



*Revelation and Science*  
*Vol. 13, No. 01 (1444H/2023) 1-14*

## **A Brief Reflection on Islamic Astronomy in 13<sup>th</sup> Century: The Case of Qutb Ad-Dīn Al-Shīrāzī Norzakiah binti Saparmin**

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### **Abstract**

This paper focuses on the life and scholarship of Qutb ad-Dīn al-Shīrāzī (d. 1311 CE), a Muslim Persian polymath, who has contributed in many fields such as philosophy, astronomy and medicine. A talented and precocious student, and was tutored by his own father, the young man of Qutb ad-Dīn al-Shīrāzī was already appointed as a physician even during his teenage years. Eventually the quest for knowledge led him to leave his hometown of Shīrāz and visit several scholars before he eventually settled in Marāghah. Here he learned and collaborated with many other great scholars such as Naṣīr al-Dīn Ṭūsī (d. 1274 CE) and Mu'ayyad al-Dīn al-'Urḍī (d. 1266 CE) in the field of observational astronomy. They set up and worked in the famous Marāghah observatory, and Qutb ad-Dīn al-Shīrāzī collaborated in the production of *Zīj-l Ilkhānī* or the Ilkhānī Tables, which was one of the most important astronomical tables being produced from the Marāghah observatory. Other than his contribution in astronomy, we would also briefly mention his contribution in other fields such as philosophy and medicine. The methodology is a literature review, which we used both the secondary sources and the primary source. The primary source is the astronomical text of Qutb ad-Dīn al-Shīrāzī which is called *Nihāyat al-Idrāk*, and it is in the form of a manuscript, which had been acquired from the British Library.

**Keywords:** Qutb ad-Dīn al-Shīrāzī, Marāghah observatory, Islamic astronomy, Islamic philosophy, Islamic medicine

### **Abstrak**

Kertas kerja ini memberi tumpuan kepada kehidupan dan keserjanaan Qutb ad-Dīn al-Shīrāzī (maut 1311 M), polimath Parsi Muslim, yang telah menyumbang dalam pelbagai bidang seperti falsafah, astronomi dan perubatan. Seorang pelajar yang berbakat dan bijak, dan diajar oleh bapanya sendiri, Qutb ad-Dīn al-Shīrāzī telah dilantik sebagai doktor semasa zaman remajanya. Beliau meninggalkan kampung halamannya dan melawat beberapa ulama sebelum beliau akhirnya menetap di Marāghah, bekerjasama bersama ulama seperti Nasir al-Din Tusi dan Mu'ayyad al-Din al-Urdi dalam bidang pemerhatian astronomi. Selain sumbangan beliau dalam bidang astronomi, kami juga akan menyebut secara ringkas sumbangannya dalam falsafah dan perubatan. Metodologi adalah kajian literatur, menggunakan sumber utama dan sekunder. Sumber utama adalah teks astronomi beliau, *Nihayat al-Idrak* yang dipeoleh dari perpustakaan British.

**Kata Kunci:** Qutb al-Din al-Shirazi, Balai cerap Marāghah, astronomi Islam, falsafah Islam, perubatan Islam

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## 1. Introduction

Quṭb ad-Dīn al-Shīrāzī (d. 1311 CE), is a famous Muslim Persian polymath, who has contributed in many fields such as theology, philosophy and including the illuminationist theosophy (*ishrāq*), Qur'anic commentaries, the sciences of *ḥadīth*, medicine, astronomy, mathematics, geography, physics and even poetry. He is highly multi-talented, and his name and works are considered to be at par as with many others great polymath of Muslim scholars such as Ibn Sīnā, al-Fārābī, al-Bīrūnī, al-Ghazālī, Ibn Rushd, Naṣīr al-Dīn Ṭūsī and many others. In this paper, we would focus more on his contribution in astronomy and the role he has uphold as one of the main astronomers in the famous Marāghah observatory, which was founded by his teacher, Naṣīr al-Dīn Ṭūsī (d. 1274 CE). We would delineate first on his early life and education, which began under the tutelage of his father and teachers in his hometown of Shīrāz. And then during his teenage years, due to his high intelligence and capability, he was appointed as a physician at a local hospital. However, after about a decade serving at the hospital, he decided to step down as a physician, and left his hometown, travelling to many places seeking teachers in various fields. Thus, for the next part of the paper, we would focus first on his learning journey and contribution in astronomy, particularly at the Marāghah observatory, and his relations with many other scholars at the observatory, such as Naṣīr al-Dīn Ṭūsī, who was his teacher, Mūayyad al-Dīn al-'Urdī (d. 1266 CE), Muḥyī al-Dīn al-Maghribī (d. 1283 CE), Kamāl al-Dīn al-Fārisī (d. 1320 CE), Bar Hebraeus (d. 1286 CE), i.e., the Christian philosopher and astronomer,

and many others. And then after about 8 years later, he decided to leave

Marāghah, and continued his journey of seeking knowledge, meeting many other great scholars such as the philosopher and the astronomer, Najm al-Dīn Dabīrān Kātibī al-Qazwīnī (d. 1276 CE), the great Sūfī poet, Jalāl ad-Dīn Muḥammad Rūmī (d. 1273 CE), and the famous disciple of Ibn 'Arabī, Ṣadr al-Dīn al-Qūnawī (d. 1274 CE). And it is during these later journeys that Quṭb ad-Dīn al-Shīrāzī began to produce many outstanding works in various fields such as astronomy, philosophy, and medicine.

