PATRONS AND PATRONAGE IN CENTRAL ASIAN ASTRONOMY

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Abstract: This paper provides a brief overview of the main stages in the development of Islamic astronomy involving scholars from Central Asia between the ninth and fifteenth centuries. The influence of Central Asian astronomers extended across a vast territory of the Islamic world, from the Arab Caliphate in the West to China (Yuan and Ming Dynasties). The study primarily focuses on the role of ruler–patrons in setting research agendas and supporting astronomers who worked in institutions they established or at their courts. Patronage by rulers was not always smooth; it often took place amid military conquests, where scholars were taken captive and forced to leave their well-equipped workplaces and start anew. At times, astronomers had to persuade rulers to allocate funds for building observatories and conducting long-term observations. As a result, Islamic astronomers compiled around 200 astronomical tables (*zijes*), which they dedicated to their patrons. Despite the challenges, the symbiotic relationship between scholars and their patrons enabled Islamic astronomy to reach a high level and significantly contribute to the further development of science.

Keywords: Islamic astronomy; Al-Mamun; Bayt al-Hikmah; Alfraganus; Abu Mahmoud al-Khujandi; Fakhr al-Dawla; al-Biruni; Shams al-Maʻali Qabus; Mamun ibn Mamun; Mahmud of Ghazni; Masud;Jamal al-Din; Avicenna; SN 1006; Naṣīr al-Dīn al-Ṭūsī; Hulegu Khan; Ulugh Beg; Qāḍī Zāde al-Rūmī; Jamshid al-Kāshī; Ali Qushchi.

1 INTRODUCTION

The rise of astronomy in Muslim countries during the Middle Ages coincided with the rapid economic development of these regions. Solving many practical problems—such as creating geographical maps, compiling calendars, determining time and prayer times, and addressing navigation challenges—required rulers to establish their own scientific centers or at least maintain court astronomers and mathematicians. A ruler's prestige largely depended on his ability to organize the resolution of these tasks and ensure their quality. Astrology also played a significant role.

Astronomers successfully tackled these challenges, yet they sought greater personal freedom to explore general scientific and theoretical problems. Above all, they wanted to engage in research for its own sake—science for the sake of science. They resisted when forced to deal with administrative matters unrelated to their professional interests. This often led to conflicts, forcing scholars to leave their patrons and seek new ones.

Despite these challenges, medieval Muslim astronomers preserved and transmitted the knowledge of their predecessors, particularly Greek astronomers, to future generations. They refined old astronomical instruments, invented new more precise ones, conducted numerous valuable astronomical observations, and wrote detailed scientific treatises. Through their efforts, they laid the groundwork for the further advancement of global astronomical science.

2 AL-MAMUN'S BAYT AL-HIKMAH (HOUSE OF WISDOM)

The origins of Islamic astronomy began in Baghdad in the late eighth and early ninth centuries. Caliph Hārūn al-Rashīd (786–809), the legendary figure from *The Thousand and One Nights*, established the translation school *Bayt al-Hikmah* (*House of Wisdom*) in the capital of the caliphate, Baghdad. There, Persian, Greek, and Syriac literature was translated into Arabic (Chandio, 2021). The *Bayt al-Hikmah* reached its peak under Hārūn al-Rashīd's son, al-Maʾmūn (Ihsanoğlu, 2023; Krachkovsky, 1957).

The famous Russian–Ukrainian writer Nikolai Gogol vividly described this period in his *Arabesques* (1835):

> No ruler ever took power at such a brilliant moment for his state as al-Maʾmūn. The mighty caliphate towered majestically over the classical lands of the ancient world. It encompassed all of the flourishing southwestern Asia to the east and extended to India, while to the west, it stretched along the African coast to Gibraltar. A powerful fleet covered the Mediterranean Sea; Baghdad, the capital of this new marvelous world, saw its orders carried out in the distant provinces …
>
> Such was the state inherited by al-Maʾmūn, a ruler whose name history has placed among the benefactors of humankind. He envisioned transforming his political empire into a state of

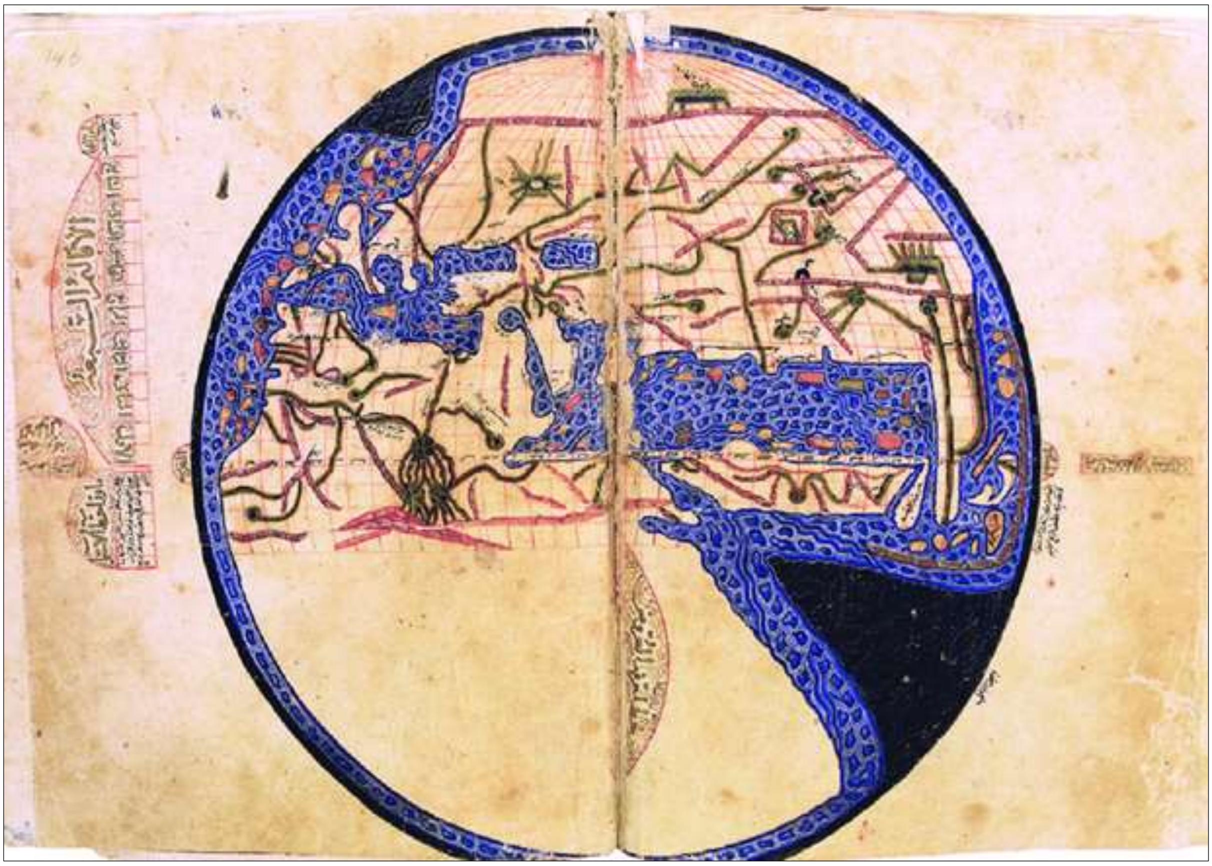

Figure 1: A copy of Al-Ma'mūn World Map. In Islamic cartography, the South is at the top, and the North is, accordingly, at the bottom of the map. However, on Al-Ma'mūn's map, the cardinal directions correspond to modern maps. The 'blue triangle' in the East represents the Indian Ocean, and to the West of it, the vast African continent is depicted (after Al-'Umarī, 1340).

learning. His character was marked by nobility. The pursuit of truth was his motto. He loved science purely for its own sake, without concern for its practical applications. He devoted himself to it with an exclusive passion. The noble al-Maʾmūn sincerely wished to bring happiness to his subjects. He knew that the surest path to this was through sciences that contributed to human development. He used all his power to introduce enlightenment to his people.

Al-Maʾmūn (reigned 813–833) went beyond merely absorbing the knowledge of previous generations; he sought to develop it further and make new discoveries.

One of his remarkable achievements was the creation of one of the earliest world maps (Figure 1). This map has survived thanks to later copies (Al-Umari, 1340).

