The Reliability of Early East Asian Astronomical Records

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You did something because it had always been done, and the explanation was "but we've always done it this way". A million dead people can't be wrong, can they?

Terry Pratchett, The Fifth Elephant

Ph.D. THESIS ABSTRACT

THE RELIABILITY OF EARLY EAST ASIAN ASTRONOMICAL RECORDS

THOMAS JOHN YORK (2003)

The large body of observations extant from pre-telescopic East Asia - China, Japan and Korea - provide the opportunity to investigate the behaviour of the Sun and solar system over a much longer period of time than that since telescopic observations began in Europe. Much past work in this field has tended to concentrate on individual records of particularly significant observations. In this study the variations in the frequency of the observation of meteors, comets, eclipses, planetary conjunctions and occultations, sunspots, and aurorae during the pre-telescopic period are examined in contemporary records from these three countries.

It is to be expected that data artefacts (frequency variations not of astronomical origin) are present to some degree in early sources. The records are translated and collated where necessary, and by comparing patterns across the three countries and across different types of event several major data artefacts are identified and classified. The problem of such artefacts has not previously been the subject of analysis. The results of this study are therefore of significance in considering the reliability of these sets of data for the examination of long term variations in the solar system.

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Preface and Declaration

The work presented in this thesis was undertaken whilst the author was a graduate student working in the Department of Physics at the University of Durham under the supervision of Prof. F. Richard Stephenson. No part of this work has previously been submitted for a degree in this or any other university. The majority of the work is the author's own, but the material contained in the Appendix was compiled with the assistance of Donald Starr and Lin Wang, of the East Asian Studies Department of the University of Durham. Ephemeris data provided by Dr Steven Bell, of the Nautical Almanac Office, underpins the analysis of Chapters 3 and 4.

The analysis comprising the majority of Chapter 3 appears in York 2001.

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I would like to thank all my friends and family for letting me explain exactly what it is that I study, as I have consistently had to do. My gratitude goes to Jenny Radcliffe, for keeping me sane when needed. Finally, special thanks go to Melanie Mehew, for the last two years entire.

Tom York 23$^{\mathrm{rd}}$ January 2003.

Chapter 1

Ancient Records

1.1 Introduction

Astronomical records from pre-telescopic times (before about AD1600 or so) represent an important resource in understanding the behaviour of the Sun and solar system. Although mainly far less precise than telescopic observations, the long timescale which they cover provides several important advantages:

(1) Certain very rare events, notably Galactic supernovae, are completely absent from the telescopic record. However, over the long period covered by pre-telescopic data, several important sightings are preserved. (Stephenson & Green 2002))

(2) Long-term trends which cannot be detected over the few centuries covered by telescopic observations can often be discerned from pre-telescopic records. This is especially true for studies of Earth's rotation. Over the telescopic period, short-term variations in the length of the day completely swamp the long-term trend, which is in the form of a gradual lengthening of the day, largely due to tidal forces. However, ancient eclipse records going back to 700BC clearly reveal the trend and also provide evidence for non-tidal variations on the millennial timescale. (Stephenson 1997)

In addition, historical observations of sunspots and aurorae have been used to investigate the long-term variability of solar activity, while observations of comets and meteors exhibit marked variations in frequency on the centennial to millennial timescale. These have been used to support theories of large scale variation in the long term cometary and meteor fluxes (Bailey et al. 1990). However, with data in these categories, there is a very real possibility of data artefacts (that is, variations in frequency which are of human origin) affecting the intrinsic signal, as here it is the frequency of observations (rather than the accuracy of an individual observation) that is important.

After the introduction of the telescope in the early seventeenth century, astronomical observation in Europe quickly spread, such that a great amount of comparatively high quality information was produced from that time onwards. However, records of astronomical events from before AD1600 in Europe are scattered and, apart from eclipses, are relatively small in number. These are mainly found in chronicles, rather than dedicated astronomical texts. Some chroniclers showed a considerable interest in celestial phenomena, whilst others make no mention of such events at all.

Although there are substantial numbers of Arab chronicles dating from pre-telescopic times, few have been investigated, because most are still in manuscript form and are relatively inaccessible (King 1993). The few preserved Arab astronomical treatises (*zij*) are mainly concerned with eclipses and other cyclical phenomena such as planetary movements. In particular, comets were regarded as purely atmospheric phenomena, following the views of Aristotle, and both these and meteor showers are ignored in the *zij*.

Babylonian records, although very numerous - especially for observations of the Moon and planets - only cover about three centuries (350-50BC) in any quantity (Sachs & Hunger 1988-2002), and even here the degree of preservation (less than about 10% of the original) is very variable. In particular, only a very few sightings of aurorae and comets are present.

Hence, to effectively investigate long-term trends in such phenomena as solar variability, or the cometary and meteor flux, the only approach to a systematic set of data covering a suitably large period of time is found in East Asian history. Observations of sunspots, aurorae, comets and meteors from China, Korea and Japan have been used from time to time to investigate such trends. However, so far, relatively little attention has been paid to data artefacts arising from varying degrees of making, recording and preserving observations. It is therefore the purpose of this investigation to:

(i) intercompare the frequency of records of the same type of event reported independently in China, Korea and Japan over the same period;

(ii) For each of these three countries independently, compare observed variations in regular phenomena (those whose circumstance may be retrospectively calculated) such as lunar and planetary conjunctions with their expected frequency, and with the frequencies of other types of record from the same source.

What types of event exist to be examined in ancient texts?

Of the events that are recorded in East Asian history before 1600, records of the following exist in sufficient numbers that their frequency may be examined in some detail:

(i) Comets

A great number of comets are recorded in various documents. They are the only recorded astronomical phenomenon that can be observed systematically over a period of weeks or even months; as such they are of special importance, since it can be assumed with a reasonable degree of confidence that no bright comet can have been missed due to bad weather or similar day-to-day variations in making observations.

(ii) Meteors

These are of great interest, as, in the long term, the meteor flux may be expected to be related to the cometary flux. However, the nature of observing is in stark contrast to that of comets, since a single meteor is very easy to miss. We can only assume that the single meteor records that survive are a reasonably representative sample of the meteor flux during any one period, subject to variations in the level of observation and preservation. Meteors are fairly local events; only with meteor showers, lasting one or more nights, may we consider the likelihood of specific events being visible to all East Asian astronomers.

(iii) Eclipses of the Moon and of the Sun

Records of eclipses of both kinds appear relatively frequently in East Asian history. Such events, which are predictable to us today, are able to give important information into both long-term trends (the determination of the change in Earth's rotation speed through records of, notably, total solar eclipses being a prime example) and the quality of observation of early East Asian astronomy. However, there are clear indications in sources from China and Korea (Foley 1989) that astronomers were in the practise of predicting eclipses and recording their predictions. By around AD1000, predictions were sufficiently accurate that a correct but unobserved eclipse prediction often cannot be differentiated from an observation (unless there are descriptive details of the event). Most East Asian records of eclipses are very brief and do not state whether an event was predicted or actually observed. From around AD1000 onwards, identification of successful predictions is only possible when the record states that cloud or rain prevented observation.

It is thus not possible to use eclipse records as a measure of the reliability of observation, although work has been done on their potential as a measure of the quality of prediction. (Steele 1998)

(iv) Movements of the Moon and of the planets

The motion of the Moon and planets across the sky appears very frequently in astronomical records from all three countries. The dates on which the Moon or a planet entered a particular asterism or enclosure were often noted, as were occultations and conjunctions of an individual star or planet by/with the Moon, conjunctions between two or more planets, and conjunctions of a planet and a bright star.

These events, although not precise enough to complement the information on the rotation of the Earth obtained from the records of eclipses, do not suffer from the major drawback of such records. Although we can calculate the motion of the Moon and planets with precision today, and thus predict when an occultation or a conjunction will have occurred, this was not possible for the astronomers of pre-telescopic China, Japan or Korea. Hence, it is clear that we are consistently dealing with an observational record. As a result, the variation in the frequency of these records is useful in investigating the reliability of other types of data.

The following are typical records of this type. Where appropriate, day numbers of the sexagenary cycle are noted. It should be noted that I have chosen to apply the Wade-Giles system of romanisation for Chinese phrases, with the exception of Korean names, for which the McCune-Reischauer system is used.

20th April AD350, *Chin-shu* (China):

> "On a wu-hsü day [35] in the intercalary second month of the 6th year of the Yung-Ho reign-period, Mars trespassed against Jupiter - a presage of war according to the standard prognostication."

10th September AD1128, *Koryŏ-sa* (Korea):

> "On a ping-yin day [3] in the 8th month of the 6th year of the reign of King Injong, Venus trespassed against Regulus."

27th March AD1136, *Nihon Temmon Shiryō*, (Kanda 1934) (Japan):

> "On the 23rd day of the second month of the second year of the Hōen reign-period of Emperor Sutoku, the moon trespassed against Saturn."

(v) Aurorae

Records of aurorae are relatively common in early East Asian astronomical documents. The total number of separate sightings from all three countries during pre-telescopic times is around 800 (Yau et al. 1995). The value of these records lies in the low geomagnetic latitude from which the phenomena were observed; European observations - which are the only other substantial source of auroral records from pre-telescopic times - were made from significantly higher geomagnetic latitudes. The gradual motion of the earth's geomagnetic field over time is such that the difference in geomagnetic latitude between the two regions is not constant. However, even during the twelfth century AD (when the pole was aligned towards the Far East) the difference was such that it is likely that all aurorae recorded in East Asian history occurred during periods of unusually intense solar activity. Aurorae visible to European observers are much less exceptional. East Asian records therefore have the potential to contain important information about the solar cycle during these times.

(vi) Sunspots

Observations of sunspots, though indicative of the same variation as that of aurorae, have an important advantage; they are a direct indication of solar activity, whereas aurorae are the result of the interaction between the Earth's magnetosphere and the solar wind. Unfortunately, the number of sunspot observations from East Asia is much smaller than that for the auroral record; a total of 157 separate sightings (Yau et al. 1988) in the pre-telescopic period, a long term average of less than one per decade. The likely reason for this is that aurorae, being spectacular events, would be much more difficult to miss (in the same way that we might expect the proportion of comets that are observed - although not necessarily the recorded or preserved proportion - to be much higher than other phenomena). Sunspots, in comparison, may easily be missed if they are not actively being searched for; it is interesting to note that around 40% of all East Asian pretelescopic sunspot records were made in March or April, when dust storms in China and Korea were liable to lessen the effective brightness of the solar disc (Willis et al. 1980). Only a single sunspot observation survives from Japan before AD1600:

> "Ninju reign-period, 1st year, 11th month, day *chia-hsu* [11] (2 Dec 851). The sun was dim. Within it there was a black dot as large as a plum."

Other astronomical phenomena which appear in documents from pre-telescopic East Asia include novae and supernovae (although these can often be confused with comets, particularly if the record is lacking in detail), sightings of the planets in daytime (primarily Venus), and sightings of Canopus. Atmospheric phenomena such as solar haloes are also often included.

1.2 Sources

In China, astronomical events were recorded systematically in sections of the dynastic histories. These histories still exist today, reaching back to 200BC in one form or another. There are significant gaps in the record due to such events as the fall of the usurper Wang Mang in AD23 (with considerable destruction of the capital) and the An Lu-shan rebellion around AD755-760; the latter event in particular resulted in the loss of centuries' worth of astronomical - and other - data. Records from Korea are very sparse before AD1000, but after that date they cover the period up to the 20th century relatively consistently. In Japan, by way of contrast, no systematic central astronomical record now exists, although significant quantities of records survive from around AD600 onwards to the 20th century.

1.2.1 Astronomical sources from China

The dynastic histories of Imperial China contain a large amount of astronomical data. These histories - modern reprints of which are accessible in major libraries worldwide - are largely written in a fairly standardised form, comprising four main sections. The first of these section (*pen-chi* or Imperial Annals) chronicles the general history of the dynasty; although astronomical events are often mentioned they do not usually appear in any detail, and are mainly reiterations of events, in abbreviated form, recorded in the Astronomy treatise (below).

The second section (*chih* or Treatises) is devoted to a wide variety of subjects. Of the 26 dynastic histories, only 19 contain Treatises. The complete list of subjects is given in Table 1.1. It should be noted, in particular, the relative prominence of the astronomical treatise, which appears in all but one Treatises section.

Occasionally the subject of a treatise absent from a history is dealt with in a different treatise - for instance, Music is sometimes part of the treatise on Rites.

Treatise	English translation	Number of occurrences
Li	Rites	18
Yüeh	Music	17
Lü	Harmony	7
Li	Calendar	12
T'ien-wen	Astronomy	18
Chiao-ssu	Sacrifices	4
Kou-hsu	Rivers and canals	8
Shih-huo	Food and commodities	14
Hsing-fa	Law and punishments	14
Wu-hsing	Five phases	14
Ti-li	Geography	18
I-wen	Literature	7
Po-kuan	Offices	16
Yü-fu	Chariots and costumes	11
Fu-jui	Auspicious influences	4
Shih-lao	Buddhism and Taoism	1
I-wei	Imperial guards	5
Hsüan-chu	Civil service	8
Ping-wei	The army	8
Ying-wei	Militia and colonisation	1
Chiao-t'ung	Communications	1
Pang-chiao	Foreign relations	1

Table 1.1: Treatises of the Chinese dynastic histories, along with the number of histories (of a total of 19) that they occur in

In any given history, as many as three of these treatises may contain references to celestial phenomena: *Tien-wen* (astronomy), which deals with astronomical events of all kinds; *Li* (Calendar), which can also include records of eclipses; and *Wu-hsing* (Five phases), which sometimes includes a substantial number of eclipse, cometary and auroral records. The *Wu-hsing-chih* which are particularly important for astronomical records are in the *Han-shu*, the *Hou-han-shu* and the *Sung-shu*.

The third section of a dynastic history is made up of chronological tables (*piao*) for the dynasty, and the fourth by biographies (*lieh-chuan*). This last section, which is usually very extensive, may very occasionally include some astronomical material.

Within the Treatises, there is often no separation of astronomical records by type (notable exceptions are the astronomical treatises of the histories of the Chin (AD265-420), Nan-ch'i (479-502) and Sung (970-1275) dynasties, which are also exceptionally detailed). This, and the fact that the great majority of the histories have never been translated, mean that acquiring data from the original documents is fairly difficult and has only been attempted by a small number of Western scholars. The complete list of dynastic histories is given in Table 1.2. Note that during the periods of division separate histories were kept in the north and the south.

An early secondary source, the *Wen-hsien T'oung-k'ao* (Comprehensive study of documents and records), is of particular note here. This work, published in AD1319, was compiled around AD1280 by Ma Duan-lin, and draws material from all dynastic histories then available, and other compilations now lost. Its astronomical section is detailed and ordered by type, making it a much more accessible document.

For the Ming dynasty (AD1368-1644), a detailed work - the *Ming Shih-lu* (Veritable records of the Ming dynasty) exists in addition to the dynastic history. This chronicle is a much more in-depth history of the Ming than a standard dynastic history and contains much valuable astronomical material scattered throughout. Although *shih-lu* for previous dynasties existed - at least back to the Sung - none survive to the present day. The equivalent work covering the subsequent Ch'ing dynasty (AD1644-1912) is relatively poor from an astronomical perspective.

A large amount of work has been done in China by Chinese scholars on extracting various records from these histories. In particular, a substantial volume published by Beijing Observatory in 1988 provides an essentially exhaustive list of records of eclipse, comet and meteor sightings from China. It should be noted that this volume, which covers the entire time period of Imperial China (from the earliest surviving records to 1912) incorporates much data from local histories, which begin to appear in number in China from about 1500-1600 onwards. These are extremely numerous (around 1000 exist from the Ming dynasty alone) but contain a much smaller proportion of astronomical material than the dynastic histories or the *Ming*

History	Dynasty	Dates
Shih-chi		Up to 122BC
Han-shu	Former Han	122BC-AD9
Hou-han-shu	Later Han	AD23-220
San-kuo-chih	Three Kingdoms period	220-265
Chin-shu	Chin	265-420
Sung-shu	Liu-sung	420-479
Nan-ch'i-shu	Northern and Southern dynasties	420-589
Liang-shu	"	"
Ch'en-shu	"	"
Wei-shu	"	"
Pei-ch'i-shu	"	"
Chou-shu	"	"
Nan-shih	"	"
Pei-shih	"	"
Sui-shu	Sui	581-618
Chiu-t'ang-shu	T'ang	618-907
Hsin-t'ang-shu	T'ang	"
Chiu-wu-tai-shih	Five Dynasties period	907-960
Hsin-wu tai-shih	Five Dynasties period	"
Sung-shih	Sung	960-1279
Liao-shih	Liao	10th century - 1125
Kin-shih	Kin	1115-1234
Yüan-shih	Yüan	1271-1368
Hsin-yüan-shih	Yüan	"
Ming-shih	Ming	1368-1644
Ch'ing-shih-kao	Ch'ing	1644-1911

Table 1.2: The 26 Chinese dynastic histories

Shih-lu .

For nearly all of the pre-telescopic period, then, the observations made from the capital constitute the only systematic chronicle of astronomical events from China, and the only primary source available before the beginning of the Ming dynasty.

Thanks to the work of Ho Peng Yoke, the astronomical chapters of one dynasty - the Chin - has been completely translated into English and annotated. (Ho 1966) This comprises a substantial number of events of many different types, mainly covering the period from AD265 to 420 but with some records from the Three Kingdoms period (AD220-265). In addition, Ho's work with Chiu Ling Yeong (Ho et al. 1986) on the records of the *Ming Shih-lu* identifies and separates out the astronomical records of this period - AD1368-1644 - by type. (The official history of the Ming dynasty, the *Ming Shih*, simply condenses the material found in the *Ming Shih-lu* ; there is little that is original to be found in it.)

The Chinese cometary record has in the past been the subject of much research. The catalogue of Biot (Biot 1846a, Biot 1846b) was the first Western compilation of such records, which translated into French the cometary observations contained in chapter 291 of *Wen-hsien T'oung-k'ao* . Williams' work (Williams 1871) expanded upon this, adding records extracted from the *Shih-chi.* This is the first dynastic history, written in the second century BC by Szu-ma Ch'ien. It deals with all periods up to the reign of the Han Emperor Wu-ti (140-88BC). Williams' compilation was the first to give translations in English. Two catalogues produced by Ho Peng Yoke - the latter with Ang Tian-se (Ho 1962, Ho & Ang 1970) drew upon most - but not all - of the dynastic histories, as well as *Wen-hsien T'oung-k'ao* , but did not draw upon the local histories. The first catalogue, which covers the period from ancient times to AD1600, also includes much Korean and Japanese material. The second catalogue supplements the first with data from the *Ming Shih*, although there seem to be relatively few records extracted from the *Ming Shih-lu* . These represented the most complete compilations available until the publication of the Beijing Observatory book.

Recently, a new work (Xu et al. 2000) has been published which represents a wide ranging translation of early oriental astronomical records into English. Eclipses of both kinds, novae, sunspots, aurorae and conjunctions of two or more planets are covered in depth; the sunspot data in particular being drawn from the earlier catalogue of Yau and Stephenson (Yau & Stephenson 1988). Comets are absent from the work with the exception of sightings of Comet Halley; meteors are completely missing. It is important to note that, since the book draws records from a wide variety of different sources from all three East Asian countries, the observations made available through it are not systematic; the overall number of records seen changes through the pre-telescopic period as sources begin and end. Hence this work, as a multiplicity of individual sources, is of limited use in determining the flux of events, but valuable in selecting and translating data from the original and much less accessible texts.

1.2.2 Astronomical sources from Korea

The earliest surviving historical work from Korea, covering the period from antiquity (nominally around 100BC) up to AD918, is the *Samguk Sagi* (History of the Three Kingdoms), written around AD1145 by Kim Pu-sik. This is written in the style of a Chinese dynastic history, but comprises only the first (Annals) section. There are unfortunately few astronomical records in the work, and most of these appear to have been copied from Chinese history.

A history of the Koryo dynasty (AD918-1392), the *Koryŏ-sa* (History of the Kingdom of Koryo), is the earliest significant source of Korean astronomical records. This work, which is written in the style of a Chinese dynastic history, contains very few astronomical sightings before AD1000, but a large number thereafter. It was based upon more detailed writings - *sillok* (Veritable Records), exactly equivalent to the Chinese *shih-lu*. These no longer exist for the Koryo dynasty. The *Koryŏ-sa* includes three chapters (47-49) of astronomical records, though no separation of events by type occurs. Although sightings during the day and during the night are recorded separately, the former first, this does not match the demarcation of chapters in the *Koryŏ-sa* . In addition, a substantial amount of astronomical material appears in the Annals of the history; as with the Chinese works, however, this essentially consists of data taken from the astronomical chapters, and offers nothing in addition. Aurorae, however, are frequently noted in the Five Phases treatise (chapter 53).

The *Choson Wangjo Sillok* , the detailed annals for the subsequent Yi dynasty (1392-1910), survive, and are extremely extensive, containing a large amount of astronomical data. These chronicles comprise a multi-volume work, listing events of all kinds, reign by reign, day by day, in chronological order. It is written, as are the earlier Korean works, entirely in classical Chinese. Fortunately, the astronomical records for each day are usually either listed at the very beginning or at the very end of that day's records. The *sillok* are most valuable in their treatment of phenomena that are visible for some time, such as comets or galactic supernovae, as day by day observations are sometimes available over several months (whereas in a dynastic history this would normally be condensed to a single account). Due to the size of the work, searching the *sillok* for astronomical records is a difficult task. A partial index exists, as does an electronic copy; the latter, however, is heavily commented in Hangul (the Korean alphabet, designed in the fifteenth century), making it less accessible to Western scholars than would otherwise be the case.

In addition, a secondary source published in 1747, *Chung-bo Munhon Pigo* , combines historical records obtained from all three of the above sources, and is divided into sixteen sections by category; astronomy is one of these. The astronomical records are further separated by type. As such it can be thought of as a Korean equivalent to the *Wen-hsien T'oung-k'ao* . However, it is not particularly useful as a source of astronomical data, as it is fairly deficient in the proportion of records it transcribes, and there are numerous copying errors.

1.2.3 Astronomical sources from Japan

Unlike the Chinese and Korean sources, historical records from Japan are largely scattered and are in no way systematic. One major work, *Dai Nihon Shi* (History of Great Japan), written around 1750, exists, but although it contains some astronomical material this is very patchy, and its astronomical section is only small. The main language of the various texts is classical Chinese, although often with the addition of the *Kana* syllabic symbols.

Two notable compilations have been made of astronomical records of all kinds, drawn both from this history and from a great number of additional, but fragmented, sources, such as privately compiled histories, diaries of courtiers, and temple records. Kanda Shigeru's *Nihon Temmon Shiryō* (Japanese astronomical records), published in 1935, is of primary interest here, covering the period from AD628 up to 1600; Osaki's *Kinsei Nihon Temmon Shiryō* (Pre-modern Japanese astronomical records) deals with records from 1600 onwards. For all practical purposes, Kanda's compilation represents the only accessible source of pre-telescopic Japanese astronomical records outside Japan itself. They are, fortunately, divided by type and dated (in the Julian or Gregorian calendar).

It should be noted that, as a compilation based on many sources, the observations contained in Kanda's work cannot be considered to be systematic; with the number of possible observers of any one event varying dramatically with time, the probability of observation cannot be taken to be constant. This is a great advantage of the centralised observations of the Korean and Chinese histories.

Chapter 2 Background History

2.1 China

The first period of civilisation in China that can be considered to be historically reliable - that is, where chronicles and other late texts are well supported by contemporary finds - is the Shang state, which arose in the first half of the second millennium BC and lasted for several centuries. Vast numbers of "oracle bones" recovered from the probable site of one of the Shang capitals provide much information on the dynasty, although at this stage there is little astronomical information. The Shang ruled for several centuries, beginning around 1500BC. However, at around 1050BC, they were overthrown by the Chou, a people that had been previously conquered by the Shang.

The Chou expanded on the territory held by the Shang, each king reigning over a number of feudal states. In time the balance of power swung towards the princes of the individual states, and following a number of crises the monarchy came to rule only in name. This occurred around 771BC, when the capital was moved to Lo-yang. From this point on, for over 500 years, more or less continuous warfare existed between the many Chou states for control of land. This period is generally divided into two; the Spring and Autumn Period (722-481BC), and the Warring States (403-221BC) - the latter seeing much more military activity and resulting in the conquering of the weaker states by the strongest few states. This situation came to an end with the rise to power of the state of Ch'in from around the beginning of the fourth century BC. From around 312BC onwards, the Ch'in began its military conquest of the other remaining states. The Ch'in ruler deposed the last Chou king in 256BC.

In the years up to 221BC the remaining states were conquered by the Ch'in, who were then the rulers of a unified China, with its capital as Hsien-yang. A draconian system of law was imposed, and territory was expanded further. From a historical perspective, however, the most notable point of the rule of the Ch'in was their widespread destruction of most of the writings of preceding centuries in 213BC, as part of the effort to consolidate power. It is significant that records of all kinds - including astronomical - only exist in any substantial number from after this period. The beginning of the third century BC is an effective cut-off point for nearly all astronomical data.

The death in 210 of the first Ch'in emperor was the event that led shortly after to the downfall of their rule by insurgent forces. The struggle that followed - in which, unfortunately, many more valuable documents were destroyed - led ultimately to the establishment in 202 of the Han dynasty. The Han set up a new capital at Ch'ang-an (a little to the east of Hsien-yang) whose site lies near the modern city of Xi'an.

Most of the early works of the Han were concerned with restoring the great damage dealt by the Ch'in ascendancy and subsequent fall. A political system was set up in which part of China was ruled directly by the emperor and his government and part by semi-independent "kings" (although these had significantly less power than the feudal princes under the Chou). A short-lived revolt of seven of the kings in 154BC was part of the process that slowly transferred power towards the central government.

At the same time China was engaged in a continuing struggle with the nomadic Hsiung-nu people to the north and northwest. These campaigns, which lasted up until the disintegration of the Hsiung-nu empire in 58BC, led to further territorial expansion, as did wars to the south, and, significantly, into North Korea. Around 100BC, large numbers of Chinese settlers moved into Korea; this was a significant part of the beginning of the spread of Chinese culture to Korea and eventually to Japan.

The Han expansion, however, was at great financial expense, and an economic crisis resulted. After the long reign of Emperor Wu (140-87BC) - during which much of the expansion took place - this crisis, combined with growing social problems and a number of weak emperors, eventually led to the rule of Wang Mang, who usurped the throne in AD9. A series of reforms failed to have any great effect on the worsening conditions of the peasant class; this, and extensive famine in the second decade AD, led to widespread revolt. Wang Mang was killed in AD23, but the struggle for power amongst the insurgent Liu clan lasted until AD25. Kuang Wu became emperor and re-established the Han dynasty; the capital was moved back to Lo-yang from Ch'ang-an, which had been completely destroyed. A large number of historical documents were lost with the city's destruction.

During the Later Han, the social and economic conditions, though dramatically improved in the wake of the reforms made following the fall of Wang Mang, once again deteriorated. From AD126 a number of unsuccessful peasant rebellions took place, the greatest of these being that of the Yellow Turbans in AD184. The role of private, provincial forces in defeating these movements, however, weakened the centralised government; a struggle for power between these forces began which ended the Han rule and began the *San-kuo* (Three Kingdoms) period. In 190 the Emperor was dethroned by one of the provincial generals and replaced by his brother as a puppet ruler, who ruled in name until 220. The rulers of the states of Wei, Shu and Wu each claimed to be the legitimate ruler of China. During this time there was great destruction in the cities; Lo-yang itself was pillaged and burned early on, and it is likely that a substantial number of records were lost as a result.

The Three Kingdoms period lasted until AD265, when the last king of Wei was deposed by his general, Ssu-ma Yen, who became the first emperor of the Chin dynasty. By 280 he had conquered his way back to a united China; his death in 289 led to an extended struggle for power which severely weakened the country over the following seventeen years. This was followed by invasions by the nomadic tribes from the west; both Lo-yang and Ch'ang-an were once again captured and destroyed. Much of North China came under Mongol rule. The Chin capital, originally at Lo-yang, was moved first to Ch'ang-an and then to Chien-kang (modern Nanjing), to the south; the dynasty lasted until 419, without recovering the territory lost to the north. Rule there was divided between hostile states, eventually reducing down to the victorious Toba clan at the end of the fourth century AD. China remained divided into two for around two hundred years.

During this - the period of division - four further dynasties ruled the south;

the Liu Sung (420-479), the Nan-ch'i (479-502), the Liang (502-557) and the Ch'en (557-589). This came to an end when, in 581, Wen-ti founded the Sui dynasty in the newly reunited north; in 589 he invaded and conquered the south. When he died in 604, Yang-ti ascended the throne; his reign, marked by expansive construction schemes and military campaigns, once again bankrupted the country. Notably, he conducted a series of campaigns against Korea from 611 to 614. Peasant uprisings and subsequent desertions led to a situation of complete chaos; Yang-ti was killed in 618, and subsequently a new emperor - Kao-tsu, the first of the T'ang dynasty - was declared.

The T'ang dynasty represented a long and relatively stable period. As part of a continuing effort to expand the empire, China attempted several times to conquer the three kingdoms of Korea, none of which succeeded for any length of time, but led to the unification of Korea by the kingdom of Silla around 670. The influence of Chinese culture on Korea was, however, greatly magnified from this time onwards.

The stability of the T'ang was disrupted in 755, when the courtier An Lu-shan rebelled and raised armies against the emperor. Both Lo-yang and Ch'ang-an were conquered; it took until 763 for the T'ang to crush the An Lu-shan rebellion. The war resulted in great loss of life; many records were also destroyed at this time.

Although the T'ang ruled for over a century more, the dynasty became increasingly less powerful after the rebellion, due to a succession of weak emperors and the economic and social wake of the war. A great peasant rebellion took Ch'ang-an in 880, holding it for two years, and although the T'ang prevailed, they had lost virtually all power and authority; the imperial family were murdered in 904, and China once again reverted into a number of independent states. A succession of short-lived dynasties in the north suffered more or less continual warfare and deprivation. The southern kingdoms fared rather better. This situation continued until their eventual conquest from the north, where a more stable and enlightened dynasty, the Sung, had been founded, in AD960.

The Sung (whose capital was Pien - modern Kaifeng) ruled over a much smaller territory than its predecessors, and - after its first two strong emperors - was an administration dogged with intrigue and corruption. As such it was weak when, in the 1120s, China was once again threatened by invasion from nomadic peoples - the

Jurchen - from the north. In 1141 the Sung, having lost the north of the country, signed a peace treaty which was essentially a capitulation. The new Southern Sung capital was at Lin-an (modern Hangzhou). Despite a number of unsuccessful campaigns by both sides, the period following was one of relative stability in both the north and the south, lasting up until 1208. In this year a great Mongol invasion of the north began. Their campaigns against the southern Sung began in 1235 and continued sporadically for much of the thirteenth century; the final campaign, beginning in 1268, lasted eleven years. Its end saw the destruction of the Sung dynasty and the Mongols holding dominion over the whole of China.

The Mongols adopted the Chinese administrative system, establishing the Yüan dynasty, and ruling from Ta-tu (Beijing); lasting a little under a century, they were again plagued by rebellion and political infighting. During this time several unsuccessful campaigns were launched against Japan (Korea having been conquered by the Mongols several decades before). The downfall of the rule of the Mongols came in the form of multiple peasant rebellions; in 1368 the last Yüan emperor fled China, and the peasant rebel leader, Chu Yuan-chang, became Hung-Wu, the first emperor of the Ming dynasty.

The Ming, whose rule lasted from 1368 until 1644, are as such the last whose records contribute towards the body of pre-telescopic astronomy. Events of note include the continuing wars with the Mongols and with the Japanese in the sixteenth century AD; however, neither of these were on the scale of those of previous centuries, in that no significant loss of records took place. Since the fall of the Ming was not accompanied by the destruction and chaos that some of the earlier dynasties ended with, the records of this period are significantly more complete than from those preceding it.

The location of the Chinese capitals are given in Table 2.1, adopting the convention that longitudes to the east of the Greenwich meridian are negative.

2.2 Korea

Before about the fourth century BC, civilisation in Korea had not advanced beyond the tribal level; the advent of bronze at this time was the stimulus for the creation

Capital	Modern name	Latitude (degrees)	Longitude (degrees)
Ch'ang-an (during Han)	Xi'an	34.35	-108.88
Ch'ang-an (during T'ang)	Xi'an	34.27	-108.90
Chien-k'ang	Nanjing	32.03	-118.78
Lin-an	Hangzhou	30.25	-120.17
Lo-yang	Luoyang	34.75	-112.47
Pien	Kaifeng	34.78	-114.33
P'ing-ch'eng	Datong	40.20	-113.20
Sung-chiang	Songjiang	31.00	-121.22
Ta-hsing Ch'eng	Xi-an	34.27	-108.90
Ta-tu	Beijing	39.92	-116.42

Table 2.1: The longitudes and latitudes of Chinese capitals.

of larger scale alliances. Ancient Choson was the most significant of these, and can be considered to have been on a similar level to that of one of the Warring States in China, which it was contemporary with.

After the Ch'in unification of China in 221BC, events in China began to have a direct effect on Korea; as a result of a failed rebellion against the newly founded Han dynasty around 190BC, a significant number of Chinese refugees entered Ancient Choson, which at this time occupied much of the north of the country. Their leader, Wiman, probably aided by rebellious clans within Korea, was able to seize the throne; he and his descendants ruled for a little under a century, when the Han Emperor, Wu-ti, invaded. Ancient Choson was conquered in 110BC.

Northwestern Korea remained under Chinese rule for centuries. After the Han dynasty fell and the Three Kingdoms period began, it was held by the kingdom of Wei; it was claimed by the Chin after reunification. The Chinese were finally driven out of Korea in AD313 by the Koguryo tribes of the northeast.

By this time Koguryo in the north and Paekche in the south had solidified into kingdoms; for much of the fourth century AD Koguryo was at war with both Paekche and with the tribes which had conquered Northern China. The state of Silla also arose during the fourth century in the southeast.

During the fifth century AD the power of Koguryo waxed; it held most of modern

Korea and a large expanse to the north. Three other kingdoms - Paekche, Kaya and Silla - occupied the southernmost third of the peninsula, following the taking of the Paekche capital and much of its territory in 475. In the following years the power of Silla grew, swallowing up the Kaya tribes and expanding to separate Koguryo from Paekche.

Silla was now the most powerful of the Three Kingdoms. When China was reunited by the short-lived Sui dynasty, Silla entered into an alliance with China; in 598 war broke out between the Sui and Koguryo, but the multiple Chinese campaigns were not able to take the kingdom.

A similar state of affairs continued after the T'ang dynasty replaced the Sui in China. Silla's growing power and its relations with China ultimately led to the conquest of Paekche in 660, and subsequently of Koguryo in 668. The T'ang claimed the territory as part of China. It quickly became apparent that the Chinese would attack Silla; in 671 Silla took the former Paekche territory, and in the following years it expelled the Chinese forces from most of the peninsula. China formally rescinded its territorial claims and acknowledged the sovereignty of Silla in 735.

After the eighth century AD, Silla's considerable power began to decline. Power struggles between different claimants to the throne, as well as rebellion from both the aristocracy and the peasants, led to a state of civil war from the early ninth century onwards. The power of the central government was essentially destroyed. By early in the tenth century several rebel leaders had formed independent kingdoms - most significantly those of Later Paekche and Koryŏ. In 935 Silla surrendered to Koryŏ; in 936 Koryŏ conquered Later Paekche to reunite Korea. The capital was established at Songdo (Kaesong), where it remained for most of the dynasty.

The Koryŏ dynasty ruled for more than four hundred years. Its records represent the earliest body of astronomical observations from Korea that exist in any number. Korea was threatened many times during this time. The first major threat came in 993, when, as a result of Korea's diplomatic relations with the newly created Sung dynasty in China, the Khitan tribes to the north attacked Koryŏ. The move was only partially successful, and the two sides came to a peaceful agreement. However, the Khitan, at the zenith of their power, invaded once again in 1010. The city of Kaesong fell to them and there was widespread destruction; the Khitan forces were ultimately destroyed, however, and the war was ended by 1019. As a result of the fall of Kaesong and the loss of documents associated with it, however, historical works on the reigns of the seven previous kings of Koryŏ were commissioned.

Koryŏ survived the Jurchen's rise to power to their north and their subsequent conquering of North China, though the threat from the Jurchen and factional politicking fueled a large scale rebellion in 1136. The rule of King Uijong, who came to the throne in 1146, also resulted in rebellion; a military coup d'etat occurred in 1170-1, and for the next 26 years generals fought against each other for power under the puppet King Myongjong.

In 1196 the general Ch'oe Ch'ung-hon gained power and managed to establish a more stable rule. His family effectively ruled Korea for sixty years. However, the first half of the thirteenth century brought a new threat to Korea in the form of the Mongols. The Jurchen and Khitan fell, and in 1231 the fourth Ch'oe dictator - Ch'oe U - sued for peace. The next year, however, resistance to the Mongols began with the displacement of the entire Korean government to the island of Kangwha, which from then became the capital; fighting continued until 1257, when Mongol overlordship was recognised. The destruction during this time was immense; vast numbers of documents were lost.

In 1258, Ch'oe U was assassinated, and King Kojong regained control of the government. The military, who wished to continue resistance against the Mongols, enacted a coup in 1269; it failed within a year, however, and in 1270 the then King Wonjong returned to power, and Mongol control over most of Korea was complete. Resistance continued in the south until 1273.

Mongol dominion over Korea continued until the weakening of their control of China in the mid fourteenth century. In 1368, with the defeat of the Mongols in China and the beginning of the Ming dynasty, Koryŏ was once again free of Mongol rule. The Koryŏ court, however, was still plagued by factionalism; in 1364 King Kongmin was assassinated and replaced by King U (also referred to as Sin-u). The end result of this continuing struggle was the seizure of power by the general Yi Song-gye, in an effort to prevent war with China. King U was deposed and a succession of puppet kings were elevated to the throne. In 1391 Yi Song-gye was appointed commander-in-chief of the military; in 1392 he was declared to be the rightful king, taking the name T'aejo, the first of the Yi dynasty.

The early Yi implemented many reforms to ensure, amongst other things, that - after the last years of Koryŏ - authority remained with the monarch. The capital was moved to Hansong (modern Seoul). It was around this time, during the reign of King Sejong (1418-1450), that Hangul, the Korean alphabet - which is in standard use in Korea today - was invented.

Sejong was succeeded by his son, Munjong, who died only two years later. A struggle for power ensued in which one of Sejong's sons, Sejo, usurped the throne; this, and the disastrous reign a little under fifty years later of Yonsan'gun, were the most marked periods of instability in the early Yi, neither of which led to significant destruction of records. It was only at the end of the sixteenth century that another major threat appeared, in the form of invasion from Japan. The Japanese, under Toyotomi Hideyoshi, took most of the country in a few weeks in 1592; widespread resistance and forces from China forced the Japanese to negotiate. The negotiations came to no agreement, and in 1597 Japan invaded Korea again, this time with much less success. The country was left in a bad condition by the war; many books and records were destroyed when Seoul fell to the Japanese. Three of the four copies of the extensive records of the reigns of the Yi kings - the *Choson Wangjo Sillok* - were lost at this period. Following the Japanese invasion, the Yi dynasty continued, with no more major crises, until the Japanese annexation of Korea in 1910.

Capital	Modern name	Latitude (degrees)	Longitude (degrees)
Songdo	Kaesong	37.97	-126.57
Kangwha	Kangwha	37.73	-126.48
Hanyang	Seoul	37.55	-126.97

Table 2.2: The longitudes and latitudes of Korean capitals.

2.3 Japan

Written history in Japan began much later than in China; the two countries first came into contact during the Han dynasty, and the Han records are the earliest written source of information on Japan. Archaeological finds remain the primary source for several centuries after this. Around the 5th century AD, the Yamato state arose with its capital at Asuka. Writing was introduced to the Yamato by scribes from Paekche in Korea; the *Paekche Chronicles*, dating from this time, were later incorporated into the *Nihon shoki*, the Japanese court history. From AD507, when Emperor Keitai to the throne, many individual family histories were also chronicled.

During the seventh century, a series of reforms - the Taika reform - were undertaken as the Yamato state adopted many of the methods of the T'ang in China at the time. A new capital was built in the Chinese style at Fujiwara in 694; however, in 710 the capital moved again, this time to Heijō in the Nara basin. The first years after this move saw the compilation of the first histories - the *Kojiki* in 712 and the *Nihon shoki* in 720. Both draw much of their content from earlier works that are no longer extant; although there is a significant portion of legendary material, it is thought that both works are chronologically accurate from around AD500 onwards. There followed, in 797, the *Shoku nihongi*, which covered the eighth century; four more subsequent state histories were compiled in the Heian period (AD794-1185). During the eighth century the court moved temporarily several times, and in 784 the capital was once again relocated, to Nagaoka; then in 794 to Heian-kyō (modern Kyōto), where it remained for nearly four centuries.

The reason for the move had its roots in the factional infighting between the imperial family, the powerful Fujiwara family, numerous other noble families and the monks of the Buddhist temples and monasteries. Heian was chosen as the "final" site for the new capital due to the association between the local inhabitants and the then-current emperor's branch of the imperial family. The monolithic aristocratic bureaucracy remained; the complex system of privileges led to the rise in power of the Fujiwara family, whose policy of intermarrying with the imperial family gave them significant power over the emperors. In 858, Fujiwara Yoshifusa became the first non-member of the imperial family to become regent, with his grandson on the throne. From the mid tenth to mid eleventh centuries every emperor had a Fujiwara regent.

The monopoly ended in 1068 with the elevation of Go-Sanjō to emperor. He abdicated after four years to be better placed to prevent the Fujiwara regaining power; however, his policy - and that of his heirs - of reclaiming land rights to be kept by the imperial family gave them much more power independent of the Fujiwara. There followed an increased reliance on provincial officials with military forces available to them. By the middle of the twelfth century the widespread use of military force to achieve and maintain power - rather than politics - had ended the dominance of the court. The Taira warrior clan came to dominate the court in much the same way that the Fujiwara had, but only briefly; in 1185 the Taira's power was broken by the Minamoto clan. The Minamoto general, Yoritomo, became the first shōgun.

There followed a period of coexistence between the imperial court and the Bakufu (warrior government) of the Minamoto, based much to the east in Kamakura. The Hōjō clan dominated the Bakufu and later the imperial succession after the end of the Minamoto line early in the 13th century; there followed several attempts by the court to recover power, which resulted in civil war. In 1336, the emperor Go-Daigo fled Kyōto, and the Muromachi Bakufu was founded under a new shōgun and a puppet emperor. Two rival courts existed in the north and the south for the next thirty years. Japan descended into a feudal society with little central control for around three hundred years. Two attempted invasions by the Mongols at the end of the the thirteenth century were repulsed by the Bakufu.

During the late fifteenth and sixteenth centuries the increasing unrest and discontentment of the peasants, along with continuing political instability, provided the climate for the reunification of Japan. A series of military successes gave control of central Japan - including Kyōto - to one man, Oda Nobunaga, by 1576. His plans for extending control to the whole of Japan were halted by his assassination in 1582; however, power and military might subsequently passed to the strategist, Toyotomi Hideyoshi. Under his leadership Japan was effectively reunited by 1590; in 1592, he launched a devastating attack upon Korea, lasting several years, but eventually coming to an end with the withdrawal of Japanese forces after Hideyoshi's death. In the aftermath of Hideyoshi's rule, power was seized by Tokugawa Ieyasu, and the dynasty of Tokugawa shōguns, which lasted for the greater part of the telescopic period, began in 1603.

N.B. In my creation of the above historical summaries the most significant ref-

Capital	Modern name	Latitude (degrees)	Longitude (degrees)
(Yamato Plain)	-	34.6	-135.8
Nara	-	34.68	-135.82
Heian-kyo	Kyoto	35.03	-135.75
Edo	Tokyo	35.67	-139.75

Table 2.3: The longitudes and latitudes of Japanese capitals.

erences used were Han(1970), Rodzinski(1979), Nahm(1988), Bowring & Kornicki (1993).

Chapter 3

Regular Phenomena: Chin dynasty

3.1 Introduction

The subset of astronomical phenomena for which we may reliably calculate circumstances based on present day knowledge includes, for the most part, those due to the regular motion of the planets and of the sun and moon (that is, we may today predict and model their behaviour). Although certain other events - such as past sightings of Comet Halley - may be said to be regular under this definition, such events are very sparse compared to solar, lunar and planetary observations. Similarly, although phenomena linked to the solar cycle, such as sunspots, can be to some extent modelled and predicted, there is not enough information available on the long-term variability of solar activity to be able to do so over a millennial timescale. These events will be examined in a separate chapter. In addition, as records of eclipses in particular are, uniquely, influenced by the ability of early astronomers to make and record predictions, they will be examined separately.

The numerous records of conjunctions between two planets or a planet and a star, of occultations of a star or a planet by the moon, or of the motion of the moon and planets with respect to the Chinese constellations (asterisms) have not been as widespread a subject for analysis as, for example, the East Asian cometary record; since it is possible to calculate the positions of the moon and planets to a high degree of accuracy, these records, alone, cannot provide any astronomical information that is not already available. Their value lies in the information they can provide about the observing process.

The details of many of the lunar and planetary records depend on the Chinese celestial system; if a particular star is not referred to in the text, the asterism in which the event took place is usually mentioned. A brief description of the system is therefore included.

3.2 The East Asian sky

There are, traditionally, a total of 283 Chinese star groups, which are usually referred to as *asterisms*, covering the night sky as visible from East Asia. These are generally smaller than their Western equivalents; the average number of stars is around six, and several only contain one star visible to the naked eye. In addition, three larger areas, referred to as *yuan* (enclosures) were defined; *T'ien-shih* (the Celestial Market), which lies mostly in Hercules; *T'ai-wei kung* (the Grand Forbidden Palace, often abbreviated to *T'ai-wei*), which occupies much of Leo and Virgo; and *Tsu-wei kung* (the Purple Forbidden Palace, often abbreviated to *Tsu-wei*), which occupies the north polar region.

28 of the 283 asterisms were considered particularly important. These constitute the *hsiu* or lunar lodges. These star groups, which circle the sky in the equatorial zone, acted as coordinate markers; this, and the fact that (since roughly half of their number lie close to the ecliptic) a large proportion of recorded lunar and planetary events naturally take place in the *hsiu*, mean that they feature prominently in astronomical texts. They are listed in Table 3.1, along with their determinative star; these stars' positions were used to determine the western edge of each lodge.

