse period is also how far away we are from the next eclipse.

For example, if we calculate using 4 months as the remainder of the number of months after taking out the Meeting Year: We multiply 4 by 23 to find 92. Since 92 is less than 135, no eclipse has happened in the past 4 months. To find the next eclipse we need to go beyond 135 and so we must add on two more multiples of 23 to get to 138, which is larger than 135. Thus, there will be an eclipse in the second month of that year. If we calculate using 100 months as the remainder of the number of months after taking out the Meeting Year we will find: 100 times 23 equals 2300, which is greater than 135. We therefore need to take out multiples of 135, which can be done by dividing 2300 by 135 to find 17 5/135, from which we can remove the integer part to be left with 5/135. Next, we subtract 5 from 135 and divide the result by 23 to give 5 15/23, meaning that there will be an eclipse in the fifth month of the year.

3.2 The eclipse theory in the *Si fen li*

When the Eastern Han replaced the Xin Dynasty in AD 25, it continued to use the *San tong li*. However, several tests of the accuracy of the system and proposals to reform it were made, for example by Yang Cen 楊岑 in AD 62, Dong Meng 董萌 in AD 66, Zhang Sheng 張盛, Jing Fang 景防 and Bao Ye 鮑業 in AD 68, Jia Kui 賈逵 in AD 92, Zong Gan 宗紺 in AD 100, Huo Rong 霍融 in AD 102 and Cai Yong 蔡邕 in AD 175.[38] Bian Xin and Li Fan were appointed by the Han Zhang 章 Emperor to revise the calendrical system. However, the *Si fen li*, which recorded in the treatise of temperament and calendar in the *Hou han shu,* is possibly a combination of developments by other astronomers and the work done by Bian Xin and Li Fan.[39] The eclipse theory has been tested and revised a few times in the reforms mentioned above and this led to a much longer and complicated eclipse theory in the *Si fen li* than the *San tong li* theory. But both system use the same eclipse period, 23 eclipse possibilities in 135 months:[40]

月食數之生也，乃記月食之既者。率二十三食而復既，其月百三十五，率之相

---

[38] See below Table 5.1 for the reasons and results of these calendrical reform suggestions. See Cullen (2000) for the details of Jia Kui's memorial, see Cullen (2007a) for three cases in the Eastern Han, Yang Cen, Jia Kui and Cai Yong debates, Cullen (2007b) for the reform by Huo Rong in AD 102. Yabuuti (1963) and Chen Meidong (2003) have also discussed the astronomical reforms in the Eastern Han in detail.

[39] Chen Meidong (2003) pp. 177-179.

[40] Chen meidong (2003).

除，得五〔月〕二十三之二十而一食。以除一歲之月，得歲有再食五百一十三分之五十〔五〕也。分終其法，因以與蔀相約，得四與二十七，互之，會二千五十二，二十而與元會。

元會，四萬一千四十。
蔀會，〔二〕千五十〔二〕。
歲數，五百一十三。
食數，千八十一。
月數，百〔三〕十五。
食法，二十〔三〕。

The origin of the number of lunar eclipse, is from marking the cycle of lunar eclipse. It governs 23 eclipses and when the cycle is completed, there are 135 months. The ratio from dividing, is 5 20/23 [months] per eclipse. Divide it from the months in a solar year, and get 2 and 5[5] / 513 eclipses in a solar year. To remove the factors separately, thus by finding the common multiple of (513 and) the Bu Factor. Get 4 and 27, to multiply each other, and meet at 2052, (multiply) 20 and it meets with *yuan*.

Yuan Meeting, 41040.
Bu Meeting, [2]05[2].
Sui Number, 513.
Eclipse Number 1081.
Month Number, 1[3]5.
Eclipse Factor, 2[3].

推入蔀術曰：以元法除去上元，其餘以紀法除之，所得數從天紀，筭外則所入紀也。不滿紀法者，入紀年數也。以蔀法除之，所得數從甲子蔀起。筭外，所入紀歲名命之，筭上，即所求年太歲所在。

The method to calculate into *bu* says, take out Epoch Factor from the Ultimate Epoch, divide the remainder by Era Factor, the number you get follows the heavenly era. Count out, it is the era you entered. What less than the Era Factor, is the year number inside that era. Divide it by the Bu Factor, the result begins from the *Jia zi bu*. Count the preceding out, name it by the *sui* name of that *Era*. Count the preceding in, it is where the *tai sui* is of the year to calculate.[41]

推月食所入蔀會年，以元會除去上元，其餘以蔀會除之，所得以〔二〕十〔七〕

[41] Where the *tai sui* is of the year means to calculate the name of a year in the *ganzhi* sequence.

乘之，滿六十除去之，餘以二十除〔，〕所得數從天紀，筭外，所入紀。[42]不滿二十者，數從甲子蔀起，筭外，所入蔀會也。其初不滿蔀會者，入蔀會年數也。各以〔所〕入紀歲名命之，筭上，即所求年〔太歲所在〕。

To calculate the year of a lunar eclipse in a *bu*, take out Yuan Meeting from the Ultimate Epoch, divide the remainder by the Bu Meeting, multiply (27) to the result, take out 60 when it reaches 60, divide the remainder by 20, what you get follows the heavenly order, take one from it, inside the *Era*, if it does not reach 20, the number begins from the *bu* of *jiazi*, take one from it, it is the entry to the Bu Meeting. When it first does not reach the Bu Meeting, it is the year number into that *bu*. Count the preceding in, it is (where the *tai sui* is) at of the year to calculate.
(*Hou han shu*, chapter 13)

There are two sections of texts related to eclipses in the *Si fen li*. The first section provided the eclipse period, related astronomical terms, and the method to calculate the cycle of *bu*, which is related to the eclipse theory in the second section. The second section provided detailed methods to predict eclipses. Between these two sections are other parts of the calendrical system. The first section began by straightforwardly giving the eclipse period of the system, 23 eclipses in 135 months. Then it explains the astronomical meaning and value of the six terms listed behind. According to this eclipse period, Month Number is 135 and Eclipse Factor is 23. It gives the length of time for an eclipse, and the number of eclipses in a solar year (*sui*). In the *Si fen li*, there are 235 / 19 months in a *sui*. Divide 235 / 19 by 135 / 23 and the result is that, in each solar year, there are 2 and 55 / 513 eclipses, or 1081 / 513 eclipses. After 513 years, the eclipse period comes to a complete cycle in line with the intercalation cycle. Thus, 513 is named the Sui Number. 1081 is the Eclipse Number. Then the text calculates the least common

[42] The text in the *Han hou shu* (1965) edtion is:"余以二十除所得數，從天紀，算外，所入紀。"Here I adopted the revised version by Liu (2003). Chen (2008) adopted Liu's suggestion on the punctuation.

number of the Sui Number 513 and the Bu Factor 76: 513 × 4 = 2052 and 76 × 27 = 2052. This makes 2052 the value of Bu Meeting, which equals a cycle of 4 times the Sui Number. All these periods repeat after a yuan, "(multiply) 20 and it meets with yuan," this is why 41040 is named the Yuan Meeting. Table 3.1 summarizes the relevant values found in the *San tong li* and the *Si fen li*.

The second and third paragraphs in the first section are a preliminary stage in the calculation of an eclipse. It calculates the name of the year with an eclipse in the *ganzhi* sequence. First it calculates the position of the year to be calculated in the cycle of a *bu*, which combines the eclipse period, as well as the cycles of year, month and day. It could be useful to the eclipse prediction by telling us when an eclipse happen in a year, the position of that year in a *bu*. In the *San tong li*, a similar cycle, 513 years, is called the Meeting Year (*hui sui* 會歲). During this period, there are 1081 eclipses. The aim of the eclipse prediction method in the *Si fen li* is to find out the time of the happening of eclipse according to the eclipse cycle. If we know the beginning of the *bu* cycle, then we know the starting point to apply the eclipse prediction method. Cycles bigger than a *bu* include *yuan* and Era. In order to find the position of a year in a *bu*, first we need to find out when does the *bu* begin. We locate the biggest cycle *yuan* by taking out the cycles of *yuan* from the Ultimate Epoch, then find a smaller cycle *ji* by taking out the cycles of Era from the remainder. Once the number we get is less than an Era then we calculate how many *bu* there are in this period. At the end we find when an eclipse happens in

San tong li					
Eclipse period	equals	135 months			
Rule		235 months	6939.75 days		
1 Meeting Year		27 Rule	47 EP	513 years	6345 months
1 *tong*		81 rule	1539 years	19035 months	
1 *yuan*		3 *tong*	4617 years		
Ultimate Epoch		5120 *yuan*	15360 *tong*	23639040 years	
Si fen li					
synodic month	equals	29 499 / 940 days			
tropical year		365 1/4 days			
1 Rule		Rule Month 235 months	6939 3/4 days		
1 *bu*		4 Rule	Bu Factor 76	Bu yue 940 months	Bu ri 27759 days
1 Era		20 *bu*	80 Rule	Era Factor 1520	Era month 18800 months
1 *yuan*		3 Era	60 *bu*	240 *bu*	Yuan Factor 4560
Ultimate Epoch		2760320 years			

Table 3.1 The different cycles in the *San tong li* and *Si fen li*. For example, in both the *San tong li* and the *Si fen li*, 1 Rule equals 235 months, which also equals 6939.75 days. The Chinese names are provided along with the number for terms specifically referred to in the system.

a year and the position of that year in a *bu*. The method to calculate into *bu* says keep taking out Epoch Factor (4560) from the Ultimate Epoch, until the remainder is less than an Epoch Factor. According to the table of the names of *ji* and *bu* in the *Si fen li*, there are three eras in a yuan: the era of heaven, the era of earth and the era of human. Divide the remainder by the Ji Factor, if the number you get is 1, it follows the era of heaven; if it is 2, it follows the era of earth; if it is 3, it follows the era of human. Similarly, we find out the name of the *bu* according to the same table. The next section is to calculate the year of a lunar eclipse in a *bu*, by taking out the Yuan Meeting from the Ultimate Epoch. Since 1 Bu Meeting equals 27 *bu*, it multiplies the number of *bu* (27) to the result, and keeps taking out the *ganzhi* cycle 60, then divides by 20 to convert the cycle of *ganzhi* (60) to the cycle of the name of *ji* (3). We then find the entry again according to the table of the names of *ji* and *bu*. These entries are calculated because it is helpful know where the year is in a bigger cycle. After locating the position in a bigger cycle it is then possible to use the eclipse cycle to predict the time of eclipse in that year.

> 推月食術曰：置入蔀會年數，减一，以食數乘之，滿歲數得一，名曰積食，不滿爲食餘。以月數乘積[食]，滿食法得一，名爲積月，不滿爲月餘分。積月以章月除去之，其餘爲入章月數。當先除入章閏，乃以十二除去之，不滿者命以十一月，筭盡之外，則前年十一月前食月也。求入章閏者，置入章月，以章閏乘之，滿章月得一，則入章閏數也。余分滿二百二十四以上至二百三十一，爲食在閏月。閏或進退，以朔日定之。求後食，加五[月]二十分，滿法得一月數，命之如法，其分盡食筭上。
>
> The method to calculate lunar eclipse says: set the number of years into the Bu Meeting, subtract 1, multiply it by the Eclipse Number, turn to 1 when it reaches the Sui Number, name it the accumulated eclipses, the remainder is called the Eclipse Remainder.

Multiply the Month Number to accumulated eclipses, turn to 1 when it reaches the Eclipse Factor, name it accumulated months, the remainder is Month Remainder Fen. Keep taking out Rule Month from accumulated months, the remainder is the number of months in the Rule. First keep taking out intercalation from the Rule, use 12 to keep subtracting from it, the remainder is named by the eleventh month, take out one from the count, it is the eclipse month before the eleventh month of the year before last. To calculate intercalations in the Rule, set the month into the Rule, multiply it by the Rule Intercalation, convert to 1 when it reaches the Rule Month, then it is the number of intercalations in the Rule. If the remainder is between 224 and 231, the eclipse is in an intercalary month. The advance and retreat of the intercalation, is known by the *shuo* day. To calculate the next eclipse, add 5 months and 20 *fen*, turn to 1 in the number of months when it reaches the Factor. Count it as if it is the Factor, when the fen ends, count in an eclipse.

推月食朔日術曰：置食積月之數，以二十九乘之，爲積日。又以四百九十[九]乘積月，滿蔀月得一，以并積日，以六十除之，其餘以所會蔀名命之，筭盡之外，則前年天正前食月朔日也。

求食日，加大餘十四，小餘七百一十九半，小余滿蔀月爲大餘，大餘命如前，則食日也。

The method for calculating the *shuo* day of a lunar eclipse says: use the number of Accumulation Month of Eclipse, multiply it by 29, to get the Accumulated day. Multiply 499 to the accumulated months, turn to 1 when it reaches the Bu Month, add it to the Accumulated day, divide it by 60, name the remainder by the name of *bu* of the conjunction. Take out one from it, it is the *shuo* day of the eclipse month before the Heavenly Right of the year before last year.

To calculate the day of eclipse, add 14 to Major remainder, 719 1/2 to Minor Remainder, turn Minor Remainder to Major Remainder when it reaches the Bu Month, use Major Remainder to follow the earlier method, then it is the eclipse day.

求後食朔及日，皆加大餘二十七，小餘六百一十五。其月餘分不滿二十者，又加大餘二十九，小餘四百九十九。其食小餘者，當以漏刻課之，夜漏未盡，以筭上爲日。

To calculate the *shuo* day of the next eclipse, add 27 to Major Remainder, 615 to Minor Remainder. When the Remainder fen of the month does not reach 20, again add 29 to the Major Remainder, 499 to the Minor Remainder. The minor remainder of the eclipse, should be examined by water clock, if the water clock has not finished over the night, count in the preceding day.

一術，以歲數去上元，餘以〔月章乘之，章法而一〕爲積月，以百一十二乘之，滿月數去之，餘滿食法得一，則天正後食。[43]

Another method: Take out the Sui Number from the Ultimate Epoch, [multiply *yuezhang* to the] remainder, [divide it by Zhang Factor,] it is the accumulated months, multiply it by 112, take months out when it reaches a month, convert to 1 when remainder reaches the Eclipse Factor, then it is the second eclipse after the beginning of the year.
[*Hou han shu*, chapter 93]

This passage contains the main eclipse theory in the *Si fen li*, including calculations of the *shuo* day of a lunar eclipse, the day of that eclipse, the next *shuo* day and eclipse day, as well as a second method. In the method to calculate lunar eclipse, multiply the number of eclipses 1081 / 513 in a solar year to the number of years to find the number of eclipses in whole numbers (the accumulated eclipses) and fractions (the Eclipse Remainder). Now we have a number for the eclipse and we need to know the month of the eclipse. We multiply the Month Number 135 to the accumulated eclipses, and keep taking out the Eclipse Factor from it to get the Accumulated Months. If we know the beginning point and the number of months between, we know when an eclipse happens. We first take out whole numbers of months of the cycles of Rule from the Accumulated Months, then the intercalary months during that period. Finally, we divide the result by 12 to see the year number and the month number of the lunar eclipse. To calculate the next eclipse, simply add 5 20 / 23 months to it.

[43] The text in the Han hou shu (1965) edtion has: "以歲數去上元，余以爲積月，以百一十二乘之." Here I adopted the revised version by Li (1890) and Liu (2003). Chen (2008) also adopted Li and Liu's suggestion.

The method for calculating the *shuo* day of a lunar eclipse aims to calculate the name of the *shuo* day, and then the eclipse day. The method is to separately multiply 29 and 499 to the Eclipse Accumulation Month and then add the results together. It is mathematically identical to multiplying 29 499 / 940, the length of synodic month to the number of Accumulation Month of eclipses, to get the number of days. The next step is to divide that number by 60 to find the name in the *ganzhi* cycle. To calculate the day of the eclipse is to add half a month (14 719.5 / 940) to the result, and follow the same method to find the name. This is because the preceding calculation is for the day of conjunction at the beginning of the month and so we need to add ½ a month to get to opposition for a lunar eclipse. To calculate the *shuo* day of the next eclipse, the next eclipse possibility is 5 20 /23 months away from the current one, which means the next eclipse possibility is either 5 or 6 months away from the current one. If it is 5 months away, we add 5 × 29 499/940, which equals 147 615 / 940 to the Major and Minor Remainder. Since the result would be in the *ganzhi* sequence, that equals adding 27 615 / 940 to the Major and Minor Remainder. If the next eclipse possibility is 6 months away from the current one, we add another month to the result. Whether the next eclipse is at a 5 or 6 months interval is determined by whether the Remainder fen of the month reaches 20 or not, and we will either add 27 to Major Remainder, 615 to Minor Remainder or add another 29 to the Major Remainder, 499 to the Minor Remainder. Finally, the text emphasized checking the Minor Remainder by means of observation rather than simply calculation. It suggests to use the water clock to check whether the result is at the preceding day or the following day.

One more problem needs to be addressed here. One difficulty in interpreting terms in calendrical systems is related to how the terms are constructed. Rather than modern Chinese which use words in expression, Classical Chinese usually uses single characters to construct a sentence. However, a particular exception here is that many technical terms in calendrical systems were words combined from two or more characters. There are two kinds of these terms, first, when they were constructed, characters with its own meaning were combined to give the term a combined meanings, for example, Yuan Meeting has the character *yuan*, meaning origin or beginning, and the character *hui*, meaning meeting or cycle (Sivin calls it Epoch Cycle in his 1969 article). The second situation is these so called terms may or may not be of the same meaning as we understand it as a term in astronomical theories. They could also be simply a combination of meanings of Chinese character. For example, the term *hui yu sui* 會餘歲 simply puts the character 餘 (remainder) in between *hui sui* 會歲, to show the remainder of the Meeting Year. Here *hui sui* is constructed from the first rule and *hui yu sui* is constructed following the second rule, and yet they were used in calendrical systems together.

3.3 The eclipse theory in the *Qian xiang li*

In AD 206, an amateur astronomer Liu Hong 劉洪 constructed and submitted a system, the *Qian xiang li* after decades of observations, investigations and debates with other astronomers. Although Liu only served as an astronomical official for a very short time of his bureaucracy career, his system was a major step forward compared to earlier systems, with considerations for the first time of the variable lunar velocity.[44] In the *Qian xiang li* the eclipse theory was not considered as its major development, yet has its own features. The eclipse period is given by the terms including the Meeting Year 893, the Meeting Month 11045 and the Meeting ratio 1882. These terms mean there are 1882 eclipses in 893 years, which equals 11045 months. As a result, there are 5 and 1635 / 1882 months between two eclipses. This is a more accurate number than the *San tong li* and the *Si fen li*. The *Qian xiang li* period is 11045 / 1882 months, which in decimal equals 5.8687566 months; the equivalent value in the *San tong li* and the *Si fen li* is 135 / 23 months, 5.8695652 months. The modern value of this period is 5.8688183 months.

The *Qian xiang li* eclipse theories are as follows:

> 推月蝕
>
> 置上元年，外所求，以會歲去之，其餘年以會率乘之，如會歲爲積蝕，有餘加積一。會月乘之，如會率爲積月，不盡爲月餘。以章閏乘餘年，滿章歲爲積閏，以減積月，余以歲中去之，不盡，數起天正。
>
> 求次蝕，加五月，月餘千六百三十五，滿會率得一月，月以望。
>
> Lunar eclipse prediction
>
> Set the year of the Ultimate Epoch, do not count the calculating year in, take out the Meeting Year from it, multiply the Meeting Ratio to the remainder of the years, divide it

[44] See Chen Meidong (1986) for Liu Hong's life and his astronomical achievements.

> by the Meeting Year to get accumulated eclipses, add 1 to the accumulation if there is a remainder. Multiply the result by the Meeting Month, divide the Meeting Ratio to get the accumulated months, the left is the remainder of months. Multiply Rule Intercalation to the remainder of years, turns it to accumulated intercalations when it reaches the Rule Year, subtract it from the Accumulated Month, keep taking out *sui zhong* from it,[45] for the remainder, count it from the heavenly beginning.
>
> To calculate the next eclipse, add 5 months, 1635 to the remainder of month, turns it to 1 when it reaches Meeting Ratio, it is at the full moon of the month.
> (*Jin shu*, chapter 17)

The method here is very similar to the eclipse prediction method in the *Si fen li*. First find the number of years after taking out whole numbers of eclipse cycles. The steps are to keep taking out the Meeting Year 893 from the Ultimate Epoch. Then calculate the number of eclipses during the period by multiplying by the Meeting Ratio 1882 and dividing by the Meeting Year. Finally multiply by the Meeting Month 11045 and divide by the Meeting Ratio 1882 to convert the number of eclipses to months. The result will be known after taking out intercalary months. To calculate the next eclipse, Liu Hong simply adds the time between two eclipses, 5 1635 / 1882 months, to the current eclipse.

In the *Qian xiang li*, Liu Hong further improved the traditional method by the invention of eclipse limits. Eclipse limits show the distance between the sun and the moon's positions. If the distance is within of a certain range when an eclipse possibility happens, an eclipse will happen. In a table showing the distance between the Yellow Path, the sun's path and the White Path, the moon's path, in a month, Liu Hong recorded his eclipse limits in two entries:

[45] *sui zhong* equals 12.

二日，限餘千二百九十，微分四百五十七。此爲前限
……
十三日，限餘三千九百一十二，　微分一千七百五十二。此爲後限

Day 2, the limit remainder is 1290, minor factor is 457. It is the Front Limit.
……
Day 13, the limit remainder is 3912, minor factor is 1752. It is the Back Limit.
(*Jin shu*, chapter 17)

When the sun and the moon are in motion, they do not always stay in the same plane. At an opposition, there might be an eclipse when the sun and the moon cross each other's orbit (an eclipse possibility). If the cross coincidence happens within a certain range, an eclipse could happen. In this passage, Liu Hong presented Eclipse Limits as ranges. According to the text, we know the Front limit is 1 days and (1290 457 / 2209) / 7874, between day 2 and day 3, and the Back limit is 12 days and (3912 1752 / 2209) / 7874, between day 13 and day 14. Chen Meidong (1991) explained how these numbers are calculated:

1) Since a solar year 365 145 / 589 = 215130 / 589 days

2) 215130 × 941 half of Meeting Ratio / 11045 the Meeting Month = (18328 914/2209) / 2

3) (18328 914/2209) / 2 = 1 (1290 457 / 2209) / 7874

4) 13 5203 / 7874 - 1 (1290 457 / 2209) / 7874 = 12 (3912 1752 / 2209) / 7874

These limits numbers are in the unit of day. Chen Meidong converted the numbers into unit of *du*: Liu Hong uses less than 14 1115/1457 *du* and greater than 158 (790+232/1882)/1457 *du* as the eclipse limits.[46]

[46] See Chen Meidong (1991) for the numbers and calculation of the eclipse limits.

3.4 Summary

There is no evidence of an eclipse theory before the Han. My discussion in the second chapter showed the development of solar eclipse divination from the pre-Qin to the Han. Such a type of divination, which focuses on anomalous events, is unlikely to have developed if astronomers were already able to make accurate predictions of solar eclipses. This provides further evidence that there was no solar eclipse theory before the Eastern Han.

As the first calendrical system which include an eclipse theory, Liu Xin provided the first eclipse cycle, which is 23 eclipses in 135 months, as well as a simple but clear eclipse prediction method, in the *San tong li*. In the Eastern Han, the new calendrical system the *Si fen li* used a same eclipse period as the *San tong li*. However, the way that the eclipse period is used is a part of a much more complicated system. Later, in the Three Kingdoms period and the Jin, several new techniques were incorporated into eclipse theory, in particular the consideration of lunar velocity. Compared to the early theories the *Qian xiang li* is significant for the adoption of lunar velocity theory.[47] It was not directly used in the *Qian xiang li* eclipse theory, but was related to the invention of the concept of eclipse limits. Liu Hong is the first astronomer in China who constructed method to discuss this. His eclipse limit provided a lead to later astronomers and inspired them to discover theories not only concerning the time of eclipses, but also related issues such as the magnitude and direction. In the next chapter, we

[47] Cullen (2002).

will be able to see more eclipse theories by Yang Wei, who learned from Liu Hong. There is a clear pattern to the chronological development of eclipse theories. Over time, better eclipse cycles were applied and more features of the eclipses were calculated.

Chapter Four The Eclipse Theory in the *Jing chu li*

As the official calendrical system of the Wei Kingdom during the Three Kingdoms period, the Jin dynasty and then the Song dynasty, the *Jing chu li* was used for more than 200 years. From the *San tong li* to the *Jing chu li*, eclipse theory expanded from predicting only the date of eclipse to calculating various other details of the eclipse. It also developed from only relying on an eclipse cycle to combining cycles with newly developed theories such as the lunar velocity theory. Thus, the development of eclipse theory is a marker of the development of mathematical astronomy in the calendrical systems in early imperial China. This chapter aims to investigate the methods of solar and lunar eclipse prediction in the *Jing chu li* (Luminous Inception System 景初曆). In addition to translations and commentaries on the texts concerning eclipse theory in the *Jing chu li*, further analysis will be made in this chapter of the mathematical astronomy related to the texts.

4.1 The general eclipse prediction method in the *Jing chu li*

Liu Hong made significant developments to the mathematical astronomy in calendrical system, for example, the lunar velocity theory in his *Qian xiang li*. However, as discussed in chapter three, his eclipse theory was not significantly better than the earlier systems, at least according to the text of his system. The *Jing chu li* was constructed by Yang Wei, and was adopted by the Wei kingdom in AD 237 after a few years of debates and contest between different calendrical systems.[48] It was constructed only three decades later than the *Qian xiang li*, yet has a much more complicated eclipse theory. Three issues are discussed in the eclipse section in the *Jing chu li*: first, the general eclipse method; second, related issues in eclipse prediction, for example the magnitude of the eclipse, the relative position of the moon to the sun's path, and the direction of obscuration when the eclipse happens; and third, the adoption of lunar velocity theory in the eclipse theory in order to determine the time of the eclipse.