But why am I discussing this in a research paper dedicated to astronomy in *Transoxania*—Central Asia? The reason is that before al-Maʾmūn ascended the caliphal throne after his father Hārūn al-Rashīd, he served as the Caliph's Governor in Transoxania (Krachkovsky, 1957). During that time, he established a scientific school in the capital of his domain, Merv (modern-day Turkmenistan), recruiting local scholars. In 819, after taking the throne in Baghdad, he brought all these scholars with him to the capital. Thus, the core of the *Bayt al-Hikmah* scientific school consisted of scholars from Central Asia.

The most significant figure in the *Bayt al-Hikmah* was a scholar from Khwarazm (modern Uzbekistan), Muhammad al-Khwarizmi, best known as the mathematician who laid the foundations of algebra (Sarton, 1927). One of al-Khwarizmi's most outstanding contributions was introducing the Indian numeral system, which, thanks to his work (written in Arabic), is now known as 'Arabic numerals'. This system, where a digit's value depends on its position in a number, greatly simplified arithmetic operations and essentially democratized calculations. Now, even a semi-literate person could calculate their income, taxes, and so on. This was a massive leap forward compared to the Roman numeral system used previously. If anyone doubts this, try multiplying CCCLXXXVI (386) by itself. Moreover, the Roman system lacked a symbol for zero.

Al-Khwarizmi compiled the *Zij al-Khwarizmi*, which, however, has only survived in translations. He adhered to the Indo–Iranian tradition in astronomy, which differed from the Greek–Ptolemaic tradition. The fundamental difference between these two approaches was that the Indo–Iranian tradition focused on purely practical rules and tables for planetary, solar, and lunar ephemerides, without any theoretical analysis or justification. In contrast, the Greek–Ptolemaic astronomy interpreted celestial phenomena using a kinematic–geometric model of the world (Krachkovsky, 1957). Astronomical observations in the Greek tradition were conducted to refine this model, a significant methodological advancement. This approach encouraged more precise astronomical observations, leading to developments in instrumentation and ultimately contributing to the heliocentric revolution (Krachkovsky, 1957).

Al-Maʾmūn placed great importance on the advancement of astronomy. In 828, by his order, the first Islamic astronomical observatory was built in the al-Shammasiyya quarter of Baghdad. Sometime after observations began there, another observatory was established on Mount Qasioun near Damascus. Al-Maʾmūn himself often participated in observations, and some significant results were officially recorded and sealed with the state seal. Based on these observations, the *Zij al-Mumtahan* (translated as *The Verified Tables*) was compiled (Al-Khalili, 2011).

Another major scientific achievement of the *Bayt al-Hikmah* astronomers was the measurement of a degree of the meridian in 828–830, conducted by al-Maʾmūn's order in the Sanjar Desert (modern Iraq). The motivation for these measurements was the lack of precise information about the exact length of a 'stadium' unit. The structures used for earlier determinations of this unit had not survived, and various definitions of the stadium (Egyptian, Greek, etc.) existed, creating confusion about which unit ancient sources referred to.

As Al-Biruni (1966: 172) wrote:

> Al-Maʾmūn's measurement took place after he read in Greek books that one degree of latitude equals five hundred stadia. However, he could not find any convincing explanation from translators regarding the exact length of a stadium.

The measurements were conducted on a flat desert terrain by two groups of scholars. One group traveled strictly south along the meridian, while the other moved north from the same starting point. Each day at noon, they measured the Sun's altitude above the horizon. They continued until the solar altitude differed by exactly one degree. This distance corresponded to one degree of the meridian arc. Then the average value of the two measurements was obtained. Al-Mamun's astronomers measured distances in Arabic miles or 4000 cubits (about 2000 m). According to Delambre (1819), one cubit equals four palms, which equals four *polles*, with a *polle* equaling six barley grains. Despite this detailed system of measurement, they only had an approximately standardized unit for their time. Nevertheless, their measured value of one degree—56⅔ Arabic miles—remained unsurpassed in accuracy for several centuries (Krachkovsky, 1957). These results were preserved thanks to *The Book of Astronomical Elements* by Ahmad al-Farghani from Ferghana (modern Uzbekistan) (Al-Farghani, 1998)—another brilliant representative of Al-Maʾmūn's scientific school.

It is known that *The Elements* by al-Farghani is a summary of Ptolemy's *Almagest*, with some additional sections. However, its importance lies in the fact that, written between 833 and 857 (Al-Farghani, 1998), the book contains nearly all of the significant astronomical observations and measurements conducted at the *Bayt al-Hikmah*.

Alfraganus (the Latinized name of al-Farghani) played a crucial role in ensuring that the further development of astronomy followed the Ptolemaic tradition (Alfraganus, 1669; Saliba, 1998).

The Book of Astronomical Elements remained highly popular in Europe for centuries (Ehgamberdiev, 1998). It is enough to mention that the renowned Italian poet Dante Alighieri actively used this book in his description of the heavens. It is believed that Dante's cosmography was entirely borrowed from al-Farghani (Scott, 2004: 22).

After al-Maʾmūn, Ahmad al-Farghani continued his astronomical work under the patronage of other caliphs. However, he also gained fame as a talented engineer. The only reliably documented date in al-Farghani's biography is 861 when he was appointed by Caliph al-Mutawakkil (r. 847–861) to oversee the restoration of the Nilometer (Figure 2) on Rawda Island near Cairo (Wiet, 1924).

This Cairo Nilometer is the most famous surviving example of dozens of similar structures built by the Egyptians. William Shakespeare even referenced the Nilometer in *Antony and Cleopatra* (Act 2, Scene 7):

Figure 2: The Nilometer on Rawda Island near Cairo. This was designed to measure the water level during the Nile floods, was used annually to determine the amount of tax levied on the peasants. In 861, the Cairo Nilometer was restored by Ahmad al-Fargani on the orders of Caliph al-Mutawakkil (r. 847–861) (courtesy: A. Akhmedov).

ANTONY:
Thus do they, sir: they take the flow o' th' Nile
By certain scales i' th' Pyramid; they know
By th' height, the lowness, or the mean if dearth
Or foison follow. The higher Nilus swells,
The more it promises. As it ebbs, the seedsman
Upon the slime and ooze scatters his grain,
And shortly comes to harvest.

The Nilometer was designed to determine the water level during the annual flooding of the Nile. The harvest, and consequently the amount of taxes imposed on the peasants, depended on it. This is what the then-President of Egypt, Ḥusni Mubarak, referred to in 1998 during the ceremonial unveiling of the monument to Ahmad al-Farghani on Rawda Island: "Ahmad al-Farghani, for centuries, ensured the establishment of justice on Egyptian soil." (from TV news).

We have mentioned here two of the most prominent representatives of the scholarly world of *Bayt al-Hikmah*. However, dozens of other scholars from Central Asia also worked there, whose deeds and names are referenced in the literature (e.g. see Krachkovsky, 1957).

3 AL-BIRUNI AND AVICENNA UNDER ROYAL PATRONAGE

Another center of Islamic science, particularly astronomy, was established in Khwarazm (modern Uzbekistan) during the tenth and eleventh centuries It is associated with the names of such outstanding encyclopedists as al-Biruni and Avicenna (the Latinized form of Ibn Sina).

Al-Biruni was born in an outlying district of Kath (modern Uzbekistan), the capital of the Afrighid Kingdom of Khwarazm, in 973 (Bosworth, 2000). Most of the works of al-Biruni are written in Arabic. His list of works includes about 110 titles, divided into 12 categories: astronomy, mathematical geography, mathematics, astrological aspects and transits, astronomical instruments, chronology, comets, an untitled category, astrology, religion, etc.

The following list of his main works gives an idea of the scale of al-Biruni's scientific activity (Bulgakov, 1972):

- *A Critical Study of What India Says, Whether Accepted by Reason or Refused*, popularly called *Kitāb al-Hind* (*The Book on India*); English translations are called *Indica* or *Alberuni's India*.
- *The Remaining Signs of Past Centuries*, a comparative study of the calendars of cultures and civilizations (including several chapters on Christian cults), which contains mathematical, astronomical, and historical information.
- *The Mas'udi Law*, an encyclopedia of astronomy, geography, and engineering, dedicated to Mas'ud, son of the Ghaznavid Sultan Mahmud of Ghazni.
- *Understanding Astronomy*, a question-and-answer style book about mathematics and astronomy, in Arabic and Persian.
- *Pharmacy*, a work on drugs and medicines.
- *Gem and Geology*, a manual about minerals and gems, dedicated to Mawdud, the son of Mas'ud.
- *A History of Mahmud of Ghazni and his Father*.
- *A History of Khwarezm*.
- *Risālah li-al-Bīrūnī* (Epître de Berūnī).