Note that there are three lodges with the romanised name *Wei*. The character for each was different; as can be seen, the three names mean very different things.

The 28 *hsiu* were used to divide up the sky along lines of right ascension. Thus there is an important difference between the asterisms listed above and the lunar lodges of the same name, which extend from pole to pole, encompassing the asterisms somewhere in the middle. (The alignment is not exact; one star in each of these asterisms was used as the determinative star for the lodge. The lodge was considered to extend eastwards from that star to the determinative star from the next asterism; hence, in many cases, substantial parts of an asterism fall outside the zone of the lodge with the same name.) For lunar and planetary observations,

	Name	Translation	Determinative Star
1	Chio	Horn	α Vir
2	K'ang	Neck	κ Vir
3	Ti	Base	α Lib
4	Fang	Chamber	π Sco
5	Hsin	Heart	σ Sco
6	Wei	Tail	μ Sco
7	Chi	Basket	γ Sgr
8	Nan-tou	Southern Dipper	ϕ Sgr
9	Ch'ien-niu	Ox	β Cap
10	Hsu-nü	Maid	ϵ Aqr
11	Hsu	Emptiness	β Aqr
12	Wei	Rooftop	α Aqr
13	Ying-shih	Encampment	α Peg
14	Tung-pi	Eastern Wall	γ Peg
15	K'uei	Stride	ζ And
16	Lou	Harvester	β Ari
17	Wei	Stomach	35 Ari
18	Mao	Mane	17 Tau
19	Pi	Net	ϵ Tau
20	Tsui-hsi	Turtle Beak	ϕ^1 Ori
21	Shen	Triad	δ Ori
22	Tung-ching	Eastern Well	μ Gem
23	Yu-kuei	Ghost Vehicle	θ Cnc
24	Liu	Willow	δ Hya
25	Ch'i-hsing	Seven Stars	α Hya
26	Chang	Extended Net	υ Hya
27	I	Wings	α Crt
28	Chen	Axletree	γ Crv

Table 3.1: The twenty-eight lunar lodges

the distinction between the lodge and the asterism is less important, since, usually, the asterism the body is seen in at any one time more or less corresponds to the lodge in which the body's position falls. However, when dealing with phenomena that can occur anywhere in the sky, such as comets or meteors, this distinction is critical.

Standard terminology appears in the surviving records of lunar and planetary observations in describing the apparent closeness of an approach. The term *fan* (to "invade", "offend") is most commonly used, and indicates a reasonably close approach; an occultation or conjunction with several degrees between the bodies, for example, would not merit this description, and usually would not be recorded. Hence the motion of the moon does not lead to recorded approaches to the five naked eye planets every month.

A less common term, *yen* (to "hide", "conceal"), was employed to indicate an apparent occultation. Such an event need not involve the moon; a conjunction between two planets or one planet and a star in which the bodies were too close to be resolved would also be described in this way.

The names consistently used for the five naked eye planets were their astrological names. A second set of names, indicating the association of the planets with the five elements, were also occasionally used. They are given in Table 3.2. The moon was known as *Yue*, or, less frequently, as *T'ai-yin*.

Planet	Traditional name	Translation	Elemental name	Translation
Mercury	Chen-hsing	Chronographic Star	Shuo-hsing	Water Star
Venus	T'ai-po	Grand White	Chin-hsing	Metal Star
Mars	Ying-huo	Sparkling Deluder	Huo-hsing	Fire Star
Jupiter	Sui-hsing	Year Star	Mu-hsing	Wood Star
Saturn	Chen-hsing	Quelling Star	T'u-hsing	Earth Star

Table 3.2: Names of the five visible planets

3.3 Lunar and planetary records in China

3.3.1 Introduction

The investigation of early Chinese records of lunar and planetary movements - of close conjunctions and occultations and also of the more mundane motion of the moon and planets through the lunar lodges and other star groups - poses more of a problem than might be expected. The 1988 compendium from Beijing Observatory, *Zhongguo Gudai Tianxing Jilu Zongji*, though very thorough otherwise - particularly with regard to comets, meteors and solar phenomena - is lacking in this area; only occultations of the five bright planets by the moon are covered (although the records of such events included appear to be comprehensive). To include, in particular, close conjunctions, it is necessary to examine the original sources.

The importance of records of these regular phenomena lies in the fact that the contemporary astronomers were not able to predict them. With reference to a suitably accurate modern ephemeris, it is then possible to compare what was recorded with the complete list of events, enabling an estimate of the efficiency for the process of observation, recording, and preservation to be made. With enough data, the variation of this proportion with the minimum separation of the two objects can be found. This is critical, since events not close enough to be considered a *fan* or *yen* by the observers must not be included in the total. For these purposes, conjunctions between the planets are much more useful events than either lunar occultations (the brightness of the lunar disc making naked eye judgements less accurate) or planet-star conjunctions (as it is often the case that the modern equivalent of a named star is unknown, or at least highly uncertain).

The most useful Chinese source for examining individual records in detail is thus the only dynastic history whose astronomical chapters have been translated into English; the *Chin-shu*, which chronicles the Chin dynasty (AD265-420) and the preceding Three Kingdoms period (AD220-265). This is the first of the dynastic histories to contain a substantial number of planetary conjunctions and lunar occultations. An example of a conjunction recorded in the work, taken from Ho Peng Yoke's translation (Ho 1966), is given below.

"On a kuei-wei day in the fifth month of the 1st year of the Chien-Wu reign-period (*28th May +317*) Venus and Mars met (*ho*) at Tung Ching (*22nd lunar mansion*). Meeting (*ho*) of Venus and Mars, also known as "fusion" (*shou*) symbolises death. At that time Emperor Min Ti took refuge at P'ing-yang, and died during the twelfth month at the hands of rebels."

As in the above example, the time at which the conjunction is observed is never given more precisely than the day. (Ho Peng Yoke converted all Chinese dates to the Julian calendar using standard tables.) However, by calculating the elongation of the planets from the Sun, it is usually possible to estimate the time of day when the observation was made - for instance, Venus is seldom visible for more than 2 or 3 hours after sunset or before sunrise. The only indication of the closeness of the conjunction we can obtain from the above record itself is the description of a "meeting", which suggests that the conjunction was not particularly close - certainly not close enough to give the impression of an occultation. It should be noted that this term - *ho* - is a relatively uncommon description in the *Chin-shu* for such an event. For the purposes of comparison, an example of a record using the more usual term *fan* follows.

"On a ting-mao day in the seventh month of the 12th year of the Yung-Ho reign-period of Mu Ti (*15th August +356*) Venus trespassed against (*fan*) Saturn at Liu (*24th lunar mansion*). According to the standard prognostication this foreboded military activities at (the region of) Chou. During the eighth month of that year Huan Wên attacked Fu Chien, but later withdrew. He then defeated Yao Hsiang at I-shui and captured (the land of) Chou."

The relatively large number of conjunctions recorded in the *Chin-shu* allows the determination of the limiting angular separation beyond which the event would not be considered as a conjunction by East Asian astronomers. Since the techniques of Chinese astronomy were later adopted in Korea and in Japan, and changed remarkably little with time in China itself, it is not unreasonable to consider the limit thus obtained to be a fair approximation for other chronicles.

3.3.2 Example analysis

The *Chin-shu* conjunctions must each therefore be analysed individually; the analysis of the former record above is given as an example. The (angular) minimum separation of the two bodies is known from the use of Bretagnon's ephemeris (Bretagnon 1982); however, the observed time of closest approach is not necessarily the same as the time of true conjunction since this latter event may well occur during daylight or when the planets were below the horizon. Estimating the time of closest visible approach is extremely important for the fast moving planets Mercury and Venus, which can travel more than one degree in a day.

It is therefore necessary to find the time of day at which the planets were visible in a dark sky. I take the day as recorded in the *Chin-shu* to be from sunrise to sunrise (as in Clark and Stephenson's *The Historical Supernovae*), so, for the record in question, the observation would have been during the following night (i.e., AD 317 May 28/29). The planets were 37° east of the Sun, and would be above the horizon in the west for approximately 2.5 hours after sunset on May 28.

Since the time of closest approach can be estimated only to within about one hour, it is not necessary to calculate the exact times of visibility. The length of twilight during the Chin dynasty was nominally regarded as 2.5 *k'o* - about 40 minutes. I take twilight to last one hour, in order to ensure darkness. Likewise, since the conjunction occurs in late May, the length of the night at the latitudes concerned may be taken to be about 10 hours, putting sunset at approximately 19:00. Hence the planets would set around 21:30, being visible in a dark sky from around 20:00 until 21:30.

The fundamental time system of Bretagnon's ephemeris is effectively TT (terrestrial time), a theoretically invariant time system defined by the motion of the Sun, Moon and planets. Hence local time must be converted to TT. There are two main stages in this process (neglecting the equation of time - the effect of the Earth's orbital ellipticity and axial tilt - which does not exceed about 0.25 hours): firstly, local time (LT) must be corrected for longitude to give UT (universal time). Around AD 320 the Chinese capital moved from Lo-yang (longitude 112.8° E) to Chien-k'ang (Nanjing: longitude 118.8° E). To a fairly good approximation the LT at both of the cities was 7.5 hours ahead of UT.

Secondly, small differences in the speed of rotation of the Earth over the centuries lead to a difference in the time of day at which the conjunction falls. This difference, usually denoted ΔT = TT - UT, is close to 2 hours during the Chin dynasty. The amendment $UT = TT - \Delta T$ must be made, and hence LT was ahead of TT by about 5.5 hours.

The above time was at least 12 hours after conjunction. The important point to consider is whether the planets are still close together at this time. Again taking the positions from Bretagnon, we find the separations listed in Table 3.3.

Local time	Latitude difference (degrees)	Longitude difference (degrees)	Absolute separation (degrees)
20:00	0.701	0.024	0.705
20:30	0.701	0.036	0.706
21:00	0.701	0.048	0.707
21:30	0.701	0.059	0.709

Table 3.3: Separation of Venus and Mars during possible times of observation

It is apparent that there is very little change in the absolute separation of the two planets between the times of observation and closest approach, the difference being far smaller than the separation.

It is now necessary to do similar calculations for each pair of planets for which an observation exists in the catalogue. In some cases an extremely close approach is recorded, so that the latitude difference would be very small. Magnitude differences may be significant in such instances, in that the limit of the separation necessary for two bodies to appear as one to the naked eye will be smaller for those which appear less bright; one will not be lost in the glare of the other.

I give below a sample analysis from the *Chin-shu* for conjunctions involving each of the five planets.

3.3.3 Venus/Jupiter

A conjunction between Venus and Jupiter is recorded for a date corresponding to 3 October 343. The term *fan* is used, rendered into English by Ho Peng Yoke as "trespassed against". For this event the computed closest approach occurs at 11:00 UT (18:30 local time), with a minimum separation of 0.10°. The planets were not visible in China at this time: they were 35° west of the Sun, giving about 2.5 hours of visibility before sunrise. For early October the length of the night is taken to be about 12 hours, giving sunrise around 06:00, and visibility in a dark sky from approximately 03:30 to 05:00 (as we are neglecting the hour of twilight in order to ensure that both planets were clearly visible).

Taking the time of observation to be the midpoint of this period, we find the observable absolute separation of the two planets to be 0.37°. The conjunction is still close, but significantly less so than at minimum separation.

3.3.4 Venus/Saturn

A conjunction between Venus and Saturn is recorded for 3 January 339. The term *fan* is again used. For this event the closest approach occurs at 12:00 UT (19:30 local time), with a minimum separation of 0.06°. The planets were not visible in China at this time: they were 33° west of the Sun, again giving about 2.5 hours of visibility before sunrise. For January the length of the night is taken to be about 14 hours, giving sunrise at around 07:00, and visibility in a dark sky from approximately 04:30 to 06:00. The absolute separation at the midpoint of this period is 0.46°. Again the longitude difference is significant for a conjunction this close.

3.3.5 Mars/Jupiter

A conjunction between Mars and Jupiter is recorded for 17 November 361. The term *fan* is again used. For this event the closest approach occurs at 18:00 UT (01:30 local time) with a minimum separation of 0.10°. The planets were not visible in China at this time: they were 88° east of the Sun, giving about 6 hours of visibility after sunset. For November the length of the night is taken to be about 14 hours, giving sunset at around 17:00, and visibility in a dark sky from approximately 18:00

to 23:00. The absolute separation at the midpoint of this period is 0.14°, scarcely greater than the minimum value.

3.3.6 Mars/Saturn

A conjunction between Mars and Saturn is recorded for some time during the month between 13 June and 12 July 348. The term *fan* is again used. Such a conjunction occurred on 30 June, with the closest approach at 05:00 UT (12:30 local time) with a minimum separation of 0.30°. This is during the day, so the observation must have been made either during the following or the previous night, since there is no exact date. The planets were 92° west of the Sun, giving about 6 hours of visibility before sunrise. For June the length of the night is taken to be about 10 hours, giving sunrise at around 05:00, and visibility in a dark sky from approximately 23:00 to 04:00. The absolute separation at the midpoint of this period is 0.34° for an observation on 1 July, or 0.46° for an observation on 30 June. Either date is possible, since the actual date is nor recorded precisely and no allowance for unfavourable weather can be made.

3.3.7 Jupiter/Saturn

A conjunction between the slow moving planets, Jupiter and Saturn, is recorded for 6 March 372. The term *fan* is again used. For this event the closest approach occurs at 12:00 UT (19:30 local time) with a minimum separation of 0.03°. The planets were not visible in China at this time: they were 53° west of the Sun, giving about 3.5 hours of visibility before sunrise. For March the length of the night is taken to be about 12 hours, giving sunrise at around 06:00, and visibility in a dark sky from approximately 02:30 to 05:00. The absolute separation at the midpoint of this period is 0.04°. The two planets would appear almost as a single object.

3.3.8 Conjunctions involving Mercury

Mercury is not often readily visible to the unaided eye. There are only three records in the *Chin-shu* of a conjunction involving Mercury. Two of these are conjunctions involving more than two planets, and will not be discussed. Unfortunately, the third record (for 18 August 380, between Mercury and Saturn) is incorrect - calculation shows that such a conjunction does not occur for several months either side of this date. In this instance there is no obvious copying error in that a conjunction between these two planets does not occur on any obvious date which could have easily been mistaken for the one given - for example, on the same day (recorded here as a *ping-tzu* day) in a different month of the same year. Since the *Chin-shu*, like other dynastic histories, was compiled several centuries after the observations were made, it is not unusual to find errors of this sort.

3.3.9 Variation of the minimum visible separation

From the analysis of the conjunction records that the history contains, it would seem to be extremely unlikely that a conjunction would be excluded from the *Chin-shu* due to the planets being below the horizon at the time of closest approach. The difference in position over the hours that may pass between closest approach and observation does not take the planets out of conjunction, even when the relatively fast moving Venus is involved. The lack of records of conjunctions involving Mercury is unfortunate, but - judging by the small proportion of the whole that the inaccurately dated records of this type represent - such conjunctions would only form a tiny proportion of the surviving data. Importantly, given that the typical difference between minimum separation and minimum visible separation for an observer in East Asia will not vary significantly with time, this is valid for sources other than the *Chin-shu*; for all intents and purposes, the computed minimum separation may be used.

Plotting the number of records for different minimum separations, we obtain the bar graph shown in Figure 3.1. Note that the separation to which each frequency refers, to the nearest 0.1°, is that at the midpoint of the bar, and also that here the "zero" column is used to indicate a minimum separation of under 0.1°.

For the sake of clarity, one observation is omitted from this plot, with a minimum separation of 3°. This is in fact the very last conjunction of two planets in the *Chin-shu*, and it seems likely that the political situation at the dynasty's end led to a greater number of events being recorded for astrological reasons.

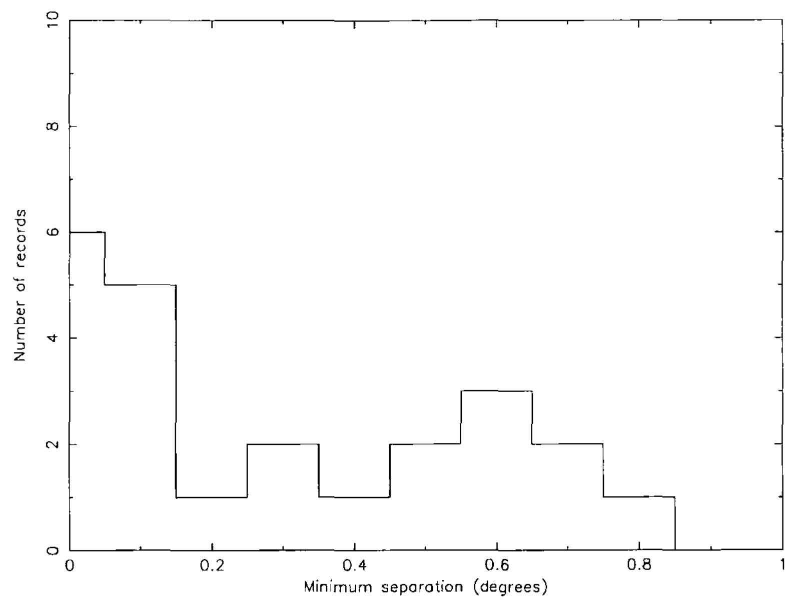

Figure 3.1: Frequency of two-planet conjunctions recorded in *Chin-shu.*

It is clear that, at least for the *Chin-shu*, there is a trend towards the closest conjunctions; those with a minimum separation of 0.1° or less account for 11 of the 24 observations.

3.3.10 Completeness

In order to assess the significance of the pattern in Figure 1, a complete list of conjunctions between two planets during the Chin dynasty was required for reference. This was provided at my request by Dr Steven Bell, of the Nautical Almanac Office, using an ephemeris (DE406) similar to that used for the *Astronomical Almanac.* It gave, for every conjunction, the time of closest approach (assumed, due to the negligible difference in planetary latitude over the period of time of a conjunction, to be the time at which the longitudes were equal) to the nearest hour, the minimum separation, and (in critical cases) whether or not the conjunction was likely to be invisible due to proximity to the Sun.

For this the following minimum angular distances from the Sun (elongations) for visibility in a dark sky (also used in the preparation of the *Astronomical Almanac*) were imposed: 10° for Mercury, Venus and Jupiter, and 15° for Mars and Saturn.

The bar graph in Figure 3.2, based on the computations of Steven Bell, shows the variation in the number of visible conjunctions during the Chin dynasty against minimum separation. Note that, again, the zero column represents a minimum separation of less than 0.1°, and the minimum separation to which each bar refers is that at the midpoint of the bar. Although it is expected that not all events could have been observed from China on account of unfavourable weather, it is striking that the frequency of computed very close conjunctions is not significantly higher than those at greater minimum separations. This implies a very large amount of conjunctions of a minimum separation of 0.2° and above are missing from the record. This is a significant point; previous estimates of the completeness of such records have generally been much higher - perhaps through comparison to the completeness of eclipse records, which have been calculated to be much more complete, probably because eclipses were of calendrical and astrological importance. (The ability of early East Asian astronomers to make reasonably reliable eclipse predictions, as discussed in Chapter 8, is also likely to be a factor.)

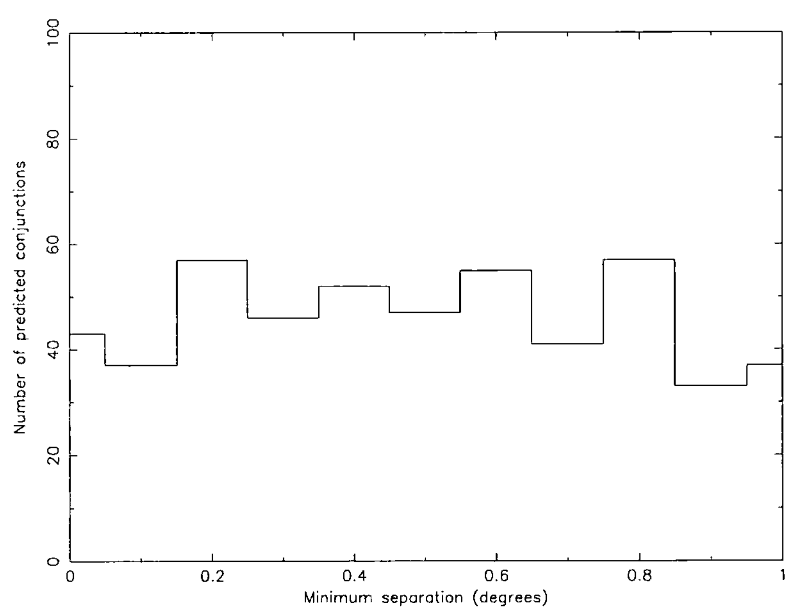

Figure 3.2: Frequency of predicted two-planet conjunctions during the Chin dynasty involving any two of the five bright planets

The typical efficiency is therefore only about 4%. Even for very close conjunctions the efficiency is only about 12-15%. Despite the small sample size, the fact that nearly half the recorded events are contained in the first two columns of Figure 3.1 suggests that the difference between these two figures is significant. The low efficiencies lead us to suspect that a very large number of conjunctions at greater minimum separations have been omitted from the record, and that the frequency of other phenomena recorded in Chinese histories may be a considerably depleted fraction of the actual frequency. This is particularly significant with respect to the proportion of eclipses recorded in East Asia, which (as mentioned above) is significantly higher (Stephenson 1998). Alone, this higher figure could be taken to imply similar efficiencies for the recording of all astronomical phenomena, contrary to the above finding.

It could also be argued that planetary conjunctions were regarded as fairly routine events, only recorded if they coincided with some major historical occurrence. Efficiencies for more astrologically significant or unusual events (for example, comets) might then be expected not to be so low.

Chapter 4

Regular Phenomena: other sources

4.1 Other sources of conjunction records from China

Whilst the Chin records are particularly detailed, the relatively short duration of the dynasty - and, more significantly, the lack of parallel records from other countries at the time - means that the examination of data from later dynasties is valuable.

The founding of the Sung dynasty in China in AD960 marked the beginning of a period of relative stability, before which several short-lived dynasties ruled the north and south of China separately. Following the Sung, which came to an end in AD1279, there are only two further dynasties - the Yüan and the Ming - before the end of the pre-telescopic period. With the great majority of parallel records from Korea and Japan occurring after AD960, the histories of these three dynasties are therefore a convenient starting point for further analysis.

It should be noted, at this point, the relative difficulty inherent in extracting such information from the original sources. Although modern reprints of the Chinese dynastic histories - and, to a lesser extent, of Korean works such as *Koryŏ-sa* - are to be found in many major libraries, the astronomical treatises of the *Chin-shu* alone exists in an English translation. Certain types of record - notably, those involving comets or solar phenomena - have been translated in modern secondary compilations. However, the great majority of entries, including those of observations of occultations and conjunctions and - in the case of Korea - of meteors, are only available from the original works. To be able to investigate the behaviour of these phenomena, therefore, it is necessary to be familiar with written classical Chinese.

To develop the required level of understanding I chose to examine the astronomical treatise of *Koryŏ-sa* . Besides being an important source of Korean data in its own right, the records are often very short, with little extraneous information (for example, the lengthy astrological interpretation seen in *Chin-shu*). As the work also contains no separation by type of event, careful study of sections of *Koryŏ-sa* is effective in obtaining precisely the vocabulary necessary to interpret astronomical records of all kinds present in untranslated East Asian chronicles. (It should be noted that extreme care must be taken in the interpretation of the names of individual stars and asterisms, to ensure that no description of a conjunction between a planet and a star is miscategorised as the motion of a planet through an asterism, and vice versa. Such names make up the greater part of the terminology necessary.) This in-depth study of *Koryŏ-sa* was the basis for the translation of meteor records in Appendix A, and allowed me to obtain the conjunction data used below from the three previously mentioned dynastic histories.

Figure 4.1 shows how the frequency of recorded two-planet conjunctions varies throughout this period. It should be noted that here the data is only to be used in comparing frequencies; no efficiency is computed from these records. As such only the year of the date is used in binning the data. The effect of this, since the new years in the Chinese and western calendars are somewhat more than a month apart, is that a small number of dates - equivalent to a proportion of a few weeks in ten years - may be attributed to the wrong year. The effect of this is very small.

The amount of variation in this plot is significant. The large peak in the distribution occurs around 1150-1200, but has fallen off well before the end of the Sung dynasty late in the thirteenth century. It corresponds to the period of relative stability after the loss of the north of China to the Jurchen in AD1127, but before the wars against the Mongols; that is, the Southern Sung period, when the capital was (necessarily) moved south to Lin-an (modern Hang-chou). There would thus have been a new observatory built, but whether this had any effect on the frequency of recorded conjunctions is speculative. The remainder of the plot shows the frequency remaining relatively unchanged over this long period, as would be expected from a phenomenon whose true frequency varies very little.

It is important to be able to determine whether a feature, such as this, which

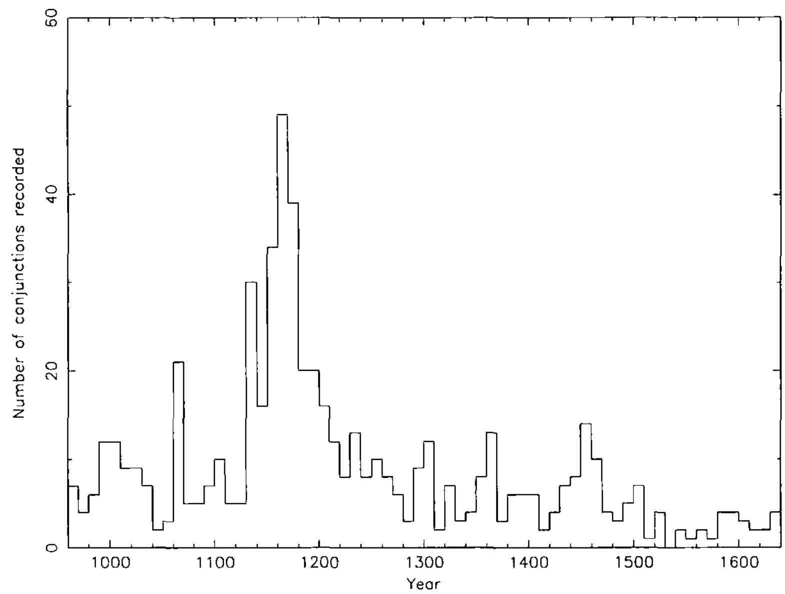

Figure 4.1: Frequency of two-planet conjunctions recorded during the Sung, Yüan and Ming dynasties

is identified by eye, can be considered significant. In this case, where the feature stands out from the overall record particularly well, such a procedure may not be necessary; for confirmation of the peak's significance, however, and for the purposes of comparison with other records, it is desirable.

Consider a series of records of some astronomical phenomenon, and assume that the probability of a record being made at any one time does not change. (This is then the null hypothesis. It is true if the actual frequency of occurrence of the phenomenon does not change and there are no data artefacts.) In this case, the time between each event and the next event follows a Poisson distribution, as does the number of events recorded in a given, fixed period (which here is ten years).

Thus, the plot of number of bins against bin frequency should follow a Poisson curve. The Poisson parameter μ - both mean and variance - is taken to be the mean of the bin frequencies. Figure 4.2 shows this plot, with the theoretical Poisson curve also shown.

The match, as may be expected, is not good. The Poisson curve peaks somewhat higher than the Chinese data; while the two have the same mean, the standard deviation of the data is significantly higher. This, alone, indicates that it cannot be considered to follow a Poisson distribution, where the mean and variance are equal. A χ^2 test is sufficient to confirm this.

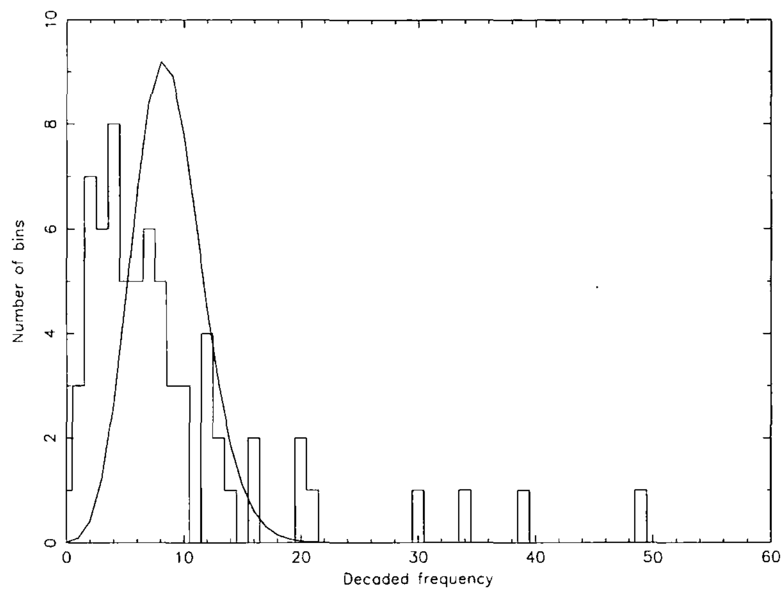

Figure 4.2: Two-planet conjunctions recorded during the Sung, Yüan and Ming dynasties: match of data to Poisson curve

There are 68 ten-year bins in the data set; since the mean has been calculated and used to produce the Poisson curve, there are 67 degrees of freedom. χ^2 thus has a 1% probability of exceeding the critical value, which is around 1.45.

Note that by the nature of the expression for χ^2, given by the square of the difference between the expected and observed numbers of bins of each frequency, divided by the expected value, and summed over all possible values, the test is extremely good at picking out outliers. As the number of events per bin becomes large, the Poisson distribution falls off as the inverse factorial; a single outlying value with a frequency for which the Poisson curve's prediction is much smaller than 1 leads to a huge contribution to χ^2. Such is the case here; the total χ^2 is vast - 4.19×10^{18}.

A simple way to pick out outliers is to examine the standard deviation of the data, and to note any features with frequencies more than two or three standard deviations away from the mean. The drawback to this approach is that the presence of peaks with outlying frequencies changes the mean and standard deviation significantly themselves; however, the effect will be for both - if anything - to increase. Any peak which still exceeds (for example) three standard deviations above the mean is clearly exceptional.

Figure 4.3 shows the conjunction data from the three dynasties again, together with lines indicating two and three standard deviations above the mean.

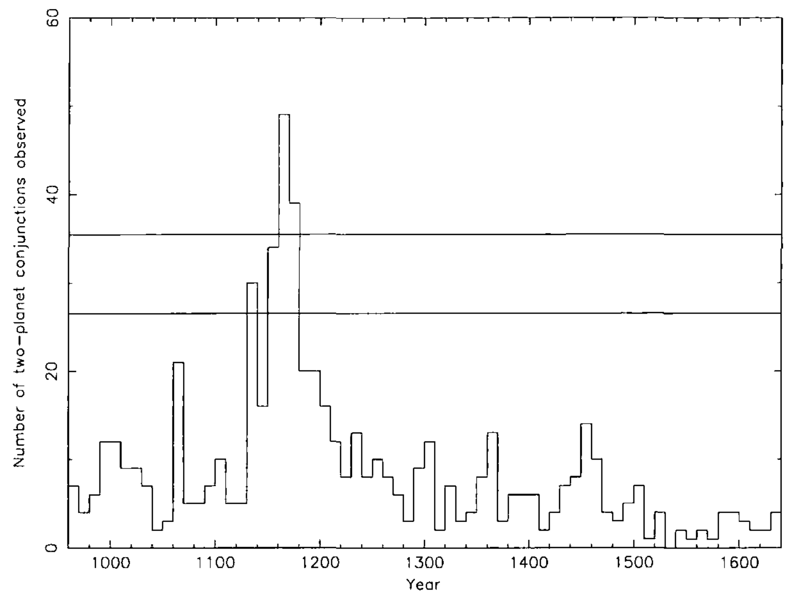

Figure 4.3: Two-planet conjunctions recorded during the Sung, Yüan and Ming dynasties: plot with standard deviation lines

The fact that the major peak exceeds the three standard deviation line by a sizeable amount is not surprising. If it is removed - since it constitutes all the most extreme outliers in the dataset - there is much more uniformity in the record. Figure 4.4 shows the match of the data to the Poisson curve again, with the records from AD1130-1210, the period which covers the rise in frequency whose peak exceeds the two lines, removed.

The data is still far from being a close match to the Poisson curve, although the situation is somewhat better than with the peak included; the value of χ^2 has now dropped to 10457.1. It is clear that the data cannot be made to fit a Poisson curve; more values could be taken out, but as there is no one feature which can be selected to be removed, there is much less justification for doing so. It must be concluded that, although the data can be said to follow the general form of the Poisson curve, the variation seen in the number of conjunctions recorded is dominated by data artefacts.

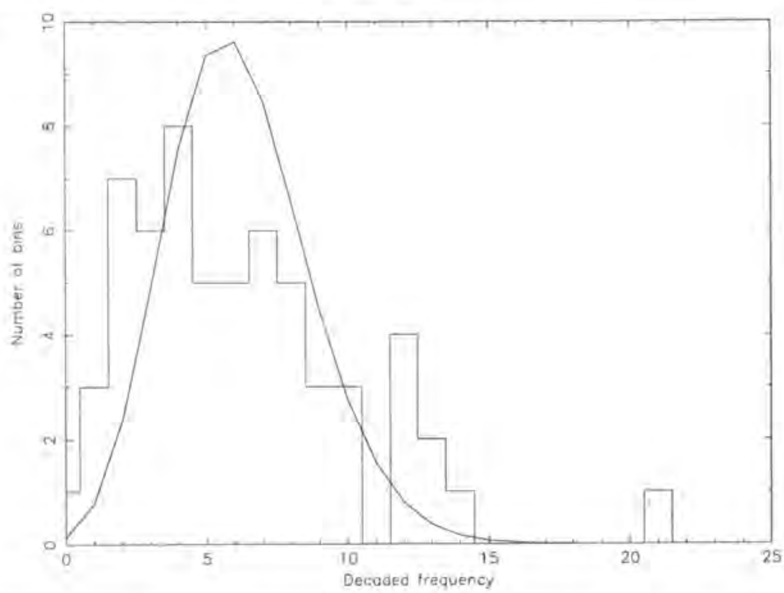

Figure 4.4: Two-planet conjunctions recorded during the Sung, Yüan and Ming dynasties: match of data to Poisson curve, excluding data from AD1130-1210

4.2 Lunar and planetary records in Korea

4.2.1 Introduction

The examination of Korean astronomical records of all kinds is in many ways a more difficult task than of those from China. No usable compilation identifying and separating out different types of event exists; the late compilation known as *Chung-bo Munhon Pigo* does categorise events, but is not always particularly reliable (Stephenson & Green 2002). It is necessary, therefore, to examine the surviving original documents, which have never been translated into English.

Two works then essentially contain all the surviving early Korean astronomical data. *Koryŏ-sa* , the history of the Koryŏ dynasty, contains the earliest data (from around AD1000 to 1392); the *Choson Wangjo Sillok* , the extensive annals of the Yi dynasty, contains data from the end of the Koryŏ dynasty until the 20th century. Of these, the *sillok* is relatively difficult to examine, since - being a chronicle - the astronomical data is interspersed with all other records and scattered over the extent of the entire work. Hence the *Koryŏ-sa* , providing the records in its dedicated astronomical chapters, is the primary Korean source of astronomical data for the present investigation.

The three astronomical chapters of *Koryŏ-sa* offer a substantial quantity of lunar and planetary records. Taken as a whole, they constitute by far the most numerous class of record of any type of event from the chronicle, numbering several thousand in total.

Of these, a substantial proportion are concerned with the motion of the moon and planets with respect to various asterisms, or - in particular - the boundaries of the enclosure *T'ai-wei*. The remainder are the more precise records of occultations and conjunctions. Many of these are those involving bright stars; Regulus, Aldebaran, Antares and Spica are frequently mentioned, as are the stars making up the boundary and the interior of *T'ai-wei*. For accuracy, and for consistency with the foregoing analysis, only conjunctions involving two planets are selected for investigation.

In total, two-planet conjunctions in the *Koryŏ-sa* number nearly two hundred, a much greater number than that obtained from the *Chin-shu* (even considering the difference in the lengths of the two dynasties). The *Koryŏ-sa* records are generally of much shorter length than their Chin counterparts; virtually no astrological analysis is included, which is a marked contrast. The following is a fairly typical record of this type.

> "On a ping-chen day in the 4th month of the 11th year of the reign of King Myŏngjong (*25th May 1181*), Venus and Jupiter met."

Records of this type are rarely any longer than this; occasionally the asterism in which the two planets were seen will be mentioned, but no more precise detail is given. As in the Chinese records, standard terminology is used to describe the occurrence; *fan* is again often used, although *yen* is not. (Only one of the two-planet conjunctions in the history is described by *yen*.) The other prevalent term is *ho*, which is used in the above example and is translated as "met". In addition, *fan* is occasionally used in the context of the two planets together trespassing against another entity, which is usually an asterism. In analysing these events those described in each of these three ways have been examined separately. (It is unlikely, given the smaller number of events in *Chin-shu*, that any similar investigation there would give particularly useful results.)

4.2.2 Variation of frequency with time

Comparing the Korean records with the conjunctions calculated from DE406, it was found that 159 were true observations of two-planet events. The remainder, numbering 85 events in total, was made up of events for which the date given was invalid (likely to be due to copying errors), events involving more than two planets (which are excluded as these are special cases, where conjunctions considerably less close than usual would have been included; they may therefore skew the distributions of minimum separation), and events for which no conjunction occurred nearby in time. Observations said to be made up to three weeks on either side of an actual conjunction were accepted. This was chosen as up to around this limit observations of the expected conjunction are relatively common; reducing it (for example, to two weeks) would cut out a large proportion of the records. Beyond this limit the only observations made are those that are clearly apocryphal (with no conjunction occurring for months in either direction) or, occasionally, observations of Jupiter and Saturn in years when the two remained close together for months at a time.

Figure 4.5 shows the frequency distribution of two-planet conjunction records over the time covered by *Koryŏ-sa* (AD918-1392). It should be noted that, since there are virtually no astronomical records of any type from before AD1000, the figure begins with the eleventh century AD.

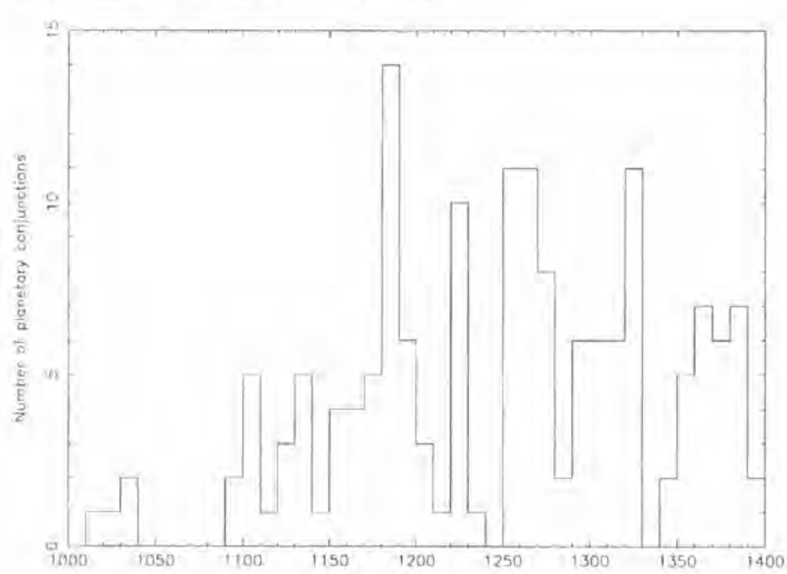

Figure 4.5: Frequency of observed two-planet conjunctions during Koryŏ dynasty

Perhaps the most significant feature of this distribution is its variability. Periods of relatively efficient observing are interspersed with times in which there are no planetary records at all. From the results of the investigation of the efficiency of the *Chin-shu* records this may not be particularly surprising; the overall efficiency of observing two-planet conjunctions, with 159 correct observations out of a possible 3,319 occurring between AD918 and 1392, is only 3%, comparable to that from the Chin. It is interesting to compare this data with that for lunar and planetary events as a whole. Figure 4.6 shows this distribution; it includes all occultations and conjunctions from *Koryŏ-sa* , but not those merely concerned with the motion of the moon and planets relative to various asterisms.

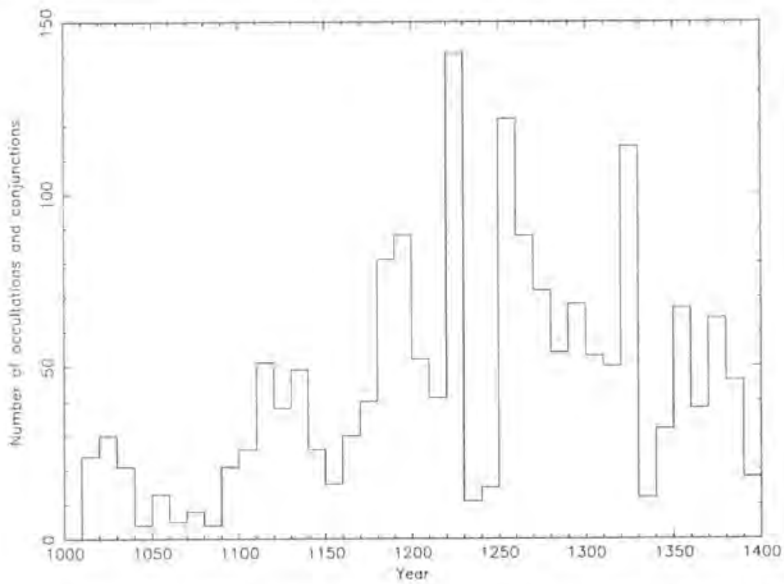

Figure 4.6: Frequency of all occultations and conjunctions during Koryŏ dynasty

There is a great deal of similarity between the two distributions; this would seem to indicate that whatever factors cause the observed frequencies to vary in this way apply in the same way to two-planet conjunctions and to events involving the moon and planets in a wider sense.

For the purposes of this investigation, of course, the important question is how much of the variation is due to the true variation in frequency of the event and how much is due to data artefacts. By reference to the planetary conjunction data provided by Steven Bell, this can be found. Taking each 10 year bin and dividing through by the total number of visible conjunctions (as defined in the previous section), a percentage efficiency is obtained. The results are given in Figure 4.7.

As might be expected, given the relatively small variation in the numbers of

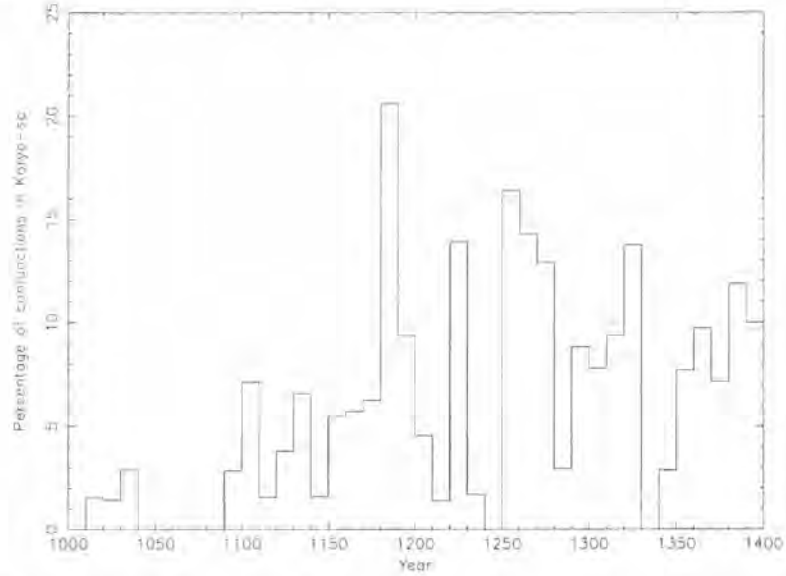

Figure 4.7: Percentage efficiency of observing, recording and preserving two-planet conjunctions during Koryŏ dynasty

planetary conjunctions, the dramatic variation seen in Figure 4.5 is indeed largely due to non-astronomical factors. Beside the fact that the efficiency is so variable, it is important to note that the overall efficiency figure of 3% does not adequately reflect the situation as a whole, in which the efficiency, although often dropping to zero for substantial times, is often in the teens and at one point even exceeds 20%. Overall, the situation is similar to that seen in China; the overwhelming majority of events are not recorded.

4.2.3 Match of data to Poisson curve

It might be expected - as stated above - that, since the variation in the frequency of recorded conjunctions is here so large, the pattern arises primarily from data artefacts, rather than from random fluctutations. Once again, it is necessary to carry out a χ^2 test to determine this, using a Poisson distribution as the expected data, that which would arise from random fluctutations alone. Figure 4.8 compares the two.

The two are not a good fit. The value of χ^2 here is 672.8; comparatively low, but orders of magnitude higher than the critical value for the test (at the 1% confidence level, with 40 bins and 39 degrees of freedom, this is around 1.6). The dominance of data artefacts is therefore confirmed. Here there is no individual large feature which

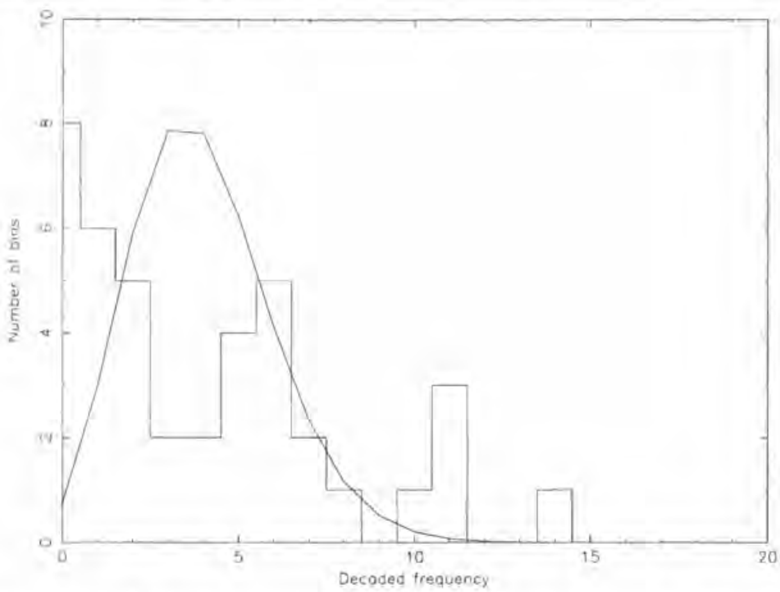

Figure 4.8: Two-planet conjunctions recorded in *Koryŏ-sa* : match of data to Poisson curve

can be said to be distorting the distribution; Figure 4.9, showing the binned data with the boundaries of 2 and 3 standard deviations above the mean, demonstrates this.

