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Jesuit Astronomers in Beijing, 1601–1805

Agustín Udías
Department of Geophysics, Universidad Complutense, Madrid

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SUMMARY

Jesuit astronomers worked in Beijing for almost 200 years from 1601 to 1805 and occupied posts as directors of the Astronomical Observatory and presidents of the Board of Astronomy. During this time, they carried out an unprecedented transfer of scientific knowledge between Europe and China, especially in the fields of astronomy and mathematics. They took advantage of the need to reform the calendar to introduce western astronomy to China. They built astronomical instruments, brought European astronomical tables and made an extended programme of observations. The work, in particular, of Ricci, Schall, Verbiest, Kögler and Hallerstein highlights this story.

1 JESUITS AND ASTRONOMY IN CHINA

The history of astronomers who were members of the Society of Jesus in China in the 17th and 18th centuries is little known, despite their considerable importance in the history of science. Information on their lives and work, though abundant, is very dispersed and only the principle figures have been the object of detailed studies. Recently (1992 May 2–4), an international symposium (1) was organized by the Institut Monumenta Serica to commemorate the 400th anniversary of the birth of J.A.Schall. The complete history of the Jesuit astronomers in China, however, is not easily accessible and many of the references are difficult to find. For this reason, a brief account is presented here with the aim of making it known to a wider audience.

For nearly two centuries, Jesuit astronomers worked in China and occupied the positions of directors of the Astronomical Observatory in Beijing and presidents of what was called the Board, Bureau or Tribunal of Astronomy. These posts carried with them the status of Mandarin and considerable influence in the imperial court (2). During this period, these Jesuits introduced western astronomy and mathematics into China, for the first time. Since the 14th century, after the end of the Mongol domination and with the inauguration of the Ming dynasty, China was not very open to foreign influences. Jesuit missionaries in the 17th century were the first Europeans to establish themselves in Beijing. They carried out, through profound accommodation to the Chinese culture, a deep scientific and cultural exchange between West and East. In his work on science in China, J.Needham opens his chapter on the Jesuits saying: 'In the history of intercourse between civilisations there seems no parallel to the arrival in China in the 17th century of a group of Europeans so inspired by religious fervour as were the Jesuits, and, at the same time, so expert in most of those sciences which had developed with the Renaissance and the rise of capitalism'

(3). Since the beginning, when Matteo Ricci entered the gates of Beijing, all the Jesuit fathers were convinced that scientific interchange, especially in the fields of astronomy and mathematics, was the best way to establish a relationship with western culture paving the way for the introduction of Christianity into China.

In 1549, Francisco Javier, the first Jesuit missionary in the East, arrived in Japan. His contacts with its culture made him change his ideas regarding mission work which should take into account cultural differences. In 1552, he wrote to Rome that Jesuits to be sent to Japan must have some astronomical knowledge, since the Japanese were interested in the motion of the heavens, solar eclipses, lunar phases, rain, snow, comets and other natural phenomena (4). Attracted by the mystery of China he tried to travel to that great Empire, but died on the small island of Sangchwan in 1552. In 1557, Portuguese merchants had established a permanent commercial post in Macao, where they were allowed to trade with China through Canton, but the rest of the Empire remained firmly closed to all foreigners. In 1563, there was a small Jesuit community in Macao which had tried in vain to enter China. An important change in the Jesuit activities took place in 1578 with the arrival of Alessandro Valignano as visitor to the missions in the East Indies. He had a new concept of mission work, based mainly on adaptation and cultural dialogue. Christianity should not be preceded by imposing European ways, but by entering quietly into the body of Chinese culture it must endeavour to transform it from within (5). The first two Jesuits in charge of this mission were the Italians Michele Ruggieri and Matteo Ricci. They learned the Chinese language, became familiar with Chinese poetry and philosophy and adopted the dress and customs of the Chinese scholars, presenting themselves as western scholars eager to familiarize themselves with the rich Chinese culture and ready to communicate the scientific achievements of the West, especially in the fields of mathematics and astronomy.

The development of astronomy in China is a vast subject; the reader may consult Needham's work (6). Only a very short notice is given here that may help to understand the work of the Jesuits. First of all, the official character of astronomy must be noted since it was needed for the preparation of the calendar which each year was promulgated by the emperor and used by the whole empire and vassal countries. During the Former Han dynasty (206 BC to AD 9) astronomy experienced a period of great development. At this time, the Board of Astronomy was founded as an official department of the Imperial government. Simultaneously, important developments in astronomy were achieved in the East, centuries before they were in the West. Some of these are: the concept of heavenly bodies floating in an empty infinite space, the use of an equatorial polar reference system (not used in the West until 1585 by Tycho Brahe), the drawing of star maps and the construction of astronomical instruments, armillary spheres and celestial globes. Since the 5th century BC and probably some centuries before, celestial phenomena, such as solar and lunar eclipses, novae and supernovae, comets and solar spots were carefully observed and registered (7). As a matter of fact, Chinese astronomers were more interested in unusual and extraordinary phenomena than in the regular motion of heavenly bodies. During the Mongolian Yuan dynasty (1279–1368), a fruitful collaboration was established with Arabian and Persian astronomers. During this period, a Muslim school of astronomy was founded in Beijing which continued after the Mongols were expelled from power. During the Ming dynasty (1368–1644), which succeeded the Mongolian domination, astronomy and all sciences in general suffered a considerable decline. It is at the end of this dynasty that the first Jesuits arrived in Beijing. They found a feeble state of astronomy and mathematics, in which the brilliant findings of the past were practically forgotten (**8**). Astronomical predictions of solar and lunar eclipses, for example, suffered notable errors. This situation allowed the Jesuits to demonstrate the superiority of western astronomy and led to their being put in charge of the reform of the calendar and later of the Board of Astronomy.