## 2. Early Life of Quṭb ad-Dīn al-Shīrāzī

Quṭb ad-Dīn al-Shīrāzī or his full name is Quṭb ad-Dīn Maḥmūd ibn Ḍiā' al-Dīn Mas'ūd al-Shīrāzī was born in the Persian city of Shīrāz in the month of Ṣafar in the year of 633 AH/1236 CE. His father, Ḍiā' al-Dīn Mas'ūd Kāzirūnī, who originally was from the nearby town of Kāzirūn, was known as a distinguished physician and a Sufi master in the school of the famous Sufi cum philosopher Shihāb al-Dīn Suhrawardī (d. 1191 CE), i.e., the founder of the school of 'Illuminationist' (*ishrāqī*) philosophical tradition. Thus, it was from his father that Quṭb ad-Dīn al-Shīrāzī had received his early education and training especially in medicine and Sufism. Moreover, Ḍiā' al-Dīn had received his Sufi robe (*khirqah*) from Shihāb al-Dīn Suhrawardī himself and later he, as a father, bestowed a Sufi robe to his own son, Quṭb ad-Dīn al-Shīrāzī, as a sign of blessings and the robe was called *khirqah tabarruk* or "a cloak of blessing," when the latter was about ten years old. Later in his life, Quṭb

ad-Dīn al-Shīrāzī received his own robe from another teacher and a famous Sufī master, Najīb al-Dīn ‘Alī Bozghush Shīrāzī (Anwār, 2005).

Quṭb ad-Dīn al-Shīrāzī’s father was a physician and an ophthalmologist at the Muẓaffarī hospital in Shiraz. However, when Quṭb ad-Dīn al-Shīrāzī was only about fourteen years of age, his father passed away. In fact, as the turn of event, before his father’s death, the father had ensured that his teenage son would be entrusted to replace him as the physician and ophthalmologist at the same hospital (Nasr, 1996). Indeed, Quṭb ad-Dīn al-Shīrāzī was a brilliant and prodigious young man. His intelligence is attested in the works of biographers and scholars such as Ibn Qāḍī Shuhbah (d. 1448 CE) and Tāj al-Dīn al-Subkī (d. 1355 CE), and thus he was able to perform his duty as a young well-respected physician (Bakar, 2006). Moreover, Quṭb ad-Dīn al-Shīrāzī continued his learning in medicine from his well learned family of uncles including Kamāl al-Dīn Abū’l Khayr al-Kāzirūnī, Sharaf al-Dīn Zākī al-Būshkanī and Shams al-Dīn Muḥammad ibn Aḥmad al-Kabshī. All of them were known to be specialists in the medicine of Ibn Sīnā and from them he learned further Ibn Sīnā’s *Kitāb al-Qānūn fī’l-Tibb*, and its commentaries such as the commentary of the Canon by the famous theologian Fakhr ad-Dīn ar-Rāzī (d. 1209 CE) (Anwar, 2005).

However, around 1260 CE, at the age of twenty-four, Quṭb ad-Dīn al-Shīrāzī felt that his knowledge of medicine was still unsatiated, that he decided to quit his post as a physician and left his hometown of Shīrāz. In fact, he felt a burning desire for learning, and began to travel extensively, which took many years of his adult life to many cities through

Khurāsān, Iraq and Anatolia. His main intention was seeking authoritative masters in philosophy and medicine, especially in the medicine of Ibn Sīnā, a figure whom he greatly admired. However, this does not stop him from learning and meeting various expertise of scholars in various fields of knowledge. In fact, during these travels, he also met many Sufī masters, and often he would join their gatherings, and he was formally initiated into Sufism in the hands of the Sufī master Muḥyī al-Dīn Aḥmad ibn ‘Alī, a disciple of Najm al-Dīn al-Kubrā (d. 1221 CE), the founder of the Kubrawīyah Sufi Order (*ṭarīqah*) (Nasr, 1996).

### **3. Quṭb ad-Dīn al-Shīrāzī’s Life and Scholarship with Scholars of Marāghah Observatory**

Around 1262 C.E., he finally arrived in Marāghah, or to be specific, at the Marāghah observatory complex, to study under the famous philosopher cum astronomer, Naṣīr al-Dīn al-Ṭūsī (d. 1274 CE). Quṭb ad-Dīn al-Shīrāzī’s first intention, however, was not to study astronomy, but primarily to study the medicine and philosophy of Ibn Sīnā from Naṣīr al-Dīn al-Ṭūsī. However, Shīrāzī later realized that Ṭūsī’s medical knowledge was not that satisfactory to him; and despite that fact, he decided to continue staying in Marāghah and learn mathematics, astronomy and philosophy from Ṭūsī. Thus began a long and close relationship between a teacher and a disciple in one of the most important observatory complexes that was built during the past Islamic civilization (Anwār, 2005).

Naṣīr al-Dīn al-Ṭūsī himself was the mastermind in the establishment of the huge complex of the Marāghah observatory, which was in the western part of the city

Marāghah, of which today it is a city in the East Azerbaijan Province of Iran. Just like Quṭb ad-Dīn al-Shīrāzī, Naṣīr al-Dīn al-Ṭūsī himself was a great polymath who produced more than one hundred and fifty works in various fields in three languages, Arabic, Persian and Turkish. He wrote treatises in both the traditional and rational sciences such as philosophy, logic, ethics and law, theology, Sufism, astronomy, mathematics, and medicine. Thus, due to his vast knowledge in various sciences, especially in philosophy, he was given the title “The Third Teacher,” after whom the Greek philosopher Aristotle was called “The First Teacher”, and the Muslim philosopher Abū Naṣr al-Fārābī (d. 950 CE) was called “The Second Teacher” (Nasr, 1996).

