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Islamic astronomy in medieval China

The idea of a "scientific community" is generally thought to have arisen in Europe during the 17th century, but active transmission of scientific knowledge across cultural borders – and whole continents – began long before the dawn of the modern era. Indeed, contacts between the Far East, Central Asia and Europe were already well established in the Middle Ages. In a project financed by the LMUexcellent strategy, mathematician Dr. Benno van Dalen is investigating the links forged between Muslim astronomers and their Chinese colleagues during the 13th century.

When Marco Polo made obeisance to Kublai Khan at the Mongol court in Peking in the year 1275, he had travelled a distance of more than 12,000 kilometers from his native Venice. The mounted messengers that served as the Great Khan's postal service had kept the Emperor informed of the Venetian's progress, and he received his guest cordially and bestowed many honors upon him. Kublai Khan was the grandson of the famous Genghis Khan, who initiated the Mongol conquest of China. Kublai Khan had acceded to the Chinese throne in 1260, founding the Yuan dynasty. He now ruled over an area that encompassed virtually all of Eurasia. During the reign of the Yuan dynasty China had a population of over 60 million, many of whom were enjoying an age of peace and prosperity. Profits from trade in spices, porcelain and other exotic goods were more than enough to supply the needs of the state's coffers. As business flourished, diverse cultural contacts were initiated between East and West. Kublai Khan recruited his bureaucrats and state officials, artists and scholars from all the lands and cultures represented among his dominions. Marco Polo, who would serve the Great Khan for nearly 20 years, was one of the beneficiaries of this policy, but it also attracted tens of thousands of Muslims to China. "The highly developed system of communications connecting the far-flung parts of the Khan's realm greatly facilitated scientific exchanges between Chinese and Muslim scholars, including many astronomers", says Dr. Benno van Dalen, a mathematician and historian of science at the Institute for the History of Science at LMU Munich. In 1271, Kublai Khan founded the Bureau of Islamic

Astronomy in Peking, which operated alongside the long-established Chinese Astronomical Bureau. The founding Director of the the Islamic Observatory in Peking was Zhamaluding (Jamal al-Din), a Persian astronomer who was later entrusted with overseeing the activities of both Astronomical Offices. "Unfortunately, none of the original records of the work of the Muslim astronomers in Peking has survived. However, their contents can be reconstructed on the basis of extant, albeit unpublished, Persian and Arabic manuscripts and from Chinese documents", says Benno van Dalen. The Dutch historian of science is now engaged on a comprehensive survey of the extant sources related to the activities of the Muslim (mostly Persian) astronomers in China during the Yuan Period. His goal is to elucidate how their techniques and insights were communicated to, and received and adapted by their Chinese colleagues. "Knowledge of astronomical phenomena was enormously important in Chinese culture, so there is a very long tradition of astronomical observation and methods of prediction", says Benno van Dalen. The Chinese regarded the whole of the cosmos as a single entity. Each individual was a part of this unity, and the whole structure could be discerned in each of its parts. Droughts, floods and other natural disasters were not understood as random occurrences, but were interpreted as consequences of events in the celestial sphere. The Emperor ruled as the "Son of Heaven", and his mandate was confirmed by the calendar, which allowed the prediction of the regular recurrence of astronomical phenomena. So even the all-powerful Mongol Khan depended on the advice of his Chinese and Muslim astronomers to enable him to choose the most auspicious time for each of his most important undertakings. Astronomical phenomena such as stellar oppositions, planetary alignments and solar and lunar eclipses were all taken into consideration in his assessment of political affairs, served as warnings of imminent danger and dictated the appropriate responses to them.

ISLAMIC ASTRONOMERS OBSERVE THE SKIES OVER PEKING

Benno van Dalen's study is part of an LMUexcellent project entitled "Knowledge Transfer between Orient and Occident" at the Institute for the History of Science. In collaboration with Professor Charles S. F. Burnett of the Warburg Institute in London and Dr. Sonja Brentjes from Seville University, van Dalen's aim is to discover the channels by which scientific knowledge was passed down through time and transmitted from place to place, and identify the forces that determined how it was received and appropriated. "Only detailed studies of how scientific and technical knowledge was communicated can reveal how, for example, astronomical knowledge from 6th-century India found its way to 15th-century England" says Benno van Dalen. He is particularly interested in how the information may have been altered or distorted in the process of transfer between the originating and receiving cultures. The links between Muslim and Chinese scholars in the 13th century can also throw light on this question. The Islamic Observatory in Peking had a staff of about 40, including astronomers, teachers and administrators. The observers used astronomical instruments that had either been brought from Iran or had been built on site, on the basis of models or designs of Iranian origin. We can assume from entries made in the official annals of the Yuan dynasty that

Kublai Khan (1215-1294) was the grandson of the famous Genghis Khan. He became Emperor of China in 1271 and was the founder of the Yuan dynasty.
Source: Wikimedia Commons