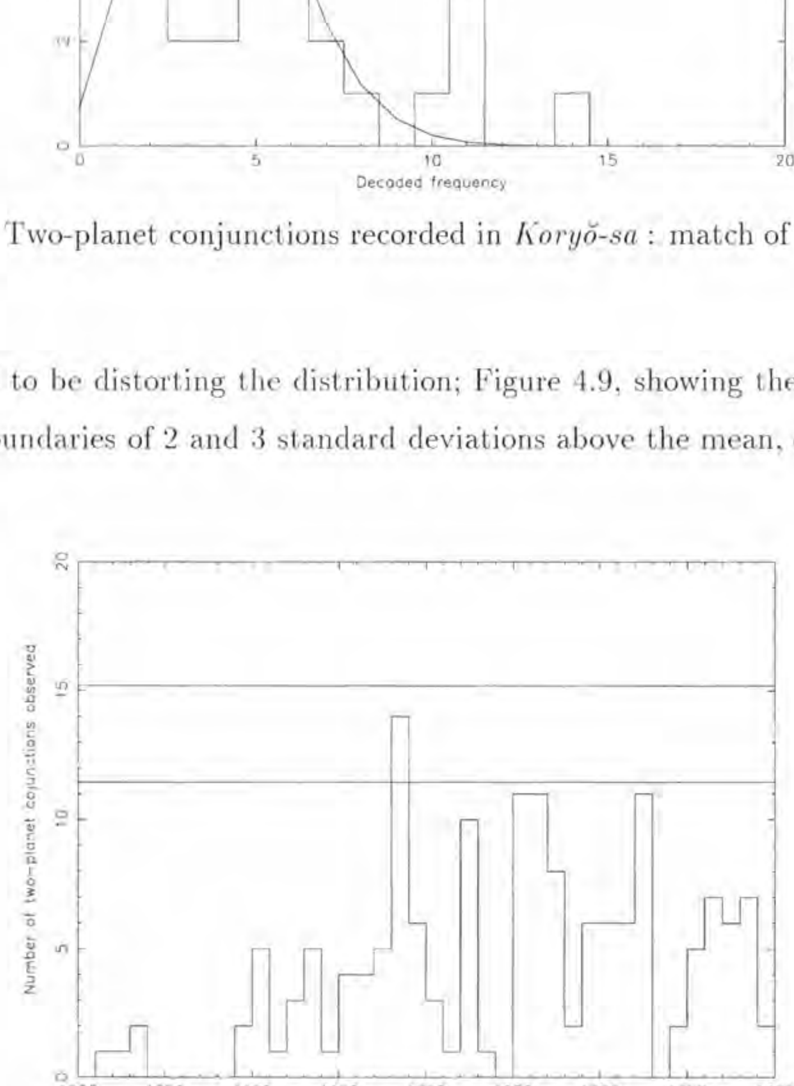

Figure 4.9: Two-planet conjunctions recorded in *Koryŏ-sa* : plot with standard deviation lines

Only a single bin breaks the 2σ boundary, and none the 3σ. Although the variation below these limits is large, there are no features that can be singled out for exclusion in order to make the distribution as a whole significantly more uniform.

4.2.4 Variation of frequency with minimum separation

Of the 159 events recorded which match up with conjunctions, 60 are described by *fan* and 69 by *ho*. (The remaining 30 were either cases in which no particular standard phrase was used, or in which the two planets were described as together trespassing (*fan*) against a third body, as mentioned above.) Plotting the frequency of events against the minimum separation of the conjunction in each case yields results as seen in Figures 4.10 and 4.11. Note that, as for the similar figure derived from the Chinese data, the first column - zero to 0.1° - refers to conjunctions for which the minimum separation is less than 0.1°; the next refers to those for which it is given as 1°; and so on up to the final column, which represents all conjunctions for which the minimum separation exceeds 2°.

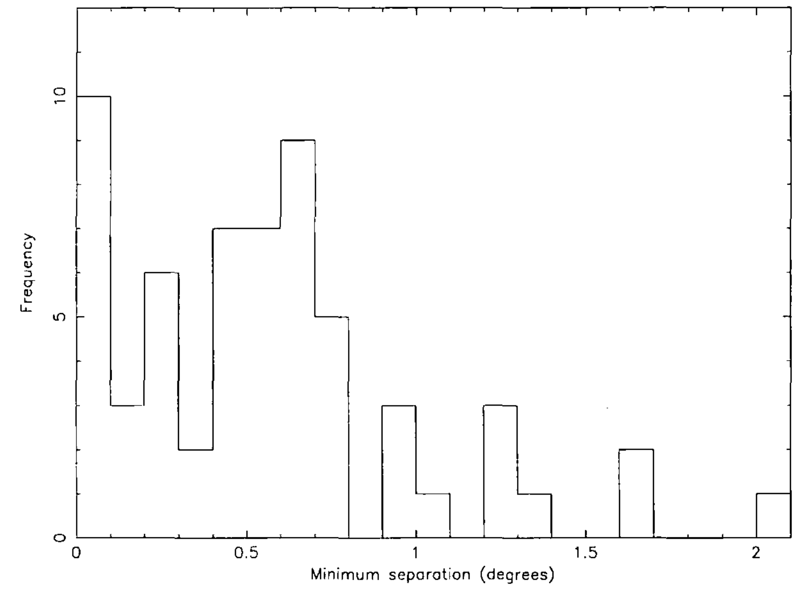

Figure 4.10: Frequency of two-planet conjunctions described by *fan* against minimum separation in *Koryŏ-sa*

It can be seen that there is a clear distinction between the meaning of the two terms as applied in *Koryŏ-sa* . Conjunctions described as the meeting of two planets show very little bias towards the closest events; those described as one planet trespassing against another very definitely do. There are then two distinct possibilities. Either the two terms are descriptive of the bodies appearing different distances apart, or they are used to describe subtly different occurrences.

Another example of this is the use of *yen* as opposed to *fan*. The former is used

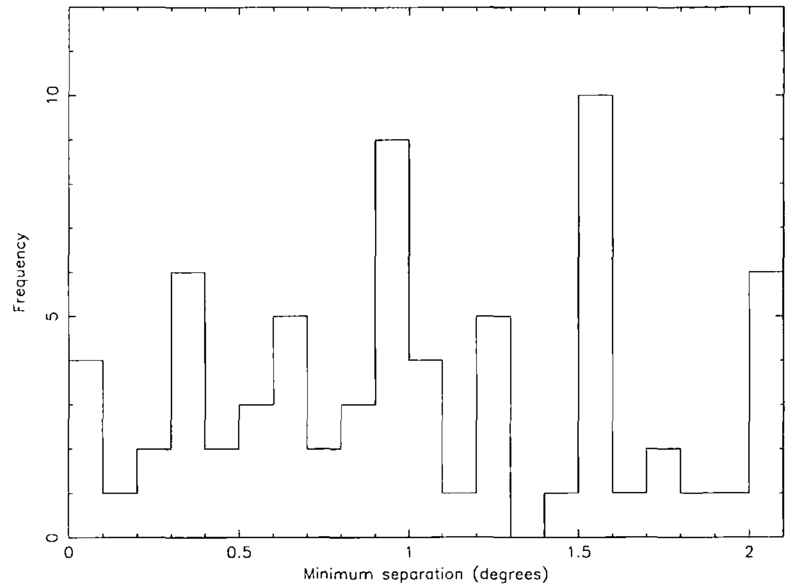

Figure 4.11: Frequency of two-planet conjunctions described by *ho* against minimum separation in *Koryŏ-sa*

when the objects in question appeared to merge together; it is therefore considerably more common in records of occultations of a planet by the Moon than in those of conjunctions between two planets (at least in *Koryŏ-sa* , where its appearance in a conjunction record of any kind is rare), and is descriptive of, from the point of view of a naked eye astronomer, a different kind of event.

The criteria applied to an observation to determine whether it would be considered a *fan* or a *ho* event are not known; however, it seems likely that the use of two different terms in approximately equal number (throughout *Koryŏ-sa* - the frequency of use of both is not heavily dependent on time in the work) indicate that there was an appreciable difference between the two types beyond just minimum separation.

It can be said, however, that:

(a) events described by the term *fan* are heavily weighted towards close conjunctions, with the great majority having a minimum separation of less than one degree;

(b) events described by the term *ho* are spread much more loosely over all possible minimum separations for planetary conjunctions, including several at more than a two-degree separation.

The overall efficiency of recording of two-planet conjunctions over the range of minimum separations may be obtained similarly to in the Chinese case. Figure 4.12 shows the result.

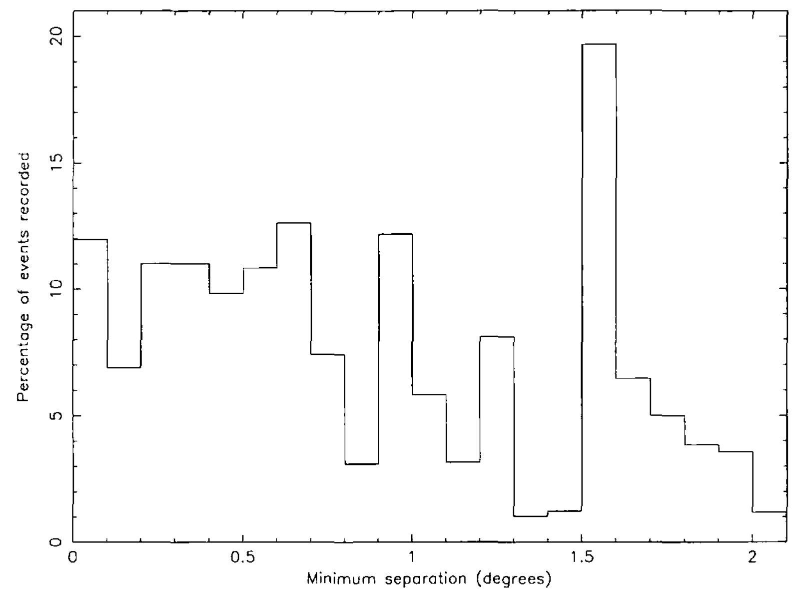

Figure 4.12: Percentage efficiency of observing, recording and preserving two-planet conjunctions, varying with minimum separation, in Koryŏ-sa

This shows a considerably better picture than that from the *Chin-shu*; a substantial proportion of less close conjunctions $(1 - 2^{\circ})$ are recorded, although the low proportion of those where the minimum separation is greater than 2° accounts for the similar overall recording efficiency.

4.3 Lunar and planetary records in Japan

4.3.1 Introduction

Astronomical observations from early Japan, in contrast to the consistent centralised systems of China and Korea, do not derive from a single, persistent source. The surviving records are drawn from numerous different, individual chronicles, and as such cannot be assumed to be in any way consistent over long periods of time. The above analysis of the use of *fan* and *ho* in Korea, for example, is much less significant when applied to the Japanese data, as it cannot be assumed that any pattern thus arising would apply equally to all sources from which the data is derived. Probably more significant is the fact that at any one time the number of active Japanese observing sites may be different from that at any other time; in Korea, and in China up until around the 16th century AD, it may be assumed that - with only a single central observing point - this is invariant. In Japan, this variation introduces a new unknown into the probability that any one event will be observed, recorded and preserved. As such the frequency variation of events seen from Japan is more prone to data artefacts than that from China or Korea.

In essence, the only work that can be effectively used as a source of pre-telescopic astronomical data from Japan is Kanda's extensive compilation (Kanda 1934). In this work astronomical events are divided up by type and dated in both lunar and Western calendars. Planetary events constitute one section; it is relatively simple to separate out purely two-planet events from planet-star or multiple-planet events. (The former are not part of the section, and Kanda's summary of each event recorded makes the latter obvious.)

The style of the records in Kanda's work is somewhat different to that used in *Koryŏ-sa* . Since there are often several different accounts of an event, Kanda includes a short summary of each event as a standard description, and - for consistency - it is these that I examine for planetary information. These offer a similar amount of detail to those from Korea; this is sufficient for this analysis. Again it is found that the term *ho* is common, as is *fan*, although the distinction between *fan* used to describe one planet trespassing against another and *fan* used to describe two planets, in proximity, both trespassing against an asterism or other celestial entity is not seen in Kanda's compilation. The term *yen* is again extremely rare, only occurring once. In addition, events are included in the planetary section which are only described as "Two stars met", "Three stars met", and so on up; these are almost certainly conjunctions between planets. These have not been included in the statistics. Because of the lack of detail, even if the dates of such events were to fall close to that of a conjunction, it would not be possible to be confident that such events were a record of the conjunction. The great majority of these records specify three or more bodies, and as such would be excluded from my investigation in any case; those remaining would have no great effect on the statistics if included.

4.3.2 Variation of frequency with time

The number of two-planet observations from Kanda's compilation which match up with calculated conjunctions - using the same criteria as above - is 79. Of these, 49 are described using *fan*, 26 using *ho*, and 4 using neither. Figure 4.13 shows the distribution against time.

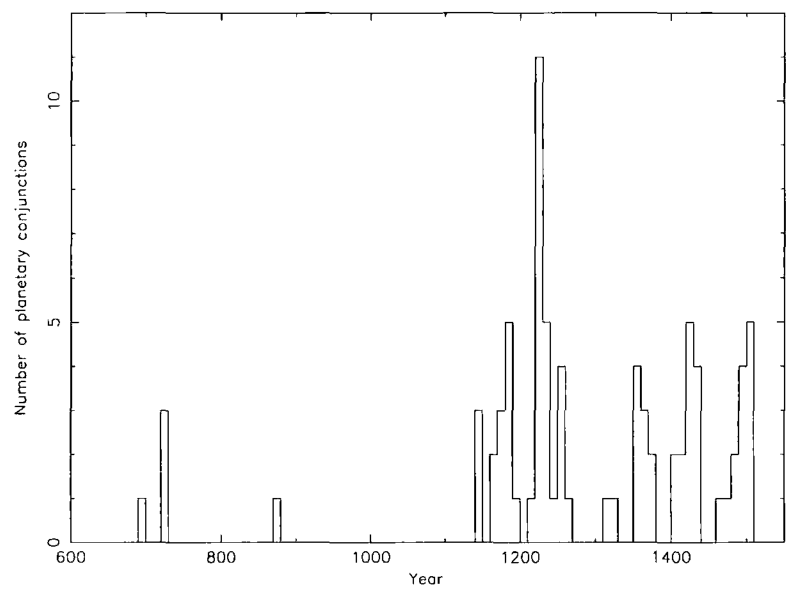

Figure 4.13: Frequency of observed two-planet conjunctions in pre-telescopic Japan

The data are spread over nearly a thousand years, although the great majority is contained in the final 400. Although the pattern is less clear here than in the Korean data, due to the number of records being substantially lower, it can be seen that once again there are frequent gaps in the record interspersed with relatively active periods. This, however, could very easily be accounted for by a variation in the number of observing sites; loss of records is also likely to play a significant role.

Again it is useful to compare this to the more extensive set of data covering all occultations and conjunctions compiled in Kanda; this is contained in Figure 4.14.

Again we see a good match between the two distributions; this is hardly surprising, but it is important to confirm - with a smaller set of data spread over a longer time - that the features visible in Figure 4.13 are not merely caused by the sparsity of the records.

With a similar, large amount of variation in the frequency of such events, (considering that peaks as sharp as those present in Figure 4.14 should not be present

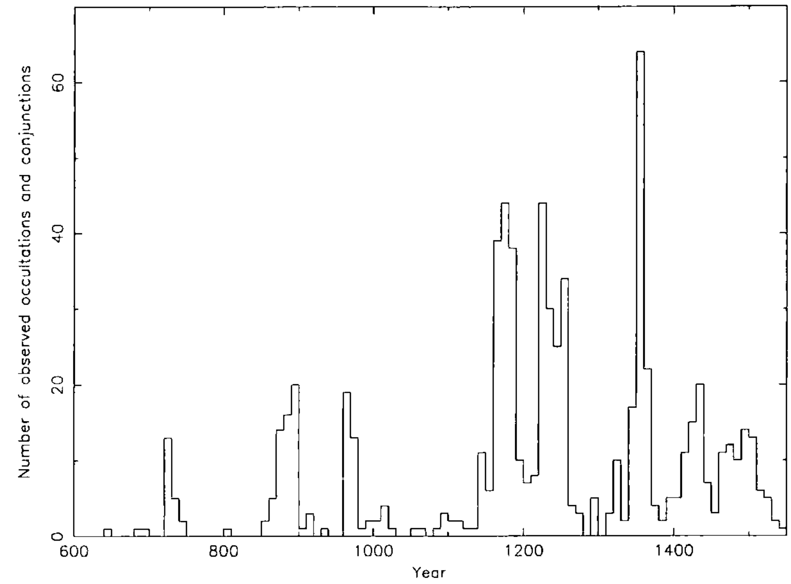

Figure 4.14: Frequency of all occultations and conjunctions recorded in pre-telescopic Japan

in data obtained from these regular phenomena) it may be expected that the pattern must be dominated by data artefacts - particularly as records from Japan are subject to an additional source of variation, as described above. Figure 4.15 gives the frequency as a percentage of the total number of observable conjunctions; this pattern is, as before, therefore that arising from the combination of all data artefacts.

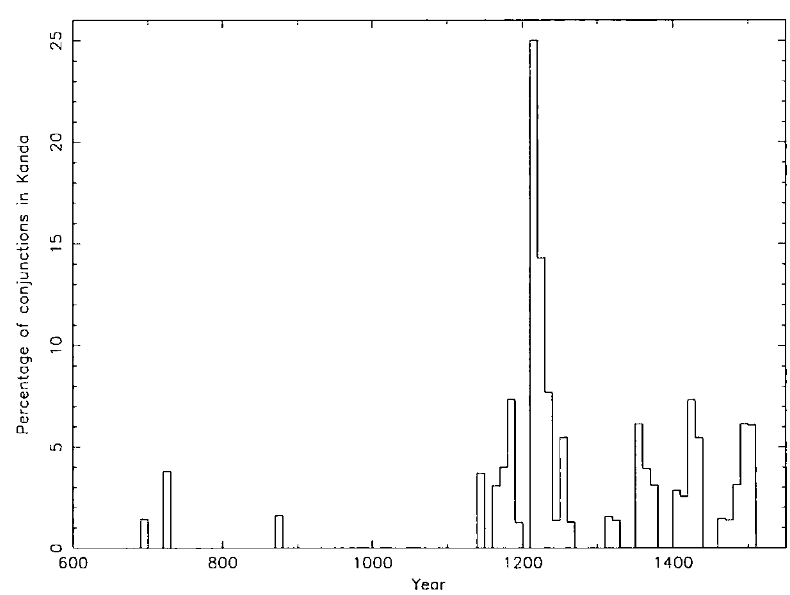

Figure 4.15: Percentage efficiency of observing, recording and preserving two-planet conjunctions in pre-telescopic Japan

The situation is roughly similar to that found in the Korean records. There is a large amount of variation, although the scarcity of records makes it difficult to see the pattern for much of the time covered. The variation in efficiency seen is even greater than that in *Koryŏ-sa* , however.

4.3.3 Match of data to Poisson curve

It would seem very unlikely - given this apparent level of variation - that the pattern seen could possibly arise without the presence of significant data artefacts, particularly considering the lengths of time for which there are no records at all. With 100 bins, and thus 99 degrees of freedom, the critical value of χ^2 is here about 1.36 at the 1% significance level; Figure 4.16 compares the data to the theoretical Poisson curve.

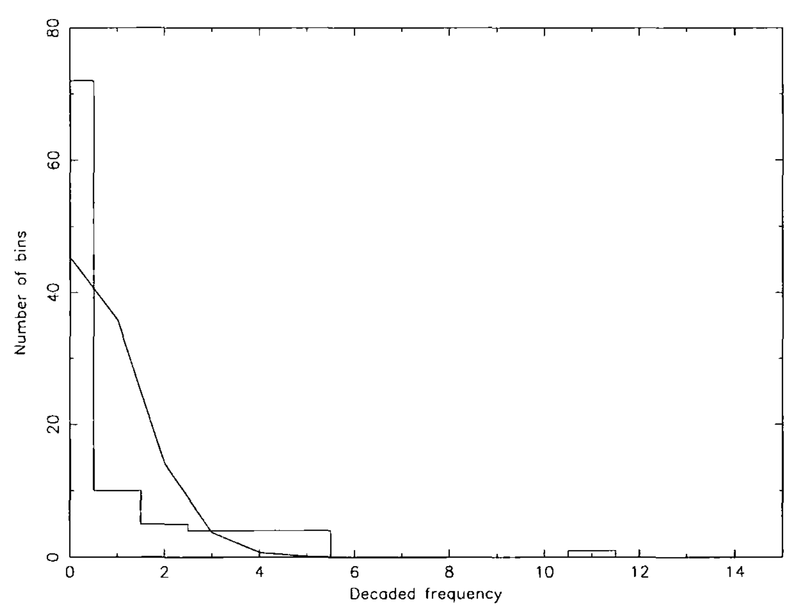

Figure 4.16: Two-planet conjunctions recorded in pre-telescopic Japan: match of data to Poisson curve

The fit, from inspecting the plot, is surprisingly reasonable. With relatively few events scattered over the millennium of pre-telescopic Japanese observing time, the large number of decades with no observations is not surprising. The variation seen, however - with the records being much more clumped than would be expected randomly, leading to a lack of bins with frequency 1 and 2 and more than would be expected at higher frequencies - is sufficient to produce a χ^2 value of 1.18×10^7, strongly indicating the dominance of data artefacts. Figure 4.17, showing the binned data with the boundaries of 2 and 3 standard deviations above the mean, indicates that there is a case for the exclusion of a single bin from the record; however, beyond this, the number of smaller spikes in the distribution would preclude any further exclusion, as they cannot be said to be outliers. With the exceptional peak removed, the value of χ^2 drops to 302.8. This is, however, high enough that the original conclusion, that data artefacts are again here dominant, holds.

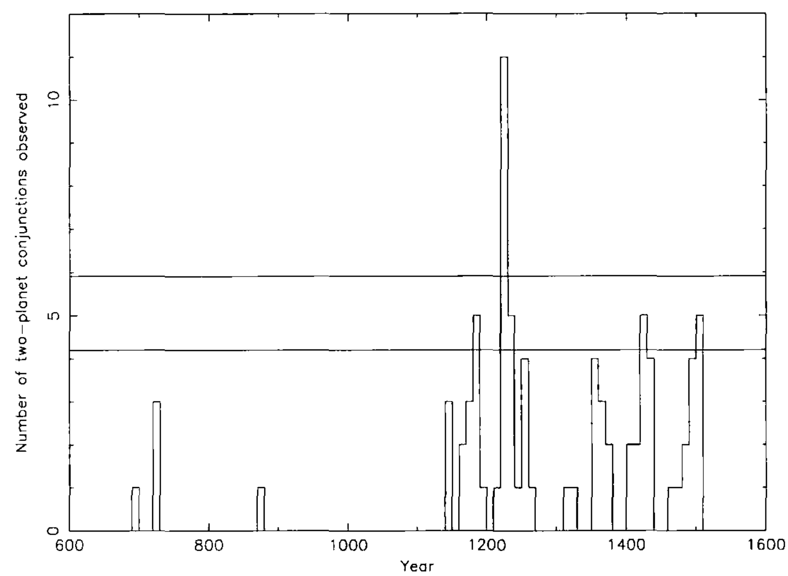

Figure 4.17: Two-planet conjunctions recorded in pre-telescopic Japan: plot with standard deviation lines

4.3.4 Variation of frequency with minimum separation

A similar analysis to that performed on the Korean data may be useful here, to ascertain if there is evidence for differing uses of the two terms *fan* and *ho* between the two countries. The separation data are shown in Figures 4.18 and 4.19; the binning system used is exactly the same as that for Korea.

There is no evidence of any difference in use from these plots. Although the patterns do not follow those of the Korean data sets precisely, this is not unusual given the relatively small number of events. The general trend of *fan* events being biased towards those with a small minimum separation, and *ho* events showing relatively little bias, matches that from *Koryŏ-sa* . A detailed investigation of the reason behind the different uses of the two terms, however, would have to be

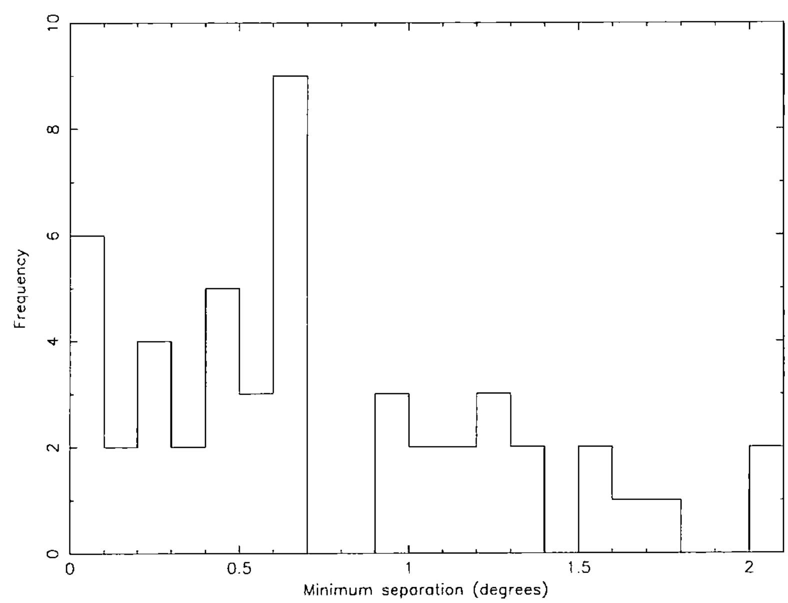

Figure 4.18: Frequency of two-planet conjunctions described by *fan* against minimum separation in pre-telescopic Japan

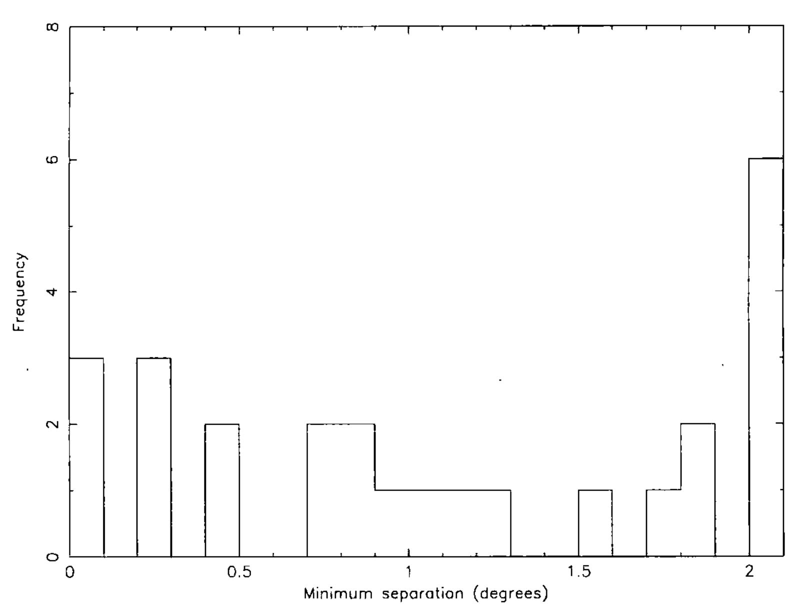

Figure 4.19: Frequency of two-planet conjunctions described by *ho* against minimum separation in pre-telescopic Japan

culturally and linguistically based.

Figure 4.20 shows the percentage efficiency of observing, with reference to minimum separation, as performed above for China and Korea.

The percentages, though showing the same general trend of higher efficiency for closer conjunctions, are significantly lower than those seen in Korea or even during the Chin. The inconsistency of Japanese observing is almost certainly to blame;

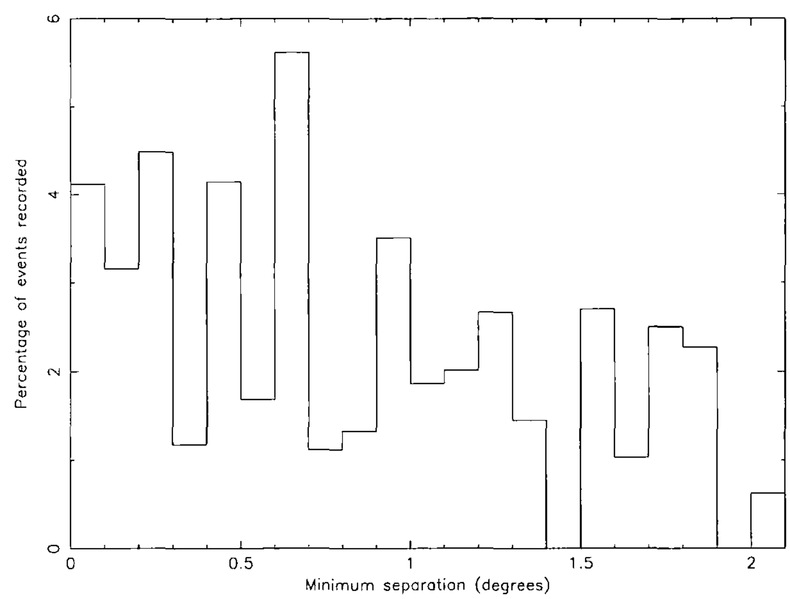

Figure 4.20: Percentage efficiency of observing, recording and preserving two-planet conjunctions, varying with minimum separation, in pre-telescopic Japan

with many decades in which no conjunctions were being observed or recorded at all, such low efficiencies are to be expected.

4.4 Summary

From examining the available data on two-planet conjunctions, the following may be concluded:

(a) that the difference between the minimum separation for a conjunction and the separation at the closest time (to that of the minimum separation) at which observation could have occurred is sufficiently small that it may be neglected when considering whether a conjunction would have been recorded;

(b) that the overall efficiency of observing, recording and preserving two-planet conjunctions is extremely low: specifically, around 4% for the Chin dynasty, and around 3% for the Koryŏ (note that the large number of different sources from which the Japanese records are drawn make an equivalent figure for Japan of little worth);

(c) that this efficiency is highly variable from decade to decade, and is also dependent on the minimum separation of the conjunction, with there being a general trend (most strongly in the Chinese data) towards recording events with a small minimum separation;

(d) that the variation in efficiency with time dominates the conjunction record, so that it is not possible to derive any estimate of the actual number of conjunctions occurring from the data;

(e) that the possibility that random fluctuations in the intrinsic signal could be responsible for the frequency variations seen may be discounted;

(f) that the two terms *fan* and *ho* were used in substantially different ways, with the former usually indicating a closer conjunction, and the latter being used with conjunctions of any minimum separation.

Chapter 5 Comets

5.1 Introduction

Variations in the frequency of comets observed at different times in history are of very great significance, as the long term behaviour of the flux of comets - relatively short lived bodies on an astronomical timescale - offers insight into the workings of the outer solar system which are as yet unknown. The mechanisms which determine changes in the cometary flux are poorly understood; the four hundred years of telescopic astronomy do not provide an adequate baseline with which to examine long term cometary variability. Records of observations of comets are relatively numerous in East Asian - and, in particular, Chinese - histories; furthermore, since there is a (physical) causal link between comets and another major body of early astronomical data (that of meteors and meteor showers), the total number of related records is very great, comparable to that of lunar and planetary records. (Bright meteors are seen very frequently and are recorded for their own sake in the various histories on numerous occasions.)

Comets occupy something of a middle ground as far as astronomical phenomena are concerned. They are not particularly common occurrences, as conjunctions or even meteors could be considered to be; but they are frequent - and distinctive - enough that early astronomers were aware of their existence as a discrete class of event, unlike (for example) galactic supernovae, or even aurorae. The other major class of events which have this property, for which there are also numerous early records, are eclipses; these, of course, are of limited use, as explained in the previous chapter. The significance of this middle ground is that, as relatively unusual and noticeable events, they may be expected to have a somewhat increased chance of being recorded than more common and less spectacular events. They are also one of the longest-lasting of naked eye astronomical events. In the case of a planetary conjunction, the event might only be visible for a few days, an eclipse for a matter of hours or minutes, and a single meteor only momentarily. As such the potential for the event being missed due to, for example, bad weather is much higher. However, with weeks or months to observe a comet, such misfortune is far less likely, and again the efficiency of observing such events may be expected to be improved as a result (although, of course, the preservation of records makes no such distinctions).

5.2 Cometary compilations

The East Asian cometary record, particularly that from China, has attracted a great deal of attention in past years; as a result, the majority of surviving records are not difficult to examine; many have been translated into English. It is worth briefly taking a look at some of the compilations that have been created.

5.2.1 19th century compilations

Biot's compilation (Biot 1846a, 1846b) (in French) was the first translation of part of the East Asian cometary record. Only one source was used for the work; this was *Hsu Wen-hsien T'oung-k'ao* (Supplement to the Comprehensive Study of Documents and Records), which contains material covering the years AD1224-1644; hence Biot's work is limited to this period. Biot's catalogue, although using only one source, does not benefit from the major advantage of doing so (that is, that a single source usually chronicles a single series of observations, as in a dynastic history). Because Biot's source is itself a secondary compilation, any data artefacts present in the sources drawn upon by *Hsu Wen-hsien T'oung-k'ao* are compounded with those arising in the compilation itself and passed on to Biot.

The compilation of Williams (Williams 1871) expands upon Biot's catalogue with data from the earlier *Wen-hsien T'oung-k'ao* (Comprehensive Study of Documents and Records) itself, and, to a lesser extent, from dynastic histories (although his reference to *Shih-chi*, the first dynastic history, only, is odd; records are in fact drawn from many dynasties). Williams' work, the first translation of the records into English, identifies many records that are duplicated between the *Wen-hsien T'oung-k'ao* encyclopaedia, its supplement, and also the dynastic histories.

5.2.2 Ho Peng Yoke's compilations

Two compilations, the work of Ho Peng Yoke (the second jointly with Ang Tian-se) (Ho 1962, Ho & Ang 1970) represent a much more comprehensive collection of cometary data. The first of these papers contains comet observations dating from antiquity to AD1600, and contains records taken from China, Korea and Japan; the second contains observations dating from AD1368 to 1911, but only draws upon Chinese records. I have separated the Korean and Japanese records out in order to be able to compare the sets of data later; there are many comets which were seen in two or even all three countries. At the present time these catalogues are the most complete available in an English translation. The records are drawn from a wide variety of sources: the dynastic histories, *Wen-hsien T'oung-k'ao* and *Hsu Wen-hsien T'oung-k'ao* , and many further works.

Both sets of data also include sightings of novae and supernovae. The descriptions of these are such that there are a substantial number of borderline cases which could easily be either novae/supernovae or comets. In determining and removing the nova records, I have applied the following criteria:

(a) Several standard terms for describing comets are used throughout. The most common of these are *hui* and *po*, which are both usually translated simply as "comet". *Hui*, literally "broom", normally identifies a long-tailed comet; *po*, meaning "bushy", is therefore indicative of a comet with a less well developed tail. Any record with such a description is considered to be a comet unless the details of the record indicate otherwise (criterion (b), in particular).

(b) Since the aim is to differentiate between comets and novae, any mention of the object moving is a good indication that it should be included. Rare exceptions, such as obfuscated meteor records, are usually relatively easy to spot. Conversely, an object described as a comet which is said to remain stationary for a long period of time before vanishing is likely to be a nova.

(c) If a tail is described in the record, it is considered to be a comet, unless the description strongly indicates otherwise.

(d) Records which are uncertain, having none of the properties described above (i.e., no indication of a tail or of motion) whilst not obviously being a nova, are excluded from the list, in order to be reasonably certain that the list contains only comets.

The changing frequency of the Chinese cometary records in both catalogues is shown in Figure 5.1; for comparison, that for the records from all three countries is shown in Figure 5.2.

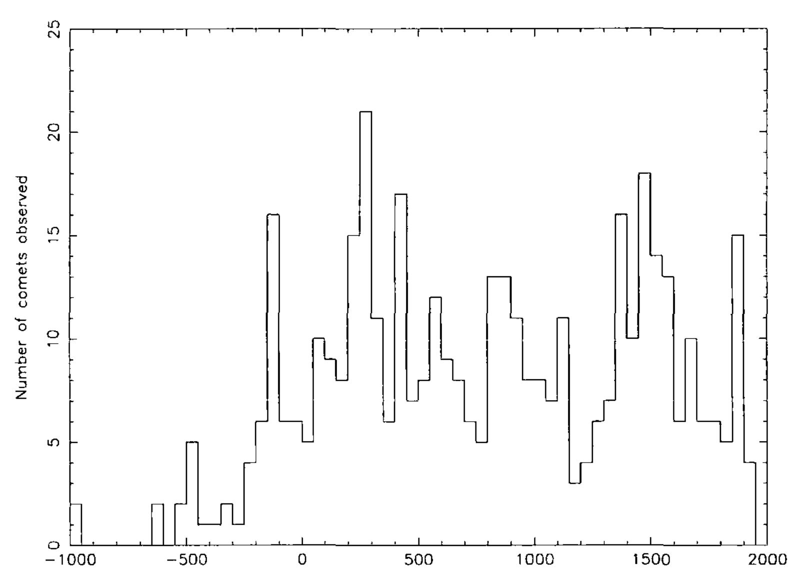

Figure 5.1: Frequency of cometary records from China present in the two Ho Peng Yoke catalogues; bin size is 50 years.

The two frequency distributions are extremely similar; compared to the number of events seen in China, those only seen in either Korea, Japan or both are few in number. The most noticeable consequence of combining the lists is the increased number of records around 1000-1200; this is due partially to the beginning of systematic Korean observations in *Koryŏ-sa* and partially due to the fact that the Japanese records escaped the attention of the Mongols, who invaded China and Korea during

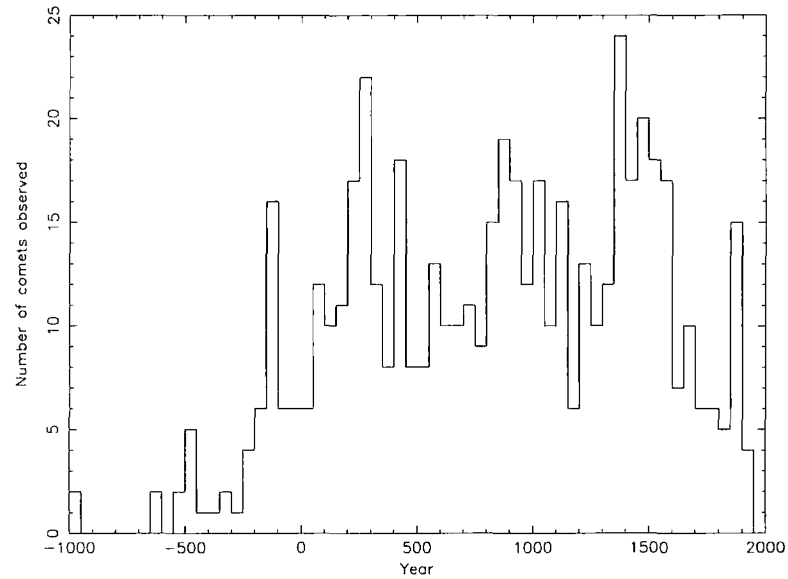

Figure 5.2: Frequency of cometary records from China, Korea and Japan present in the two Ho Peng Yoke catalogues; bin size is 50 years.

this period. The peak around 1400-1600 is predominantly due to Chinese records, and is likely to be due to the numerous records made and preserved from the Ming dynasty at this time, relative to the preceding Yüan (from which records of all types are considerably sparser) and the subsequent Ch'ing (which begins slightly after the end of the period covered by the first and larger compilation).

Given the number of different sources that the catalogues are drawn from, the variation seen in this plot is actually quite small. Since observations in China, at least until around AD1600, were largely made only from a central point (the exception to the rule being the periods during which China was split into more than one dynasty) the source of Chinese data for all of the various surviving works is the same. Thus the variation in the level of observing events is largely independent of the work from which the record is taken; it is the variation in the level of preservation that changes, and this can be said to be due to:

(a) whether the original record still survives, and, if not, how long it survived for;

(b) the number of compilations created from such records during the time for which the record existed;

(c) the occurrence of widespread destruction of records (both originals and compilations).

Thus, the level of preservation may be expected to increase (due to factor (a)) as we approach the present day; given less time to be destroyed, more records will have survived. This is seen in the plot for all three countries, but is here largely caused by the "switching on" of parallel records in Korea and Japan. The pattern for the Chinese records alone displays little evidence for this being a major factor; this is an indication of the high proportion of early Chinese records which have survived.

The creation of a major compilation, such as *Wen-hsien T'oung-k'ao* , is also likely to cause a surge in the number of astronomical records preserved from a particular period. This factor is not particularly evident in the case of the AD1280 compilation of *Wen-hsien T'oung-k'ao* ; however, the high point in the distribution between 1300 and 1600 is likely to be due to the publication of numerous surviving compendia during the Ming, including that of *Hsu Wen-hsien T'oung-k'ao* . Factor (c) can be seen in several places where the frequency becomes very low (as years of records are destroyed) and then rises quickly; principally, the rule of the Ch'in at the end of the third century BC, the fall of Wang Mang around AD20, the An Lu-shan Rebellion in the mid 8th century AD, and the Mongol invasion that ended the Sung dynasty and began the Yüan in the late thirteenth century AD.

It is therefore unclear whether the trends seen in Figure 5.1 are dominated by these data artefacts, or whether it does in part provide evidence for variation in the cometary flux over the centennial and millennial timescales. The prevalence of data artefacts can be tested, as with the conjunction data, with a χ^2 test against the theoretical distribution of bin frequencies for the case where there are no data artefacts and no underlying variation in the number of events occurring over these timescales. For this purpose it is necessary to define reasonable start and end points for the analysis. These have been chosen to be 220BC (the earliest point from which continuous astronomical data exists in the Chinese histories) and AD1600 (essentially the end of the pre-telescopic era). The data under consideration thus consists of 36 fifty-year bins, giving 35 degrees of freedom for the χ^2 test. Figure

5.3 compares the two curves.

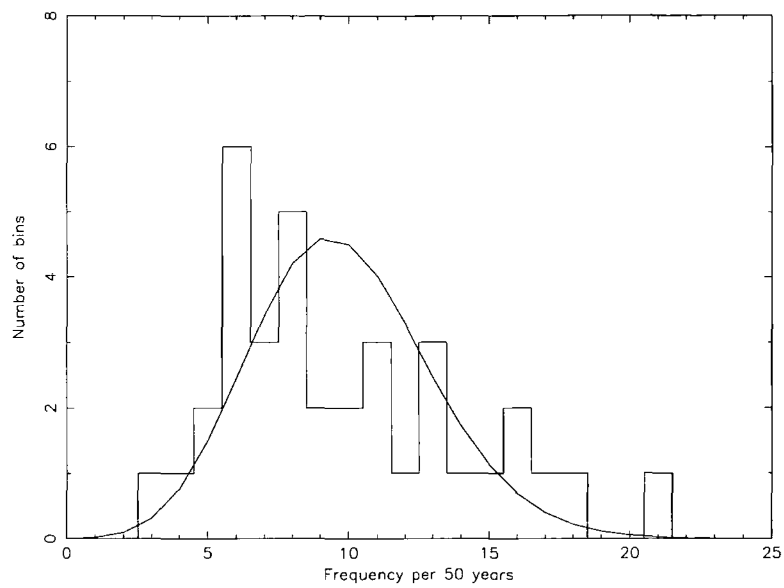

Figure 5.3: Cometary records from China present in the two Ho Peng Yoke catalogues (50 year bins): match of data to Poisson curve

The situation is similar to that seen in the previous chapter with reference to planetary conjunctions. Overall, the theoretical distribution given by the Poisson curve peaks earlier and higher than that of the actual data. The value of χ^2 for the comparison between the two is 55.589; far less extreme than the figures from the Chinese conjunction data, but easily high enough to be able to be confident that non-random variations dominate the data. (The critical value of χ^2 at the 1% confidence level, with there being 35 degrees of freedom, is around 1.6.) Figure 5.4 shows the binned data compared to the limits of 2 and 3 standard deviations from the mean.

The contrast with the two-planet conjunction plot is marked. There are no large features that can be said to dominate the distribution; although one peak exceeds the 2σ boundary, it is clear that its removal would not noticeably affect the mean or standard deviation. Other, similar peaks exist throughout the period under consideration.

Ho Peng Yoke's catalogues are valuable in being a full, detailed and accurate translation of the originals. However, it is now important to examine the most complete compilation of Chinese data now available.

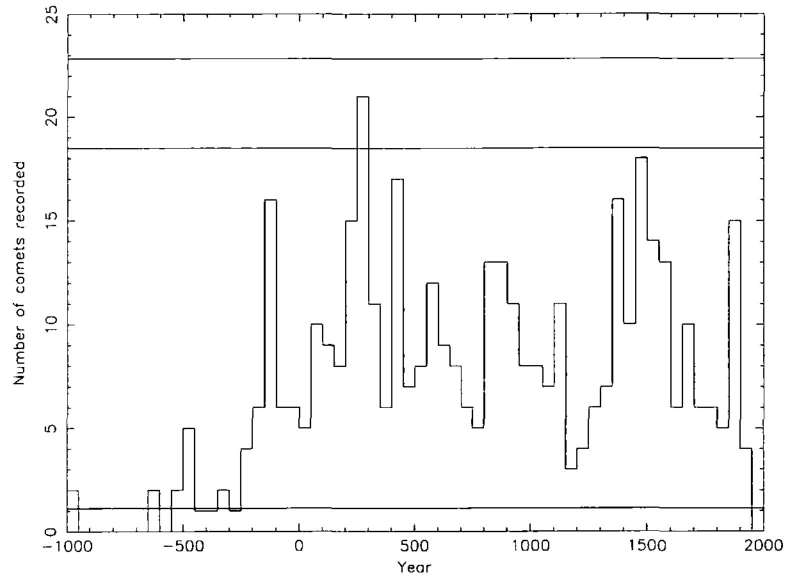

Figure 5.4: Cometary records from China present in the two Ho Peng Yoke catalogues (50 year bins): plot with standard deviation lines

5.3 The Beijing catalogue

This, the 1988 work *Zhongguo gudai tianxiang jilu zongji* (A union table of ancient Chinese records of celestial phenomena), published by Beijing Observatory, constitutes the most complete record of most Chinese astronomical phenomena - including comets - that is available outside China. Its principal additions to the catalogues of Ho Peng Yoke are the inclusion of material from the Chinese local histories; however, these are of little interest in the case of pre-telescopic astronomy, as they only begin to contribute substantial numbers of records after about AD1600. A considerable number of additional earlier records are, however, also included. The distribution with time of the records in the compilation is shown in Figure 5.5.