Al-Biruni was fortunate that his first teacher was a cousin of the ruler of Khwarazm, Abu Nasr Mansur ibn Irak, a talented scholar who left many works on astronomy and mathematics. It is enough to say that he is credited with one of the first proofs of the sine theorem for both planar and spherical triangles. As a result, his education and early scientific work were conducted under the guidance of this well-known scholar and with the patronage of the ruler of Khwarazm. All this influenced the developing scientist al-Biruni and determined astronomy and mathematics as the primary fields of his activity (Bulgakov, 1972).

In Kath, al-Biruni constructed a globe of the Earth (or rather a hemisphere) about 5 meters in size, on which he plotted the positions of known cities, and he planned to add the positions of new cities whose locations he intended to determine. However, these plans were never realized. In 995, Kath was conquered by the Emir of Gurganj, al-Mamun ibn Muhammad. As a person close to the court, al-Biruni faced danger and was forced to flee, leaving all his records behind. His globe was destroyed (Bulgakov, 1972).

Al-Biruni moved to Ray (modern Iran), where he met the famous astronomer and mathematician Abu Mahmud al-Khujandi. The latter developed a unique astronomical instrument (Figure 3), which consisted of one-sixth of an arc with a radius of about 20 meters, part of which was placed in a trench. On either side of the trench, he built walls and created a diopter hole on the roof. The arc was placed along the meridian, allowing it to measure the solar altitude at noon. He built this instrument on Mount Tabarak, which rises above Ray, and named it the *Sextant Fakri* in honor of his patron the Buyid ruler Fakhr al-Dawla. With this instrument, the geographical latitude of Ray (more precisely, its observatory) was determined with high accuracy, as well as the inclination of the ecliptic to the celestial equator. Descriptions of the *Sextant Fakri* and its observing methods have been preserved thanks to Al-Biruni's (1966) work.

Four centuries later, Ulugh Beg constructed an improved meridian instrument with a diameter of about 40 meters in Samarkand (Figure 4). He accounted for errors in the construction of the *Sextant Fakri*. According to Al-Biruni (1966) after the instrument of Khujandi was built, the diopter shifted by about 20 cm due to settling of the walls, causing him much trouble.

In Ray, the young, still unknown al-Biruni could not expect support from the ruler, and therefore, he went through very difficult times financially. His later life was spent searching for a patron who would provide him with financial support for living and working. Since he did not

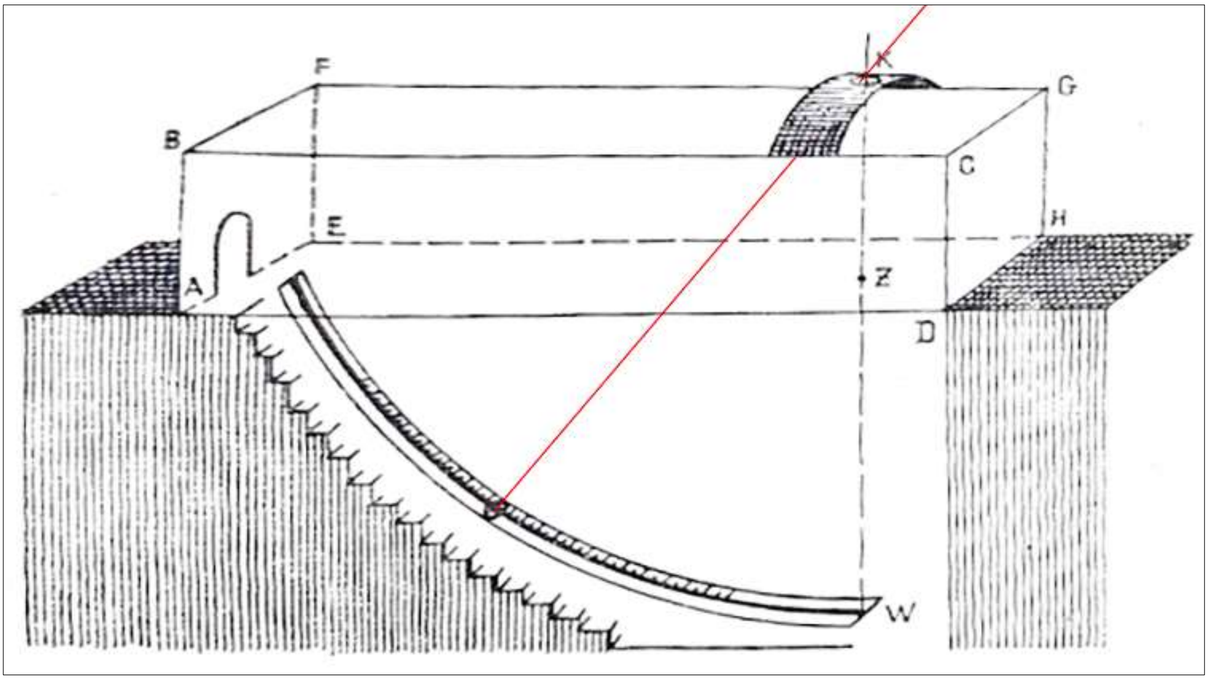

Figure 3: Scheme of the 'Fahri sextant,' a tenth-century meridian instrument invented by Hujandi. This instrument was named in honor of his patron the Buyid ruler Fakhr al-Dawla (after Bulgakov, 1972: 35).

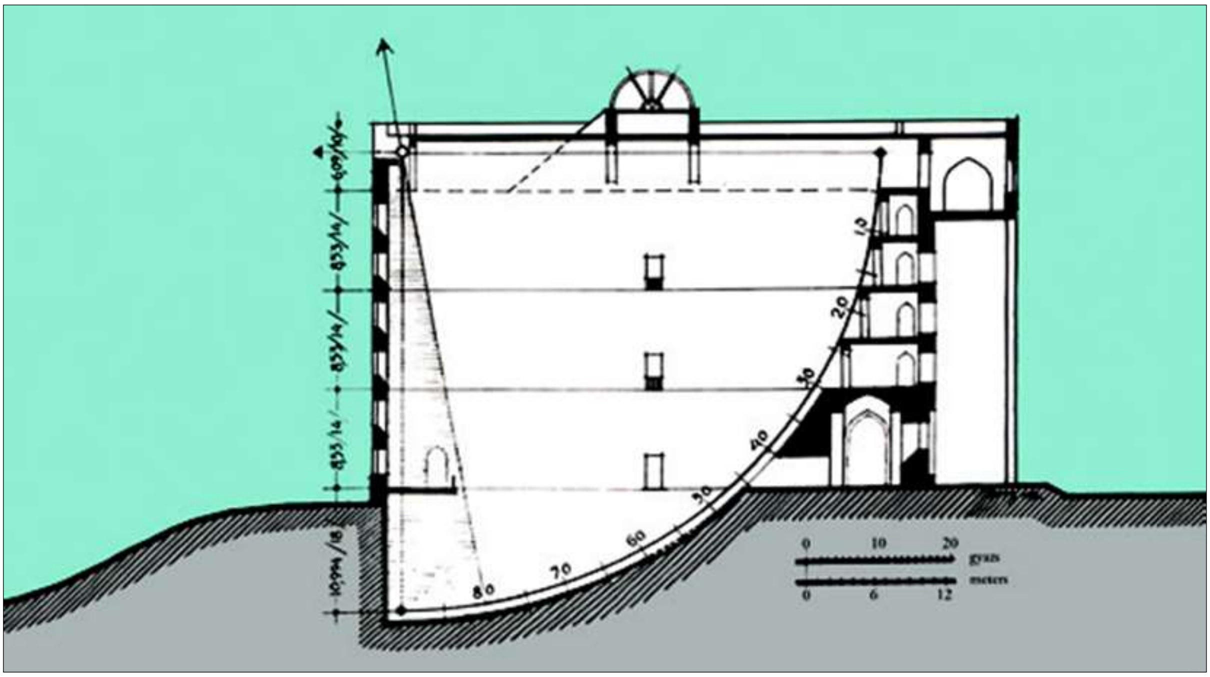

Figure 4: Scheme of the Ulugh Beg Observatory's main instrument—the double meridian arc with a radius of about 40 m (diagram: Sh. Ehgamberdiev).

leave any autobiographical information, his further movements can be inferred from the sparse dedicatory references in his works. One of his famous works, *Chronology*, was dedicated to the Emir of Gurgan (the southern coast of the Caspian Sea), Shams al-Ma'ali Qabus. Experts conclude that around 1000 AD, al-Biruni was at his court (Bulgakov, 1972).