2 THE REFORM OF THE CALENDAR

Matteo Ricci (**9**) (1522–1610), born in Macerata, Italy, was the first Jesuit to enter the Chinese Empire. With a keen mind and an extraordinary memory, together with a charming personality, he was the perfect man to carry out Valignano's projects for the penetration of China (**10**). He had studied in the Collegio Romano under Christopher Clavius (1537–1612), an eminent professor of mathematics who was held in great esteem by Galileo and he was the author of numerous books, among them an edition of Euclid's work with commentaries. Ricci who had arrived in Macao in 1583 used his knowledge of mathematics to gain the good will of Chinese scholars (**11**). In 1598, after several years living in the south of China, he received the visit of Wang tso, an important officer in the Tribunal of Rites in Nanjing who invited him to go to Beijing with the idea of working on the reform of the calendar, whose deficiencies were notorious at that time. Accompanied by the Spanish Jesuit Diego de Pantoja, he arrived in Beijing in 1601. In the memorial he presented to the Emperor Wan li, together with several gifts, he stated that having studied astronomy, geography and mathematics he wished to enter the Emperor's service.

On his way to the capital, Ricci visited the Astronomical Observatory of Nanjing, and admired the armillary spheres, celestial globes, gnomes and other astronomical instruments, all admirably worked out in bronze. He discovered that the Chinese astronomers themselves were not very familiar with these very old instruments. These instruments were, in fact, the work of the astronomer Guo Shoujing (Kuo Shou Ching; 1231–1316) who lived during the reign of the Mongolian emperor Khublai khan. Two copies had been made of these instruments and installed in the new capital of Beijing and in Ping yang. Those of Ping yang were transferred later to Nanjing. Ricci, who had been taking measures of latitude during his travel to Beijing, realized that the orientation of the instruments did not fit with their location in Nanjing. The shortcomings of the contemporary Chinese astronomers that he met made Ricci conceive the idea of using the knowledge of European astronomy to gain good will in scholarly circles. In a letter to Rome in 1605, he asked for a good Jesuit astronomer to be sent to China in order to carry out the reform of the calendar. He expected, in this way, to gain access and establish good relations among intellectuals and in the imperial court.

Attracted by the personality of Ricci and moved by his curiosity for

European science, the scholar Xu Guanqi (Hsü Kuang ch'i; 1562–1633) became the most influential Christian of his time. In 1595, he collaborated with Ricci in the translation to Chinese of the first six books of Euclid, using Clavius's edition 'Euclides Elementorum Libri XV'. Besides this work, Ricci also translated several other of Clavius's works such as *Epitome Arithmeticae Practicae* and *Gnomonica* and wrote some short texts on geometry. He also drew the first world map with the correct position of China in relation to the other countries and the newly discovered lands of America, translating all geographical names into Chinese (**12**). This chart, which soon became very popular, contrasted sharply with the traditional Chinese maps that reduced the world to the Chinese Empire surrounded by a few small countries. In all this work, Ricci was helped by Xu Guanqi and another scholar, also converted to Christianity, Li Zhizao (Li Chih tsao) (1565–1630).

After his death in 1610, Ricci's work was continued by the Portuguese Jesuit Manuel Dias who, in 1614, published a compendium in Chinese of the Ptolemaic system which was used widely by Chinese astronomers. In this book, Dias described for the first time in China the discoveries of Galileo and the use of the telescope in astronomy (**13**). On 1610 December 15, the astronomers of the observatory of Beijing made an important error in the prediction of a solar eclipse. The eclipse was correctly predicted by Sabatino de Ursis, an Italian Jesuit, who had arrived in Beijing in 1607 to help Ricci in his astronomical work. This was the first prediction of a solar eclipse by a Jesuit astronomer in China. On this occasion, Xu Guangqi, then member of the Tribunal of Rites, succeeded in convincing the other members and finally the Emperor Wan li to entrust the Jesuits with the reform of the calendar. Sabatino de Ursis and Diego de Pantoja started to work on the calendar, but the project had to be abandoned because of the opposition of Chinese astronomers. In 1616, because of the insidious plots of Shen Ch'üeh, a strong persecution against Christians occurred and de Ursis was expelled to Macao where he died in 1620. The same year, the Emperor Wan li died and after the short reign of T'ien ch'i, the new Emperor Chogzhen (Ch'ung chen) named Xu Guangqi vice president of the Tribunal of Rites in 1627 and later member of the Imperial Council. From this influential position, Xu Guangqi again proposed the calendar reform and finally, in 1629, through an imperial edict, the Jesuits were formally put in charge of the revision.

