Ulumuna
Vol. 29, No. 2, 2025, p. 876-899
Journal of Islamic Studies Published by State Islamic University Mataram
p-ISSN 1411-3457, e-ISSN 2355-7648, available online at https://ulumuna.or.id

TYPOLOGY AND CHARACTERISTICS OF 9TH HIJRI/15TH-CENTURY CE ASTRONOMICAL MANUSCRIPTS IN CAIRO

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Abstract: Cairo's astronomical manuscripts (*falak*) are abundant, yet many remain understudied and insufficiently analyzed in contemporary scholarship. This study focuses on astronomical manuscripts produced in the 9th century Hijri (15th century CE), which display distinct typologies and characteristics compared to earlier periods, particularly in terms of structure, content organization, and methodological orientation. These differences are shaped by evolving socio-religious and intellectual dynamics, including changes in educational institutions, scholarly networks, and the patronage of scientific knowledge. The production of these manuscripts was driven not only by the practical needs of the community—such as calendrical calculation, prayer times, and determination of the *qibla*—but also by intellectual pursuits and the development of astronomical science as a scholarly discipline. To some extent, these typologies share affinities with falak manuscripts found in Indonesia, especially in their practical orientation. However, significant differences remain, particularly in the depth, mathematical rigor, and complexity of the discussions.

Keywords: Manuscripts, Astronomy, Tahqiq

DOI: https://doi.org/10.20414/ujis.v29i2.1769

Introduction

ISLAMIC MANUSCRIPTS serve as primary sources for understanding the historical development of knowledge, religious thought, and culture of Muslims.[1] These manuscripts record the works of

[1] Nasr, Seyyed Hossein. "The Significance of Islamic Manuscripts." In *The Significance of Islamic Manuscripts: Proceedings of the Inaugural Conference of al-*

Muslim scholars, scientists, and thinkers from various eras and regions, ranging from Qur'anic interpretation and hadith to philosophy, natural sciences, literature and law.[2] Manuscripts also bear witness to the journey of cultural interaction, knowledge transfer, and influence across civilizations, both in the Arab world, Asia, Africa, and the archipelago.[3]

Egypt holds the world's second-largest collection of manuscripts , after Turkey. The long history that Egypt went through with all its scientific-Islamic dynamics made an important contribution to the progress of Islamic civilization. Many scholars and scientists born from this land of a thousand towers bore abundant written works. These works are now known as manuscripts (*makhthut, makhthuthat*) scattered and stored in various places (museums, libraries, mosques, special galleries, and others).

Among the manuscripts that are widely stored are manuscripts in the field of Astronomy. Some sites and manuscript centers of astronomy include Dar al-Kutub al-Mishriyyah, Al-Azhar Library, and the Arabic Manuscript Institute Library. A few decades ago, a science researcher from the United States named David A King researched the manuscripts of Astronomy of the Mamalik era. The results of his rise are scattered in various journals and books, one of his significant contributions is a manuscript catalog (as many as 2 volumes thick) containing information on manuscripts of astronomy in Dar al-Kutub al-Mishriyyah.

Furqān Islamic Heritage Foundation, 30 November–1 December 1991. London: al-Furqān Islamic Heritage Foundation, 1992.

[2] Dedi Kuswandi, Abdul Rohman, dan Ghazi Abdullah Muttaqien, "The Quran Manuscripts in Indonesia: A Historical Review," *Suhuf* (2024). T. Taufiqurrahman, A. Hidayat, Efrinaldi, Sudarman, dan Lukmanulhakim, "The Existence of the Manuscript in Minangkabau Indonesia and Its Field in Islamic Studies," *Journal of Al-Tamaddun* (2021).

[3] Jonathan Ouellet, "'From Samarqand to Toledo: Greek, Sogdian and Arabic Documents and Manuscripts from the Islamicate World and Beyond,' by Andreas Kaplony and Matt Malczycki," *Journal of Islamic Archaeology* (2024). L. H. Riwarung, "Islamic Manuscripts of Meranaw Muslims in Mindanao: An Inquiry of the Richness of the Intellectual Heritage," *Al-Albab* (2021).