Similar to the earlier systems, the *Jing chu li* uses an eclipse period and other cycles in its general eclipse method. The section reads as follows:

> 推合朔交會月蝕術曰：置所入紀朔積分，以所入紀下交會差率之數加之，以會通去之，餘則所求年天正十一月合朔去交度分也。以通數加之，滿會通去之，餘則次月合朔去交度分也。以朔望合數各加其月合朔去交度分，滿會通去之，餘則各其月望去交度分也。朔望去交分，如朔望合數以下，入交限數以上者，朔則交會，望則月蝕。
>
> The method of calculating conjunction, the Cross Coincidences, and lunar eclipse says: use the Lunar Accumulated Fen of that Era, add the number of the Draconitic-Synodic Differential Value of that Era to it, take the Conjunctional Connect out of it, the remainder is the Draconitic Value at the new moon of the eleventh month of the year. Add the Connect Number to it, take the Conjunctional Connect out when it reaches Conjunctional Connect, the remainder is the Draconitic Value at the new moon of the next month. Add the Syzygy Conjunction Constant to the Draconitic Value of the new moon of one month, take the Conjunctional Connect out when it reaches Conjunctional Connect, the remainder is the Draconitic Value at the full moon of the month. If the

[48] See Morgan (2013) and section 5.2 of this dissertation for a detailed discussion on the Huang chu debates.

> Draconitic Value at the new or full moon is smaller than the Syzygy Conjunction Constant or bigger than the Inner Draconitic Limit, there will be Cross Coincidence at the new moon, lunar eclipse at the full moon.
> (*Jin shu,* chapter 18).

Even though the first sentence of the text indicates it only predicts lunar eclipse, it is quite clear that this method is also intended to be used in the prediction of solar eclipse, given that both the new moon's day and the full moon's day are mentioned. The basis of the general eclipse method is to calculate the differences between one cycle and another, here, between the draconitic cycle and the eclipse cycle. In Fig. 4.1, the arc above the line shows the draconitic cycle (corresponding to the draconitic month, the time between the moon's crossing of the ecliptic in the same direction) starting from the beginning of the Era. The arc below the line shows the eclipse cycle (the mean time between eclipse possibilities), which starts a little earlier than the beginning of the Era. The reason it starts earlier is because Yang Wei invented a term Draconitic-Synodic Differential Value to mark the difference at the beginning of the Era between the draconitic cycle and the synodic cycle. This is the first time calculations in a calendrical system are designed to start from multiple points rather than from the Li Epoch (*li yuan* 曆元) only. The Draconitic-synodic differential value for *Jia shen* Era 甲申紀 is 620139.

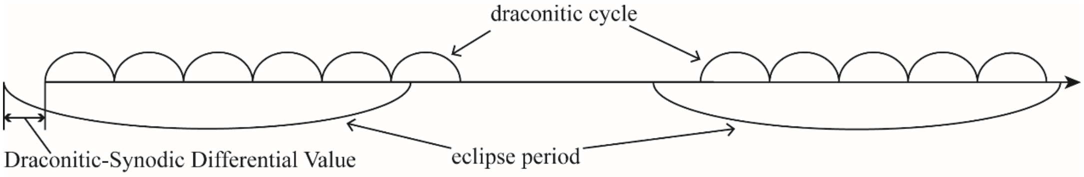

Figure 4.1 The draconitic cycles, eclipse periods and the Draconitic-Synodic Differential Value

The principle of this method is to calculate the Draconitic Value, the interval between the moment of the beginning of the draconitic cycle and the moment of conjunction. This shows the difference in time between the moment of conjunction and the moment when the lunar latitude is zero. If they are close enough, an eclipse may happen. If they are not close, the distance between the moon and the sun will be too great for the shadow to cause the eclipse. The way to judge whether it is close enough is to use eclipse limits, which are named the Syzygy Conjunction Constant and the Inner Draconitic Limit in the *Jing chu li*. The term Lunar Accumulated Fen refers to the fen at the beginning of one particular month and equals the number of synodic months from the beginning of that Era to the month we are calculating multiplied by the Connective Number, *tongshu* 通數 134630, the length of a synodic month in the unit of the Day Divisor. The Chinese character fen shows the period related to the Lunar Accumulated Fen is also in the unit of Day Divisor, 1/4559 of one day. To calculate the Draconitic Value, one should take multiples of the Conjunctional Connect, 790110, out of the sum of Lunar Accumulated Fen and Connective Number to get the result. The term Inner Draconitic Limit shows how close is the end of one draconitic cycle to the end of one eclipse period: if the result is smaller than 67315 or bigger than 722795, there will be either a solar eclipse possibility at the new moon or a lunar eclipse at the full moon (recall that all the calculations are in the unit of the Day Divisor). See Fig. 4.2 for the situation around the end of the cycles. The arc above the line shows the draconitic cycle, the arc below the line shows where one eclipse cycle ends.

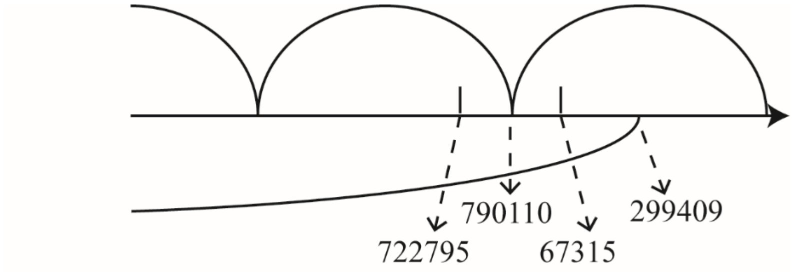

Figure 4.2. Inner Draconitic Limit.

For example, if we want to calculate the first year of Jing Chu 景初, AD 237, according to the first sentence in the *Jing chu li*, "From (the year of) *Ren Chen* to the first year of the Jing Chu, there is a total of 4046 years." 壬辰以來，至景初元年丁巳歲，積四千四十六，算上。[49] Each Era has 1843 years and so the first year of Jing Chu will be the 360th year of the third Era, *Jia Shen* 甲申 Era. We now only need to consider the situation in the *Jia Shen* Era in the general eclipse theory. To calculate the total number of months before the first year of Jing Chu, we multiply 360 by 235 and divide by 19 to find the result 4452 12/19. This means there are a total of 4452 months before the eleventh month of the first year of Jing Chu. To calculate the Lunar Accumulated Fraction, we multiply the accumulated months 4452 by the Connective Number, 134630. The result of the Lunar Accumulated Fraction is 599372760. To calculate the Draconitic value, we add the Draconitic-Synodic Differential Value for the *Jia Shen* Era 620139 to it, take multiples of Conjunctional Connect, 790110, out, and the result 299409 is the Draconitic Value of the new moon's day of the eleventh month of the year. This value is bigger

[49] *Jin shu*, chapter 19.

than 67315 but smaller than 722795, so there is neither a Cross Coincidence at the new moon nor a lunar eclipse possibility at the full moon in this eleventh month.

4.2 The theory of direction, position and eclipse limits

Compared to earlier calendrical systems, the *Jing chu li* eclipse theory is not significantly better in its general method to predict eclipses because it still relies upon the use of mean cycles. Where the *Jing chu li* eclipse theory shows considerable improvement over earlier theories, however, is in its ability to calculate additional information about the predicted eclipses. This section discusses the parts of the eclipse theory which enable the calculation of the magnitude of an eclipse, the relative position of the moon to the sun's path, and the direction of obscuration when the eclipse happens.

> 推合朔交會月蝕月在日道表裏術曰：置所入紀朔積分，以所入紀下交會差率之數加之，倍會通去之，餘不滿會通者，紀首表，天正合朔月在表；紀首裏，天正合朔月在裏。滿會通去之，表滿在裏，裏滿在表。[50] 求次月，以通數加之，滿會通去之，加裏滿在表，加表滿在裏。
>
> The method of calculating whether the moon is outside or inside the solar path at conjunction, the Cross Coincidence and lunar eclipse says: set the Lunar Accumulated Fen of that Era, add the number of the Draconitic-Synodic Differential Value of that Era to it, take doubles of the Conjunctional Connect out of it, the remainder is less than a Conjunctional Connect, if the beginning of Era is outside, at the conjunction of astronomical first month, the moon is outside; if the beginning of Era is inside, at the conjunction of astronomical first month, the moon is inside. Take out a Conjunctional Connect when it reaches a Conjunctional Connect. When fills up outside, it is inside, when fills up inside, it is outside. To calculate the next month, add the Connect Number

[50] The Zhonghua shuju *Jin shu* edition texts reads "表滿在裏，裏滿在表。". The Zhonghua shuju *Song shu* edition texts reads "表在裏，裏在表。". According to Chen Zhanyun (1988), the text should be "表滿在裏，裏滿在表。". Chen Meidong (2008) has also adopted this change to the *Song shu*.

to it, take out the Conjunctional Connect when it reaches one Conjunctional Connect. When adding fills up inside, it is outside, when adding fills up outside, it is inside.

先交會後月蝕者，朔在表則望在表，朔在裏則望在裏。先月蝕後交會者，看蝕月朔在裏則[次月]望在表，朔在表則望在裏。[51] 交會月蝕如朔望合數以下，則前交後會；如入交限數以上，則前會後交。其前交後會近于限數者，則豫伺之；前會後交近于限數者，則後伺之。[52]

When there is first a Cross Coincidence and then a lunar eclipse, if new moon is outside then full moon is outside, if new moon is inside then full moon is inside. When there is first a lunar eclipse and then a Cross Coincidence, see the month with an eclipse, if new moon is inside then [in the next month] full moon is outside, if new moon is outside then full moon is inside. If the Cross Coincidence of a lunar eclipse (the Draconitic Value) is less than the Syzygy Conjunction Constant, then first crossing and then conjunction. If (it) is more than the Inner Draconitic Limit, then first conjunction and then crossing. If first crossing and then conjunction, it is close to the Limit Number, then observe it in advance; if first conjunction and then crossing, it is close to the Limit Number, then observe it later.
(*Jin shu,* chapter 18).

This method is calculating whether the position of the moon is outside or inside the solar path at conjunctions and oppositions when there is a Cross Coincidence. The first paragraph presents the method step by step, the second paragraph explains a handy rule to quickly find the result. By setting the Lunar Accumulated Fen of that Era, and adding the number of the Draconitic-Synodic Differential Value of that Era, the difference between the draconitic cycle and the synodic cycle, we find the beginning of an eclipse cycle as the start point to calculate.

[51] The Zhonghua shuju edition texts is "看蝕月朔在裏則望在表", According to Liu (2003), the texts should be "看蝕月朔在裏則次月望在表"Chen (2008) adopted this change.
[52] The Zhonghua shuju *Jin shu* edition texts is "其前交後會近于限數者，則豫伺之；前會後交近于限數者，則後伺之", The Zhonghua shuju *Song shu* edition texts is "其前交後會近于限數者，則豫伺之前月；前會後交近于限數者，則後伺之后月" According to Liu (2003), there is no need to add 前月 or 后月 into the sentence and 后月 could cause misunderstanding. I agree with Liu.

Then we take double of the Conjunctional Connect (790110), the eclipse period (5 116960/134630 months, which equals to one Conjunctional Connect in *fen*, 790110 / 134630, the length of one month, equals 5 116960/134630 months), out of it. This is because when the moon crosses the solar path, it takes the moon an eclipse period to move away from the solar path, move back and reach the solar path again. Then it keeps moving to the other side of the solar path. As a result, the moon's position according to the solar path returns to its original place after two eclipses periods. If the remainder is less than one eclipse period, the position of the moon is the same to that at the beginning of that Era, or more precisely, the start point of our calculation, which is after adding the number of the Draconitic-Synodic Differential Value of that Era to the Lunar Accumulated Fen of that Era. If the remainder is more than one eclipse period but smaller than two, the position of the moon is on the opposite of that at the beginning of that Ji. If the remainder is more than one eclipse period and less than two eclipse periods, the moon will be on the opposite to the beginning of that Era, thus, "take out the Conjunctional Connect when it reaches one Conjunctional Connect, when it reaches outside, it is inside, when it reaches inside, it is outside."

To calculate the next month, add one synodic month, the Connect Number, then follow the same rule to determine whether it is the same as at the beginning of that Era or the opposite. If the remainder is less than one Conjunctional Connect, the position of the moon is the same as it was in the last month, if the remainder is more than one Conjunctional Connect, take one

Conjunctional Connect out of it, and the position of the moon is on the opposite side: "When adding fills up inside, it is outside, when adding fills up outside, it is inside."

For example, let us try to calculate whether the position of the moon is outside or inside the solar path of the first month of the second year of Jing chu 景初, AD 238. As we calculated in the last section, we multiply the accumulated months 4452 to the Connect Number (*tongshu* 通數, 134630, the length of a synodic month) to get the accumulated lunar fraction 599372760. Then add the Draconitic-Synodic Differential Value (*jiaohui chalü* 交會差率) for *jia shen ji* 620139 to it, take multiples of doubles of Conjunctional Connect (*huitong* 790110) out, the result is 1089519. It is bigger than one Conjunctional Connect and smaller than the double of Conjunctional Connect 1580220. At the beginning of the third Ji, the position of the moon is inside the solar path. As a result, the position of the moon at the first month of the second year Jingchu is on the opposite to that at the beginning of that Ji. It is outside the solar path.

The text continues with the theory to calculate the Draconitic Value

求去交度術曰：其前交後會者，今去交度分如日法而一，所得則却去交度分也。[53] 其前會後交者，以去交度分減會通，餘如日法而一，所得則前去交度也，餘

[53] Both the Zhonghua shuju *Jin shu* and *Song shu* texts are "今去交度分如日法而一", the *Song shu* edition suggests in a note to change "今" to "令".

皆度分也。[54] 去交度十五以上，雖交不蝕也。十以下是蝕。十以上，虧蝕微少，光晷相及而已。虧之多少，以十五爲法。

The method of calculating the *du* of the Draconitic Value says: when there is first an conjunction and then a crossing, divide the *fen* of the Draconitic Value by the Day Divisor, the result is the Backward Draconitic Value, the remainder is the fraction. When there is first a crossing and then a conjunction, take Conjunctional Connect from Draconitic Value Fen, divide the remainder by the Day Divisor, the result is the Forward Draconitic Value, the remainders are the fractions of *du*. If the *du* of the Draconitic Value is more than 15, there is a Cross Coincidence but no eclipse. If it is less than 10, there is an eclipse. If more than 10, the obscuration of eclipse is very small, just a contact of light and shadow. The magnitude of obscuration, 15 is used as the denominator.
(*Jin shu,* chapter 18).

At the beginning of section 4.1, the general eclipse prediction method started by calculating the *qujiaodu fen* 去交度分, Draconitic Value in the unit of *fen,* at the beginning of a year and that of the next month. This paragraph shows how to further calculate the *du* of the Draconitic Value, and how to use it to predict the magnitude of an eclipse. The Draconitic value comes from taking the Conjunctional connect out of the sum of lunar accumulated fen and Connect Number. The principle is straightforward and simple: divide the Day Divisor from the *fen* of the Draconitic Value to get the *du* of the Draconitic Value. But there is a difference between first an opposition or first a conjunction. If there is first a lunar crossing (opposition) and then a solar crossing (conjunction), the Draconitic Value we are calculating is ahead of the crossing we are looking at, thus it is forward. If there is first a solar crossing (conjunction) and then a lunar crossing (opposition), we need to take one eclipse period

[54] The Zhonghua shuju *Jin shu* edition texts is "所得則前去交度也。餘皆度分也。"The Zhonghua shuju *Song shu* edition texts is "所得則前去交度，餘皆度分也。" There is no difference in English translations.

(Conjunctional Connect, 790110) out, thus the Draconitic Value to be calculated, the difference to crossing, turns out to be the difference between this crossing to the beginning of the last eclipse cycle. Therefore, if there is first an opposition and then a conjunction, the result is called Backward Draconitic Value. If there is first a conjunction and then an opposition, take one eclipse period out of it and the result is called the Forward Draconitic Value. In comparing the positions of the sun and the moon when Cross Coincidence happens, the *Jing chu li* uses 15 as a denominator, and says that if the distance between the sun and the moon is more than 15 *du*, then the eclipse possibility will not turn into an eclipse; if it is between 10 and 15 *du*, there will be a minor contact, but it is possible that it could be spotted in observation; if the distance is less than 10 *du*, the distance is small enough for the eclipse to be clearly observed.

> 求日蝕虧起角術曰：其月在外道，先交後會者，虧蝕西南角起；先會後交者，虧蝕東南角起。其月在內道，先交後會者，虧蝕西北角起；先會後交者，虧蝕東北角起。虧蝕分多少，如上以十五爲法。會交中者，蝕盡。月蝕在日之衝，虧角與上反也。
>
> The method of calculating the obscuration beginning direction of solar eclipse says, when the moon is in the outer path, if there is first a conjunction and then a crossing, the obscuration begins from the south west corner, if there is first a crossing and then a conjunction, the obscuration begins from the south east corner. When the moon is in the inner path, if there is first a conjunction and then a crossing, the obscuration begins from the north west corner. If there is first a crossing and then a conjunction, the obscuration begins from the north east corner. The magnitude of eclipse is (known) as above with 15 as the denominator. If the conjunction was at crossing, the eclipse is total. The lunar eclipse is the opposite to the solar eclipse, the obscuration direction is the opposite.
> (*Jin shu,* chapter 18).

This section finishes with a method to calculate the direction of impact of solar eclipses. The rules are divided in the cases of whether the moon is in the outer or inner path, and whether the crossing or the conjunction happens first. The cause of an eclipse is that the sun on the solar path and the moon on the lunar cross each other. The text descripts the situation of solar eclipses, thus the direction shows how the moon contacts the sun, rather than the opposition. From the text we also understand if the moon is in the outer path, the contact is from the south of the sun, if the moon is in the inner path, the contact is from the north of the sun. The sun and the moon both move from west (left) to east (right). The moon moves much faster than the sun, thus it usually traces and contacts the sun from west to east. If it catches the sun before a crossing happens, it is to the west of the sun, then the direction is either south west, when the moon is in outer path, or north west, when the moon is in inner path. If the conjunction happens after a crossing, it looks like the sun is contacting the moon, although the moon moves faster and will let the contact be short. In this situation if the moon is in outer path, then the direction of contact is south east, when the moon is in inner path, it is north east. Finally, the text briefly mentioned the equivalent situation for lunar eclipses. The rules are opposite to those for solar eclipses, since it will be based on how the sun's shadow contacts the moon on its lunar path.

4.3 The adoption of lunar velocity theory in eclipse theory

One significant feature in the *Jing chu li* is the consideration of lunar velocity within eclipse theory. Earlier systems only used the mean synodic month to calculate eclipse times. The *Qian*

Xiang li is the first system in China to consider lunar velocity,[55] but in that system the lunar velocity theory was not applied to the prediction of eclipses. In the *Jing chu li*, lunar velocity is used to calculate the time of the eclipse. This is explained in the next section of the *Jing chu li*:

> 推合朔交會月蝕入遲疾曆術曰: 置所入紀朔積分, 以所入紀下遲疾差率數加之，以通周去之，餘滿日法得一日，不盡為日餘，命日算外，則所求年天正十一月合朔入曆日也。
>
> 求次月，加一日，日餘四千四百五十。求望，加十四日，日餘三千四百八十九。日餘滿日法成日，日滿二十七去之。又除餘如周日餘，日餘不足除者，減一日，加周虛。
>
> The method of calculating a lunar eclipse in the Velocity Calendar at the conjunction at the new moon, the Cross Coincidences says, first add the Velocity Differential Value of that Era to the Lunar Accumulated Fen of that Era, take (multiples of) the Connect Cycle out, what is left is in days if it reaches the Day Divisor, the remainder is the Day Remainder. Count out the starting day, it is the moment of the conjunction of the eleventh month of the to-be-calculated year in the Velocity Calendar.
>
> To calculate the next month, add one to day and 4450 to the Day Remainder. To calculate the full moon's day, add 14 to day and 3489 to the Day Remainder. Convert the remainder to days when it reaches the Day Divisor; take out the days when it reaches 27. Take the remainder from the Circuit Day Remainder. If the remainder is not enough to subtract, take one day from it and add the Cycle Vacancy to it.
> (*Jin shu,* chapter 18).

This section shows how to calculate the conjunction at the new moon, the Cross Coincidences and eclipses according to the Velocity Calendar. To calculate the conjunction, we first calculate the difference between the numbers in synodic month and anomalistic month. The start point of all calculation is the beginning of that Era. First add the Lunar Accumulated Fen, which corresponds to the length of time from the beginning of that Era to the first day of the

[55] Cullen (2002).

to-be-calculated month, to the Velocity Differential Value, which corresponds to the difference between the beginning of that Era to the moment of the moon's closest perigee. Take multiples of the Connect Cycle 125621, the length of anomalistic month, out of it. The result gives the difference between synodic months and anomalistic months. Accordingly, the result shows the difference between the synodic cycle and the velocity cycle. This section is a preparative step for the calculation afterwards. All calculations are in the unit of the Day Divisor.

To calculate the next month, add the difference between one synodic month and one anomalistic month: one synodic month is 134630/4559 and one anomalistic month is 125621/4559, thus the difference is (134630–125621)/4559 = 9009/4559 = 1 4450/4559. According to the text, "to calculate the next month, add one to day and 4450 to the Day Remainder". The full moon's day is half a month from the beginning of one month. Half a month is (134630/2)/4559, that equals 67315/4559, which is also 14 3489/4559. According to the text, "to calculate the full moon's day, add 14 to day and 3489 to the Day Remainder".

This method is calculating the day and fraction within the cycle of the anomalistic month. The following sections contain the Velocity Calendar, a table showing the velocity of the moon in different days in one month, and an explanation of how to calculate the true position of the moon based on the lunar velocity in any day. The table is named *Chi ji li* 遲疾曆(the three characters *chi* 遲, *ji* 疾 and *li* 曆 literally mean slow, fast and calendar) and is summarized in Table 4.1.[56]

The table shows the velocity of the moon in an anomalistic month. There are six parameters in the table: the day, the speed of the moon in *du* (degree), and fen (1/19 of a *du*), the Velocity Difference in fen, the Regulation Accumulative Fen in the Day divisor and the Lunar Traveling Fen. The Velocity Calendar in the *Qian xiang li* has five columns (see Table 4.2),[57] the velocity columns (*ri zhuan du* fen 日轉度分) are similar to column 1–3 in the Velocity Calendar in the *Jing chu li*. The Rate (*lie cui* 列衰) column only appears in the *Qian xiang li*. It shows the changing of the moon's day-to-day speed. The Velocity Difference (*sun yi lü* 損益率) column, the Velocity Accumulative fen (*ying suo ji fen* 盈縮積分) column and the Lunar Traveling Fen (*yue xing fen* 月行分) column are similar to the third, fourth and fifth column here. The Velocity Accumulative fen in the *Jing chu li* appears in the unit of Day Divisor after multiplying 4559 to the Velocity Accumulation.

56 The velocity table in the *Jing chu li* is based upon the one devised by Liu Hong in the *Qiang xiang li* but calibrated to work with the *Jing chu li* Day Divisior.

57 For a detailed discussion of the velocity table in the *Qian xiang li*, see Cullen (2002).

1	2	3	4	5	6
	The velocity 月行遲疾度		Velocity Difference 損益率	Regulation Accumulative Fen 盈縮積分	Lunar Traveling Fen 月行分
Day	unit: *du*	fen_1 (1 / 19 *du*)	fen_1	fen_2	fen_1
1	14	14	More 26	The beginning of +	280
2	14	11	More 23	+ 118534	277
3	14	8	More 20	+ 223391	274
4	14	5	More 17	+ 314571	271
5	14	1	More 13	+ 392074	267
6	13	14	More 7	+ 451341	261
7	13	7	Less	+ 483254	254
8	13	1	Less 6	+ 483254	248
9	12	16	Less 10	+ 455900	244
10	12	13	Less 13	+ 410310	241
11	12	11	Less 15	+ 351043	239
12	12	8	Less 18	+ 282658	236
13	12	5	Less 21	+ 200596	233

14	12	3	Less 23	+ 104857	231
15	12	5	More 21	The beginning of -	233
16	12	7	More 19	- 95739	235
17	12	9	More 17	- 182360	237
18	12	12	More 14	- 259863	240
19	12	15	More 11	- 323689	240
20	12	18	More 8	- 373838	243
21	13	3	More 4	- 410310	246
22	13	7	Less	- 428546	250
23	13	12	Less 5	- 428546	259
24	13	18	Less 11	- 405751	265
25	14	5	Less 17	- 355602	271
26	14	11	Less 23	- 278099	277
27	14	12	Less 24	- 173242	278
Circuit Day	14 *du* 13 *fen*, 626		Less 25 and 626	- 63826	279 626 / 4559

Table 4.1. Velocity Calendar (lunar velocity table) in the *Jing chu li*.