The Chinese calendar was a lunar–solar calendar, consisting of 12 lunar months of 29 or 30 days with an intercalary month added seven times every 19 years and with the first month of the astronomical year when the winter solstice took place. Many traditional Chinese scholars tried to synchronize, in different ways, the discrepancies between the lunations and the solar year. A special significance was given to certain year cycles such as those of 19, 60 and 76 years and some of their multiples. The longest was the world cycle of 23 639 years whose beginning was called the supreme ultimate grand origin (**14**). It is difficult nowadays to comprehend the importance of the calendar in the life of Chinese society at that time. According to Confucius' doctrine, the ideal of human life consists in its harmony with nature and the phases of the universe. From this view follows the need to adjust society and private lives to the rhythm of the heavens. The position of the heavenly bodies determined the propitiousness or suitability of days for social and religious celebrations and ceremonies and even for the small details of everyday life. High affairs of state and low affairs of family life were decided with an eye upon the calendar. A special department of the Board of Astronomy prepared each year a calendar that was solemnly proclaimed by the Emperor and used by the whole empire. The calendar contained the astronomical ephemerides of the Sun, Moon and planets and included information and prediction of the weather and the occurrences of extraordinary phenomena such as severe storms, earthquakes and the apparition of comets. It also fixed which days were propitious for different activities, according to the position of the planets and stars, and other astrological considerations.

In 1619, three Jesuits arrived in Macao who were to play an important role in this story, Johann Schreck (most commonly known by the latinized form of his name Terrentius or Terrenz), Wenzeslaus Kirwitzer and Johann Adam Schall. Johann Terrenz (1576–1630) had also been a student of Clavius in Rome and was accepted into the Accademia dei Lincei together with Galileo. His work during an earlier stay in India merited him the name of Plinius Indicus. He introduced the first telescope in China, given as a gift to the Emperor and he wrote to Galileo trying without success to get him interested in astronomical work in China. When his attempt to interest Galileo failed, he turned to Kepler (**15**). On 1629 June 21 a solar eclipse took place that was calculated by the two schools of Chinese astronomers, the traditional and the Muslim, and by Terrenz, whose prediction was the only correct one. He insisted that this was not an error of the astronomers, but a failure of the system, pointing to the necessity of adopting European astronomy. This prediction moved the Emperor to follow the counsel of Xu Guangqi and he decided to entrust the Jesuits with the reform of the calendar. Terrenz himself took charge of the work, helped by Nicholas Longobardo. Johann A.Schall and Giacomo Rho succeeded Terrenz after his death in 1630.

Johann Adam Schall von Bell (**16**) (1592–1666), born into a noble family of Cologne, Germany, was also a student of Clavius in the Collegio Romano and probably was present at the warm reception that was given there to Galileo in May 1611. After his arrival in China, Schall finally established himself in Beijing in 1630 to work on the calendar. After Rho's death in 1638, Schall assumed all the responsibility of this work. Before his coming to Beijing, he had been active in astronomical work, determining with precision two lunar eclipses in 1623 October 8 and 1624 September 9 and he wrote a short book in Chinese on lunar eclipses that was officially published by the Board of Civil Office. Using astronomical observations, he determined the difference in longitude between Rome and Beijing. From 1630 on, Schall worked strenuously on the reform of the calendar and in the translation of diverse material on western astronomy and mathematics to Chinese.

After the death of Xu Guangqi in 1633, Li Tianjing (Li Tien king), also a Christian, was named director of the Astronomical Observatory. Schall continued his work, without any official position, and received a direct recognition by the Emperor Chongzhen in 1638. In 1641, after a new exact prediction of a solar eclipse observed by the Emperor himself, he was ready to introduce the new calendar that was already finished. At that time, the political situation deteriorated with unrest and popular revolts giving an opportunity to the Manchu army to move from the north and invade the

Chinese empire. Chongzhen committed suicide in 1644 ending the Ming dynasty and a new Manchu emperor Shun chih occupied the imperial throne starting the Qing dynasty. The new Manchu government soon became aware of the advantages of western science and technology and maintained good relations with the Jesuits. A new prediction was made for an eclipse on 1644 September 1. The Chinese astronomers committed an error of an hour, while Schall was correct and convinced the new government of the superiority of western astronomy. Schall was named director of the Observatory with the dignity of Mandarin of fifth class and his calendar for 1645 was finally approved and officially proclaimed.

3 JESUIT PRESIDENTS OF THE BOARD OF ASTRONOMY

The Board of Astronomy was created during the Former Han dynasty (206 BC to AD 9) and depended on the Tribunal of Rites. It was formed by four departments the most important of which was in charge of the calendar (**17**). This department was divided into three sections, the first of which was dedicated to the astronomical part of the calendar and the other two to the other aspects, namely, fixing the days propitious for services, feasts, rites and ceremonies and the prediction of the weather, earthquakes and other phenomena. Schall was the first Jesuit to be named director of the Board of Astronomy by the Emperor Shun chih in 1644. The appointment was confirmed by the Tribunal of Rites in 1645. Jesuits occupied this post from 1644 to 1805, except for the period 1665–1668. The Society of Jesus was suppressed in 1773, but four ex-Jesuits continued in this position on the Board until 1805.