Through instinctive research conducted by King, many things can be revealed and make a significant contribution to the study of astronomy, especially in Indonesia. The study and research are in the form of two things, namely content analysis (dirasah) and script analysis (tahqiq). These two things are core and integral segments in manuscript studies, especially astronomy manuscripts. Search for the characteristics, content-substance of astronomy texts, and the typology of these Astronomy texts is useful in the development of astronomy in the country, especially for Islamic boarding schools (Pesantren).

This study employs a historical and literary analysis approach, namely exploring the construction and typology of the works (manuscripts) of Muslim astronomers in the 9th/15th century and analyzing their substance. Furthermore, because what is analyzed are astronomical manuscripts from about five centuries ago, a philological approach is also used to analyze these manuscripts.

Terminology of Manuscripts and Astronomy

Astronomy (Falak)

Astronomy is a science that studies the movement of celestial bodies, especially the moon and the sun in their orbits, systematically and scientifically. Astronomy is often regarded as one of the oldest scientific disciplines. The word 'falak', the plural is 'aflāk', in Arabic means orbit (circulate) celestial bodies (al-madār yasbahu fīhi al-jirm as-samāwy).[4] In the Qur'an, this word is stated twice with the meaning of orbit or trajectory, namely in QS. Al-Anbiya' [21] verse 33 and in QS. Yāsīn [36] verse 40.[5] Carlo Nillino in his work 'Ilm al-Falak Tārīkhuhu 'Inda al-'Arab fī al-Qurūn al-Wusṭā stated that the word 'falak' in the Qur'an does not come from Arabic, but comes from the Babylonian language 'Pulukku'.[6]

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[4] Majma' al-Lughah al-'Arabiyyah, *Al-Mu'jam al-Wajīz* (Republik Arab Mesir: t.t.), 481.

[5] Muhammad Fu'ād 'Abd al-Bāqī, *Al-Mu'jam al-Mufahras li Alfāẓ al-Qur'ān al-Karīm* (Beirut: Dār al-Fikr, 1986), 526.

[6] Carlo Nallino, *'Ilm al-Falak: Tārīkhuhu 'Inda al-'Arab fī al-Qurūn al-Wusṭā* (Kairo: Maktabah al-Thaqāfah al-Dīniyyah, t.t.), 105–106.

At-Tahanawi (12th century AH) defined falak as an illustration of a round sphere that moves in its entirety forever *(kurrah mutaharrikah bi aż-żāt dā'iman)*.[7] Meanwhile, Ibn Khaldun (d. 808/1405) in his *"Muqaddimah"* defines this science as a science that discusses the movement of fixed stars (planets), moving and scattered clouds.[8]

Meanwhile, in *"Dā'irah Ma'ārif al-Qarn al-'Isyrīn"* It is stated that astronomy is the science of the trajectory of celestial bodies *(al-ajrām al-'uluwiyyah)* i.e. the sun and all types of planets *(as-sayyārāt wa śawābit)*. The science of astronomy itself is divided into two parts, namely *naẓary* (theory) and *'amalī* (practice).[9]

Muhammad Ahmad Sulaiman, professor of astronomy at the Helwan-Egypt Observatory of Astronomy and Geophysics, said that astronomy is a science that studies everything related to the universe in the form of celestial bodies outside the earth's atmosphere, such as the sun, moon, stars, galaxy systems, planets, satellites, comets, and meteors in terms of origin, motion, physics and chemistry, and even biology.[10] From the various definitions above, it can be concluded that the formal object of astronomy is celestial bodies, while the material object is the trajectory of celestial bodies. Astrology, astrophysics, astromechanics, cosmology and are disciplines that have formal objects of celestial bodies, but the material objects are different.[11]

Manuscript

The Arabic term for manuscript is called "al-makhthūth", the plural form is "al-makhthūthāt". Etymologically, it means that the

[7] Muhammad 'Āli al-Tahānawī, *Kashshāf Iṣṭilāḥāt al-'Ulūm wa al-Funūn*, jil. 2, ed. Dr. 'Alī Dahrūj (Lebanon: Maktabah Lubnān Nāshirūn, cet. I, 1996), 1287.