When the Mongols, led by Chinghiz Khan (d. 1227 CE), the first great Khan and the first emperor of the Mongol Empire, started to conquer the Islamic lands in the early 13<sup>th</sup> century, Naṣīr al-Dīn al-Ṭūsī seek refuge by accepting an invitation from an ‘Ismā’īlī leader Naṣīr al-Dīn Muhtashim, to stay at an ‘Ismā’īlī city, Alamut. Alamut was a mountain fortress, and it was relatively saved from the hordes of the Mongol, and Naṣīr al-Dīn al-Ṭūsī stayed here relatively save for about 25 years, doing research and wrote many works in philosophy, logic and astronomy (Blake, 2016). Only later eventually in 1256 CE, the Mongol general Hulagu Khan, the grandson of Chinghiz Khan, was able to defeat the ‘Ismā’īlī forces and Naṣīr al-Dīn al-Ṭūsī was caught as their captive. However, his reputation as a scholar, especially as an astronomer, was well known to the Mongols that later he was released and appointed as their chief astronomer. Although the Mongols’ favored attention on Naṣīr al-Dīn al-Ṭūsī’s

expertise was due more to the former interest in astrology than in astronomy, this however spurred them to support and patronized his work and scholarship, not just in astronomy and astrology, but also in various other sciences that Naṣīr al-Dīn al-Ṭūsī had greatly contributed.

Rashīd al-Dīn Hamadānī (d. 1318 CE), the famous historian and physician for many generations of the Ilkhanate rulers, wrote in his well-known work on the history of the Mongols, *Jāmi al-Tawārīkh*, that Hulagu “is also said to have valued philosophy very highly and to have encouraged scientists to hold discussions on the *awāil* sciences (i.e., philosophical sciences),” and that “Hulagu allotted salaries and pensions to scientists and philosophers and had his royal residence embellished with their presence” (Sayili, 1998).

Moreover, Hulagu’s brother, the great Khan Mongke (d. 1259 CE) or also known as Mangū, was also said to be a generous patron on sciences and learning. It was mentioned by a historian that “two important *madrasahs* of Bukhārā were probably built during Mangū’s reign. They are the *Khānī* and *Mas’ūdiyyah Madrasahs*. Each accommodated a thousand students a day. ‘Alā al-Dīn al-Juwaynī says that the *Khānī Madrasah* was built by the son Quyū Bey. This may refer to Kuyuk, who was Mangū’s father and predecessor. The *Mas’ūdiyyah Madrasah* was built by Mas’ūd Bey, son of Yalwāj, who was Mangū’s governor. The passage where these two *madrasahs* are mentioned deals mostly with Bukhārā under the rule of Mangū” (Sayili, 1998).

Thus, when Hulagu had conquered Alamut and captured Naṣīr al-Dīn al-Ṭūsī, Mongke had asked Hulagu to send Naṣīr al-Dīn al-Ṭūsī either to Beijing or to Qaraqorum, the

Mongol capital, to build an observatory for him. However, eventually, to Naṣīr al-Dīn al-Ṭūsī's relief, Hulagu decided that the scholar should build the observatory at Marāghah, his new capital of the western side of the Mongol empire (Sayili, 1998).

Hulagu had patronized fully the construction of the observatory, and thus it is mentioned by historians that Naṣīr al-Dīn al-Ṭūsī had started the construction of the Marāghah observatory in the month of *Jamādī l-awwal* in the year of 657 AH, i.e., in the month of April-May 1259 CE, just only about a year after Hulagu and his Mongol hordes had conquered and destroyed Baghdad, the capital of the 'Abbāsīd caliphate, in January 1258 CE (Sayili, 1998). In order to build the observatory and all its various instruments, Naṣīr al-Dīn al-Ṭūsī had invited another well-known astronomer, Mūayyad al-Dīn al-'Urḍī (d. 1266 CE), to move from Damascus— in which place al-'Urḍī had lived in there for most of his life and worked as an astronomer and as an engineer to the Mamlūk caliph, Mālik al-Manṣūr— to Marāghah to help him in constructing the observatory (Blake, 2016).

Mūayyad al-Dīn al-'Urḍī himself was an outstanding astronomer; thus, al-'Urḍī and along with Naṣīr al-Dīn al-Ṭūsī and Quṭb ad-Dīn al-Shīrāzī, all the three of them are known to be prominent member of Marāghah observatory. Mūayyad al-Dīn al-'Urḍī was also known, just like al-Ṭūsī, criticized Ptolemy's planetary models, and invented his own planetary model, which was known as “'Urḍī lemma”. Al-'Urḍī's planetary model and Naṣīr al-Dīn al-Ṭūsī's planetary model, of which the latter was known as “Ṭūsī Couple,” both solved the problem that was already inherent in Ptolemy's theory; however, it is al-'Urḍī's model that was later used by Copernicus (d.

1543 CE), the Polish astronomer and mathematician, in his book “On the Revolutions of the Celestial Sphere,” i.e., the book of which in it Copernicus proposed a revolutionary theory that it is the sun, instead of the earth, that is at the center of the solar system (Blake, 2016).

Thus, when Mūayyad al-Dīn al-'Urḍī arrived in Marāghah in the late 1250s, he immediately started to help Naṣīr al-Dīn al-Ṭūsī in building the Marāghah observatory. It is known that “The Marāghah observatory was located outside the city on the flattened top of a hill—400 meters long and 150 wide. To lift water to the site 'Urḍī designed a complex system of water wheels and aqueducts. He also oversaw the construction of a residence for Hulagu and a mosque. A small structure nearby contained a large dome. The rays of the Sun entered a hole in the dome, enabling the Marāghah astronomers to measure both the elevation (at different times and seasons) and the mean motion (in degrees and seconds) of the Sun. The building was oriented so that the solar rays hit the threshold of the dome precisely on the vernal equinox (21st March). On its inner walls were illustrations: of the celestial spheres, the phases of the Moon, and the signs of the zodiac. Here also were terrestrial and celestial globes, maps of the seven climes, and graphs showing the length of the days and nights. The original terrestrial globe was made of paper pulp but 'Urḍī's son fabricated a later version (1279-80) out of metal” (Blake, 2016).