It should be noted that, since the Beijing catalogue is intentionally the most complete compilation of such records so far created (that is, it was the aim to consult as many historical sources as possible or practicable in compiling it), each individual comet sighting has been included separately. As such, it has been necessary to reduce the data to allow for multiple sightings of the same comet. Without a complete examination of each record, this must necessarily be done somewhat approximately. Firstly, records which do not specify the day or the month of the

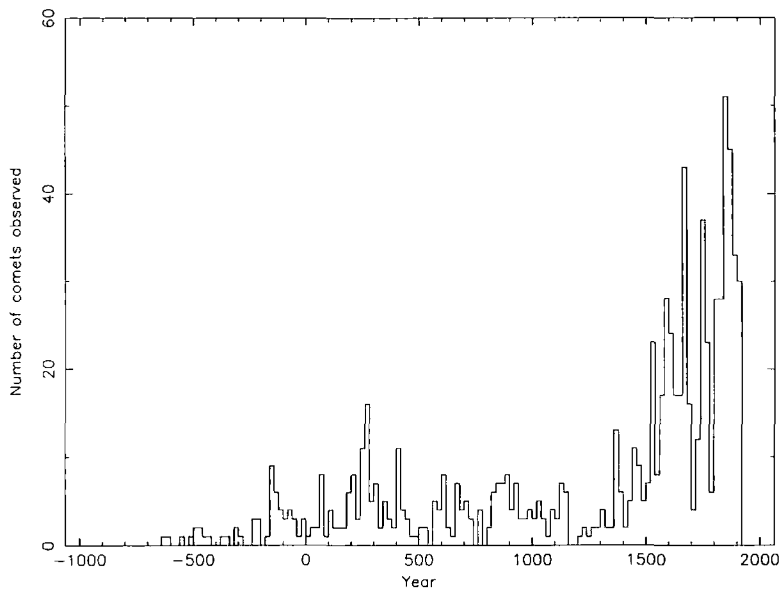

Figure 5.5: Frequency of cometary records present in the Beijing catalogue; bin size is 20 years.

sighting (which thus may have occurred at any time over the course of either a month or a year) for which another record describes a comet that was seen during the period in question were removed; it cannot be proved that such records were not duplicates. It was decided that the great majority of duplicate records were likely to be within days of each other; those with months between them have the potential to be records of different comets. Thus, where there were multiple comet sightings in one month, these were reduced to a single sighting. This method, while crude, eliminates the majority of multiple sightings comparatively easily. Figure 5.5 shows the reduced data.

Again there are marked dips in the record where records have been destroyed in large numbers. The rule of the Ch'in, the fall of Wang Mang, the An Lu-shan rebellion, and the Yüan dynasty are all marked by noticeable drops in frequency. Here there is again little evidence of any gradual increase in the number of records over the centuries; only after around AD1200 does this trend become apparent, whereas it is mainly due to the inclusion of the local histories from about AD1500-1600 onwards that the frequency increases so dramatically. Other than these, the most significant feature is that, despite being composed from many different sources (most of these are dynastic histories), the comet frequency is essentially flat for most of the pre-telescopic period. The variations that are seen are relatively small; however, as has been noted previously, it cannot be assumed that they arise from random fluctuations. A match of the data to the theoretical Poisson curve is required; for this, as for the previous case, the bins considered are those between 220BC and AD1600. Since the bin size is here 20 years, there are 91 frequencies in the data set and 90 degrees of freedom for the calculation of the critical χ^2 value. This is 1.379 at the 1% confidence level. Figure 5.6 compares the two.

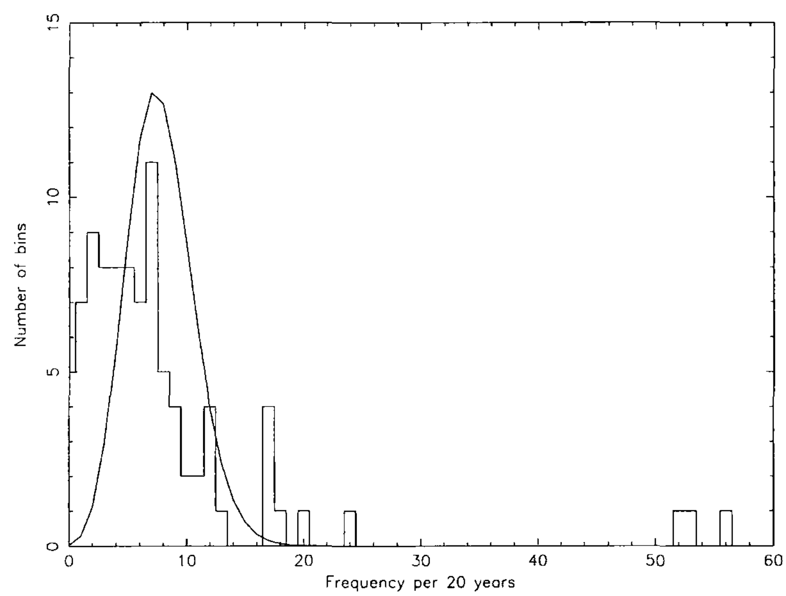

Figure 5.6: Cometary records from China present in the Beijing catalogue (20 year bins): match of data to Poisson curve

A handful of high-frequency outliers can be seen to be distorting the statistics; the peak of the Poisson curve is at a slightly higher value than that of the binned data. Once again the data as a whole is more spread out, with more variation than can be explained with random fluctuations alone. The value of χ^2 for this plot is a quite substantial 2.08×10^{26}; easily large enough to indicate the presence of non-random variation. The magnitude of this value is to some extent due to the presence of the outliers, which arise from the steep increase in frequency from the sixteenth century AD onwards as the local histories begin to have a significant effect on the amount of surviving data. Figure 5.7 shows the binned data together with the 2σ and 3σ boundaries.

As with the Chinese conjunction data examined in the previous chapter, the indication from this plot is hardly surprising. The last few bins before the cut-off point of AD1600 are the only points exceeding even 2 standard deviations above

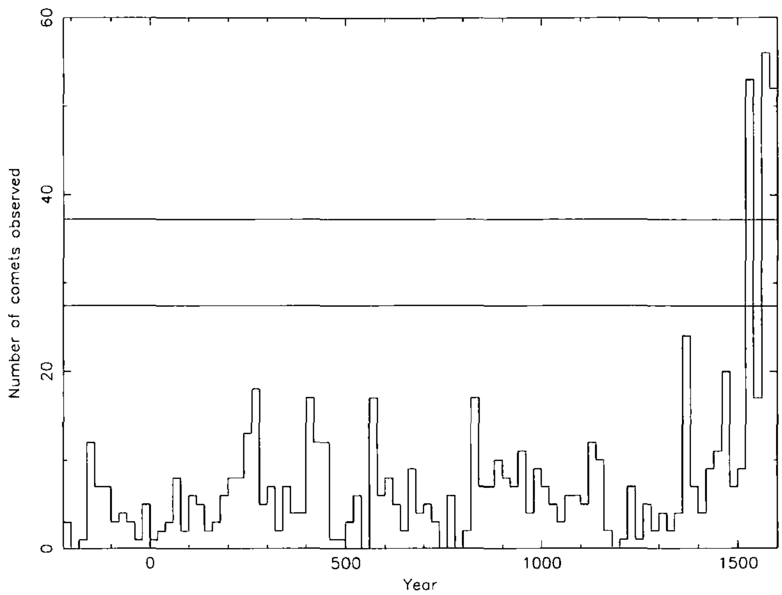

Figure 5.7: Cometary records from China present in the Beijing catalogue (20 year bins): plot with standard deviation lines

the mean. It is thus worthwhile removing the data from observations made after AD1520 for the purposes of matching the earlier bins to the Poisson curve. There are now 87 bins and 86 degrees of freedom, giving a critical χ^2 value of around 1.4 at the 1% confidence level. Figure 5.8 compares the reduced data set to the Poisson curve.

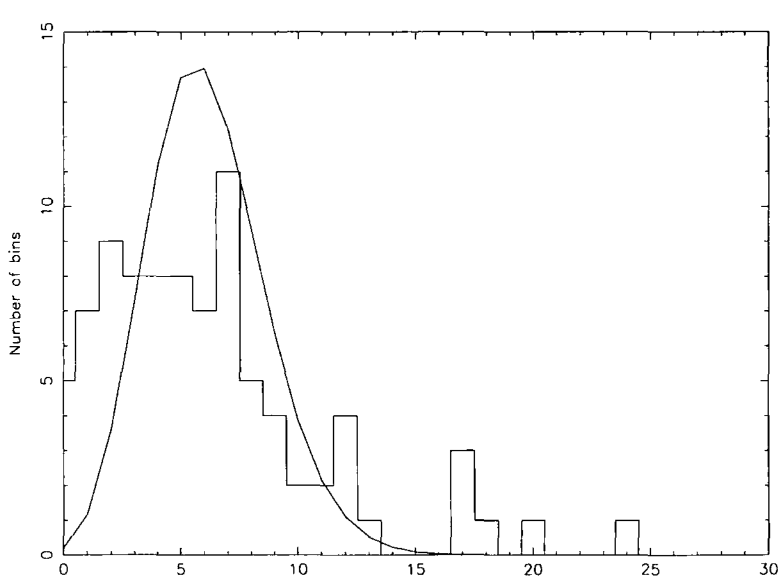

Figure 5.8: Cometary records from China present in the Beijing catalogue (20 year bins): match of data to Poisson curve, excluding data from AD1520-1600

The match, although certainly far from being close, is (unsurprisingly) significantly better, with a χ^2 value of 4.35×10^5. Given that the remaining peaks in the distribution are relatively short in duration and scattered, it is not appropriate to remove any more bins from the data set. The conclusion drawn from the cometary data in the previous section therefore stands; that the variation seen cannot be attributed to random fluctutations, and must be due to some level of data artifice.

A significant point to be noticed here is the relative sizes of the variations seen in the cometary plots compared to those of two-planet conjunctions. Although it might be expected - as a phenomenon whose long-term variability is unknown, rather than completely predictable - that the cometary data would show more variation, this is not the case; if anything, from examination of the respective χ^2 values, the reverse is true, and the level of data artifice in the cometary records is less extreme.

5.4 Cometary records from Korea

Surviving Korean cometary records are relatively few compared to those found in China. They are derived essentially from the *Choson Wangjo Sillok* , the *Koryŏ-sa* and - to a much lesser extent - the works which make up the *Samguk Sagi.*

The comets recorded in these sources were included in Ho Peng Yoke's first compendium; since this covers the time up to AD1600, this may be considered a sufficiently complete list of those records which survive. The Korean sources - with the exception of the encyclopaedia *Chung-bo Munhon Pigo* , from which only a handful of records are derived - each cover a different period of Korean history, and may therefore be considered to be free of data artefacts arising from factor (b), as detailed above. The frequency of cometary data from Korea is given in Figure 5.9.

It can be seen that the Koryŏ dynasty (that is, the tenth century AD onwards, ending in AD1392) represents a major increase in the number of surviving records; the frequency only increases further during the Yi (from AD1392). The frequencies from the different periods are difficult to compare to one another; the Yi records arise from the detailed *sillok* , for which the Koryŏ equivalent is lost. The *Samguk Sagi*, from which virtually all the pre-Koryŏ records are drawn, does not provide a systematic record; it is comprised of several different chronicles (i.e., the chronicles of Koguryo, of Paekche, and of Silla), of which none have dedicated sections on

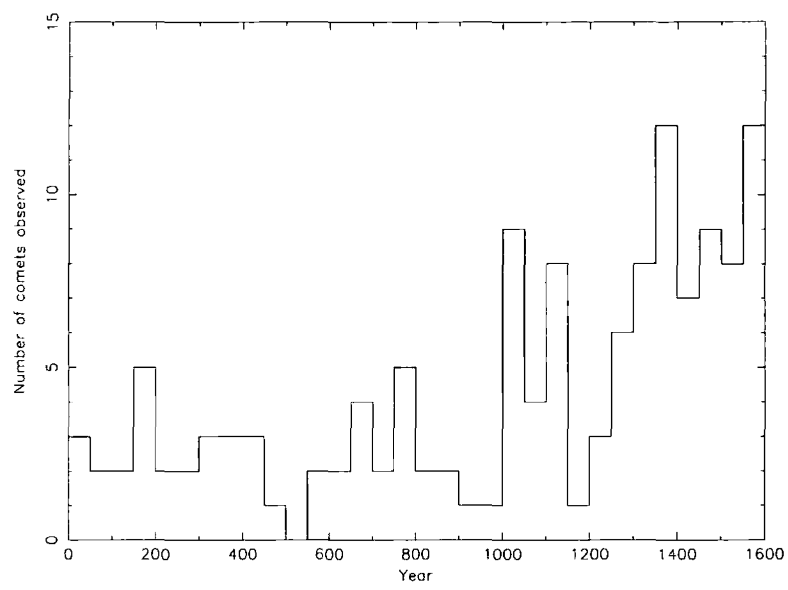

Figure 5.9: Frequency of cometary records from Korea present in the first Ho Peng Yoke catalogue; bin size is 50 years.

astronomy. (It is highly likely that much of the *Samguk Sagi* astronomical material is copied from the Annals of the Chinese dynastic histories of the time.) (Stephenson 1998)

Taking each period individually, there is little evidence for large scale changes in the comet flux. Records are spread reasonably evenly throughout the period covered by the *Samguk Sagi* and the *Choson Wangjo Sillok* (although, since the compilation only extends to the end of the pre-telescopic era, the *sillok* contains more information than is shown here). The variation during the Koryŏ period is probably largely attributable to the destruction caused by the Mongols, which leads to a gap mirroring that seen in China during the same period.

Since the most noticeable variations in the cometary recording frequency can be attributed either to differences between the major Korean sources or to the destruction of records, it is not valid to use a χ^2 test to match the data to a Poisson curve; this assumes a null hypothesis where the process of observation, recording and preservation does not change noticeably over the time period being considered.

5.5 Cometary records from Japan

Early cometary records from Japan are similar in number to those from Korea. Kanda's compilation is the only work in which records from the hundreds of individual Japanese sources are brought together. A handful of records that are not included are identified in Ho Peng Yoke's first catalogue, which used Kanda's compilation as its major Japanese source, and it is Ho's catalogue which is used as the source here. As noted in the previous chapter, the records are drawn from a large number of different sources, and are in no way systematic. The frequency of Japanese cometary data is given in Figure 5.10.

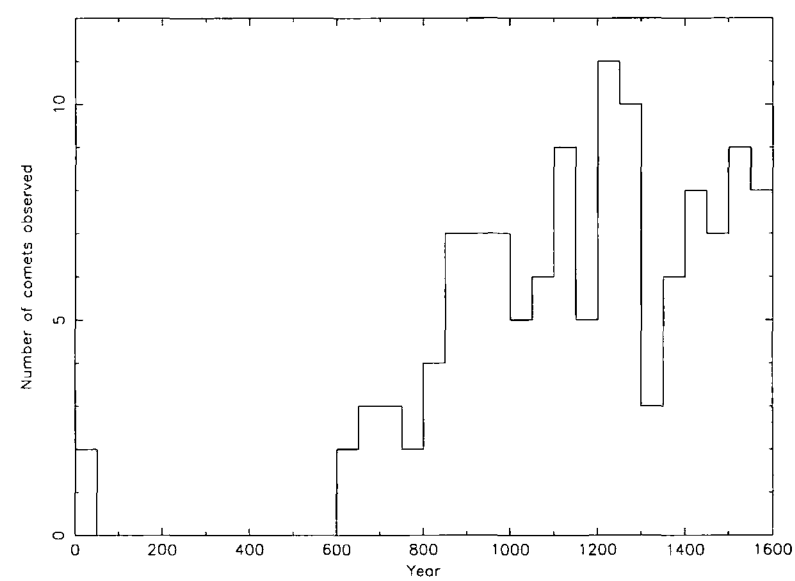

Figure 5.10: Frequency of cometary records from Japan present in the first Ho Peng Yoke catalogue; bin size is 50 years.

It can be seen that the seventh century AD essentially marks the beginning of recording astronomical events in Japan; historically, this is what would be expected, with the first major Japanese chronicles being compiled early in the eighth century. Due to the relatively small size of the dataset - and, equally significantly, the fact that the records are not systematic - it is not clear whether the pattern is that of the observed flux varying about an essentially invariant true level - as would be suggested by the data from China and Korea - or there being a significant variation in the true flux that is lost in the noise. The large drop in frequency during the 14th century coincides with the advent of the Muromachi Bakufu and a civil war which lasted three decades; a decrease in observation due to instability, or the destruction of records as its result, are likely to be the cause of the decrease.

Since a large number of sources provide the surviving records, it is to be expected that - taking the true cometary flux to be uncertain - the most influential factor affecting the frequency of observations in the long term would have been the number of active observers and chroniclers at any one time.

Although there is no continuous record from Japan, it is appropriate to carry out a χ^2 test on the data. Note, however, that this assumes a null hypothesis under which the variation in the number of observers at any one time, as well as the other factors that may give rise to data artefacts, does not affect the distribution. The period for which Japanese cometary data can be considered is from the beginning of the keeping of astronomical records (AD600) to the end of the pre-telescopic era (AD1600). This gives 20 fifty-year bins, and 19 degrees of freedom for the test. Figure 5.11 compares the data to the Poisson curve with the same mean.

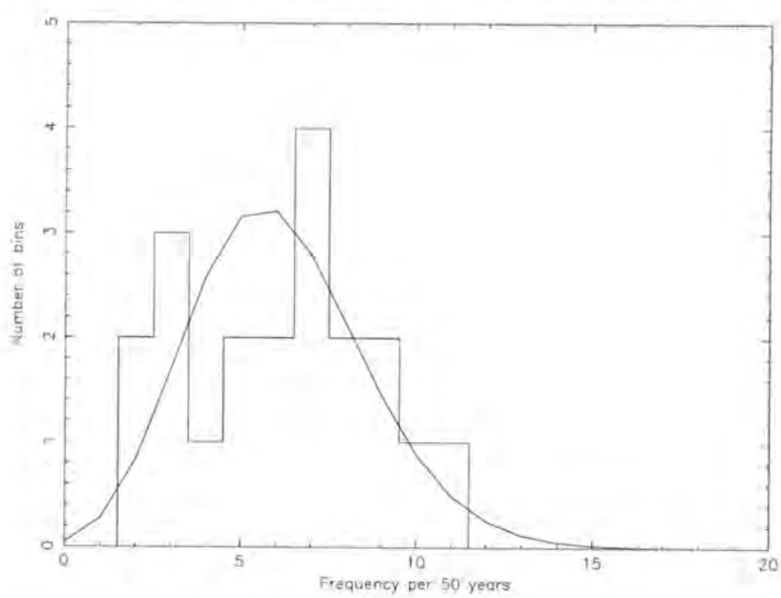

Figure 5.11: Cometary records from Japan present in the first Ho Peng Yoke catalogue (50 year bins): match of data to Poisson curve

Again, the theoretical curve is less spread out and peaks at a lower frequency to that of the real data. The value of χ^2 is 6.538; much lower than those for the previous sets of data, but, with the critical value of χ^2 at the 1% confidence level at 1.905, the possibility that random effects can account for the frequency variations may be discounted. Figure 5.12 shows the 50-year binned data compared to the 2σ

and 3σ from the mean boundaries.

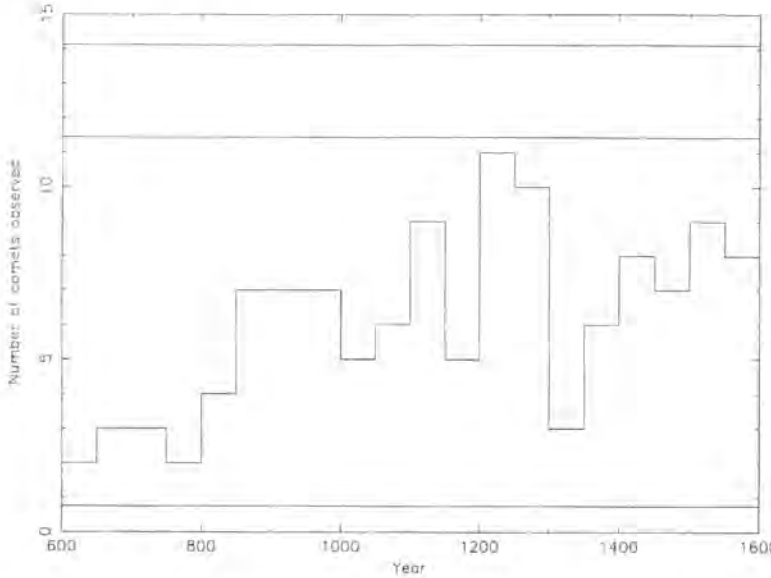

Figure 5.12: Cometary records from Japan present in the first Ho Peng Yoke catalogue (50 year bins): plot with standard deviation lines

In this case, no features are sufficiently extreme to cross even the 2σ boundaries, and thus the possibility that a significantly better match to the curve could be found by excluding aberrant features can be discounted.

5.6 Summary

The changing frequency of early cometary records from both China and Korea does not show any evidence for large variations in the cometary flux. Most of the large variations in the frequency of records are linked to periods where widespread destruction of records took place. It also seems likely that the increased chance of records surviving when being included in a compilation plays a significant role, particularly in China. The variations seen, however, are sufficiently far from those arising only from a constant level of recording of a constant source to be confident that non-random variations (data artefacts, real variation in the cometary flux, or both) dominate the statistics.

In Japan, where there is no systematic central record, secondary compilations are the only available source of astronomical information; since these are both extremely numerous and relatively small compared to their Chinese counterparts, this effect is likely to be a great influence on the frequency of records. For the same reason, no firm conclusions can be drawn from the Japanese data.

Chapter 6

Meteors and meteor showers

6.1 Introduction

The opportunities offered by pre-telescopic meteor records are especially interesting. As mentioned in the previous chapter, they are extremely numerous compared to those of every other phenomenon except lunar and planetary movements, and have a causal link to another phenomenon (comets) for which a large number of records also survive. A comparison between the frequencies of records of comets and meteors is therefore both statistically useful and potentially enlightening in terms of investigating the level of data artefacts in the record.

Two distinct types of event must be considered. The first - individual meteor sightings - constitutes the overwhelming majority of entries. These are described by the standard phrase *liu-hsing* - "flowing star". This terminology is common to all three countries, and makes identifying such records relatively easy. The second phenomenon - meteor showers - are rare in East Asian records, especially so when considering the great number of individual meteors recorded. It may well be that the standard description of a meteor shower ("stars fell like rain") was only considered appropriate for truly spectacular meteor showers. Certainly entries exist where, over a course of a night, several meteor sightings are reported individually, without recourse to the more dramatic term.

Individual meteors are, by definition, transient, momentary phenomena. Given that it has already been demonstrated that planetary conjunctions - events taking at the very least several hours to take place - were detected with an efficiency never greater than 25%, then - if conjunctions and meteors were observed without bias towards one or the other - the chance of any individual meteor being recorded is extremely low. Thus the true meteor flux cannot be hoped to be observed (in contrast to that of more spectacular phenomena, such as comets or aurorae), but only sampled, with the sample size being a tiny fraction of the whole.

It may therefore be expected that specific nights during which many meteors fell will feature heavily; if one meteor was seen, it is reasonable to expect that the observers would become more vigilant in looking for others. Whether or not they then thought it fitting to record *every* meteor, or only the most spectacular, such nights of high activity are likely to account for a significant portion of the total number of records, simply because they are so much harder to miss than nights with only two or three meteors. It is therefore necessary to only count one sighting per night; otherwise parts of the record are liable to be swamped.

6.2 Meteor records from China

The records of individual meteors from China constitute the single largest set of data for any phenomenon from one source before the invention of the telescope. They constitute around a third of the Beijing catalogue, and run to several thousand different dates. The variation with frequency of the observations are given in Figure 6.1.

It can immediately be seen that the frequency distribution is anything but flat. For much of the time covered the frequency is somewhat similar to that of the cometary record, showing some of the same features: the small peak around AD500, for instance, and the lack of records before 220BC can be readily seen. However, it is the dramatic differences between the two plots that dominate. Twice - first during the eleventh century AD, and again during the fourteenth and fifteenth centuries - the frequency of meteor records soars, becoming two orders of magnitude above that preceding the periods in question. These features are absent from the cometary record.

It is important to gain some measure of the magnitude of the effect that these features have on the distribution. As with the data from previous chapters, a χ^2 test may be carried out against the null hypothesis that the variations seen arise from

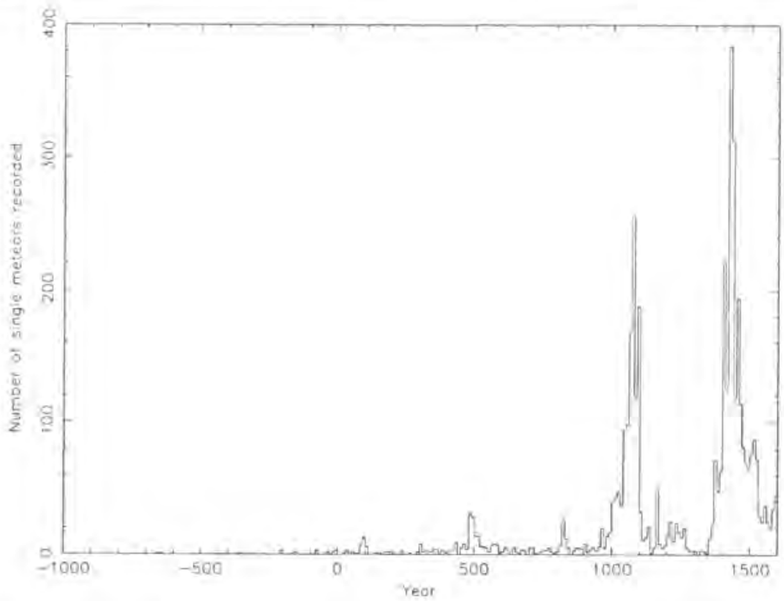

Figure 6.1: Frequency of single meteor records present in the Beijing catalogue; bin size is 10 years. Note that the telescopic period (AD1600 onwards) is omitted from the plot.

random fluctuations. Although this is clearly false, the χ^2 values obtained from the data both before and after the obvious outliers are removed give information on the peaks' effect and the prevalence of data artefacts over the remainder of the distribution respectively. Figure 6.2 compares the bin frequencies to the Poisson curve, as before. There are 182 bins, which leads to a critical value of χ^2 at the 1% significance level of around 1.26.

For clarity, the bin frequency scale only goes up to 150 records per decade; seven bins have frequencies beyond this, and are spread from below 200 to nearly 400. It is clear from the plot that to attempt to match a Poisson curve to such data is highly unrealistic: the value of χ^2 generated is 2.08×10^{80}, a figure which is overwhelmingly due to the outliers making up the two peaks. Figure 6.3, showing the original data with the 2σ and 3σ boundaries, indicates that no other feature of the plot even approaches 2 standard deviations from the mean.

Thus it is appropriate to remove the upper parts of the peaks (note that, since it is somewhat unclear where either feature begins or ends, it is not valid to simply remove large numbers of bins which cannot be considered outlying merely because of proximity to the highest frequency bins). It can be seen, however, that in each case the decades of very high activity - as opposed to surrounding decades, which

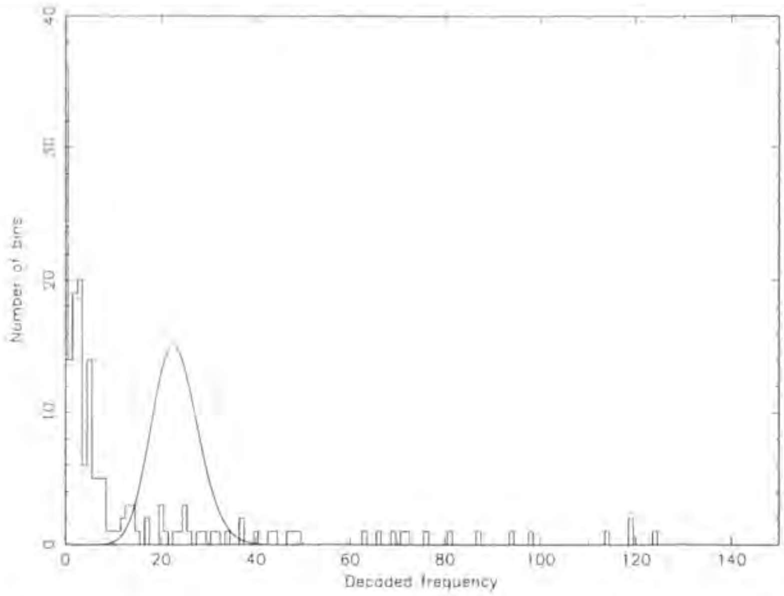

Figure 6.2: Single meteors recorded in the Beijing catalogue: match of data to Poisson curve

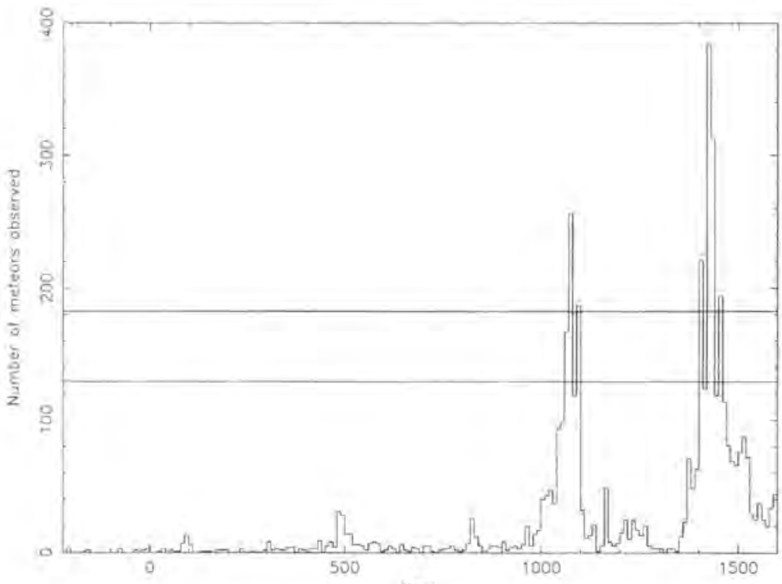

Figure 6.3: Single meteors recorded in the Beijing catalogue: plot with standard deviation lines

are merely high compared to the plot as a whole - are suitably distinct, and can be identified and removed. I take these periods to be 1040-1100 and 1400-1470; Figure 6.4 compares the plot to the Poisson curve again without these outliers.

The new value of χ^2 produced is 1.556×10^{45} - in other words, even with the most significant outliers removed, the data still shows more deviation from the situation where there are no data artefacts than any other single data set so far examined.

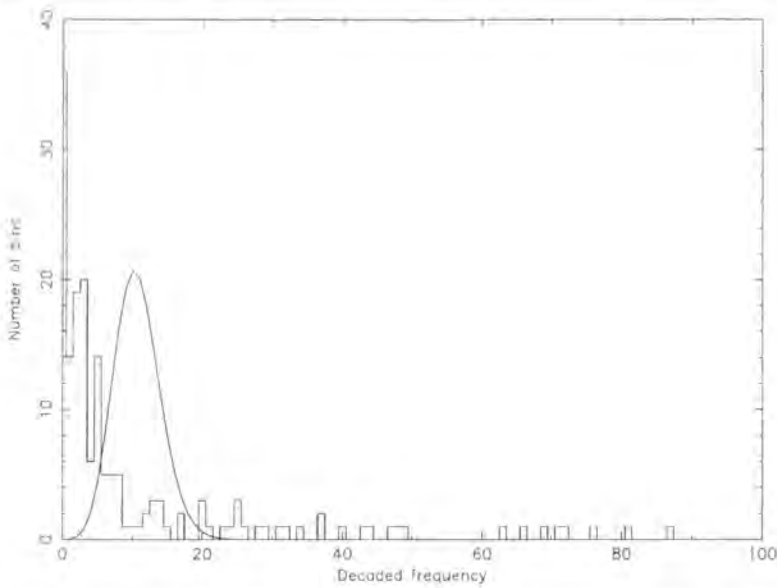

Figure 6.4: Single meteors recorded in the Beijing catalogue: match of data to Poisson curve

It should be noted in passing that this is the largest single set of data available for examination from an early East Asian source. Although it might be considered that the detail thus available for analysis could be responsible for the magnitude of the deviation - particularly in contrast to the much smaller figures obtained from the cometary data - this is largely not the case. The size of the data set determines the minimum bin size which can be applied; using larger bins throws more of the available data away. Thus a smaller bin size from a larger data set provides a more reliable value of χ^2; the huge differences in magnitude seen between those for comets and meteors - and, for that matter, conjunctions - cannot be considered to be due to such effects.

The possible sources of such a vast frequency variation must be considered. It is to be expected that any variation will be a combination of these factors:

(a) Variations in the amount of astronomical observation of all kinds being carried out.

(b) Bias towards observing different types of event. These first two factors are both observation-related data artefacts.

(c) Recording-related data artefacts: distortion of the probability that a record will survive, through it being recorded in secondary compilations or otherwise in different places.

(d) Preservation-related data artefacts: times where the frequency of records is suppressed due to destruction of documents, the attrition of older records compared to newer ones, and whether the original record is preserved.

(e) A real variation in the frequency of meteors.

Each possible source of variation defines properties which can then be used, to some extent, to ascertain if that source has a noticeable effect in this case. Taking factors (a) and (b) as an example, a variation in the amount of observations being carried out of all kinds will be visible in records for all different phenomena, whilst differing bias towards various types of phenomena will not; however, both will be linked to the conditions in China at the time of observation. Times of political unrest may, for example, be marked by a surge in observations of one or more kinds, depending on the perceived significance of astrology at the time. This factor, of course, can never be known, but increases in recorded frequencies of various kinds are seen to occur in the last years of dynasties; the end of the Chin is a good example of this.

Factor (c) is somewhat easier to account for. If records are better preserved because they are recorded in more than one place, then the effect of additional copies can be seen by merely looking at the data found in the dynastic histories themselves. It should be noted here that, unfortunately, this does not quite give the orderly two thousand years of observations from a single point that would be desired; due to the times (AD420-589, 907-960, and 1127-1179) during which more than one dynasty co-existed in China, there are occasionally two parallel records. The effect is, however, comparatively minor.

The destruction of records - factor (d) - is the most simple to deal with. The Chinese cometary data from the previous chapter exhibited this effect well, with the low points due to destruction being several of its most prominent features. In effect this factor acts like part of factor (a) - the change in the amount of observations that are being conducted as a whole - in that it affects all phenomena in the same way, except that its effects are only seen as a reduction in frequency. Since large scale destructions of records is usually linked to prominent times of upheaval, this effect is also more readily noticeable than those due to factor (a).

It is worthwhile - in particular for this case, where both cometary and meteor records exist in relatively large numbers - to examine the ratio between the two. Figure 6.5 shows this. Note that, for the sake of clarity, the upper reaches of the two highest peaks are not shown.

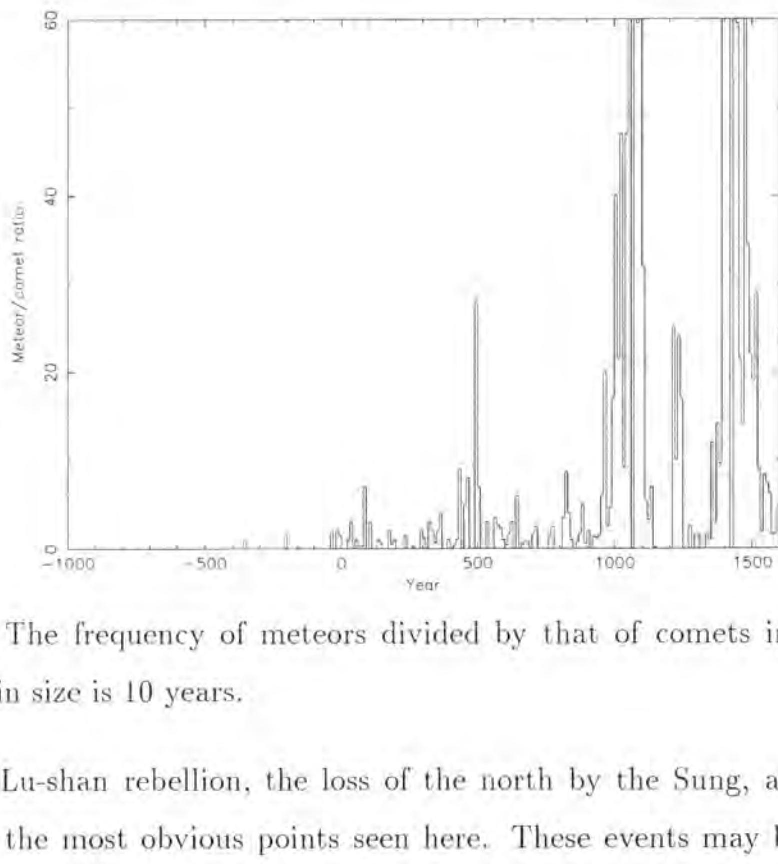

Figure 6.5: The frequency of meteors divided by that of comets in the Beijing catalogue; bin size is 10 years.

The An Lu-shan rebellion, the loss of the north by the Sung, and the Yüan dynasty are the most obvious points seen here. These events may be considered to be those which have had a marked effect on both records. There is no obvious correlation between the two frequency patterns, however (which would lead to a smoothing of the variation of the ratio with respect to the meteor frequency).

As it is factor (e), the true variation, that is of primary interest, it is fortunate that there is a reasonably simple way to ascertain its influence on the pattern seen in Figure 6.1. Just as certain other factors influence the recorded frequencies of all events in the same way, the true variation - as the only factor which is invariant between observers in different countries - must influence the recorded frequencies of that event for all observers in the same way. Thus, it is necessary to compare the different recorded frequencies of meteors between China, Korea, and Japan; an analysis of all three can then be carried out.

6.3 Meteor records from Korea

As with the analysis of Korean records from the previous chapter, only those contained in the *Koryŏ-sa* will be analysed. The Koryŏ period covers the first of the major peaks in the Chinese record; given the indications from the Korean cometary record, it is likely that data from *Choson Wangjo Sillok* , whilst extending over the second Chinese peak, will not be comparable with that from the Koryŏ period.

The Korean meteor record has not been investigated in detail before; unlike that for comets, it is necessary to go back to the original to obtain the data set. Again it is fortunate that *Koryŏ-sa* closely follows the style of a Chinese dynastic history; although it is necessary to separate out individual records from those of other phenomena, the standard terminology and style in which they are recorded makes the task significantly simpler.

The frequency variation of the meteor data from *Koryŏ-sa* is shown in Figure 6.6.

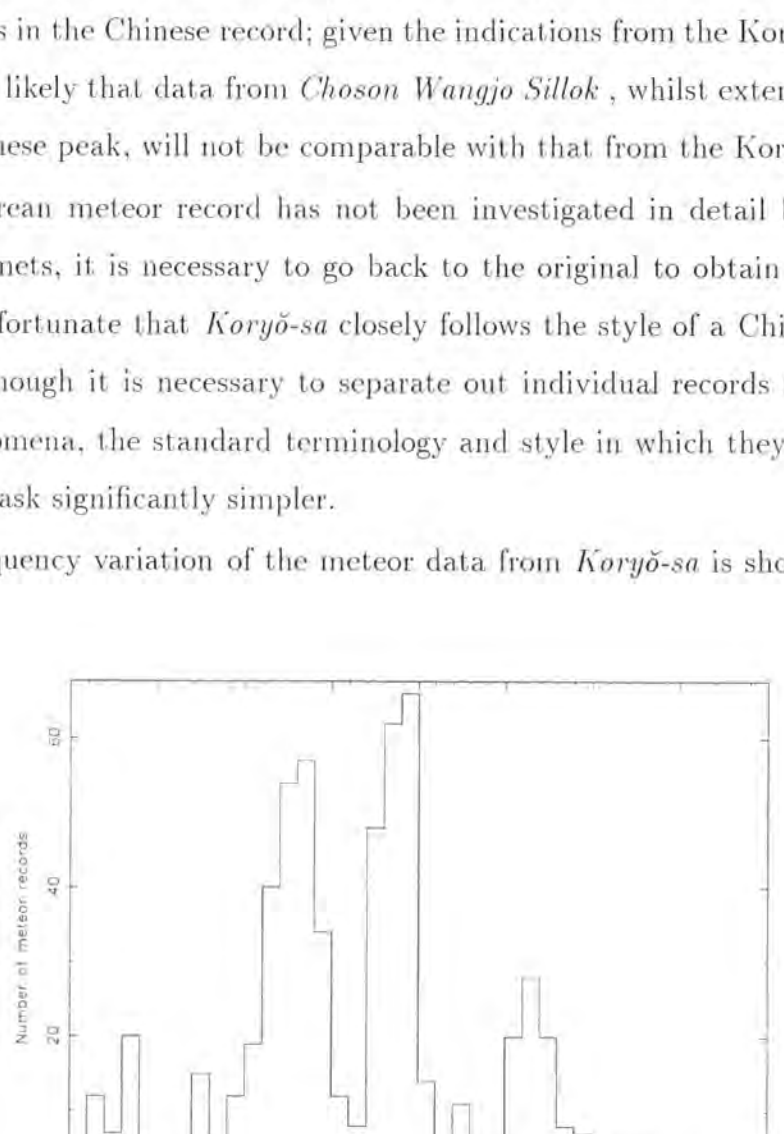

Figure 6.6: Frequency of single meteor records present in *Koryŏ-sa* ; bin size is 10 years.

As is the case for that from China, the most striking thing about the meteor record from Korea is the great amount of variation in its frequency. Although not quite so extreme as the features in the Chinese record, the two peaks in the above plot reach frequencies around five times above the average. The peaks are also narrower than in the Chinese data, lasting around 50 years rather than a century. Figure 6.7 shows the comparison between the Korean data and the theoretical Poisson curve. The critical value of χ^2 at the 1% confidence level is around 1.6.

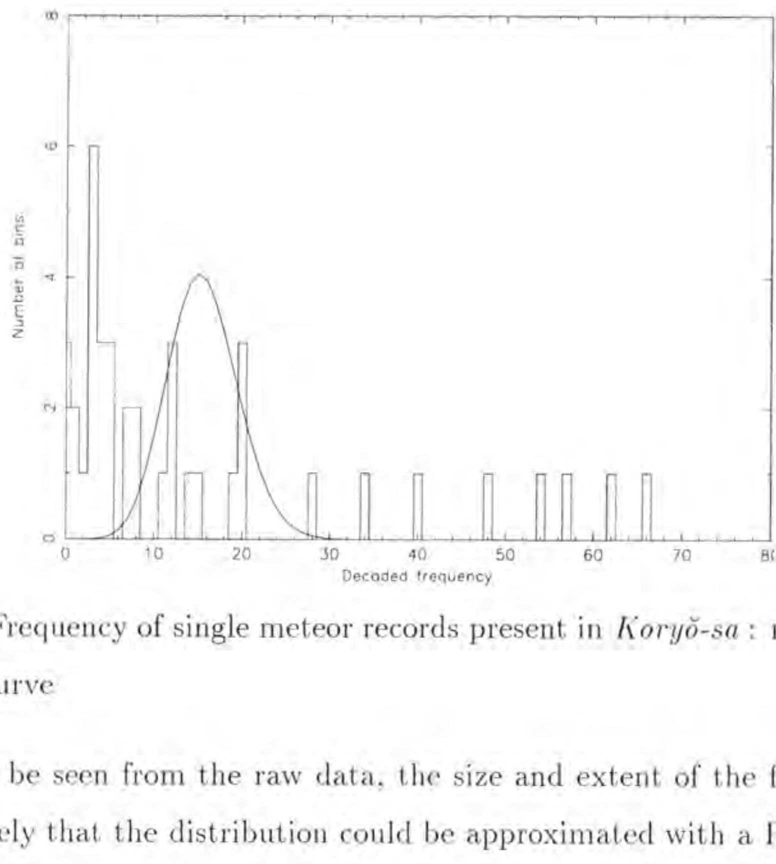

Figure 6.7: Frequency of single meteor records present in *Koryŏ-sa* : match of data to Poisson curve

As could be seen from the raw data, the size and extent of the features make it very unlikely that the distribution could be approximated with a Poisson curve, and the plot bears this out - the number and size of the outliers clearly drawing the theoretical curve to higher values than those reflected by the majority of the bins. χ^2 comes out as 1.58×10^{19} for this comparison.

Looking at the position of the 2σ and 3σ above the mean boundaries (for which the plot is given in Figure 6.8) it can be seen that only the pinnacles of the two large peaks can be considered to be significant. Since there is no obvious point - unlike those of the Chinese distribution - at which the higher parts of either peak can be obviously separated from the surrounding data, and since removing the entirety of both peaks would account for more than a quarter of the whole distribution, it is not appropriate to reduce the data; the prevalence of non-random variations - due to one or more of the factors listed above - must be accepted.

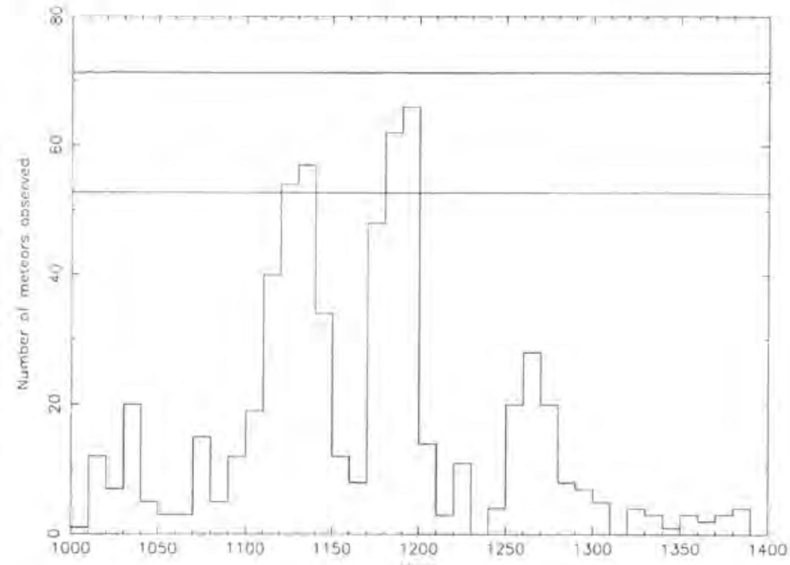

Figure 6.8: Frequency of single meteors present in *Koryŏ-sa* : plot with standard deviation lines

It is now necessary to compare the binned data from China and Korea, as noted above, to narrow down the factors from which both patterns could have arisen. Figure 6.9 shows both sets of data.