[8] Abdurrahmān bin Khaldūn, *Muqaddimah*, Editor: Hamid Ahmad aṭ-Ṭāhir [Kairo: Dār al-Fajr li at-Turāś, cet. I, 1425/2004], p. 602.

[9] Muhammad Farīd Wajdi, *Dā'irah Ma'ārif al-Qarn al-'Isyrīn*, j. 7, (Beirut: Dār al-Ma'rifah, cet. III, 1971), 481.

[10] Muhammad Ahmed Sulaimān, *Sibāḥah Faḍā'It fī Āfāq 'Ilm al-Falak* (Kuwait: Maktaba al-'Yajiri, 1420/1999), 20.

[11] Susiknan Azhari, *Theory and Practice of Philosophy* (Yogyakarta: Lazuardi, cet. I, 2001), 2-3.

manuscript is written by hand, not with a tool.[12] Abd as-Sattar al-Haluji in his work "al-makhthūth al-'Araby" said that Arabic manuscripts (al-makhthūth al-'araby) are Arabic manuscripts either in the form of folds, collections of sheets, in the form of books or in the form of separate sheets. With this limitation, records (rasā'il), treaty texts (al-'uhūd), documents, instruments and written inscriptions are not included in the definition of Arabic manuscripts.[13]

In general, the manuscript referred to here is a manuscript by scholars of the past that is still in the form of handwriting from the author or the copyists of the manuscript that has reached us. In general, these Arabic manuscripts are written on parchment *paper (ar-raqq),* papyrus *(al-bardy),* and Chinese paper *(kāghid).* The majority of the manuscripts written on both skin, papyrus and *kaghid* have not been widely identified both in terms of age, materials, and especially their contents. These manuscripts are generally stored in various world libraries, research institutions and private collections. The terminology *"al-makhthūth"* (manuscript) is not widely circulated in classical Arabic *literature (turāts).* This is understandable because this term actually appeared after the printing activity *(al-mathbū').* However, Az-Zamakhsyari (d. 538/1143) in his work *"Asās al-Balāghah"* and Fairuz Abadi (1205/1790) in *"Tāj al-'Arūs"* have briefly mentioned this term.[14] In this context, a manuscript is a collection of handwritten texts that store various expressions of thoughts, feelings, knowledge and experiences as the creation of an author.

An Overview of Astronomy in the 9th/15th Century in Cairo

Egypt is one of the countries in the African continent. In Arabic, Egypt is called *"Juhuriyyah Mishr al-'Arabiyyah"* or "Arab

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[12] Majma'al-Lughah al-'Arabiyyah, *Mu'jam al-Wajīz* (Republik Arab Mesir: t.t.), 203.

[13]. Abdussattār al-Ḥalūjī, *Al-Makhṭūṭ al-'Arabī* (Kairo: ad-Dār al-Miṣriyyah al-Lubnāniyyah, cet. I, 2002), 15.

[14] Ahmad Syauqi Binbin, "Mā al-Makhṭūṭ?," dalam majalah *Turāthiyyāt*, edisi 3 (Zulkaidah 1424/Januari 2004) (Kairo: Dār al-Kutub wa al-Wathā'iq al-Qawmiyyah), 10; compare with 'Ābid Sulaymān al-Mashūkhī, *Fihrasat al-Makhṭūṭāt al-'Arabiyyah* (Yordania: Maktabah al-Manār, cet. I, 1409/1989), 19–20.