Most of the major instruments were built outdoor, and most are designed and constructed by Mūayyad al-Dīn al-'Urḍī, from the time he arrived in Marāghah about 1259 CE, until most of the equipment had been constructed in about 1262 CE. Some of

the major instruments included a mural quadrant with a radius of about 430 centimeters, an armillary sphere or spherical astrolabe with five rings and an alidade, a solstitial armilla with a diameter of 250 centimeters and equipped with an alidade, an equinoctial armilla, a dioptrical ruler of Hipparchus for measuring the apparent diameter of the sun and the moon, an azimuth ring with two quadrants, and a parallactic ruler for measuring the altitude of heavenly bodies with a radius of 250 centimeters (Sayili, 1998). Moreover, the observatory complex was equipped with a library, *madrasahs* or schools, and an administrative office, which managed and maintained the entire complex with a large and active *waqf* system, i.e. a charitable endowment fund (Blake, 2016).

According to the 14<sup>th</sup> century Syrian historian, Muḥammad Ibn Shākir al-Kutubī (d. 1363 CE), the library was said to have about 400,000 books. Due to waves of conquests of the Mongols throughout Islamic lands, many libraries had been destroyed; however, Hulagu and Naṣīr al-Dīn al-Ṭūsī were able to collect as much books as they could find, and this made the Marāghah library as the first major and one of the largest observatory libraries in the Islamic civilization (Bakar, 2016). Moreover, the *madrasahs* of the observatory complex provided classes that focused on rational sciences such as philosophy, astronomy, and mathematics. This is usually in contrast with the normal *madrasah* system that usually offered only traditional sciences. Moreover, it is known that “And for astronomy and astrology theoretical knowledge needed to be supplemented by practical, hands-on-experience with instruments and calculations. Thus, from the very beginning organized instruction was an

important part of the institution’s mission. Abū al-Faraj, one of the early members of Ṭūsī’s staff, seems to have specialized in teaching rather than research. From 1272 to 1279 he lectured on geometry, mathematics, and astronomy— covering Euclid’s *Elements* in 1270 CE and Ptolemy’s *Almagest* in 1272 CE. His lecture notes drew heavily on the writings of Ṭūsī himself. The observatory provided support for students as well as for professors. Abaqa, Hulagu’s successor, awarded stipends to nearly one hundred of Ṭūsī’s students after his death” (Blake, 2016).

Abū al-Faraj is the famous Christian Syriac encyclopedist and philosopher, Bar Hebraeus, or his Arabic name Abū al-Faraj bin Hārūn al-Malaṭī, or also known as Abū al-Faraj Ibn al-Ibrī; and while his Latin name is known as Gregory Grigorios. Bar Hebraeus originally came from ‘Ebrā, Syria, following his father, who was a physician and who had treated a Mongol ruler on several occasions. Eventually, Bar Hebraeus himself later became a physician, serving Hulaga Khan in Marāghah, and while being in Marāghah, he was also entrusted to lecture on Euclid’s *Elements* and Ptolemy’s *Almagest* at the Marāghah observatory. He stayed in Marāghah until his death in 1286 CE (Blake, 2016).

Bar Hebraeus himself was a talented polymath and wrote many books in various fields such as philosophy, medicine, astronomy and mathematics. His well-known work is the encyclopedic work known as “The Cream of Wisdom,” which he tried to cover every known knowledge at that time, and other works such as “Ascent of the Mind,” which is a book on astronomy, and “Book of the Pupils of the Eye’s,” which despite its title, is a book on logic. Moreover, he is also

known to have travelled extensively to many cities in the Islamic land in his quest for knowledge, such as Baghdad, Musul, Tabriz and Marāghah. Thus, other than being an instructor at the Marāghah observatory, he is also known to have learn philosophy and astronomy under Naṣīr al-Dīn al-Ṭūsī, whom he greatly admired and in fact, he had formed a very close relationship with al-Ṭūsī during his stay in Marāghah (Doru, 2017). These are some of the few words he had written on Naṣīr al-Dīn al-Ṭūsī, “And there were gathered about him in Marāghah, a city of Adharbayjān, a numerous company of wise men from various countries. And since the council of all the mosques and the houses of instruction (i.e., colleges) of Baghdad and Assyria were under his direction he used to allot stipends to the teachers and pupils who were with him. About this time, having set out for Baghdad to visit various places, he died in Baghdad. And certain men have reported that he was blind” (Sayili, 1998). In his book on history, known as “Chronicon,” Bar Hebraeus wrote, “This year, Naṣīr al-Dīn al-Ṭūsī is dead. He had a big observatory in Marāghah and, he worked on all kinds of wisdom. He wrote many books on logic, physics, theology, Euclid, and Majesty. In his extraordinarily beautiful ethical book in Persian language, he collected all texts of Plato and Aristotle on practical philosophy” (Doru, 2017). Here Bar Hebraeus was referring to the famous Naṣīr al-Dīn al-Ṭūsī’s book in ethical philosophy which was entitled as “Nasirean Ethics” or *Akhlāq-i Nāsiri*.

However, it is not known whether Bar Hebraeus had met Quṭb ad-Dīn al-Shīrāzī or not at Marāghah, since the latter had arrived much earlier during the early years of the Marāghah observatory. However, regardless of if they have met or not,

both are important scholars in the long-lasting operation of the observatory, which had lasted for more than half a century. Thus, when Quṭb ad-Dīn al-Shīrāzī arrived at the observatory in 1262 CE, most parts of the observatory complex had already been completed. His first intention, however, in arriving at Marāghah, was not to study astronomy actually, but primarily to study the medicine and philosophy of Ibn Sīnā from Naṣīr al-Dīn al-Ṭūsī. However, Shīrāzī later realized that Ṭūsī’s medical knowledge was not that satisfactory to him; but in spite of that fact, he continued staying in Marāghah to study mathematics, astronomy and philosophy from Ṭūsī. Eventually he was known to become one of Ṭūsī’s outstanding students, and often Ṭūsī would bring him along in his travels and introduced him to various caliphs and rulers (Anwār, 2005).