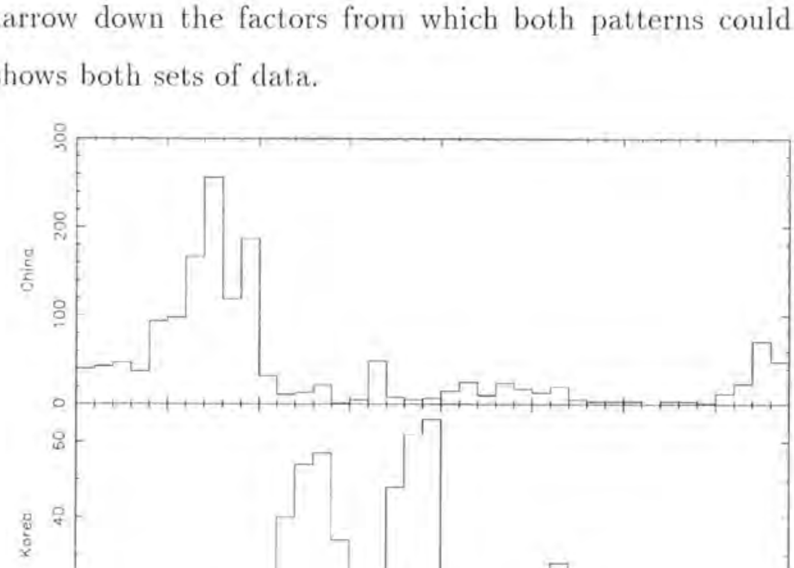

Figure 6.9: Frequency of single meteor records present in (upper) the Beijing catalogue and in (lower) *Koryŏ-sa* ; bin size is 10 years.

It is obvious that the peaks in the two records utterly fail to match up; each peak occurs at a time of a relatively low recorded meteor frequency in the other country; although it cannot be said, following the analysis already performed, that the variation seen in the other country at these times is statistically insignificant, it is clear that the factors from which each pattern have arisen are not common across China and Korea. It must be concluded that there is no evidence that any of the peaks appear in more than one country; as such it must be concluded that they are not of astronomical origin.

The peaks are thus data artefacts, completely swamping the record across the decades they last for. The sheer size of the variations means that further investigation of their origin is important.

Figures 6.10 and 6.11 compare the meteor frequency to that for the data for lunar and planetary phenomena, for China and Korea respectively. In the Chinese case only records of two-planet conjunctions are used; for Korea no distinction of this kind is made. The number of records available is suitably large in both cases. It is more appropriate to use these for comparison than the cometary data, primarily due to the causal link between comets and meteors. From the earlier examination of planetary data, it has been seen that the overall frequency variation of lunar and planetary phenomena is extremely similar to that of two-planet conjunctions alone; hence it is appropriate to use either as a comparison.

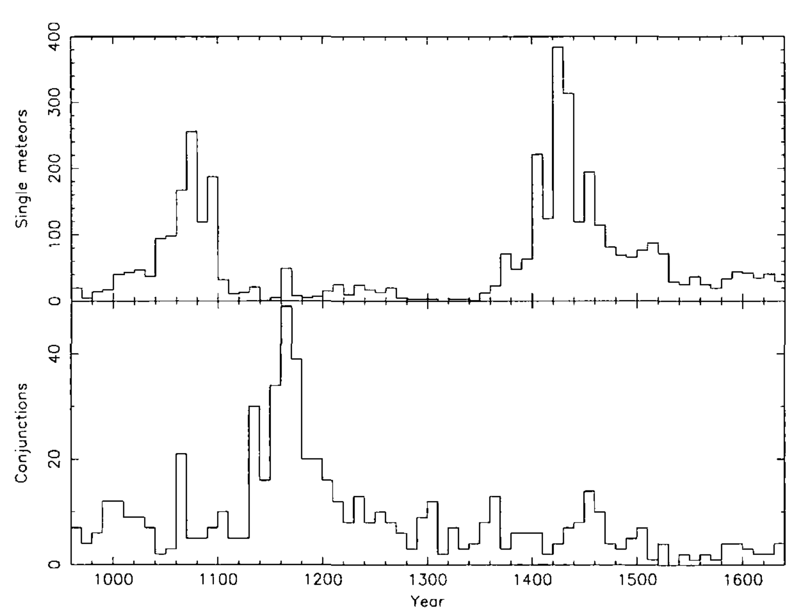

Figure 6.10: Frequency of single meteor records compared to that of two-planet conjunctions present in the dynastic histories of the Sung, Yüan and Ming dynasties; bin size is 10 years.

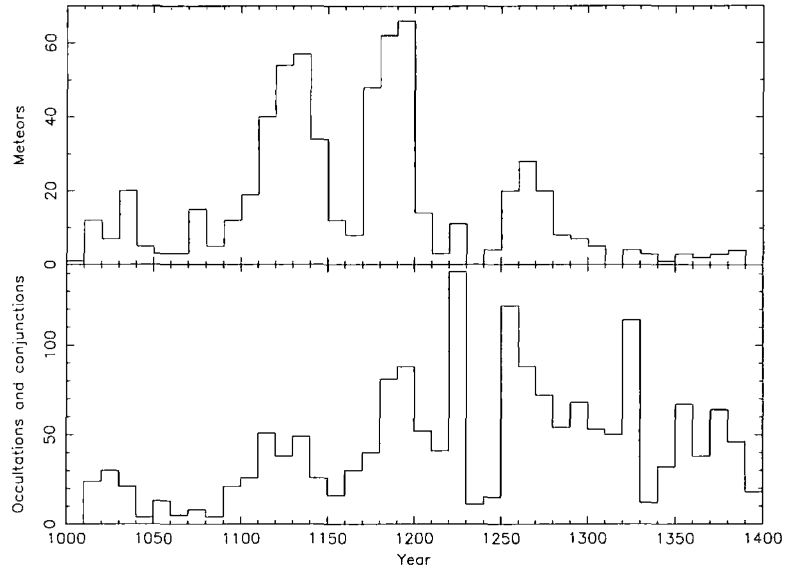

Figure 6.11: Frequency of single meteor records compared to that of lunar occultations and planetary conjunctions present in *Koryŏ-sa* ; bin size is 10 years.

Several of the possible causes of the data artefacts may now be eliminated. As variations rising above the frequency level of their surroundings, they cannot be due to the destruction of records (although, in the case of the second Korean peak, the fact that it falls off shortly before the period where the Mongol invasion destroyed large numbers of records suggests that part of its extent may have been lost). It can be seen that, for the peaks in the Chinese meteor record, there is no corresponding increase in the frequency of planetary data, and vice versa. In *Koryŏ-sa* there is some evidence for a reflection of the single meteor peaks in the occultation and conjunction records, although - in particular for the second half of the dynasty - elsewhere there is no obvious correlation. The data in Figure 6.12 shows this pattern as the ratio of occultation and conjunction records to single meteor records.

The result is telling. Nearly all the variation that makes up the major peaks in the meteor record vanishes when the data artefacts found in the lunar and planetary records are applied. Only *after* the time of the two peaks does the difference between the two records become apparent.

The peaks in both records, by process of elimination, must be due to a combination of the three remaining factors; variation in the number of astronomical records being recorded as a whole, bias towards recording particular types of event, and variation in the probability that a record survives due to the publication of

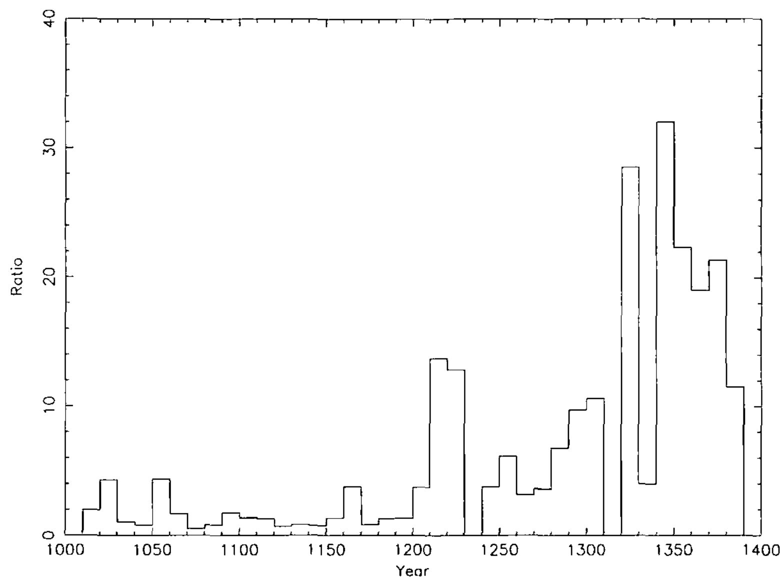

Figure 6.12: Ratio of records of lunar occultations and planetary conjunctions to single meteors present in *Koryŏ-sa* ; bin size is 10 years.

compilations or in multiple places. This last factor does not apply to the Korean record, since it is drawn from a single work; thus it must be concluded that the two Korean peaks arise almost entirely from general variations in the level of astronomical observation; as mentioned before the destruction of records may well also be an influence. For the Chinese meteor record, however, the peaks appear to be specific to the phenomenon; this immediately suggests that bias is the principal cause of the two peaks seen. It must be considered, however, that the comparative conjunction record is specifically drawn from three consecutive dynastic histories. Like *Koryŏ-sa* , there is thus no possibility that the record shows the preservative effect of the publication of compilations; the meteor record as a whole, however, may include this factor.

6.4 Meteor records from Japan

Kanda's catalogue contains a substantial section on meteor records, and, as before, this is considered to essentially represent the entirety of the pre-telescopic Japanese data. Although the same drawback applies here to the data from Kanda as elsewhere - that the variation in the number of active contributors to the dataset during any given period is unknown - it is nevertheless interesting to compare the Japanese variation to that from the other two countries. It may be expected that, since the prior comparison indicates that the major peaks in the records from both other countries are data artefacts, neither pattern will bear close resemblance to that from Japan.

Note that there is only one section dealing with meteors in Kanda's work; therefore any records of meteor showers are not separated out as they are for the Chinese records. The overall variation of meteor records in Kanda's catalogue is given in Figure 6.13.

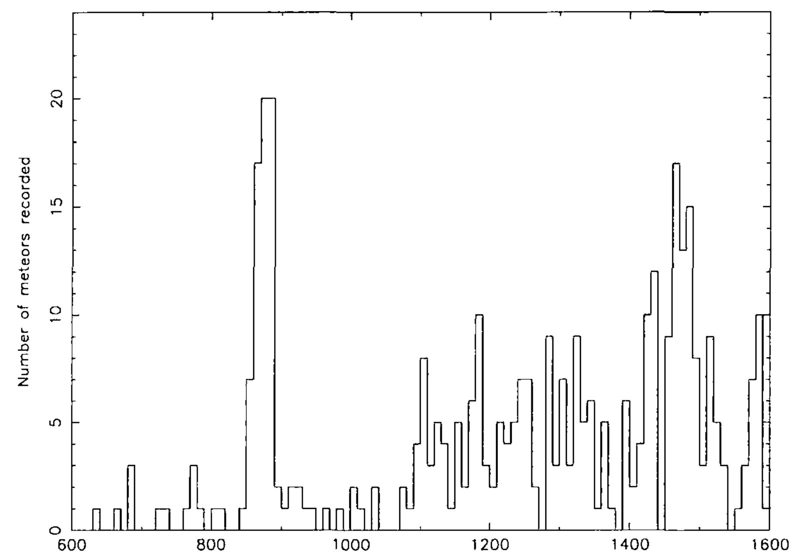

Figure 6.13: Frequency of meteor records present in Kanda's compilation; bin size is 10 years.

In general, the level of variation is in line with expectation. Again we see several periods from which no records are included; whether or not this is due to lack of observers is debatable, but a comparison with the lunar and planetary data from the catalogue should allow for this. The variation in the number of observers may be considered to affect different types of phenomenon in the same way; thus, although it may be difficult to separate from the factors which also have this property (namely, general variations in the level of observer interest, and the destruction of records) it is possible to discern between this additional factor and the true variation.

Figure 6.14 shows the match of the data to the Poisson curve, for comparison with those from the Chinese and Korean sources. It is interesting to note that, despite the extra factor that may act as a source of data artefacts for the Japanese data, the match here is actually closer than the records from either China or Korea, with a χ^2 value of 1.87×10^7. The prevalence of non-random variations, however, is still supported by this result.

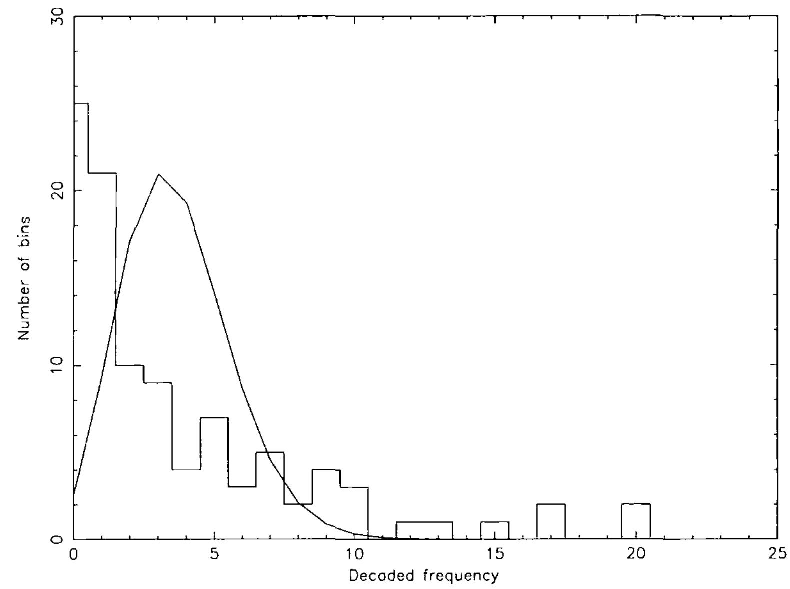

Figure 6.14: Frequency of single meteor records present in Kanda's compilation: match of data to Poisson curve

Although there are at least two major features, one of which - that in the ninth century AD - is well defined enough, with sufficiently clearly defined start and end points, that it may readily be separated and removed from the record, inspection of the plot shows that the remainder of the data is much too variable for it ever to be approximated by a Poisson curve. Figure 6.15, which shows the data with the 2σ and 3σ boundaries, shows that only these two are of sufficient size to be considered outliers.

It should be noted that the Japanese plot does not show any sign of reflecting the major peaks in either the Chinese or Korean record, and that its peak in the second half of the ninth century is itself not seen in the contemporary Chinese record.

Figure 6.16 compares the frequencies of records of the two different phenomena in Kanda's work.

It is interesting to note, in comparing the two, that it is the lunar and planetary data that display the greater level of variation overall, where no large variation can be anything other than a data artefact. This may be due to such events having greater astrological significance, but the greater size of the lunar and planetary

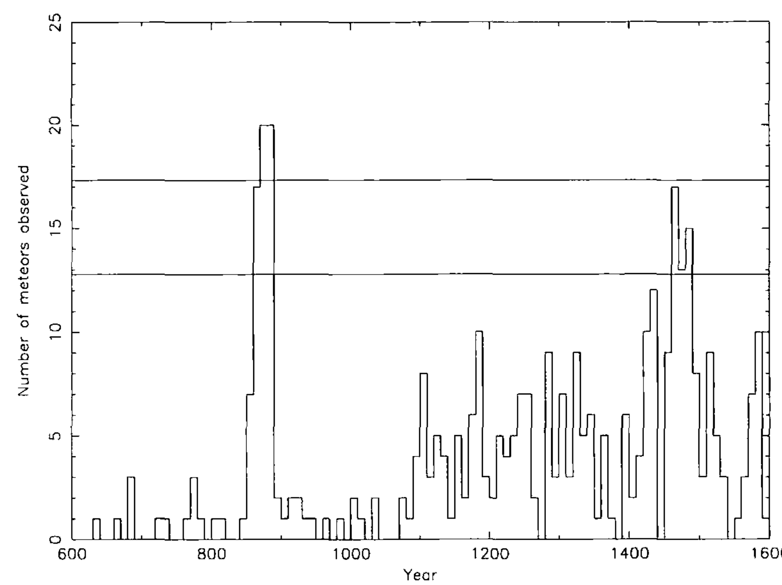

Figure 6.15: Frequency of single meteor records present in Kanda's compilation: plot with standard deviation lines

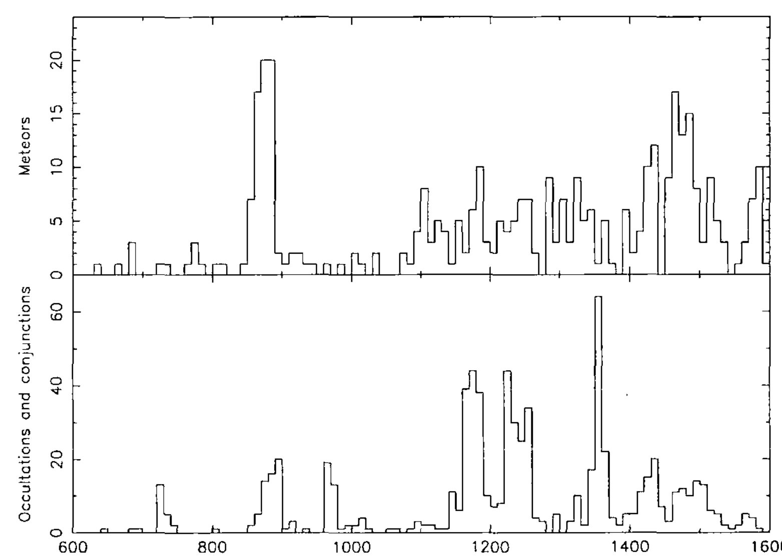

Figure 6.16: Frequency of meteor records compared to that of lunar occultations and planetary conjunctions present in Kanda's compilation; bin size is 10 years.

dataset is likely to be the primary cause; with the smaller number of Japanese records, any large variation is less well defined. The large peak in the meteor record is (to some extent) mirrored in the larger set, suggesting that artefact-generating factors common to all types of event equally are responsible for its presence. Figure 6.17 shows the ratio between the two.

The match between the two frequency distributions appears good in many places - particularly, as noted, the major, early peak, and for much of the second half of

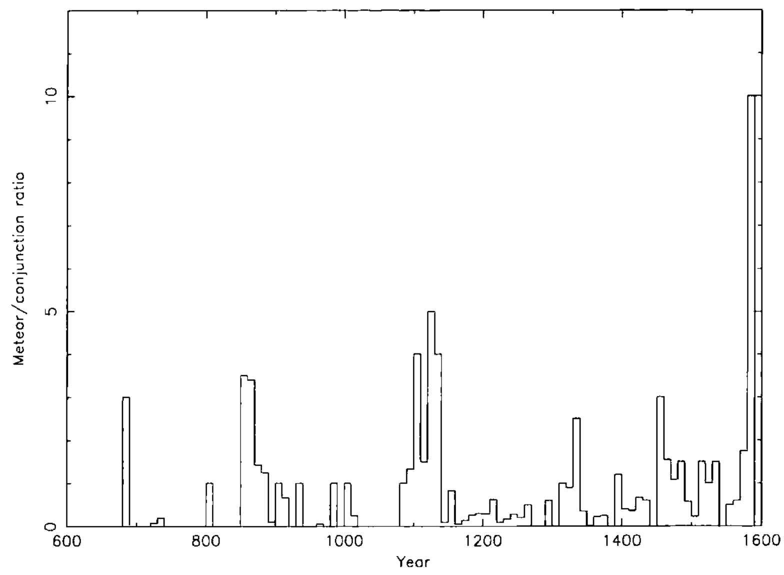

Figure 6.17: The frequency of meteor records divided by that of lunar occultations and planetary conjunctions in Kanda's compilation; bin size is 10 years.

the record. There are places where the two are not particularly close, however; they are far from being a perfect match.

A further work is worthy of mention at this point. Ichiro Hasegawa's catalogue of 'daytime fireballs' - that is, very bright meteors seen during the day (Hasegawa 1997) draws on meteor records from China and Japan; his sources are the Beijing catalogue and Kanda's compilation respectively. These are therefore a particular subset of the events examined above. Overall, the long term variation in the number of such events is similar to that for meteors as a whole in both countries.

6.5 Summary

The analysis of meteor records from these three sources, and their comparison against each other and against the corresponding lunar and planetary data from the same source, leads to the following conclusions:

(a) that the amount of variation seen in the Chinese data set is vast, and that seen in those from Korea and Japan, whilst less extreme, is still large. The deviation from the Poisson curve for which the only variation is random is much larger than that for the cometary data in China and Korea, and comparable in the case of the Japanese data.

(b) that the variations in the Chinese and Korean data sets do not match up at all, and are due to data artefacts, rather than intrinsic variations.

(c) that the first major peak in the Chinese distribution, by process of elimination, arises from data artefacts due to a combination of a variation in the number of records being made as a whole, changing bias towards observing and recording different types of event, and changing probability that a record survives due to the changing publication of contemporary compilations.

(d) that the two major peaks in the Korean distribution arise in the same way, except that the publication of compilations is not a factor, and that there is strong evidence from the comparison with the lunar and planetary data that overall changes in the number of astronomical records, common to both types of event, are dominant until around AD1200.

(e) that the remaining features of the Chinese and Korean data arise in the same way as the peaks in each distribution, except that, in the case of decreases in frequency, the destruction of records may also be a factor.

(f) that the variations in the Japanese data set do not match up with those seen in the other two, and are due to data artefacts.

(g) that the features of the Japanese data set arise from data artefacts due to much the same factors as for the Chinese data set, except that an extra factor - that of variation of the number of active observing sites - is present.

(h) that there is some evidence for the effect of an overall variation in the number of events being recorded, but unlike the case of the Korean peaks, this effect is not dominant.

Chapter 7

Solar phenomena

7.1 Introduction

Other than the early cometary and meteor records which have already been examined, the only pre-telescopic astronomical records from East Asia which pertain to a long-term variation whose form is *not* predictable, and which exist in any number, are those of solar phenomena - that is, of sunspots and aurorae. For these, a similar situation to that of comets and meteors exists in the link between the two. Variation in solar activity may be directly measured by the prevalence of sunspots; periods of greater solar activity lead to an increase in the flux of charged particles to the Earth's magnetosphere, leading to more spectacular aurorae, and - significantly - aurorae that may occur at lower geomagnetic latitudes. Variations in the auroral record, though based on the same underlying pattern as that in the sunspot record, are thus subject to more factors (largely due to the behaviour of the Earth's geomagnetic field) than those in the sunspot record; the latter is therefore intrinsically more valuable.

Sunspot and auroral records are somewhat more sparse than those of the phenomena previously examined. Unfortunately, it is the sunspot records which are especially sparse. In examining the recorded frequency of the two phenomena, I shall be making use of the catalogues compiled by K.K.C.Yau and F.R.Stephenson (that pertaining to auroral observations also with D.M.Willis), both published relatively recently (Yau et al. 1988, Yau et al. 1995), which may be considered to be the most complete compilations available. These cover records from all three countries; in the case of the catalogue of sunspots, a handful of records from pre-telescopic Vietnam are also covered. The earliest record in each catalogue falls in the second century B.C., with the lists covering the period of time up to 1918 (for the catalogue of sunspots) and 1770 (for that of aurorae).

7.2 Records of sunspots

The number of individual records of sunspots in Yau and Stephenson's catalogue totals only 235, of which 157 fall before AD1600. As noted in the catalogue's introduction, this amounts to a mean frequency of about one per decade, which is extremely low; based on the present day frequency of occurrence sunspots, and the size necessary for a large sunspot or compact group of sunspots to be visible to the naked eye, Yau and Stephenson estimate that the existing sunspot record amounts to around 0.1% of the total number of naked eye sunspots. (The size necessary for naked eye visibility is taken to be a diameter of 1 minute of arc - 500 millionths of the area of the solar disc.)

This figure is extremely low; considerably lower than that for the other phenomena examined. This decrease in observing and recording efficiency is probably mostly due to observations of the phenomenon being sporadic. Sunspots are much less dramatic phenomena than, for example, aurorae or comets, and they are not an everyday occurrence in the way that conjunctions are. It is likely, then, that - unless an observer knows to look for sunspots - only the largest and most obvious of naked eye sunspots are likely to be included in the record.

Figure 7.1 shows the overall variation in the frequency of sunspot records from China, Korea, Japan and Vietnam. (Of these, 195 are from Chinese sources, 39 from Korea, 3 from Vietnam, and 1 from Japan; 3 events are recorded in both China and Korea.)

The pattern of observation is, as noted, extremely sporadic, with large periods of time - particularly in the earlier sections, before extensive astronomical records were kept in Korea - entirely lacking in events. There is a large amount of variation throughout, with several obvious peaks and one spike in the second half of the fourteenth century AD. The sparsity of the data makes it impossible to bin the data narrowly enough to discern the 11-year solar cycle - except during the periods of relatively high observing efficiency, as noted above; it may be assumed that it does not noticeably affect the frequency levels on the 50-year bin timescale. It is im-

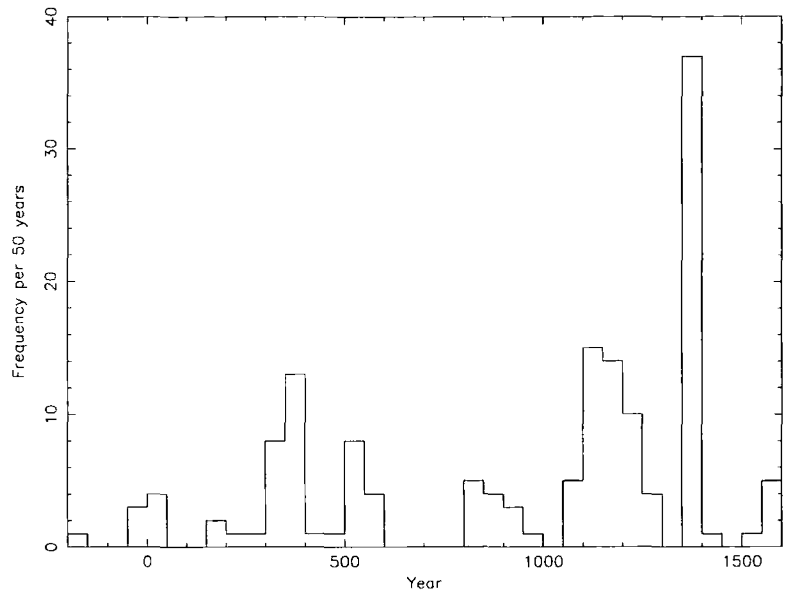

Figure 7.1: Frequency of sunspot records from China, Korea, Vietnam and Japan present in the catalogue of Yau and Stephenson; bin size is 50 years.

portant to see the differences that exist between records from the different sources; Figure 7.2 shows the distribution split into its Chinese and Korean components. For the purposes of this examination, the four records from Japan and Vietnam have been neglected, and the three events recorded simultaneously in both China and Korea are represented in both plots.

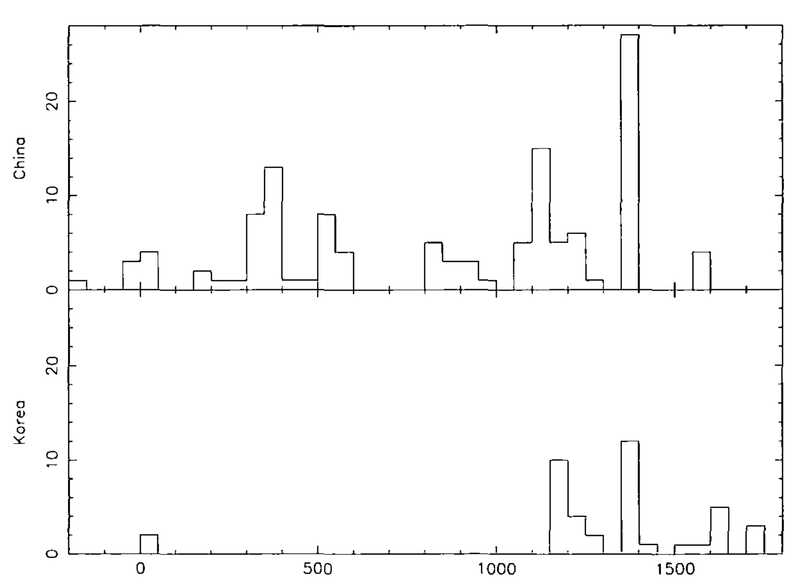

Figure 7.2: Comparative frequency of sunspot records from China and Korea present in the catalogue of Yau and Stephenson; bin size is 50 years.

Interestingly, despite the patchy nature of the sunspot record as a whole, the patterns in the two records more or less complement one another. The large spike (AD1350-1400) seen in the overall record is not a product of records from only one country, being distinct in both sections, and the peak between the eleventh and thirteenth centuries (and the gap between the two) can also be seen in both records. The Spörer minimum (the period of low solar activity between AD1420 and 1530) (Eddy 1977) is also visible.

Given the existence of protracted periods of low solar activity such as this, and the more recent Maunder minimum (Eddy 1976), the fact that there are large variations from century to century in the number of sunspots recorded is to be expected. It may appear surprising - considering the results obtained from the comparisons of the previous chapters - that the similarity between the Chinese and Korean frequency distributions is as clear as it is, particularly when the small size of the data sets is taken into account. Nevertheless, since none of the factors that can give rise to data artefacts hold when a pattern is seen in two different independent records, it must be concluded that - overall - the frequency variations seen in the sunspot record (from AD1150 onwards, from which time forward there are significant numbers of records from both countries in parallel) are to a good extent due to real long term variations in solar activity.

The presence of data artefacts in the sunspot record, however, must be considered. There is no reason to believe that the factors which have been seen to affect records of other phenomena would not apply here. The great two-century gap in the record - from around AD600 to 800 - is seen, to a lesser extent, in the Chinese cometary record, and is likely to correspond to the destruction of data in the An Lu-shan rebellion, when Ch'ang-an was sacked in AD755. Stephenson's comments on the presence of data artefacts in the record (Stephenson 1990) cite cases of the effect which changing astrological bias has had on the record; the fact that over half the total of Chinese sunspot records are found during the reign of only six (of around 150) emperors.

The short period in the second half of the fourteenth century for which large numbers of records exist is worth a closer examination. With 37 records arising from this fifty-year period alone, the potential exists to be able to discern the presence of the 11-year solar cycle. Figure 7.3 shows the data from this period with a suitably small bin size.

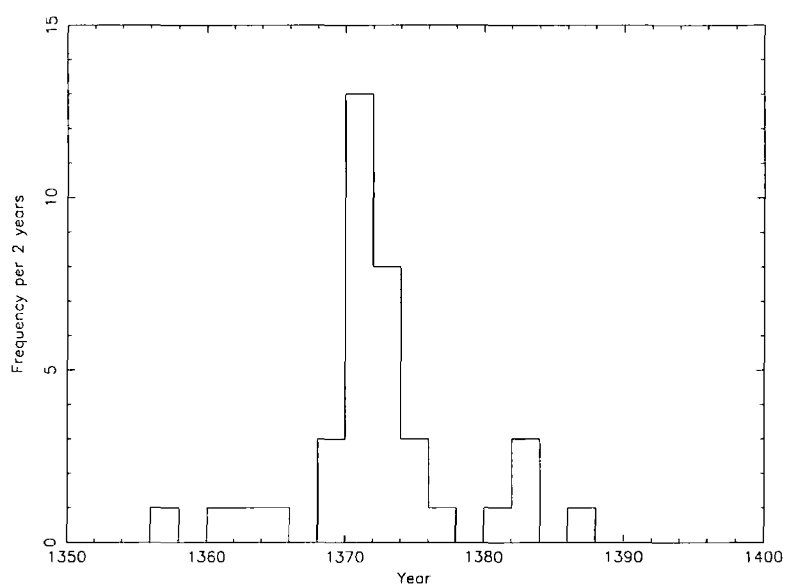

Figure 7.3: Frequency of sunspot records from China, Korea, Vietnam and Japan present in the catalogue of Yau and Stephenson between 1350 and 1400; bin size is 2 years.

The period of intensive observing is relatively short - thirty years at most - but some evidence of the presence of the solar cycle can be seen. Clearly, the amount of observation is changing significantly over this period, and thus it cannot be assumed that the relative heights of the peaks that can be seen are any indication of the amount of solar activity occurring during the peaks of the solar cycle. Nonetheless, the presence of troughs - during which no sunspots would be recorded at all - can be seen, occurring around ten years apart.

This is by far the highest concentration of events in the record; elsewhere it is much more difficult to see any evidence of the presence of the solar cycle. One other period contains sufficient numbers of records, spread over a suitably large amount of time, for the pattern to be visible; this is the twelfth and early thirteenth centuries. Figure 7.4 shows the result of applying a 2-year bin size to the data from this time.

Although the frequencies seen are far lower than those from Figure 7.3, and thus it is much more difficult to reliably match the high and low points to the peaks and troughs of the solar cycle, it can be seen that there are, indeed, regular gaps in the record which would fit with a roughly 11-yearly solar minimum. Since the effect of data artefacts on the record cannot modify the frequency in years when,

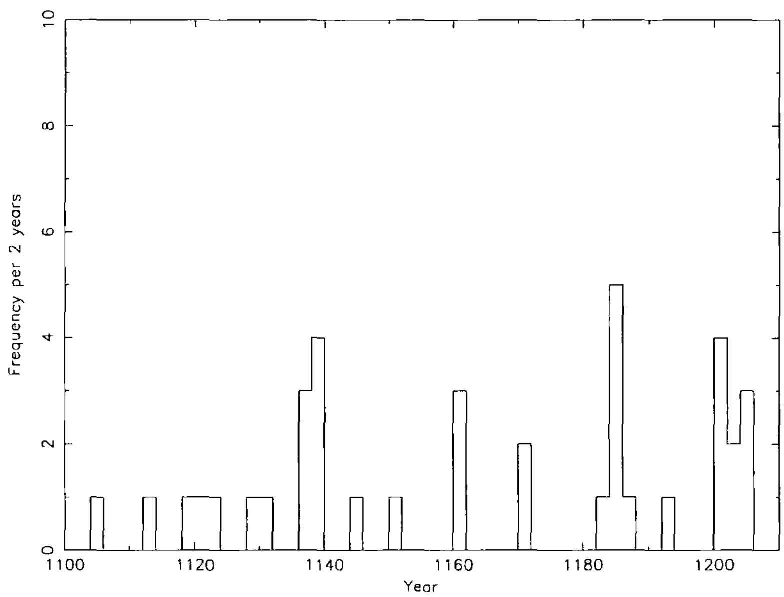

Figure 7.4: Frequency of sunspot records from China, Korea, Vietnam and Japan present in the catalogue of Yau and Stephenson between 1100 and 1210; bin size is 2 years.

by definition, the number of naked eye sunspots is effectively zero, this is to be expected as long as observations are taking place - irrespective of the effects of data artefacts. It must be concluded, therefore, that the evidence points to the presence of a solar cycle of approximately the same length as that seen today during the years 1100-1210 and 1360-1390, but that no conclusions can be drawn for other periods due to lack of records. (A similar conclusion is drawn by Yau (Yau 1987) in conducting a "pseudo-spectral" analysis of the oriental sunspot data, showing a peak around a frequency of 10 years.)

7.3 Records of aurorae

The 1995 catalogue of East Asian auroral records by K.K.C.Yau, F.R.Stephenson, and D.M.Willis is used as the source for the following analysis; as mentioned above, this may be considered to constitute the most complete catalogue of such records available. The records included number, in total, 846, of which 239 are from China, 559 from Korea, and 59 from Japan. Only three of these events were seen in more than one country; two in China and Korea and one in China and Japan. This is an *extremely* low proportion, particularly for such noticeable and spectacular events, and considering the relatively large number of aurorae in the record. Figure 7.5 shows the binned data, and Figure 7.6 compares the contributions to the total from the three different countries.

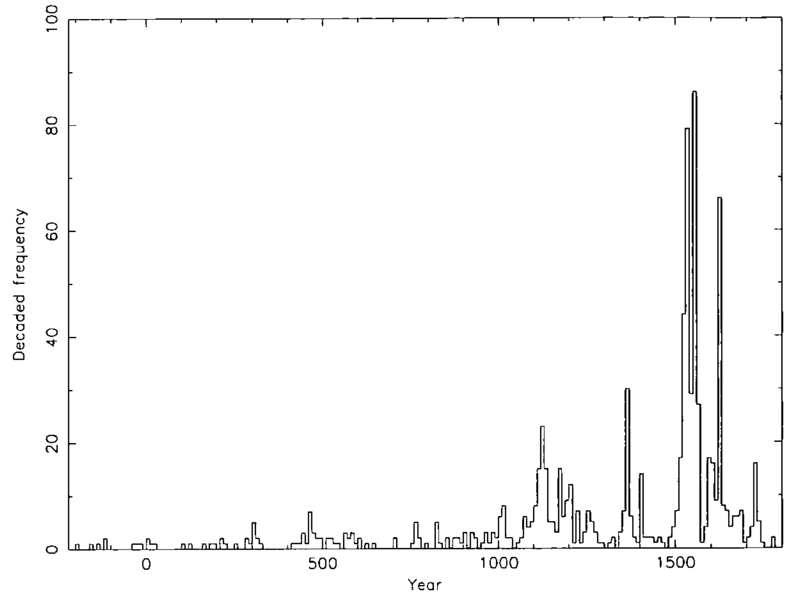

Figure 7.5: Frequency of auroral records from China, Korea and Japan present in the catalogue of Yau, Stephenson and Willis; bin size is 10 years.

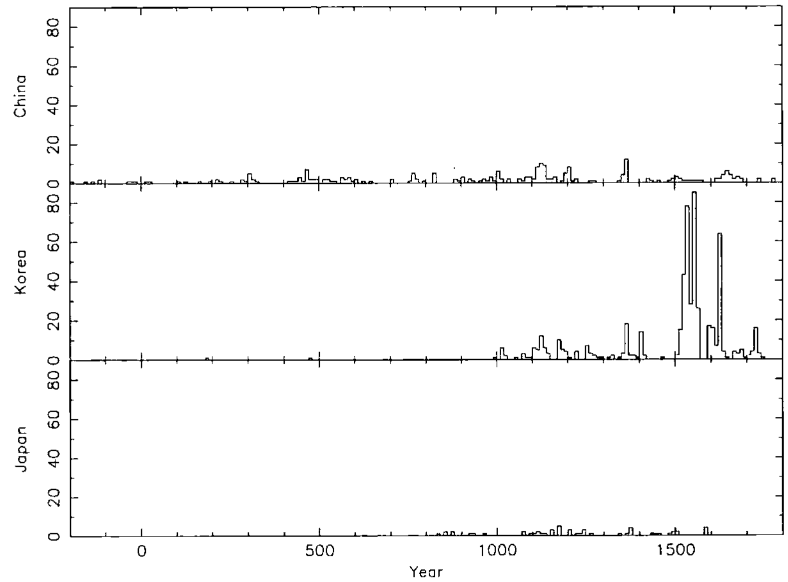

Figure 7.6: Comparative frequency of auroral records from China, Korea and Japan present in the catalogue of Yau, Stephenson and Willis; bin size is 10 years.

The large features of the plot are *entirely* due to the Korean contribution. The excess of aurorae recorded in Korea after AD1500 is not seen in records from the other two countries. Given the sheer number of Korean records from this period, these features must be taken to be due to data artefacts; the Korean capital at Songdo (taken to be the point of observation) was not at a sufficiently high geomagnetic latitude that extensive auroral displays would be visible on a regular basis. Only during periods of exceptional solar activity, occurring once in around ten to twenty years, would such aurorae be seen. Furthermore, the repetitive nature of the Korean records under consideration, in which exactly the same terminology to describe successive events is used ("a vapour like fire" or similar), is suggestive. A paper by D.M.Willis and F.R.Stephenson (Willis et al. 2000) concludes that the excess of Korean records from this time is likely to be due either to the presence of some local phenomenon (that is, sufficiently local to not be visible to astronomers in China or Japan), or that the Korean astronomers were being particularly assiduous in recording faint aurorae. There is also a possibility that the records themselves are spurious. Without more evidence to suggest a local phenomenon - or particularly assiduous observers - it must be considered that the case where the records are spurious is the more likely. (Less numerous cases of a number of nearly identical records appearing close together do occur in *Koryŏ-sa* ; for instance, in the reign of the last king of the dynasty, where no less than nine sightings of Venus in daytime are recorded within the space of four months.)

In previous periods, the comparative frequencies of auroral records are still of use. Figure 7.7 shows the Chinese and Korean data again (that from Japan being too sparse to be particularly useful), excluding the post-1500 data.

When considering only this section of the record (that is, AD1000-1500, for which parallel data exists) the most striking thing is that the major features in each case *are* seen in both the Chinese and Korean records. Furthermore - as far as can be ascertained bearing in mind the low level of recording - they seem to be in general agreement with the features seen during the same period in the sunspot record! In particular, the largest feature of the auroral record - the spike seen in both countries towards the end of the fourteenth century - occurs alongside the great surge in sunspot records seen in the previous section.

It is probable, for this period (AD1000-1500) that the frequency of auroral records appears to be significantly affected by the true frequency of events, and that the high frequency features - particularly that in the mid to late fourteenth

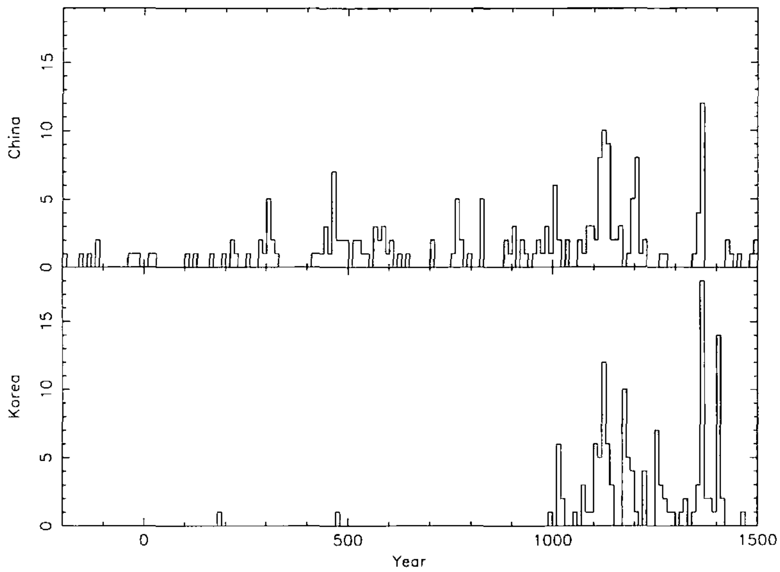

Figure 7.7: Comparative frequency of auroral records from China and Korea present in the catalogue of Yau, Stephenson and Willis, excluding records later than AD1500; bin size is 10 years.

century - correspond to periods of high solar activity. The size of the differences between the Chinese and Korean plots may be taken as an indication of the effect which the presence of data artefacts has on the data. (It should be noted that, since a sizeable real variation in the frequency of the event is present, analysis on the closeness of the data to a sample of a flat distribution is not appropriate.)

7.4 Summary

The sunspot and auroral records from East Asia are exceptional in displaying clear, real variations in the frequency of the phenomena being observed. Whether this is due to a relatively low level of data artifice, or merely that the variability of solar activity is the strongest astronomical signal available for naked eye astronomers to record - or both - is debatable; the next chapter will compare the frequencies for all the phenomena examined, and attempt to identify probable periods of data artifice in each country. The following conclusions are reached:

(a) that the frequency variation of sunspot records is largely due to a real variation in the solar activity, for the period AD1150-1600 (the portion of the pre-telescopic period for which parallel records exist);

(b) that there is evidence for the presence of the 11-year solar cycle during the periods 1100-1210 and 1360-1390, with too few records having been made during other periods to be able to draw any conclusions;

(c) that the parallel auroral records for the period 1000-1500 support the long-term variations in solar activity seen in the sunspot record, and are also largely due to real variations in solar activity;

(d) that the excess of auroral records from Korea after AD1500 is likely, although not certain, to be due to data artifice.

Chapter 8 Data artifice

8.1 Introduction

The investigations of the previous chapters indicate that the presence of data artefacts in the East Asian astronomical record is extremely strong. The dominance of data artefacts in the varying frequency of meteor, cometary and planetary conjunction records is such that any underlying pattern in the frequency of occurrence of the observed phenomena cannot be discerned. However, this is not the case for sunspots and aurorae.

So far, the criterion for identifying a feature in the plot of the frequency of records from a specific country in East Asia has largely been that the feature is not mirrored in equivalent plots for records from either of the other two countries. As an example, the comparison given in Chapter 6 - between the conjunction and meteor record frequencies in *Koryŏ-sa* - shows another approach, which indicates the presence of data artefacts without a parallel record. If a feature is mirrored in the frequencies of independent, unrelated events in records taken from the same source, it is likely that at least some level of data artifice is present. The above example is unusual in the clarity of this mirroring; it indicates that only data artefacts affecting different types of record equally are significant for the period in question.

Frequency variations may be divided up into three groupings, which may be separated out to indicate which factors are present. Again, these are noted in Chapter 6.

(a) *Variations which affect different types of event equally in one country*

These consist of:

(i) Overall variation in the amount of observing taking place.

(ii) Variation in the probability that a record will survive, due to its inclusion in secondary works.

(iii) Loss of information by the destruction of records.

(b) *Variations which affect the same event equally in different countries*

These must be caused by a real variation in the frequency of the event. The records of each country were made completely independently, with one exception; the astronomical material in the Korean *Samguk Sagi*, before around AD800, is largely copied from Chinese sources (Stephenson 1998). These latter records are, however, few in number, and may be neglected.

(c) *Variations which are unique to records of one type in one country*

These are caused by bias towards observing different types of event.

It is therefore data artefacts of type A that can be identified by comparing records of unrelated events from the same source. Those of type C are indicated when there is little similarity both across countries and across types of event.

In order to be able to identify those of type A, therefore, it is necessary to compare frequencies across all the types of record that are available, for each country in turn. In order to examine the full range of events that are available, the eclipse records must first be accessed.

8.2 East Asian eclipse records

The catalogue used for the purposes of this investigation is that compiled by N. Foley (Foley 1989) from the Chinese dynastic histories and from the Korean chronicles *Koryŏ-sa* and *Chung-bo Munhon Pigo* . There are thus no Japanese records included; in addition, the Foley catalogue is concerned only with *solar* eclipses.