Schall reorganized the Board of Astronomy and reduced the five calendars that existed in the Ming dynasty to two. The first was directed to the Imperial administration and contained the ephemerides of the Sun, Moon and planets and other astronomical observations. The second was for the people and gave more simple information, established the propitiousness of the days and included predictions of the weather and other phenomena. The astronomers of the Board were divided into two schools: Chinese and Muslim. Schall tried to create a third western school, but soon abandoned the project. His influence in the court continued to grow and the young Manchu emperor Shun chih became so attached to him that he called Schall 'honourable father' and in 1658 bestowed upon him the honour of Mandarin of the first class. This honour was held only by the imperial ministers and princes (Fig. 1). Sun chih came to visit Schall often and received instruction from him about western culture and science. No westerner in the whole history of China ever enjoyed so much influence as Schall. Jesuit collaborators in the astronomical work were Ludovico Buglio, Gabriel Magalhâes, Nikolas Smogulecki and Johann Grueber. During this time, Schall worked tirelessly; beside his duty of publishing annual calendars, he taught western astronomy to Chinese astronomers, made many astronomical instruments and published up to 30 books on astronomy in Chinese, among them one on the telescope; others dealt with the theory of solar and lunar eclipses, trigonometric tables, catalogues of stars and a summary of European astronomy including the work of Copernicus, Tycho Brahe, Galileo and Kepler (**18**). His Chinese handbook on astronomy which included the work of Terrenz, Rho, and

FIG. 1. Johann A.Schall dressed with the attributes of the mandarins of the first class.

Longobardo consisted of 150 volumes divided into three parts 'Theoretical and Practical Astronomy', 'Astronomical Tables' and 'Auxiliary Sciences'.

One of the main advantages of the Jesuit astronomers over their Chinese colleagues was their use of better astronomical tables. Ricci brought the traditional Alfonsine Tables, completed in 1252. Later, Jesuits brought to China more modern tables, such as the Ephemerides Brandeburgicae published by D.Origanus in 1609, the Tabulae Frisicae (Amsterdam, 1611), those included in *Astronomia Danica* (1622) by C.S.Longomontanus (Longberg) and the *Tabulae Motuum Coelestium Perpetuae* (1632) by Phillipus Lansbergius. The latter two were both based on the system of Tycho Brahe. In 1646, Schall received the *Tabulae Rudolphinae* published by Kepler in 1627 and started to use them in his calculations.

The favour of the Emperor Shun chih, the many honours and the real influence that Schall enjoyed in the court were the cause of strong animosity on the part of some Chinese astronomers, especially of Yang kuan hsien and Uming Huen. In 1661, the Emperor Sun chih died at the early age of 23 and was succeeded by a council of regents. The enemies of Schall took advantage

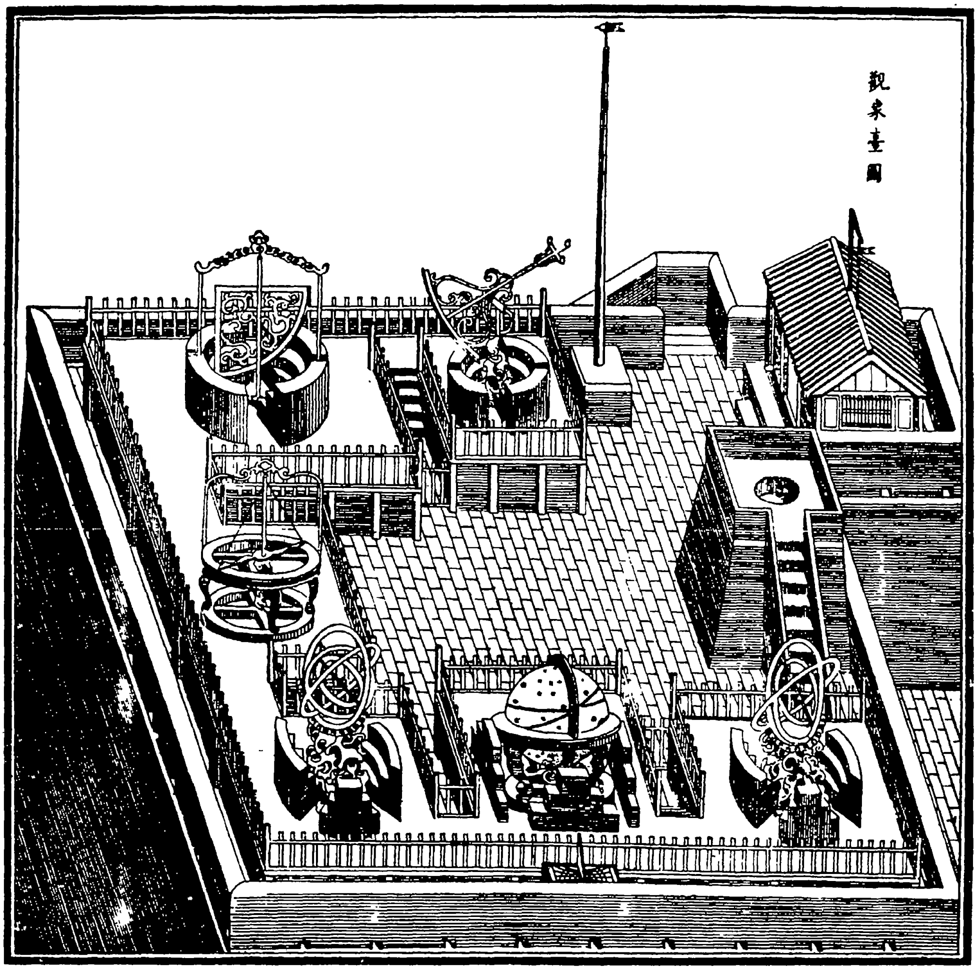

FIG. 2. The Astronomical Observatory of Beijing in the 17th century according to a drawing in F.Verbiest, *Liber Organicus Astronomiae Europeae.*