Moreover, while studying at Marāghah, Shīrāzī played a role as one of the members of the Marāghah astronomers in producing the most important production of the observatory, which is *Zīj-I Ilkhānī*. *Zīj-I Ilkhānī*, just like other *zījs*, is an astronomical book and almanac for the use of astronomers and astrologers alike in determining the positions of the celestial objects, i.e., the sun, the moon, the planets, and the fixed stars. There are many other *zījs* that have been produced by many other Muslim astronomers during this period; however, *Zīj-I Ilkhānī* has been the most influential and reliable in the 13<sup>th</sup> and 14<sup>th</sup> centuries of the Islamic civilization, until it was later superseded by *Zīj al-Sultān* of the Timurid King, i.e., Ulugh Beg (d. 1449 CE) (Blake, 2016). Ulugh Beg is the grandson of Timūr (d. 1405 CE), i.e., the founder of the Timūrid Dynasty, and although his grandfather was a ruthless and a mighty conqueror,

Ulugh Beg focused more on supporting scholars and their scholarships in various fields of learning, and he himself was known to be a great and distinguished scholar.

Naṣīr al-Dīn al-Ṭūsī originally composed *Zīj-l Ilkhānī* in Persian, and then later it was translated into Arabic, and it took about 13 years, including data collection, for Ṭūsī to complete writing it, from 1259 CE until about 1272 CE. Although Quṭb ad-Dīn al-Shīrāzī was not among the main astronomers who contributed towards the production of *Zīj-l Ilkhānī*, he was, however, singled out by Ṭūsī, that after the death of the latter, Shīrāzī would correct certain mistakes that have occurred in *Zīj-l Ilkhānī*. The correction would be conducted with the collaboration of Ṭūsī's second son and the third director of the Marāghah observatory, Aṣīl al-Dīn. In fact, Naṣīr al-Dīn al-Ṭūsī's first born, Ṣadr al-Dīn, was the second director of the Marāghah observatory, and he was appointed right after the death of his father. The fifteenth century astronomer Rukn al-Dīn ibn Sharaf al-Dīn al-Amulī wrote in his *Zīj-i Jāmi-i Sa'ādī*: "As is well known Ṭūsī...had made certain mistakes in the Ilkhānī Zīj and had willed that these mistakes be rectified and the tables in the zīj be corrected by Aṣīl al-Dīn in collaboration with Quṭb ad-Dīn al-Shīrāzī. Now the Khwaja (i.e. Ṭūsī) had mentioned the names of the astronomers of the observatory in the introduction to the Ilkhānī Tables and had passed away, and had not included the Mawlāwī's (Quṭb ad-Dīn al-Shīrāzī) name among them. Because of this Quṭb ad-Dīn did not busy himself with the correction of the tables. Upon Aṣīl al-Dīn's insistence he merely indicated on the margins...that in using the mean positions of the planets from the tables, 30 minutes should be added to

the mean position of the moon and 7 minutes to the center of Saturn's epicycle, that Jupiter's epicyclic configuration should be increased by 1 degree 21 minutes and that 1 degree 30 minutes should be added to the center of Mars's epicycle and the same quantity subtracted from that of Venus, but he did not make any references to the sun and to Mercury."

Other well-known astronomers that were recorded to have worked at Marāghah observatory included 'Alī ibn 'Umar al-Qazwīnī, Fakhr al-Dīn al-Akhlātī, Fakhr al-Dīn al-Marāghī, Muḥyī al-Dīn al-Maghrībī, Shams al-Dīn al-Shirwānī, Najm al-Dīn Dabīrān al-Qazwīnī, 'Abd al-Razzāq ibn al-Fuwaṭī (or Fūṭī), i.e. the librarian, Kamāl al-Dīn al-Aykī (or Īkī), Ṣadr al-Dīn, i.e. another son of Naṣīr al-Dīn al-Ṭūsī and who later replaced his father in becoming the second director of Marāghah observatory, Athīr al-Dīn al-Abharī, Ḥusām al-Dīn al-Shāmī, and Shams al-Dīn ibn Muḥammad ibn Muayyad al-'Urḍī. Moreover, since during this period the Mongol Empire had stretched from China to parts of Eastern Europe, it is mentioned that the Mongol rulers had brought some Chinese astronomers from China to work at the Marāghah observatory; however, only one name was mentioned which was Fao Mun Ji. And adding to the "international" characteristic of the group of astronomers at the Marāghah observatory,

Other than the three prominent members of the Marāghah Observatory, which are Naṣīr al-Dīn al-Ṭūsī, Muayyad al-Dīn al-Urḍī and Quṭb ad-Dīn al-Shīrāzī, there is also another well-known member which had been mentioned above which is Muḥyī al-Dīn al-Maghrībī (d. 1283 CE). Muḥyī al-Dīn al-Maghrībī originally came from Andalusia; he was born in Toledo



and acquired his learning in mathematics and astronomy from the Toledo school of astronomers there before at about the age of 30 he decided to move to Damascus and continued his work in astronomy in the Syrian capital. Thus, in the year 1260 CE, when Damascus had fallen under the control of the Mongols, Hulaga Khan invited him to join his team of astronomers at the Marāghah observatory. It is said that he remained at the observatory for 25 years, assisting Naṣīr al-Dīn al-Ṭūsī in the production of *Zīj-I Ilkhānī*, and making many astronomical observations from the year 1262 CE till 1274 CE. He also produced his own *zīj* in the year 1280 CE, which is known as *Zīj-I Muhy al-Dīn al-Maghribī al-Andalus*. However, it is still unknown if Muhyī al-Dīn al-Maghribī had ever produced his own planetary model—just like his three colleagues at the Marāghah observatory had done—in order to compensate the discrepancy that had occurred in the Ptolemaic model. And most likely Quṭb ad-Dīn al-Shīrāzī had worked with Muhyī al-Dīn al-Maghribī since the latter had stayed quite long at Marāghah.