Qabus was an educated ruler, a great admirer of scholars, poets, and people of art. However, when he demanded absolute obedience to his will and the fulfillment of only his orders from al-Biruni, the latter refused. As a result, he had to leave Qabus' court. It is possible that Qabus was displeased with the *Chronology* (here and henceforth, the titles of al-Biruni's works are given according to the established names in modern literature (ibid.). The original titles in Arabic differ from those provided here), which he had dedicated to the Emir himself. Nevertheless, al-Biruni maintained respect for him. This explains why, many years later, al-Biruni recommended that Avicenna seek employment at Qabus' court. However, Avicenna arrived after Qabus' death. He spent some time at the court of Qabus' successors and even conducted astronomical observations at the request of Qabus' daughter. This curious story can be found in Al-Biruni (1966).

The next mention of al-Biruni's astronomical observations in the capital of the Khwarezmshah Dynasty, Gurganj (do not confuse Gurgan and Gurganj), dates back to 1004. In the same year, al-Biruni completed his *Geodesy*, which he also dedicated to Qabus as a sign of gratitude for the support he received during his years in Gurganj. From this time, and until 1017, Khwarezm experienced a period of rapid, and most importantly, peaceful development. Under Abu ibn Mamun and, after his death, under his brother Mamun ibn Mamun, from 1010 to 1017, there was a flourishing of science. The brothers created a scientific center and gathered famous scholars of their time. Brockelmann (1937: 871) called this center the Khwarezmian Academy of Mamun. The leading stars of the Academy were al-Biruni and Avicenna. They met in person during their time at the Academy, though they had already been acquainted through correspondence. History has preserved Avicenna's responses to al-Biruni's philosophical questions. As Starr (2009: 38) notes:

> In 998 AD, two young men living nearly 200 miles apart, in present-day Uzbekistan, entered into a correspondence. With verbal jousting that would not sound out of place in a 21st-century laboratory, they debated 18 questions, several of which resonate strongly even today.

However, in 1017, Khwarezm was conquered by Sultan Mahmud of Ghazni (a city in modern-day Afghanistan). Al-Biruni was captured and forcibly taken to Mahmud's capital, Ghazni. He had to leave his home and start all over again. Al-Biruni worked in Ghazni until the end of his life. In the beginning, and until 1037, he worked under the patronage of Mahmud himself, who was busy with military campaigns and was not particularly interested in science, but supported it nonetheless for prestige. These were not the best times for al-Biruni. After Mahmud died, al-Biruni worked for his son Mas'ud, and from 1041 to 1048 under Mas'ud's son Maudud. In Ghazni, he wrote his main astronomical treatise *Qanon Masudis.* He dedicated this to Mas'ud, who was the most respectful of all the rulers at whose courts al-Biruni worked.

Sultan Mahmud of Ghazni conducted several military campaigns into India. During one of these campaigns he took al-Biruni along, and al-Biruni spent several years there. During this expedition, al-Biruni conducted a very interesting experiment to measure the size of the Earth. At the Nandana fortress, located near the city of Punjab (32˚ N), he determined the Earth's circumference by measuring the horizon's depression from the summit of a mountain, the height of which he had previously measured. This experiment is described in detail in Baloch (1983). During his stay in India, apart from studying the astronomical knowledge of the Hindus, al-Biruni thoroughly examined information about the country's population, customs, geography, etc. As Prime Minister of India Nehru (1946) once noted, *India* by al-Biruni became the first historical, scientific, ethnographic and philosophical encyclopedia of this country.

The *Qanon Masudis* and *India* are perhaps al-Biruni's most significant works. These two works alone would suffice to immortalize his name (Bulgakov, 1972).

Here is an instructive example for those whose native language is not English. Al-Biruni wrote all his main works in Arabic, which was the language of science at that time. His works have been translated into modern languages: Uzbek, Persian, English, French, Russian, etc. In 2014, an international conference took place in Samarkand, dedicated to the study of the contribution of Central Asian scholars to world science and culture. A young PhD student from Utrecht University, Wilfred de Graaf, gave a presentation on an unknown work of al-Biruni, *The Zawraqi Astrolabe*. This was a work about the invention of al-Biruni's original astrolabe design (Figure 5), in which the tympanum was not flat but made in the shape of a boat ('Zawraq' in Arabic) with a mast (De Graaf and Roelens, 2015). In the seventeenth century al-Biruni's work was translated, not into Latin, which was the language of science at that time, but into Dutch! Wilfred de Graaf discovered it in his university library, and based on al-Biruni's description, he built a model of the astrolabe and demonstrated how to use it (ibid.). Thus, this work by al-Biruni only became known to the scientific community a thousand years after it was written about. The use of a common language (even if different across various eras) for communication between scholars and the writing of scientific papers was a groundbreaking step in the history of human-kind, ensuring the progress of science. It is frightening to think about the great legacy we would have lost if al-Biruni had written his works in the ancient

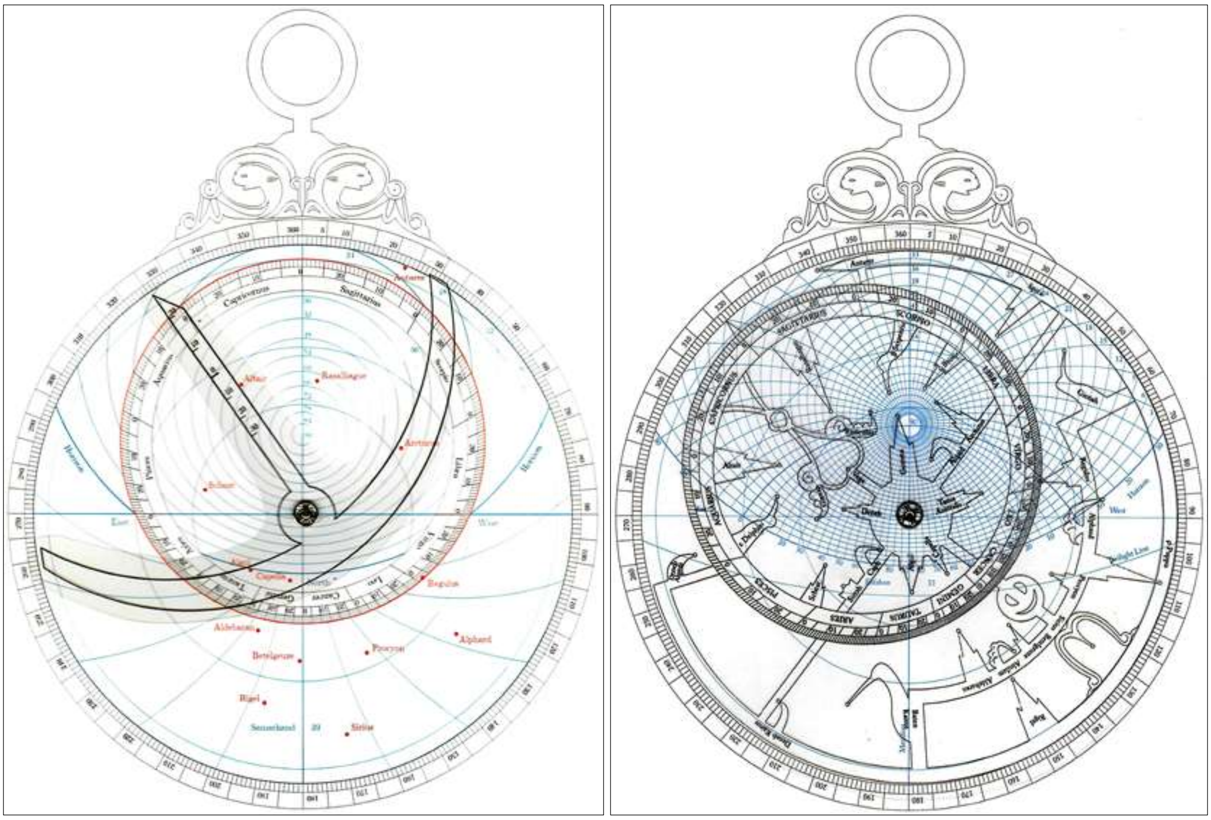

Figure 5: The Zawraqi Astrolabe developed by al-Biruni. In the Zawraqi Astrolabe, the *zawraq* ('boat'), containing the projection of the local horizon and meridian, rotates over the plate (courtesy: W. De Graaf).