In her catalogue, records are compiled from throughout the pre-telescopic period, the latest included being from AD1621. The country of origin is noted in each entry (with different parts of China noted for those recorded during the Three Kingdoms and Nan-pei periods); multiple records of the same eclipse are treated as different entries, but in every case the day of observation is specified. Thus, although the catalogue contains some 971 separate entries, only 753 separate events are recorded. There is a substantial amount of overlap, with 709 being recorded in China and 196 in Korea. Such overlap is probably largely due to both Chinese and Korean astronomers predicting eclipses and their knowing when to watch for them (often the same or similar eclipse tables were used in both countries). Figure 8.1 shows the overall variation in frequency; Figure 8.2 compares the separate frequencies from the two countries.

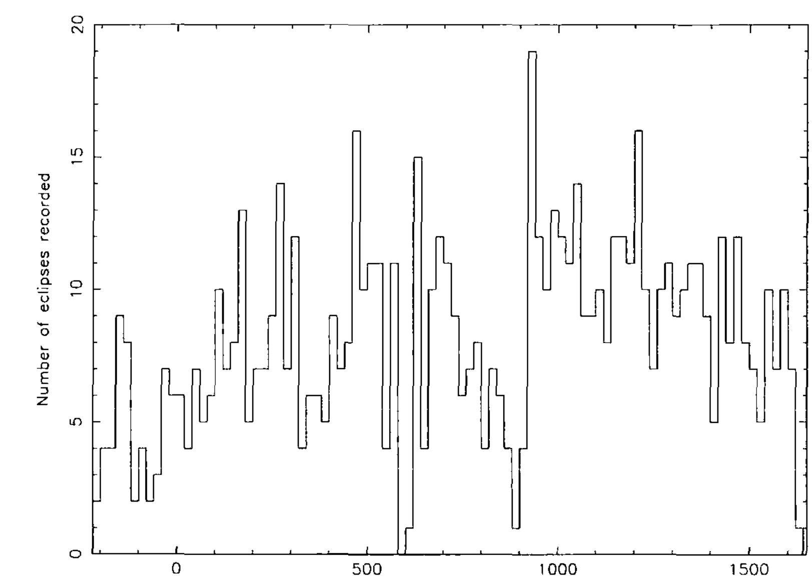

Figure 8.1: Frequency of solar eclipse records from both China and Korea present in the catalogue of Foley; bin size is 20 years.

It is interesting to note that the level of variation in both graphs is relatively small. The most significant feature seen is the marked drop in the Chinese frequency around AD850-900, after which the number of eclipses being recorded quickly returns to a high level. As noted in Foley's work, the peasant rebellion which took Ch'ang-an in AD880, and the likely resulting loss of records, is the most probable cause of this. The An Lu-shan rebellion, a century earlier, and previous times of instability (Wang Mang's rule, for example) do not appear to have had any major

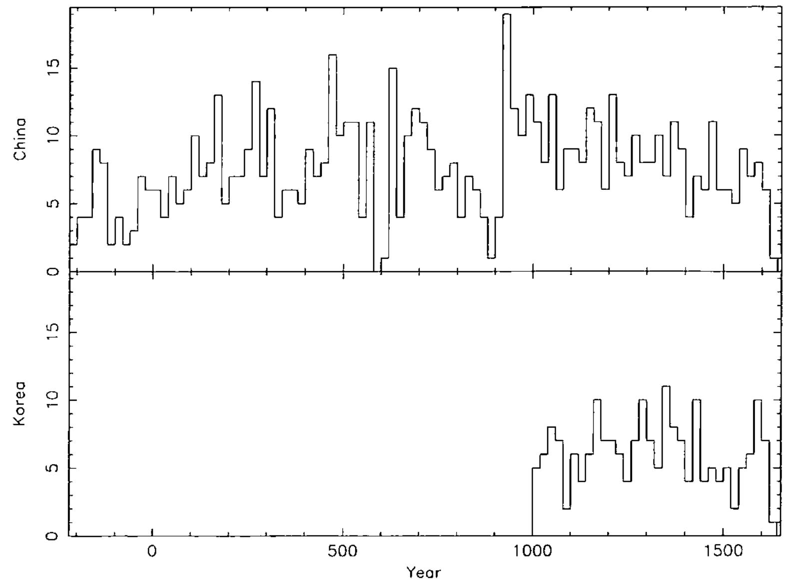

Figure 8.2: Comparative frequency of solar eclipse records from China and Korea present in the catalogue of Foley; bin size is 20 years.

effect on the continuity of the eclipse record. In the Korean record, there are no obvious large features at all.

Previous analysis of the Korean eclipse records (Stephenson 1998) has yielded relatively high figures for the percentage efficiency - particularly with respect to those for occultations and conjunctions. The difference is very likely to be in part due to the practice of eclipse prediction, for which much the same calculation method was used in each of the three countries. The astrological significance in which eclipses would have been held is also a likely factor here.

It should be remembered, as noted earlier, that the eclipse record cannot be used as an indication of the efficiency of early East Asian astronomy. An indeterminate number of the eclipses making up the above set of data may have been predictions rather than observations; certainly there are significant numbers of entries for which Foley notes that no eclipse actually occurred when in fact one was recorded. The proportion of correct predictions to actual observations can only be guessed at.

8.3 Comparisons

8.3.1 China

It is now appropriate to compare the astronomical records of the three countries across types of record. Figure 8.3 displays this comparison for China. The sources used are: for conjunctions and occultations, the dynastic histories of the Sung, Yüan and Ming (based on my own literature searches); for comets and meteors, the Beijing catalogue (Beijing Observatory 1988); for sunspots and aurorae, Yau's catalogues (Yau et al. 1988, Yau et al. 1995); and for eclipses, Foley's catalogue. Note that conjunction and occultation records from before AD960 are not shown.

It is not necessary for a feature to appear in all six plots to be considered a data artefact of type A; indeed, given the existence of data artefacts of type C, such occurrences are unlikely. However, there are several instances of features mirrored between types of event. Note that similarities between the auroral and sunspot records (as examined in the previous chapter) and between cometary and meteor records - at least alone - are not considered strong evidence for the presence of artefacts, due to the similarity between the types.

Firstly, the effect of the destruction of records can be seen. Although the fall of Wang Mang does not appear to have had a widespread effect on the frequencies, the An Lu-shan rebellion in the eighth century AD is the likely cause of the lack of sunspot and auroral records between AD600-800, and the notable lull in meteor records at the same time. The rebellion of 880, as noted above, is likely to be the cause of the drop in eclipse records at that time; similar reductions in frequency are seen in the meteor and auroral records. Finally, there is a significant gap around AD1280-1350, where the sunspot, auroral and meteor records are very low. (The other three sets of records at this time show no significant peaks.) This period occupies most of the Yüan dynasty (1279-1368); it is likely that the upheaval caused by the Mongol conquest of China and the change of administration resulted in records being lost and fewer observations being made.

There are several instances of likely artefacts where peaks are mirrored across the types. These are difficult to determine during the earlier dynasties due to lack of data; it is possible that the clear peak in the meteor record around AD500 is related to that in the auroral record at the same time (particularly since that peak is not seen in the sunspot record), but this cannot be ascertained. A much more likely candidate is the peak that occurs in the first half of the ninth century, which is seen distinctly in the meteor and auroral records and possibly also in the sunspot and cometary data. This does not appear to correspond to any major historical event, however.

The large peak in the conjunction and occultation data, occurring around AD1150-1200, may be mirrored by the spike in the meteor record at the same time; significant surges in the number of sunspots and aurorae are also present earlier in the century, but given the time difference it is likely that these are either due to a separate artefact or a real variation in solar activity.

There is virtually no evidence in favour of the two great peaks in the meteor record having any significant reflection in the frequencies of other types of event. It must be concluded that these features are due to data artefacts of type C.

8.3.2 Korea

Figure 8.4 shows the comparison graph for the Korean data. Here the sources are: for conjunctions and occultations, and for meteors, *Koryŏ-sa* ; for comets, Ho Peng Yoke's first catalogue; for sunspots and aurorae, Yau's catalogues; and for eclipses, Foley's catalogue.

Due to the incompleteness of the record, it is difficult to identify the presence of data artefacts that arise during the Yi dynasty. A comprehensive search of the *Choson Wangjo Sillok* is needed to provide the missing data for conjunctions, occultations and meteors. Several conclusions can still be drawn, however.

The first half of the thirteenth century clearly shows the destructive effect of the Mongol invasion of Korea. The records of conjunctions and occultations, meteors, and aurorae mirror each other closely for this period. It is unfortunate that records of comets and sunspots are so sparse (although the complete lack of the latter would seem to support the above reasoning). Eclipse records do not strongly mirror the pattern seen in the other types of record.

The variations in frequency during the twelfth century examined earlier, in the conjunction/occultation and meteor records, can also be seen to be mirrored in the auroral record (although the small number of records present during this period makes the pattern somewhat unclear). Again, the cometary and sunspot records are inconclusive at this time, and there is no sign of any marked variation in the recorded eclipse frequency.

The only other large feature that can be considered particularly significant is the glut of auroral records beginning after AD1500, which dwarfs the number of aurorae seen before that time. There is no evidence that the feature is mirrored between types of event, but since it has not been possible to extract the conjunction/occultation and meteor records from *Choson Wangjo Sillok* , the type of data artefact present - A or C - cannot be determined.

8.3.3 Japan

Due to the difficulty in obtaining comprehensive astronomical data from pre-telescopic Japan, this study is limited to comparing the frequencies of types of event for which catalogues are already available. The sources used are thus: for conjunctions and occultations, and for meteors, Kanda's catalogue; for comets, Ho Peng Yoke's first catalogue (note, however, that this draws upon data from Kanda, and from other sources); and for aurorae, Yau's catalogue. Figure 8.5 compares the data.

It might be expected, since the data from Japan is drawn from numerous different sources rather than one central chronicle, that the effect of the destruction of records would be less catastrophic than was the case for China or Korea. One of the effects of having no continuous centralised record is to create the possibility that, at any one time, no observations were being made. It thus cannot be stated that periods from which few records of any type date are due to record destruction rather than due to lack of observers. (The early eleventh century is perhaps the most visible of these sparse periods.)

The presence of surges in frequency due to data artefacts of type A can be seen in the Japanese data, however. Firstly, the large peak in the meteor data from AD850-900 is reflected in the conjunction/occultation plot, and (possibly) also in the auroral plot. A peak in the conjunction/occultation plot between AD1160-90 can be seen in the meteor and auroral plots; later the spike in the conjunction frequency may also be mirrored in the auroral plot. This last comparison cannot be considered a particularly strong indication, however, simply because of the low number of aurorae recorded in Japan.

8.4 Summary

It has to be taken into consideration that there is no certain way of identifying features that appear to be mirroring each other as such. Therefore, it can only be concluded that it is probable, or possible, that the relevant periods of history in each country discussed above produced records that contain appreciable levels of type A data artefacts. The following are thus concluded.

(a) The periods of Chinese history for which it is *probable* that the astronomical records contain appreciable levels of type A data artefacts are AD600-800, 850-900, and 1280-1350, all of which show a fall in recorded frequency, and all of which correspond to periods of political instability.

(b) The periods of Chinese history for which the presence of such artefacts are *possible* are around AD500 and AD1150-1200, but the peaks seen during these periods may also be attributed to type C data artefacts.

(c) The huge peaks in the Chinese meteor record (11th and 14th centuries) are very probably data artefacts of type C.

(d) The periods of Korean history for which it is *probable* that type A data artefacts are present are 1200-1250 (through the loss of records to the Mongol invasion) and 1100-1200.

(e) No conclusions can be drawn about the type of data artefact producing the high frequency of aurorae recorded in Korean history from 1500 onwards, due to a lack of comparable data. It is questionable whether these are actual aurorae or some other phenomenon.

(f) The periods of Japanese history for which it is *probable* that type A data artefacts are present are AD850-900 and 1160-90. A *possible* artefact occurs in 1340-70.

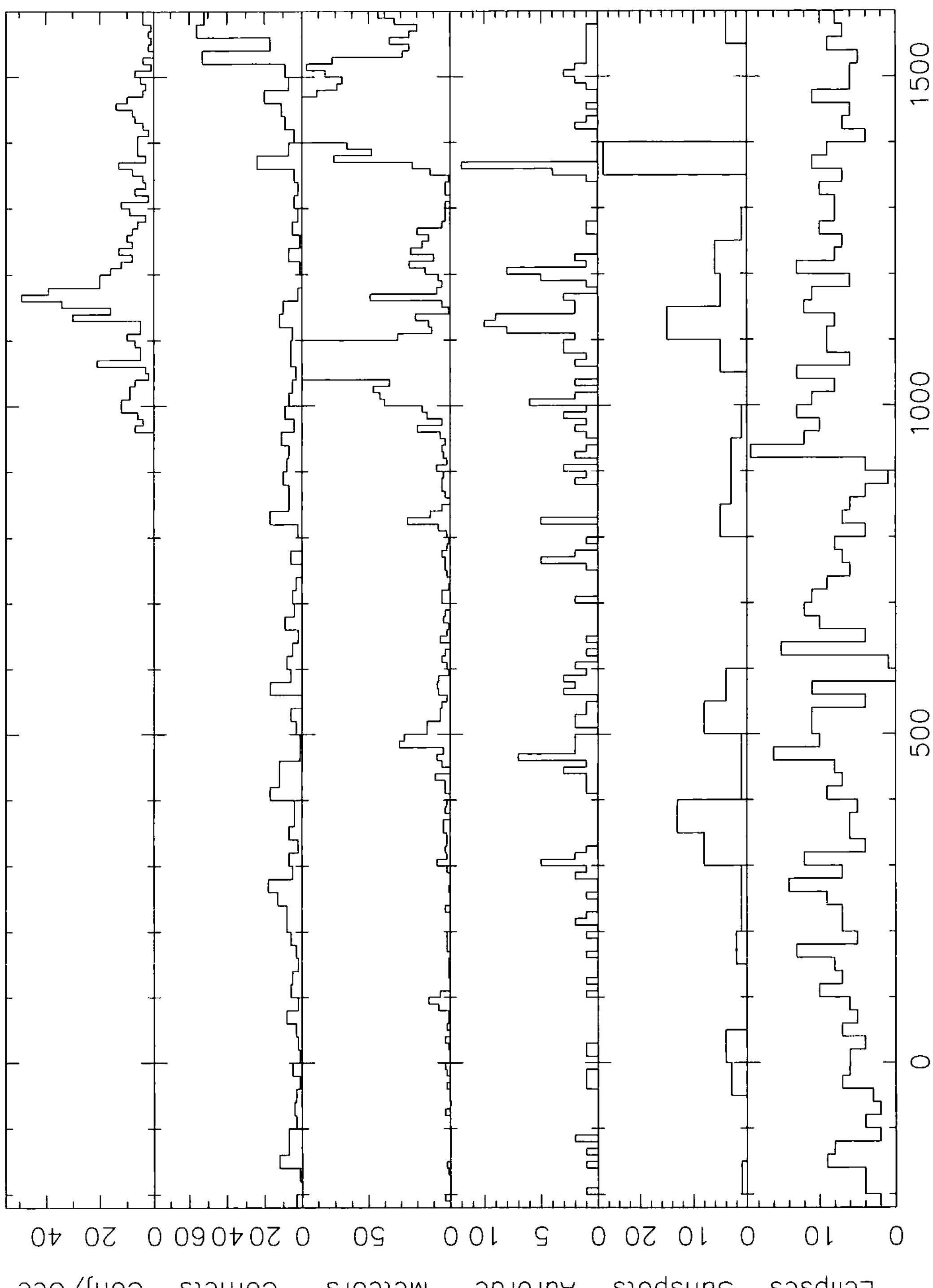

Figure 8.3: Comparative frequency of all types of record from China. Bin size is 10 years (conjunctions and occultations, meteors, aurorae), 20 years (comets, eclipses), and 50 years (sunspots).

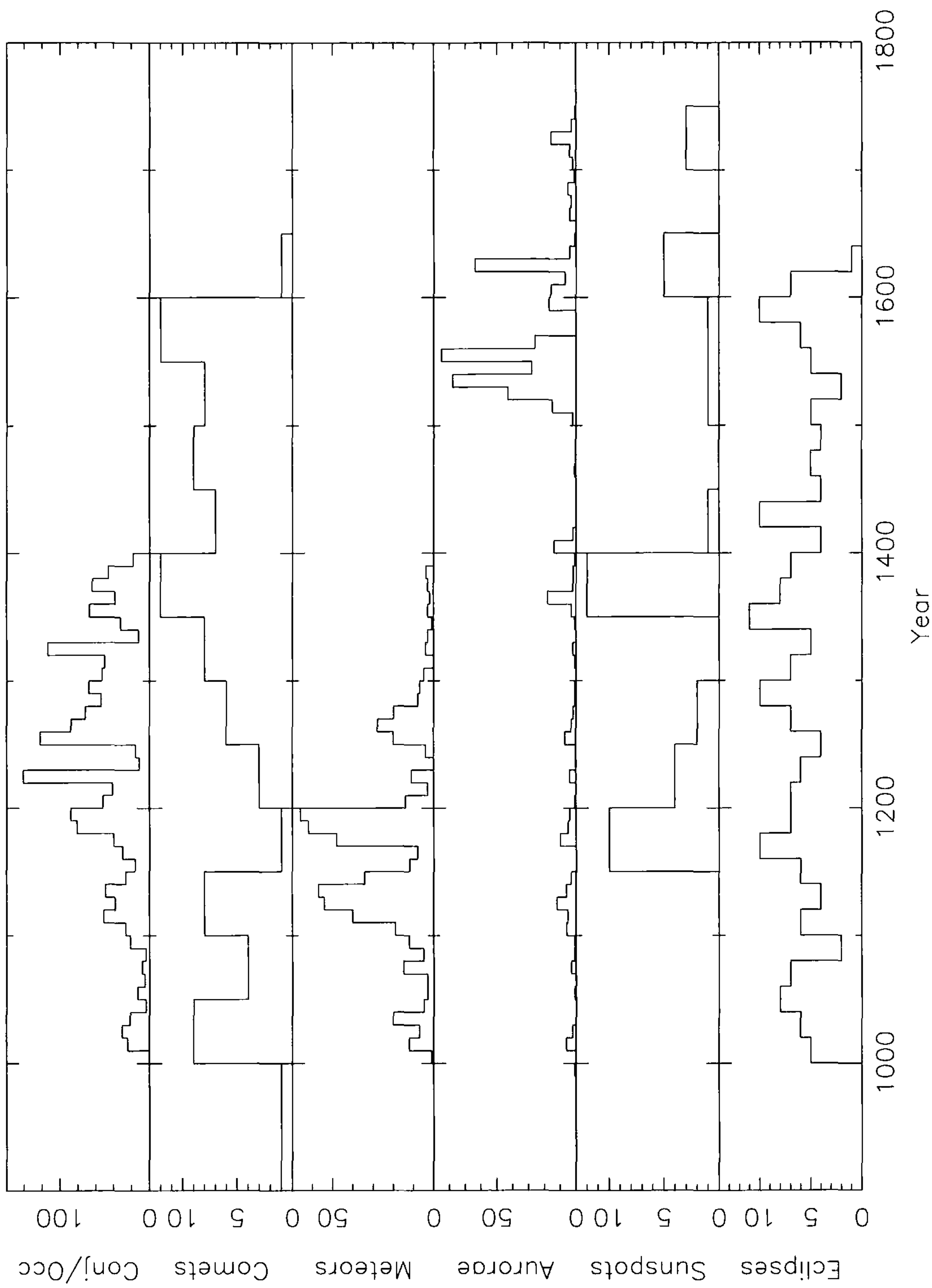

Figure 8.4: Comparative frequency of all types of record from Korea. Bin size is 10 years (conjunctions and occultations, meteors, aurorae), 20 years (eclipses), and 50 years (comets, sunspots).

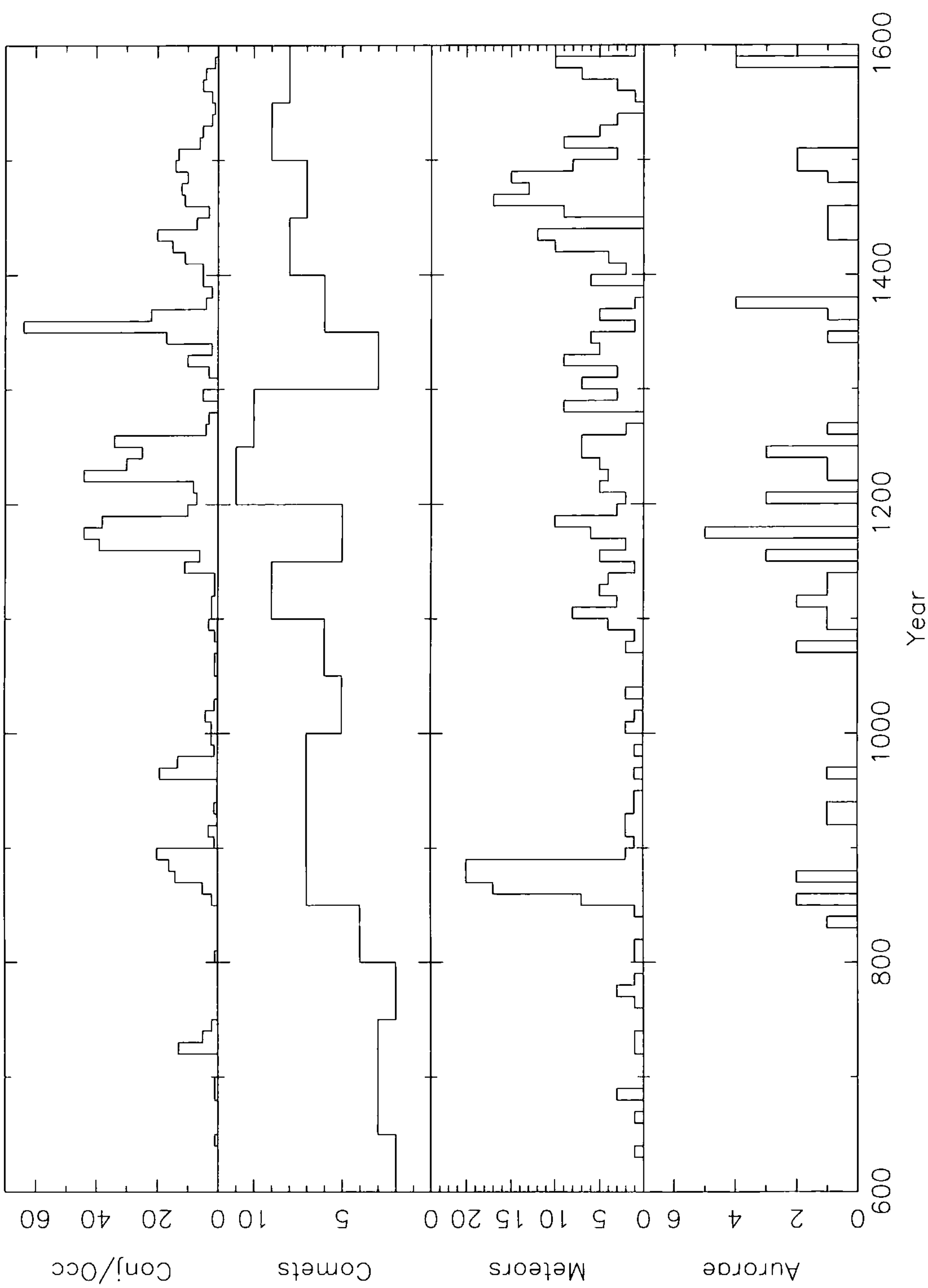

Figure 8.5: Comparative frequency of all types of record from Japan. Bin size is 10 years (conjunctions and occultations, meteors, aurorae) and 50 years (comets).

Chapter 9

Conclusions

9.1 Findings

In my earlier chapters 3 to 8, I have examined the major types of astronomical phenomenon that are recorded in significant numbers in early East Asian records. Here I shall draw together the more important findings of each study and consider the overall implications for the use of these records - as a whole - as sources of astronomical information. I shall also briefly examine other recent work which touches on the frequency patterns studied here.

Perhaps the most significant finding of this study has been that, as regards the records of comets, meteors, occultations and conjunctions, the patterns that are seen are overwhelmingly due to data artefacts. There is very little similarity between frequency variations of the same phenomenon in the different countries of East Asia (China, Japan and Korea); the huge variations seen in records of occultations and conjunctions and of meteors only ever appear in one of the three countries' chronicles. Analysis shows, however, that the variations for all of these phenomena cannot be ascribed to statistical fluctuations; they represent changes in the efficiency of the process of observation, recording and preservation, specific to each country. These may be categorised as follows:

Type A Data Artefacts are those which affect multiple types of phenomenon recorded in the same country, and include both variations in the amount of observing taking place and drops in frequency due to the destruction of records. Such destruction is particularly visible in the cometary and eclipse records. Its presence in the former is perhaps due to the lack of large artefacts of type C, and in the latter due to the fact that, with eclipses being systematically predicted for much of the pre-telescopic period in all three countries, only preservation-related data artefacts can apply.

Type C Data Artefacts are those which only affect one type of phenomenon in one country, due to changing bias towards the observation of such events.

Any pattern which is seen in the records of more than one country must be of astronomical origin and not a data artefact; these are designated type B.

The cross-phenomenon comparison carried out in chapter 8, using the above definitions, yielded several periods in the histories of China, Korea and Japan during which type A data artefacts are probable or possible (the latter here indicated by brackets):

China: (around AD500), 600-800, 850-900, 1280-1350, (1150-1200)
Korea: AD1100-1250
Japan: AD850-900, 1160-90, (1340-70)

These periods account for the majority of the most prominent variations in all phenomena and countries. The most significant of those not covered are the large peaks in the Chinese meteor record, which are data artefacts of type C.

The variations in the auroral and sunspot records, although relatively sparse compared to those of other phenomena, appear to be largely due to real variations in solar activity. Records from China and Korea - in both cases - show matching variations in frequency between AD1000-1500, and during this period the overall sunspot and auroral patterns match each other. Events recorded during the second half of the fourteenth century AD denote a period of increased solar activity; this feature appears in the records of both phenomena in both countries. There is no significant disagreement between the frequencies recorded in the two countries, or between those for the two phenomena, during these 500 years.

Analysis of the occultation and conjunction record reveals the percentage efficiency of observation of East Asian astronomers with regards to this phenomenon. This is very low - in particular, 3% for the Chin dynasty in China, and 4% for the Koryo in Korea - but very variable, ranging from around 20% of conjunctions being recorded in a decade to none at all. (The only other phenomenon for which such analysis is possible is eclipses. Records of these generally have a much higher efficiency. (Stephenson 1998)) Such low figures for one phenomenon suggest that similar low efficiencies may apply for others; this certainly seems likely in the case of auroral and sunspot records, where the data is extremely sporadic. Whether the efficiencies of recording comets and meteors are similarly low, however, is unknown, since the numbers cannot be predicted with any confidence.

9.2 Implications for other work

A relatively recent work dealing with the frequencies of astronomical events, a book entitled *The Origin of Comets* (Bailey et al. 1990) considers records from East Asia covering the pre-telescopic period (up to AD1600). This work examines Chinese pre-telescopic records of comets, single meteors, and meteor showers, for which the catalogues of Ho (Ho 1962), Biot (Biot 1848), and Tian-shan (Tian-shan 1977) are used. The authors contrast the relatively flat cometary record with the great increase seen in Biot's meteor catalogue. Biot's work, which is derived from the astronomical events recorded in *Wen-hsien T'oung-k'ao* , shows the first great peak in the Chinese meteor record (during the eleventh century AD) but not the second (during the 14th century). The authors suggest that the great increase seen was caused by the gradual breaking up of a body in the Taurid meteor stream. It is suggested that a greatly enhanced meteor flux would lead to greater levels of observation of meteors, enhancing the size of the peak.

Both this peak and the later one not covered by Biot's catalogue are clearly data artefacts of type C, there being no evidence at all of their presence in the Korean or Japanese records. The possibility that Korean astronomers, in particular, could miss a real astronomical event of the size implied by the Chinese data must be discounted; regular observation during the Koryŏ dynasty took place consistently during both the 11th and 14th centuries AD, and even the unsystematic Japanese records may be expected to have reflected such an event to some extent if it were indeed significant.

Bailey et al. put forward the view that the meteor flux varied dramatically in the pre-telescopic period, and suggest that the variations in the recorded frequency are indicative of this. Although the latter is not the case, the present study does not imply that there are no significant variations in the pre-telescopic meteor or cometary flux; however, any such signal contained within East Asian records of these phenomena is so masked by data artefacts as to be invisible.

An examination by Stephenson of recorded evidence for solar variability (Stephenson 1987) notes the high levels of variation seen in *Koryŏ-sa* (Yau 1988) for the total frequency of all types of phenomena (lunar and planetary data, as well as comets, meteors, and solar events), pointing out that most types of event would not be expected to vary significantly. Stephenson's paper is otherwise concerned with the frequencies of observation of solar phenomena, which have generally benefitted from a greater level of attention than those in other areas (Foley 1989, Yau et al. 1988, Yau et al. 1995).

9.3 Concluding remarks

The fundamental limitation on the analysis of frequency variations in early astronomical records is, of course, lack of data. Reasonable allowances can be and have been made above for the fact that the data available are relatively low in number. Thus, while a positive result (such as, in particular, the above indications of the presence of type A and type C data artefacts, or the agreement between the sunspot and auroral records) is important, we lack the ability to improve on the observations; such results are limited by the nature of the early records from which they are derived. Results may be obtained over some time periods for some types of observation. (This is most starkly evident in the sunspot and auroral records, where the periods of time for which data exist show strong evidence for a real variation in solar activity, but where for most of the pre-telescopic period the number of records is tiny.)

Therefore, it would be possible to expand this study by the inclusion of a number of sources which, due to time and accessibility constraints, are not represented here. Although drawn upon by a number of secondary sources, the *Choson Wangjo*

Sillok has not been consulted by me directly. As a consequence, records of conjunctions and occultations and of meteors from Korea are absent from the analysis from AD1392 onwards. As *sillok* data for these two phenomena would give strong indications as to the nature of the great surge in Korean auroral records from 1500 onwards, such an addition would be extremely useful. Elsewhere, a consultation of the dynastic histories prior to the Sung for records of occultations and conjunctions would allow a complete comparison of the records of all six phenomena examined in chapter 8 over the 1800-year Chinese pre-telescopic period for which records exist.

Much previous work has tended to focus on the study of individual astronomical records. Applications of early records, due to their sparse nature, are most readily available when a single observation is able to produce results (for example, records of galactic supernovae, total solar eclipses with a time sufficiently well determined to yield information on the changing speed of Earth's rotation, or long-period comets). Consideration of patterns of frequency as a whole, and of their implications, is in comparison a far less well explored area. In undertaking a broader study, I hope to have achieved three things. Firstly, in highlighting the low and variable percentage efficiency of observation of early East Asian astronomers - in the case for which such analysis is possible - the prospect of much larger data artefacts is raised.

Secondly, it is demonstrated that such artefacts can be located, positively identified and - to some extent - classified. It may thus be possible, using such data and detailed historical background, to determine the causes of many data artefacts; those due to the destruction of records being only the most obvious of these. Finally, the clear existence of a real variation in *solar activity*, as derived from early records, shows that the presence of data artefacts is by no means ubiquitous, and that the sources are sometimes able to lead to important astronomical findings in their own right.

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Appendix A
Meteors in Koryŏ-sa

A.1 Introduction

The following is a rendition into English which I have undertaken of part of the astronomical treatise (chapters 47 to 49) of *Koryŏ-sa* . These chapters list a large number of astronomical observations of all kinds from approximately AD1000 to 1392. The work, the earliest version of which was written in 1395, is based upon the *sillok* of the Koryŏ dynasty, which no longer exist. The final version of *Koryŏ-sa* was compiled between 1445 and 1451 under the direction of Chŏng In-ji. Here I have selected observations of meteors, which are indicated in the treatise by the standard phrase *liu xing*, flowing star.

Dates used in the treatise are expressed in the Chinese lunar calendar (as adopted in China), but the year is numbered according to the reign of the Korean king. I have also provided the date in the Julian calendar in each case. The beginning of the Chinese year falls in the first two months of the Julian year. For the sake of convenience, I have grouped the records by Julian year.

Koryŏ-sa uses the Chinese sexagenary cycle of days throughout. Each individual day in the cycle is denoted by a combination of one of the ten celestial stems (*jia*, *yi*, *bing*, *ding*, *wu*, *ji*, *geng*, *xin*, *ren* and *kui*) and one of the twelve terrestrial branches (*zi*, *chou*, *yin*, *mao*, *chen*, *si*, *wu*, *wei*, *shen*, *you*, *xu* and *hai*). The cycle thus starts on a *jia-zi* day, cycling through both stems and branches simultaneously (i.e., the second day of the cycle is a *yi-chou* day), and is therefore sixty days long.

The classical Chinese of *Koryŏ-sa* contains no grammar or plurality; in order to provide an English version I have had to make certain assumptions about the structure of each record. Due to the formal way in which the records are set out, containing many standardisations (for example, each record always starts with the date, usually followed by the standard phrase *liu xing*), it has been possible to set out a consistent interpretation of the text. The occasional ambiguities are noted, and occur surprisingly rarely.

Where it is clearer to retain the Chinese phrases (the names of asterisms, for example) I have chosen to use the pinyin system of romanisation (note that elsewhere in this work the Wade-Giles system is instead adopted). The one exception to this is in the names of the Korean kings, for which the McCune-Reischauer system is retained. There are also some cases where it is debatable whether it is preferable to include the pinyin or English translation. This occurs primarily where records describe the apparent size of a meteor; *"it was as large as a bowl"*, for instance. For clarity, the first instance of each description references the dictionary definition. Where the translation makes the original expression unclear, it has generally been left in pinyin. Translations are based on Matthews' Chinese-English dictionary (Matthews 1979).

The objects used to compare the apparent sizes of meteors are listed in Table A.1. It should be noted that there is no way to establish the actual angular sizes of meteors from these, or to ascertain whether these comparisons were systematic. Those for which a translation is given in the table use the English version in the main text. The remainder represent those for which the translation is less clear cut; the translated meaning of each of these are detailed in a footnote at the point at which the term is first used.

bei (cup)	*gua* (melon)	*ji zi* (hen's egg)	*bo*
deng (lamp)	*kuan*	*ju* (torch)	*wan* (bowl)
yu	*fou*	*deng zhan* (lantern)	*pen*
dou	*li* (pear)	*weng*	*niu* (ox)
hu			

Table A.1: Common comparison objects for the sizes of meteors

In addition to this, estimates of the apparent lengths for the tails of meteors are often given in *chi* (Chinese feet). As shown by Kiang(1971), there is an approximate equivalence between the degree and the *chi*. Lengths are occasionally also given in *zhang* or *cun*; ten *cun* equal one *chi*, and ten *chi* equal one *zhang*.

A number of other standard phrases used in *Koryŏ-sa* deserve attention. The use of *you* ("also") at the beginning of a record is an indication that it is part of a larger entry for the night, of which the previous section or sections often do not refer to meteors. A "*gate*" usually refers to a section of sky between two prominent asterisms, but occasionally to part of a single asterism, e.g., an area between two stars.

A few lunar lodges are usually written in shortened form in the treatise. *Qianniu* is often written *Niu*; *Xunü* as *Nü*; *Dongbi* as *Bi*; *Dongjing* as *Jing*; *Yugui* as *Gui*; and *Qixing* as *Xing*.

Until now, this catalogue has never been presented in a western language. My aim is to make it generally available for those who would wish to study its content and make use of the astronomical information it provides.

Reign of King Mokchong (997-1009)

1003

On a ding-si day in the 2nd month of the 6th year (Dating error), there was a meteor which shone on the ground like a candle.

Reign of King Hyŏnjong (1009-1031)

1010

On a geng-shen day in the 12th month of the 1st year (22nd January 1011), a great meteor fell in Guo county.

1013

On a gui-mao day in the 3rd month of the 4th year (24th April 1013), there was a great meteor from the east to the west, and a sound like thunder.

On a gui-si day in the 9th month (11th October 1013), a great meteor entered at the gate between *Zhang* and *Yi*.

1014

On a gui-si day in the 1st month of the 5th year (8th February 1014), a meteor entered *Yi*.

On a xin-hai day in the 11th month (23rd December 1014), a meteor entered *Di*.

1015

On a xin-chou day in the 5th month of the 6th year (11th June 1015), a great meteor fell in the southwest.

On a ren-yin day in the 8th month (10th October 1015), a meteor entered *Di*.

1016

On a wu-yin day in the 2nd month of the 7th year (14th March 1016), also a meteor appeared in *Xuanyuan* and entered *Santai.*

On a ji-chou day in the 4th month (24th May 1016), a great meteor came from the east and arrived in the west.

On a xin-chou day in the 8th month (3rd October 1016), there was a meteor like thunder. Its light shone on the ground, people were shocked and in commotion.

On a ren-zi day in the 9th month (14th October 1016), a meteor as large as the moon appeared in *Zhang* and *Xing*[1] and entered *Mingtang* and *Lingtai.*

1018

On a ding-you day in the 6th month of the 9th year (21st July 1018), a meteor appeared in *Tianshi* and entered *Beidou*[2].

1023

On a ji-chou day in the 9th month of the 14th year (15th October 1023), a meteor as large as the moon entered the gate between *Wangliang* and *Tianche.*

On a gui-mao day in the 10th month (Dating error), a meteor entered *Tianchan.*

On a ji-hai day in the 11th month (24th December 1023), a meteor entered *Sheti* gate.

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[1]Since *xing* is both the name of a lunar lodge and the word for "star", this could also refer to a bright star in *Zhang*; however, the two lodges neighbour each other, so this seems less likely.

[2]This asterism consists of the seven stars of the Plough.

1025

On a jia-chen day in the 6th month of the 16th year (Dating error), a great meteor appeared in *Jiao* and moved to the west.

1026

On a ren-yin day in the 1st month of the 17th year (14th February 1026), a meteor appeared in *Taiwei* and entered *Ziwei*.

1028

On a ji-hai day in the 7th month of the 19th year (30th July 1028), a great meteor moved from north to south. Its light shone on the ground.

1029

At the hour of *pu*[3] on a ding-hai day in the 8th month of the 20th year, a great meteor moved to the southwest.

1031

On a gui-mao day in the 4th month of the 22nd year (20th May 1031), a great meteor entered *Tianshi* wall[4].

On a xin-si day in the 6th month (27th June 1031), there was a meteor as large as the moon in the northwest direction.

Reign of King Tŏkchong (1031-1034)

1032

On a ding-you day in the 3rd month of the 1st year (8th May 1032), a meteor appeared in *Taiwei* and entered *Xuanyuan*.

[3]Between 3.00pm and 5.00pm

[4]The boundary of the *Tianshi* enclosure.

On a jia-zi day in the 8th month (2nd October 1032), a meteor appeared in *Wangliang* and entered *Tianji.*

On a bing-zi day in the 9th month (14th October 1032), a meteor appeared in *Beidou* and entered *Ziweigong.*

1034

On a gui-you day in the 7th month of the 3rd year (Dating error), a meteor appeared in *Wuche* and entered *Zhuwang.*

Reign of King Chŏngjong (1034-1046)

1035

On a ren-wu day in the 9th month of the 1st year (5th October 1035), a meteor appeared in *Tianchan.*

On a wu-chen day in the 10th month (20th November 1035), a meteor moved from the southwest to the northeast.

1036

On a ding-you day in the 1st month of the 2nd year (17th February 1036), a meteor appeared in *Taiwei* and entered *Zhen.*

On a wu-chen day in the 8th month (15th September 1036), a meteor appeared in *Wuche* and entered *Zhuwang.*

On a xin-si day in the 9th month (28th September 1036), a meteor appeared in *Tianyuan* and entered *Yulin.*

On a ding-wei day in the 10th month (24th October 1036), a meteor appeared in *Wuche* and entered *Luejuan.*

On a jia-chen day in the 11th month (20th December 1036), a great meteor appeared in *Jiao* and entered *Nülin.*

1037

On a ding-si day in the 4th month of the 3rd year (2nd May 1037), a meteor appeared in *Di* and entered *Taiwei.*

On a ding-mao day in the 7th month (9th September 1037), there were three meteors as large as a cup[5]. One appeared in *Juanshe* and entered *Wuche.* One appeared in *Tianchuan* and entered *Gouchen.* Both were coloured red. One appeared in *Bagu* and entered *Gouchen.* It was coloured white.

On a bing-zi day in the 10th month (17th November 1037), a meteor as large as the half moon appeared in *Yi* and entered the head of *Nandou*[6]. It was coloured red.

1038

On a gui-you day in the 8th month of the 4th year (10th September 1038), a meteor as large as the half moon appeared in *Tianyuan.*

On a ren-chen day in the 8th month (29th September 1038), a meteor as large as a cup appeared in *Wuzhuhou* and entered *Xuanyuan.*

[5]*bei*: a cup, a tumbler, a glass. It should be noted that three separate symbols are used to denote *bei* in *Koryŏ-sa.*

[6]This is a lunar lodge of six stars in a similar pattern to *Beidou.* The "head" probably denotes the square of four stars in each asterism.

1040

On a jia-yin day in the 11th month of the 6th year (9th December 1040), a meteor as large as *sheng*[7] with a tail more than one *zhang* long appeared in *Dongjing* and entered *Xuanyuan*.

On a geng-shen day in the 11th month (15th December 1040), a meteor as large as *sheng* with a tail one *zhang* long appeared at the stars of *Shen* and entered *Queqiu*.

On a gui-mao day in the 12th month (27th January 1041), a meteor as large as a cup with a length of approximately 30 *chi* appeared in *Zhinü* and entered *Tianshi* wall.

1042

On a ding-wei day in the 7th month of the 8th year (25th July 1042), there were many stars flowing and turning.

Reign of King Munjong (1046-1083)

1048

On a gui-you day in the 2nd month of the 2nd year (21st March 1048), a meteor appeared in the east of *Langjiang* and entered the gate between *Dajiao* and *Sheti*. It was as large as a melon[8]. Red light shone on the ground.

1050

On a ren-wu day in the 6th month of the 4th year (18th July 1050), a meteor appeared in *Nou* and entered *Ji*[9]. It was as large as a melon, and was coloured red.

[7] In this context this term probably refers to a measure of volume.

[8] *gua*: melons, gourds, cucumbers, etc.

[9] This may or may not refer to the lunar lodge *Ji* (a basket) as the symbol used is *Ji* (a chicken). The relative proximity of the lodges *Nou* and *Ji* makes it more probable that it does, however.

1052

On a ji-hai day in the 6th month of the 6th year (24th July 1052), a meteor as large as a melon appeared in *Taiwei* and entered *Tianshi.* It was coloured red.

1053

On a jia-yin day in the 7th month of the 7th year (3rd August 1053), a meteor appeared in *Nou* and entered *Tiantian.* It was coloured red, and had a length of more than one *zhang.*

1061

At the hour of *pu* on a xin-chou day in the 1st month of the 15th year (9th February 1061), there was a meteor as large as a melon. It travelled to the northwest and faded.

1065

On a ji-chou day in the 10th month of the 19th year (3rd November 1065), a meteor appeared in *Shi* and entered *Tianjiangjun.* It was as large as a melon.

1067

On a xin-si day in the 7th month of the 21st year (17th August 1067), a meteor appeared in *Muliwei* and quickly entered *Zhinü* and divided into six or seven parts, looking like red tassels linked to a piece of white jade. The front part was as large as a melon. The back part was like a hen's egg[10]. There was a sound like thunder. It went on for a long time, then stopped.

1072

On a jia-yin day in the 2nd month of the 26th year (25th February 1072), a meteor appeared in *Kang* and entered *Fang.* It was as large as the moon.

[10] *ji zi*: hen's eggs. Occasionally the term *ji luan* is used instead.

1073

On a ji-you day in the 1st month of the 27th year (14th February 1073), a meteor appeared in *Dajiao* and entered within the head of *Beidou.*

On a gui-you day in the 1st month (10th March 1073), a meteor appeared in *Daling* and entered the south of *Lou* and *Wei*[11].

On a bing-wu day in the 7th month (10th August 1073), a meteor appeared in *Wangliang* and entered *Hegu.*

On a jia-xu day in the 10th month (6th November 1073), there was a meteor which appeared in *Liu* and entered *Xuanyuan.* It was as large as *bo*[12].

1074

On a wu-yin day in the 2nd month of the 28th year (10th March 1074), a meteor appeared in *Shen* and moved west. It was as large as a melon.

On a ji-hai day in the 11th month (26th November 1074), a meteor appeared in *Wenchang.* It arrived in the northwest and disappeared. It was as large as *bo.*

1075

On a geng-yin day in the 4th month of the 29th year (16th May 1075), a meteor appeared in *Jiao* and entered the gate between *Jing* and *Gui.*

On a gui-you day in the 7th month (27th August 1075), a meteor appeared in *Nandou.* It quickly moved from *Wei* and spread out. It had a length of more than one *zhang.*

[11]These two lodges neighbour each other. This may refer to either an area within these asterisms or an area to the south of them.

[12]*bo*: an earthenware basin.

On a xin-si day in the 9th month (3rd November 1075), a meteor entered *Tianshu*[13]. It was as large as a melon.

On a ren-wu day in the 9th month (4th November 1075), a meteor appeared in *Tianjin* and entered *Hegu*. It was as large as a cup.

On a ding-hai day in the 9th month (9th November 1075), a meteor appeared in the northeast of *Xiatai* and entered *Xuanyuan*.

On a wu-zi day in the 9th month (10th November 1075), a meteor entered *Huagai*. It was as large as a lamp[14].

On a gui-si day in the 10th month (15th November 1075), a meteor appeared in the southern sky and entered *Zhen*. It was as large as a melon.

1078

On a ren-zi day in the 10th month of the 29th year (18th November 1078), a meteor appeared in *Daling* and entered *Tianyuan*. It was as large as a melon.

Reign of King Sŏnjong (1083-1094)

1086

On a xin-mao day in the 6th month of the 3rd year (18th July 1086), a meteor appeared in *Wenchang* and penetrated *Wei* and *Ku*. It had a length of more than 10 *chi*, and was curved like a ring with a gap at the east. It was coloured red, but presently changed to white. It only faded after a long time.

On a jia-chen day in the 8th month (29th September 1086), a meteor appeared in *Lou* and arrived in *Wangliang*. It was as large as a melon.

[13]This is an unusual reference to one of the individual stars of *Beidou*, the Plough.
[14]*deng*: a lamp, a lantern.