However, it is inconclusive if Quṭb ad-Dīn al-Shīrāzī had ever met or worked with Muayyad al-Dīn al-Urdī, since the latter had only stayed at Marāghah for a short period of time. However, regardless of if he had ever met or not Muayyad al-Dīn al-Urdī, Quṭb ad-Dīn al-Shīrāzī did mention Urdī's planetary model, which is Urdī's lemma, in one of his major works, *Nihāyat al-Idrāk fī Dirāyat al-Aflāk* (The Highest Attainment in the Knowledge of the Spheres).

#### 4. Quṭb ad-Dīn al-Shīrāzī's Travels Outside of Marāghah

Quṭb ad-Dīn al-Shīrāzī also did not stay very long at Marāghah. Although

he was considered one of the best students and working colleagues of Naṣīr al-Dīn al-Ṭūsī, al-Shīrāzī decided to leave Marāghah in about 1270 CE, to continue further his studies. At first, he went to Khurasan, with the company of Naṣīr al-Dīn al-Ṭūsī, to study philosophy under Najm al-Dīn Dabīrān Kātibī al-Qazwīnī (d. 1276 CE), a famous Persian philosopher and logician in the Shafī'i school of law. Then he traveled to Qazvīn (a city in Persia, which later in the 16<sup>th</sup> century became the capital city of the Safavid Dynasty) and Baghdad, seeking teachers in various disciplines. In Baghdad, he stayed at the Nizāmiyyah University for some time; the university was founded by the famous Seljuk vizier, Nizām al-Mulk (d. 1092 CE) in the year 1065 CE and was considered as the largest university in the medieval world. Then he travelled to Konya in Anatolia, and met the great Sūfī poet, Jalāl ad-Dīn Muḥammad Rūmī (d. 1273 CE), and the famous disciple of Ibn 'Arabī, Ṣadr al-Dīn al-Qūnawī (d. 1274 CE). The latter was an outstanding scholar himself, just like his teacher, Ibn 'Arabī (d. 1240 CE), the great Andalusian mystical philosopher; in fact, Ibn 'Arabī himself appointed Ṣadr al-Dīn al-Qūnawī as his successor. Al-Qūnawī was later known to be a master in both exoteric and esoteric religious sciences, and thus from him, Quṭb ad-Dīn al-Shīrāzī studied Qur'ānic commentary and the sciences of *ḥadīth*. In fact, it is reported that al-Shīrāzī studied the collection of the books of *ḥadīth*, which is *Jāmi' al-Uṣūl fī Aḥādīth al-Rasūl*, as compiled by the great muḥaddīth, Ibn al-Athīr (d. 606 AH), with Ṣadr al-Dīn al-Qūnawī.

Quṭb ad-Dīn al-Shīrāzī stayed in the company of Ṣadr al-Dīn al-Qūnawī until the latter passed away, and he then travelled again and stayed awhile

in two cities in Anatolia, Sivas and Malatya. He was appointed as a *qāḍī* (religious judge) of both cities, and this gave him a lot of time to devote himself in writing many of his major works.

### 5. Some of Quṭb ad-Dīn al-Shīrāzī's Major Works

Quṭb ad-Dīn al-Shīrāzī wrote many major works in astronomy, geography, philosophy, and medicine. In astronomy, one of his major works is *Nihāyat al-Idrāk fī Dirāyat al-Aflāk* (The Limit of Understanding of the Knowledge of the Heavens), which was completed in Sivas in 1281 CE and was dedicated to a vizier of the Mongol ruler. The whole text of *Nihāyat al-Idrāk* is divided into four treatises: "On what that needs to be presented by way of introduction," "On the configuration of the celestial bodies," "On the configuration of the earth," and "On finding the measurements of the distances and the bodies." Shīrāzī had done many astronomical observations while staying at the Marāghah observatory, and this had prepared him well in writing the text *Nihāyat*. In fact, the text *Nihāyat* and Shīrāzī's other astronomical works are evidence of his extensive knowledge of astronomy. As for the format of the *Nihāyat*, it is almost similar to the format of the famous work of his teacher Naṣīr al-Dīn al-Ṭūsī, which is *Tadhkīrah fī 'ilm al-hay'ah* (Memoirs in Astronomy). In fact, there are quite a few parts in the *Nihāyat* which are almost similar to the ones in the *Tadhkīrah*. In spite of the similarity, the *Tadhkīrah* is written as general introduction to the science of astronomy, as an abridgement to the whole corpus of astronomical knowledge known at that time, and thus, not all astronomical theories in the *Tadhkīrah* are being given its

mathematical proofs. In the *Nihāyat* however, al-Shīrāzī would mention the theory, and following it is its explanation, and then he would mention the observational evidence and mathematical proofs. The *Nihāyat* in fact is a larger book than the *Tadhkīrah*, as observed by Seyyed Hossein Nasr, "There are sections on cosmography, geography, geodesy, meteorology, mechanics and optics, reflecting both the older scientific views of Ibn al-Haytham and al-Bīrūnī and new scientific theories in optics and planetary motion" (Nasr, 1996).

Just like his predecessors, Naṣīr al-Dīn al-Ṭūsī and Mu'ayyad al-Dīn al-'Urḍī who were critical of Ptolemy's planetary model, so did Quṭb ad-Dīn al-Shīrāzī, and he mentioned his criticisms of the model in the second treatise of the *Nihāyat*. This second treatise focused on the science of "configuration" or '*ilm al-hay'ah*' of the heavenly bodies, and it is in this treatise that Quṭb ad-Dīn al-Shīrāzī criticized and departed from Ptolemaic modeling. Ptolemaic astronomy has been successful in predicting the motions and positions of the heavenly objects, however, for the Muslim astronomers in general, '*ilm al-hay'ah*' should not just only able to predict but it must also configure the physical aspect of the motions of the heavenly objects. Since it is an accepted principle, in ancient and medieval astronomy, that the orbs of the heavenly bodies are solid spheres with no void should be in between, thus, the orbs of these celestial bodies must not in any circumstances violate any physical principles, such as the principle of uniform motion. Ptolemy, however, violated it in his theories of the moon and the upper planets. It is this inconsistency in Ptolemaic theories that sparked the momentum for many Muslim astronomers to create an