Khwarezmian language, which is now forgotten. But there are also oddities. Islamic scholars wrote in Arabic. Therefore, Islamic science, and astronomy in particular, are often referred to as 'Arabic', even though it was created by thousands of outstanding representatives of peoples from vast territories stretching from Spain in the West to China in the East.

To conclude our account of al-Biruni, we should note that according to his biographers he had neither a wife nor children, nor even any known pupils. His life's goal was to leave as much knowledge as possible to humanity. Throughout his long life (he lived an exceptionally long life by the standards of his time, 75 years!), he left over 110 fundamental works that enriched world science. It is no co-incidence that the famous historian of science Sarton (1927) called the eleventh century 'The Age of al-Biruni'.

A prominent contemporary of al-Biruni was Ibn Sina or Avicenna (980–1037), who was born in the village of Afshona near Bukhara in modern Uzbekistan (Avicenna is the Latin corruption of the Arabic patronym *Ibn Sina*). He gained world-wide fame primarily as a philosopher and physician but was also a true encyclopedic scholar. Avicenna's treatises had a tremendous influence on the development of many areas of science, including medicine, philology, mathematics, astronomy, physics, and music (Goodman, 1992). His works totaled nearly 450 volumes, of which about 240 have survived. In particular, 150 volumes of his surviving works are devoted to philosophy, and 40 to medicine (O'Connor and Robertson, 1980). His most famous works are *The Canon of Medicine* and *The Book of Healing*.

The Canon of Medicine is a five-volume medical encyclopedia that was used as the standard medical textbook in the Islamic world and Europe up until the eighteenth century (McGinnis, 2010: 227).

He began his career as a physician at the age of 17 in Bukhara under the Samanid ruler Nuh II. However, in 999, the Samanid Empire fell to the Kara Khanids. Avicenna, due to his high position at court, found himself in danger and had to leave Bukhara. In 1005, he moved to the capital of Khwarezm, Gurganj, to the court of the Ma'munid ruler Abu al-Hasan Ali (Avicenna, 1964). Here, he met al-Biruni, with whom he had already been in correspondence since 978. We have already mentioned the responses of Avicenna to al-Biruni's philosophical questions, which discuss a number of worldview issues.

Although Avicenna's main works are dedicated to philosophy and medicine, he also made contributions to astronomy. An overview of Avicenna's astronomical works is provided by Ragep and Ragep (2004). Avicenna invented a new observational instrument in which he invented a method of using a secondary scale to improve the accuracy of angle-measuring instruments such as astronomical quadrants (Sezgin, 1985). This treatise was written in Isfahan (between 1024 and 1037) and dedicated to *'Ala' al-Dawla*. A similar attachment was re-invented six centuries later by French mathematician Pierre Vernier (1631), and was called the Vernier scale.

During his stay in Jurjan (1012–1014), at the order of Amir Qabus' daughter Zarrayn Kishe Avicenna determined the latitude of the city (Ragep and Ragep, 2004).

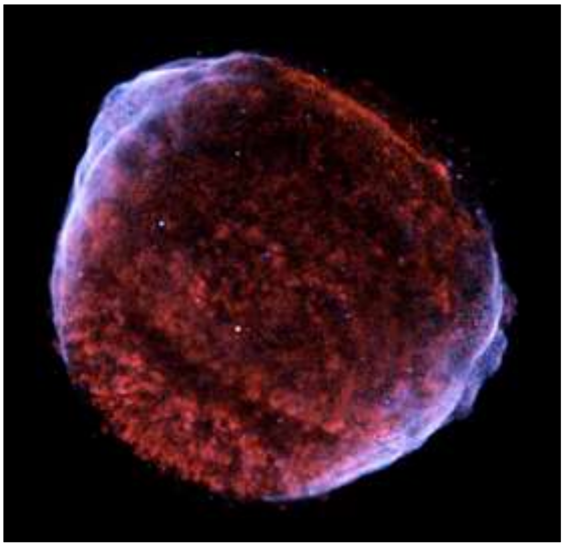

Figure 6: This 'guest star', officially named supernova SN 1006, appeared on 1 May 1006, in the constellation of Lupus. It was observed across China, Japan, Egypt, and Europe. It was also observed by Avicenna at the Khorezmian Mamun Academy. The above photograph was obtained in 2006, a thousand years after its appearance, and shows a color X-ray image of the SN 1006 supernova remnant (https://en.wikipedia.org/wiki/SN_1006).

In one of his works, Avicenna criticized Aristotle for his claim that stars shone with reflected sunlight. He wrote that "… the stars are self-luminous …" (Ariew, 1987: 84) but at the same time, he believed that planets were also self-luminous. Avicenna also authored a *Summary of the Almagest*, which contained detailed commentaries on Ptolemy's work (Ragep and Ragep, 2004).

During his time at the Khwarazmian Academy of Ma'mun, Avicenna made an important discovery in the field of astronomy. Relatively recently, German orientalists R. Neuhauser, C. Ehrig-Eggert, and P. Kunitzsch discovered a description of the SN 1006 supernova explosion in *The Book of Healing* (Neuhauser et al., 2011). This supernova is mentioned in Chinese and Arabic sources; however, Avicenna not only records the rate at which the star dimmed but also describes changes in its color, which is crucial for researchers studying this phenomenon. In Figure 6, an image of SN 1006 taken by modern telescopes in 2006—exactly 1000 years later—is shown. The image reveals the star's gas shell, which was ejected during the explosion and has been expanding at tens of thousands of km/s for a millennium.

It is interesting to note that, despite the fact that >60% of al-Biruni's works are dedicated to astronomy, there is no mention of this supernova explosion in his writings. At the very least, we have not come across references to this catastrophic event in our studies of al-Biruni's legacy.

Throughout his life, Avicenna was forced to seek a patron who would allow him to engage in science without restricting his personal freedom. Often, his reputation as a physician helped him, as rulers supported him in exchange for medical services. However, at times, he had to accept offers for tasks he was completely unwilling to undertake.

Such was the case when Buyid Amir Shams al-Dawla forced Avicenna to become his vizier (Adamson, 2013). He even had to flee when Shams al-Dawla's son ordered him to remain in that position under his rule. Despite these difficulties, Avicenna managed to work on his writings, sometimes producing up to 50 pages per day.

His final place of refuge was Hamadan, where he passed away in 1037 at the age of 57 (Adamson, 2013).

4 PATRONAGE FOR ISLAMIC ASTRONOMY IN CHINA

In ancient Chinese chronicles, there is a record of an annular solar eclipse that occurred on 22 October 2137 BCE. The account includes a story about the Royal Astronomers Hi and Ho, who were reportedly too drunk to warn the Emperor about the eclipse (Brown, 1931).

From this, we would like to highlight two important points. First, this story testifies to the high level of development of Chinese astronomy more than four millennia ago, as predicting eclipses was already considered the duty of astronomers. Second, and crucial in the context of this paper, from the earliest times Chinese rulers maintained a staff of court astronomers who conducted observations, compiled calendars, and performed other astronomical tasks.

During the Middle Ages, when astronomy was flourishing in Islamic countries, Chinese emperors could not ignore these advancements, as the accuracy of calendar calculations and the prediction of celestial events were seen as important proofs of a ruler's divine mandate and power.