1	2	3	4	5	6	7
	the velocity		Rate	Velocity Difference	Velocity Accumulation	Lunar Traveling Fen
Day	Unit: *du*	Fen (1 / 19 *du*)		Fen		Fen
1	14	10	Lag - 1	More 22	The beginning of + (Ying 盈)	276
2	14	9	Lag - 2	More 21	+ 22	275
3	14	7	Lag - 3	More 19	+ 43	273
4	14	4	Lag - 4	More 16	+ 62	266
5	14	0	Lag - 4	More 12	+ 78	262

Table 4.2. The first five days of the Velocity Calendar in the *Qian xiang li.*

In the first column of the *Jing chu li* velocity table, days are sequentially listed from 1 to 27. The Circuit Day in the last line refers the fraction of the day in an anomalistic month after 27 whole days. This fraction is 2528 / 4559 in the *Jing chu li*. In column 2 and 3, the speed of the moon is listed day by day in *du* and *fen*, = 1 / 19 *du*. In the fourth column, the Velocity Difference compares the speed of the moon on one day and the average daily speed. From day 1 to day 14, "less" means add the speed by a certain number to get the average speed; "more" means subtract the speed by a number to reach the average speed. From day 15 to the Circuit

Day, "less" means subtract the speed by a number to reach the average speed; "more" means add the speed by a number to get the average speed. The line of the Circuit Day listed the distance traveled by the moon with 14 *du*, 13 fen_1 and 626. The number 626 has a denominator 2526. This makes the total of the velocity from day 1 to day 28 is 374 *du* 17 fen_1 and 626/2526. We are able to calculate the numbers in column 4 by calculating the difference between the value in column 2 and 3 and the average speed of the moon, 13 *du* 7 fen_1. For example, the speed of the moon in the 11th day is 12 *du* 11 fen_1. We subtract 12 11 / 19 from 13 7 / 19 to get 15 / 19 and put 15 in column 4, day 11. The result corresponds to the "Less 15" in column 4, day 11. In the column of the Regulation Accumulative Fen, the value shows the total of the Velocity Difference in Fen beginning from the first day. The positive and negative sign shows the difference of the daily speed of the moon compare to the average speed of the moon. The numbers are calculated from column 2 and conversed to the unit of fen_2 by multiplying the Day Divisor 4559. Yang Wei uses the same Chinese character fen 分 for both the unit fen_2 and fen_1. 1 *du* equals 19 fen_1 and 1 fen_1 equals 4559 fen_2. As a result, 1 *du* equals 86621 fen_2. The number 86621 comes from the Rule divisor, 19, multiplied by the Day Divisor, 4559. We are able to calculate the data in column 5 from column 4. For example, day 1 in column 4 is 26. This means the moon travels 26 fen, or 1 7/19 *du* per day. In order to calculate the value for the third day in the fifth column, we multiply 1 7/19 by 86621 to get 118534. The Velocity Difference for day 2, column 4 is 23. This means the moon travels 23 fen_1, or 1 4/19 *du* per day. In order to calculate the value for the third day in the fifth column, we multiply 1 4/19 to 86621, the result is 104857. The total of the Velocity Difference for day 1 118534 and day 2 104857 is 223391, which gives us the value in day 3, column 5. The value for Day n in column 5 is the total of the Velocity Difference in column 4 from day 1 to day n-1 multiplied by 4559, which equals 86621/19. Column 6 has the number showing the distance of the moon in *fen*, for each day. It was calculated by multiplying 19 to the value of lunar velocity from column 2 and 3.

> 推合朔交會月蝕定大小餘：以入曆日餘乘所入曆損益率，以損益盈縮積分，爲定積分。以章歲減所入曆月行分，餘以除之，所得以盈減縮加本小餘。加之滿日法者，交會加時在後日；減之不足者，交會加時在前日。月蝕者，隨定大小餘爲日加時。入曆在周日者，以周日日餘乘縮積分，為定積分。以損率乘入曆日餘，又以周日日餘乘之，以[入历日余乘]周日日度小分，並之，以損定積分，餘為後定積分。以章歲減周日月行分，余以周日日餘乘之，以周日度小分並之，以除後定積分，所得以加本小餘，如上法。
>
> To calculate the Velocity Major and Minor remainder of lunar eclipse at the new moon and the Cross Coincidences, multiply the fraction of day in the (Velocity) Calendar by the Velocity Difference in the Calendar, subtract or add (the result) from the Regulation Accumulative Fen to get the Velocity Accumulation fen. Subtract the Rule Year from the Lunar Traveling Fen according to the Velocity Calendar, divide the remainder from it (the Velocity Accumulation fen), subtract the positive or add the negative result to the minor remainder. If it reaches the Day Divisor, the Cross Coincidence is on the following day. If it is not enough to subtract, the Cross Coincidence is on the preceding day. Follow the Velocity Major and Minor Remainder to set the moment of the eclipse. If the moment is in the Circuit Day of the (Velocity) Calendar, multiply the fraction of day in the Circuit Day by the Negative Accumulative Fen to get the Velocity Accumulation Fen. Multiply the Decreasing Ratio by the fraction of day in the (Velocity) Calendar, then multiply it by the fraction of day in the Circuit Day, add it to [the multiplication of the remainder of the day according to the Calendar and][58] the minor fen of the Circuit Day, subtract it from the Velocity Accumulation Fen, the remainder is the Post Velocity Accumulation Fen. Subtract the Rule Year from the Lunar Traveling fen in the Circuit Day, multiply the remainder by the fraction of day in the Circuit Day, add it to the *du*

[58] The phrase "[multiplication of the remainder of the day according to the Calendar and 入历日余乘]" is added to the text according to the explanations on the method from Wang Yingwei 王應偉 (1998) and Liu Hongtao (2003).

> and the minor fen of the Circuit Day, divide it from the Post Velocity Accumulation Fen, add the result to the Minor Remainder, as the earlier method.
> (*Jin shu,* chapter 18)

The *Jing chu li* is able to calculate not only the date of the Cross Coincidences and lunar eclipses, but also the exact moment. In earlier sections, we calculated the conjunction at the new moon, the Cross Coincidences and lunar eclipses based on the mean speed of the moon. This section allows us to calculate the actual position of the moon based on the lunar velocity table in the preceding section and the mean position of the moon at the beginning of the month. In order to make an accurate prediction, Yang Wei needs to adopt the lunar velocity theory in the general eclipse theory with mean lunar motion. The difficult part is to consider where the moment of the eclipse is in the Velocity Calendar and how much the moon has moved compared to its mean position. In order to calculate the exact time, Yang Wei calculates the Minor Remainder of the moment. He calls this the Velocity Minor Remainder. He does not calculate the Velocity Major Remainder because it is according to the result of the Minor Remainder. If the moon's velocity is big enough, he adds or subtracts one day the mean major remainder; if not, the major remainder remains and is used as the Velocity Major Remainder. The starting point of all calculations is the beginning of that Era. All calculations are in the unit of the Day Divisor.

There are two parts in the text, one explaining how to calculate the Velocity Minor Remainder from day 1 to day 27 in the Velocity Calendar; the other explaining how to calculate the

Velocity Minor Remainder in the Circuit Day. The first step for both methods is to calculate the Velocity Accumulative fen (accumulative velocity fen). For day 1 to day 27,

$$V.A.F. = R.A.F \pm F.V.C. \times V.D.$$

Then the *Jing chu li* calculates the Velocity Minor Remainder,

$$[m.r. \pm V.A.F. / (L.T.F. - R.Y.)] / D.D.$$

where

m.r.	minor remainder calculated earlier for the Cross Coincidence
R.A.F	Regulation Accumulative Fen
F.V.C.	the fraction of day in the (Velocity) Calendar
V.D.	Velocity Difference
V.A.F.	Velocity Accumulation fen
R.Y.	Rule Year, 19
L.T.F.	Lunar Traveling Fen
D.D.	Day Divisor, 4559

The reason to divide the Day Divisor is because the numbers of the m.r., R.A.F. and F.V.C. are all in the unit of the Day Divisor. We only need to discuss the astronomical meaning of m.r. ± V.A.F. / (L.T.F. – 19). Yang Wei begins the calculation from m.r., the result from earlier section and adds the regulation V.A.F. / (L.T.F. – 19) to it. According to the Velocity Calendar, the V.A.F. shows the regulation from the beginning of the month to the preceding day. Yang Wei wants to get the actual position of the moon by means of i) adding the velocity of the moon from the beginning of the month to the preceding day by adding the V.A.F. to the m.r. and ii) adding the velocity of the moon on the calculating day by multiplying F.V.C. to the V.D., which marks the change of the speed of the moon on that day. The result shows how far the moon moved in the unit of *fen*$_1$ (the R.A.F. is in the unit of *fen*$_2$, the multiplication of *fen*$_1$ and the D.D., V.D. is in the unit of *fen*$_1$), Yang Wei divides it by the difference between the sun and the moon's motion. The speed of the sun is 1 *du* per day, which equals 19 *fen*$_1$ per day. L.T.F. means the moon travels 231-280 *fen*$_1$ in one day. This changes the result from having a distance unit to fraction without unit. Then Yang Wei adds the result to the minor remainder to get the Velocity Accumulation fen. If it is bigger than the Day Divisor, add one to the major remainder, which marks the day of the Cross Coincidence. Then the time of the Cross Coincidence will be on the following day. If the result is negative, subtract one to the major remainder and the time of the Cross Coincidence is in the preceding day. If the result is between 0 and 1, there is no more regulation on the major remainder and the Cross Coincidence is on the day calculated from the mean periods. Following the method from this section, the time of lunar eclipse should be based on the Velocity Minor Remainder, that is to say, the lunar velocity theory.

The second part to calculate the Velocity Minor Remainder in the Circuit Day is mathematically more complicated but astronomically the same. Yang Wei uses a Post Velocity Accumulation Fen. This method can be converted to the same method used to calculate the Velocity Minor Remainder from day 1 to day 27 in the Velocity Calendar (Liu Hongtao 2003).

Velocity Accumulation Fen = F.C.D.×R.A.F.

Post Velocity Accumulation Fen = F.V.C×R.A.F. – (V.D.×F.V.C.×F.C.D.+m.f.C.D.)

F.C.D. the fraction of day in the Circuit Day in the (Velocity) Calendar

m.f.C.D. the minor fen of the Circuit Day

推加時：以十二乘定小餘，滿日法得一辰，數從子起，算外，則朔望加時所在辰也。有餘不盡者四之，如日法而一爲少，二爲半，三爲太。又有餘者，三之，如日法而一爲強，半法以上排成之，不滿半法廢棄之。以強幷少爲少強，幷半爲半強，幷太爲太強。得二強者爲少弱，以之幷少爲半弱，以之幷半爲太弱，以之幷太爲一辰弱。以所在辰命之，則各得其少、太、半及強，弱也。其月蝕望在中節前後四日以還者，視限數；在中節前後五日以上者，視間限。定小餘如間限、限數以下者，以算上爲日。

To calculate the time, multiply the Velocity Minor Remainder by 12, convert it to double-hours when it reaches the Day Divisor. The counting begins from Zi 子, count out. The result is the moment of oppositions in double-hour. If there is a remainder (of double-hours), multiply it by 4 and divide it by the Day Divisor. One (1 / 4) is small (shao 少), two is half (ban 半), three is larger (tai 太). If there is again a remainder, multiply it by three and divide it by the Day Divisor. One names strong (qiang 強). If (the remainder) is more than one half (1/2), adopt it. If it is less than one half, take it out. Add

strong and small (1/12 + 3/12) to get strong small (4 / 12). Add strong and half (1/12 + 6/12) to get strong half (7/12). Add strong and large (1/12 + 9/12) to get strong large (10 / 12). Two strong (1/12) makes it a weak small (2/12), add it to small (3/12) to get weak half (5/12), add it to half (6 /12) to get weak large (8/12), add it to large (9/12) to get weak (11/12) in one double-hour. Name it with the related double-hour and get the small, large, half, strong and weak. If the full moon's day when the eclipse happens is no more than 4 days away from one solar term, see the Limit Number. If the full moon's day is more than 5 days away from the solar term, see the Interval Limit Number. If the Velocity Minor Remainder is less than the Interval Limit Number or the Limit Number, count in the preceding day.
(*Jin shu,* chapter 18)

Zi	Chou	Yin	Mao	Chen	Si	Wu	Wei	Shen	You	Xu	Hai
子	丑	寅	卯	辰	巳	午	未	申	酉	戌	亥
1	2	3	4	5	6	7	8	9	10	11	12

Table 4.3. Use of the twelve branches in double-hours reckoning.

qiang	shao ruo	shao	shao qiang	ban ruo	ban	ban qiang	tai ruo	tai	tai qiang	ruo
強	少弱	少	少強	半弱	半	半強	太弱	太	太強	弱
Strong	weak small	small	strong small	weak half	half	strong half	weak large	large	strong large	weak
1/12	2/12	3/12	4/12	5/12	6/12	7/12	8/12	9/12	10/12	11/12

Table 4.4. The twelve divisions of a double-hour.

This section shows how to convert the result of the time in the last section to the 12 double-hours civil time reckoning. The twelve branches are used as the names of the 12 double-hours (see Table 4.3). Twelve divisions are used to provide exact time reckoning within double-hours (see Table 4.4). Strong and weak are adjectives used on the divisions and whole numbers. Strong means "1/12 more" and add 1/12 to the divisions. Weak means "1/12 less" and subtract 1/12 from the divisions.

4.4 Summary

As one of the most significant astronomical phenomenon in Chinese mathematical astronomy and astrology, eclipses and eclipse theories are important parts in Chinese *li*. Chapters three and four aimded to study how did ancient Chinese astronomers improve eclipse prediction methods from the *San tong li* to the *Jing chu li*. Over this period, methods for predicting eclipses developed in three important ways: (i) from predicting only lunar eclipses to the prediction of both solar and lunar eclipses; (ii) from relying only on the mean periods of the sun and the moon to taking into consideration the variation in lunar velocity; (iii) from estimating only a rough date to predicting the eclipse's magnitude and the direction of the eclipse shadow. The adoption the lunar velocity theory in the *Qian xiang li* and *Jing chu li* is a significant improvement on eclipse theory.

In conclusion, I would like to use two sections from the *Song shu* to reflect the treatment of eclipses during the Three kingdoms period. The first paragraph discusses the causes of eclipses and reflects upon the difficult in predicting them:

> 魏高貴鄉公正元二年三月朔，太史奏日蝕而不蝕。晉文王時為大將軍，大推史官不驗之負。史官答曰：「合朔之時，或有日掩月，或有月掩日。月掩日，則蔽障日體，使光景有虧，故謂之日蝕；日掩月，則日於月上過，謂之陰不侵陽，雖交無變。日月相掩必食之理，無術以知，是以嘗禘郊社，日蝕則接祭，是亦前代史官不能審蝕也。自漢故事，以為日蝕必當於交。每至其時，申警百官，以備日變。故《甲寅詔》有備蝕之制，無考負之法。古來黃帝、顓頊、夏、殷、周、魯六曆，皆無推日蝕法，但有考課疏密而已。負坐之條，由本無術可課，非司事之罪。」乃止。
>
> On the first day of the second month, the second year of Zhengyuan of the Gao gui xiang Duke[59], the Grand Scribe presented a solar eclipse but it did not happen. The Wen emperor of Jin was the Chief General at that time, strongly demanded the scribe of the responsibility of not verified. The scribe replied: "At the moment of crossing, it was either the sun covered the moon, or the moon covered the sun. If the moon covered the sun, then it sheltered the body of the sun, made the lights obscured, thus it is called solar eclipse. If the sun covered the moon, then the sun transited from above the moon, it is called *yin* can not intrude *yang*, there would be no change even with the cross. The reasons to know eclipses when the sun and the moon covers each other, there is no theory to understand it. Thus hold the *ti* sacrifice and heavenly rituals, when the sun eclipses, the rituals were performed, it is also how the earlier scribes can not determine eclipse. Since Han, solar eclipse was thought to be must happen at crossing, each time when that moment comes, the officials would be warned, to prepare for the change of the sun. Thus the Jia yin edict contains the rituals to prepare for eclipses, but not the theory to determine it. From ancient time, the Huang di, Zhuan xu, Xia, Yin, Zhou and Lu, six calendrical system, all don't have the method to predict solar eclipses, only have the differences on examining. The clause of bearing the responsibility, there was no theory to know, it is not the guilty of the related official." Thus stopped it.
> (*Song shu*, chapter 14, chapter of ritual)

In the dynastic histories, there is a tradition of making comments on people and their work in earlier periods. In an evaluation paragraph on the early *li* makers found in the *Song shu*, Shen Yue 沈約 aptly sums up the importance of Yan Wei's work,

[59] *Gao gui xiang* Duke 高貴鄉公 is the title Cao Mao 曹髦 held before he was chosen as the emperor of Wei. the second year of Zhengyuan refers to the second year of his imperial reign.

古之為曆者，鄧平能修舊制新，劉洪始減《四分》，又定月行遲疾，楊偉斠酌兩端，以立多少之衷，因朔積分設差，以推合朔月蝕。此三人，漢、魏之善曆者，然而洪之遲疾，不可以檢《春秋》；偉之五星，大乖於後代，斯則洪用心尚疏，偉拘於同出上元壬辰故也。

Among the ancient li makers, Deng Ping was able to revise the existing method and establish new ones based on it. Liu Hong is the first to criticize the *Si fen li*; he also worked on lunar velocity. After careful considerations, following the intention of examining the differences, Yang Wei set a parameter called difference based on the accumulated fen at conjunction and used it to predict lunar eclipse. These three people are li masters in the Han and Wei, however, Hong's lunar velocity table cannot be used to check the dates in the *Chun qiu* and Wei's planetary theory is significantly wrong with time passes. This is because Hong has not paid enough attention; Wei is limited by putting Shang Yuan in the day Ren chen.
(*Song shu,* chapter 12).

Chapter Five Development, tradition and reform: calendrical systems in early imperial China

This chapter is an attempt to study the calendrical reforms in early imperial China and the transmission of knowledge between different calendrical systems and related astronomers. It focuses on how astronomers choose to adopt theories from other astronomers and how they incorporated new theories into the methods from the earlier calendrical systems. When an astronomer proposed a new calendrical system, they made efforts, for example a test of the accuracy of calendrical system or a contest between their system and the official one, to convince the emperor to adopt their system as the new official system. The debate and tests between Liu Hong 劉洪, Han Yu 韓翊 and Yang Wei 楊偉 during the era of Huang Chu of the Wen 文 emperor in the Wei on the adoption of *li,* and the adoption of the *Yuan jia li* from AD 443 to AD 445 are particularly interesting. I am going to use excerpts from the *Hou han shu,* the *Jin shu* and the *Song shu*, to examine the following questions: How is astronomical knowledge studied and transmitted between different scholars? What processes led to the decision to undertake a calendar reform? What opinions were brought up and what opinions were valued in debates concerning calendrical systems? And what reasons are significant in the choice of a new calendrical system in early imperial China?

5.1 The reforms in the Han and Three Kingdoms period

5.1.1 The Mandate of Heaven

The word for astronomy in classical Chinese is *tian wen* 天文, usually translated as "Celestial Patterns". The word literally means the natural phenomena of heaven. However, it also contains diverse cultural meanings related to heaven and mankind, particularly related to observational astrology. In the preface of the *Shi ji* 史記, Sima Qian claims he writes this historical treatise "to explore the boundaries between Heaven and Man, to comprehend changes old and new, and finally to form a total perspective (of the cosmos) 究天人之際，通古今之變，成一家之言".[60]

In the pre-Qin period, scholars in China began to make detailed celestial observations and attached significant political meaning to heaven. The idea of *tian ming* 天命 'Mandate of Heaven' first appears in the Zhou.[61] Examples showing patterns of using astronomical phenomena in divination are noticed in the later Chun qiu period. Heaven is closely related to the human world.[62] During the Han, this relationship became even closer. In the *Huai nan zi* 淮南子, a treatise of essays related to a variety of issues including philosophy and astronomy

---

[60] Translated by Sun Xiaochun 孫小淳 (2009).

[61] Kominami Ichiro (2006) discusses evidence for the concept of the Mandate of Heaven in inscriptions on bronze wares from the Zhou period. For arts related astronomy in early imperial China, see Tseng, Lillian Lan-ying (2011).

[62] See chapter 2 for details of the development of celestial divination in the Pre-Qin period. For the development of the idea of Mandate of Heaven in early China, see Pankenier (2013), Lu Yang (2007), Jiang Xiaoyuan (1991) and (2004) and Huang, Yi-Long, (2011). For general discussion on Chinese astrology, see Nakayama (1966), Sun Xiaochun (2000) and Jiang Xiaoyuan (2009).

written in the second century AD during the Western Han,[63] it is stated that Heaven could show either good or bad signs based on actions of the ruler of the state:[64]

> 人主之情，上通于天，故诛暴则多飘风，枉法令则多虫螟，杀不辜则国赤地，令不收则多淫雨。四时者，天之吏也；日月者，天之使也；星辰者，天之期也；虹霓、彗星者，天之忌也。
>
> The natures of the rulers of men penetrate to Heaven on high. Thus if there are punishments and cruelty, there will be whirlwinds. If there are wrongful ordinances, there will be plagues of devouring insects. If there are unjust executions, the land will redden with drought. If (lawful) commands are not accepted, there will be great excess of rain. The four seasons are the officers of Heaven. The sun and moon are the agents of Heaven. The stars and planets mark the appointed times of Heaven. Rainbows and comets are the portents of Heaven.
> [*Huainanzi*, chapter 3, section III; trans. Major (1993), p.67.]

To study the calendrical reforms in early imperial China requires us to study the role of astronomy to the emperor, and to other members of society. What factors could affect the adoption of calendrical systems? Why is a reform necessary? How did the astronomers and officials know which system is best? In order to investigate all these questions, we not only need to study how Chinese astronomers constructed their system, but also to discuss why they need to do this work, and what is the meaning of their work to other people, to officials, to the emperor and to the state. In other words, what is the importance of calendrical systems on state politics?

In 134 BC, Dong Zhongshu 董仲舒 submitted three memorials to the emperor in which he

---

63 Le Blanc (1985). Loewe (1993).

64 For study on the chapter of astronomy in the *Huai nan zi*, see the complete translation and study in Major (1993) and Tao Lei (2003).

discussed the connection between Heaven and the state. Grounded on the theory of the Chun qiu philosopher Mencius, who argued that changes on the earth are related to changes in the metaphysical world, Dong claimed that there is a corresponding mechanism connecting Heaven and Man. Heaven is regarded as the supreme power in the universe of Heaven and Earth and it has the power to grant the legitimacy of rule. The ruler, bearing the name as "the Son of Heaven 天子", rules the state on behalf of Heaven's will. However, if the ruler does not act righteously, Heaven could send signs, such as astronomical phenomena, to warn him.[65] To keep the Heavenly Mandate, the ruler of the state needs to issue appropriate calendrical system and perform heavenly rituals on appropriate dates.[66] In the bibliographic treatise in the *Han shu*, the role of celestial patterns (*tian wen*) and calendars and chronologies (*li pu*, 曆譜) are introduced as follows:

> 天文者，序二十八宿，步五星日月，以紀吉凶之象，聖王所以參政也。
>
> *Tian wen* was concerned with the order of the twenty-eight lodges, the movements of the five stars and sun and moon, the manner of relegating images as auspicious or inauspicious. It was by this means that the sage kings governed.
>
> 曆譜者，序四時之位，正分至之節，會日月五星之辰，以考寒暑殺生之實。故聖王必正曆數，以定三統服色之制，又以探知五星日月之會。凶阨之患，吉隆之喜，其術皆出焉。此聖人知命之術也，非天下之至材，其孰與焉！道之亂也，患出於小人而強欲知天道者，壞大以為小，削遠以為近，是以道術破碎而難知也。
>
> Calendars and chronologies fixed the order of the four seasons, rectified the periods of the equinoxes and solstices, noted the periods of concordance of the sun, moon and five

[65] For more details, see Loewe (1987), (2002), (2011).

[66] For example, the emperor and officials need to follow the *wuxing* cycles in political practices to accord the Earth, Man, and Heaven. See Wang (2000).

planets [five stars], and in this way predicted cold and heat, death and birth with exactitude. Therefore the sage kings maintained the numbers of the calendar in good order, and in this way used the System of the Three Kings to regulate the colors of clothing; also in this way they knew the periods of conjunction of the five planets, sun and moon. By their arts they made manifest the misfortune of calamities and the good fortune of prosperity. This is the art by which the sage kings knew the commands of heaven. But men of small talent, how they pursued it! The Dao became disordered and disasters proceeded from small men who desired to know the Dao of heaven. They harmed the great and made it small, and pared down the far in order to make it near, in this way the arts of Dao were scattered and became difficult to understand.
[*Han shu*, chapter 30; trans. Raphals (2008). pp. 83-85.]

There has been a recent transition in the understanding of the influence of calendrical systems to Chinese society. Joseph Needham (1975) emphasized the agricultural purpose of calendars, an idea without much evidence. Jiang Xiaoyuan has argued that ancient Chinese astronomy, "*tian wen*", significantly concerns judicial astrology (Jiang Xiaoyuan 1991). Sun Yinggang argues there is a distinction between astronomy and astrology, and astronomy serves for the use of political divination (Sun Yinggang 2012). Calendrical systems are significant to the ruler of the state because they are a symbol of the legitimacy of political power. If what happens on the earth is good, Heaven will not send a sign. If not, a warning sign will be released. To keep this system running is about how to find a way to live with Heaven and connect with Heaven. In order to do this, everyone needs to hear from Heaven and learn from Heaven. When there is a sign from Heaven, scholars need to interpret the sign and rulers need to take corresponding actions. One reason to reform the astronomical systems was therefore to improve its accuracy in following the heavenly motions.