alternative model which would replace the model of Ptolemy. However, despite the extensive knowledge of astronomy that can be found in the *Nihāyat*, al-Shīrāzī did not give much attempt to create his own theory. He depended heavily on the theories of his predecessors, and then would just elaborate further on the explanation. He seemed to be satisfied with the solutions to the Ptolemaic problems as given by al-Ṭūsī and al-‘Urḏī that he did not attempt to propose any new theory. However, there are parts of the *Nihāyat* where al-Shīrāzī would criticize even his own teacher, Naṣīr al-Dīn al-Ṭūsī, such as the non-circularity of al-Ṭūsī’s planetary orb, and the impossibility of a solid sphere of an epicycle to be contained inside al-Ṭūsī’s couple.

About three years later, in 1284 CE, al-Shīrāzī completed another major work in astronomy, which is known as *al-Tuḥfat al-Shāhiyya fi’l-Hay’ah* (The Royal Gift on Astronomy). It is in this later work that eventually al-Shīrāzī solved further some of the astronomical problems that he had mentioned earlier in the *Nihāyat*. Here in this work al-Shīrāzī proposed a new model for the moon and he applied both al-Ṭūsī’s couple and al-‘Urḏī’s lemma to solve the irregular orb of Mercury’s motion.<sup>1</sup> E. Wiedemann (d. 1928 CE), a German historian of science, mentioned that these two works of Shīrāzī are some of the best works ever produced in Islamic astronomy: “Quṭb ad-Dīn al-Shīrāzī has in my opinion given the best Arabic account of astronomy (cosmography) with mathematical aids.”

There are other major works of astronomy written by Quṭb ad-Dīn al-Shīrāzī, and one of them which was

<sup>1</sup> See further in Saliba, “Arabic planetary theories,” 98-99 & 118-120.

highly popular is called *Ikhtiyārāt-i muẓaffarī* (Muẓaffarī Selections). It is written in Persia and was considered one of his great works in astronomy. It is a synopsis of his *Nihāyat*, i.e., a summary of each of the four sections of the *Nihāyat* and was completed before 1304CE. His other works of astronomy are *Kitāb fa’altu fa-lā ta’lum fī’l-hay’ah* (A Book I Have Composed But Do Not Blame [Me for It], on Astronomy), *Kitāb al-tabṣīrah fī’l-hay’ah* (The Commentary on Astronomy), *Sharḥ al-tadhkirat al-naṣīriyyah* (A Commentary Upon the *Tadhkīrah* of Naṣīr al-Dīn al-Ṭūsī), *Kharidā al-‘ajā’ib* (The Wonderful Pearl), *Khulāṣat iṣlāḥ al-majisī li-Jābir ibn Aflaḥ* (Extracts of Correction of the *Almagest* of Jābir ibn Aflaḥ), *Ḥall mushkilāt al-majisī* (Solution of the Difficulties of the *Almagest*), *Tahrīr al-zīj al-jadīd al-riḍwānī* (Recension of the New *Riḍwānī* Astronomical Tables), and *al-Zīj al-sulṭānī* (The *Sulṭānī* Astronomical Tables). This *al-Zīj al-sulṭānī* is not the same as *al-Zīj al-sulṭānī* of Ulugh Beg (d. 1449 CE), the famous scholarly king of the Timurid Dynasty, whom also had built an impressive observatory in Samarqand after more than a hundred years after the end of the era of the Marāghah observatory. And moreover, this *al-Zīj al-sulṭānī* of Quṭb ad-Dīn al-Shīrāzī is a collaborative work with another astronomer, known as Muḥammad ibn Mubārak Shams al-Dīn Mīrak al-Bukhārī.

All these great works of Quṭb ad-Dīn al-Shīrāzī and his other colleagues in astronomy are proofs that their astronomical activities and writings, among 13<sup>th</sup> century Muslim astronomers, are highly advanced and sophisticated, especially in comparison to their counterparts in medieval Europe. Their observations and

theories even though were adopted from the works of Ptolemy (d.c.170CE), an ancient astronomer from Alexandria, are new formulations with advancement in observations and ingenious solutions to the Ptolemaic problems.

Moreover, most of these astronomers are polymaths, and contributed many great works in other areas of scholarship. Quṭb ad-Dīn al-Shīrāzī, as we know of, wrote authoritative texts in medicine and philosophy. His masterpiece in medicine is called *Kitāb nuzhat al-ḥukamā' wa rawḍat al-aṭibbā'* (Delight of the Wise and Garden of the Physicians), or also known as *al-Tuḥfat al-sa'diyyah* (The Presentation to Sa'd), or as *Sharḥ kullīyyāt al-qānūn* (Commentary upon the Principles of the Canon of Ibn Sīnā). This commentary was written when Quṭb ad-Dīn al-Shīrāzī were staying in Egypt under the Mamlūk dynasty, and Egypt was one of the places he had stayed for quite sometime after he had left Marāghah.

After leaving Marāghah, and after he had spent some time in Anatolia, Shīrāzī decided to travel back to Persia, and settled in Tabrīz, which then has become the capital of the Mongol Ilkhānīd Empire. In Tabrīz, he was welcomed by the Mongol ruler Aḥmad Takūdār, the son of Hulagu Khan, whom then had him being appointed as an ambassador of the Ilkhanid Dynasty to be sent later to the Mamlūk Dynasty of Egypt. Quṭb ad-Dīn al-Shīrāzī was then to serve at the court of the Mamlūk caliph, Sayf al-Dīn Qalā'ūn (d. 1290 CE), and in Egypt, he was able to gain access to three of the most important commentaries of Ibn Sina's magnum opus *al-Qānūn fī al-Ṭib*. The commentaries were complemented with glossaries and information of

other medical treatises. Thus, with these sources in hand, Shīrāzī began to write his own commentary of *al-Qānūn*. The commentary was his longest work, which had five volumes, and it took him more than 20 years, devoting his self in writing several editions of the commentary. The second edition was published in 1294 CE, while the third edition was finished in 1310 CE, about a few months before his death in 1311CE. The commentary was dedicated to Muḥammad Sa'd al-Dīn, the vizier of Arghūn Khan (d. 1291 CE), the fourth ruler of the Ilkhānīd Dynasty.

