Eclipses and the Victory of European Astronomy in China

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In the late Ming dynasty, European astronomy was introduced into China by the Jesuits. After a long period of competition with traditional Chinese astronomy, it finally came to dominate imperial astronomy in the early Qing dynasty. According to historical documents, the most important factor in the success of European astronomy in China was its exactitude in the calculation of celestial phenomena, especially solar and lunar eclipses, which not only played a very special role in traditional Chinese political astrology but belonged among the most important celestial events for judging the precision of a system of calendrical astronomy.¹ This was true in ancient China from the Eastern Han (25-220) period all the way up to the late Ming period (1368-1644). During the calendar-debate between European, Islamic and Chinese astronomy in the Chongzhen reign period (1628-1644), Xu Guangqi 徐光啟 (1562-1633) also pointed out: “The erroneousness and exactness of a calendrical system can obviously only be seen from eclipses, while other phenomena are all too shady and dull to serve as indication.”² Recently, Shi Yunli and I have made a systematic analysis of the degree of precision of both the calculation and the observation of luni-solar eclipses in the late Ming

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¹ The astronomer Liu Hong 刘洪 of the Eastern Han dynasty pointed out that eclipse prediction was an important way to check the accuracy of a calendar. Guo Shoujing 郭守敬 (1231-1316) also emphasized that the accuracy of a calendar should be confirmed with eclipse predictions and observations. Cf. Lü Lingfeng 吕凌峰 and Shi Yunli 石云里 (2001).

² Hashimoto (1988).

³ Zhili yuanqi 治曆缘起 (The Reasons for the Calendar Reform) in the Xiyang xinfashu 西洋新法曆書 (Treatises on Calendrical Astronomy according to the New Western Methods), p. 8.
and Qing periods (1644-1911). Drawing on these results, this paper will discuss how the practice of eclipse calculation and observation determined the victory of European astronomy in China, and how this victory in turn changed the practice itself. I will try to show that, whereas this practice was the main factor in securing the success of European astronomy in the Qing dynasty, this victory also changed the features of this hundreds-of-years old practice in ancient Chinese astronomy.

Eclipses and the Failure of Traditional Astronomy

Since the mid-Ming dynasty, the official system of calendrical astronomy of the Ming dynasty, the Datong li 大統曆 (Great Inception Calendar), frequently showed errors in eclipse prediction. Officials in the Qintianjian 欽天監 (Bureau of Astronomy) were unable to introduce improvements, and suppressed any suggestion of revision. In 1594, the Ming government decided to compile the official history of the dynasty and began to collect related documents and literature from all over the country. Zhu Zaiyu 朱載堉 (1536-1610), a member of the imperial family, submitted his works on calendrical astronomy and pleaded for calendar reform. As Wang Yinglin 王應遴 (?-1645) explained later, Zhu’s motives were straightforward – the Datong li was basically a “barbarian” system of calendrical astronomy inherited from the Mongol Yuan dynasty and therefore was not suitable for inclusion in the official history of the Ming dynasty, and it was also outdated and erroneous. The court received Zhu’s work with splendid words of praise, but his suggestion for reform was tacitly declined. As a follow-up to Zhu’s action, Xing Yunlu 邢雲路 (1549-?), a local official in Henan and Hebei, also memorialized the throne in February 1597 about the necessity of a calendar reform on account of the serious errors of the Datong li in both the determination of the seasonal times and the prediction of a recent solar eclipse. Again, however, his petition was suppressed by the Bureau of Astronomy, in particularly the director Zhang Yinghou 張應侯. Disappointed but not totally discouraged, Xing continued to prove the error of the Datong li through observation and gnomon shadows and to write an ambitious work on calendrical astronomy, the Gujin lüli kao 古今律历考 (A Study of the Works on Musical Harmonics and Calendrical Astronomy from Antiquity to the Present) in preparation for the reform.
In 1610, the Bureau of Astronomy again made mistakes in the prediction of the solar eclipse of December 15. Fan Shouji, an official from the Military Ministry in Nanjing, impeached the Bureau and again appealed to the throne to carry out a reform, recommending Xing Yunlu and himself as the potential organizers. Soon after, in the following year, other officials, including Weng Zhengchun from the Ministry of Rites and Zhou Ziyu from the Bureau of Astronomy, also submitted a memorial requesting reform. In addition to Fan’s suggestion, they mentioned that officials such as Xu Guangqi and Li Zhizao were also familiar with the principles of calendrical astronomy, and that the Jesuit astronomers from “the Great West” such as Diego de Pantoja (1571-1618) and Sabatino de Ursis (1575-1620), had brought with them European books on astronomical observation and calculation. These books contained detailed discussions of the underlying principles of calendrical astronomy and were worthy reference tools. They therefore proposed that these persons should be asked to translate these books so that Xing could refer to them. Unfortunately, these petitions did not reach the throne, because the Wanli emperor (r. 1572-1620) was then living in seclusion in his court for Taoist cultivation.