5.1.2 Calendrical reforms

There are a total of around fifty calendrical systems officially adopted in China. The procedure by which a new system is adopted is the same throughout most of Chinese history: the emperor orders his astronomers to produce a new calendrical system to replace the existing one. Officials in the astronomical bureau will follow the call and work on the new system. After testing the system against astronomical observations, the system will be submitted and accepted. Many reasons could be used to initiate a calendrical reform, such as the transfer of political power of the state, a technical flaw in the system which needs to be rectified because the predictions made by the system are not correct, or unexpected omens leading to chaos and rebellion in the state. Thus, calendrical reforms are not only scientific activities, but also activities with cultural and political features.[67] According to Sivin, four situations could happen. First, the officials do their work on astronomy well and produce an exceptional system, as expected or required by the emperor and the empire. Second, the new system is not an improvement over the existing one. Third, the new system is not adopted, even though it is better than the existing one. Fourth, it is also possible that an astronomer, whether an official on astronomy or not, himself develops new theories and realizes the current system is not accurate enough. He presents and succeeds in persuading the emperor and other officials to adopt the new calendrical system and replace the old one.[68]

[67] See, for example, Niu Weixing (2004), Cullen (2007a), Sivin (2011), and Morgan (2013).

[68] Sivin (2011).

Table 5.1 Calendrical systems reforms and contests in the Han.

Date	Figures	Debate or test	Reasons	Result
7 BC	Liu Xin	no debate or test	System is off heavenly motions, this results in late predictions on the qi, shuo and planets.	San tong *li* replaced the *Tai chu li*.
AD 62, 66, 68	AD 62 Yang Cen, AD 66 Dong Meng, AD 68, Zhang Sheng, Jing Fang, Bao Ye	AD 62, one observation, AD 66, discussion, AD 68, test for more than a year	AD 62, lunar eclipse misprediction, AD 66, system is off, AD 68, claim to have better method	AD 62, begins the reform of the *Tai chu li*. AD 66, no result, AD 68, replaces Yang Cen
AD 85	Bian Xin, Li Fan	Reform required by the emperor. Observations made by Bian xin and Li Fan	System is off heavenly motions.	*Si fen li* replaced the *Tai chu li*.
AD 100	Zong Gan	Test on a solar eclipse in AD 100	Revised eclipse period (details are not preserved).	New eclipse theory in the Si fen *li*, replaces the one identical to the San tong *li*.
AD 123,	AD 123, Liang Feng, etc. AD 143, Bian Shao, etc. , AD 175, Cai Yong with Feng Guang and Chen Huang,	debate	The principle in deciding epoch in calendrical system	No change is made
AD 175-179	Liu Hong, Han Yue with Feng Xun, Zong Cheng	test	Eclipse period	Liu Hong's New eclipse period is adopted

The tradition of calendrical system reform begins in the period covered by this dissertation. The process of adopting a new system is influenced by at least three factors: the outcome of an astronomical contest, political influence and the social relations between astronomers. Table 5.1 summarizes the reforms during the Eastern and Western Han.[69]

From these examples, debates and tests often happen when an astronomer proposes a reform to the current calendrical system. However, the result varies significantly: there could be a new system, or new theory to part of a system, or there could even be no change to the calendrical system at all. When astronomers face more technical problems, such as when the eclipse period needs to be improved, tests are favored.

5.1.3 The cultural tradition in calendrical reforms in early imperial China

In imperial China the importance of a calendrical reform lay not only in the development of astronomical theories, but also in the political significance of the calendrical system to the ruling of the state. An accurate calendrical system acts as a symbol that the country is governed by an appropriate ruler who follows the will of Heaven. The calendrical system is therefore a reflection of the Mandate of Heaven and is important for demonstrating imperial legitimacy. Thus, a calendrical system needs to be issued and accepted when a new dynasty or

[69] For the Tai chu reform, see Cullen (1993). For details of three representative debates of Yang Cen, Jia Kui and Cai Yong, see Cullen (2007a).

a new emperor came to power, as is explained in the following passages from the *Shi ji* 史記 and the *Han shu* 漢書:

> 王者易姓受命，必慎始初，改正朔，易服色，推本天元，順承厥意。
>
> When a new dynasty rose by accepting the Heavenly Ordinance, at first it had to be prudent. It had to obey the will of Heaven by renewing the basis of all things: the calendar and the color.
> [*Shi ji*, chapter 25; trans. Yabuuti (1974)]
>
> 帝王必改正朔，易服色，所以明受命於天也。創業變改，制不相復
>
> It is to demonstrate his acceptance of the Heavenly ordinance that the emperor should reform the calendar and the color. In founding a new dynasty, the Emperor should not depend upon former institutions.
> [*Han shu*, chapter 25; trans. Yabuuti (1974)]

Reform of the calendrical system was usually prompted by one of two situations: either the emperor orders for a new system, often because of the need to reestablish political legitimacy, or an astronomer proposes one to the emperor, generally because of perceived astronomical failings of the current system. In order to convince the emperor his system is better than any other and should be adopted as the official system, the astronomer needs to explain why the current system is not accurate or perhaps hold a contest comparing observed astronomical phenomena and calculations of that phenomena made by his system and other systems. As shown by Niu Weixing calendrical debates and reforms are not just scientific activities, there are complicated scientific, cultural and political reasons behind the results.[70] Thus the reform is not merely a technical or political event, it is a combination of the two. Based upon an

[70] Niu Weixing (2004).

examination of examples of reforms during the Western and Eastern Han, Yabuuti has suggested that reforms in the Western Han are influenced by metaphysical theories such as *chenwei* 讖緯[71] and *shouming gaizhi* 受命改制,[72] while the Eastern Han reforms are motivated by more scientific reasons.[73] In the Three Kingdoms period and the Jin dynasty, debates and tests over calendrical systems took place frequently. Observations were used to claim that a particular astronomer's suggestions were verified or to provide a basis for arguments over the determination of which calendrical system should be adopted. When deciding whether to adopt a system or not, a procedure needs to be developed to find the most appropriate system. For example, during the 2nd century, the *San gong yi* 三公議, a public debate on the "system origin" *li yuan* 曆元, was held among astronomers in front of three high excellencies.[74]

In early imperial China, the importance of calendrical systems to the emperor's rule under the Mandate of Heaven meant that they were designed to follow not only the heavenly motions, but also what I term 'cultural tradition'. This cultural tradition resulted in non-technical (i.e. non-astronomical) factors playing a significant role in the occurrence and process of reform of the calendrical system. First, because the calendrical system needed to be changed when a

---

[71] *Chen* 讖 (prophecy), *wei* 緯 (apocrypha). *Chenwei* 讖緯 makes prognostications based on the *yinyang* and *wuxing* theories. It appeared on the apocryphal texts (*weishu* 緯書) in the Qin and Han and was prohibited in the southern and northern dynasties

[72] *Shouming gaizhi* 受命改制 is an idea developed by Zou Yan 鄒衍 during the Warring States Period: when a new dynasty replaces the old one, the mandate of the new dynasty comes from Heaven.

[73] Yabuuti (1974).

[74] Cullen (2007a).

dynasty is found, or when ominous phenomena happen, as explained above the in the quoted passages from the *Shi ji* and the *Han shu*, although sometimes this led to nothing more than changing the name of a system. Second, the system must be not only accurate astronomically, but also favored both politically and culturally. For example, the system was often considered in relation to metaphysical theories such as *chenwei* by the Han people or *wuxing* 五行 in most times in early imperial China.[75] Third, in astronomical debates and tests, a calendrical system was considered to be successful when it performs well in the traditionally valued theories, such as eclipses prediction and calculating the position of the sun at winter solstice. Correspondingly, when an astronomer constructs his calendrical system or proposes a calendrical reform, he also has two perspectives to make arguments: first, how to better follow the cultural traditions; second, what are the technical improvements on astronomy. In early imperial China, these two issues are closely related. In the memorials submitted to the emperor and the prefaces of calendrical systems, astronomers usually emphasized that their systems are able to follow both ways at the same time. In order to do the second, astronomers need to observe certain astronomical phenomena to show that the current system is not following the heavenly motions very well; in other words, it does not follow the traditions well. Even if a technical improvement is helpful to improve the accuracy of the calendrical system, if it does not fit in the cultural traditions, it could still be opposed by other astronomers or officials or even neglected. In the debates and tests of adopting a calendrical system, both the

[75] *Wuxing* 五行, "Five Phases", a theory of correlative thinking with correspondence between Metal, Wood, Water, Fire and Earth.

astronomical improvements and the cultural traditions were valued by people who make decisions, although exactly what is valued during the reform by the ruler and the officials could change in different dynasties, or with the development of astronomy.

This chapter aims to discuss the complexity of the cultural traditions and astronomy in early imperial China using as examples the 3rd century debates in the Kingdom Wei 魏 between the *Qian xiang li* 乾象曆, the *Huang chu li* 黄初曆 and the *Jing chu li* 景初曆, and the process of calendrical reform between AD 443 to AD 445 which led to the adoption of the *Yuan jia li* 元嘉曆. By examining the materials related to the reforms and the debates and tests on astronomical theories, I aim to explore the following questions: What is valued in the procedure to choose the best calendrical system for the country? How do astronomers, officials and the emperor balance the weights of cultural tradition and technical development? What kind of development is important for astronomers when they construct their systems? Is that affected by cultural tradition? How is astronomical knowledge studied and transmitted between different scholars?

5.2 The Huang chu debate

The centralization of imperial reign gradually fragmented into several local powers at the end of the Eastern Han. In the first few decades of the 3rd century AD, the union of China under the Han emperor was succeeded by three regional kingdoms: Wei (AD 220 – AD 265) in northern

China, Shu 蜀(AD 221 – AD 263) in the southwest and Wu 吳(AD 222 – AD 280) in the southeast. During the Huang chu Era (Yellow reception, AD 220 to AD 226) of Emperor Wei Wen 文, the first emperor of the Wei kingdom, the Prefect Grand Scribe 太史令 Gaotang Long 高堂隆 managed a calendrical reform to replace the current *Si fen li* system. The Assistant Grand Scribe 太史丞 Han Yi 韓翊 submitted his *Huang chu li* for discussion. It led to a *San gong yi* public debate in front of three high officials and tests between the *Huang chu li* and the *Qian xiang li* , a system constructed by Liu Hong 劉洪 in AD 206, against observations. This debate is described in the *Song shu*:

> 光和中，穀城門候劉洪始悟《四分》於天疏闊，更以五百八十九為紀法；百四十五為斗分，造《乾象法》。又制遲疾曆以步月行。方于《太初》、《四分》，轉精微矣。魏文帝黃初中，太史丞韓翊以為《乾象》減斗分太過，後當先天，造《黃初曆》，以四千八百八十三為紀法，一千二百五為斗分。其後尚書令陳群奏，以為"曆數難明，前代通儒多共紛爭。黃初之元，以《四分曆》久遠疏闊，大魏受命，宜正曆明時。韓翊首建《黃初》，猶恐不審，故以《乾象》互相參校。曆三年，更相是非，舍本即末，爭長短而疑尺丈，竟無時而決。按三公議，皆綜盡曲理，殊塗同歸，欲使效之璿璣，各盡其法，一年之間，得失足定，合於事宜。"奏可。明帝時，尚書郎楊偉制《景初曆》，施用至於晉、宋。
>
> During the era of Guang He (光和, Glorious Harmony, AD 178 to AD 184, the third reign period used by the Ling 靈 emperor in the Eastern Han), the Observer of the Gucheng Gate 穀城門候 Liu Hong was the first to realize that the *Si fen li* is off the heavenly motions.[76] He built the method of *Qian xiang* with 589 as Era Divisor and 145 as Dou

[76] Translations of official titles are mostly taken from Bielenstein (1980). However, there are a few cases where I do not agree with Bielenstein. For example, I translate 穀城門候 as "the Observer of the Gucheng Gate" instead of "the Captain of the Gucheng Gate." I take the Chinese character 候 for

Fraction (the fraction of Dipper, the Lodge Dou). He built the Velocity Calendar (*Chi ji li* 遲疾曆) to pace the lunar motion. It is similar to the *Tai chu li* and the *Si fen li*, while finer and more accurate. During the era of Huang Chu (黄初, Yellow Inception, AD 220 to AD 226, the first reign period used by the Wei kingdom) of the Wen 文 emperor in the Wei, the Assistant Grand Scribe 太史丞 Han Yi believed the *Qian xiang li* reduced the Dou Fraction too much, and it will be ahead of the heavenly motions as time goes on. He built the *Huang chu li* with 4883 as Era Divisor and 1205 as Dou Fraction. Later, the Prefect of the Masters of Writing 尚書令 Chen Qun 陳群 presented a memorial, which said, "it is difficult to get a clear understanding on the *li* and the numbers. Scholars from earlier dynasties argued a lot. The inauguration of the *Huang chu li* is because the *Si fen li* is aged and inaccurate. The mandate has come to Wei, it is a good time to correct the *li* and ascertain the seasons. Han Yi first built the *Huang chu li*, he was afraid it was not accurate and used the *Qian xiang li* to compare and adjust. During three years, even more opinions were brought up on right or wrong. (They) neglect the essential (issues) and concern only the minor ones. To argue on the size, (they) question the measures. This took a long time and there is no result. According to the *San gong yi* debate by the three high officials, both (systems) synthesize and explicitly made arguments, they are heading to one place from different roads. It is better to let them use instruments, to practice their theories. In the time of one year, the advantages and disadvantages will certainly be judged. The matters will be agreed." (The emperor) agreed. During the era of the Ming 明 emperor, Gentleman of the Masters of Writing 尚書郎 Yang Wei 楊偉 built the *Jing chu li*, it has been used through the Jin and the Song.
(*Song shu,* chapter 12)

In this concise history of the calendrical systems and reforms in the Wei Kingdom it is explained that when Liu Hong realized that the *Si fen li* is off the heavenly motions he first built his own system with 589 as Era Divisor and 145 as Dou Fraction and then constructed the Velocity Calendar to pace the lunar motion, a new theoretical development in calendrical

an observer who keeps watching sky rather than a captain of a guard team.

systems which can be credited to Liu Hong himself. Changing the Era Divisor and the Dou Fraction modifies the length of a solar year, a key factor to keep the calendrical system in line with the seasons. These arguments are based upon astronomical reasons, which concern the *Dou* fraction (Dou fen 斗分, or literally Dipper Fraction), which has long been focused on in the astronomical tradition. In the 28 lodges system, the lodge *dou* is the only lodge with a length than includes a fraction rather than a whole number of *du*. The *Dou* fraction (Dou fen 斗分, or literally Dipper Fraction) therefore corresponds to the fraction of a day in a solar year and therefore represents the accuracy of a solar year in a calendrical system. The length of a solar year was a concern of all earlier and later astronomers and thus became a significant part of the cultural tradition. When Han Yi argues the *Qian xiang li* will be gradually ahead of the heavenly motions as time goes on, he also emphasizes the length of a solar year: "He built the *Huang chu li* with 4883 as Era Divisor and 1205 as Dou Fraction." Although the *Qian xiang li* and the *Huang chu li* differ in their treatment of this significant subject, it is still difficult to know which one is better only by debates. With no astronomical observations, the *San gong yi* public debate was intense but not very fruitful, as stated straightforwardly in the text: "during three years, even more opinions were brought up on right or wrong. (They) neglect the essential (issues) and concern only the minor ones. To argue on the size, (they) question the measures. This took a long time and there is no result." Under such circumstances, a contest of astronomical observations was deemed necessary to decide which system is more accurate. According to the *Jin shu*, Dong Ba 董巴, an Attendant Serving within the Palace 給事中,[77]

[77] Dong ba was also the author of *Yu fu zhi* 輿服志(Treatise on Carriages and Robes) and coauthor of

explained the significant context of a variety of astronomical observations from a historical perspective:

> 聖人迹太陽於晷景，效太陰於弦望，明五星於見伏，正是非於晦朔。弦望伏見者，曆數之綱紀，檢驗之明者也。
>
> Sages tracked the Great Yang (sun) from gnomon shadows, verified the Great Yin (moon) via quarter and full moons, elucidated the Five Stars (planets) via appearances and concealments and settled right and wrong via the first and last day of the month. Quarter moons, full moons, concealments and appearances are the guiding order of li numbers and are brilliant for inspection and verification.
> (*Jin shu,* chapter 17, translated by Morgan, 2013, p.302)

Three kinds of astronomical events are mentioned by Dong Ba, the sun's motion, planetary appearances and the major stages of the phases of the moon. Are these events as well the ones considered important in the cultural tradition*s* in calendrical reforms? Observational tests are valued when people can not decide which system is better in the debate: "According to the *San gong yi* debate by the three high officials, both (systems) synthesize and explicitly made arguments, they are heading to one place from different roads. It is better to let them use instruments, to practice their theories." What kind of observations are important in determining the calendrical system? Xu Yue 徐岳, a disciple of Liu Hong,[78] suggested solar eclipses:

> 效曆之要，要在日蝕。熹平之際，時洪為郎，欲改四分，先上驗日蝕：日蝕在晏，加時在辰，蝕從下上，三分侵二，事御之後如洪言，海內識真，莫不聞見，劉歆以來，未有洪比。

---

the *Wuxing zhi* 五行志 (Treatise on wuxing) of the *Hou han shu*.

[78] Xu Yue of Donglai 東萊 was also the author of mathematical treatises S*hushu Jiyi* 數術記遺 and have commented on the *Nine Chapters* 九章算術.

> The key to testing a *li* lies in solar eclipses. In the Illustrious Tranquility period (172–178), Hong was, at the time, a Court Gentleman and wished to reform the Quarter-remainder. Previously, he had sent up a solar eclipse prediction. The eclipse was on a clear day at the double-hour chen (08:00–10:00), and the eclipse went from bottom to top, intruding two thirds (over the disk of the sun). After the matter had been inspected, it was found to have happened just as Hong said. Everyone within the oceans recognized the truth of it, and there was no one who did not hear of it. Since Liu Xin, there has been no match for Hong.
> (*Jin shu,* chapter 17, translated by Morgan, 2013, p.305)

We do not know whether Xu Yue suggested solar eclipses only because he believes "the key to testing a li lies in solar eclipses," or he has an inclination to the *Qian xiang li* in this contest. However, it may be significant that that Xu Yue had studied calendars and astronomy from Liu Hong. Furthermore, he was impressed with Liu Hong's ability to predict solar eclipses. These two reasons might have together influenced his argument. In any case, a series of tests using eclipses and planetary motions were decided to be held in the following years. In the end, the *Qian xiang li* was preferred by the majority of scholars in the debate and achieved slightly better results in the test.[79] According to the *Jin shu*, "Among the predictions of five solar and lunar eclipses, the *Qian xiang* has four further, the *Huang chu* has one closer. 凡課日月食五事，乾象四遠，黄初一近。"; "Among fifteen appearances and disappearances of four planets, *Qian xiang* made seven closer and two correct, *Huang chu* has five closer and one correct. 凡四星見伏十五，乾象七近二中，黄初五近一中。"[80]

Two issues need to be further addressed according to these results. First, where were the

[79] See Morgan (2013) for the details of the results of the debate and the observation test.
[80] *Jin shu,* chapter 17.

observation tests made? Second, what was the time and direction reckoning system used in this eclipse contest? There are a few possible locations for the place of the observatory: the capital of the kingdom Wei, Luoyang; the place the last Eastern Han emperor, the Han Xian 獻 emperor stayed, Xuchang 許昌; or Yangcheng 陽城, a place regarded as the center of earth. In his analysis of these eclipses, Chen Jiujin 陳久金 used Xu Chang (34°03' N, 113°51' E, +40 meters) as the place of the observation.[81] By contrast, Morgan provided an eclipse list calculated to Luoyang 洛陽(34°45' N, 112°28' E, +144 meters) with the NASA Five Millennium Canon of Solar Eclipses by Fred Espenak and Jean Meeus.[82] Yangcheng is almost at the cross point to the north of Xuchang and the east of Luoyang. As the practical administration center of the Eastern Han, Xuchang is where Cao Cao 曹操 ruled the state as the prime minister. When his son Cao Pi 曹丕 acquired power as the Wei Wen Emperor, abandoned the Han Xian 獻 emperor and founded the Wei kingdom, he moved the capital back to Luoyang in AD 220 (the first year of Huangchu). According to the following quote from the *San guo zhi*, Cao Pi seems to travel a lot between Luoyang and Xuchang during the transfer of administration.

（黄初元年）十二月，初营洛阳宫，戊午幸洛阳。二年，筑陵云台。

The twelfth month (of the first year of Huang chu), the palace of Luoyang was run for the first time, (the king) visited Luoyang on the day of Wuwu. In the second year, a cloud platform is constructed.

三年春正月丙寅朔，日有蚀之。庚午，行幸许昌宫。……十一月辛丑，行幸宛。

[81] Chen Jiujin (1983).

[82] (http://eclipse.gsfc.nasa.gov/eclipse.html). Morgan (2013), pp.320-321.

庚申晦，日有食之。

On the first day Bingyin of the first month in the spring of the third year, there was an eclipse. On the day Gengwu, (the emperor) traveled to the palace in Xuchang.......On the day Xinchou in the eleventh month, (he) visited Wan. On the last day Geng shen of that month, the sun was eclipsed.
(*San guo zhi,* chapter 2)

However, this text does not indicate where the observations were made. Given the significance in deciding the official calendrical system, it would be a rational assumption that the observations for the contest took place at the official observatory. There were usually two possibilities in choosing the official observatory: the center of the earth, or the capital of the state. Two locations have been argued by Chinese astronomers as the center of the earth: Luoyang according to an early theory from Zhou 周 to the Han and Yangcheng according to a better accepted theory from Zhou to the Song or even later periods.[83] We currently do not have direct evidence showing the Wei kingdom used which place to build its official observatory. If they follow the rule to observe in the capital, the capital of the Eastern Han Luoyang is an obvious candidate. Even though Cao Cao moved the administrations to Xuchang, Cao Pi rebuilt the palaces in Luoyang in AD 220 and move the bureaucracy back. The earliest *Huang chu* eclipse was observed on Aug 5, AD 221, with other eclipses in the following couple years. The *Huang chu* eclipse contest would then have happened in Luoyang. However, if they follow the rule to set the observatory at the center of earth, it is possible that the observatory was not moved during the transfer of administration power and the eclipses were always observed at Yangcheng.

[83] Guan Zengjian (2000).

The time reckoning system used in this eclipse contest is quite particular. In similar examples from later dynasties, a 12 double-hours system is much more commonly used. However, here it is clear that a 24 single-hours system using 24 characters from the *gan zhi* system to represent 24 hours which makes a day.[84] In the Aug 5, AD 221 example, the eclipse happens in Xin 辛, which is only used in the 24 single-hours system. Qu Anjing 曲安京 discovered that the solar eclipse and planetary phenomena records quoted in this debate all used this 24 single-hours system. Moreover, this 24 single-hour system combined hours and directions together.[85]

> 三年正月丙寅朔加時申北日蝕。
>
> 3rd year, 1st month, the day of Bingyin, the first day of the month. The sun was eclipsed at the north of the hour of Shen.
>
> 三年十一月二十九日庚申加時西南維日蝕。
>
> 3rd year, 11th month, 29th day, the day of Gengshen. The sun was eclipsed at the time of direction of southwest.
> (*Jin shu*, chapter 17)

[84] Sivin (2009)

[85] Qu Anjing (1994).

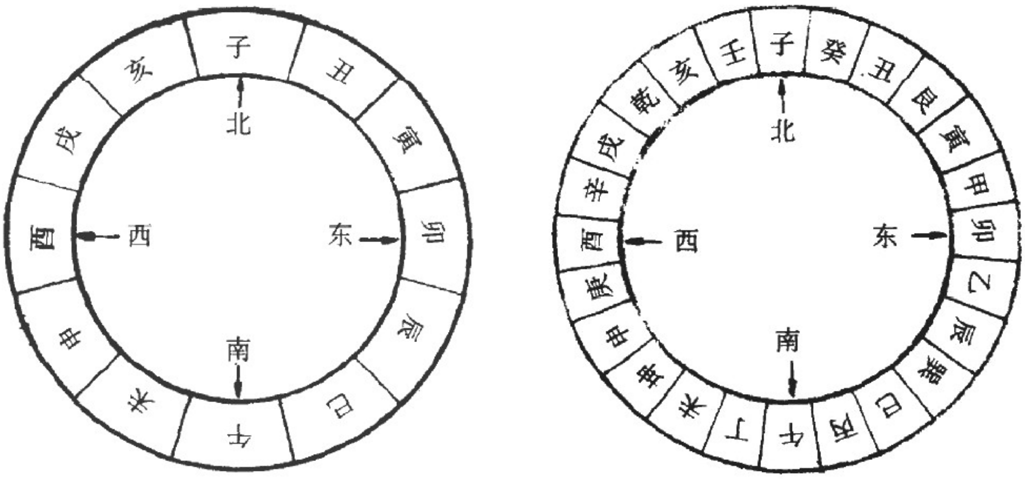

Figure 5.1 the time-direction system in the Han.[86]

The text used two particular ways of stating exact time: "the north of the hour of *shen*" and "the time of direction of southwest." North of *shen* means the upper part of the hour *shen*, which is close to the hour of *geng*. The direction of southwest means it is at the 5/8 if we count in the clockwise. However, another way to say this is it is at 225° from the start point. Morgan believed the start point corresponds to the beginning of the hour *zi*. However, I think the directions are placed in between the hour of *zi* to make the directions balanced. That is to say, the hour of *zi* is right on the direction of north, as a result, the start point is the midpoint of the hour *zi*. See Figure 5.1 for an example of the double-hour and single-hour system.[87]

As argued earlier in this chapter, theoretical development within astronomy is not the only reason that could affect the adoption of a system, cultural traditions were making impacts as

86 Pictures adopted from Guan Zengjian (2000), p21-22.

87 Also see Figure 4.2: Six Dynasties bronze liu ren-style diviner's board on page 323 in Morgan's dissertation, which as well placed north to the mid-point of the hour *zi*.

well. If we look at the big picture by taking debates, tests and reforms all together it is apparent that more factors need to be considered to an understanding of the construction of calendrical systems. Three dimensions are worth looking at besides the theoretical astronomy and the cultural tradition*s* of calendrical reforms in astronomical society in the Three Kingdoms period: politics, astronomical knowledge and "teacher and students" relations. According to a recent study by Morgan, the astral sciences are not only tightly operated by the government and by hereditary practitioners. There is a knowledge network between astronomers.[88] Politics and astronomical knowledge are obvious factors in adopting a new calendrical system. However, the social relationship between astronomers also affected this process.