Moreover, there are also other works of medicine written by Quṭb ad-Dīn al-Shīrāzī, such as *Risālah fī'l-barāṣ* (Treatise on Leprosy), *Sharḥ al-urjūzah* (Commentary on Ibn Sīnā's *Conticum*), and *Risālah fī bayan al-ḥājah ila'l-tibba' wa-waṣāyāhum* (Treatise on the Explanation of the Necessity of Medicine and of the Manners and Duties of Physician).

In philosophy, his masterpiece is *Durrat al-tāj li-ghurrat al-dībāj fī'l-ḥikmah* (Pearls of the Crown, the Best Introduction to Wisdom) which is encyclopedic in nature and consists of five books (*jumlah*) on topics of logic, metaphysics, natural philosophy, mathematics, and theodicy. And finally in the conclusion of *Durrat al-tāj*, Quṭb ad-Dīn al-Shīrāzī also included topics on religion, ethics and Sufism. For the various topics in *Durrat al-tāj*, Quṭb ad-Dīn al-Shīrāzī referred to the works of various scholars, such as Ibn Sīnā, Suhrawardī, Fakhr al-Dīn al-Rāzī, and Sa'd al-Dīn al-Farghānī (d. 1300 CE), who is a disciple of both Mawlānā Jalāl al-Dīn al-Rūmī and Ṣadr al-Dīn al-Qunyawī.

His other masterpiece in philosophy is *Sharḥ Hikmat al-Ishrāq* (Commentary Upon the Theosophy of the Orient of Light), which is a

commentary upon Suhrawardī's work *Ḥikmat al-ishrāq*, and this is considered as the best commentary ever written on Suhrawardī's magnum opus, and has been mentioned previously, Quṭb ad-Dīn al-Shīrāzī's father was a direct disciple to the master Suhrawardī. Moreover, Quṭb ad-Dīn al-Shīrāzī has also written other works in philosophy such as *Sharḥ kitab rawḍat al-nāzīr* (Commentary upon the *Rawḍat al-nāzīr* (of Naṣīr al-Dīn al-Ṭūsī)), *Sharḥ al-najāt* (Commentary upon the *Najāt* (of Ibn Sīnā)), *al-Sharḥ wa'l-ḥāshiyah 'ala'l-ishārāt wa'l-tanbīhāt* (Commentary upon the *Ishārāt* (of Ibn Sīnā)), and *Ḥāshiyah 'alā ḥikmat al-'ayn* (Glosses upon the *Ḥikmat al-'ayn* (of Najm al-Dīn Dabīrān al-Qazwinī (d, 1276 CE), a philosopher and also an astronomer that had worked with Naṣīr al-Dīn al-Ṭūsī at the Marāghah observatory)).

## 6. Conclusion

Indeed, Quṭb ad-Dīn al-Shīrāzī is a well-rounded scholar and an expert in various field of sciences. Other than astronomy, medicine, and philosophy, he also wrote sporadically in many of his works on topics such as mathematics, physics, optics, and geography. Moreover, he was honored with the title 'Allāmah, i.e., a very distinguished title that referred to a scholar who are well versed in many sciences, and very few were entitled to receive it. Furthermore, the Mamluk historian Abu'l-Fidā' (d. 1331 CE), who wrote his masterpiece in history entitled *Tārīkh al-Mukhtaṣar fī 'Akḥbār al-Bashar* (An Abridgement of the History of the Human Race), referred to Quṭb ad-Dīn al-Shīrāzī with the title al-Mutaffannin, "master in many sciences." He was honored also with the title "the scholar of the Persians", and was an important figure in reviving the 16<sup>th</sup> century Safavid

Empire's renaissance in philosophy and sciences. In fact, his works are equally and highly influential in both among the Sunnīte and Shi'ite scholars and continued to be as major references even among scholars in the Sunnīte empires such as the Ottoman and the Mogul empires.

Eventually, after traveling many years throughout the various Muslim empires, Quṭb ad-Dīn al-Shīrāzī decided to return to Tabriz, which was still the capital city of the Ilkhānīd Empire just as he had left it. Here, he had the opportunity to meet the famous learned vizier of the Ilkhānīd, Rashīd al-Dīn Faḍlallāh (d. 1318 CE) or also known as Rashīd al-Dīn Hamadānī, a Jewish convert to Islam, and who later became a powerful vizier to the Ilkhānīd Caliph, Maḥmūd Ghāzān (d. 1304 CE). Rashīd al-Dīn Faḍlallāh was also known to be a *ḥakīm*, a physician and a historian, and famously known for his masterpiece, *Jāmi' al-tawārīkh*, a historical text that focused mainly on the Mongols and their various Ilkhānīd dynasties.

Quṭb ad-Dīn al-Shīrāzī spent a little bit more than a decade in Tabriz, writing and teaching *al-Qānūn* and *al-Shifā'* of Ibn Sina, before he died on the 17<sup>th</sup> of Ramaḍān, 1311 CE. It is said that before his eventual demise, he had spent most of his wealth to his students and various charities, that eventually there's not even enough money to be spent for his funeral, and it was one of his wealthy students who finally took the responsibility to give him a proper and honored burial. Indeed, he was a very humble scholar despite being gifted with high intelligence and contributed immensely for the betterment of the scholarship of the Muslim ummah.

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## *Article History*

*Received: 03/01/2023*

*Accepted: 19/06/2023*