of this occasion to present three accusations against him: conspiracy against the state, preaching a religion dangerous to Chinese society and the promotion of western astronomy that was full of errors. The trial lasted 7 months and Schall and his collaborators, Jesuits and Chinese, were put in prison. On 1665 January 16 the relative value of western and Chinese astronomy was put to test with the prediction of a solar eclipse. Schall helped by his new Jesuit assistant F.Verbiest determined the exact time; while Chinese astronomers failed by more than half an hour. Nevertheless, Schall was sentenced to death and the other Jesuits to exile. A large earthquake that destroyed part of Beijing convinced the judges of the Jesuits' innocence. Such a calamity was a sign of the commission of a serious injustice. Schall died a year later in 1666 and his innocence was not officially proclaimed until 1669 by an imperial edict of the new Emperor.

Schall also had problems with his own Jesuit companions. Not all of them agreed with his work on the calendar, his dignity as Mandarin and his influence at the court. In 1649, Buglio and Magalhâes sent letters to Rome, denouncing the superstitious elements included in the calendar, especially in the setting of propitious and unpropitious days and other astrological aspects. Schall defended himself arguing that he was only responsible for the

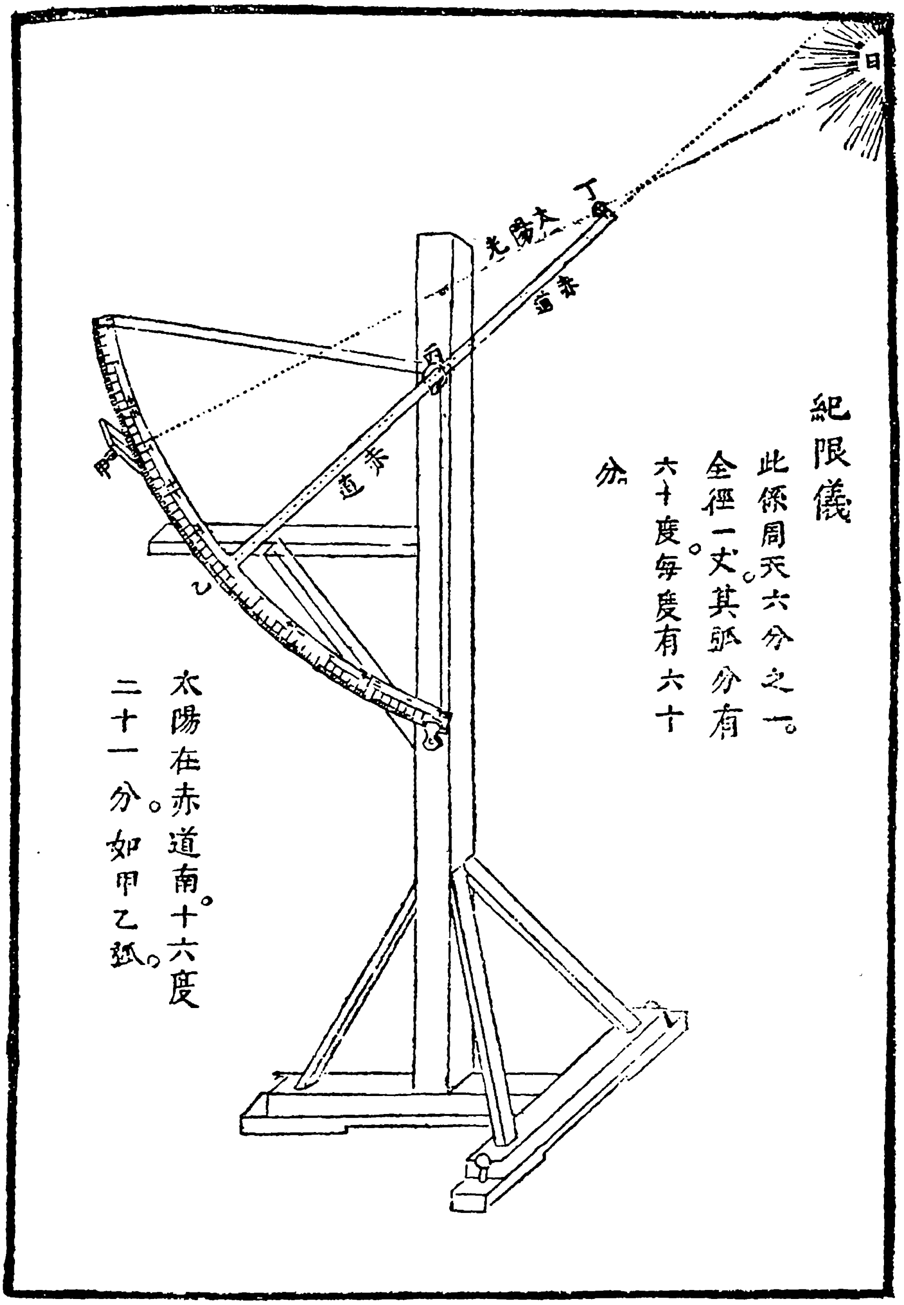

FIG. 3. Sextant used by F.Verbiest.