The indifference of the emperor did not stop the Datong li from producing new mistakes, which appeared again in the prediction of the lunar eclipse of May 15, 1612. This time, the Ministry of Rites’ impeachment of the Bureau of Astronomy finally attracted the attention of the emperor, who in turn asked the Ministry of Rites to discuss remedial measures. The Ministry of Rites therefore decided to take action and, through the Duchayuan (Chief Censorate), issued a writ to recruit astronomical talents from all over the country. Soon both Xing Yunlu and Li Zhizao were summoned to Beijing to work on the project of calendrical astronomy. While Xing Yunlu used his own studies, Li Zhizao relied on the Western method.

After the outbreak of the prosecution of the Jesuits stirred up by Shen Que in 1616, Xing became the only one to continue the work. From 1616 to 1621, he completed two treatises on calendrical astronomy and predicted one solar and three lunar eclipses that occurred after 1616, but his degree of precision was proved to have been even worse even than that of the Datong li.

On October 14, 1620, Xing submitted his Cezhi lishu (Final Observation of the Constants of Calendrical Astronomy) to the court as the conclusion

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10 Shi Yunli and Song Bing (2006).
11 Peterson, Willard (1986); Shi Yunli and Song Bing (2006).
of his reform efforts. In the spring of 1621, he predicted the solar eclipse of May 21 with his “new method” and discussed anew in detail the calculation methods of luni-solar eclipses from antiquity to the present. He argued that, while the Datong li was erroneous, his “new method” would be accurate. His prediction of the solar eclipse of May 21 was again different from that made by the Bureau of Astronomy, but he still claimed that the “new method” was “extremely exact”.

As test observations proved, however, both the predictions made by Xing and the Bureau of Astronomy were in disagreement with the heavens. This event doubtlessly shook Xing’s confidence in his “new method” and signalled the failure of his reform.\textsuperscript{15} Later the same year, he memorialized the throne again to try to vindicate his failure. He attributed the error of the last prediction to his adoption of some old constants taken from Guo Shoujing and claimed that the problem would disappear after revising these constants.\textsuperscript{16} Unfortunately, his prediction of the lunar eclipse of October 8, 1623 was wrong again, much worse than the prediction made with the Datong li,\textsuperscript{17} although he probably did not live long enough to see this final failure with his own eyes.\textsuperscript{18}

The Victories of the Western Method in Eclipse Prediction

In 1628, the Chongzhen emperor (r. 1628-1644) ascended the throne and Xu Guangqi began to supervise the Bureau of Astronomy as the Deputy Minister of Rites. On June 21, 1629, a solar eclipse took place. Again, the Bureau of Astronomy failed in the prediction, while Xu Guangqi, as it was reported to the throne, made an accurate prediction using the Western astronomical method. Afterwards, the recently enthroned Chongzhen emperor gave imperial instructions to the Bureau of Astronomy:

\begin{quote}
The solar eclipse prediction by the Bureau of Astronomy is inaccurate again. Astronomy is important for the whole country. This mistake can be excused only one time, in future you should calculate carefully. If there is a mistake next time [again], you will be punished severely.\textsuperscript{19}
\end{quote}

It was because of this failure that in July of that year the Chongzhen emperor nominated Xu Guangqi to supervise the calendar revision. Then, in November, the Liju (Calendar Bureau) was established to preside over calendar revising independent of the Bureau of Astronomy. No doubt, the solar eclipse of that

\textsuperscript{15} Wang Miao (2004).
\textsuperscript{16} Shi Yunli and Song Bing (2006).
\textsuperscript{17} Wang Miao (2004).
\textsuperscript{18} Shi Yunli and Song Bing (2006).
\textsuperscript{19} Zhili yuanqi in Xiyang xinfa lishu, p. 3.
time can be regarded as the event that triggered the compilation of the *Chongzhen lishu* (Chongzhen Treatises on Calendrical Astronomy).