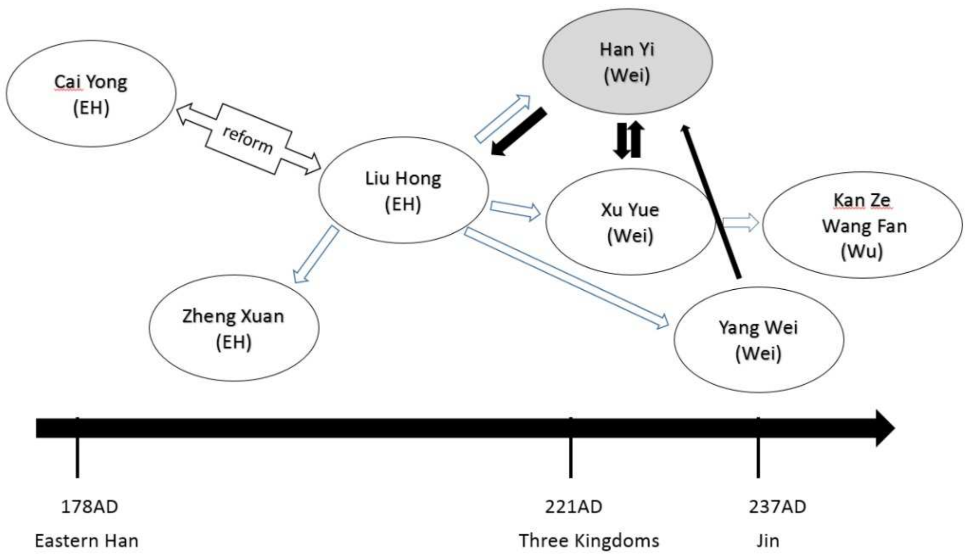

Figure 5.2 Transmission of knowledge between Chinese astronomers in the 2nd and 3rd centuries AD. EH represents the Eastern Han.

[88] Morgan (2015).

Figure 5.2 shows the transmission of knowledge between Chinese astronomers in the 2nd and 3rd centuries AD. Hollow arrows point to the scholar who learns from another at the other end of the arrow. A solid arrow indicates that the scholar either has a different opinion or argues against another in the debates. The arrow points to the scholars being argued against. Located in the center circle, Liu Hong (AD 135?-210?) is the key figure in this knowledge tree. In the first year of Guanghe, AD 178, he expanded the *lüli zhi* (treatise on temperament and calendar) of the *Hou han shu* with Cai Yong.[89] In AD 179-180, he discussed the new eclipse period with Wang Han 王漢, Feng Xun 馮恂 and Zong Cheng 宗誠, and predicted a solar eclipse. In AD 187-189, he submitted the *Qian xiang li*, which included the first lunar velocity theory in Chinese mathematical astronomy and completed the system with improved theories by AD 206.[90] As we see from figure 5.2, the transmission of knowledge not only happened between astronomers who worked with or learned from Liu Hong, but also among different kingdoms. He passed his astronomical knowledge to Zheng Xuan 鄭玄, Han Yi, Xu Yue and Yang Wei separately, the latter three all played important roles in the Huang chu calendrical reform. Kan Ze 闞澤 learnt from Xu Yue and held the position of the Master of Writing after Sun Quan 孫權 claimed himself as the emperor of Wu in AD 222. He is said to "also know *li* and methods, (and) earned his reputation from this 兼通曆術，由是顯名."[91] We do not know whether the Wu astronomers and officials know the results of the Huang chu debate

[89] Cullen (2007).
[90] See Chen Meidong (1986) for Liu Hong's life and astronomical achievements.
[91] *San guo zhi*, chapter 53.

and test or not. But obviously these astronomers know the *Qian xiang li* quite well. Kan Ze wrote a book *Qian xiang li zhu* (Commentaries on the *Qian xiang li*). Wang Fan 王蕃 "passed on the *Qian xiang li* and made an armillary sphere with the Qian xiang methods 傳劉洪《乾象曆》，依《乾象法》而制渾儀."[92] Then there is no surprise that Kan Ze acted to let the Wu emperor to adopt Liu Hong's *Qian xiang li* as its official calendrical system. Therefore, even though *Qian xiang li* was better in astronomy, it was soon no longer an option for the Wei kingdom when it was adopted by the Wu Kingdom in the second year of Huang wu 黄武 (AD 223). On the one hand, *Qian xiang li* had gained a small advantage in the observational test (it was more accurate in eclipse prediction but was not significantly better in the planetary contest). It would therefore not be reasonable to pick *Huang chu* over *Qian xiang*. On the other hand, *Qian xiang li* has already been claimed by another kingdom and it would be rather inappropriate to use the same system as another kingdom. Thus, neither *Huang chu li* or *Qian xiang li* was chosen after a series of debates and tests. The death of Wei Wen Emperor put a temporary end to the contest. Another reform was initiated by his successor the Wei Ming Emperor (AD 227-233), the second emperor of the Wei kingdom:

> 《魏略》曰：太史上漢曆不及天時，因更推步弦望朔晦，爲太和曆。帝以隆學問優深，於天文又精，乃詔使隆與尚書郎楊偉、太史待詔駱祿參共推校。偉、祿是太史，隆故據舊曆更相劾奏。紛紜數歲，偉稱祿得日蝕而月晦不盡，隆不得日蝕而月晦盡。詔從太史。隆所爭雖不得，而遠近猶知其精微也。
>
> Wei Lüe says:[93] The Grand Scribe claimed the Han *li* is behind the heavenly seasons, then

[92] *Song shu*, chapter 13.

[93] This citation is from the notes of Pei Songzhi 裴松之 (AD 372-451) on the *San guo zhi*. Pei quoted Wei Lüe 魏略, a third century book written by a Wei Kingdom scribe Yu Huan 魚豢.

even calculate and pace the lunar phases, and constructed the *Tai he li*. The emperor believed Gaotang Long is excellent and profound with his scholarship, especially mastering in astronomy, and then ordered Long and the Master of Writing Yang Wei, the Alternative Grand Scribe Luo Lu, to participate in prediction and revision together. Wei and Lu are Grand Scribes, Long thus even argued against them according to the former *li*. After a few years of complexities, Wei claimed Lu predicted solar eclipses but did not have the lunar (cycle) completed at the last day of a month; Long did not work out solar eclipses, but had the lunar (cycle) completed at the last day of a month. (The emperor) ordered to follow the Grand Scribe. Although Long did not get what he argued for, the far and close still know he is fine and accurate.
(*San guo zhi*, chapter 25)

The contest between Huang chu and Qian xiang was replaced by a briefly recorded contest between three officials: Yang Wei, a high-ranking specialist on astronomy, Luo Lu, a lower ranking scribe on astronomy, and Attendant Serving within the Palace Gaotang Long. Gaotang Long used to be the Prefect Grand Scribe, but was holding a title as a general advisor to the emperor. He was chosen to work on the calendrical reform with two Grand Scribes whose duty is on astronomy, because of his reputation of mastering astronomy. Yet it was Yang Wei who was favored in this contest and appeared to judge the work of his two colleagues. Similar to what we have seen of the cultural tradition of calendrical reforms in the Wei, solar eclipse and lunar cycle were again valued in the contest. In AD 237, *Jing chu li*, a system constructed by Yang Wei, was adopted by the Emperor Ming and was used until AD 265. When the Western Jin replaced the Wei kingdom after it conquered the Shu and the Wu, the Jin emperor decided to keep using the *Jing chu li*, but change its name to *Tai shi li* 泰始曆.

晉武帝泰始元年，有司奏：“王者祖氣而奉其囗終，晉于五行之次應尚金，金生於己，事於酉，終於丑，宜祖以酉日，臘以丑日。改《景初曆》為《泰始曆》。”

奏可。

In the first year of *Tai shi* (泰始, Peaceful Harmony, AD 265 to AD 274, the first reign period used by the Emperor Wu 武 in the Western Jin), relevant department submitted a memorial, "kings succeed *qi* and keep following it to the end.[94] According the order of *wuxing*, Jin should belong to *jin* (metal), *jin* comes from *ji*, works following *you* and ends at *chou*. It is good to sacrifice on the *you* day, to sacrifice the ancestry at the *chou* day.[95] (We should) change the *Jing chu li* to *Tai shi li*." (The emperor) agreed to the memorial. (*Song shu*, chapter 12)

5.3 The preface of the *Jing chu li*

When an ancient Chinese astronomer constructed a calendrical system, he also needed to explain why his system is better than the existing systems, usually by means of writing a preface. Its purpose is either to persuade the emperor and other officials to accept his system, or as an announcement to let people know the advantages of this system, or both. Prefaces usually begin with the background of his study, especially how these methods are constructed and why this system is better than the earlier ones, just like scholars write introductory sections when they work on a science article today. In the following I provide a complete translation of the preface of the *Jing chu li* written by Yang Wei. Commentaries and discussions follow the texts.

---

[94] According to the Zhonghua shuju edition, there is a missing character in the text. I believe what appears on the text "keep following it to the end 奉其口終" is originally "keep following it from the beginning to the end 奉其始終."

[95] *zu* 祖 is asacrifice for the five heavenly gods of the East, South, Central, West and north, and the five deities of *wuxing*: metal, wood, water, fire and earth. la 臘 is a sacrifice for the ancestry at the end of a year.

At the beginning of this preface, Yang Wei introduced the history of Chinese astronomy from his own perspective. Most calendrical systems in historical dynasties begin this way; to write a preface is to begin with an essay explaining how this system not only followed the traditional way to construct a system, but also how accurate it can be when making predictions. On the one hand, it is to trace the merits and drawbacks of ancient astronomy. On the other hand, it is an effort to let the reader know the advantage of his own ways and systems. The purpose of writing a preface is not only to introduce this calendrical system, but also to explain why this system is better and the reasons it should be adopted. Since the text is a memorial to the emperor, here Yang Wei is trying to convince him to use his calendrical system.

> 魏尚書郎楊偉表曰："臣覽載籍，斷考曆數，時以紀農，月以紀事，其所由來，遐而尚矣。乃自少昊，則玄鳥司分，顓頊、帝嚳，則重黎司天；唐帝、虞舜，則羲和掌日，三代因之，則世有日官。日官司曆，則頒之諸侯，諸侯受之，則頒於境內。夏後之世，羲和湎淫，廢時亂日，則《書》載《胤征》。由此觀之，審農時而重人事，歷代然之也。
>
> Yang Wei stated in his memorial to the emperor: I have read related books, I have thoroughly thought over the *li* and methods. The methods to use seasons in regulating agricultural affairs, months in regulating human affairs, can be dated back to long ago. Since the period of Shao hao, the son of Huang di (yellow emperor), the swallow was believed to arrange the equinoxes. (During the period of) Zhuan xu and Di ku, Zhong and Li were appointed as the official astronomers. In Yao and Shun period, Xi and He obtained the position, and after the Xia, Shang and Zhou dynasties, the official astronomer became a regular position. They constructed *li* and issued it to the dukes. They accepted it and issued to their governing region. In later Xia dynasty, Xi and He drank too much with excessive pleasure, abandon the time and make the Heaven in disorder. Then *Shang shu* recorded it in Yin zheng. It will be seen from this that, to examine the agricultural seasons and put importance on human affairs is accepted by past dynasties.

(*Jin shu,* chapter 18)

In this first section, Yang Wei tried to construct a tradition of relating astronomy to not only agricultural issues, but also human affairs. He started by revealing situations from the so-called "three sovereigns and five emperors" time, time of legendary people such as Shao hao 少昊, the son of Huang di 黄帝, the yellow emperor; Zhuan xu 顓頊, the grandson of Huang di and Di ku 帝嚳, later generations of Zhuan xu, the great grandson of Huang di. Then Yang Wei talked about using the natural phenomena as signs of different seasons. The leave and return of swallow was around the autumnal equinox and spring equinox. "To examine the agricultural season and put importance on human affairs" are major uses of astronomy before Han dynasty. Here 'human affairs' means divinatory affairs. Yang Wei as well tried to establish this tradition based on book and he mentioned *Yin Zheng* 胤征, one section in the *Shang shu* 尚書. *Shang shu* literally means esteemed documents and can be translated as "Classic of History" or "Classic of Documents". The book contains documentary records of early China from the legendary age to the Chun qiu period, as well as a solar eclipse record which has been discussed in chapter 2. *Yin Zheng* means the campaign by Yin, it is a speech made by Marquis Yin when he sets for a campaign to Xi and He, who failed to accomplish their duties on astronomy.

> 逮至周室既衰，戰國橫騖，告朔之羊，廢而不紹，登臺之禮，滅而不遵，閏分乖次而不識，孟陬失紀而莫悟，大火猶西流，而怪蟄蟲之不藏也。是時也，天子不協時，司曆不書日。諸侯不受職，日禦不分朔，人事不恤，廢棄農時。仲尼之撥亂於《春秋》，托褒貶糾正：司曆失閏，則譏而書之；登臺頒朔，則謂之有禮。

When the Zhou dynasty declined, fighting was endless in the Warring States Period. Using sheep on the new moon day was abandoned and not continued. The ritual of standing on a high platform have been ignored from then on. The mistake of one ci in the setting of intercalary month, one Ji in the observation of Ying shi and Dong bi.[96] When the star of *dahuo*(α Scorpius) sets to the west, people should not blame the insects has not disappeared. At that time, the king did not play his role in the harmony between man and nature, the astronomer who is responsible for the calendar cannot produce an appropriate one. The dukes do not accept their role in protocol. The first day of the month was not recognized. Human affairs were not appropriately considered and agricultural affairs were in disorder. Confucius recorded these behaviors in the book *Chun qiu Annals*, and made judgments on right and wrong. Mistake on the computation of the first day of month was satirized and recorded. Standing on the high place to announce the first day of a month is called suitable to protocols.
(*Jin shu,* chapter 18)

In this second section Yang Wei introduced how rituals are not valued in the Chun qiu period and the Warring States period when the country has several kingdoms at the same time. He believed this is when traditional protocols such as the ceremonies to show respect to the king of Zhou are not followed. The astronomers cannot realize the mistakes of the calendar. For example, when Antares (α Scorpius) will be disappearing in the west, this indicates it was in the seventh month. According to the calendar been used at that time, it should be much later and the insects should have disappeared. This is a proof that there are mistakes in the calendar. *Chun qiu Annals* is a history book in the Chun qiu period often attributed by early authors to Confucius. In the book the author satirized on the improper affairs, and appraised the good things according to rituals.

自此以降，暨于秦漢，乃複以孟冬為歲首，閏為後九月，中節乖錯，時月紕繆。加時後天，蝕不在朔，累載相襲，久而不革也。至武帝元封七年，始乃悟其繆

[96] Ying shi and Dong bi, Mansion of Shi and Mansion of Bi, are two mansions in the 28 mansions system.

焉，於是改正朔，更曆數，使大才通人，更造《太初曆》，校中朔所差，以正閏分，課中星得度，以考疏密，以建寅之月為正朔，以黃鐘之月為曆初。其曆斗分太多，後遂疏闊。

From then on, to the time of Qin and Han, the first month of winter was set as the beginning of a year. The intercalary month was set to be the second of the ninth month. There are mistakes in *zhong qi* and *jie qi*. The time and months have many mistakes. The exact time is later than the time of Heaven. The eclipse is not on the first day of a month. Year after year, time has passed and mistakes remained. On the seventh year of Yuan feng, Wu Emperor in the Han dynasty, astronomers realized the mistakes, they changed Zheng shuo, used new methods for a new calendar. The *Tai chu li* was worked out by talented learned people. The calendrical system corrected the errors in *zhong qi*, s*huo*, the intercalation and equinoxes. In order to check its accuracy, it also measured the distance in the sky by means of the zenith star. *Tai chu li* used the month of *yin* as z*heng shuo*, and the month of *Huang Zhong* as the beginning of calendrical system. The *system* was not good at calculating Dou Fen. As time passes, the system gradually became inaccurate.
(*Jin shu,* chapter 18)

In this section Yang Wei talked about the reasons and process of the reform of calendrical system in the Qin and Han. A few pieces of astronomical terminology appeared in this section. *Meng dong* is the first month in winter. *Meng*, *Zhong*, *Ji* respectively means the first, the second and the third. Yuan Feng 元封, the sixth title of emperor Wu's reign, lasted for 6 years from 110 BC to 105 BC, the author may use Yuan Feng 7th year here for 104 BC, which is actually *Tai Chu* 1st year since the *Tai chu li* is also been issued in that year. *Zheng Shuo* is the righteous first month in a year. *Dou Fen* is the fraction part in the lodge *Dou.*

至元和二年，複用《四分曆》，施而行之，至於今日，考察日蝕，率常在晦，是則斗分太多，故先密後疏而不可用也。是以臣前以制典餘日，推考天路，稽之前典，驗之以蝕朔，詳而精之，更建密曆，則不先不後，古今中天。以昔在唐帝，協日正時，允厘百工，鹹熙庶績也。欲使當今國之典禮，凡百制度，皆韜合往古，郁然備足，乃改正朔，更曆數，以大呂之月為歲首，以建子之月為曆初。臣以為昔在帝代，則法曰《顓頊》，曩自軒轅，則曆曰《黃帝》，暨至漢之孝武，革正朔，更曆數，改元曰太初，因名《太初曆》。今改元為景初，宜

曰《景初曆》。

> Till the second year of Yuan he, *Si fen li* was again issued and used. Till the present day, the predictions of solar eclipses often fall on the Hui day. Then the *Dou* fraction is too much, that is the reason it was first accurate but later inaccurate and should not be used. Therefore, I, your servant used to take advantage of my free time apart from producing the code, to calculate and study the paths of Heaven, to refer to existing treatises and check it with the eclipses on the *shuo* day. I improved my methods in detail. I checked them by means of the prediction of eclipses and *shuo*. I built my accurate calendrical system, which accords with the celestial motions from antiquity to the present. In Yao period, the date and time agree with natural phenomena. The *li* was used to regulate all kinds of work. It should be credited with the flourishing of society. If we want to make the rituals agree with the ones in antiquity and fulfill the requirement from our people. We should change the *zheng shuo* and adopt a new calendrical system, which uses the month of *Dalű* as the beginning of year and the month of *Jianzi* as the beginning of the system. In the time of Yao, the *li* was named *Zhuanxu*, in the time of Xuanyuan, it was named *Huangdi*. In the beginning of the Han, *zhengshuo* was changed and the system was modified, the name of Shangyuan was *taichu*, the system got its name as *Tai chu li*. Now Shangyuan was renamed *Jingchu*, the new system should be named *Jing chu li*.
> (*Jin shu,* chapter 18)

After introducing the situations when calendrical reforms happened in the history, Yang Wei followed by talking about why a reform is needed today, what he has worked on and accomplished to fulfill this need, and what standards are important in constructing a new system. He mentioned the prediction of eclipse often falls on Hui in the observation. The eclipses should happen on Shuo, the first day of a month. When it falls on Hui, there is a roughly one day error in the calendar. After explaining the work he has done on the new system, Yang Wei argued the reason to change to his system not only refers to the system being used is not accurate, but also because it is not following the tradition in earlier times. On the contrary, his system not only technically agrees with a tradition, but also followed the tradition to be named following the change of era name.

> 臣之所建《景初曆》，法數則約要，施用則近密，治之則省功，學之則易知。雖複使研桑心算，隸首運籌，重黎司晷，羲和察景，以考天路，步驗日月，究極精微，盡術數之極者，皆未能並臣如此之妙也。是以累代曆數，皆疏而不密，自黃帝以來，常改革不已。
>
> The *Jing chu li* I built uses brief and accurate methods and precise numbers. It is accurate to implement and use, efficient to regulate and easy to learn. Even if we again ask Yan and Sang to mentally calculate, Li shou to operate using counting rods,[97] Zhong and Li to observe with gnomon, Xi and He to measure the shadow. Even ask them to observe the heavenly motion, predict and verify of the motions of the sun and the moon to a highly accurate extent and to the extreme of the calculations. However, all of these are not as good as mine. As a result, the systems and the numbers all became inaccurate after dynasties. From the Yellow Emperor on, it has been always frequently reformed without ceasing.
> (*Jin shu,* chapter 18)

Here Yang Wei mentioned several figures before his time. Ji Ran and Sang Hongyang are famous mathematicians. Yan, Ji Ran 計然, who is also known as Ji Yan. He is a counsellor in the Chun qiu Period. Sang, Sang Hongyang 桑弘羊, 152-80 BC, is a politician in the Han Dynasty. Zhong, Li, Xi and He are early astronomers. The actions described in the text such as observing with gnomon and measuring the shadow did not actually happen. Yang Wei was indicating these figures have the ability to calculate the motions of heavenly bodies. Nevertheless, Yang Wei further indicates that their predictions are not as accurate as his. This is not only trying to state the necessity of calendrical system reform, but also implies his system is the most advanced one ever. Before AD 237, there had been considerable discussion over the official system in the kingdom Wei, but the *Si fen li* was able to keep its official status because of the lack of clarity over what system was better. This situation finally changed when

97 *Chou* 籌, counting rods, traditional Chinese mathematical tools. Numbers were carved on bamboo strips. Mathematicians use the strips in calculation.

Emperor Ming decided to adopt the *Jing chu li* as the official system. The *Jing chu li* continued to be the official system in the Wei, Jin, Song and Northern Wei for more than two hundred years (AD 237-443).

5.4 The test of the *Yuan jia li*

The *Jing chu li* continued to be used throughout the rule of the Eastern Jin in southern China. When the Song succeeded the Jin in AD 420, it kept using the existing system but changed its name to *Yong chu li* 永初曆. In total, therefore, the *Jing chu li* was used as the official system during the Wei, Jin, Song, and Northern Wei for more than two hundred years (AD 237–451). Although neither the Jin nor Song adopted a new system when they replaced earlier dynasties, astronomers still made various efforts to study and discuss the calendrical systems. In AD443, the 24th year after the Song replaced the Eastern Jin, He Chengtian 何承天 submitted his *Yuan jia li* to the Song emperor and started a calendrical reform. The debates used and discussed observational results from the past 10 years. Two years later (AD 445), the *Yuan jia li* was adopted as the official calendrical system and replaced the *Jing chu li*. A detailed account of the reform is recorded in the *Song shu*, a translation of the texts and discussion of the historical context will be provided in this section:

> 晉武帝時，侍中平原劉智，推三百年斗曆改憲，以為《四分法》三百年而減一日，以百五十為度法，三十七為斗分。飾以浮說，以扶其理。江左中領軍琅邪王朔之以其上元歲在甲子，善其術，欲以九萬七千歲之甲子為開闢之始，何承天云"悼于立意"者也。《景初》日中晷景，即用漢《四分法》，是以漸就乖差。其

推五星，則甚疏闊。晉江左以來，更用《乾象五星法》以代之，猶有前卻。

During the era of the Emperor Wu in the Jin (AD 265-290), the Palace Attendant Liu Zhi of Pingyuan, calculated the course of *dou* in three hundred years to change the system, suggested the *Si fen* method is short of one day in three hundred years, to use 150 as the Du Divisor, 37 as the *dou* fraction. He decorated it with superficial reasons, to support his theory. The Middle Rank Commissioner over the Army to the East of the Yangtze river Wang Shuozhi of Langya, thought this method was good, since the Ultimate Epoch is when the *Sui* is at *jiazi,*[98] wanted to use the *jiazi* of 97000 years as the beginning of creation.[99] This is what He Chengtian said: "it grieves at the idea". The gnomon shadow of the sun at noon by the *Jing chu* used the *si fen* method from the Han, that is why it gradually produces discrepancies. Its planetary predictions are even quite off. Since the Eastern Jin, the planetary theory of *Qian xiang* has been used to replace it, yet it has the early inadequacies.
(*Song shu*, chapter 12)

This section is a historiographical overview of the development of calendrical systems during the Eastern Jin. It introduces two figures who made suggestions to the calendrical systems. Liu Zhi "calculated the course of *dou* in three hundred years to change the system" and used "150 as the Du Divisor, 37 as the *dou* fraction." This means he set the *Dou* fraction at 37 / 150 (= 0.24667), which corresponds to the fraction of a day in excess of 365 days in the length of a solar year. When Liu Hong and Han Yi constructed the *Qian xiang li* and the *Huang chu li*, they both specifically noted their own value for the *Dou* fraction. The *Si fen li* had used 1 / 4 as the fraction of a day after 365 days implying a year length of 365.25 days. The year length in the *Qian xiang li* is 365 145 / 589 (= 365.24618), the *Huang chu li* 365 1205 / 4883 (= 365.24677), the *Jing chu li* is 365 455 / 1843 (= 365.24688). Liu Zhi used 365 37 / 150 (= 365.24667) days, which is

98 *Jiazi* is the beginning of the *ganzhi* cycle. Wang Shuozhi favors Liuzhi's method because Liuzhi uses the year of *jiazi* as the epoch.
99 Wang Shuozhi agrees with the principle to use *jiazi* as the epoch. Among all the years of *jiazi*, he further suggests to use the j*iazi* at 97000 years ago as the first year.

closer to the modern value 365.2422 than the other early systems and therefore his system follows the sun's motion quite well, only second to the *Qian xiang li*. Wang Shuozhi suggested using the *jiazi* of 97000 years as the epoch of his system. Generally speaking, a discrepancy between the actual seasons and the calendrical system could be caused by two possible reasons: first, the starting point of all cycles, the epoch of the system, is not properly determined; second, the value for a solar year is not accurate. Even if the system has a proper epoch, it could still go wrong because of the accumulated differences between the solar years and the actual seasons. Thus, He Chengtian commented on Wang Shuozhi "it grieves at theidea," implying Wang Shuozhi could not make his system follow the actual seasons by changing only the epoch.