astronomical part of the calendar. In Rome, a commission of professors of the Collegio Romano was named to study the case. The commission gave a favourable decision in 1659 confirmed in 1664 with the approval of pope Alexander VII to Schall's position as director of the Observatory and his dignity as Mandarin.

Ferdinand Verbiest (**19**) (1623–1688), born in the Flemish village of Pitthem, arrived in Beijing in 1660 and took the second position in the Observatory under Schall's direction. Faithful collaborator of Schall, Verbiest was put into prison with him and defended him in the controversy over the calendar. In 1665, after the imprisonment of the Jesuits, Yang kuang hsien was named director of the Observatory and in charge of the calendar. A year later, the great Manchu Emperor Kangxi (Kang hsi) assumed all power and suppressed the council of regents. Verbiest pointed out the many errors contained in the calendar proposed by Yang kuang hsien for the year of 1669. The new Emperor took the problem in his hands. Verbiest in his presence explain the errors of the calendar that the Chinese astronomer could not answer and challenged Yang kuang hsien to predict the length of the shadow of a vertical rod in a determined day and hour. Yang kuang hsien did not accept the challenge and Verbiest successfully repeated the test several times in the presence of the Emperor, showing the superiority of western astronomy. He was finally named, in 1669, director of the Observatory and asked to correct the calendar.

Verbiest, as director of the Observatory, was engaged in an intense activity, taught european astronomy to Chinese astronomers, and made new astronomical instruments to substitute for the old ones. He wrote more than 20 books on astronomy in Chinese. Two of the most important, known by their latin titles, are *Liber Organicus Astronomiae Europeae* (1668) and *Astronomia Perpetua Imperatoris Kam Hi* (1683) (**20**). The latter contains the ephemerides of the Sun, Moon and planets and tables of solar and lunar eclipses for 2000 years. Besides his works on astronomy, he also wrote books on the thermometer and on the barometer.

Although Schall had built several astronomical instruments it was Verbiest who in 1669 started to replace the old instruments on the astronomical platform of the Observatory by new ones. Some of them can still be seen there. The main instruments, all of them finely cast in bronze, are the following (**21**): an ecliptic armillary sphere supported on four dragon heads; an equatorial armillary sphere supported on the arched back of a dragon; a large celestial globe encased in a horizontal framework with four pedestals; a horizon circle for azimuth measurements; a quadrant supported on a vertical shaft with upper and lower bearings; a sextant on a single pedestal (Figs 2, 3). All these instruments are described in his work published in Chinese in 1673, *De Theoria, Usu et Fabrica Instrumentorum Astronomicorum et Mechanicorum*. The purpose of these instruments in addition to their use in the astronomical observations, was to serve as a demonstration of the superiority of western astronomy.

In 1678, Verbiest was appointed president of the Tribunal or Board of Astronomy and promoted to a higher mandarin class. From 1676 on, his influence in the court increased and he became a regular counsellor of the Emperor and interpreter with European embassies. He was even given the task to construct 150 pieces of light artillery. On this occasion he wrote in Chinese a book on the construction of cannons. In 1673, the Jesuits astronomers Fillipo Grimaldi and Tomas Pereira arrived in Beijing, and in 1684, Antoine Thomas (1644–1709), who became the closest collaborator of Verbiest in the last years of his life. Verbiest's influence in the court and his ideas about the accommodation of Christian ways to Chinese customs created him some problems with other Jesuits and missionaries. However, Pope Innocence XI approved of his work with a papal brief in 1688. Verbiest died in 1688 and was buried near the graves of Ricci and Schall with solemn funerals decreed by the Emperor.

Verbiest was succeeded by Fillipo Grimaldi from 1688 to 1707 and again from 1709 to 1712. During a long trip to Europe (from 1688 to 1694) he was substituted by Tomas Pereira and Antoine Thomas. In 1702, Thomas made the first measurement of a degree of latitude in China, near Beijing. At this time, the famous controversy about the Chinese rites started. Basically, this controversy refers to the permission for Christians to take part in the ceremonies of reverence to the ancestors and Confucius. Jesuits defended the position of the civil character of these ceremonies, while other missionaries insisted on their religious character and the need for their prohibition. The controversy did not run well for the Jesuits and the rites were condemned by Pope Innocence XII in 1707 and 1715 and again by Benedict XIV in 1742. This condemnation angered Emperor Kangxi who withdrew his favour from the missionaries. The Jesuit astronomers participated in the controversy, but this did not affect their scientific work. Even in the most difficult times when the Emperor forbade preaching Christian doctrine, the Jesuits continued directing the Astronomical Observatory.