During the compilation of the *Chongzhen lishu*, Xu Guangqi and Li Tianjing, the advocates of European astronomy, had many disputes with the Datong ke (Grand Inception Department) and Huihui ke (Islamic Department, which produced the calendar *Huihui li*) of the Bureau of Astronomy. One of the most contended issues was which method of astronomy was the more accurate for eclipse calculation. In order to verify accuracy, all sides predicted an eclipse before it took place, and then observed it together to see whose prediction was more exact. The competition procedures and the prediction and observation data were recorded in the *Xiyang xinfa lishu*, the reprint of *Chongzhen lishu* published by Johann Adam Schall von Bell at the beginning of the Qing dynasty. He also collected the observations of a number of eclipses between 1572 and 1621, and compared them with the predictions made using the Datong *li* and Western methods.

All these predictions, observations and retrospective calculations showed the Western method to have been overwhelmingly more accurate than the Datong *li* and Huihui *li*. In the prediction of solar eclipse times, the standard error of the Western method was about 13 minutes, while the standard error of the Datong *li* was about 24 minutes. In the prediction of lunar eclipse times, the standard errors of the Western method and Datong *li* were about 2 and 50 minutes respectively. Checking with results calculated using modern techniques, we found that these records and calculations generally reflect the truth—the standard errors of the Western method and Datong *li* turn out to be about 13 and 24 minutes respectively in the prediction of the times of solar eclipses, and about 13 and 35 minutes respectively in the prediction of the times of lunar eclipses. As far as the Huihui *li* is concerned, its performances were always very poor in the tests conducted during the compilation of the *Chongzhen lishu*. Our analysis shows that its standard errors in the prediction of the times of both solar and lunar eclipses were typically one hour.

If we take a look at some particular observations during this period, however, we can find some interesting exceptions. The most typical is the solar eclipse on June 21, 1629, which was mentioned above. The reports claim that the Datong *li* again erred seriously, while Xu Guangqi is said to have made an accurate prediction using the Western method. The truth, however, is totally different, as shown in Table 1, where we list the predictions of eclipse times and magnitude made with the Datong *li* and the Western method, together with the observation re-

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20 Cf. *Gujin jiaoshi kao* (The Study of Eclipses from Antiquity to the Present) in the *Xiyang xinfa lishu*.


22 Lü Lingfeng and Shi Yunli (2003b).
We have converted the times into modern units, i.e. hours after midnight in local time (no unit for the magnitude). Checked against the theoretical results, the error of the maximum phase and last contact of the Western method is much larger than that of the Datong li, whereas the error of the magnitude and first contact of the Western method is smaller than that of the Datong li. Checked against the observation results, the error of the magnitude, maximum phase and last contact of the Western method is also much larger than that of the Datong li, while only the error of the first contact is slightly smaller than that of the Datong li. In sum, the results of the prediction provided by the Datong li were very bad, but those made by the Western method were even worse.

Table 1. Data on the prediction of the solar eclipse of June 21, 1629

<table>
<thead>
<tr>
<th></th>
<th>Magnitude\textsuperscript{24}</th>
<th>First contact</th>
<th>Maximum phase</th>
<th>Last contact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Datong li (D)</td>
<td>0.324</td>
<td>10.72</td>
<td>11.72</td>
<td>12.72</td>
</tr>
<tr>
<td>Western method (W)</td>
<td>0.2</td>
<td>10.725</td>
<td>11.494</td>
<td>11.962</td>
</tr>
<tr>
<td>Observation (O)</td>
<td>0.3</td>
<td>11.24</td>
<td>12.24</td>
<td>12.72</td>
</tr>
<tr>
<td>Theoretical results (T)</td>
<td>0.166</td>
<td>10.98</td>
<td>11.71</td>
<td>12.45</td>
</tr>
</tbody>
</table>

\[
\begin{array}{cccc}
\text{T – D} & -0.158 & 0.26 & -0.01 & -0.27 \\
\text{T – W} & -0.034 & 0.255 & 0.216 & 0.488 \\
\text{O – D} & -0.024 & 0.52 & 0.52 & 0 \\
\text{O – W} & 0.1 & 0.515 & 0.746 & 0.758 \\
\end{array}
\]

Interestingly, however, the first report of the observation is obviously in favour of Xu Guangqi, as it reads,

on the day [of the eclipse] we went to the Ministry of Rites and held the ceremony of saving the eclipsed sun together with the Minister He Ruchong 何如宠 and Associate Minister Xu Guangqi. According to the prediction of Xu Guangqi, the magnitude of the eclipse is only a little more than 2 fen 分 and [the eclipse time] does not reach five ke. According to the observation made, [Xu’s prediction] really

\textsuperscript{23} For the predictions of the Datong li, Huihui li and the Western method, cf. Zhili yuanqi in Xiyang xinfa lishu, pp. 4a-5b. For the result of the observation, cf. ibid., pp. 8ab.