the Muslim experts carried out systematic astronomical observations and preserved their data and calculations in written form. Sadly, none of the original records has survived. However, in the period following the end of Mongol hegemony in China, when the Ming dynasty ruled the country (1368-1644), some astronomical treatises were translated from Arabic and Persian into Chinese. In the main, Benno van Dalen works with three sources. The most important of these is the *Huihui lifa*, translated most probably from a Persian original in the Ming capital Nanjing in 1383. This is an astronomical handbook which includes a collection of tables, in Arabic and Persian referred to as *zījes* (pronounced "zeeches"). The columns of figures that make up the *zījes* enable one to calculate the future positions of planets and predict the times and magnitudes of solar and lunar eclipses using a few simple arithmetical methods. The texts that accompany the *zījes* inform the reader how the tables should be used, and sometimes provide explanations and even proofs of the validity of the recommended arithmetical and geometrical procedures. More than 250 different *zījes*, written in Arabic or Persian, or in a few cases other languages, were produced by Muslim astronomers between the 8th and the 19th centuries. Most of these deal with the standard topics such as chronology, trigonometry, spherical astronomy (geometrical procedures for determining celestial coordinates and other points and arcs on the heavenly sphere), the prediction of solar and lunar eclipses, and mathematical astrology. One also frequently finds lists of geographical coordinates and star positions in these works. Almost all such handbooks produced by Islamic astronomers are based on the geocentric geometrical models for the motions of the planets developed in the Almagest by the Greek scholar Claudius Ptolemaeus (Ptolemy) in Alexandria in the 2nd century. According to Benno van Dalen, the original Persian version of the Huihui lifa was in use at the Islamic Observatory in Peking at least until the end of the Mongol period. The original Chinese translation of the handbook has been lost, but several copies of a revised version of the Chinese text, prepared in 1477 by Bei Lin (who was Vice-Director of the Astronomical

Bureau at the time), have survived. Copies are now held in the Chinese National Library in Peking, the National Archive of Japan in Tokyo, and elsewhere.

The second major source that Benno van Dalen has been using to explore the state of astronomical knowledge among Islamic and Chinese astronomers in Peking during the Mongol era is the *Sanjufini Zīj*. This is an astronomical handbook written in Arabic by the otherwise unknown astronomer al-Sanjufini for the Mongol viceroy in Tibet in 1366. This collection of tables, which includes a librarian's annotations in Chinese, Tibetan transcriptions of the names of the months, and translations of the table headings into Mongolian, is now in the Bibliothèque Nationale de France in Paris. Quite fortuitously, Benno van Dalen himself rediscovered an astronomical text from the Ming period that was virtually unknown up until a few years ago. A colleague first drew his attention to an article written by an astronomer at Pulkowo Observatory near St. Petersburg, which had appeared in the journal *Copernicus* in 1868. This paper described a manuscript with astronomical tables that had been acquired by a Russian Ambassador to China and was then held in the Library at Pulkowo Observatory. "The manuscript was described in such detail that it soon became obvious to me that it was related to the tables that appear in the *Huihui lifa*, which are otherwise known only in Chinese versions. But the manuscript in Pulkowo was written in Persian!" Van Dalen immediately made inquiries as to the whereabouts of the manuscript, only to discover that the Library at Pulkowo Observatory had been extensively damaged by fire in 1997. It seemed as if the manuscript was irretrievably lost. But Van Dalen's contacts in St. Petersburg refused to give up the search. "In the end, it turned out that the manuscript had actually been transferred from the Pulkowo Library to the Academy of Sciences in St. Petersburg prior to the outbreak of the Second World War". – And indeed, when Van Dalen consulted the catalogue of manuscripts held in the Academy's collections, he discovered an entry referring to "24 folios of Astronomical Tables", which led him to the valuable document.

IDENTIFYING THE COMMON SOURCE OF THE CHINESE HANDBOOKS

In order to be able to uncover the relationships between Chinese and Arabic sources, the LMU researcher has developed computer programs that allow him to analyze the astronomical data and algorithms that appear in them. This approach enables him to determine how their authors influenced one another and which of them had contributed original results to the various extant versions. "The analysis of the mathematical content of the *Huihui lifa* and the *Sanjufini Zīj* , for instance, demonstrates that, although the two handbooks are quite different, both must derive from a common source", says Benno van Dalen. "Both of them contain the same set of parameters for planetary motions, but these differ from those found in Arabic or Persian handbooks. This strongly suggests that the source upon which the two Chinese works are based was compiled by a Muslim astronomer who worked at the Islamic Observatory in Peking during the reign of Kublai Khan." One of the versions of the Huihui lifa also includes a list of stars that is distinct from that in Ptolemy's Almagest, providing

The manuscript acquired by a Russian Ambassador to China was thought to have been lost in the fire that destroyed the Library at Pulkowo Observatory near St. Petersburg in 1997. Thanks to a tip he received from Russian colleagues, Benno van Dalen was finally able to locate the manuscipt in the Academy of Sciences in the city.
Source: St. Petersburg, Institute of Oriental Manuscripts, MS C 2460, fol. 20v.

further proof that Zhamaluding's astronomers made and recorded original observations at the Islamic Observatory. Comparable data are nowhere to be found in any of the Islamic sources known from this period. According to Van Dalen's analyses, the manuscript in St. Petersburg, on the other hand, seems to have served as an accessory source for the Chinese text of the *Huihui lifa*.

The world that Marco Polo encountered in Kublai Khan's realm was entirely alien to him, but enormously stimulating. He saw things there that he had never before dreamt of. One of these was the Chinese Observatory, which was built upon a hill and was equipped with what were then the most modern astronomical instruments available anywhere. These included armillary spheres, which had long been known in China, and several different types of sundial. In his Travels, published after he had returned to Europe, Marco Polo gives details of the splendid instruments that the Chinese astronomers used for their observations. He describes a highly civilized culture in the Far East that was in many respects superior to that of contemporary Christian Europe, although many Europeans refused to believe his account. Benno van Dalen draws a parallel with the results of his own work on medieval Muslim astronomers: "Many people in the West today know very little about the Arab world and its past achievements", he says. The contribution made by Islam to the evolution of European culture and science is greatly underestimated. "Our project may perhaps help to reemphasize the significance of Islam and the scholars it has produced over the centuries for the development of our modern view of the world."

Dr. Benno van Dalen joined the staff at the Institute for the History of Science at LMU Munich in 2008. He was editor of Historia Mathematica, International journal of history of mathematics, from 2003 to 2009.
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