1087

On a xin-you day in the 7th month of the 4th year (12th August 1087), a meteor appeared in *Tianjun* and arrived in *Tianyuan*. It was as large as a melon.

On a wu-xu day in the 8th month (18th September 1087), a meteor appeared in *Lou* and arrived in *Wangliang*. It was as large as a melon.

1088

On a ji-si day in the 7th month of the 5th year (14th August 1088), a meteor appeared in *Tianjin* and arrived in *Dongbi*. It was as large as a melon.

1090

On a jia-xu day in the 9th month of the 7th year (8th October 1090), a meteor appeared like fire in *Gui* and entered *Taiwei*.

On a geng-yin day in the 9th month (24th October 1090), a meteor appeared in *Shangtai* and trespassed against the lower star of *Zhongtai*. It was as large as the sun.

On a ren-chen day in the 10th month, the first day of the month (26th October 1090), a meteor appeared in *Xuanyuan* and entered *Taiwei*. It was as large as a melon.

1091

On a ren-wu day in the 3rd month of the 8th year (14th April 1091), a meteor appeared in *Zhinü* and arrived in *Tianjin*.

On a ding-si day in the 4th month (19th May 1091), there were meteors; some were blue-green, some were red. They had tails more than 10 *chi* long. They appeared in *Fang* and entered *Xuanyuan*. There was a sound like thunder.

1092

On a wu-wu day in the 2nd month of the 9th year (15th March 1092), a meteor appeared in the north of *Taiwei* and arrived south of *Xing*.

1093

On a geng-yin day in the 3rd month of the 10th year (11th April 1093), a meteor appeared in *Zaofu* and arrived in *Wangliang*. It was coloured red, and was as large as a melon. It had a tail approximately 7 *chi* long.

Reign of King Hŏnjong (1094-1095)

1095

On a yi-you day in the 6th month of the 1st year (25th July 1095), a meteor, which was as large as a melon and coloured red, with a tail approximately 9 *chi* long, appeared in *Yingshi* and entered the head of *Nandou*. There were many small stars flowing south.

Reign of King Sukchong (1095-1105)

1097

On a gui-wei day in the 8th month of the 2nd year (10th September 1097), a meteor appeared in *Zhinü* and arrived in *Wangliang*.

1098

On a yi-si day in the 2nd month of the 3rd year (31st March 1098), a meteor, which was coloured red, first large but later small, appeared in *Tengshe* and arrived in *Yingshi*.

On a geng-shen day in the 11th month (11th December 1098), a meteor, which was coloured red, first large but later small, appeared in *Nanhe* and arrived in *Tianjun*.

1099

On a gui-wei day in the 11th month of the 4th year (29th December 1099), a meteor, which was coloured white, first small but later large, appeared in the stars of *Zhang* and arrived in *Tianchao*. It was as large as *kuan*[15].

1100

On a geng-shen day in the 4th month of the 5th year (3rd June 1100), a meteor appeared in *Yi*. It was approximately 3 *chi* long, and fell to the southwest.

On a ren-xu day in the 10th month (2nd December 1100), a meteor appeared in *Yulin* and entered the stars of *Xu*. It was approximately 5 *chi* long. It was green and red, and its rays were very bright[16]. There was a sound like thunder.

1103

On a xin-hai day in the 8th month of the 8th year (7th September 1103), one meteor appeared in *Beiji* and entered *Tianjin*. It was as large as a torch[17], and had a tail approximately 3 *zhang* long. One meteor appeared inside *Wuzhuhou* and entered *Shangtai*. It was as large as *kuan*, and had a tail approximately one *zhang* long. One meteor appeared in *Wangliang* and entered *Wenchang*. It was as large as a melon.

1105

On a geng-wu day in the 6th month of the 10th year (17th July 1105), at the beginning of the night, a meteor appeared within *Ziwei* wall and entered *Langwei*. It was coloured red, and was approximately 5 *cun* across round[18]. It had a tail approximately 1 *zhang* long. Two more appeared in *Tianjin* and entered *Tianshi*.

[15]*kuan*: a small wooden stand, a faggot, or a type of tree. (It is unclear which meaning is being referred to.)

[16]The exact description is ambiguous.

[17]*ju*: a torch, made of twisted reeds.

[18]*yuan*: round, circular. Here it may be referring to the meteor's diameter.

They were coloured white, and their tails were 2 *zhang* long. On the fifth night, (a meteor)[19] appeared in *Hegu* and entered the head of *Nandou*. It was coloured red, and as large as a hen's egg.

On a geng-zi day in the 9th month (15th October 1105), a meteor appeared in *Wuche* and entered *Tengshe*. It was as large as *kuan*, and had a length of approximately one *zhang*.

On a xin-chou day in the 9th month (16th October 1105), one meteor appeared in the head of *Beidou* and entered *Langjiang*. It was coloured blue-green, and more than 5 *cun* across. It had a tail approximately one *zhang* long. One appeared in *Zhongtai* and entered *Langjiang*. It was coloured red, and was as large as a torch. It had a tail approximately one *zhang* long. One appeared in *Beihe* and entered *Beiji*. It was coloured red, and was as large as a torch. It had a tail one half *zhang* long.

On a jia-yin day in the 11th month (28th December 1105), at night, there was a meteor which appeared in *Shangtai* and entered *Beiji*. It was as large as a torch, and had a length of approximately one *zhang*.

On a ding-mao day in the 12th month (10th January 1106), a meteor appeared at the east of *Yi* and entered *Daling*. It was shaped like a hen's egg.

Reign of King Yejong (1105-1122)

1106

On a jia-shen day in the 6th month of the 1st year (26th July 1106), a meteor appeared in *Wangliang* and entered *Yingshi*. It was approximately two *zhang* long.

On a yi-you day in the 6th month (27th July 1106), a meteor appeared in *Tianjin*

[19]The phrase for *meteor* is omitted here, but it seems likely that this is a copying error.

and entered *Zongren.* It was as large as a cup, and had a tail approximately 2 *zhang* long. Also, two meteors appeared in *Xu* and entered *Jiukan*, as large as a hen's egg. Also, from dusk until dawn, there were many stars flowing in the four directions.

On a gui-chou day in the 6th month (Dating error), a meteor appeared in *Wangliang* and entered *Yingshi.* It was as large as a hen's egg, and was approximately two *zhang* long.

On a yi-wei day in the 9th month (5th October 1106), also there was a meteor which appeared in *Shangtai* and entered *Langjiang.* It was as large as a hen's egg, and had a length of approximately 2 *zhang.*

On a ji-hai day in the 9th month (9th October 1106), a meteor appeared in *Chailang* and entered *Tianyuan.*

On a ding-hai day in the 11th month (26th November 1106), a meteor appeared in *Wei* and entered *Leibizhen* and *Yulin.* It was as large as a bowl[20].

1107

On a ding-you day in the 1st month of the 2nd year (4th February 1107), a meteor appeared in *Huanzhe*, passed through the east of *Taiwei*, and entered the stars of *Ping.* It was as large as a hen's egg, and was approximately 2 *chi* long.

On a ji-chou day in the intercalary month (23rd November 1107), also a meteor appeared in *Dongjing* and entered *Junshi.* It was as large as a bowl, and had a tail approximately 5 *chi* long.

On a ren-yin day in the 12th month (4th February 1108), a meteor appeared in *Xuanyuan*, moved into *Zhongtai*, and entered *Wenchang.* It was as large as a hen's egg.

[20] *wan*: a bowl, a basin, a cup, a dish.

On a bing-wu day in the 12th month (8th February 1108), a meteor appeared in *Huagai* and entered the sky[21]. It was as large as a hen's egg, and had a tail approximately one *zhang* long.

1109

On a ji-you day in the 5th month of the 4th year (5th June 1109), a meteor appeared in *Guansuo* and entered *Kang*. It was as large as *yu*[22].

1110

On a ji-you day in the 1st month of the 5th year (31st January 1110), a meteor appeared in *Guansuo* and entered *Tianshi*, inside *Zongren*. It was shaped like a hen's egg.

On a xin-chou day in the 3rd month (24th March 1110), a meteor appeared in *Genghe* and entered *Tianchan*. It was as large as a hen's egg.

On a ting-mao day in the 3rd month (19th April 1110), a meteor trespassed against *Tianshi* wall, inside *Chesi*, and entered *Liesi*. It was as large as a cup, and had a length of approximately 9 *chi*.

On a yi-chou day in the intercalary 8th month (14th October 1110), a meteor appeared in *Dongjing* and entered *Yugui*[23]. It was as large as a cup.

On a geng-wu day in the 9th month (19th October 1110), a meteor appeared in *Wenchang* and entered *Tianchang*. It was approximately 2 *zhang* long, and was as large as a hen's egg.

On a ren-shen day in the 9th month (21st October 1110), a meteor appeared in *Chuanshe* and entered *Tianpou*. It was as large as a torch, and was approximately

[21]This phrase may indicate that *Huagai* was very near the horizon, if it is not a copying error.

[22]*yu*: a basin; a large cup.

[23]This is the lunar lodge usually referred to as *Gui*.

4 *zhang* long. Light shot down onto the ground.

1111

On a ji-hai day in the 4th month of the 6th year (16th May 1111), a meteor moved from west of *Beiji* and entered the first gate between *Zongren* and *Zong.*

On a bing-shen day in the 11th month (Dating error), a meteor appeared in *Xuanyuan* and entered the stars of *Zhang.* It was as large as a bowl, and its tail was approximately 6 *chi* long.

1112

On a gui-chou day in the 6th month of the 7th year (23rd July 1112), a meteor appeared in *Wangliang* and entered *Wei.* Its tail was approximately one *zhang* long.

On a yi-mao day in the 9th month, the first day of the month (23rd September 1112), a meteor appeared in the northwest of *Wuche* and entered *Beihe.* It was as large as *yu*, and had a tail approximately 7 *chi* long.

On a bing-chen day in the 9th month (24th September 1112), a meteor appeared in *Juanshe.* It was as large as a cup, and had a tail approximately 5 *chi* long.

On a ding-si day in the 9th month (25th September 1112), a meteor appeared in the stars of *Tianchuan* and *Fang*[24], and entered the northwest of *Wuche.* It was as large as *yu*, and had a tail approximately 7 *chi* long.

On a ding-chou day in the 9th month (15th October 1112), a meteor appeared in the east of *Bi* and entered *Tianyuan.* It was as large as *yu.*

On a ji-mao day in the 9th month (17th October 1112), a meteor appeared in *Hegu*,

[24]This record is ambiguous; it may be referring to *Tianchuan*, *Xing* and *Fang*, for example, although the lunar lodges *Xing* and *Fang* are widely separated.

approached *Tianji*, and faded. It was as large as a cup.

On a ren-wu day in the 9th month (20th October 1112), a meteor appeared in *Xuanyuan* and entered *Ziwei*. It was as large as *yu*, and had a tail approximately 3 *chi* long.

On a gui-si day in the 10th month (31st October 1112), a meteor appeared in *Zhongtai* and entered the west of *Ziwei*. It was as large as a cup, and had a tail approximately 10 *chi* long.

On a bing-shen day in the 10th month (3rd November 1112), a meteor appeared in *Mao* and entered *Bi*. It was as large as *yu*.

On a wu-yin day in the 11th month (15th December 1112), a meteor appeared in *Leibizhen* and entered *Yulin*. It was as large as a cup, and had a tail approximately 5 *chi* long. Light shone on the ground. Also, a meteor appeared in the east of *Sheti* and entered *Kang*. It was as large as *yu*, and was approximately 10 *chi* long.

1113

On a jia-yin day in the 8th month of the 8th year (17th September 1113), a meteor appeared in *Xuanyuan* and entered *Shaowei*. It was as large as a cup, and was approximately 6 *chi* long. Also, a meteor appeared in *Tianjun* and entered *Junjing*. It was approximately 3 *chi* long.

On a ji-si day in the 8th month (2nd October 1113), a meteor appeared in *Lou* and entered *Yingshi*. It was as large as a cup.

On a bing-wu day in the 9th month (8th November 1113), also a meteor appeared in *Tianjun* and entered *Tianchang*. It was as large as a bowl, and was 15 *chi* long.

On a ji-you day in the 10th month (11th November 1113), a meteor appeared in the north, fell into *Shimen*, and entered *Bakui*[25]. It was as large as a cup, and was approximately 20 *chi* long.

On a jia-shen day in the 11th month (16th December 1113), a meteor appeared in *Zhongtai* and entered *Taiwei*. It was as large as a cup, and had a length of approximately 15 *chi*.

1114

On a bing-chen day in the 2nd month of the 9th year (18th March 1114), a meteor appeared in *Beidou* and *Ziwei*, and entered *Wangliang*. It was as large as a bowl.

On a geng-zi day in the 3rd month (1st May 1114), a meteor appeared in *Guqi* and entered *Tianji* and *Gouguo*[26].

1116

On a ji-wei day in the 1st month of the 11th year (Dating error), a meteor appeared within *Taiwei* and entered the northeast star of *Zhen*.

On a geng-xu day in the 3rd month (30th April 1116), a meteor appeared in *Qigong* and the stars of *Guansuo*, and entered *Tianshi*. It was as large as a hen's egg, and was approximately 3 *chi* long.

On a wu-xu day in the 9th month (15th October 1116), a meteor appeared in *Zhongtai* and entered *Taiyang*. It was as large as a hen's egg.

On a geng-chen day in the 12th month (25th January 1117), a meteor appeared in *Kang* and entered *Di*. It was as large as a hen's egg.

[25]This record is ambiguous.
[26]This record is ambiguous.

1117

On a jia-zi day in the 4th month of the 12th year (9th May 1117), a meteor appeared in the north of *Zhaoyao* and entered within the head of *Beidou*. It was as large as a hen's egg, and had a length of approximately 7 *chi*.

On a ding-chou day in the 4th month (22nd May 1117), a meteor appeared in *Guanxing* and entered *Waichu*. It was as large as a bowl, and had a length of approximately 5 *chi*.

On a xin-si day in the 4th month (26th May 1117), a meteor appeared in the northeast star of *Jiao* and entered *Qifu*. It was as large as a hen's egg, and had a length of approximately 15 *chi*. Also, a meteor appeared at the gate of *Tianshi* and entered into the midst of the stars of *Chuanshuo yu*[27]. It had a length of approximately 7 *chi*.

On a gui-si day in the 5th month (7th June 1117), a meteor appeared in *Zhaoyao*, entered within the head of *Beidou*, and trespassed against the 4th star.

On a wu-wu day in the 8th month (31st August 1117), at dusk, a meteor trespassed against the moon and fell down to the southeast.

On a geng-shen day in the 10th month (1st November 1117), a meteor appeared in *Wuche* and entered *Tianjun*. It was as large as a bowl, and had a length of approximately 10 *chi*.

1118

On a bing-xu day in the 9th month of the 13th year (23rd September 1118), a meteor appeared in the north of *Youqi* and entered the east of *Tianshi*. It had a length of approximately 10 *chi*.

[27]There are several possible interpretations here, but it seems likely that it refers to only one asterism.

On a geng-zi day in the 9th month (7th October 1118), a meteor appeared in the stars of *Kui* and entered *Tianchan.*

On a jia-chen day in the 9th month (11th October 1118), a meteor appeared in *Beihe* and entered *Xuanyuan.*

On a ji-mao day in the 12th month (14th January 1119), a meteor appeared in *Xuanyuan* and entered *Taiwei.* It had a length of approximately 5 *chi.*

On a bing-xu day in the 12th month (21st January 1119), a meteor appeared in *Ziwei* and entered the gate between *Suo*[28] and *Nülin.* It had a length of approximately 30 *chi.*

1121

On a ji-hai day in the 6th month of the 16th year (22nd July 1121), one meteor appeared in the north of *Zhinü* and entered *Ziwei.* One appeared in *Ziwei* and entered *Gouchen.* One appeared in the stars of *Kui* and entered *Leidian.*

On a xin-chou day in the 6th month (24th July 1121), a meteor appeared in *Tianjin* and entered *Tianbian.*

On a jia-chen day in the 7th month (Dating error), a meteor appeared in *Hegu* and entered *Nandou.*

On a wu-shen day in the 12th month (27th January 1122), a meteor appeared in *Gedao* and entered *Tianjian.* It had a length of approximately 7 *chi.*

1122

On a bing-shen day in the 2nd month of the 17th year (16th March 1122), a meteor appeared inside *Beidou* and entered the gate between *Tianchu* and *Chuanshe.* Also,

[28]This may be either a copying error or shortening of *Guansuo.*

one appeared in the 1st star of *Beidou*, divided into two, then faded.

On a ding-hai day in the 8th month, the first day of the month (3rd September 1122), a meteor appeared in the east wall of *Taiwei* and entered *Wei*. First it was large, but later it was small. It had a tail approximately 2 *chi* long.

On a wu-zi day in the 12th month (2nd January 1123), a meteor appeared in *Xuanyuan* and entered *Yugui*. It had a tail approximately 4 *chi* long.

Reign of King Injong (1122-1146)

1124

On a wu-wu day in the 6th month of the 2nd year (25th July 1124), a meteor appeared in *Ziwei* and entered *Sheti*. It had a tail approximately 30 *chi* long.

On a bing-wu day in the 8th month (11th September 1124), a meteor appeared in *Wenchang* and entered *Beidou*.

On a yi-chou day in the 8th month (30th September 1124), a meteor appeared in *Daling* and entered *Ziwei*.

On a yi-wei day in the 9th month (30th October 1124), also there was a meteor which was as large as a torch.

On a ren-yin day in the 9th month (6th November 1124), a meteor appeared in the northeast. It was as large as a torch.

On a yi-mao day in the 10th month (19th November 1124), a meteor appeared in *Wenchang*, entered *Ziwei*, penetrated *Beiji* and faded at the eastern *fan*[29] of *Taiwei*.

[29]*fan*: a hedge, a boundary, a frontier.

On a gui-you day in the 10th month (7th December 1124), a meteor appeared in the right foot of *Shen* and entered *Junyin.*

On a yi-hai day in the 11th month (9th December 1124), a meteor appeared in *Wuche* and entered *Tianyuan.* Also one appeared within the head of *Beidou* and entered *Ziwei.*

On a geng-shen day in the 12th month (23rd January 1125), a meteor appeared in *Kulou* and entered *Gouchen.*

1126

On a ren-chen day in the 3rd month of the 4th year (20th April 1126), a meteor appeared in *Tianshi* and entered the stars of *Xin.*

On a jia-shen day in the 9th month (9th October 1126), a meteor appeared in *Yingshi* and entered *Ziwei.* It had a length of approximately 7 *chi.*

On a bing-xu day in the 9th month (11th October 1126), a meteor appeared in *Ziwei* and entered the eastern *fan.*

On a jia-wu day in the 10th month (19th October 1126), a meteor appeared in *Tianjiangjun* and entered *Gouchen.* It was as large as a melon, and had a length of approximately 10 *chi.*

On a geng-zi day in the 10th month (25th October 1126), a meteor appeared in *Tianjiangjun* and entered *Ziwei.* Also, a meteor entered *Taiwei* and *Wudizuo.*

On a ding-hai day in the 11th month (11th December 1126), a meteor appeared in *Shuiwei* and entered *Zhang.* There was a sound like thunder. It was as large as a bowl, and had a length of approximately 1 *zhang.*

On a gui-si day in the intercalary month (17th December 1126), a meteor appeared in *Taiwei* and entered *Dizuo*. It was as large as a lamp.

On a ding-you day in the intercalary month (21st December 1126), a meteor appeared in *Beidou* and *Zhongtai*. It was as large as a melon.

On a bing-xu day in the 12th month (8th February 1127), a meteor appeared in *Kulou* and entered *Taiwei*.

1127

On a jia-zi day in the 2nd month of the 5th year (18th March 1127), a meteor appeared in *Jian* and entered *Fang*. It was as large as a melon.

On a wu-zi day in the 2nd month (11th April 1127), a meteor appeared large in *Jiao* and entered *Shi*[30] wall within *Huanzhe*.

On a jia-wu day in the 3rd month (17th April 1127), a meteor appeared in *Jian* and entered *Fang*. It was as large as a melon, and had a length of approximately 15 *chi*.

On a geng-shen day in the 6th month (12th July 1127), a meteor appeared in *Yingshi* and entered *Wei*. It was as large as a melon.

On a geng-yin day in the 7th month (11th August 1127), a meteor appeared in *Lou* and entered *Wuche*. It was coloured yellow, and as large as a melon.

On a gui-mao day in the 9th month (23rd October 1127), a meteor appeared in *Dongbi* and entered *Yulin*. It was as large as a bowl.

On a ren-zi day in the 9th month (1st November 1127), a meteor appeared in *Wuche*

[30]This is almost certainly a shortening of *Tianshi*.

and entered *Beidou.*

On a wu-wu day in the 10th month (7th November 1127), a meteor appeared in *Dongbi* and entered *Yulin.*

On a wu-wu day in the 12th month (6th January 1128), a meteor appeared in *Kulou* and entered *Taiwei.* It was as large as a hen's egg.

1128

On a xin-si day in the 4th month of the 6th year (28th May 1128), a meteor appeared in *Niu* and entered *Tiantian.* It was as large as a melon.

On a ding-hai day in the 5th month (3rd June 1128), a meteor appeared in *Tianjin* and entered *Yingshi.* It was as large as a melon and coloured red.

On a xin-hai day in the 5th month (27th June 1128), a meteor appeared in *Tianjin* and entered *Yingshi.*

On a ding-chou day in the 6th month (23rd July 1128), there was a meteor as large as *fou* [31]. It was coloured white, and there was light. It appeared in *Ziweigong*, and was approximately 10 *chi* long. It quickly moved and entered the stars of *Lishi.* Also, a meteor as large as *bo* appeared in the stars of *Tianshi.* It was coloured red, and had a length of approximately 5 *chi.* It quickly moved and entered the stars of *Di.* Also, a meteor as large as a lantern[32] appeared in the stars of *Zhen.* It was coloured red, and had a length of approximately 7 *chi.* It quickly moved and entered the left star of *Jiao.* 4 more meteors, as large as *bo*, appeared in the stars of *Tianjin.* They were coloured like fire, and were approximately 3 *chi* long. They quickly moved and entered the stars of *Hegu.* 5 more meteors, as large as a lantern, appeared in *Leibizhen.* They were coloured white. They entered *Yulin.* Also, a meteor as large as a lantern, with a length of approximately 10 *chi*, entered

[31] *fou*: pottery, earthenware.

[32] *deng zhan*: lamps, collectively; also part of a lamp.

the stars of *Mao*.

On a gui-wei day in the 9th month (27th September 1128), a meteor appeared in *Bi*, entered *Wangliang*, moved and entered *Yingshi*.

On a bing-wu day in the 9th month (20th October 1128), a meteor appeared in *Kui* and entered *Yingshi*.

On a ji-wei day in the 10th month (2nd November 1128), a meteor, which was as large as a torch and coloured red, appeared in *Yi* and entered the stars of *Jiao*.

On a wu-chen day in the 10th month (11th November 1128), a meteor appeared in *Yi* and entered the left (star)[33] of *Jiao*. It was as large as a torch.

On a geng-wu day in the 10th month (13th November 1128), a meteor appeared at the great star of *Xing* and entered within the stars of *Yi*.

On a jia-chen day in the 11th month (17th December 1128), a meteor appeared in *Tianshi* wall and entered *Yi*.

On a ding-wei day in the 11th month (20th December 1128), a meteor appeared in *Tianjun* and entered *Shen*. It was as large as a torch.

On a ji-yu day in the 11th month (22nd December 1128), a meteor appeared in *Wuche* and entered *Shen*. It was as large as a melon.

1129

On a wu-chen day in the 8th month of the 7th year (7th September 1129), a meteor appeared in *Kui*. It was as large as a bowl, and had a tail approximately 15 *chi* long. The people in the village lanes cried out in alarm. Also, a meteor appeared

[33] "Star" is missing, but this is a common reference.

in *Wei* and entered *Tianlin.* It was as large as a torch.

On a wu-yin day in the intercalary month (17th September 1129), a meteor appeared in *Lou* and entered *Tianchan.* It was as large as a bowl.

On a yi-si day in the intercalary month (14th October 1129), a meteor, which was as large as a melon, appeared in the stars of *Bi* and entered *Tianjun.* Also, a meteor, which was as large as a lantern, appeared in the stars of *Bi* and entered the stars of *Shen.*

On a ding-wei day in the 9th month (16th October 1129), a meteor, which was as large as a melon, appeared in the stars of *Bi* and entered *Tianjun.*

On a xin-hai day in the 9th month (20th October 1129), a meteor, which was as large as a melon, appeared in *Yingshi* and entered *Wei.* Its tail was approximately 8 *chi* long. Also, there was a meteor as large as a hen's egg, which appeared in *Shen* and *Ji*, and entered the stars of *Gou*[34].

On a bing-zi day in the 10th month, the first day of the month (14th November 1129), a meteor appeared in *Taiwei* and entered *Tiangou.* It was as large as a bowl, and had a length of approximately 10 *chi.*

On a ren-shen day in the 11th month (9th January 1130), a meteor appeared in *Yi* and entered *Zhongtai.* Its tail was approximately 7 *chi* long.

On a ding-chou day in the 12th month (14th January 1130), there was a meteor from the southwest direction. It was pointing northeast, and fell to the ground. There was a sound like thunder. It was as large as *pen*[35], and had a length of approximately 6 *chi.*

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[34]This is either a shortening of another asterism (*Gouchen*, for example) or an individual *Gou* (dog) star.

[35]*pen*: a basin, a tub, a pot, a bowl.

1130

On a ji-mao day in the 4th month of the 8th year (16th May 1130), a meteor appeared in the stars of *Zong* and entered *Shilou.*

On a xin-si day in the 6th month (17th July 1130), a meteor appeared at the western *fan* of *Ziwei* and entered *Hegu.* It had a length of approximately 5 *chi.* There was a sound like thunder.

On a bing-xu day in the 6th month (22nd July 1130), a meteor appeared in *Tianshi* wall and entered *Hegu.*

On a ji-chou day in the 6th month (25th July 1130), a meteor appeared in *Wei* and entered *Nou.*

On a ding-wei day in the 7th month (12th August 1130), a meteor, which was as large as a hen's egg, appeared in *Tianlin* and entered *Yulin.*

On a ding-chou day in the 8th month (11th September 1130), a meteor, which was as large as a cup, appeared in *Wuche* and entered *Dongjing.*

On a yi-si day in the 9th month (9th October 1130), a meteor appeared in *Kui* and entered *Wei.* It was as large as a hen's egg, and had a tail approximately 9 *chi* long.

On a ding-wei day in the 9th month (11th October 1130), a meteor appeared in *Zui* and entered *Shuiwei.* It was as large as a hen's egg, and had a tail approximately 5 *chi* long.

On a yi-hai day in the 10th month (8th November 1130), a meteor appeared in *Bi* and entered *Tianjun.* It was as large as a bowl, and had a length of approximately 10 *chi.*

On a geng-chen day in the 10th month (13th November 1130), a meteor, which was as large as a hen's egg, appeared in *Beidou* and entered *Ziwei* and *Dizuo*.

On a ren-xu day in the 11th month (25th December 1130), a meteor, which was as large as a hen's egg, appeared in *Neijie* and entered *Gouchen*.

1131

On a xin-mao day in the 6th month of the 9th year (22nd July 1131), a meteor appeared in *Hegu* and entered *Nandou*. It was as large as a torch, and had a length of approximately 10 *chi*.

On a jia-wu day in the 6th month (25th July 1131), a meteor appeared in *Tianji* and entered *Ji*. Also, a meteor appeared in *Shiligong* and entered *Hegu*.

On a yi-wei day in the 7th month (26th July 1131), a meteor, which was as large as a hen's egg, appeared in *Tianji* and entered *Ji*. Also, a meteor, which was as large as a cup, appeared in *Shiligong* and entered *Ji*.

On a ji-wei day in the 7th month (19th August 1131), a meteor appeared in *Wei* and entered *Nou*. It was as large as a torch, and had a length of more than 10 *chi*.

On a bing-xu day in the 8th month (15th September 1131), a meteor appeared in *Bi* and entered *Zui*. It was as large as a bowl, and had a length of more than 10 *chi*.

On a wu-xu day in the 9th month (27th September 1131), also there was a meteor, which was as large as a cup. It appeared in *Beiji* and entered *Langjiang*.

On a yi-you day in the 10th month (13th November 1131), a meteor, which was as large as a hen's egg, appeared in *Tianjun* and entered *Tianchan*.

1132

On a geng-xu day in the 1st month of the 10th year (6th February 1132), a meteor appeared in *Qigong* and entered *Kang*.

On a bing-chen day in the 1st month (12th February 1132), a meteor appeared in *Taiwei* and entered *Zhen*. It had a length of approximately 10 *chi*.

On a ding-si day in the 1st month (13th February 1132), a meteor appeared in *Taiwei* and entered *Beidou*. It had a length of approximately 10 *chi*.

On a gui-si day in the 8th month (16th September 1132), also a meteor appeared in *Tianjiangjun* and entered *Wuche*.

On a ren-yin day in the 10th month (24th November 1132), a meteor appeared in *Langwei* and entered *Sheti*. It was as large as a bowl, and had a length of approximately 30 *chi*.

On a ding-si day in the 10th month (9th December 1132), a meteor appeared in *Beidou* and *ba*[36] *Gouchen*.

1133

On a xin-si day in the 3rd month of the 11th year (2nd May 1133), a meteor appeared at the gate between *Di* and *Kang*, and entered the stars of *Qiguan*. It was approximately 5 *chi* long.

On a ding-chou day in the 5th month (27th June 1133), a meteor, which was as large as a melon, appeared in *Yingshi* and arrived in *Tianshi* and *Dizuo*. Its tail was approximately 20 *chi* long.

On a jia-chen day in the 6th month (24th July 1133), a meteor appeared in *Tianjin*

[36] *ba*: eight. Almost certainly a misprint for *ru* (entered).

and entered the wall of *Tianshi.* Its tail was approximately 7 *chi* long.

On a ding-wei day in the 6th month (27th July 1133), a meteor appeared in *Zhuanshe* and entered *Zhinü.*

On a gui-hai day in the 7th month (12th August 1133), a meteor appeared in *Tianji* and entered *Tianshi.*

On a ji-you day in the 8th month (27th September 1133), a meteor appeared in *Wuche* and entered *Yingshi.*

On a ji-hai day in the 12th month (15th January 1134), a meteor appeared within the south of *Beihe* and trespassed against the left *jian*[37] of *Shen.* It was as large as a melon and had a tail 5 *chi* long. Also, a meteor appeared within *Nanhe* and entered *Lang xing*[38]. It was as if it had hit something; it broke up, and *Lang xing* shook.

On a xin-chou day in the 12th month (17th January 1134), a meteor appeared in *Dongjing* and entered the stars of *Hu.* It had a tail approximately 10 *chi* long.

1134

On a ji-wei day in the 3rd month of the 12th year (5th April 1134), a meteor fell to the ground. It was as large as *dou*[39].

On a jia-shen day in the 4th month (30th April 1134), a meteor appeared in *Wangliang* and entered *Nandou.*

On a jia-yin day in the 5th month (30th May 1134), a meteor appeared in *Wangliang* and entered *Nandou.* It was as large as a torch, and had a tail approximately

[37] *jian*: the top of the shoulder.
[38] Sirius.
[39] *dou*: a dry measure.

5 *chi* long.

On a xin-chou day in the 6th month (16th July 1134), a meteor appeared in *Tengshe* and entered *Hegu.* It was as large as a melon, and had a length of approximately 10 *chi.*

On a ren-yin day in the 6th month (17th July 1134), a meteor appeared in *Wangliang* and entered *Gedao.* It was as large as a lamp.

On a jia-chen day in the 6th month (19th July 1134), a meteor appeared in *Yingshi* and entered *Beidou.* It was as large as *fou.*

On a ren-zi day in the 7th month (27th July 1134), a meteor appeared in the handle of *Beidou* and entered *Sheti.* Also, a meteor appeared in *Wei* and entered *Nou.* Also, a meteor appeared in *Yingshi* and entered *Leibizhen.*

On a yi-mao day in the 9th month (28th September 1134), a meteor appeared in *Lou*, penetrated *Tianchan*, and fell to the south.

On a ding-si day in the 9th month (30th September 1134), a meteor appeared in *Xuanyuan* and entered the stars of *Xiatai.*

On a geng-zi day in the 10th month (12th November 1134), a meteor appeared in *Shen* and *Ji*, and fell to the south.

1135

On a ding-wei day in the intercalary 2nd month of the 13th year (19th March 1135), a meteor appeared at the western wall of *Tianshi* and entered *Sheti.*

On a geng-wu day in the intercalary 2nd month (11th April 1135), a meteor appeared in *Jiao* and entered *Zhen.*

On a gui-you day in the intercalary 2nd month (14th April 1135), a meteor appeared in *Nandou*, passed over *Fang* and *Xin*, and entered the left of *Jiao*[40]. It was as large as a melon, and had a length of approximately 40 *chi*.

On a wu-yin day in the 5th month (18th June 1135), a meteor appeared in *Dongbi* and entered *Wei*.

On a wu-shen day in the 6th month (18th July 1135), a meteor appeared in *Hegu* and entered *Nou*.

On a gui-hai day in the 6th month (2nd August 1135), a meteor appeared in *Tianbian* and entered *Nandou*.

On a wu-xu day in the 7th month (6th September 1135), a meteor appeared in *Tianguan* and entered the northeast star of *Wuche*.

1136

On a geng-yin day in the 6th month of the 14th year (Dating error), a meteor appeared in *Huagai* and entered *Wenchang*.

On a xin-mao day in the 6th month (Dating error), a meteor appeared in the stars of *Jin*[41] and entered *Ji*. It was as large as a bowl, and had a length of 6 *chi*. Also, a meteor appeared in *Hegu* and entered *Nandou*. It was as large as a bowl, and had a length of approximately 20 *chi*.

On a ding-si day in the 12th month (17th January 1137), a meteor appeared in *Sheti* and entered *Di*. It was as large as a torch and had a length of approximately 2 *zhang*.

[40]This could also read *...entered the left corner.*, although "the left star of *Jiao*" commonly refers to ζ Vir, and the asterism is in the right part of the sky.

[41]This is probably a shortening; possibly of *Tianjin*.

1137

On a yi-you day in the 1st month of the 15th year (14th February 1137), a meteor appeared in *Zhang* and entered *Tianchao.*

On a ding-hai day in the 7th month (15th August 1137), a meteor appeared in *Tianjun* and arrived in *Lou.* It had a length of approximately 15 *chi.*

On a ding-wei day in the 11th month (2nd January 1138), a meteor appeared in *Zhen* and arrived in *Kulou.*

On a jia-yin day in the 11th month (9th January 1138), a meteor appeared in *Tianjiangjun* and entered *Yulin.*

1138

On a jia-shen day in the 2nd month of the 16th year (9th April 1138), a meteor appeared in *Di* and entered *Zhen.*

On a jia-yin day in the 8th month, the first day of the month (6th September 1138), one meteor appeared in *Lou* and entered *Tianchan.* One appeared in *Shen* and entered *Tiangou.*

On a ji-wei day in the 10th month (10th November 1138), a meteor appeared in *Junshi* and entered *Shen.*

On a bing-yin day in the 12th month (16th January 1139), one meteor appeared in *Wangliang* and entered *Lou.* One appeared in *Tianshi* and entered *Nandou.*

1140

On a wu-shen day in the 9th month of the 18th year (19th October 1140), a meteor appeared in *Wuche* and entered *Beidou.*

1141

On a geng-xu day in the 5th month of the 19th year (18th June 1141), a meteor appeared in *Hegu* and entered *Nandou*.

On a geng-wu day in the 10th month (5th November 1141), a meteor appeared in *Nanhe* and entered *Junshi*. It was as large as a melon, and had a tail 3 *chi* long.

On a xin-wei day in the 10th month (6th November 1141), a meteor appeared in *Xing* and entered *Yi*. It was as large as a melon, and had a tail 2 *zhang* long.

1142

On a ren-chen day in the 7th month of the 20th year, the first day of the month (25th July 1142), a meteor appeared in *Tianjie* and entered *Bi*.

On a gui-hai day in the 12th month (23rd December 1142), a meteor appeared in *Sheti*. It had a length of approximately 10 *chi*.

1143

On a ding-wei day in the intercalary 4th month of the 21st year (5th June 1143), a meteor appeared in *Gouchen* and entered *Dizuo*. Also one appeared in *Zhaoyao* and entered *Beidou*.

On a geng-chen day in the 7th month (6th September 1143), a meteor appeared in *Nandou* and entered *Tiantian*. Also one appeared in *Kui* and entered *Tianchuan*.

On a ji-mao day in the 9th month (4th November 1143), a meteor appeared in *Shen* and entered *Junshi*.

1144

On a geng-xu day in the 4th month of the 22nd year (2nd June 1144), a meteor appeared in *Tianshi* and entered *Dongxian.* It was as large as a melon, and had a length of approximately 5 *chi.*

On a yi-chou day in the 5th month (17th June 1144), a meteor appeared in *Dajiao* and entered *Tianpou.* It was as large as a melon, and had a length of approximately 10 *chi.*

On a xin-chou day in the 6th month (23rd July 1144), a meteor appeared in *Ji* and entered *Wei.* It was as large as a melon, and had a length of approximately 5 *chi.*

On a geng-chen day in the 8th month (31st August 1144), a meteor appeared in *Tianjian.*

On a gui-si day in the 8th month (13th September 1144), a meteor appeared in *Wangliang* and entered *Tianchuan.*

1145

On a wu-xu day in the 2nd month of the 23rd year (17th March 1145), a meteor appeared in *Dajiao* and entered *Di.* It was as large as a melon, and had a length of approximately 5 *chi.*

On a ren-chen day in the 4th month (10th May 1145), a meteor appeared in *Yi* and entered *Tianchao.* It had a length of approximately 15 *chi.*

On a ji-si day in the 5th month (16th June 1145), a meteor appeared in *Sheti* and entered *Zhen.*

On a wu-xu day in the 6th month (15th July 1145), a meteor appeared in *Sheti* and entered *Zhen.* It was as large as a melon.

Reign of King Ŭijong (1146-1170)

1147

On a bing-chen day in the 6th month of the 1st year (23rd July 1147), a meteor appeared in *Hegu* and entered *Xunü*.

On a ji-chou day in the 9th month (30th September 1147), a meteor appeared and arrived in *Hushi*.

1148

On a geng-zi day in the 2nd month of the 2nd year (3rd March 1148), a meteor appeared in *Xu* and entered *Wei*.

On a ji-wei day in the 7th month (20th July 1148), a meteor appeared in *Kui* and entered *Yulin*.

On a xin-si day in the intercalary month (10th October 1148), a meteor appeared in *Bagu* and entered *Gedao*.

1149

On a geng-yin day in the 1st month of the 3rd year (16th February 1149), there was a meteor which looked like *Tiangou*[42]. It came from the east and pointed west.

On a ji-wei day in the 2nd month (17th March 1149), a meteor appeared in *Ziwei* and entered *Wei*.

On a ding-wei day in the 3rd month (4th May 1149), a meteor appeared in *Xuanyuan* and entered *Beihe*. Its tail was approximately 7 *chi* long.

[42]Literally *heavenly dog*. It may or may not refer to the asterism of the same name.

On a geng-wu day in the 4th month (27th May 1149), a meteor appeared in *Zhang* and entered *Kulou*. It was as large as a cup.

On a jia-xu day in the 6th month (30th July 1149), there was a meteor from the west and the south. It was as large as *fou*. There were two small stars which followed it. It faded, later there was a sound like thunder.

On a xin-si day in the 9th month (5th October 1149), a meteor appeared in *Wuche* and entered *Tianchan*. Also, there was a meteor which appeared in *Bi* and entered *Tianjun*. It was as large as a cup, and had a length of approximately one *zhang*.

On a yi-you day in the 9th month (9th October 1149), a meteor appeared in *Lang* and entered the stars of *Hu*.

On a xin-chou day in the 9th month (25th October 1149), a meteor appeared in *Hu* and entered *Junshi*. It was as large as a melon, and had a tail approximately 6 *chi* long.

On a ren-shen day in the 10th month (25th November 1149), a meteor appeared in *Lou* and entered *Tianpou*. It was as large as *bo*, and had a tail approximately one *zhang* long. There was a sound like thunder.

On a bing-zi day in the 10th month (29th November 1149), a meteor appeared in *Zui* and entered *Tianyuan*. Also, a meteor appeared in *Beidou* and entered the eastern *fan* of *Ziwei*.

1150

On a jia-chen day in the 1st month of the 4th year (25th February 1150), a meteor appeared in *Tianshi* and entered *Nandou*.

1151

On a yi-si day in the 2nd month of the 5th year (21st February 1151), there was a meteor, and the people of the capital were alarmed.

On a jia-chen day in the 4th month (21st April 1151), a meteor appeared in *Xu* and *Wei*, and entered *Yingshi* and *Dongbi.*

On a gui-chou day in the 5th month (29th June 1151), a meteor appeared in *Kang* and entered *Fang.* It was as large as a melon.

On a wu-chen day in the 8th month, the first day of the month (12th September 1151), a meteor appeared at the eastern *fan* of *Ziwei* and entered *Gouchen.*

On a gui-si day in the 8th month (7th October 1151), a meteor appeared at the gate between *Jiao* and *Kang*, crossed *Taiwei* within *Xiatai*, *Wenchang*, *Tianchuan*, *Daling*, *Bagu*, and *Tianjiangjun*, and arrived at the gate between *Kui* and *Lou.* It was as large as a cup, and had a tail approximately 7 *chi* long.

1156

On a bing-yin day in the 5th month of the 10th year (15th June 1156), a meteor appeared in *Xiatai* and entered *Zhongtai.* It was as large as *bo.*

On a gui-mao day in the 7th month (22nd July 1156), a meteor appeared in *Ziwei* and entered *Qigong.* It was as large as a melon.

On a xin-you day in the 7th month (9th August 1156), a meteor from the south entered *Wei.* It was as large as a melon, and had a length of approximately 3 *chi.*

On a xin-mao day in the 8th month (8th September 1156), a meteor appeared in *Wuzhuhou.* It was as large as a melon.

1157

On a yi-you day in the 5th month of the 11th year (29th June 1157), a meteor trespassed against the north of *Dizuo*. It was as large as a melon, and had a length of approximately 10 *chi*.

1159

On a ji-chou day in the 2nd month of the 13th year (23rd February 1159), a meteor appeared in *Zhongtai* and entered the eastern *fan* of *Ziwei*. It was as large as *bo*, and had a tail approximately 3 *chi* long.

1161

On a ren-shen day in the 7th month of the 15th year (25th July 1161), a meteor appeared in *Gouchen* and entered *Beidou*. Also one appeared in *Yingshi* and entered *Nou*.

On a bing-shen day in the 11th month (16th December 1161), a meteor appeared in *Tianlin* and entered *Yulin*.

1162

On a xin-chou day in the 9th month of the 16th year (17th October 1162), a meteor appeared in *Wangliang* and entered *Tianyuan*.

On a bing-chen day in the 11th month (31st December 1162), a meteor appeared in *Wuche* and entered *Daling*.

On a xin-you day in the 11th month (5th January 1163), also a meteor appeared in *Wei*, crossed *Xuanyuan*, *Taiwei* and *Dizuo*, and entered the eastern *fan* of *Ziwei*.

1163

On a wu-yin day in the 4th month of the 17th year (22nd May 1163), there was a meteor from the northwest. It faced the southeast and moved.

1164

On a ren-yin day in the 12th month of the 18th year (4th February 1165), a meteor appeared in *Dongjing* and entered *Junshi.*

1169

On a ren-xu day in the 5th month of the 23rd year (3rd June 1169), a meteor appeared in *Yi* and entered the great star of *Hegu.* It was as large as a torch, and had a length of approximately 5 *chi.*

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1173

On a xin-chou day in the 7th month of the 3rd year (20th August 1173), a meteor appeared in *Hegu* and entered *Tianpou.*

On a ding-si day in the 7th month (5th September 1173), a meteor appeared in *He*[43] and entered *Liu.*

1175

On a bing-xu day in the 7th month of the 5th year (26th July 1175), a meteor appeared in *Xu* and entered *Jian.*

On a geng-xu day in the intercalary month (18th October 1175), a meteor appeared in *Tianyuan* and entered *Yulin.*

[43]Literally *river*; possibly the Milky Way, or a short form of an asterism.

On a ren-shen day in the intercalary month (9th November 1175), a meteor appeared in *Kui* and entered *Ligong.*

On a gui-you day in the intercalary month (10th November 1175), a meteor appeared in *Lang* and entered *Kui.*

On a bing-shen day in the 10th month (3rd December 1175), a meteor appeared in the great star of *Xuanyuan* and entered *Taiwei* and *Wudizuo.*

On a yi-wei day in the 12th month (31st January 1176), a meteor appeared in the south of the five stars of *Ji* and entered *Tianji*[44].

1176

On a ji-si day in the 1st month of the 6th year (10th February 1176), a meteor appeared in *Kangchi* and entered *Xixian.* It was as large as a melon, and had a length of approximately 3 *chi.*

On a yi-wei day in the 2nd month (31st March 1176), a meteor appeared in *Taiwei* and entered *Mingtang.*

On a ji-chou day in the 4th month (24th May 1176), a meteor appeared in *Tianjin* and entered *Tianchan.*

On a yi-hai day in the 6th month (9th July 1176), a meteor appeared in *Dizuo* and entered *Huanzhe.*

On a bing-zi day in the 6th month (10th July 1176), a meteor appeared in *Xunü* and entered *Qi.* It was as large as a melon.

On a geng-zi day in the 6th month (3rd August 1176), a meteor appeared in

[44]This probably refers to the horizon.

Leibizhen and entered *Chubao.* It was as large as *fou*, and had a tail approximately 10 *chi* long.

On a yi-chou day in the 7th month (28th August 1176), a meteor appeared in *Tengshe* and entered the south star of *Xu.*

On a gui-you day in the 8th month (5th September 1176), one meteor appeared in *Leibizhen* and entered *Yulin.* It was as large as a melon. One appeared in *Tianjun* and entered *Taiyin.* It had a tail approximately 3 *chi* long.

On a wu-chen day in the 9th month (30th October 1176), a meteor appeared in *Bi* and entered *Tianjun.* It had a tail approximately 4 *chi* long.

On a ding-you day in the 12th month (27th January 1177), a meteor appeared in *Sangong* and entered *Ziwei.* It was as large as *fou*, and had a tail approximately 15 *chi* long.