\textsuperscript{24} In a solar eclipse, the magnitude is the fraction of the sun’s diameter covered by the moon at greatest eclipse. For total and annular eclipses, this value is actually the ratio of the apparent diameters of the moon to the sun.
conformed [to the heavens], while the prediction of the Bureau of Astronomy proved wrong, just as was wisely anticipated by your Majesty.  

In a memorial of the Ministry of Rites petitioning for calendar reform submitted several days later, the Datong li error is singled out again, while there is no mention of the bad performance of the Western method. More strangely, in the first report of the observation, the Chongzhen emperor is said to have “wisely anticipated” the exactness of the Western method and the erroneousness of the Datong li. How could he have done this? The most reasonable explanation is that the Chongzhen emperor had already made up his mind about the defects of the Chinese method and the merits of the Western method, and determined to launch the calendar reform adopting the Western method before the occurrence of the eclipse.

Although the Chongzhen lishu was basically completed in 1634, it was not officially adopted by the Ming dynasty because of opposition from some Chinese officials and astronomers. As soon as the Manchus occupied Beijing, Schall submitted the Bureau of Calendar and himself to the new Qing dynasty, and was thus appointed to the position of Xiuzheng lifa (Reviser of the Calendar). Soon he predicted, together with the Datong and Huixui Departments of the Bureau of Astronomy, the solar eclipse of the first day of the sixth month in the first year of the Shunzhi reign-period (September 1, 1644). Again, the Western method was reported to have been correct, the other two methods erroneous.

In the wake of that contest, the Shunzhi emperor ordered Schall to “direct the officials and students at the Bureau of Astronomy and the Bureau of Calendar to carefully adopt the new method [of calendrical astronomy], and hand it down forever.” Later that year, the almanac compiled with the Western method was officially promulgated, and soon Schall was put in charge of the affairs of the Bureau of Astronomy. Then, after Schall had presented the Xiyang xinfa lishu to the throne, the Shunzhi emperor issued a decree, declaring:

The new almanac conforms to the motion of the heavens exactly and has [now] been promulgated. The newly contributed books on calendrical astronomy contain delicate and detailed investigations. The theories are clear and the constants are established. Hereby I order the officials and students in the two Bureaus to study them diligently and to abide by them ever after.

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25 Zhili yuanqi in Xiyang xinfa lishu, p. 3ab.
26 Zhili yuanqi in Xiyang xinfa lishu, pp. 6a-10ab.
27 Cf. Tang Ruowang zoushu (Memorials of Johann Adam Schall von Bell) in Xiyang xinfa lishu, pp. 32b-33a.
28 Idem, pp. 3b–4a.
This marked the final victory of the Western method in China, in spite of the episode of the “Calendar lawsuit” stirred up by Yang Guangxian between 1664 and 1668. As a matter of fact, this episode strengthened the position of Western astronomy in China even further due to Ferdinand Verbiest’s successful counter-charge against Yang Guangxian and Yang Jingnan after the Kangxi emperor took over actual power from the regent Oboi.

Verbiest’s victory also won over the Kangxi emperor and ignited his enthusiasm for studying Western astronomy and mathematics. He became an eager student of the Jesuit fathers in these fields. In the second decade of the eighteenth century, he founded an Office of Mathematics (Suanxue guan) within his palace for the compilation of a series of works on mathematics, calendrical astronomy and musical harmonics. Among these was the famous Yuzhi lixiang kaocheng (Thorough Investigation of Calendrical Astronomy, Imperially Composed), which was basically a compact edition of the Xiyang xinha liushi with only slight changes in some basic constants and the format of some tables. The most important difference, however, was that the “Western method” had now become a firmly established part of knowledge “imperially composed” by the emperor of the Qing dynasty, and thus the “fixed law” of the heavens, as Dominique Parrenin (1665-1741) put it. Although the Yuzhi lixiang kaocheng houbian (Later Volumes of the Thorough Investigation of Calendrical Astronomy, Imperially Composed) was compiled between 1730 and 1742, it was looked upon merely as a supplement to the “imperially composed” system of the Kangxi emperor, and was kept in use together with the Yuzhi lixiang kaocheng all the way up to the end of the Qing dynasty.