In 1260, Khubilai Khan, the grandson of Genghis Khan, was enthroned in Kaiping as the Great Khan of the Mongolian Empire. He established an observatory in his capital. As Shi (2014) noted, Khubilai invited a Muslim astronomer named Zhamaluding, supposedly Jamal al-Din, to Kaiping to work in the Observatory. From that time onward, a dual system of Chinese and Islamic astronomy was traditionally maintained in China. Recently, Professor Shi Yunli (private communication, 2025) discovered that Zhamaluding was from Bukhara (modern Uzbekistan).

This tradition continued under the Tang Dynasty, which succeeded the Ming Dynasty. In 1369, the founding Emperor of the Ming Dynasty, Zhu Yuanzhang (1328–1398), invited a Muslim astronomer named Madeluding to Nanjing. He arrived at the court along with his three sons, Mahsyihei, Mahama, and Mahasha (Shi, 2014). The Emperor was so impressed by the work of Islamic astronomers that he awarded them the honorary title 'The Hall of Great Measurement' and even gave one of his princesses in marriage to Mahsyihei, the son of Madeluding. This was an unprecedented recognition of an astronomer's contributions to astronomy!

5 MARAGHA OBSERVATORY UNDER MOGHUL RULER PATRONAGE

Another center of Islamic astronomy was Maragha Observatory, founded by Naṣīr al-Dīn al-Ṭūsī (1201–1271). Strictly speaking, Maragha is located outside Central Asia. However, the Observatory had such a profound influence on the further development of Islamic (and even global) astronomy that we have decided to write about it as well.

Moreover, it is known that Ulugh Beg visited this Observatory in his youth, and it most likely influenced his future scientific career—perhaps even planting the idea of establishing an astronomical observatory in his homeland (Kary-Niyazov, 1950).

In 1256, the Mongol ruler Hulegu Khan, grandson of Genghis Khan, conquered several Muslim states in southwestern Asia, including Central Asia, Iran, Syria, and Baghdad. He made Maragheh (located in present-day Iran) his capital and invited Nasir al-Din al-Tusi to his court. By that time, al-Tusi was already a well-known encyclopedic scholar (Dabashi, 1996). However, his fame as an outstanding astronomer spread far beyond Iran.

According to Mongol tradition, a supreme ruler was elected, and all other rulers were obliged to follow his orders. In 1251, Möngke Khan was declared the supreme Khan. After Iran was conquered, Hulegu Khan received orders from Möngke Khan to send Nasir al-Din al-Tusi to Karakorum to establish an astronomical observatory. However, before his departure, news arrived of Möngke Khan's death (Yunli, private communication, 2025).

As a result, Hulegu Khan decided to build an observatory in Maragha instead. However, when al-Tusi named the required budget, the Khan hesitated. According to a well-known legend (Rozenfeld, 1984), Hulegu Khan asked, "Is the science of the stars truly so important that it requires such significant financial resources?"

In response, al-Tusi devised a clever demonstration. He ordered large copper basins to be placed at the top of a hill overlooking the Mongol military camp and filled them with stones. When the soldiers had fallen into a deep sleep, he had the basins tipped over, sending the stones crashing down the hillside. The loud noise caused panic among the troops, leading to confusion and disorder.

Observing this, al-Tusi turned to Hulegu Khan and said:

> You see, my lord, we remain calm because we understand the cause of this noise. But look at what happens to those who do not know the cause. Imagine what could happen if something like this were to occur in the heavens.

Following this demonstration, Hulegu Khan allocated the necessary funds for the construction of the observatory.

Maragha Observatory was completed in 1259 on a hill west of the city of Maragheh, then the capital of the Ilkhanate Empire. After years of observation at the Observatory, al-Tusi compiled the *Zij-Ilkhani* (*Ilkhanic Tables*) and dedicated it to Hulegu Khan. The title *Ilkhan* is a combination of two words: *Il* (or *El*), meaning 'population' in Turkic and *khan*, meaning 'king' or 'sovereign'. So, the Huleguids were called Ilkhans, i.e. 'khans of the people'.

Al-Tusi's greatest contribution to astronomy was the creation of very accurate tables of planetary motion. His planetary system model was considered the most advanced of its time and was widely used until the development of the heliocentric model (Daiber and Ragep, 2007).

Al-Tusi also invented a mathematical mechanism that provided a solution for the latitudinal motion of inferior planets. This mechanism, later known as the 'Tusi couple' was presented in 1247 in his Commentary on the *Almagest* (Daiber and Ragep, 2007).

Al-Tusi's scientific legacy includes about 150 works on astronomy, mathematics, philosophy, and chemistry. He was also a physician, a skill that often helped him secure patronage before he finally settled at Maragha Observatory (Dabashi, 1996).


SIVE
TABVLÆ
LONG. AC LAT. STELLARUM FIXARUM,
EX OBSERVATIONE
ULUGH BEIGHI,
TAMERLANIS Magni Nepotis, Regionum ultra citrâque GJIHUN (i. Oxum) Principis potentissimi.
Ex tribus invicèm collatis MSS Persicis jam primùm Luce ac Latio donavit, & Commentariis illustravit, THOMAS HYDE A. M. è Coll. Reginæ Oxon.
In Calce Libri accesserunt MOHAMMEDIS TIZINI TABULÆ Declinationum & Rectarum Ascensionum. Additur demum ELENCHUS Nominum Stellarum.
OXONII, Typis Henrici Hall Academiæ Typographi, Sumptibus Authoris. Venales prostant apud Richardum Davis Bibliopolam. CIƆIƆCLXV.

Figure 7: Title page of Ulugh Beg's catalogue of fixed stars published by Thomas Hyde, Oxford, 1665. Hyde promotes Ulugh Beg's catalogue by using Tamerlane's name to promote in Europe the unknown astronomer Ulugh Beg by mentioning the "Astronomical Tables of Ulugh Beg, the grandson of the magical Tamerlane" (Ulugh Beghi Tamerlanis Magni Nepotis).

The interaction of astronomical traditions took place not only in the direction from West to East, but also in the opposite direction. Thus, Chinese astronomers who on the instruction of Hulegu Khan to Isfahan also worked at Maragha Observatory (Dabashi, 1996).

6 ULUGH BEG—ASTRONOMER AND GENEROUS PATRON

Ulugh Beg (1394–1449) was the only case in the history of astronomy where a ruler of a powerful state was also a professional astronomer. However, it is worth mentioning his contemporary, the outstanding ruler of Korea, Sejong (1397–1450), who also professionally engaged in astronomy (Nha, 1997; 2004). Nevertheless, under Ulugh Beg, the capital of his realm, Samarkand, became the "… astronomical capital of the world." (Kennedy, 1994: 19).

Ulugh Beg did not need to seek a patron for the support of his scientific work. He himself was a patron of scholars, poets, and all those engaged in fine arts, architecture, printing, miniatures, etc.

From his grandfather, the great military leader and statesman Tamerlane, Ulugh Beg inherited a vast legacy, which he used for the betterment of his country, the development of science, and education during his forty years of rule. However, his grandfather's support was not limited to financial aid. Tamerlane was very popular in Europe as the savior of Europe from Turkish conquest. Therefore, the first publishers of Ulugh Beg's astronomical tables in seventeenth-century medieval Europe used Tamerlane's name to advertise the unknown astronomer Ulugh Beg in Europe. In the title pages of the books they mention Astronomical Tables of Ulugh Beg, the grandson of the magical Tamerlane (Figure 7).

To avoid being groundless regarding the claim that Samarkand was an international center of science and education, let us give one example. In a letter from one of Ulugh Beg's closest associates, the famous astronomer and mathematician Jamshid al-Kashi to his father in Kashan (Bagheri, 1997), there is the following excerpt:

> His royal majesty [Ulugh Beg] had donated a charitable gift amounting to 30,000 kopaki dinars, of which 10,000 had been ordered to be given to students. [The names of the recipients] were written down: [thus] 10,000-odd students steadily engaged in learning and teaching, and qualifying for a financial aid, were listed.

10,000 students studying mathematics and astronomy is a lot even for all of the present-day universities of Uzbekistan! Moreover, al-Kashi says in his letter that in addition to the students studying with financial aid, there are about 500 persons, including notables and their sons, who began studying mathematics, which was taught at twelve places.