Republic of Egypt" with its capital Cairo. The current system of government adopted by Egypt is the Republican system of government, which is a system of government with the head of state a President. Previously, the country was in the form of a monarchy ruled by King Farouk.

In history, Egypt has been passed by many dynasties (kingdoms), namely the Tuluiniyah era, Ikhshidiyah, Ayyubid, to the Mamalik era. Researchers and historians of science reveal that of the many dynasties that once ruled in Egypt, the Mamalik Dynasty (1250-1517 AD) is the most scientifically productive. Various advances have been made in this era. Scientifically, the Mamluk era reached a high level of maturity, various advances in the field of science have been achieved. These various advances are inseparable from the role of its rulers who provide support to scholars and scientists to develop their research. The discipline of astronomy is a study that did not escape the attention and support of the Mamalik kings at that time.

The pattern of astronomy in the Mamluk era differed from earlier periods, marked by the development of more practical astronomical instruments for determining prayer times, the qibla direction, and the beginning of the month. These instruments included planispheric and universal astrolabes for timekeeping and solving astronomical problems; horary and sine quadrants for measuring celestial altitudes, calculating time, and teaching spherical astronomy; sundials and gnomons in mosques to indicate prayer times; and large-scale observational tools like mural quadrants, armillary spheres, and celestial spheres in observatories for systematic observations of the Sun and Moon.[15] On the other hand, the tendency of astrological studies (astrology) has begun to decrease drastically in this era. King said that astrology was widely practiced in the Middle Ages, but it is surprising that very few astrological works in the Mamalik era can be studied.[16]

[15] François Charette, "The Locales of Islamic Astronomical Instrumentation," *History of Science* 44, no. 2 (2006): 123–138.

[16] David A. King, "The Astronomy of the Mamluks: A Brief Overview," in *Islamic Mathematical Astronomy* (London: Variorum Reprints, 1886), 74.

History records that the Mongol conquest of the city of Baghdad in 656/1258 brought drastic changes to the development of science in the Islamic world in general. This conquest marked the transfer of cultural and scientific centers from the city of Baghdad to the cities of Cairo and Damascus. There are several factors that make the Mamalik area (especially Cairo and Damascus) a center of knowledge, including the serious attention of the Mamalik rulers at that time to science which was marked by the optimization of the role of scholars (scientists) in the development of science. During this period, the halakah of knowledge was so rampant, and the research also received financial support from the rulers. In addition, the loss of Baghdad's overall dominance from the Islamic world politically, automatically makes the positions of Cairo and Damascus even more important. The peak was marked by an exodus of clerics from the city of Baghdad to the cities of Cairo and Damascus.[17]

In its development, the scientific life of the Mamalik era really reached its peak and made it the center of science and scholars of the world. The Mamalik kings had a major role in the development of science, especially in Egypt. In addition, the Mamalik kings also had a passion for science, as shown by Zahir Baibar, who always lived and participated in religious and scientific discussions.[18]

However, despite the various weaknesses that remain, the long history of the Mamalik dynasty has given birth to various advances in various fields, especially in the political and scientific fields.[19] In the scientific field, Mamalik continues to develop and produce a large number of scholars (scientists) in various fields of discipline. Al-Qalqasyandi (d. 821/1418) said that written works at

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[17] Zhamyā‘ ‘Abbās al-Sāmirā’ī, "al-Hibāt al-Haniyyāt fī al-Muṣannafāt al-Ja‘bariyyah," in *Majallat Ma‘had al-Makhṭūṭāt al-‘Arabiyyah*, edisi 54, jil. 2 (Zulkaidah 1431/November 2010), 7–8.

[18] See the analysis (*dirāsah*) of the manuscript *Ghunyah al-Fahīm wa al-Ṭarīq Ilā Ḥall al-Taqwīm* by Aḥmad bin Rajab al-Majdī (d. 850/1446), ed. (taḥqīq) Arwin Juli Rakhmadi (Cairo: Ma‘had al-Makhṭūṭāt al-‘Arabiyyah, master's thesis, 2008), 16.