Eclipse Predictions and Observations in the Qing Dynasty

When discussing the exactitude of the Western method in the prediction of eclipses, Xu Guangqi claimed in 1629 that with the application of the Western method the error in the prediction of eclipse times could now be controlled to within roughly half a ke (1 ke = 14.4 minutes). When reading about the

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30 Huang Yinong (1991a).
31 Parrenin, Dominique (1730).
33 Xu Guangqi wenji (徐光启文集), p. 415.
34 After the Western method was officially adopted in the Qing Dynasty, the ninety-six-ke-per-day system (jiushiliu ke zhi) took the place of the traditional hundred-ke-per-day system (bai ke zhi). A few researchers believe that the ninety-six-ke-per-day system had already been used during the calendar-debate at the end of the Ming Dynasty, but that is incorrect. In fact, during the period from the calendar revision at the end of Ming Dynasty to the official adoption of the
above mentioned examples of the success of the Western method in the prediction of luni-solar eclipses, we may get the impression that Xu’s claim is correct. As we showed above, however, the standard error of the Western method in the prediction of both lunar and solar eclipses amounted to about 13 minutes, which differs quite widely from his rhetoric. How then did the Western astronomy perform in the Qing dynasty?

Figure 1. Prediction time errors for solar eclipses in Qing China

Western method at the beginning of the Qing dynasty, the hundred-ke system was still applied in the Western method for eclipse prediction. For example, it is recorded in Zhili yuanqi (p. 118) in the Xiyang xinfa lishu that the first contact of the lunar eclipse in September, the seventh year of the Chongzhen reign-period (1634) was at shen-zheng 3 ke 82 fen 39 miao 申正 三 刻 八十二 分 三十九 秒. Clearly this is an indication of the use of the hundred-ke system, because in the ninety-six-ke system, 1 ke is equal to 60 fen, and 1 fen to 60 miao, while in the hundred-ke system, 1 ke is equal to 100 fen, and 1 fen to 100 miao. From the 82 fen mentioned in the record it can be deduced that the hundred-ke system was adopted.
Figure 2. Lunar eclipse first contact prediction errors in Qing China

Figure 3. Lunar eclipse maximum phase prediction errors in Qing China
From the *Qingchao wenxian tongkao* (Comprehensive Survey of Documents of the Qing Dynasty), the *Qingtianjian dang’an* (Archives of the Bureau of Astronomy of the Qing) and some Korean archives\(^{35}\) we collected a full set of predictions of both solar and lunar eclipses made by the Qing Bureau of Astronomy between 1644 and 1898, and checked them against results calculated using modern techniques.\(^{36}\) The error patterns in the predicted times of both solar and lunar eclipses are shown in Figures 1, 2, 3 and 4. It is clear from these that the exactitude of the predictions improved dramatically around 1731, when the new method included in the *Yuzhi lixiang kuocheng houbian* was formally adopted.\(^{37}\) The standard error in the prediction of the three major phases of both solar and lunar eclipses can be shown in Tables 2 and 3 respectively.

**Table 2. Comparison of the average accuracy of predictions of solar eclipses before and after 1731**

(Unit: Minute)

<table>
<thead>
<tr>
<th></th>
<th>First contact</th>
<th>Maximum phase</th>
<th>Last contact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before 1731</td>
<td>13.62</td>
<td>15.42</td>
<td>16.02</td>
</tr>
<tr>
<td>After 1731</td>
<td>8.28</td>
<td>7.92</td>
<td>8.46</td>
</tr>
</tbody>
</table>

\(^{35}\) For eclipse predictions issued by the Qing government to the King of the Chôson dynasty, cf. Shi Yunli, Lü Lingfeng and Zhang Binglun (2000).

\(^{36}\) Lü Lingfeng and Shi Yunli (2003a).