Even decades after the tragic death of Ulugh Beg, Samarkand continued to remain a well-known center of science and education. The famous first Islamic laureate of the Nobel Prize, Pakistani theoretical physicist, recounts the story of a young man Saif-ud-din Salman

Figure 8: Ruins (left) of the main instrument at the Ulugh Beg Observatory, the 40-meter radius double meridian arc (photograph: Shuhrat Ehgamberdiev), and on the right an artist's depiction of how it was used (courtesy: Museum of the Ulugh Beg Astronomical Institute).

from Kandahar (modern Afghanistan), who, around 1470, left for Samarkand without his father's permission and wrote him a letter justifying his behavior (Salam, 1966). Here is an excerpt from this letter:

> Admonish me not, my beloved father, for forsaking you thus in your old age and sojourning here at Samarkand. It's not that I covet the musk-melons and the grapes and the pomegranates of Samarkand; it's not the shade of the orchards on the banks of the Zar-Afshan river that keeps me here.
>
> I love my native Kandhar and its tree-lined avenues even more and I pine to return. But forgive me, my exalted father, for my passion for knowledge. In Kandhar there are no scholars, no libraries, no quadrants, no astrolabes. My star-gazing excites nothing but ridicule and scorn. My countrymen care more for the glitter of the sword than for the quill of the scholar. In my own town, I am a sad, a pathetic misfit. It is true, my respected father, so far from home, men do not rise from their seats to pay me homage when I ride into the bazaar. But someday soon, all Samarkand will rise in respect when your son will emulate Beruni and Tusi in learning and you too will feel proud.

Hundreds of papers have been written about Ulugh Beg, revealing his multifaceted activities as a scholar and a statesman (see, for example, Bartold, 1918; Kennedy, 1994; Ehgamberdiev, 2020). Therefore, there is no need to repeat them here. Let us only highlight his key achievements. First, he built a large astronomical instrument—a double meridian arc with a radius of about 40 meters (Figure 8). The giant size allowed for a significant increase in the accuracy of determining the latitude of Samarkand and some astronomical constants, such as the inclination of the ecliptic to the celestial equator and the length of the tropical year (Figure 9). It should be noted that the larger the size of the instrument, the more difficult its construction due to possible deformations and deviations of the arcs from the meridian, etc. Nevertheless, he managed to create an instrument without the flaws found in the Fakhri Sextant of al-Khojandi (Biruni, 1957).

One of the main duties of Islamic rulers was the organization of the compilation of *Zijes*. As it is presented in Wikipedia,

> … the word zīj is derived from the Persian term zih or zīg, meaning 'cord'.

Figure 9: Sketches of degree signs (left) at the surface of the meridian arc and a photograph of the 71° sign (right). The interval of 1 degree on the arc corresponded to 72 cm. With these dimensions, the midday height of the Sun could be determined with great accuracy (source: Sh. Ehgamberdiev).

> The term is believed to refer to the arrangement of threads in weaving, which was transferred to the arrangement of rows and columns in tabulated data.

Thus, *zijes* were collections of numerous tables, with explanations accompanying them. *Zijes* were used by historians (for converting dates of various events from one calendar system to another), traders (for determining distances between settlements), and astrologers. With the help of *zijes*, the direction towards Mecca was determined when building mosques, and the dates of Muslim holidays—Eid al-Fitr and Eid al-Adha were calculated based on the Moon's movement. Given the enormous importance of *zijes*, rulers commissioned their court astronomers to compile them, and they were named after the rulers, thus immortalizing them (Kennedy, 1956).

Over nearly nine centuries of the Islamic era, more than 200 *zijes* were created in astronomy. However, some of the *zijes* contained star catalogs. Star catalogs compiled based on personal observations were especially valued. An example of such star catalogue presented in the *Zij of Ulugh Beg*, which includes 1018 stars (of which the coordinates of 992 stars were obtained based on many years of observations in Samarkand). This is what makes the *Zij of Ulugh Beg* so valuable. As the famous British researcher Baily (1843: 20) noted:

> If we assume Ptolemy's catalogue to have been originally observed by Hipparchus, we may consider this catalogue of Ulugh Beg as the only other original one, now in existence, that has been formed after a lapse of sixteen centuries.

Among the astronomical treatises containing star coordinates obtained from personal observations is *A Book of Fixed Stars* by al-Sufi (1437), which was actively used by Ulugh Beg. However, Bīrūnī (1954) in his *Kitāb al-Qānūn al-Maʿsudī* harshly criticizes al-Sufi, accusing him of lacking scientific rigor. Therefore, in compiling his own catalog, he relied on Ptolemy's *Almagest*. The shortcomings of al-Sufi's catalog did not go unnoticed by Ulugh Beg. In the introduction to his own *Zij*, he wrote:

> Abdurrahman Sufi wrote a special book on the recognition of fixed stars, to which all scholars refer and accept the positions of the stars as presented in it. Before our own observations, we also frequently turned to this book written by Abdurrahman Sufi and accepted the star positions on the sphere according to it. However, when Allah granted us the ability to conduct our own observations, we found the star positions in Sufi's book to be in contradiction with what we observed directly. (Akhmedov, 1994: 4).

This realization led Ulugh Beg to begin his own observations.

It should also be noted that *A Book of Fixed Stars* by al-Sufi is unique in that it contains one of the few surviving Islamic depictions of constellations (Ehgamberdiev et al., 2025; Hafez, 2010; Hafez et al., 2011).

Speaking of Ulugh Beg, we must also mention the representatives of his scientific school. First and foremost is Qāḍī Zāde al-Rūmī, who is considered Ulugh Beg's teacher. Qāḍī Zāde al-Rūmī was born in Bursa around 1357. His teacher was the famous philosopher Shamseddin al-Din Mahammad al-Fanari. Noticing his student's special abilities in astronomy and mathematics, al-Fanari advised him to travel for further study and work in Horasan and Mavaraunnahr. However, Qāḍī Zāde al-Rūmī did not

Figure 10: The horoscope of Iskandar Sultan, a cousin of Ulugh Beg. It was compiled by Mahmood al-Kāshī, the grandfather of the famous companion of Ulugh Beg, al-Kāshī, and is a masterpiece of visual art from the Timurid era (after Kennedy, 1994: 10).

have the means to go to Samarkand. An interesting story survives about how Qāḍī Zāde's sister gave him her jewelry, which he hid in a fake book and smuggled through customs (Kehren, 1994). Initially, Qāḍī Zāde lived in Horasan, but later he moved to Samarkand and became a companion of Ulugh Beg. In 1419, Ulugh Beg completed the construction of a madrasa—a school for advanced study in theology and science—in Bukhara and in 1420 in Samarkand. Four years after the foundation of the madrasa, Ulugh Beg commenced construction of an Observatory (Kary-Niyazov, 1950). For the work at the madrasa and Observatory, Ulugh Beg employed about seventy scientists (Kennedy, 1994).

Qāḍī Zāde actively participated in organizing the educational process at these madrasas. Unfortunately, the exact dates of the Observatory's construction in Samarkand and other dates related to its activities have not survived Therefore, we only present approximate dates below. The construction of the Observatory was completed around 1428, and its first Director was Jamshid al-Kāshī, who held the position for several years until his death. After him, Ulugh Beg appointed Qāḍī Zāde as the Director, but he too only held the position for a few years. Following him, the Observatory was led by Ali Qushji. Qāḍī Zāde al-Rumi also was actively involved in teaching at Ulugh Beg's madrasas. A diploma issued under his signature in 1440 survives, confirming his involvement (Yazdi and Rezvani, 2015). Qāḍī Zāde seems to have passed away soon after.

Among the prominent figures of Ulugh Beg's school was Jamshid al-Kashi (or Kashani), an outstanding native of Kashan (Iran). He came from a family of hereditary astronomers. A horoscope (Figure 10) prepared by his grandfather Mahmood al-Kāshī for the ruler of Fars and Isfahan (central Iran), Iskandar Sultan, Ulugh Beg's cousin, has survived (Kennedy, 1994). This horoscope is a masterpiece of the visual arts from the Timurid era (ibid.).

Al-Kashi wrote two letters to his father in Kashan describing the scientific environment in Samarkand (Bagheri, 1997). From the detailed descriptions of astronomical matters in his letters, it can be concluded that his father, too, was well-versed in astronomy and mathematics.