The successors of Grimaldi, until the suppression of the Society of Jesus in 1733, were German Jesuits (**22**). Kasper Kastner (1665–1709) held the post only 2 years from 1707 to 1709. He had good relations with the emperor who named him preceptor of the prince heir. Kastner took an active part in the rites controversy defending in a trip to Rome the Jesuit position of accommodation to Chinese customs. His successor, after a short second term of Grimaldi, was Kilian Stumpf (1655–1720) who was president from 1712 to 1720. His most prominent work was the construction of astronomical instruments such as a quadrant altazimuth installed in the observatory platform. He also took an active part in the rites controversy, especially during the visit to China of the papal delegate Tournons, with a writing *Informatio pro Veritate* that was condemned in Rome. In 1720, Ignaz Kögler (**23**) (1680–1746), born in Landsberg, Germany, was named president. He had been professor of mathematics in the University of Ingolstadt and occupied the post until 1746. He was held in great regard by Emperor Kangxi who died in 1722 and his successor Yong zheng (Yung chen) who promoted him to Mandarin of second class, member of the Tribunal of Rites and preceptor of the prince heir. His main scientific work consisted in the renewal of the astronomical instruments. For example, his innovations included an elaborate equatorial armillary sphere constructed in 1744 with the help of von Hallerstein and Gogeisl. He was also responsible for the publication in Chinese of astronomical and mathematical works such as tables of logarithms, catalogues of eclipses and observations of Jupiter's satellites (**24**). In 1736, Ch'ien lung occupied the imperial throne. He maintained the Jesuit astronomers in the court, even though the new condemnation of the Chinese rites by Benedict XIV in 1742 made life difficult for Chinese Christians.

The last Jesuit, strictly speaking, to hold the presidency of the Board of Astronomy was also an eminent astronomer, Augustin von Hallerstein (1703–1774), born in Laybach, Germany. Hallerstein had arrived in China in 1739 and formed part of the Observatory since 1744. During his long presidency from 1746 to 1774, he was very active, especially in astronomical observations, such as those of Mercury in 1746 and 1747. He introduced tables for the determination of ephemerides and eclipses using Newton's calculations (**25**) and held correspondence with the Royal Society and the Academy of St. Petersbourg. He collected the astronomical observations made between 1717 and 1752 by the Jesuit astronomers Pereira, Kögler, Slaviseck and himself, which were published in Europe in 1768 by the also Jesuit Maximilian Hell, director of the Astronomical Observatory in Vienna (**26**). Using part of the work of Kögler and with the collaboration of Anton Gogeisl and Felix da Rocha, Hallerstein published in Chinese a collection of astronomical tables and observations in 35 volumes (**27**).

Although the Society of Jesus was suppressed by a papal bull of Benedict XIV in 1773, four Portuguese ex-Jesuits continued the tradition and were presidents of the Board of Astronomy till 1805, after Hallerstein's death (**28**). The first was his collaborator Felix da Rocha (1713–1781) who succeeded him from 1774 to 1781. Da Rocha had carried out cartographic work in the regions west of China and Tibet for which he was promoted to Mandarin of second class in 1755. From 1781 to 1783 he was succeeded by Jose da Espinha (1722–1788) collaborator of Hallerstein and da Rocha in astronomical and cartographic work. The last two presidents were Andre Rodrigues (1729–1796) between 1783 and 1796 and José Bernardo de Almeida (1728–1805) from 1796 to 1805. Rodrigues and Almeida had established an academy of astronomy in Beijing in 1792 that formed many students for the Observatory. These four ex-Jesuits closed this long tradition of Jesuit astronomers which began with the arrival of Ricci to Beijing in 1601.

4 THE FRENCH MISSION

Members of the French mission constituted another group of Jesuit astronomers and mathematicians established in Beijing. Although they did not hold any official position, their work was also very significant in the transfer of western science to China. The origin of this mission was a letter written by Verbiest, in 1678, to his superiors in Europe asking for material and personal help for the Chinese mission. In France, the Jesuit royal confessor François de la Chaize convinced Louis XIV of the convenience of financing a mission of French Jesuit mathematicians and astronomers to China. The expedition formed by the Jesuit Fathers Fontaney, Tachard, Bouvet, Visdelou, de Comte, Bouvet and Gerbillon, under the title of 'Mathematicians of the King of France', arrived in China in 1687 (**29**). The Tribunal of Rites, always suspicious of foreigners, forbade their entrance which was only permitted after Verbiest's intercession with the Emperor. Two of the group, Bouvet and Gerbillon, founded a residence in Beijing in 1700.

The French house soon became an important scientific centre. It possessed a good library, instruments of physics and chemistry and a small astronomical observatory. Antoine Gaubil (1688–1759) excelled among the French Jesuit astronomers. He was the author of the first European history of Chinese astronomy published in France in 1732 (**30**). Needham refers to him as 'the interpreter general and father superior of the history of Chinese astronomy' (**31**) and Humboldt praised him as the wisest of the Jesuit missionaries. Another French Jesuit, Michel Benoist, introduced the Copernican system to Chinese astronomers in 1761. French Jesuits in China maintained close ties with France and thus E.Souciet in Paris in 1729 published a collection of observations made by the Jesuit astronomers in China (32). The last Jesuit of the French mission who remained in Beijing after the suppression of the order was Joseph Amiot (1718–1793) (33).