Table 3. Comparison of the average accuracy of predictions of lunar eclipses before and after 1731

(Unit: Minute)

<table>
<thead>
<tr>
<th></th>
<th>First contact</th>
<th>Maximum phase</th>
<th>Last contact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before 1731</td>
<td>9.2</td>
<td>10.5</td>
<td>8.8</td>
</tr>
<tr>
<td>After 1731</td>
<td>13.6</td>
<td>6.7</td>
<td>3.8</td>
</tr>
</tbody>
</table>

Generally speaking, the exactitude of the Western method in the prediction of the solar eclipse before 1731 did not meet Xu Guangqi’s goal at all. The average error in the prediction of eclipse times is about 15 minutes, and in a number of cases over 30 minutes. As far as the times of lunar eclipses are concerned, the precision is better than that of solar eclipses before 1731, but there are still a lot of cases where the maximum error reaches over 15 minutes, which is true even after 1731 in the times of first contact. It has been generally taken for granted that ancient Chinese astronomers up to the Qing dynasty always kept a vigilant eye on the observation of eclipses, since they were deemed as disastrous portents in traditional Chinese astrology. This raises the question whether the astronomers of the Bureau of Astronomy noticed these errors?

In the existing archives of the Qing Bureau of Astronomy, we can find observational reports of 69 solar and 156 lunar eclipses between 1721 and 1898. Our analysis shows, however, that the data in the eclipse “observations” between 1721 and 1859 were all copied directly from the predictions, except where the report states that bad meteorological conditions made the observation impossible. The five eclipse reports between 1677 and 1721 that we have collected so far contain no detailed observational data, but only such remarks as: “the observation verified the prediction exactly”. From these reports, we infer that the copying of “observational” data directly from predictions probably had begun from the time when the Bureau of Astronomy was supervised by Verbiest. The practice did not stop until 1859 when a new method named xinni yongshu 新 擬 用 數 (newly devised numbers) was used parallel to the Lixiang kaocheng houbian. In other words, when conducting conventional observations of lunar and solar eclipses, the Qing Bureau of Astronomy usually copied data directly from predictions prior to the adoption of the new xinni yongshu method.

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38 See Bo Shuren 薄樹人 (1980); Qingdai tianwen dang’an shiliao huibian 清代天文檔案史料彙編.
40 Shi Yunli and Lü Lingfeng (2002).
Why did the Bureau of Astronomy copy “observational” data directly from predictions for so long? Was it because the observation techniques before 1859 were not good enough to discern prediction errors? The answer is no, because according to our analysis, the standard error of eclipse observation during the compilation of the *Chongzhen lishu* was only around 10 minutes,\(^\text{41}\) which is smaller than the standard time errors in the eclipse predictions made with the Western method.

It seems plausible that the Bureau of Astronomy deliberately falsified the observational data for fear that they would be punished if the emperor found that they had made mistakes in eclipse prediction, as often happened in ancient China. However, this hypothesis would seem to be countered by the fact that, according to the *Da Qing huidian* (Institutions and Laws of the Great Qing), two or more officials from the Ministry of Rites used to join the observation of every eclipse.\(^\text{42}\) In addition, the Bureau of Astronomy was a complex institution composed of personnel of different religious beliefs and nationalities.\(^\text{43}\) Therefore, it would have been very difficult to keep a big issue like this secret for more than one hundred years. Just a single informer could have resulted in the Director or related officials being imprisoned or even put to death.

The most plausible explanation is probably that after the Western method had built up its credibility through repeated successes in observational tests, emperors and officials of the Qing dynasty became so trusting of it that they thought it would not make any essential difference to take “observational data” either from the heavens itself or only from predictions. In other words, in more “peaceful times” of calendrical astronomy, eclipse observations were just a matter of ritual formality as prescribed in the *Da Qing huidian*.

This kind of excessive trust in Western astronomy can be seen most obviously in the case of the Kangxi emperor. In 1704, he observed the solar eclipse occurring on November 27 and found that the observation was different from the prediction of the Bureau of Astronomy. Therefore, he issued a decree to the Minister of Rites, stressing:

> It is not possible that the new method [i.e. the Western method] can produce any mistakes. It is likely that the mistake stemmed from an erroneous transcription or was committed by the calculators who in their calculations truncated fractions too much.\(^\text{44}\)

\(^{41}\) Lü Lingfeng and Shi Yunli (2001).

\(^{42}\) *Da Qing huidian*, vol. 86, p. 4.

\(^{43}\) Huang Yinong (1991b).