1177

On a gui-hai day in the 1st month of the 7th year (22nd February 1177), a meteor appeared in *Sangong* and entered *Qigong.* It was as large as *fou*, and had a tail approximately 10 *chi* long.

On a geng-wu day in the 1st month (1st March 1177), a meteor appeared in *Xuanyuan* and entered *Zhang.* It was as large as a pear[45], and had a tail approximately 3 *chi* long.

On a bing-zi day in the 2nd month (7th March 1177), also a meteor appeared in *Fang* and entered *Tianmen.* It had a tail approximately 2 *chi* long.

On a wu-shen day in the 3rd month (8th April 1177), a meteor appeared in *Youwei*[46]

[45] *li*: a pear.

[46] This could also be *to the right of Wei.*

and entered *Beidou* and the stars of *Shaowei.* It was as large as a pear.

On a ding-hai day in the 4th month (17th May 1177), a meteor appeared in *Dongxian* and entered *Tianjiang.*

On a xin-mao day in the 4th month (21st May 1177), a meteor appeared in *Taiwei* and entered *Zhen.* It was as large as a pear, and had a tail approximately 3 *chi* long.

On a wu-shen day in the 7th month (6th August 1177), a meteor appeared in *Bagu* and entered *Ziwei.* It was as large as a pear, and had a tail approximately 5 *chi* long.

On a wu-wu day in the 7th month (16th August 1177), a meteor appeared in *Yulin* and entered *Wei.* It was as large as a pear, and had a tail approximately 6 *chi* long.

On a gui-hai day in the 9th month (20th October 1177), a meteor appeared in *Tianlin* and entered *Tianyuan.* It had a tail approximately 3 *chi* long.

On a ji-hai day in the 11th month (25th November 1177), a meteor appeared in *Bi* and entered *Yulin.* It was as large as *fou*, and had a tail approximately one *zhang* long.

On a jia-yin day in the 11th month (10th December 1177), one meteor appeared in *Tianchan* and entered *Yulin.* It was as large as a pear, and had a tail approximately 3 *chi* long. One appeared in *Zhu* and entered *Beiji.* It was as large as a melon.

1178

On a jia-shen day in the 7th month of the 8th year (6th September 1178), a meteor appeared in *Wuche* and entered *Zhen.* It was as large as a melon, and had a length of approximately 3 *chi.*

On a yi-wei day in the 8th month (17th September 1178), one meteor appeared in the stars of *Kui* and entered *Tusikong.* It was as large as a melon. One appeared in *Neiping* and entered *Xuanyuan.* It had a tail approximately one *zhang* long. One appeared in the seven stars of *Xing* and entered *Zhang.* It was as large as a melon, and had a tail approximately 7 *chi* long. One appeared in the five stars of *Guan* and entered *Gu.* It had a tail approximately 5 *chi* long. One appeared in *Xiang* and entered *Changchen.* It was as large a melon, and had a tail approximately 15 *chi* long. One appeared in *Dongjing* and entered *Wuzhuhou.* It was as large as a melon, and had a tail approximately 5 *zhang* long. One appeared in *Yi*, pointing south, and entered *Tianji.* It had a tail approximately 1 *zhang* long. Also, there were many stars flowing in all directions. There were so many they could not be counted.

In the 10th month[47] (11th November to 10th December 1178), a meteor appeared in *Juanshe* and entered *Shen.* It had a tail one *zhang* long.

On a ding-chou day in the 11th month (28th December 1178), a meteor appeared in *Wei* and entered *Tianjun.* It was as large as a melon.

On a gui-wei day in the 11th month (3rd January 1179), a meteor appeared in the southwest of *Tianshi* and entered *Tianji.* It was as large as *fou.*

1179

On a ding-mao day in the 1st month of the 9th year (16th February 1179), a meteor appeared in *Yi* and entered *Qifu.* It was as large as a cup, and had a tail approximately 4 *chi* long.

On a bing-shen day in the 2nd month (17th March 1179), a meteor appeared in *Wei* and entered *Gui.* It was as large as a pear.

On a ding-si day in the 4th month (6th June 1179), a meteor appeared in *Wei* and entered *Jizu.* It was as large as a cup.

[47]No date is given.

On a yi-chou day in the 5th month (14th June 1179), a meteor appeared in the western wall pf *Tianshi* and entered *Wei.* It was as large as a cup, and had a tail approximately 10 *chi* long.

On a gui-wei day in the 5th month (2nd July 1179), a meteor appeared in *Tianchan* and entered *Bakui.* It was as large as a cup, and had a tail approximately 7 *chi* long.

On a yi-you day in the 5th month (4th July 1179), a meteor appeared in *Tianjiangjun* and entered *Wei.* It was as large as a melon, and had a tail approximately 3 *chi* long.

On a ren-zi day in the 6th month (31st July 1179), a meteor appeared in *Tianjun* and entered *Tianlin.* It was as large as a melon.

On a jia-zi day in the 7th month (12th August 1179), a meteor appeared in *Yulin* and entered *Baijiu.* It was as large as a pear.

On a ji-mao day in the 7th month (27th August 1179), a meteor appeared in *Tianji* and entered the eastern *fan* of *Ziwei.* It was as large as a cup.

On a bing-chen day in the 9th month, the first day of the month (3rd October 1179), a meteor appeared in *Tianchan* and entered *Tianyu.* It was as large as a melon, and had a length of approximately 9 *chi.*

On a ren-xu day in the 9th month (9th October 1179), a meteor appeared in *Shenqi* and entered the left part of *Shen* and *Jian*[48]. It was as large as a cup, and had a length of approximately 5 *chi.*

On a bing-yin day in the 9th month (13th October 1179), a meteor appeared in *Wuche* and entered *Wenchang.* It was as large as a cup, was coloured red, and had

[48]This description is ambiguous.

a tail approximately 6 *chi* long.

On a bing-zi day in the 9th month (23rd October 1179), a meteor appeared in *Yulin* and entered *Beiluo.* It was as large as a cup, and had a tail 3 *chi* long.

On a ji-mao day in the 9th month (26th October 1179), a meteor appeared in *Xiang* and entered *Dachio.*

1180

On a ji-yu day in the 4th month of the 10th year (23rd May 1180), a meteor appeared in *Di* and entered *Yi.* It was as large as a melon, and had a tail 7 *chi* long.

On a gui-hai day in the 9th month (4th October 1180), a meteor appeared in *Jiuyou* and entered *Tiangou.* It was as large as a cup, and had a tail approximately 7 *chi* long.

On a yi-wei day in the 10th month (5th November 1180), a meteor appeared in *Yingshi* and entered *Leibizhen.*

On a bing-yin day in the 11th month (6th December 1180), one meteor appeared in *Tiangou* and entered *Junshi.* It was as large as *fou,* and had a tail approximately 10 *chi* long. One appeared in *Tianjun* and entered *Tianchan.* It was as large as a cup, and had a tail 15 *chi* long.

1181

On a yi-wei day in the 2nd month of the 11th year (5th March 1181), a meteor appeared in the western *fan* of *Taiwei* and entered *Yi.* It was as large as a melon, and had a tail approximately 1 *chi* long.

On a wu-shen day in the 6th month (16th July 1181), a meteor appeared in *Tianchan* and entered *Yulin.* It was as large as a cup, and had a length of approximately

7 *chi*.

On a yi-si day in the 8th month, the first day of the month (11th September 1181), a meteor appeared in *Tiantian* and entered *Nandou*. It was as large as a pear, and had a tail approximately 3 *chi* long.

On a bing-wu day in the 8th month (12th September 1181), a meteor appeared in *Hegu* and entered *Dongbi*. It was as large as a pear, and had a tail approximately 7 *chi* long.

On a bing-zi day in the 9th month (12th October 1181), one meteor appeared in *Tianhang* and entered *Ziwei*. It was as large as *fou*, and had a tail approximately 2 *chi* long. One appeared in *Wangliang* and entered *Tianjin*. It was as large as a melon, and had a tail approximately 15 *chi* long.

On a yi-wei day in the 9th month (31st October 1181), a meteor appeared in *Tianjun* and entered *Tianchan*. It was as large as a cup.

On a bing-wu day in the 10th month (11th November 1181), a meteor appeared in *Xuanyuan* and entered *Taiwei*. It was as large as a melon, and had a tail approximately 7 *chi* long.

On a ding-wei day in the 10th month (12th November 1181), a meteor appeared in *Wei* and entered *Tianjin*. It was as large as a melon, and had a length of approximately 6 *chi*.

On a wu-shen day in the 10th month (13th November 1181), a meteor appeared in the western wall of *Taiwei* and *Shangjiang*, and entered *Wuzhuhou*.

On a ding-hai day in the 11th month (22nd December 1181), a meteor appeared in *Kang* and entered *Di*. It was as large as a melon, and had a tail approximately 3 *chi* long.

1182

On a ren-xu day in the 6th month of the 12th year (25th July 1182), a meteor appeared in *Nandou* and entered *Wei.* It was as large as a pear, and had a tail approximately 5 *chi* long.

On a yi-chou day in the 6th month (28th July 1182), a meteor appeared in *Tianjin* and entered *Hegu.* It was as large as a pear.

On a xin-mao day in the 9th month (22nd October 1182), a meteor appeared in *Xuanyuan* and entered *Zhang.* It was as large as a pear, and had a tail approximately 5 *chi* long.

On a wu-shen day in the 10th month (8th November 1182), a meteor moved from the north to the south. It was as large as *fou*, and had a tail approximately 5 *chi* long.

1183

On a yi-wei day in the 4th month of the 13th year (24th April 1183), a meteor entered *Wangliang* and moved to the south. It was as large as *fou*, and had a tail approximately 10 *chi* long.

On a ji-mao day in the 5th month (7th June 1183), a meteor appeared in *Leibizhen* and entered *Yulin.* It was as large as a melon.

On a wu-chen day in the 7th month (26th July 1183), a meteor appeared in *Tianbei* and entered *Tianjin.* It was as large as a cup.

On a ding-hai day in the 7th month (14th August 1183), a meteor appeared in *Tengshe* and entered *Hegu.* It was as large as a melon, and had a tail approximately 10 *chi* long.

On a ji-hai day in the 8th month (26th August 1183), a meteor appeared in *Hegu* and entered *Tianlei.* It was as large as a pear, and had a length of approximately 7 *chi.*

On a geng-yin day in the 9th month (16th October 1183), a meteor appeared in *Tianjin* and entered *Hegu.* It was as large as a cup, and had a tail approximately 10 *chi* long.

On a xin-wei day in the 11th month (26th November 1183), a meteor appeared in the stars of *Liu* and *Xing* and entered *Xuanyuan.* It was as large as *fou*, and had a tail approximately 10 *chi* long. Also, a meteor entered within *Tianshi.* It was as large as a melon, and had a tail approximately 6 *chi* long.

On a ren-xu day in the 12th month (16th January 1184), a meteor appeared in *Xing* and entered *Zhang.* It was as large as *fou*, and had a length of approximately 7 *chi.*

1184

On a ren-chen day in the 3rd month of the 14th year (15th April 1184), a meteor appeared in *Wei* and entered *Yulin.* It was as large as a melon, and had a tail approximately 7 *chi* long. It was coloured white and moved quickly.

On a jia-wu day in the 3rd month (17th April 1184), a meteor appeared in *Taiwei* and entered *Kulou.* It was as large as *fou*, and had a tail approximately 7 *chi* long.

On a xin-mao day in the 5th month (13th June 1184), the first day of the month, a meteor from *Leibizhen* entered *Yulin.* It was as large as a melon.

On a gui-you day in the 6th month (25th July 1184), a meteor appeared in *Tianjin* and entered the wall of *Tianshi.*

On a ji-mao day in the 8th month (29th September 1184), a meteor appeared in

Wuche and entered *Shen*. It was as large as a pear.

On a ji-hai day in the 9th month (19th October 1184), a meteor trespassed against *Xuanyuan*.

On a wu-shen day in the 9th month (28th October 1184), a meteor appeared in *Daling* and entered *Wangliang*.

On a gui-chou day in the 9th month (2nd November 1184), a meteor appeared in *Tianjie* and entered *Tianyuan*.

On a jia-zi day in the 10th month (13th November 1184), a meteor appeared in *Wenchang* and entered the head of *Beidou*. It was as large as a pear.

On a ding-mao day in the 10th month (16th November 1184), a meteor appeared in *Lang* and entered *Zhang*.

On a wu-chen day in the 10th month (17th November 1184), one meteor appeared in *Tianjin* and entered *Hegu*. One appeared in *Wangliang* and entered *Gedao*.

On a ji-chou day in the 11th month (8th December 1184), a meteor appeared in *Lou* and entered *Tianchan*. It was as large as a melon, and had a tail approximately 3 *chi* long.

On a ren-xu day in the 12th month (10th January 1185), a meteor appeared in the left part of *Jiao* and entered *Kulou*.

1185

On a jia-chen day in the 1st month of the 15th year (21st February 1185), a meteor appeared in *Yi* and entered *Shen*.

On a gui-you day in the 6th month (20th July 1185), a meteor appeared in *Wei* and entered *Bi.* It was as large as a pear.

1186

On a ding-mao day in the 4th month of the 16th year (10th May 1186), a meteor appeared in *Langwei* and entered *Taiwei.*

On a bing-wu day in the intercalary month, the first day of the month (17th August 1186), a meteor appeared in *Mao* and entered *Shen.*

On a ren-yin day in the 10th month (12th December 1186), a meteor appeared in *Tianjun* and entered *Tianchan.*

On a ren-shen day in the 11th month (10th January 1187), one meteor appeared in *Daling* and entered *Wei.* One appeared in *Xixian* and entered *Fang.*

1187

On a yi-mao day in the 5th month of the 17th year (22nd June 1187), a meteor appeared in *Daling* and entered *Wei.*

On a wu-chen day in the 5th month (5th July 1187), a meteor trespassed against *Taiwei* and entered *Duanmen.*

On a bing-shen day in the 6th month (2nd August 1187), a meteor appeared in *Tengshe* and entered *Yingshi.*

On a jia-xu day in the 8th month (9th September 1187), a meteor appeared in *Shen* and entered *Dongjing.*

On a jia-chen day in the 9th month (9th October 1187), a meteor moved quickly from the northeast to the southwest. It had a tail approximately 20 *chi* long.

On a gui-hai day in the 9th month (28th October 1187), a meteor appeared in *Yulin* and entered *Tiezhi.*

On a xin-wei day in the 10th month (5th November 1187), a meteor appeared in *Dongjing* and entered *Shen.*

On a wu-yin day in the 10th month (12th November 1187), a meteor appeared in the stars of *Xuanyuan* and entered the stars of *Beihe.*

On a ji-wei day in the 11th month (23rd December 1187), a meteor appeared in *Ziwei* and entered *Beiji.*

1188

On a gui-you day in the 2nd month of the 18th year (6th March 1188), a meteor appeared in *Kulou* and entered *Qiguan.*

On a wu-zi day in the 2nd month (21st March 1188), a meteor appeared in *Wei* and entered *Nandou.*

On a yi-wei day in the 7th month (26th July 1188), a meteor moved from the east to the west. It had a tail approximately 15 *chi* long.

On a geng-xu day in the 9th month (9th October 1188), a meteor appeared in *Wei* and entered the left *qi*[49] of *Hegu.*

On a wu-chen day in the 12th month (26th December 1188), a meteor appeared and entered the sixth star of *Beidou.*

[49] *qi*: a flag, a banner.

1189

On a jia-yin day in the 8th month of the 19th year (8th October 1189), a meteor, which was as large as *weng*[50], moved from the northeast to the southwest. Light rays shone on the ground.

On a ding-si day in the 8th month (11th October 1189), a meteor appeared in *Yulin.*

On a geng-shen day in the 9th month (14th October 1189), a meteor appeared in the head of *Nandou* and entered the stars of *Ji.*

On a ding-hai day in the 10th month, the first day of the month (10th November 1189), a meteor appeared in *Beidou* and entered *Beiji.*

On a xin-mao day in the 10th month (14th November 1189), a meteor appeared in *Junshi.*

1190

On a xin-you day in the 1st month of the 20th year (12th February 1190), a meteor appeared in *Tianyuan.*

On a yi-wei day in the 2nd month (18th March 1190), a meteor appeared in *Tianjin* and entered *Hugua.* It was as large as *fou.*

On a gui-wei day in the 8th month (2nd September 1190), a meteor, which was as large as a pear, appeared in *Kui* and entered *Tianjiangjun.*

On a ren-zi day in the the 11th month (30th November 1190), a meteor appeared in *Wangliang* and entered *Tengshe.*

[50] *weng*: an earthen jar.

1191

On a ji-you day in the 6th month of the 21st year (25th July 1191), a meteor appeared in *Wangliang* and entered *Tengshe.*

On a xin-hai day in the 6th month (Dating error), a meteor appeared in *Dongbi* and entered *Leibizhen.*

On a wu-yin day in the 10th month (22nd October 1191), a meteor appeared in *Shen* and entered *Junshi.* It was as large as a melon. Also, one appeared in *Queqiu* and entered *Waichu.* It was as large as a cup.

On a geng-chen day in the 10th month (24th October 1191), a meteor appeared in *Junshi* and entered *Wenren.* It was as large as *fou.*

On a yi-si day in the 10th month (18th November 1191), a meteor appeared in *Xing* and entered *Yi.*

On a yi-you day in the 12th month (28th December 1191), a meteor appeared in *Xuanyuan* and entered *Langjiang.* It was as large as a cup.

1192

On a jia-chen day in the 8th month of the 22nd year (12th September 1192), a meteor appeared in *Nandou.*

On a xin-you day in the 8th month (29th September 1192), a meteor appeared in *Lou* and entered *Wei.* It had a tail approximately 10 *chi* long.

On a ding-mao day in the 8th month (5th October 1192), one meteor appeared to the southwest of *Jiukan* and entered *Tianji.* One appeared in *Leibizhen* towards *Yulin.* One appeared in *Wuche* and entered *Mao.*

On a gui-you day in the 9th month (11th October 1192), a meteor appeared in *Lang* and entered *Liu.*

On a gui-wei day in the 9th month (21st October 1192), a meteor appeared in *Wuzhuhou* and entered *Xuanyuan.*

On a gui-mao day in the 10th month (10th November 1192), a meteor appeared in *Xuanyuan* and entered *Zhang.*

1193

On a yi-you day in the 1st month of the 23rd year (20th February 1193), a meteor appeared in *Jiao* and entered *Fang.*

On a geng-xu day in the 4th month (16th May 1193), a meteor appeared in *Kulou* and entered *Wei.*

On a jia-xu day in the 5th month (9th June 1193), a meteor appeared in *Tianji* and entered *Jiantai.* It was as large as a melon.

On a ren-shen day in the 7th month (6th August 1193), a meteor appeared in *Nandou* and entered *Tianji.*

On a bing-shen day in the 8th month (30th August 1193), a meteor appeared in *Shen* and entered *Dongjing.*

On a wu-xu day in the 8th month (1st September 1193), a meteor appeared in *Wuche* and entered *Tianjun.*

On a ren-wu day in the 9th month (15th October 1193), a meteor appeared in the southwest and entered the northeast. It was as large as *fou.*

On a gui-wei day in the 11th month (15th December 1193), a meteor appeared in *Tianchao* and entered *Hushi.*

On a ding-hai day in the 11th month (19th December 1193), a meteor appeared in *Tianchao* and entered *Hushi.* It was coloured red, like fire.

On a wu-xu day in the 12th month (30th December 1193), a meteor appeared at the western *fan* of *Ziwei.* It was as large as a melon.

On a yi-mao day in the 12th month (16th January 1194), a meteor appeared in *Sidu* and entered *Hushi.*

1194

On a ren-shen day in the 1st month of the 24th year (2nd February 1194), a meteor appeared in *Guansuo* and entered the wall of *Tianshi.* It had a tail approximately 3 *chi* long.

On a geng-wu day in the 5th month (31st May 1194), a meteor from *Wei* entered *Jian.* It was as large as a cup, and was 3 *chi* long.

On a ji-wei day in the 12th month (15th January 1195), a meteor appeared at the western *fan* of *Ziwei* and divided into two. It penetrated *Ziweigong*, and also *Qin* and *Beiji*, as far as the eastern *fan* of *Ziwei.*

1195

On a hsin-mao day in the 3rd month of the 25th year (17th April 1195), a meteor appeared in *Nandou* and entered *Jiukan.*

On a xin-si day in the 6th month (5th August 1195), a meteor appeared in *Fang.* It was as large as *fou.*

On a ji-hai day in the 9th month (22nd October 1195), a meteor appeared in *Shang-tai.*

On a ren-yin day in the 9th month (25th October 1195), a meteor entered *Yulin.*

On a wu-wu day in the 10th month (10th November 1195), a meteor appeared in *Beihe* and entered *Mao.*

On a yi-mao day in the 12th month (6th January 1196), a meteor appeared in *Sheti* and entered the wall of *Tianshi.*

1196

On a yi-hai day in the 6th month of the 26th year (24th July 1196), a meteor appeared in *Dongbi* and entered *Yulin.*

On a bing-yin day in the 8th month (13th September 1196), a meteor appeared in *Wei* and entered *Yulin.*

On a xin-wei day in the 8th month (18th September 1196), a meteor appeared in the head of *Beidou* and entered *Hu.*

On a ji-si day in the 11th month (Dating error), one meteor appeared in *Hu* and entered *Tianshe.* One appeared at the western *fan* of *Ziwei* and entered *Wangliang.*

1197

On a ji-mao day in the intercalary 6th month of the 27th year (23rd July 1197), a meteor appeared in *Dongbi* and entered *Yulin.*

On a ren-wu day in the 8th month (24th September 1197), a meteor appeared in *Ziwei* and entered *Wenchang.*

On a geng-yin day in the 10th month (1st December 1197), a meteor (appeared in)[51] *Tengshe* and entered the great star of *He*.

On a ren-wu day in the 12th month (22nd January 1198), a meteor appeared in *Tianji*. It was as large as *fou*. There was a sound like a drum.

Reign of King Shinjong (1197-1204)

1198

On a yi-chou day in the 1st month of the 1st year (6th March 1198), a meteor appeared in *Wenchang*.

On a ji-chou day in the 2nd month (30th March 1198), a meteor entered *Jizu*.

On a geng-yin day in the 2nd month (31st March 1198), a meteor appeared in *Dajiao* and entered *Di*.

On a yi-mao day in the 3rd month (25th April 1198), a meteor appeared in *Xuanyuan* and entered *Beihe*.

On a ren-xu day in the 3rd month (2nd May 1198), a meteor appeared in *Hegu* and entered *Tianbei*.

On a xin-chou day in the 5th month (10th June 1198), a meteor appeared in *Tianshi* and entered *Taiwei*.

1199

On a wu-zi day in the 2nd month of the 2nd year (24th March 1199), a meteor appeared in *Beidou* and entered *Taiyi*.

[51] *"Appeared in"* is missing.

On a geng-xu day in the 7th month (13th August 1199), a meteor appeared in *Wuche* and entered *Tianjie.*

On a yi-mao day in the 7th month (18th August 1199), a meteor appeared in *Xu* and entered *Jiukan.*

On a wu-wu day in the 7th month (21st August 1199), a meteor appeared in *Wei* and entered *Tianji.*

On a geng-shen day in the 7th month (23rd August 1199), a meteor appeared in *Tianchan* and entered *Tianji.*

On a bing-yin day in the 8th month (29th August 1199), a meteor appeared in *Wuzhuhou.*

On a ji-mao day in the 8th month (11th September 1199), a meteor appeared in *Wuzhuhou* and entered *Liu.*

On a geng-yin day in the 9th month (22nd September 1199), a meteor appeared in *Tengshe* and entered *Kui.*

On a xin-chou day in the 9th month (3rd October 1199), a meteor appeared in *Nanhe* and entered *Tianyuan.*

On a ding-wei day in the 9th month (9th October 1199), a meteor appeared in the wall of *Tianshi* and entered *Tianji.*

On a wu-shen day in the 9th month (10th October 1199), one meteor appeared in *Tianji* and entered *Zongren.* One appeared in *Tianjun* and entered *Tianyuan.*

On a bing-chen day in the 9th month (18th October 1199), one meteor appeared in

Zuoqi and entered *Dongjing.* One appeared in *Shenqi* and entered *Shen.*

On a ren-xu day in the 10th month (24th October 1199), a meteor appeared in *Xuanyuan* and entered *Taiwei.*

On a ding-mao day in the 10th month (29th October 1199), a meteor appeared in *Xuanyuan* and entered *Taiwei.*

On a ren-wu day in the 10th month (13th November 1199), a meteor appeared in the left of *Jiao* and entered *Tianji.*

On a ji-chou day in the 11th month, the first day of the month (20th November 1199), one meteor appeared in *Tianji* and entered *Tianyuan.* One appeared in *Zuoqi* and entered *Neiping.*

1200

On a ding-si day in the 5th month of the 3rd year (15th June 1200), a meteor appeared in *Ziwei* and entered *Tengshe.* It was as large as *fou.*

On a ji-mao day in the 7th month (5th September 1200), a meteor appeared in *Ziwei* and entered *Tianji.* It was as large as a melon, and had a tail approximately 10 *chi* long.

On a jia-shen day in the 8th month (10th September 1200), a meteor entered *Yugui.*

1201

On a yi-mao day in the 3rd month of the 4th year (9th April 1201), a meteor appeared in *Shaowei* and entered *Yi.*

On a bing-wu day in the 6th month (29th July 1201), a meteor appeared in *Kui* and entered *Yulin.* It was as large as a cup, and had a tail approximately 10 *chi* long.

On a ji-mao day in the 8th month (31st August 1201), a meteor appeared in the wall of *Tianshi* and entered *Xin*. It was as large as a cup.

On a ren-zi day in the 9th month (3rd October 1201), a meteor appeared in *Tianchan* and entered *Chuyao*. It was as large as a melon.

On a wu-chen day in the 9th month (19th October 1201), a meteor appeared in *Leibizhen* and entered *Wei*. It was as large as a pear.

On a bing-zi day in the 9th month (27th October 1201), a meteor appeared in *Kui* and entered *Tianjin*. It was as large as *fou*, and had a tail approximately 10 *chi* long.

On a ji-you day in the 11th month (29th November 1201), a meteor appeared in *Tianjun* and entered *Tianchan*.

On a ding-chou day in the 12th month, the first day of the month (27th December 1201), a meteor appeared in *Nanhe* and entered *Tiangou*. It was as large as a cup.

1202

On a geng-zi day in the 10th month of the 5th year (15th November 1202), a meteor appeared in *Beihe*, pointing north, and entered *Tianji*. It was as large as *fou*, and had a tail approximately 10 *chi* long.

1204

On a ding-si day in the 6th month of the 7th year (24th July 1204), a meteor appeared in *Wangliang* and entered *Wei*. It was as large as a melon, and had a tail approximately 10 *chi* long.

Reign of King Hŭijong (1204-1211)

1207

On a yi-hai day in the 4th month of the 3rd year (28th May 1207), a meteor appeared in *Beidou* and entered *Wenchang*. It was as large as *fou*, and had a tail approximately 10 *chi* long.

Reign of King Kojong (1213-1259)

1218

On a xin-you day in the 8th month of the 5th year (13th September 1218), there was a meteor which appeared in *Wuche* and entered *Ziwei*. It was as large as *fou*.

On a bing-xu day in the 9th month (8th October 1218), a meteor appeared in *Yulin* and entered *Leibizhen*. It was as large as a melon.

1219

On a ji-chou day in the 8th month of the 6th year (6th October 1219), a meteor appeared northeast of *Li*, *Ji*, and *Dou*, penetrated *Nandou*, and fell. It was as large as an ox[52], and had a length of approximately three hundred *chi*.

1221

On a geng-chen day in the 12th month of the 8th year (14th January 1222), a meteor appeared in *Gedao* and entered *Yingshi*. It was as large as *fou*, and had a tail approximately 5 *chi* long.

1222

On a jia-xu day in the 7th month of the 9th year (5th September 1222), a meteor appeared in *Xu* and entered *Yulin*. It was as large as *fou*, and had a length of

[52] *niu*: an ox, a cow.

approximately 3 *chi*.

On a a ji-si day in the 9th month (30th October 1222), a meteor appeared in *Yingshi*. It was as large as *fou*, and had a tail approximately 3 *chi* long.

On a ren-shen day in the 9th month (2nd November 1222), a meteor appeared in *Wei* and entered *Kui*. It was as large as a melon, and had a tail approximately 3 *chi* long.

1225

On a xin-wei day in the 3rd month of the 12th year (19th April 1225), a meteor appeared in *Jizu* and entered *Wei*. It was as large as a melon, and had a tail approximately 3 *chi* long.

On a ren-xu day in the 11th month (6th December 1225), a meteor appeared in *Ziwei* and entered *Beiji*. It was as large as *fou*.

1227

On a jia-chen day in the 7th month of the 14th year (9th September 1227), a meteor appeared in *Zhinü*. It was as large as a melon, and had a tail approximately 5 *chi* long.

On a bing-shen day in the 11th month (30th December 1227), a meteor appeared in *Taiwei* and *Dizuo*, and arrived in *Ziwei* and *Gouchen*. It was as large as a melon, and had a tail more than 10 *chi* long.

1229

On a xin-mao day in the 3rd month of the 16th year (18th April 1229), a meteor appeared in *Tianji* and entered *Hegu*. It was as large as *fou*.

On a wu-chen day in the 5th month, the first day of the month (25th May 1229), a meteor appeared in *Yingshi* and entered *Lou*. It was as large as a melon, and had a length of approximately 7 *chi*.

On a geng-yin day in the 7th month (15th August 1229), a meteor appeared in *Kui*. It was as large as *fou*.

On a ji-wei day in the 10th month (12th November 1229), a meteor trespassed against the western *fan* of *Ziwei*, and also trespassed against *Gouchen* and *Dizuo*.

1243

On a jia-xu day in the 2nd month of the 30th year (19th March 1243), a meteor appeared in *Wei* and entered *Tianji*. It was as large as a melon, and had a tail approximately 3 *chi* long.

1245

On a ren-yin day in the 9th month of the 32nd year (2nd October 1245), a meteor came from the west and arrived in the east. It was as large as *fou*, and had a tail more than 10 *chi* long.

On a ding-mao day in the 10th month (27th October 1245), a meteor came from the west and arrived in the east. It was as large as a melon.

1246

On a ding-you day in the intercalary 4th month of the 33rd year (25th May 1246), a meteor appeared in the southeast, towards the south, and arrived in the east. It entered *Tianji*. It was as large as *fou*.

1250

On a geng-wu day in the 7th month of the 37th year (5th August 1250), a meteor appeared at the western *fan* of *Ziwei* and entered *Tianji.*

On a yi-si day in the 10th month (8th November 1250), a meteor entered in the eastern direction. Its lower part; there was sound.[53]

1251

On a ding-hai day in the 3rd month of the 38th year (19th April 1251), a meteor appeared in *Kulou* and entered *Kang.*

1252

On a yi-wei day in the 7th month of the 39th year (19th August 1252), a meteor came from the north and arrived in the south. There were light rays like lightning.

1253

On a ji-hai day in the 5th month of the 40th year (19th June 1253), a meteor appeared in the north of *Tianji* and entered *Ziwei.* It was as large as a pear.

On a gui-hai day in the 8th month (11th September 1253), a meteor appeared in the north of *Tianchuan* and entered *Wuche.* It was as large as a pear.

On a xin-si day in the 9th month (29th September 1253), a meteor appeared in *Shen* and entered *Tianyuan.* It was as large as a melon, and had a tail approximately 5 *chi* long.

On a wu-zi day in the 9th month (6th October 1253), a meteor appeared in *Bi* and entered *Dongjing.*

[53]There may be words missing in this record.

On a jia-xu day in the 10th month (21st November 1253), a meteor appeared in *Tianjun* and entered *Tianchan.*

1254

On a gui-you day in the 10th month of the 41st year (15th November 1254), a meteor appeared in *Liu* and entered *Xing.* It was as large as a melon.

1256

On a ding-you day in the 11th month of the 43rd year (28th November 1256), a meteor appeared in *Taiwei* and trespassed against *Youzhifa.*

1257

On a ding-hai day in the 8th month of the 44th year (14th September 1257), some meteors appeared in *Liu*, and some appeared in *Jing.* Together they entered *Hushi.*

On a ding-hai day in the 10th month (13th November 1257), a meteor appeared in *Tusikong* and entered *Tianji.* It was as large as *fou*, and had a tail approximately 10 *chi* long.

1258

On a ren-shen day in the 9th month of the 45th year (24th October 1258), one meteor penetrated *Zhuwang* and entered the gate between *Bi* and *Mao.* One appeared in *Wenchang* and entered *Tianlao.*

On a wu-xu day in the 12th month (18th January 1259), a meteor appeared in the third, northwestern star of *Yi.* It was as large as a pear, and had a tail which was approximately 2 *chi* long and yellow.

1259

On a jia-zi day in the 1st month of the 46th year (13th February 1259), a meteor appeared in *Tianjie* and entered *Tianyuan.*

On a ji-mao day in the 6th month (28th June 1259), a meteor appeared in *Yingshi* and entered *Dongbi.*

On a ren-yin day in the 9th month (19th September 1259), a meteor appeared in *Beiji* and entered *Gouchen.*

On a yi-si day in the 9th month (22nd September 1259), two meteors appeared in *Beihe* and separately entered *Dongjing* and *Yugui.*

On a geng-chen day in the 10th month (27th October 1259), a meteor appeared in *Tianguan* and entered the stars of *Shen.*

Reign of King Wŏnjong (1259-1274)

1260

On a gui-hai day in the 2nd month of the 1st year (7th April 1260), a meteor appeared in *Santai* and entered within the head of *Beidou.*

On a ji-wei day in the 6th month (1st August 1260), a meteor appeared in *Qigong* and entered *Sheti.*

On a yi-chou day in the 6th month (7th August 1260), a meteor appeared in the south of the gate between *Kang* and *Di* and entered *Tianji.*

On a xin-you day in the 10th month (1st December 1260), a meteor appeared in the head of *Beidou* and entered within *Ziwei.* It was as large as a melon.

On a gui-wei day in the 11th month (23rd December 1260), a meteor entered within *Tianyuan*.

On a yi-you day in the 11th month (25th December 1260), a meteor appeared in *Zhang* and entered *Tianji*. It was as large as a melon.

1261

On a gui-mao day in the 2nd month of the 2nd year (13th March 1261), a meteor appeared in *Pingdao* and entered *Kulou*.

1262

On a ren-xu day in the 7th month of the 3rd year (25th July 1262), one meteor appeared in *Tianjin* and entered *Lizhu*. One appeared in *Tianpou* and entered *Tianji*.

On a yi-chou day in the 7th month (28th July 1262), a meteor appeared in *Bi* and entered *Zui*.

On a wu-yin day in the 7th month (10th August 1262), a meteor appeared in *Wuping* and entered *Tianchan*.

On a ding-hai day in the 7th month (19th August 1262), a meteor appeared in *Paogua* and entered the stars of *Jian*.

On a yi-you day in the intercalary 9th month (16th October 1262), a meteor appeared in *Wuzhuhou* and entered *Yugui*. One appeared in *Jishui* and *Wenchang* and entered *Yugui*.

On a ji-chou day in the intercalary 9th month (20th October 1262), a meteor appeared in *Juanshe* and entered *Lou*.

On a yi-si day in the 11th month (4th January 1263), a meteor appeared in *Beihe* and entered *Lang*.

1263

On a ji-mao day in the 11th month of the 4th year (4th December 1263), a meteor appeared in *Shen* and entered the wall of *Tian*[54].

1264

On a yi-mao day in the 2nd month of the 5th year (9th March 1264), a meteor appeared in *Zhang* and entered the western direction.

On a gui-wei day in the 3rd month (6th April 1264), a meteor appeared in *Liu* and entered *Shen*.

On a bing-xu day in the 5th month (8th June 1264), a meteor appeared in *Kui* and entered *Wei*.

On a bing-wu day in the 6th month (28th June 1264), a meteor appeared in *Tianjin* and *Ziweigong*, and entered *Beiji*.

On a ren-xu day in the 8th month (12th September 1264), a meteor appeared in *Shen* and penetrated within the centre of the main star.

On a gui-hai day in the 8th month (13th September 1264), a meteor appeared to the east. It was as large as a bowl, and had a tail approximately 15 *chi* long.

On a yi-si day in the 10th month (25th October 1264), a meteor appeared in *Wangliang* and entered *Ziwei*.

[54] Almost certainly *Tianshi*.

On a ding-mao day in the 10th month (16th November 1264), a meteor appeared in *Tianjun* and entered *Shuifu.*

1268

On a geng-yin day in the 10th month of the 9th year (18th November 1268), a meteor entered *Jiao.*

On a ji-wei day in the 11th month (17th December 1268), a meteor appeared in *Zhen*, penetrated *Kulou*, and entered *Tianji.* It was as large as *fou.*

1269

On a geng-xu day in the 1st month of the 10th year (6th February 1269), a meteor appeared at the eastern *fan* of *Taiwei*, trespassed against *Cijiang*, arrived in *Langwei* and trespassed against *Dajiao.*

On a ding-hai day in the 2nd month (15th March 1269), a meteor appeared in *Taiwei*, trespassed against *Youzhifa*, and entered *Zhen.*

On a gui-you day in the 5th month (29th June 1269), a meteor concealed the great star of *Xin* and entered *Di.*

1270

On a wu-yin day in the 10th month of the 11th year (27th October 1270), a meteor appeared in *Langwei* and entered *Taiwei* and *Shangxiang.*

1271

On a gui-si day in the 10th month of the 12th year (6th November 1271), a meteor appeared in *Wangliang* and entered *Zhinü.*

1273

On a wu-chen day in the 8th month of the 14th year (1st October 1273), a meteor appeared in *Zhinü* and entered the wall of *Tianshi.*

On a gui-you day in the 8th month (6th October 1273), a meteor appeared in *Hegu* and entered the wall of *Tianshi.*

On a ji-you day in the 10th month, the first day of the month (11th November 1273), a meteor appeared in *Shangtai* and entered *Xiatai.*

On a jia-yin day in the 12th month (15th January 1274), a meteor appeared in *Fang* and trespassed against the wall of *Tianshi*; the western *fan.*

Reign of King Ch'ungyŏl Wang (1274-1308)

1275

On a ding-you day in the 7th month of the 1st year (21st August 1275), a meteor, which was as large as *fou*, moved from the east to the west and fell. Light rays shone on the ground.

1276

On a ren-shen day in the 6th month of the 2nd year (21st July 1276), a meteor, which was as large as *pen*, fell towards the sleeping hall.

On a jia-wu day in the 7th month (12th August 1276), a meteor moved from the west to the east. It was as large as a bowl.

On a jia-yin day in the 7th month (1st September 1276), a meteor appeared in *Tianbian* and entered *Tianjiang.*

1277

On a ding-si day in the 3rd month of the 3rd year (2nd May 1277), a meteor appeared in *Wei* and entered *Yulin.*

On a jia-xu day in the 6th month (18th July 1277), a meteor appeared in *Kang* and entered *Chiguan.*

On a ren-wu day in the 6th month (26th July 1277), a meteor appeared in *Wei* and entered *Xu.*

On a ji-hai day in the 7th month (12th August 1277), a meteor appeared in *Tianshi* and entered *Fang.* It was as large as a melon.

On a gui-hai day in the 12th month (3rd January 1278), a meteor appeared in *Wuche* and entered *Qigong.*

On a jia-zi day in the 12th month (4th January 1278), one meteor appeared in *Wuche* and entered *Beihe.* One appeared in *Yi* and entered *Qigong.* It was as large as *bo.*

1278

On a ding-you day in the 3rd month of the 4th year (7th April 1278), a meteor appeared in *Ziwei* and arrived in *Tianjiangjun.*

On a bing-zi day in the 8th month (13th September 1278), a meteor appeared in *Wenchang* and entered *Beiji.* It was as large as a pear and was coloured red. There was light. Its tail was approximately 5 *chi* long.

On a wu-yin day in the intercalary month (13th January 1279), a meteor came from the south and arrived in the west. It was as large as a melon.

1279

On a gui-hai day in the 1st month of the 5th year (27th February 1279), a meteor appeared in *Taiwei* and entered the stars of *Di.*

On a jia-yin day in the 3rd month (19th April 1279), a meteor appeared in *Paogua* and entered the wall of *Tianshi* and *Dizuo.*

On a xin-mao day in the 10th month (22nd November 1279), a meteor appeared in the northwest and arrived in the southwest.

1280

On a yi-wei day in the 2nd month of the 6th year (25th March 1280), a meteor appeared in *Yulin* and entered *Baijiu.* It had a length of approximately 7 *chi.*

1281

On a xin-mao day in the 4th month of the 7th year (15th May 1281), a meteor appeared in *Ji* and entered *Tiangou.*

On a jia-wu day in the 4th month (18th May 1281), a meteor trespassed against *Tiangou.*

1282

On a ji-wei day in the 4th month of the 8th year (7th June 1282), a meteor appeared in *Ji* and entered *Tiangou.*

On a gui-hai day in the 9th month (9th October 1282), a meteor appeared in *Tianping* and entered the wall of *Tianshi* and *Zongren.*

1288

On a wu-wu day in the 2nd month of the 14th year (6th March 1288), a meteor was seen in daytime, and entered *Tianshi.*

1289

On a gui-wei day in the 7th month of the 15th year (24th July 1289), a meteor appeared in *Dajiao* and entered *Kulou.* It was as large as a pear, and had a length of approximately 1 *chi.* Also, a meteor appeared in the stars of *Fang* and entered *Kulou.* It was as large as a melon, and had a length of approximately 2 *chi.*

On a ding-you day in the 7th month (7th August 1289), a meteor appeared in *Hegu* and entered *Beiji* and *Gouchen.*

1291

On a ding-hai day in the 8th month of the 17th year (16th September 1291), also a meteor entered *Xuanyuan.* It was as large as a melon, and had a tail approximately 5 *chi* long.

1293

On a geng-shen day in the 3rd month of the 19th year (11th April 1293), a meteor appeared in the north of *Liu xing*, penetrated *Yi* and *Zhen*, and entered *Jiao* and the second star of *Nanping.*

On a geng-shen day in the 5th month (10th June 1293), a meteor appeared in *Zhinü* and entered *Beidou.*

On a ji-you day in the 8th month (27th September 1293), in daytime, there were stars flowing in the northwest corner.

1298

On a bing-chen day in the 10th month of the 24th year (7th November 1298), a meteor appeared in *Shen* and entered *Bi.*

On a wu-yin day in the 10th month (29th November 1298), a meteor appeared in *Yugui* and entered *Ziwei.*

On a xin-si day in the 10th month (12th December 1298), a meteor appeared in *Yi* and entered *Taiwei.*

1304

On a ren-xu day in the 5th month of the 30th year (14th June 1304), a meteor appeared in *Ziwei* and entered the gate between *Xu* and *Wei.*

Reign of King Ch'ungsŏn Wang (1308-1313)

1309

On a gui-mao day in the 6th month of the 1st year (Dating error), a meteor appeared in *Nandou* and entered *Fang.*

On a gui-mao day in the 7th month (28th August 1309), a meteor appeared in *Nandou* and entered *Fang.* It was coloured red.

In the 11th month (3rd December 1309 to 1st January 1310), a meteor fell in the southwest, and it was as bright as if it were daytime.

Reign of King Ch'ungsuk Wang (1313-1330)

1320

On a ji-you day in the 8th month of the 7th year (5th September 1320), a meteor, as large as *fou* and coloured red, entered *Gedao*.

On a ren-yin day in the 9th month (28th October 1320), a meteor appeared in *Nandou*. It had a length of more than one *zhang*.

1328

On a geng-chen day in the 9th month of the 15th year (24th October 1328), a meteor entered *Yuyuefen*.

1329

On a wu-yin day in the 9th month of the 16th year (17th October 1329), a meteor appeared in *Ziwei* and entered within *Taiwei*.

1330

On a geng-zi day in the 4th month of the 17th year (7th May 1330), a meteor entered *Taiwei* and trespassed against *Kang*.

On a gui-chou day in the 5th month (20th May 1330), a meteor appeared in the stars of *Xin* and fell to the ground.

Reign of King Ch'ungsuk Wang (1332-1339)

Note: Ch'ungsuk Wang ruled from 1313-1330 and from 1332-1339; the intermediate ruler, King Ch'unghye Wang, also ruled from 1339-1344. No records of meteors survive from his reign.

1338

On a xin-si day in the 8th month of the 7th year (3rd September 1338), a meteor appeared in the wall of *Tianshi* and entered the stars of *Xin*.

Reign of King Ch'ungjŏng Wang (1348-1351)

1349

On a ren-chen day in the 1st month of the 1st year, the first day of the month (19th January 1349), a meteor appeared in the south of *Kui*. It was as large as *fou*.

Reign of King Kongmin Wang (1351-1374)

1354

On a ren-chen day in the 8th month of the 3rd year (21st August 1354), a meteor appeared in *Wangliang*. It fell in the northeast direction. It was as large as *fou*.

1357

On a yi-si day in the 8th month of the 6th year (18th August 1357), a meteor appeared in *Mao* and entered *Shen*.

1359

On a jia-chen day in the 9th month of the 8th year (6th October 1359), a meteor appeared in the east of *Dongshi*. There was a light like a mirror.

1365

On a gui-chou day in the 10th month of the 14th year (12th November 1365), a meteor moved to the northeast corner.

1366

On a xin-si day in the 9th month of the 15th year (6th October 1366), in the western direction, a meteor fell in the daytime.

1372

On a ji-mao day in the 10th month of the 21st year (1st November 1372), a meteor appeared in the north of *Wei* and fell to the ground. It was as large as *bo*.

Reign of King U Wang (1374-1388)

1376

On a ji-chou day in the 2nd month of the 2nd year (24th February 1376), a meteor appeared in the head of *Dou*.

On a gui-wei day in the 5th month (17th June 1376), a meteor, which was as large as *hu*[55], appeared in *Xuanyuan*, pointing east, and disappeared.

1380

On a wu-chen day in the 6th month of the 6th year (11th July 1380), a meteor appeared in the southern direction, crossed the southern wall of *Taiwei*, and moved in the northwest direction. It was as large as *dou*. It divided into four.

1381

On a ren-zi day in the 3rd month of the 7th year (21st April 1381), a meteor appeared in the south and moved to the northwest corner.

[55] *hu*: a pot; a jug; a vase.

1382

On a xin-chou day in the 6th month of the 8th year (3rd August 1382), a great meteor, also from the south, fell to the north.

1385

On a ji-chou day in the 3rd month of the 11th year (7th May 1385), a meteor emerged from the south and pointed to the west.