In the Jin and Song, astronomers realized the *Jing chu li* is not accurate enough after being used for more than 200 years. The discrepancy in the length of the solar year accumulated to an obvious difference that could not be ignored. In AD 443, He Chengtian constructed his system the *Yuan jia li* and submitted a memorial to the Grand Emperor of Song:

> 宋太祖頗好曆數，太子率更令何承天私撰新法。元嘉二十年，上表曰： 臣授性頑惰，少所關解。自昔幼年，頗好曆數，耽情注意，迄于白首。臣亡舅故秘書監徐廣，素善其事，有既往《七曜曆》，每記其得失。自太和至太元之末，四十許年。臣因比歲考校，至今又四十載。故其疏密差會，皆可知也。
>
> The Grand Emperor of Song is quite fond of *li* and numbers.[100] The Clepsydra Administrator to the prince He Chengtian secretly constructed a new system.[101] In the

---

[100] "The Grand Emperor of Song" is Emperor Wen of Song 宋文帝 (AD 407 – AD 453).

[101] *Shuai geng ling* (the titles comes from the words *Shuai* 率 "governs" and *geng* 更, a time unit for

20th year of Yuan jia, (He Chengtian) submitted a memorial remarking:[102] I am naturally naughty and lazy, I do not often care and know. In the past since my childhood, I quite liked *li* and numbers, indulged in it and paid lots of attention, until my hair is white. My deceased uncle former administrator of rare documents Xu Guang, all along had mastery of these issues, has a *Qi yao li* from the past, and always marks the advantages and disadvantages.[103] Since Tai he to the end of Tai yuan, it has been more than 40 years. I thus compared, studied and examined, for again 40 years until now. That is why the accuracy, discrepancies and conjunctions can all be understood.

夫圓極常動，七曜運行，離合去來，雖有定勢，以新故相涉，自然有毫末之差，連日累歲，積微成著。是以《虞書》著欽若之典，《周易》明治曆之訓，言當順天以求合，非爲合以驗天也。漢代雜候清臺，以昏明中星，課日所在，雖不可見。月盈則蝕，必當其衝，以月推日，則躔次可知焉。捨易而不爲，役心于難事，此臣所不解也。

A perfect sphere will always be in motion, the movements of the seven Yao,[104] move away, approach, conceal and reappear, although there are certain rules, because the new and previous will interfere with each other, naturally there would be small discrepancies, with days and years passing, small amounts have accumulated to be notable. Therefore the *Yu shu* has the allusion of "*qin ruo*", the *Zhou yi* illuminates the rules to construct a *li*,[105] remarking (astronomers) should follow the Heaven to seek the agreement, rather than observe the Heaven to prove the accuracy. In the Han miscellaneous observations were done at observatory site, to use the stars culminating at dusk and dawn, to investigate the position of the sun, although it can not be seen. The moon eclipses when it is full, it must be at its opposition. Use the moon to know the sun, then the position could be known.[106] If ignore the easier way and do not apply, yet concentrate on working the difficult way, this is what I do not agree.

《堯典》云："日永星火，以正仲夏。"今季夏則火中。又"宵中星虛，以殷仲秋。"

---

reckoning nights) is an official in charge of time measurement and related internal affairs, including administrating clepsydra. This official works for the prince.

[102] The memorial is called *The Memorial on Adopting new Calendrical System* (*Shang li xin fa biao* 上曆新法表).

[103] Qi yao means seven bright stars, including the sun, the moon and five planets. *Qi yao li* is a system to calculate planetary motions. Xu Guang is not the author of the *Qi yao li*, but marked its advantages and disadvantages compared to the actual positions.

[104] The seven Yao means seven bright stars, including the sun, the moon and five planets

[105] *Yu shu* 虞書, *Book of Yu*. *Zhou yi* 周易, *Book of Change*. Q*in ruo* 钦若 literally means respect and follow. The word comes from *nai ming xi he, qin ruo hao tian* 乃命羲和，钦若昊天 ("therefore appoints *Xi* and *He*, follow the great heaven"), a quote from the *Yu shu*.

[106] *chan ci* 躔次, the position of the sun according to the 12 *ci*.

今季秋則虛中。爾來二千七百餘年，以中星檢之，所差二十七八度。則堯令冬至，日在須女十度左右也。漢之《太初曆》，冬至在牽牛初，後漢《四分》及魏《景初法》，同在斗二十一。臣以月蝕檢之，則《景初》今之冬至，應在斗十七。又史官受詔，以土圭測景，考校二至，差三日有餘。從來積歲及交州所上，檢其增減，亦相符驗。然則今之二至，非天之二至也。天之南至，日在斗十三四矣。此則十九年七閏，數微多差。復改法易章，則用算滋繁，宜當隨時遷革，以取其合。案《後漢志》，春分日長，秋分日短，差過半刻。尋二分在二至之間，而有長短，因識春分近夏至，故長；秋分近冬至，故短也。楊偉不悟，即用之，上曆表云："自古及今，凡諸曆數，皆未能並己之妙。"何此不曉，亦何以云。是故臣更建《元嘉曆》，以六百八為一紀，半之為度法，七十五為室分，以建寅之月為歲首，雨水為氣初，以諸法閏餘一之歲為章首。冬至從上三日五時。日之所在，移舊四度。又月有遲疾，合朔月蝕，不在朔望，亦非曆意也。故元嘉皆以盈縮定其小余，以正朔望之日。

Yao dian remarks: "The longest day, the star of *huo* (Antares) is at culmination at dusk." Now in the last month of summer the star of *huo* is at culmination. Then "the equal of day and night, the star of *xu* (Sadalsuud (β Aquarii) and Kitalpha (α Equulei)) is at culmination at mid-autumn." Now in the last month of Autumn the star of *xu* is at culmination. It has been more than 2700 years (since the time of *Yao dian*), check it with the star at culmination, the discrepancy is about 27 to 28 *du*. Therefore at the winter solstices during the Yao time, the sun is around 10 *du* of the lodge of *xu nü*. According to the *Tai chu li* in the Han, the winter solstice is at the beginning of the lodge of *qian niu*. The *Si fen* in the later Han and the *Jing chu* in the Wei, it is at 21 *du* of the lodge of *dou*. I used lunar eclipse to examine, then according to the *Jing chu*, the winter solstice at present, should be at 17 *du* of the lodge of *dou*. The scribes complied the imperial edict, used gnomon to measure the shadow, examined and checked the solstices, the difference (to the *Jing chu li*) is more than three days. According to (observational results from) earlier years and what *Jiao Zhou* submitted, to check the result, also confirms each other.[107] Then the solstices at present are not the heavenly solstices. The winter solstice of heaven, the sun is at around 13 to 14 of *dou*. This is because 7 intercalations in 19 years, the minor difference in numbers (lead to) big error. If again change the Factor and the Rule cycle, then the use and calculation would be complicated, it should be adjusted whenever it needs to be, to seek the correspondence. According to the *Hou han shu* treatise, daylight is longer on Spring equinox, shorter on Autumn equinox, the difference is more than half a *ke*.[108] The equinoxes are between solstices, and the daylights are not equal. It sets the spring equinox closer to the summer solstice, therefore it is longer; the

[107] "What *Jiao Zhou* submitted" refers to the observations made in the place of *Jiao Zhou*.

[108] The text is referring to the clepsydra table in the *Si fen li*, whose value of the length of daylight at the spring and Autumn equinoxes is differ when they should be same. He Chengtian is saying that Yang Wei failed to realize the error in this table and still adopted it in his *Jing chu li*.

autumn equinox closer to the winter solstice, therefore it is shorter. Yang Wei did not realize this, yet used it, submitted the li memorial saying: "from the ancient times to the present, as long as *li* and numbers, all of them are not as good as mine".[109] Yet (he) did not even know this, how could he said so. Therefore I built the *Yuan jia li*, with 608 as the Ji Factor, half of it as the Du Factor, 75 as the Shi Fen, to use the month of Yin as the first month of a year, Rainwater as the first solar term, to use the year which all Factors and intercalation remainders are whole numbers as the beginning of a Rule cycle. The winter solstice moves three days and five double-hour earlier (from the *Jing chu li*). The position of the sun, moves four *du* from former. And the moon has velocity, if the conjunction and lunar eclipse, is not at the day of *shuo* or *wang*, that is not the intention of calendrical system. Therefore *Yuan jia li* uses velocity (theory) to determine the minor remainder, to revise the day of *shuo* and *wang*.

伏惟陛下允迪聖哲，先天不違，劬勞庶政，寅亮鴻業，究淵思于往籍，探妙旨于未聞，窮神知化，罔不該覽。是以愚臣欣遇盛明，效其管穴。伏願以臣所上《元嘉法》下史官考其疏密，若謬有可採，庶或補正闕謬，以備萬分。

詔曰："何承天所陳，殊有理據。可付外詳之。"

I bend over and wish your majesty to allow (me) to succeed the sages and intellects, to not go against the Heaven, to work hard on a great many governing affairs, to respectfully illuminate the grand undertaking, to explore deep thoughts from ancient treatises, to discover subtle insights from what has not been heard, to see through the intelligence and understand the changing, to not failing to comprehend the essentials. That is why I humbly am delighted to meet the good time and the bright (minds), to serve with my simple and crude insight. I bend over and willing to use the system of *Yuan jia* I submitted to let astronomical officials to test the accuracy. If my erroneousness is adoptable,[110] if only I may correct the errors and check the mistakes, to be prepared for all possibilities.

The emperor announces: "What He Chengtian stated is particularly reasonable. It should be sent out to expand in detail."

(*Song shu*, chapter 12)

---

[109] The original quote from Yang Wei's memorial is as follows: "雖複使研桑心算，隸首運籌，重黎司晷，羲和察景，以考天路，步驗日月，究極精微，盡術數之極者，皆未能並臣如此之妙也。Even if we again ask Yan and Sang to mentally calculate, Li shou to operate using counting rods, Zhong and Li to observe with gnomon, Xi and He to measure the shadow. Even ask them to observe the heavenly motion, predict and verify of the motions of the sun and the moon to a highly accurate extent and to the extreme of the calculations. However, all of these are not as good as mine. "

[110] This is a modest way of saying if there are places I have developed good ideas in my system.

This section from the *Song shu* records the full text of the memorial He Chengtian submitted to the emperor to adopt his system *Yuan jia li*. He Chengtian begins with an introduction to his ability and experience in calendrical astronomy which led to the construction of this new system, then explains the closely bonded calendrical traditional and astronomical reasons to change the official system. An understanding of the guidelines to construct a calendrical system is essential to our understanding to the question of what is valued in the procedure to construct and choose the best calendrical system. The text referred to *Yu shu* and *Zhou yi*, "(astronomers) follow the Heaven to seek the agreement, rather than observe the Heaven to prove the accuracy. 言當順天以求合，非爲合以驗天也。" The same words appear in the *Chunqiu changli* 春秋長曆, an almanac compiled based on the *Chun qiu* by a Western Jin general and scholar Du Yu 杜預 (AD 222-285). Both sources emphasize following the actual movements of heavenly bodies and then develop theories corresponding to the heavenly motions, rather than constructing a system then observing the heavens to prove its accuracy. This guidance is clearly brought up by Jin astronomers here. Thus it is reasonable to assume it is a concern noticed by calendrical system constructors such as He Chengtian. Further, if this guidance could have affected the construction of calendrical systems, is it possible that it became part of the cultural tradition in the reform of calendrical systems?

In this memorial, He Chengtian made three theoretical astronomical arguments in detail: first, the position of winter solstice is not accurate (the *Jing chu li* is more than three days off);

second, the shadow length scheme is out of date; and third, lunar velocity should be taken into consideration when calculating *shuo*, the beginning of lunar cycles. From the examples of Liu Zhi and Wang Shuozhi, we have seen the importance of Dou fraction in *the* cultural tradition of calendrical system reforms. As I will show below, the arguments made by He Chengtian here again point at the importance of the length of a solar year and the related issues of the position of winter solstice and the shadow length scheme, which are caused by the calendrical system not agreeing with the seasons. The emperor agreed with He Chengtian that astronomers should test the accuracy to prove his suggestions. The result of two tests, one using eclipses to find out the position of the sun, another measuring the length of gnomon shadow on winter solstices, is also recorded in the *Song shu*:

> 太史令錢樂之、兼丞嚴粲奏曰：太子率更令領國子博士何承天表更改《元嘉曆法》，以月蝕檢今冬至日在斗十七，以土圭測影，知冬至已差三日。詔使付外檢署。以元嘉十一年被敕，使考月蝕，土圭測影，檢署，由來用偉《景初法》，冬至之日，日在斗二十一度少。[111] 檢十一年七月十六日望月蝕，加時在卯，到十五日四更二唱丑初始蝕，到四唱蝕既，在營室十五度末。《景初》其日日在軫三度。以月蝕所衝考之，其日日應在翼十六度半。又到十三年十二月十六日望月蝕，加時在酉，到亥初始食，到一更三唱蝕既，在鬼四度。《景初》其日日在女三。以衝考之，其日日應在牛六度半。又到十四年十二月十六日望月蝕，加時在戌之半，到二更四唱亥末始蝕，到三更一唱食既，在井三十八度。《景初》其日日在斗二十五。以衝考之，其日日應在斗二十二度半。到十五年五月十五日望月蝕，加時在戌，其日月始生而已，蝕光已生四分之一格，在斗十六度許。《景初》其日日在井二十四。考取其衝，其日日應在井二十。又到十七年九月十六日望月蝕，加時在子之少，到十五日未二更一唱始蝕，到三唱蝕十五分之十二格，在昴一度半。《景初》其日在房二。以衝考之，則其日日在氐十三度半。凡此五蝕。以月衝一百八十二度半考之，冬至之日，日並不在斗二十一度少，並

[111] The Zhonghua shuju edition *Song shu* has "土圭測影，檢署由來用偉《景初法》", I revised the marks as "土圭測影，檢署，由來用偉《景初法》." I think the text first "check and endorse" and then "to use Yang Wei's *Jing chu* system to check the context."

在斗十七度半間，悉如承天所上。

The Grand Scribe Qian Lezhi, and the Associate Scribe Yan Can presented: the Clepsydra Administrator to the Prince and serving as an Intendant of Imperial Academy He Chengtian submitted to change to the system *Yuan jia li*.[112] Checking using a lunar eclipse, on the winter solstice the sun is at 17 of the lodge *Dou*. Measure the shadow with a gnomon to, it is proved that the winter solstice is three days off. Issue an edict to send it out to check and endorse. Instruct the 11th year of Yuan jia, to check a lunar eclipse, measure the gnomon shadow, check and endorse, to use Yang Wei's *Jing chu* system to make predictions, on the winter solstice day, the sun is at 21 1/4 *du* of *Dou*. To check the lunar eclipse on the full moon's day, the 16th day of the 7th month of year 11, the hour of *mao*. Eclipse begins on the 15th day, the second *chang* of the fourth *geng*, the beginning of *chou*, (and) totality happens at the fourth *chang*, at the end of 15 *du*, *yingshi*.[113] According to the *Jing chu*, on that day the sun is at 3 *du*, *zhen*. To check it with the opposition of the lunar eclipse, on that day the sun should be at 16 1/2 *du* of *yi*.[114] Then it is the eclipse on the full moon's day, the 16th day of the 12th month of Year 13, the time is at *you*. The eclipse begins at the beginning of *hai*, the totality happens at the third *chang* of the first *geng*, at 4 *du* of *gui*. According to the *Jing chu*, the sun is at 3 *nü* on that day. Check it with the opposition, the sun should be at 6 and half *du* of *niu* on that day. Then it is the lunar eclipse on the full moon's day, the 16th day of the 12th month of Year 14, the time is at half of *xu*.[115] The eclipse begins at the fourth *chang* of the second *geng*, the end of *hai*, (and) totality happens at the first *chang* of the third *geng*, at 38 *du* of *jing*.[116] According to the *Jing chu*, the sun is at 25 *dou* on that day. Check it with the opposition, the sun should be at 22 and half *du* of *dou* on that day.[117] To the eclipse on the full moon's day, the 15th day of the 5th month of Year 15, it is at *xu*, when the sun and the moon first rose, the brightness of eclipse has come to one fourth, at a little over 16 *du* of *dou*. According to the *Jing chu*, the sun is at 24 *jing* on that day. Check it with the opposition, the sun should be at 20 of *jing* on that day. Then it is the eclipse on the full moon's day, the 16th day of the 9th month of Year 17, the time is at 1/3 of *zi*. The eclipse begins at the first *chang* of the 2nd

[112] He Chengtian's formal job is the Clepsydra Administrator of the Prince. As an expert on astronomy, he also works as an Intendant of Imperial Academy temporarily.

[113] See Stephenson (1997) pp. 279-283 for the night-watches and their divisions.

[114] According to the Zhonghua shuju edition *Song shu* notes, since the eclipse happens at the end of 15 *du*, *yingshi*, the opposite point is 16 1/2 *du* of *yi*. "15 1/2 *du* of *yi* 翼十五度半" should be "16 1/2 *du* of *yi*. 翼十六度半".

[115] The Zhonghua shuju edition *Song shu* has "the 16th of the 12th month of Year 14." According to its footnote, that month could not be eclipsed, it should be "the 16th of the 11th month of Year 14."

[116] The Zhonghua shuju edition *Song shu* has "at 38 *du* of *jing*." *Jing* only has a total of 33 *du*. According to the Zhonghua shuju edition *Song shu* note 62, it should be 26 *du* of *Jing*.

[117] The Zhonghua shuju edition *Song shu* has "the sun should be at 22 and half *du* of *dou* on that day." According to the Zhonghua shuju edition *Song shu* note 63, it should be 21 and half *du* of *dou*.

geng of *wei* on the 15th day, to the third *chang*, the sun was 12 / 15 eclipsed, at 1 and a half *du* of *mao*. According to the *Jing chu*, the sun is at 2 *fang* on that day. Check it with the opposition, the sun is at 13 and a half *du* of *di* on that day. All these five eclipses, check it with 182 and 1/2*du* as the opposition of the moon, on the winter solstice day, the sun is not at 21 and 1/4 *dou*, but around 17 and 1/2 *du* of *dou*, all as Chengtian submitted.
(*Song shu*, chapter 12)

Eclipse Date	434 Sep 4	437 Jan 8	437 Dec 28	438 Jun 23	440 Oct 26
Jing chu li predicted time	Year 11, month 7, day 16, hour *mao*.	Year 13, month 12, day 16, hour *you*.	Year 14, month 12, day 16, half of *xu*.	Year 15, month 5, day 15.	Year 17, month 9, day 16, 1/3 of *zi*.
Observed time, (beginning)	day 15, 2nd *chang*, 4th *geng*.	the beginning of *hai*.	1st *chang*, 2nd *geng*.	the hour of *xu*	day 15, 1st *chang*, 2nd *geng*, hour *wei*.
(totality)	4th *chang*, 4th *geng*.	3rd *chang*, 1st *geng*.	1st *chang*, 3rd *geng*.		12/15 eclipsed, 3rd *chang*
Jing chu li positions of the sun	3 *du*, *zhen*	3 *nü*	25 *dou*	24 *jing*	2 *fang*
Observed positions of the sun	16 1/2 *du* of *yi*.	6 1/2 *du* of *niu*	22 1/2 *du* of *dou*	20 of *jing*	13 1/2 *du* of *di*
Difference between prediction and observation	4 1/2 *du*	4 1/2 *du*	2 1/2 *du*	4 *du*	3 1/2 *du*

Table 5.2. The positions of the sun at winter solstices according to eclipses observation

In the observational test described in this section, the astronomers used five lunar eclipses to check the position of the sun at the winter solstice, to see whether He Chengtian is correct about saying the sun's position predicted by the *Jing chu li* is off at the moment. Table 5.2 summarizes the data presented for the five eclipses.[118]

The differences between positions calculated by the *Jing chu li* and the observed positions are worth noting. The calculated positions are all around 4 *du* greater than those found by observation. This systematic difference is not a general lack of accuracy of the system but rather an error in the year length or in the Ultimate Epoch. This corresponds to what He Chengtian emphasized, namely an error in the Dou fraction. It is worth noting that just as in the debate of Huang chu, five eclipses are used in the the observational test. It seems possible, therefore, that five eclipses became a standard number which were believed to be sufficient to investigate the accuracy of a calendrical system.

The text continues with a discussion of the dates of winter solstices:

> 又去十一年起，以土圭測影。其年《景初法》十一月七日冬至，前後陰不見影。到十二年十一月十八日冬至，其十五日影極長。到十三年十一月二十九日冬至，其二十六日影極長。到十四年十一月十一日冬至，其前後並陰不見。到十五年十一月二十一日冬至，十八日影極長。到十六年十一月二日冬至，其十月二十九日影極長。到十七年十一月十三日冬至，其十日影極長。到十八年十一月二十五日冬至，二十一日影極長。到十九年十一月六日冬至，其三日影極長。到

[118] See Steele (2000) Table 6.13 for predicted and computed times of these eclipses, a few columns including the predicted time, observed time and computed time are adopted from that table.

二十年十一月十六日冬至，其前後陰不見影。尋校前後，以影極長為冬至，並差三日。以月蝕檢日所在，已差四度。土圭測影，冬至又差三日。今之冬至，乃在斗十四間，又如承天所上。

Also starting from year 11, the gnomon was used to measure the shadow. According to the *Jing chu li*, in that year the winter solstice is day 7 of month 11, it was cloudy before and after and the shadow can not be seen. As for the winter solstice on the 18th day of the 11th month in year 12, the shadow was at the longest on the 15th. As for the winter solstice on the 29th day of the 11th month in year 13, the shadow was at the longest on the 26th. As for the winter solstice on the 11th day of the 11th month in year 14, it was cloudy before and after, the shadow can not be seen.[119] As for the winter solstice on the 21th day of the 11th month in year 15, the shadow was at the longest on the 18th. As for the winter solstice on the 2nd day of the 11th month in year 16, the shadow was at the longest on the 29th of the 10th month. As for the winter solstice on the 13th day of the 11th month in year 17, the shadow was at the longest on the 10th. As for the winter solstice on the 25th day of the 11th month in year 18, the shadow was at the longest on the 21th.[120] As for the winter solstice on the 6th day of the 11th month in year 19, the shadow was at the longest on the 3rd. As for the winter solstice on the 16th day of the 11th month in year 20, it was cloudy before and after and the shadow can not be seen. Find and check before and after, winter solstice is when the shadow is at its longest, there is a three days difference. To use lunar eclipse to check where the sun is, there is already a four du difference. To use gnomon to measure the shadow, the winter solstice again has a three days difference. The winter solstice at present, is around 14 *dou*, again as stated by Chengtian.
(*Song shu*, chapter 12)

As we have already seen, in order to decide the accuracy of a calendrical system, the position of the sun at the winter solstice is an important standard. Two methods are used here in the test to calculate the sun's position. First, when lunar eclipse occurs, the moon and the sun are at oppositions and so the sun's position can be determined from the moon's position. Second, since the shadow of gnomon is shortest at the winter solstice point, the time of winter solstice

[119] The Zhonghua shuju edition *Song shu* has "其前後並陰不見 it was cloudy before and after, can not be seen." It should be "其前後並陰不見影 it was cloudy before and after, the shadow can not be seen."

[120] The Zhonghua shuju edition *Song shu* has "二十一日影極長 at the longest on the 21th" It should be "二十二日影極長 at the longest on the 22th."

could be known. The data presented in the text is summarized in Table 5.3. Similar to the 4 *du* difference of the observed positions and the *Jing chu li* predictions of lunar eclipses, here the *Jing chu li* winter solstice are around 3 or 4 days late as compared with the winter solstice determined from observations using a gnomon.

Jing chu li winter solstice	Observed winter solstice	Time differences
Year 11, month 11, day 7	cloudy	not applicable
Year 12, month 11, day 18	Year 12, month 11, day 15	3 days
Year 13, month 11, day 29	Year 13, month 11, day 26	3 days
Year 14, month 11, day 11	Cloudy	not applicable
Year 15, month 11, day 21	Year 15, month 11, day 18	3 days
Year 16, month 11, day 2	Year 16, month 10, day 29	3 days
Year 17, month 11, day 13	Year 17, month 11, day 10	3 days
Year 18, month 11, day 25	Year 18, month 11, day 21	4 days
Year 19, month 11, day 6	Year 19, month 11, day 3	3 days
Year 20, month 11, day 16	cloudy	not applicable

Table 5.3. Winter solstices according to shadow measuring (the dates are in the original dating)

The text continues with some criticisms of He Chengtain's system:

又承天法，每月朔望及弦，皆定大小余，於推交會時刻雖審，皆用盈縮，則月有頻三大、頻二小，比舊法殊為異。舊日蝕不唯在朔，亦有在晦及二日。《公羊傳》所謂“或失之前，或失之後”。愚謂此一條自宜仍舊。

In the system by Chengtian, the new moon, full moon's day and the quarters in each month are all (calculated by) Velocity Major and Minor Remainder. Although it is accurate when predicting the time of conjunctions, it always refers to velocities, then the month is often three long in a row and two short in a row. It is quite different to the earlier method. Earlier, the solar eclipses not only happen at *shuo*, but also at *hui* or the second day. *Gong yang zhuan* said "it either falls to before, or falls to after." I humbly think this rule should use the former one.