The exact time of al-Kashi's arrival in Samarkand is not known. Unfortunately, neither of his letters includes dates. However, it is known that in 1424, Ulugh Beg discussed the Observatory project with his scientists, including al-Kashi and Qāḍī Zāde al-Rūmī (Kary-Niyazov, 1950). Prior to this, al-Kashi had been at the courts of various rulers, as it was the only way to find a means of livelihood while pursuing science. At the court of Iskander Sultan, al-Kashi worked on compiling a *Zij*, which was a revision of the *Ilkhānī Zij* of Naṣīr al-Dīn al-Ṭūsī. However, Iskander was murdered in 1414, the same year that al-Kashi completed his *Zij*. He called it the *Khaqani Zij*, i.e., the *Zij* of the 'Supreme Ruler'. Some researchers believe al-Kashi named his *Zij* in honor of Ulugh Beg (Kennedy, 1994). Bartold (1918), however, believes it was dedicated to Shahrukh Mirza, Ulugh Beg's father, to whose court he moved after the death of Iskandar. We also find Bartold's hypothesis more plausible, as Ulugh Beg was only the ruler of one (albeit important) province of the Empire, while the 'Supreme Ruler' was still Shahrukh Mirza. In 1427, al-Kashi, already in Samarkand, completed his monumental work *Mift¯ah al-his¯ab*, dedicated to arithmetic. It is known by the symbolic name *Key to Arithmetic*, where he describes decimal fractions long before their discovery in Europe. This crowning achievement of Islamic arithmetic was dedicated to his new patron, Ulugh Beg, since in Samarkand, after a long period of penury and wandering, al-Kashi finally obtained a secure and honorable position where he actively joined the work of the Observatory (Kehren, 1994). Although he passed away before the completion of the Observatory, his treatise, *Treatise on the Explanation of Observational Instruments*, which briefly describes the construction of astronomical instruments, especially the armillary sphere and Fakhrī sextant, played an important role in equipping the Samarkand Observatory with instruments.

Another companion of Ulugh Beg was Ali Qushji, who remained with Ulugh Beg until the end of his life. After Ulugh Beg's tragic death in 1449 Ali Qushji continued to lead Samarkand Observatory until 1470, when he was forced to emigrate to Istanbul.

Ali Qushji is considered not only a prominent representative of the Samarkand scientific school but also a scholar at the origins of the development of astronomy in Ottoman Turkey. His work in Turkey is the subject of a paper by Professor Günergun (2025) in these proceedings, so we will only focus on his life and work until his departure for Istanbul.

Ali Qushji was born in 1403. His full name was Ala al-Dīn Ali ibn Muhammed Ali Qushji. The nickname 'Qushji' ('falconer') was inherited from his father, who held a prestigious position as the falconer at the Court of Ulugh Beg's father, Shahrukh. It seems that Shahrukh, noticing Ali Qushji's abilities, and directed him to Samarkand (Keren, 1994). During the Soviet era, Ali Qushji was often portrayed as a poor commoner who was 'taken in' by a noble ruler. In reality, Ali Qushji's father held a very high position at Shahrukh's court, as Royal hunting was an important activity at the time. This suggests that Ali Qushji had the opportunity to receive a good general education before joining the ranks of Ulugh Beg's great associates, such as Qāḍī Zāde al-Rumi and Jamshid Kashi.

After the deaths of these figures, Ali Qushji became Ulugh Beg's primary companion and effectively managed the affairs of the Samarkand Observatory. He made significant contributions both to the observational program and to the compilation of Ulugh Beg's *Zij*. It is no coincidence that in the introduction to the *Zij*, Ulugh Beg refers to him as "my beloved son" ("farzandi arjumand").

Despite his noble origins and close ties to the Sultan Ulugh Beg, very little information has survived about Ali Qushji's personal life during his time at Samarkand Observatory. Only fragmentary information remains.

It is known that Ali Qushji was appointed Ulugh Beg's Ambassador to China. However, no details about the date or purpose of his mission have been found. Most likely, Ulugh Beg sent him to China to study the Chinese calendar system, which was later described in detail in Ulugh Beg's *Zij*. There are also references suggesting that Ali Qushji kept a diary of his journey to China, but neither this diary nor any information about its contents has survived.

In Saliba's (1993) work on Ali Qushji's study of Mercury's motion, it is noted that he presented his work to Ulugh Beg after he had been forgiven and returned to the court of Ulugh Beg. Most likely, he was temporarily removed from his patron's favor due to court intrigues, but when Ulugh Beg realized this, he once again drew Ali Qushji near to him. However, no information is provided about why he had fallen out of favor. This remains another mystery in the biography of Ali Qushji.

After the death of Shahrukh and the tragic death of Ulugh Beg on 27 October 1449, an era of unrest began in Mavaraunnahr. Numerous contenders for the throne of Amir Temur's Empire alternately seized power, but none managed to hold it long enough to consider the well-being of the country. Despite this, Ali Qushji remained in Samarkand for some time.

Finally, in 1451, Ulugh Beg's nephew Sultan Abu Said ascended to the Timurid throne. He was the last Timurid ruler of the entire Empire. It is known that in 1457, Ali Qushji presented Sultan Abu Said with his comments on the famous work of Nasreddin Tusi, for which he was awarded 50,000 dinars by the highest order. This allowed the Observatory to survive for some time.

Soon after this, Ali Qushji, for reasons that remain unclear, moved to the court of Uzun Hasan, ruler of the Aq-Quyunlu Empire, which included territories in Iraq, Iran, Anatolia, Armenia and Azerbaijan (Ihsanoğlu, 2023). Nothing is known about Ali Qushji's activities or works at the court of Uzun Hasan. It is only known that Uzun Hasan sought to establish peaceful relations with the Ottomans, and using Ali Qushji's great authority in the Muslim world and his diplomatic experience he sent him as an Ambassador to the Ottoman Sultan Mehmed II. The Sultan received Ali Qushji with great honor and invited him to stay in Turkey. Ali Qushji accepted the Turkish Sultan's offer but requested first to complete his mission as an Ambassador.

After this, it is known that Ali Qushji arrived in Herat, where, with the help of Alisher Navoi, he obtained a travel permit (a *yarlik*) from Sultan Husayn Bayqara, the ruler of Khorasan. This permit, which allowed him to leave the country without hindrance, was essential for his journey. Turkish sources (Ünver, 1948) tell us that Ali Qushji arrived in Istanbul with his relatives and students. His caravan consisted of two hundred camels! It is likely that the caravan carried manuscripts of priceless books from the library of Samarkand Observatory, including copies of Ulugh Beg's *Zij*. This action by Ali Qushji was of exceptional importance for the spread of the achievements of the Samarkand School in Europe, and later for their worldwide recognition.

Ali Qushji left behind a number of works in various fields of science. His most valuable works were in astronomy. Eight treatises on astronomy have survived. Among them, it is worth noting the *Commentaries on Ulugh Beg's Zij*, as well as the treatise *Concerning the Supposed Dependence of Astronomy upon Philosophy*. This work marked an important step forward from Aristotelian physics to independent astronomical physics. Ali Qushji believed that astronomers did not need to adhere to the Aristotelian idea of celestial bodies moving in uniform circular motion. However, it remains unclear whether this work had any influence on Nicolaus Copernicus' theory (Fazlıoğlu, 1999).

7 CONCLUDING REMARKS

In this paper, we have tried to provide a brief overview of the activities of Central Asian astronomers who worked across the vast expanse of the Islamic world. They enriched the knowledge of others while also gaining insights from their Arab, Persian, and Chinese colleagues. We attempted to explore the role of rulers, who significantly differed in their intellectual development, attitudes toward science, and their support of scholars. Some, like the Abbasid caliph al-Mamun, placed great importance on the development of science, understanding that only through science could he ensure the prosperity of his state. For some rulers, however, science was merely a tool to enhance the prestige of their court, with the claim, "Look at the great scholars under my patronage."

It turned out to be no trivial task to definitively determine which ruler–patron each work was dedicated to, as researchers tend to focus more on the content of the works themselves, their significance, and their influence on the further development of science. The issue of patronage is often regarded by researchers as somewhat less important. This again highlights the significance of the chosen theme for ICOA-10: *Patrons and Patronage in Middle Eastern and Asian–Oceanic Astronomy*.

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