5 TRANSFER OF WESTERN SCIENCE

There is no doubt that the Jesuits brought to China many new European developments in mathematical and astronomical knowledge not known to the Chinese astronomers. In mathematics, among the most important, one finds the Euclidean geometry necessary to understand the motion of heavenly bodies, the stereographic projections and the new developments of algebra and computing methods. In astronomy, they brought the geometrical analysis of planetary motions, the doctrine of the spherical earth and its division by meridians and parallels and the methods for predicting eclipses.

Jesuits in China also did an important and enormous work in astronomical observation which has been, in part, already mentioned in the short notices about the different presidents of the Board of Astronomy. This work included, among others, catalogues of positions of fixed stars, observations of planets, satellites of Jupiter and solar and lunar eclipses. These observations were published in Chinese in voluminous works under the authorship of the different Jesuit directors. Some of them were also published in Europe in the already mentioned collections by Maximilian Hell in 1768 in Vienna and by Etienne Souciet in Paris in 1729.

However, an important problem in the Jesuits' transfer of European astronomical science to China was their failure to introduce the heliocentric system of Copernicus (34). Copernicus's work, published in 1543, was used without problems by Jesuit astronomers in China until it was forbidden by the Catholic Church in 1616, as contrary to the literal interpretation of the Bible in the context of the trial of Galileo. Before the arrival in China of the news about the condemnation of Galileo in 1633, Jesuit astronomers used Copernicus's work and that of Tycho Brahe and Kepler together with the traditional system of Ptolomy. Some Jesuits, such as Kirwitzer and Smogulecki, were certainly Copernican. After 1635, there is no further mention in the Jesuits' writings of the Copernican system and a certain preference is shown for the system of Tycho Brahe which maintained the central stationary position of the Earth. One must remember that the influential Jesuit astronomers of the Collegio Romano, Clavius, Grienberger and Scheiner never accepted the Copernican doctrine as a representation of physical reality, but only as an alternative geometrical model for the calculation of the positions of the planets. Accepting the Church condemnation, they maintained that the Aristotelian philosophy of nature must be kept until conclusive proofs of the motion of the Earth were presented. In 1651, the Jesuit J.B.Riccioli published the *Almagestum Novum* in which 77 arguments against the system of Copernicus were presented. Although some Jesuits privately held the Copernican system, it was not until much later, around 1750, that Jesuits such as R.J.Boscovich, professor at the Collegio Romano, accepted it in public (35). Through his influence, the Church finally lifted the ban on the works defending the heliocentric theory in 1757.

Jesuit mathematicians (astronomy was considered a part of mathematics), since Clavius, distinguished themselves from physicists or natural philosophers. According to this distinction, the mathematician aimed not at discovering the true principles of things, but at finding adequate quantitative descriptions in the easiest possible ways. Jesuits, according to Heilbron, found this subterfuge comfortable and taught optics, mechanics and astronomy without troubling about truth of physical reality (**36**). Thus, they used Copernicus's theory treated as a hypothesis and heliocentrism as a useful mathematical fiction. Jesuit mathematicians kept the division between the mathematical and the physical clear and were content to leave the natural causes to the physicists (**37**). This explains how Jesuit astronomers in Europe and China in the 17th and 18th centuries used the works of Copernicus, Kepler and later of Newton, for the calculation of the relative positions of celestial bodies, in spite of the Church prohibition of heliocentrism. However, it must be admitted that ecclesiastic obedience had in this case negative consequences that affected the transfer of European astronomical knowledge to China by the Jesuits. Needham enumerates also other negative aspects such as the exclusive use of ecliptic coordinates and an erroneous doctrine of the precession of the equinoxes (**38**).

In spite of these shortcomings, important as they may be, there is no doubt regarding the positive balance of the presence of Jesuit astronomers in China. They arrived at a time when science in general, and mathematics and astronomy in particular, were at a very low level there, contrasting with the birth of modern science in Europe. They made an enormous effort to translate western mathematical and astronomical works into Chinese and aroused the interest of Chinese scholars in these sciences. They did very extensive astronomical observations and carried out the first modern cartographic work in China. They also learned to appreciate the scientific achievements of this ancient culture and made them known to Europe. Through their correspondence, European scientists learned about the Chinese science and culture. There is no doubt that the scientific transfer carried out by the Jesuits between East and West benefited both sides.

6 EPILOGUE

As an epilogue, it must be added that after the restoration of the Society of Jesus in 1814, Jesuit scientists returned to China. In 1873, they founded the Observatory of Zi ka wei, near Shanghai, devoted mainly to meteorology and in 1898, the Observatory of Zo se for astronomical and geomagnetic work. In these two observatories, Jesuits dedicated themselves to astronomy, meteorology, seismology and geomagnetism. Among them, the names of M.Dechevrens, S.Chevalier, L.Froc, P.Lejay and E.Gerzi must be mentioned. The observatories were under Jesuit direction until 1950 when they were taken over by the communist government. Thus, in this way, this new presence of Jesuit scientists in China ended.

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