員外散騎郎皮延宗又難承天："若晦朔定大小余，紀首值盈，則退一日，便應以故歲之晦，為新紀之首。"承天乃改新法依舊術，不復每月定大小余，如延宗所難，太史所上。

Associate Advisory Gentlemen Pi Yanzong as well argues against Chengtian: "To use the Velocity Major and Minor Remainder for the conjunctions, if the beginning of a year is almost full, then it could retreat one day, and set with the last day of the previous year as the first day of the new year."[121] Chengtian therefore changed the new system following the previous method, without again using velocity major and minor remainder for every month, as argued by Yanzong and presented by the Grand Scribe.

有司奏："治曆改憲，經國盛典，爰及漢、魏，屢有變革。良由術無常是，取協當時。方今皇猷載暉，舊域光被，誠應綜覈晷度，以播維新。承天曆術，合可施用。宋二十二年，普用《元嘉曆》。"詔可。

Relevant bureau presented, "to reform the calendar, change the principles, govern the country, hold the grand ceremony. Therefore during the Han and Wei, reforms are frequent. It is because methods are not changeless, it needs to be tuned with the situation of the time. At the moment the imperial mind carries brightness, shines to cover the existing field, indeed should synthesize and check the measurement of gnomon, to spread and manage the new. The system and methods by Chengtian, are appropriate to

[121] Trying to say that in this situation, the first day of the year is not orthodox.

be used. In the 22nd year of Song, *Yuan jia li* should be publicly issued." The emperor agreed.

(*Song shu*, chapter 12)

The text suggests that only the current system, the *Jing chu li,* was tested against observation. By the time of this test, the *Jing chu li* had been used for more than two hundred years, and as a result, discrepancies can accumulate to be quite apparent. In observations of lunar eclipses and gnomon shadow around winter solstice, the results were convincing enough for the Grand Scribes to agree with He Chengtian's arguments in his memorial. Even though it is difficult to say that the *Jing chu li* is intrinsically a bad system, it is easy to tell that the current system is not quite accurate. Thus, He Chengtian's suggestion of adopting a new system seems necessary, even though the accuracy of the *Yuan jia li* is not even tested. The Official astronomers Qian Lezhi and Yan Can, as well as a military official Pi Yanzong argue that when calculating the beginning of lunar cycle, if we take lunar velocity into consideration, it is possible to see three full months or two hollow months in a row. Pi Yanzong argued it is possible that the last day of the last year became the first day of the first year. This is not a convincing reason to make that decision from the perspective of astronomy. It looks like the astronomers and the attendant were all attempting to argue from the perspective of astronomy, while actually some valued reasons do not make astronomical sense. As a result, He Chengtian had to change the new method to follow some traditions of the previous method.

In AD 445, He Chengtian's *Yuan jia li* was finally accepted as the official calendrical system. Following the adoption of *Yuan jia li*, He Chengtian continued his work on astronomy and suggested to change the standards of clepsydra:[122]

> 元嘉二十年，承天奏上尚書："今既改用《元嘉曆》，漏刻與先不同，宜應改革。按《景初曆》春分日長，秋分日短，相承所用漏刻，冬至後晝漏率長於冬至前。且長短增減，進退無漸，非唯先法不精，亦各傳寫謬誤。今二至二分，各據其正。則至之前後，無復差異。更增損舊刻，參以晷影，刪定為經，改用二十五箭。請台勒漏郎將考驗施用。"從之。
>
> In the 20th year of Yuan jia, Chengtian submitted to the minister: "We now have already changed to use the *Yuan jia li*, the clepsydra is different from before and should be reformed. If we follow the *Jing chu li*, the daylight would be long on the spring equinox and short on the autumn equinox. If keep following the clepsydra in use, after the winter solstice, the clepsydra of daylight is longer than before the winter solstice. In addition, the long and short will increase and decrease. The advances and retreats are not made gradually. It is not only that the earlier method is not accurate, but also mistakes happen in circulating and copying. Now the solstices and equinoxes, each takes up the right places. Then before or after the solstices, there are no more discrepancies. Even adjust the existing clepsydra, refers to the gnomon shadow,(after the) revision set it as the standard，change to 25 *jian.* Please order to let the clepsydra gentleman general to examine, test, and put to use." (The minister) agreed.
> (*Song shu*, chapter 13)

This section is a memorial He Chengtian submitted to the emperor about changing the standard of clepsydra. This was a follow-up to the official issue of the *Yuan jia li*. He Chengtian's proposal focused on the perspective of astronomy and it seems he did not forget his own job, which was as a clepsydra administrator. It is interesting that He Chengtian submitted this memorial to the minister, instead of the emperor. This suggests that changing

[122] See Chen Jiujin (1984) and (1992) for the details of He Chengtian's astronomical achievements.

the standard of the clepsydra was not as important as changing the calendrical system: after all, it is only a change on astronomy and it does not directly concern judicial astrology or politics. Thus, He Chengtian did not raise this issue in his memorial to the emperor or include it in his calendrical system when trying to get it adopted as the official system, but rather chose to do this after the calendrical system reform.

Similar to the scholarly network in the Three Kingdoms period, in the Song we again see the influence of people in calendrical reform. In the examples of calendrical reform in the Jin, there are titles such as the Palace Attendant, the Middle Rank Commissioner over the Army to the East of the Yangtze river, the Clepsydra Administrator to the Prince, the Administrator of Rare Documents, the Grand Scribe, the Associate Scribe, the Intendant of Imperial Academy and Associate Advisory Gentlemen. Among people who held these titles, some are astronomy specialists while others are only partially related to astronomy or advising. Grand scribes who work in astronomy are responsible for the observations in the test. Nevertheless, other seemingly unrelated officials not only participate in the calendrical reforms, and had the right to make their voice heard in the process of deciding the adoption of systems.

The author of the *Yuan jia li*, He Chengtian had several official positions, but none of these positions were related to astronomy before AD 439.[123] He had shown talent during the time he

[123] Chen Jiujin (1992).

was a military official and even wrote an article *An bian lun* 安邊論 (study on stabilizing the border area) on military strategy.[124] His fate changed when he met the prince Lü. He Chengtian first became the Clepsydra Administrator to the Prince and then obtained the temporary title "Intendant of Imperial Academy". He was able to work like an official astronomer and make suggestions on the reform of the calendrical system as an Intendant of Imperial Academy.

5.5 Summary

This chapter has used two examples to discuss the complexity of calendrical reforms in early imperial China. In the first example, a debate concerning the *Qian xiang li* and the *Huang chu li* was held from AD 220 to AD 227, including tests using solar eclipses and planetary positions. The Wei kingdom finally adopted a different system, the *Jing chu li*, in AD 237, instead of the *Qian xiang li* or the *Huang chu li*. Besides astronomy and tradition, other factors, such as the transmission of astronomical knowledge between astronomy practitioners could influenced people who were involved in calendrical reforms. In the latter example, He Chengtian 何承天 constructed the *Yuan jia li* and persuaded the emperor to adopt his system after holding observational tests on lunar eclipses and the winter solstice. In this Song 宋 Dynasty system, He Chengtian invented the *tiaori fa* 調日法 (Day Divisor Regulation Method) to calculate the Day Divisor, and adopted a few better astronomical values such as the value for precession.

[124] *Song shu*, chapter 64.

The clepsydra table and gnomon shadow tables were also more accurate than in earlier systems.[125]

Considering the relationships between astronomers and society, the transmission of astronomical knowledge and its impact on the new system there are several perspectives to consider when looking at calendrical reforms during the period from the Three Kingdoms to the Jin. The first is the development of a particular theory to the internal development of astronomy. Liu Hong developed the lunar velocity theory by himself. Its development, however, made it possible for other astronomers to apply this theory to other parts of the calendrical system. In addition, when astronomers realized that a function modeling the velocity of a celestial body could be developed, it provided a template for the development of other mathematical functions within the calendrical system. Second, an individual astronomer can have a significant influence on people who learn from him. After Liu Hong's breakthrough work, his theories quickly spread to the different kingdoms, with the aid of the relationship between teacher and students. Third, there is political influence on the development of astronomy. In the Three Kingdoms period, all kingdoms need a proper system to adopt, which is not only adequate astronomically, but also politically appropriate.

When we look at these early imperial Chinese calendrical system reforms, there is one additional perspective that we can not ignore: the values of cultural tradition. The

[125] Chen Meidong (2003), pp. 261-66.

development of astronomy is not merely motivated by internal technical factors. Astronomy is never a merely technical subject. It has social and political influences, and accordingly, it has been influenced by non-technical factors such as the tradition indicated in the first section. In sum, while a calendrical reform in early imperial China can happen because of astronomical reasons, cultural factors were perhaps more important. In practice this often meant that when an astronomer suggested a calendrical reform, they needed to highlight the 'traditional' reasons for a reform. Even if they want to present the technical improvement on astronomy, they need to find traditional ways to present this improvement, and to debate and to test systems according to what had became traditional ways, otherwise the new system will not be valued. Astronomical improvement irrelevant to the traditions may still be valued by an astronomer, but is not valued or connected to the Heavenly Mandate, which is the concerned of the ruler of the state.

What opinions did the debaters bring up and what opinions are valued? How to decide the best calendrical system to choose? What procedure happened in the decision to undertake a calendar reform? And what reasons are significant in the choice of an official calendrical system in early imperial China? This chapter has attempted to show the complexity of how cultural tradition influenced the calendrical reform. Astronomers started to value the significance of astronomical theories, as seen from the quote of Du Yu, "follow the Heaven to seek the agreement, rather than observe the Heaven to prove the accuracy". Yet the cultural tradition*s* are valued in the process of calendrical reforms. Astronomers still need to apply the cultural tradition*s* into their construction and developments on calendrical systems. In order to keep their system together with actual seasons, the Dou fraction are valued in constructing a calendrical system, as well as the cultural tradition, to seek a good value for the length of a solar year. Further, in the observational contest on calendrical systems, 5 eclipses are usually considered sufficient to judge the accuracy of eclipse theories from the Three Kingdoms to the Jin. In addition, there may be other factors outside of the issues I have highlighted which may have been significant in any given reform. For example, Morgan has shown astronomers and the transmission of astronomical knowledge are more complicated than a government controlled institution[126]. How did this complexity affect the development of astronomy and the adoption of calendrical systems?

The definition of cultural tradition also changes over time. In different periods, astronomers could have a different views of the tradition. Some ideas might appear, some could be neglected and others be particularly valued. It will be too simple to think the model in this chapter could be applied to all examples of calendrical reforms in Chinese history. But it is also too simple to think astronomers only see the process of reform from the perspective of astronomical development, and do not construct and present their astronomical theory with regard of cultural tradition*s*. When an astronomer proposes a calendrical reform, he needs to revise his system and their proposal to the emperor according to political needs and cultural

[126] Morgan 2015.

influences. He needs to adjust his work and activity so that it has the best chance to be adopted as the official one. But they probably do not have a clear image in their mind that this model exists.

Chapter Six Conclusion

This dissertation has considered the treatment of eclipses in early Chinese astronomy and astrology. It has investigated the practice of eclipse divination, mathematical astronomy theories, and the historical events related to calendrical reforms. For the Pre-Qin period, I explored how eclipses earned their significance in celestial divination with regards to the ruler and to the country, as well as how that motivated the development of astronomical theories of eclipses. For the early imperial period, I aimed to draw attention to the tradition of applying and developing a complex of ideas and practices related to eclipses in calendrical reforms. As the previous chapters have shown, these two main lines started in the Pre-Qin period and were expanded, developed and evolved in the Warring States and the Han. In particular I discussed the theories and historical context of a typical calendrical system, the *Jing chu li*, in order to analyze these developments.

In chapter 2 I discussed the practice of eclipse divination in early China in chronological and evolutionary order. The eclipse records from the pre-Qin period show that solar eclipses were already regarded as an ominous occurrence from an early time. However, I argued that the *Zuo zhuan* on the *Chun qiu* is the first text to give clear and detailed explanations of the process of divination from an eclipse. This text also shows that scholars during the *Chun qiu* period were attempting to develop models for eclipse divination, for example the adoption of the *fenye* and *wuxing* theories. Records of observations of eclipses and their interpretation from the Han showed how these techniques were expanded, and provided us with patterns for rituals and ceremonies the ruler would perform after the observation of a solar eclipse.

Chapters 3 and 4 focused on the subject of eclipses within mathematical astronomy. In chapter 3 I discussed the eclipse theories in three calendars constructed during the Han (the *San tong li*, the *Si fen li* and the *Qian xiang li*) and explained the general method of using eclipse cycles to make predictions of lunar eclipses. I also discussed the question of when did Chinese astronomers start to predict solar as well as lunar eclipses. The evidence suggests that a theory for predicting lunar eclipses first appeared in the *San tong li*, while a theory for predicting solar eclipses first appeared in the *Jing chu li* later in the third century AD.

Chapter 4 serves as a detailed example showing how a calendrical system works and how eclipse theory was developed and integrated into the overall calendrical system of mathematical astronomy. Comparing the eclipse theory in the *Jing chu li* to the earlier systems reveals several new developments. For example, Yang Wei, who constructed the *Jing chu li*, understood that an eclipse does not have to happen when the moon is exactly at the intersection of the lunar and solar paths. As long as the moon is within a certain range, which he called the eclipse limit, an eclipse is possible. Other theories such as methods for calculating the magnitude of eclipse and the direction of contact are also presented for the first time in the *Jing chu li*. Most importantly, however, the *Jing chu li* integrates the theory of lunar velocity into the eclipse theory in order to allow the time of the eclipse to be determined more accurately. These innovative theories found in the *Jing chu li* were subsequently adopted in later calendrical systems.

Eclipse theory is important in Chinese calendrical systems not only because it reflects the mathematical astronomy at the time, but also for the significance of eclipses to the ruler within Chinese judicial astrology. Thus it played a significant role in calendrical system reforms. In chapter 5 I examined the calendrical reforms of the Han and Three Kingdoms periods to explore how debates between different astronomers and officials and tests of calendrical systems using observations affected the results and processes of calendrical reform. In this context, I showed through a close study of the *Huang chu* debate in the Wei kingdom and the *Yuan jia* debate in the Song that what I term "cultural traditions" were central in the decision over the adoption of a calendrical system in the process of these reforms. "Cultural traditions" are a set of accepted traditions such as the priority of eclipses in tests, the adherence to philosophical principles, etc. However, this is not to say cultural traditions were the only mattering factor in these reforms. As I have shown in the conclusion to chapter 5, the process of calendrical reform is influenced by a complicated mix of factors: in addition to cultural traditions, these include the political situation at the time, recent developments in astronomical science and personal relationships between individuals (for example, teacher/student relationships).

The context of early Chinese astral science and the importance of eclipses in early China provide such a rich amount of source material that it is impossible to cover everything in a single dissertation. This dissertation therefore serves as a starting point for further exploration of this topic. In the following I list some possible lines of further enquiry: The study of eclipse divination in the Han needs to be expanded to include all sources available to us in the Han treatises. It could also be extended to later dynasties to see if further changes in the practice of eclipse divination occurred after the Han. It would also be worthwhile to investigate further how the development of mathematical astronomy affected eclipse divination. According to the passage quoted in the summary of chapter 4, one difficulty in eclipse prediction in the Three Kingdoms period is that they were able to predict an eclipse possibility, but the eclipse might not happen. Not long after that, the eclipse limit theory was included in the calendrical system. It would be particularly interesting to see whether this theoretical development could be a factor in eclipse divination or not. The detailed discussion on the mathematical astronomy related to eclipses presented in chapters 3 and 4 needs to be expanded to later calendrical systems as well. The *Jing chu li* which I have investigated marks a significant stage in the development of eclipse theory in early imperial China, but of course there were more developments in later systems. Similarly, it would be interesting to expand the discussion of the role of cultural traditions in calendrical reform to other calendrical systems, either earlier systems or later systems. We might be able to observe the historical development of how Chinese mathematical astronomy and its cultural tradition, as well as the political and social impacts evolve together as a complexity.

Appendix: technical terms in the *Si fen li* and *Jing chu li*.

Si fen li

1. Sui Number 歲數，513. In each solar year, there are 1081 / 513 eclipses.
2. Eclipse Number 食數，1081.
3. Month Number 月數， 135. The eclipse period of the system is 23 eclipses in 135 months.
4. Eclipse Factor 食法, 23.
5. Yuan 元, a cycle of 11058 years.
6. Yuan Meeting 元會, 41040.
7. Bu Meeting 蔀會，2052. It is a cycle of 4 times the Sui Number.
8. Yuan Divisor 元法, 4560.
9. Ji Divisor 紀法, 1520.

Jing chu li

1. Yuan，元, a cycle of 11058 years.
2. Era (*ji* 紀), a cycle of 1843 years. Era Divisor (*ji fa* 紀法), 1843.
3. Rule (*zhang* 章), a cycle of 19 years, the intercalary period. Rule Year (*zhang sui* 章岁), 19, the year of one Rule. Rule Month (*zhang yue* 章月), 235, the month of one Rule. Rule Divisor (*zhang fa* 章法), 19.
4. Day Divisor (*ri fa* 日法), 4559.

5. Meeting Year (*hui sui* 會歲). In the *San tong li*, it is a period of 513 years, which equals 6345 months. 6345 is the least common multiple of 135, the number of months in one eclipse period and the month of one Rule. This means there are 47 135-month eclipse period in one Meeting Year.
6. Dou Fraction (*dou fen* 斗分), the fraction of the Lodge dou.
7. Velocity Calendar (*chi ji li* 遲疾曆). It looks like a calendar but it is a table appeared in the format of a calendar showing the speed of the moon in different days in one month.
8. Velocity Differential Value (*chi ji cha lü* 遲疾差率). The difference between the the moon's daily speed to its average daily speed.
9. Connect Number (*tong shu* 通數), 134630, the length of one synodic month in the unit of the Day Divisor 4559. Each synodic month has 29 2419 / 4559 days.
10. Connect Cycle (*tong zhou* 通周). 125621, the cycle of anomalistic month.
11. Day Remainder (*ri yu* 日餘). The remainder of a day, usually produced in calculation.
12. Cycle Vacancy (*zhou xu* 周虛). The difference between the Day Divisor and the Circuit Day Remainder is 2031, 2528 + 2031 = 4559. Yang Wei names it Cycle Vacancy, which is for mathematical use rather than astronomical. The other part of the remainder of day.
13. Cross Coincidences (*jiao hui* 交會), *jiao*, crossing, refers to the intersection of the sun's path and the moon's path, or to the transit of the sun or moon. Hui refers to

conjunctions. *Jiao hui* implies the situation that when an eclipse happens, the conjunction is close to the lunar node.[127].

14. Lunar Accumulated Fen (*shuo* 朔積分). *Shuo* means the beginning of one month, *ji* means accumulated, fen is the unit used in calculation. Lunar Accumulated Fen refers to the *fen* at the beginning of one month. The value equals the number of synodic months from the beginning of that Era to the calculating month multiply by Connect Number, 134630, the length of one synodic month.
15. Draconitic-Synodic Differential Value (*jiaohui chalü* 交會差率). *Jiao* 交 refers to 'related to draconitic cycle'. *Hui* 會 refers to 'related to synodic cycle'. The value shows the difference between two cycles when a particular astronomical phenomenon, such as an eclipse, happens.
16. Conjunctional Connect (*hui tong* 會通 790110). Conjunctional Connect is the eclipse period in the unit of day divisor 4559. If we divide Conjunctional Connect by Connect Number, the length of one synodic month, the result is 790110 / 134630, which equals 5 116960 / 134630 months.
17. Draconitic Value (*qu jiao du fen* 去交度分) means the time between the calculating time to the happening of conjunction. The term is also in the unit of day divisor. To calculate the Draconitic value, one should take Conjunctional connect out of the sum of Lunar accumulated fen and Connect Number to get the result.
18. Syzygy Conjunction Constant (*shuowang heshu* 朔望合數) is 67315. The term

[127] Sivin, *Granting the Seasons* (ref. 3).

presents half of the synodic month. The number is half of the Connect number 134630.

19. Inner Draconitic Limit (*rujiao xianshu* 入交限數), 722795. It is the difference between the Conjunctional Connect 790110 and the Syzygy Conjunction constant 67315. The term shows how close is the end of one draconitic cycle to the end of one eclipse period.
20. Li Epoch(*li yuan* 曆元), also called Grand Epoch (*shang yuan* 上元).
21. Circuit Day Remainder (*zhou ri ri yu* 周日日餘). The remainder of a day after a complete cycle, usually produced in calculation.
22. Ratio of Increasing and Decreasing (*sun yi lü* 損益率). The data showing the difference of the actual lunar speed to the average daily speed (Chen Meidong 1995). Two ratios are included in the column, Decreasing Ratio 損率, showing the values slower than the average speed and Increasing Ratio 益率, the values faster than the average speed.
23. Regulation accumulated fen (*sun yi ying suo ji fen* 損益盈縮積分).
24. Positive Accumulative Fen (*ying ji fen* 盈積分).
25. Negative Accumulative Fen (*suo ji fen* 縮積分).
26. Velocity Accumulation Fen (*ding ji fen* 定積分).
27. Post Velocity Accumulation Fen (*hou ding ji fen* 后定積分).
28. Lunar Travelling Fen (*yue xing fen* 月行分). The distance the moon traveled in fen according to the Velocity Calendar.

29. Velocity Major remainder (*ding da yu* 定大餘).

30. Velocity Minor remainder (*ding xiao yu* 定小餘).

31. Limit Number (*xian shu* 限數). Limit Number shows the length of the night on one solar term day.

32. Interval Limit Number (*jian xian* 間限). The Interval Limit Number shows the length of the night in the middle of two consecutive solar term days. The *Jing chu li* has a table showing the Limit Number and the Interval Limit Number for the 24 solar terms.

References

Primary sources

Ban Gu 班固. 1962. *Han shu* 漢書. Beijing: Zhonghua Book Company.

Beck, B. M. (1990). *The Treatises of Later Han: Their Author, Sources, Contents, and Place in Chinese Historiography* (Vol. 21). Brill.

Chen Meidong, 2008. *lidai lüli zhi jiaozheng.*歷代律曆志校正(Corrections to errers in the treatises on harmonics and astronomy). Beijing: zhonghua shuju.

Chen Shou 陳壽. 1959. *Sanguo zhi* 三國志 Beijing: Zhonghua Book Company

Cullen, C. 1996. *Astronomy and mathematics in ancient China: The Zhou Bi Suan Jing 周髀算經*. Cambridge: Cambridge University Press.

Dubs, H.H., 1938-1955. *The History of the Former Han Dynasty*. Baltimore: Waverly.

Ho Peng Yoke, 1966. *The astronomical chapters of the Chin Shu*. Mouton: 121-138

Karlgren, Bernhard, 1950, *The Book of Odes: Chinese Text, Transcription and Translation*; Translation of *Shi jing* 詩經. Stockholm: Museum of Far Eastern Antiquities.

Karlgren, Bernhard. 1950. *The Book of Documents*. Translation of *Shang shu* 尚書. *Bulletin of the Museum of Far Eastern Antiquities* 22: 1–81.

Li Rui, 1890, *Mathematical Literature by the Lis* 李氏算學遺書. 1890 edtion.

Lidai tianwen lüli dengzhi huibian 歷代天文律曆等志匯編 (Collection of treatises on astrology and harmonics and astronomy). 1975-76. Zhonghua shuju.

Major, J. 1993. *Heaven and Earth in Early Han Thought: Chapters Three, Four, and Five of the*

Huainanzi. Suny Series in Chinese Philosophy and Culture. New York: State University of New York Press

Major, John S, Queen, Sarah A, Meyer, Andrew S. and Roth, Harold D. 2010. *The Huainanzi: Liu An, King of Huainan. A Guide to the Theory and Practice of Government in Early Han China*. New York: Columbia University Press.

Qutan Xida 瞿曇悉達. *Kaiyuan zhanjing* (in Vol. 807 of the collection of *Sikuquanshu*) originally written about AD 729, Taiwan Shang-wu, Taipei reprint.

Sima Qian 司馬遷. 1959. *Shi ji* 史記. Beijing: Zhonghua Book Company

Shen Yue 沈約. 1974. *Song shu* 宋書. Beijing: Zhonghua Book Company

Yang Bojun 楊伯峻, ed. 1991. *Chunqiu Zuozhuan zhu* 春秋左傳注 Gaoxiong: Fuwen tushu chubanshe.

Xu, Zhentao, D. W. Pankenier, and Jiang Yaotiao, 2000. Astronomical Observations in Oracle-bone Inscriptions. *East Asian Archaeoastronomy: Historical Records of Astronomical Observations of China, Japan and Korea*. Vol. 5. CRC Press.

Zhuang Weifeng 莊威鳳, Wang Lixing 王立興. 1988. *Zhong guo gu dai tian xiang ji lu zong ji, 中國古代天象記錄總集. Ancient Chinese records of celestial phenomena*. Nanjing: Nan jing gao xiao ci shu press

Secondary Source

Bielenstein, H. 1950. "An Interpretation of the Portents in the Ts'ien-Han-Shu." *Bulletin of the Museum of Far Eastern Antiquities* 22: 127–143.

Bielenstein, H. 1980. *The bureaucracy of Han times*. Cambridge: Cambridge University Press.

Bielenstein, H., and Sivin. N. 1977. "Further Comments on the Use of Statistics in the Study of Han Dynasty Portents." *Journal of the American Oriental Society*, 97: 185–87.

Chemla, K., Harper D., and Kalinowski, M., eds. 1999. *Divination et Rationalité en Chine Ancienne. Extrême-Orient*, Extrême-Occident 21. Paris

Chen Jiujin 陳久金, 1983. "Zhongguo gudai rishi shike jilu de huansuan he jingdu fenxi"中國古代日食時刻記錄的換算和精度分析. *Studies in the History of Natural Sciences* 2(4). 303-315.