\(^{44}\) *Shengzu shilu* 聖祖實錄, chap. 10, p. 10.
After an “investigation”, the Manchu Director and several other officials from the Bureau of Astronomy pleaded for punishment having found out that it was really their computations that had proved to be inexact.\(^{45}\)

On February 19, 1719, a solar eclipse should have been observed in Beijing, but could not be due to adverse weather conditions. Under such circumstances, the Bureau of Astronomy had no obligation to submit an observational report. The Kangxi emperor, however, still commented in a memorial:

> Since there is no difference at all between the prediction and observation, the observational report with astrological explanations can be submitted simply according to the prediction.\(^{46}\)

Apparently, the emperor thought that the system of calendrical astronomy that he had personally determined to promulgate was absolutely exact and thus the prediction data could directly substitute observation.

In fact, eclipse predictions were copied not only in the “observational” reports of the Bureau of Astronomy, but also in some official histories compiled in the Qing dynasty, where real observations of important astronomical phenomena were supposed to be documented. For example, in the chapter \textit{Xiangwei kao} 相位考 (Investigation of Astronomical Phenomena) of the \textit{Qingchao wenxian tongkao} 清朝文獻通考 completed in 1785, there is a record of nearly 180 solar and lunar eclipses occurring between 1644 and 1785. Analysis makes clear, however, that the data of these “observations” are also copied directly from predictions.\(^{47}\) The records of eclipses in other historical works, such as the \textit{Shilu} 實錄 (Veritable Records) of each emperor, are very simple, but obviously they are copied from predictions as well. Apparently, the officials in charge of the compilation of these books also believed that the predictions were as reliable as real observations.

In imperial China, one of the most important duties of the Imperial Observatory was to watch the sky carefully and report any portent observed to the throne. These observations were then documented and incorporated into the dynastic histories. This was also common practice in the observation of lunar and solar eclipses. In the Qing dynasty, however, the victory of the Western method changed this time-honoured practice into conventionalised eclipse observation. Instead of recording real observations, predicted data were now be copied directly into both “observational” reports and historical works.

\(^{45}\) Ibid.

\(^{46}\) Bo Shuren (1980).

\(^{47}\) Shi Yunli (2000).
Concluding Remarks

Before the beginning of the reform of calendrical astronomy in the Chongzhen reign-period, Jesuit astronomers and their Chinese followers did not formally take part in any test predictions and trial observations of lunar and solar eclipses, although rumours existed about the superiority of Western astronomy in this respect. Therefore, when the Chongzhen emperor decided to carry out a calendar reform intending to adopt the Western method, he was probably convinced not so much of the practical exactitude of that method, but was driven by the previous failures in eclipse prediction of the Datong li and the Chinese method contrived by Xing Yunlu. This was probably the source of his negative assessment of the exactitude of the Datong li in the prediction of the solar eclipse of 1629 as well. Real competition between Western, Chinese and also Islamic methods, mostly via eclipse prediction, did not begin until the beginning of the calendar reform during the Chongzhen reign.

As a result of this competition, the Western method finally gained the trust of emperors and officials of the Qing dynasty. This victory changed some aspects of the routine work of the Bureau of Astronomy, such as the reporting and documentation practices for lunar and solar eclipses, but it did not change the high regard in which the study of astronomy was held. In other words, astronomy continued to be a pragmatic tool for fulfilling the ritual and political role of the Bureau of Astronomy in the bureaucratic hierarchy centred on the emperor, rather than becoming a branch of knowledge that aimed to explore the real principles of the celestial motions through careful observation. Accordingly, astronomical phenomena such as lunar and solar eclipses were still deemed politically significant portents, although the Western method demonstrated that they actually resulted from regular movements of the celestial bodies that could be described and predicted very exactly, as was then believed, with the help of mathematical rules. Within such a political context, Chinese astronomy could hardly have followed a track of modernization, even if Johann Adam Schall von Bell and other Jesuit astronomers in China had constructed a system of calendrical astronomy based on Copernican cosmology, rather than on the Tychonic cosmology they used in the Chongzhen lishu.

Acknowledgement: This paper is based on discussions with Professor Shi Yunli, who also helped me with the English translation. My special thanks are due to Prof. Catherine Jami and to John Moffett for their careful review and English correction. The Alexander von Humboldt Research Fellowship provided a wonderful opportunity to do my research in Erlangen.
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