Chen Jiujin 1984. "tiaorifa yanjiu" 調日法研究. *Studies in the History of Natural Sciences* 3, 245-250.

Chen Jiujin 1992. "He Chengtian" 何承天, *Zhongguo gudai kexuejia zhuanji 中國古代科學家傳記*. Ed by Du Shiran 杜石然. Beijing: Kexue press.

Chen Meidong 陳美東 1986. "Liu Hong de shengping, tianwenxue chengjiu he sixiang" 劉洪的生平、天文學成就和思想(Liu Hong's life and astronomical achievements). *Studies in the History of Natural Sciences* 5, 129-142.

Chen Meidong. 1991. Zhongguo Gudai de Yushi Shixian ji Shifen Jisuanfa 中國古代的月食食限及食分計演算法 (Ancient China's Algorithms of the Lunar Ecliptic Limit and the Degree of Lunar Obscuration). *Studies in the History of Natural Sciences,* 自然科學史研究 10(4)：297-314.

Chen Meidong. 1992. "Liu Zhuo Jiaoshi Tuisuanfa – Zhongguo Gudai Jiaoshi Yanjiu Xinshiqi de

Biaozhi." 劉焯交食推算法－中國古代交食研究新時期的標誌, (Liu Zhuo's eclipse theory – the mark of a new period in ancient Chinese eclipse theory). *Yazhou Wenming* 亞洲文明 (Civilization in Asia) 2.

Chen Meidong, 1995. *Guli xintan* 古曆新探, (*New perspectives on ancient calendars*). Shenyang: Liaoning Jiaoyu Press.

Chen Meidong. 2003. *Zhongguo kexuejishushi Tianwenxuejuan* 中國科學技術史·天文學卷 (History of Chinese science and technology, Astronomy). Beijing: Science Publication.

Chen Zhanyun 陳展云. 1988. "Guli jinjie jingchuli zhujie"古曆今解・景初曆注解. *Cankao ziliao.*

Chen Zungui 陳遵媯. 1980-84. *Zhongguo Tianwenxueshi* 中國天文學史(History of Chinese astronomy). Shanghai: Shang-hai Renmin Press.

Cheng A. 1993. "Ch'un ch'iu, Kung yang, Ku liang and Tso chuan," in Loewe, *Early Chinese texts: a bibliographical guide*, pp.67– 76.

Cullen, C. 1993. "Motivations for Scientific Change in Ancient China: Emperor Wu and the Grand Inception Astronomical Reforms for 104 BC." *Journal for the History of Astronomy*, *24*, 185-203

Cullen, C. 2000. "Seeing the appearances: Ecliptic and equator in the Eastern Han." *Studies in the history of natural sciences*, *19*, 352-82.

Cullen, C. 2001. "The Birthday of the Old Man of Jiang County and Other Puzzles: Work in Progress on Liu Xin's 'Canon of the Ages'." *Asia Major*, 27-60.

Cullen, C. 2002a. "Seeing the Appearances: Ecliptic and Equator in the Eastern Han." *Studies in the Histories of Natural Sciences* 自然科學史研究 19: 352-82.

Cullen, C. 2002b. "The first complete Chinese theory of the moon: the innovations of Liu Hong c. AD 200." *Journal for the history of astronomy* 33: 21-39.

Cullen, C. 2005. "Translating Ancient Chinese Astronomical Systems with Excel: How Not to Stew the Strawberries?" *Journal for the History of Astronomy 36*(3), 336-338.

Cullen, C. 2007a. "Actors, Networks and Disturbing Spectacles in Institutional Science: 2nd Century Chinese Debates on Astronomy." *Antiquorum philosophia* 1, 237-67.

Cullen, C. 2007b. "Huo Rong's observation programme of AD 102 and the Han Li solar table." *Journal for the History of Astronomy*, 38(1), 75-98.

Cullen, C. 2011a. "Translating ancient Chinese calendars." Revue de Synthèse 131(4): 605-612

Cullen, C., 2011b, "Wu xing zhan 五星占 'Prognostics of the Five Planets'." *SCIAMV* 12, 193-249.

Cullen, C. 2011c. "Understanding the Planets in Ancient China: Prediction and Divination in the Wu xing zhan." *Early Science and Medicine*, *16*(3), 218-251.

De Crespigny, R., 1976. *Portents of Protest in the Later Han Dynasty: The memorials of Hsiang-k'ai to Emperor Huan*. Canberra, ANU Press.

Eberhard, W., 1957. 'The political function of astronomy and astrologers in Han China". In Fairbank, J.K. (ed.). *Chinese Thought and Institutions*. Chicago, University of Chicago Press. Pp. 33-70.

Eberhard, W., 1970. *Sternkunde und Weltbild im alten China: Gesammelte Aufsätze*. Taipei, Chinese Materials and Research Aids Service Center.

Foley, N. 1989. *A Statistical Study of the Solar Eclipses Recorded in Chinese and Korean History during the Pre-telescopic Era*. M.S. Thesis, University of Durham.

Goodman, H. L. 1998. *Ts' ao P'i Transcendent: The Political Culture of Dynasty-founding in China at the End of the Han*. Seattle: Scripta Serica.

Graham, Angus. C. (1986). *Yin-Yang and the Nature of Correlative Thinking*. Singapore: Institute of East Asian Philosophies.

Guan Liyan 關立言, 1998, "Chunqiu rishi sanshiqishi kao" 春秋日食三十七事考(The study on the 37 records of eclipse in Chun Qiu Period). *Shixue yuekan* 史學月刊, 95-103.

Guan Liyan, 2000, "Chunqiu rishikao buyi" 春秋日食考補遺(the further study on the 37 records of eclipse in Chun Qiu Period), *Kaifeng Daxue Xuebao* 開封大學學報 14, 62一74.

Guan Yuzhen 關瑜楨, 2015. "Eclipse theory in the Jing chu li: Part I. The adoption of lunar velocity". *Archive for the History of Exact Sciences* 69: 103-23.

Guan Zengjian 關增建, 1989. "Chuantong 365 1/4 fendu bushi jiaodu" 傳統 365 1/4 分度不是角度. Ziran bianzhengfa tongxun 自然辯證法通訊 11: 77-80.

Guan Zengjian 關增建, 2000. "Zhongguo tianwenxueshi shangde dizhong gainian" 中國天文學史上的地中概念. *Studies in the History of Natural Sciences* 19(3). 251-263.

Hasebe Eiichi 長谷部英一, 1991. "Gi Shin Nanbokuchō no rekiron" 魏晉南北朝の曆論,*Chūgoku tetsugaku kenkyū* 中國哲學研究 3: 1–43.

Ho Peng Yoke, 何丙郁. 1966. *The Astronomical Chapters of the Chin Shu.* Paris: Mouton.

Ho Peng Yoke. 1991. “Chinese Science: the Traditional Chinese View.” *Bulletin of the School of Oriental and African Studies* 54. 3: 506–19.

Ho Peng Yoke. 2003. *Chinese Mathematical Astrology. Reaching Out to the Stars.* London: Routledge/Curzon.

Hu Tiezhu 胡鐵珠. 2001. “Dayanli Jiaoshi Jisuan Jingdu.” 大衍曆交食計算精度 (The accuracy of Dayan Li’s Calculation on Solar and Lunar Eclipses). *Studies in the History of Natural Sciences* 自然科學史研究 10(4): 312-319

Huang, Yi-Long, 2011. “The Impact of Astronomy on Chinese Society in the Days before Telescopes.” *The Astronomy Revolution: 400 Years of Exploring the Cosmos*: 257-270.

Hucker, Charles O. 1985. *A Dictionary of Official Titles in Imperial China.* Stanford University Press.

Hu Weijia 胡維佳 1998. “*Tangji suozai ershibaxiu xingdu jishishi xingbiao yanjiu*”唐籍所载二十八宿星度及“石氏”星表研究，*Studies in the History of Natural Sciences* 17(2): 139-157.

Jiang Xiaoyuan 江曉原. 1991. *Tianxue zhenyuan* 天学真原. Shenyang: Liaoning jiaoyu press.

Jiang Xiaoyuan. 2004. *Xingzhanxue yu chuantong wenhua* 星占學與傳統文化. Guilin: Guangxi shifan daxue press.

Jiang Xiaoyuan. 2009. *Zhongguo xingzhanxue leixing fenxi* 中國星占學類型分析. Shanghai: Shanghai shudian press.

Kalinowski, M. 2010. “Divination and Astrology: Received Texts and Excavated Manuscripts.”

China's Early Empires: A Re-appraisal, 339-52.

Kern, M., 2000. "Religious anxiety and political interest in Western Han omen interpretation: the case of the Han Wudi 漢武帝 Period (141±87 B.C.)." *Chūgoku shigaku*. 1-31.

Kominami Ichiro 小南一郎. 2006. *Kodai chūgoku tenmei to seidōki* 古代中国 天命と青銅器—諸文明の起源, 5. Kyoto: Kyoto University Press.

Lagerwey, J., and Kalinowski, M. 2009. *Early Chinese Religion. Part One: Shang through Han* (*1250 BC-220 AD*). Leiden: Brill.

Le Blanc, Charles. 1985. *Huai-nan tzu: Philosophical Synthesis in Early Han Thought* Vol. 1. Hong Kong: Hong Kong University Press.

Li Guangshen. 李广申, 1963, The Eclipse Period in San Tong Li. 論三統曆交食週期

Li Jiancheng 李鑒澄, 1994. "Zhongguo lidai riyue jiaoshi zhouqi de yanjiu."中國歷代日月交食週期的研究. *Studies in the history of Natural Science* 自然科學史研究 13: 114-122.

Li Yong 李勇. 1992. "Dui zhongguo gudai hengxing fenye he fenye shipan yanjiu," 對中國古代恒星分野和分野式盤研究, *Studies in the Histories of Natural Sciences* 自然科學史研究 9: 22-31.

Lippiello, Tiziana. 2001. *Auspicious Omens and Miracles in Ancient China. Han, Three Kingdoms and Six Dynasties*. Monumenta Serica Monograph Series, 39. Sankt Augustin: Monumenta Serica Institute.

Liu Ciyuan 劉次沅. 2002. "Astronomy in the Xia-Shang-Zhou Chronology Project." *Journal of Astronomical History and Heritage*, 5, 1-8.

Liu Ciyuan. 2003. "Zhongguo zaoqi rishijilu yanjiu jinzhan 中國早期日食記錄研究進展." *Tianwenxue jinzhan* 天文學進展(Progress in Astronomy) 21:1-10.

Liu Ciyuan. 2009. "Zhongguo gudai riyueshi ji yuewuxing weizhi jilu de yanjiu he yingyong 中國古代日月食及月五星位置記錄的研究和應用." *Zhongguo gudai tianxiang jilu de yanjiu yu yingyong* 中國古代天象記錄的研究與應用. Beijing: Zhongguo kexue jishu chubanshe.

Liu Caonan 劉操南. 1979. 28 xiu shiming 28 宿釋名(The meanings of the names of the 28 lunar lodges). Shehui kexue zhanxie, 1: 153–62.

Liu Hongtao 劉洪濤, 2003. *Gudai lifa jisuanfa* 古代曆法計算法. Tianjin: Nankai university press.

Lloyd, G. E. R., and Sivin N., 2002. *The Way and the Word. Science and Medicine in Early China and Greece.* New Haven: Yale University Press.

Loewe, M. 1987. Imperial Sovereignty: Dong Zhongshu's Contribution and His Predecessors. *Foundations and Limits of State Power in China*. School of Oriental and African Studies, University of London, 33-57.

Loewe, M. ed. 1993. *Early Chinese texts: A bibliographical guide*. Chicago: Society for the Study of Early China.

Loewe, M. 1994. *Divination, mythology and monarchy in Han China* (Vol. 48). Cambridge: Cambridge University Press.

Loewe, M. and E. L. Shaughnessy, eds, 1999. *The Cambridge history of ancient China,* Cambridge: Cambridge University Press.

Loewe, M. 2002. “The cosmological context of sovereignty in Han times.” *Bulletin of the School of Oriental and African Studies*, 6502, 342-349.

Loewe, M. 2011. *Dong Zhongshu, a ‘Confucian’Heritage and the Chunqiu fanlu* Vol. 20. Brill.

Lu Yang 盧央. 2007. *Zhongguo gudai xingzhanxue* 中國古代星占學. Beijing: Zhongguo kexue jishu press.

Martzloff, J. C. 1997. *A history of Chinese Mathematics*. New York: Springer.

Morgan, D. 2013, *Knowing Heaven: Astronomy, the Calendar, and the Sagecraft of Science in Early Imperial China*. Ph.D. diss., University of Chicago.

Morgan, D. 2015. “What Good’s a Text? Textuality, Orality, and Mathematical Astronomy in Early Imperial China”, *Archives Internationales d’histoire des Sciences*. (Accepted draft).

Mucke, H., & Meeus, J. (1983a). *Canon of Solar Eclipses,-2003 to 2526*. Wien: Astronomisches Büro.

Meeus, J., and Mucke, H., (1983b). *Canon of Lunar Eclipses: -2002 to +2526*. Wien: Astronomisches Büro.

Nakayama, Shigeru 1966. "Characteristics of Chinese Astrology." *Isis* 57.4: 442- 454.

Needham, J., et al. 1954–. *Science and Civilisation in China*. Cambridge University Press.

Needham, J., Ling, W., & Robinson, K. G. 1962. *Science and Civilisation in China. Vol. 4: Physics and Physical Technology. Part. 1: Physics*. Cambridge.

Niu Weixing 鈕衛星 2004 “Hantang zhiji lifa gaige zhong ge zuoyong yinsu zhifenxi” 漢唐

之際曆法改革中各作用因素之分析) (On the factors that caused the calendrical debates and reforms from Han to Tang dynasty)，*Journal of Shanghai jiaotong university* (*Philosophy and Social Sciences*) 12, 33-38.

Nylan, M. 2010. "Yin-yang, five phases and qi". Nylan, Michael, and Michael Loewe, eds. *China's early empires: a re-appraisal*. Vol. 67. Cambridge University Press: 398-415

Ōhashi Yukio 大橋由紀夫, 1982, "Kōkan Sibunreki no seiritsu katei" 後漢四分暦の成立過程, Sūgakushi kenkyū 數學史研究 93: 12–14).

Oppolzer, T.R. von 1887. *Canon der Finsternisse. Wien: Karl Gerold's sohn*. Reprinted 1962 as Canon of Eclipses. New York: Dover Publications, Inc.

Pankenier, D. 1995. "The Cosmo-Political Background of Heaven's Mandate," *Early China* 20: 121-176.

Pankenier, D. 2005. "Astronomy and astrology in ancient China", in Victor Mair, Paul Goldin, and Nancy Steinhardt (eds.), *Hawaii reader in traditional Chinese culture.* Honolulu: University of Hawai'i Press, 18-27.

Pankenier, D. 2012. "On the Reliability of Han Dynasty Solar Eclipse Records." *Journal of Astronomical History and Heritage*, 15(3), 200-212.

Pankenier, D. 2013, *Astrology and Cosmology in Early China: Conforming Earth to Heaven,* Cambridge: Cambridge University Press.

Pines, Y. 1997. "Intellectual Change in the Chunqiu Period: The Reliability of the Speeches in the *Zuo zhuan* as Sources of *Chunqiu* Intellectual History." *Early China*, 77-132.

Qian Baocong, 1937. "Ganshi xingjing yuanliu kao" 甘氏星經源流考, Guoli *Zhejiang daxue jikan* 國立浙江大學季刊 6 .

Qu Anjing 曲安京 1994a, Zhongguo gudai shuli tianwenxue tanxi 中國古代數理天文學探析. Xian: Xibei daxue press.

Qu Anjing, 1994b. "Zhongguo gudai lifa zhong de jishi zhidu" 中國古代曆法中的計時制度, *Hanxue yanjiu* 漢學研究 12: 157–172.

Qu Anjing 曲安京, 2000. "Zhongguo gudai lifa yu yindu ji alabo de guanxi yi riyueshi qiqi suanfa weili."中國古代曆法與印度及阿拉伯的關係——以日月食起訖演算法為例. (A Comparison Study of the Models of Eclipse Phase among Chinese, India and Islamic Astronomy). *Ziran bianzhengfa tongxun* 自然辯證法通訊(Journal of Dialects of Dialects of Nature) 10(3):58-68.

Qu Anjing, 2005, *Zhongguo lifa yu shuxue* 中國曆法與數學. Beijing: Science press.

Qu Anjing, 2008, *Zhongguo shuli tianwenxue* 中國數理天文學. Beijing: Science press.

Qu Anjing, Tang Quan. 曲安京, 唐泉. 2008. "Zhongguo Gudai Rishi Shixian yu Shifen Suanfa."中國古代日食食限與食分演算法 (Algorithms of the Limit and Magnitude of Solar Eclipse in Ancient China). *The Chinese Journal for the History of Science and Technology* 29(4): 347-357

Raphals, L. 2008. "Divination in the Han shu Bibliographic Treatise". *Early China*, 45-101.

Raphals, L. 2013. *Divination and prediction in early China and ancient Greece*. Cambridge University Press.

Shi Yunli, Xing Gang. 石雲裡, 邢鋼. 2002. "Zhongguo Handai de Riyueshi Jisuan jiqi dui xingzhanguan de yingxiang." 中國漢代的日月食計算及其對星占觀的影響. (The Calculation and Divination of Luni- solar Eclipses of the Han Dynasty and Its Impact on the Astrological Thoughts). *Ziran bianzhengfa tongxun* 自然辯證法通訊, (Journal of Dialects of Nature), 28(05): 79 - 85

Shi Yunli, Xing Gang, 2005. "The calculation and divination of luni-solar eclipses of the Han dynasty and its impact on the astrological thoughts", T*he Chinese journal for the history of science and technology* 22: 107–21 (in Chinese).

Sivin, N. 1969. "Cosmos and computation in early Chinese mathematical astronomy." *T'oung Pao*, *55*(1), 1-73.

Sivin, N. 2009. *Granting the seasons: the Chinese astronomical reform of 1280, with a study of its many dimensions and a translation of its records*. New York: Springer.

Sivin, N. 2011. "Mathematical Astronomy and the Chinese Calendar". In *Calendars and Years II: Astronomy and Time in the Ancient and Medieval World.* Steele, J. M. Oxford: Oxbow Books. 39 - 52

Smith, A. 2011. "The Chinese Sexagenary Cycle and the Ritual Foundations of the Calendar". In *Calendars and Years II: Astronomy and Time in the Ancient and Medieval World.* Steele, J.M. Oxford: Oxbow Books. 1-38

Stephenson, F. Richard, 2008. "Lunar Lodges in Chinese Astronomy". *Encyclopaedia of the History of Science, Technology, and Medicine in Non-Western Cultures*. Springer

Netherlands. 1237-1241.

Steele, J. M., 1998. "Predictions of eclipse times recorded in Chinese history." *Journal for the History of Astronomy* 29: 275-285.

Steele, J. M., 2000, *Observations and Predictions of Eclipse Times by Early Astronomers*, Kluwer Academic Publishers

Stephenson, F. R., and Kevin C. C. Yao. 1992. "Astronomical Records in the Ch'un-ch'iu Chronicle." *Journal for the History of Astronomy*, 23. 1: 31–51.

Stephenson, F. R. 1997. *Historical Eclipses and Earth's Rotation.* Cambridge: Cambridge University Press.

Stephenson, F. R., and L. J. Fatoohi. 1995. "Accuracy of Solar Eclipse Observations Made by Jesuit Astronomers in China." *Journal for the History of Astronomy*, 26. 3: 227–36

Stephenson, F. R., and M.A. Houlden. 1986. *Atlas of Historical Eclipses maps, East Asia 1500 BC – AD 1900*. Cambridge: Cambridge University Press.

Stephenson, F. R., and Kevin C. C. Yao. 1992. "Astronomical Records in the Ch'un-ch'iu Chronicle." *Journal for the History of Astronomy*, 23. 1: 31–51.

Sun Xiaochun, and Kistemaker, J., 1995. "The ecliptic in Han Times and in Ptolemaic astronomy." In Hashimoto, K. et al. (eds.). *East Asian Science: Tradition and Beyond.* Osaka, Kansai University Press. Pp. 65-72.

Sun, Xiaochun. 2000. "Crossing the boundaries between heaven and man: Astronomy in ancient China." *Astronomy Across Cultures*. Springer Netherlands, 423-454.

Sun, Xiaochun. 2009. “Connecting Heaven and Man: The role of astronomy in ancient Chinese society and culture.” *Proceedings of the International Astronomical Union* 5.S260: 98-106.

Sun Yinggang 孫英剛 2012, “Shuodan dongzhi yu Jiazi geling: lifa chenwei yu suitang zhengzhi.” 朔旦冬至與甲子革令：曆法、讖緯與隋唐政治. *The Journal of Tang Studies* 18: 21-48

Tao Lei 陶磊. 2003. *Huai nan zi tianwen yanjiu—cong shushushi de jiaodu* 『淮南子· 天文』研究—從數術史的角度. Jinan: Qi Lu shushe.

Tseng, Lillian Lan-ying 曾藍瑩, 2011. *Picturing Heaven in Early China.* Cambridge: Harvard University Asia Center.

Wang Yingwei 王應偉 1998. *Zhongguo guli tongjie* 中國古曆通解, (Explanations to Chinese calendars). Shenyang: Liaoning Jiaoyu Press. 14.

Wang Aihe. 2000. *Cosmology and Political Culture in Early China*. Cambridge: Cambridge University Press.

Wang, Chia-Hsin 王家歆, 2008, “Shangshu yinzheng chenfujiyufang kao.”《尚書》〈胤征〉辰弗集於房考. *Guoli Taizhong jishu xueyuan tongshi jiaoyu xuebao* 國立臺中技術學院通識教育學報. 23-47.

Wu Shouxian. 2000. “Research on Determining the Age of Zhongkang Solar Eclipse in Xia Dynasty”. *Studies in the Histories of Natural Sciences* 自然科學史研究 19: 114-123.

*Xia-Shang-Zhou duandai gongcheng*夏商周斷代工程. (2000), (Xia-Shang-Zhou chronology project), Beijing: Shijie Tushu Chuban Gongsi.

Xiong, V. C. 2007. "Astrological Divination at the Tang Court." *Early Medieval China*, 13-14, 185-231.

Xu Zhentao, Yau K. K. C., Stephenson F. R., 1989, "Astronomical Records on the Shang Dynasty Oracle Bones." *Archaeoastronomy*, 14, 61–72

Xu, Z., Pankenier, D.W., and Jiang, Y., 2000. *East Asian Archaeoastronomy: Historical Records of Astronomical Observations of China, Japan and Korea*. Amsterdam, Gordon & Breach.

Yabuuchi, K. 1937, "Tō Kaigen seikyō chū no seikyō." 唐開元占經中の星經, *Tōhō gakuhō*東方學報8 : 56–74.

Yabuuti, K. 藪内清, 1963. "Astronomical tables in China, from the Han to the T'ang Dynasties." In Yabuuti, K. (ed.). *Chūgoku Chūsei Kagaku Gijutsushi No Kenkyū* 中國中世科學技術史の研究. Tokyo, Kadokawa shoten. Pp. 445-492

Yabuuti, K. 1974. "The Calendar Reforms in the Han Dynasties and ideas in their Background." *Archives lnternationales d' Histoire des Sciences*, 24, 51-65.

Yabuuti, K. 1996. "Calendrical Science in the Wei-Jin period and the Northern and Southern Dynasties"魏晉南北朝時期的曆法. *Studies in the history of Natural Science* 自然科學史研究 15: 122-130.

Yasukatsu Maeyama 前山保勝, 1977, "The Oldest Star Catalogue in China, Shih Shen's Hsing Ching," in Prismata: *Naturwissenschaftliche Studien—Festschrift für Willy Hartner*. Wiesbaden: Franz Steiner Verlag, 211–45.

Zhang Peiyu 張培瑜. 1997. *Sanqianwubai nian liri tianxiang* 三千五百年曆日天象

(Calendrical days and celestial phenomena for 3500 years). 2nd edition, Zhengzhou: Da xiang press.

Zhang Peiyu 張培瑜. 1990. Forum: Zhang Peiyu. *Early China*, 15, pp 133-150

Zhang Peiyu, 張培瑜. 1999, "jiaguwen riyueshi yu shangwang wuding de niandai" 甲骨文日月食與商王武丁的年代, *wenwu* 文物: 56-63.

Zhang Peiyu 張培瑜. 2002. *Zhongguo gudai lifa* 中國古代曆法.(Ancient calendrical systems in China). Beijing: Zhongguo kexue jishu chubanshe

Zhang Peiyu 張培瑜. 2006. *Zhongguo lishi rishidian* 中國歷史日食典 (Chinese Historical Canon of Solar Eclipse). Beijing: Shijie tushu chuban press

Zhang Peiyu. 2009. "Shilun zuozhuan guoyu tianxiang jilu de shiliao jiazhi."試論《左傳》《國語》天象紀事的史料價值. *Shixue yuekan* 史學月刊, Journal of Historical Science, 2009年 01 期

Zhu Wenxin 朱文鑫. 1934. *Lidai rishikao* 歷代日食考. Beijing.

Zhu Wenxin 1935, *tianwenxue xiaoshi* 天文學小史. Reprinted in 2013. Shanghai

Zhuang Weifeng 莊威鳳, 2009 *Zhongguo gudai tianxiangjilu de yanjiu yu yingyong* 中國古代天象記錄的研究與應用. Beijing: China Science and Technology Press.