[19] Qashr al-Amīr Ṭāz, *Ibn Khaldūn Bayna al-Andalus wa Miṣr* (Cairo, 2008), 79.

this time (read: Mamalik era) were very abundant, especially works in the field of religion (Islam).[20]

According to Hitti, the emergence and rise of the Mamalik dynasty is a phenomenon that is difficult to understand.[21] The Mamalik Dynasty was formed through the accumulation and acculturation of various tribes and nations from the slave class which created a community order. The Mamalik dynasty controlled two strategic regions, Egypt and Syria. In its history, the Mamalik Dynasty managed to contain the pace of Mongol invasion under the leadership of Hulagu Khan and Timur Lenk. Historians consider that if the Mamalik failed to defend his territory from the Mongol attack, it is certain that the entire historical and cultural order in West Asia and Egypt would collapse, and the continuity of culture and civilization would no longer be witnessed.[22]

The foundation of Mamalik's power was laid by Syajarah ad-Durr, the Muslim female ruler who ruled in the North African and Western Asian regions of the Ayyubiah Dynasty, who ruled for only 80 days. She was a slave and wife (concubine) of al-Musta'shim. While Aibak (1250-1257 AD) was the first Sultan of Mamalik in the history of the Mamalik Dynasty. On his way, Mamalik was divided into two great dynasties: Bahri (1250-1390) and Burji (1382-1517 AD).[23] The most famous King of Mamalik was Zahir Baibar (1260-1277 AD), he was originally a slave bought by King Salih and appointed as the leader of the army.[24] Baibar once defeated the Mongols, he is also recorded in his struggle against the Crusaders, and he also made many conquests. Baibar's abilities were not only limited to the military field, in addition to successfully organizing the (military) defense, he built a navy, dug a number of canals, repaired ports, and most importantly he connected Cairo and Damascus which became access to the

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[20] Aḥmad bin 'Alī al-Qalqashandī, *Ṣubḥ al-A'shā fī Ṣinā'at al-Inshā'*, jil. 1 (Cairo: al-Mu'assasah al-Miṣriyyah li al-Ta'līf wa al-Tarjamah, t.t.), 467.

[21] Philip K. Hitti, *History of the Arabs: From the Earliest Times to the Present*, 10th ed. (London: Macmillan, 1970), 859.

[22] *Ibid.* 859

[23] *Ibid.*, 862.

[24] *Ibid.*, 864.

dissemination and exchange of information and science. In the religious field, Baibar appointed four judges (kadi) representing four popular schools (Maliki, Hanafi, Shafi'i and Hanbali).[25] Meanwhile, the end of the rule of the Mamalik Dynasty occurred in 1517 AD when King Salim of the Ottoman Dynasty succeeded in overthrowing the power that was in power at that time.

With the position of the center of knowledge owned by the Amalik, it is inevitable that the cities of Cairo and Damascus and other Amalik territories will become a beacon of world science. In the field of astronomy, Egypt and Syria, at that time, had a mature astronomical tradition. The tradition of research and observation became an integral part of astronomers at that time. More specifically, Islamic astronomy in the Mamalik era has its own pattern and character that is different from previous astronomy. Before the Mamalik era, the study of astronomy tended to be Ptolemaic or mathematical astronomy (*falak riyādhiy*) which was sourced from *Ptolemy's Almagest*. However, in the Mamalik era, astronomy began to experience a shift towards nature or *thabī'īy* (*falak fiziyā'iy*, astrophysics) which focused on harmony and harmony with the scientific picture of nature, which was paractic and observation-based.[26] More specifically, Islamic astronomy in the Mamalik era is more directed at practical things such as determining prayer times, the direction of the qibla, determining the hilal (crescent moon) at the beginning of the month, and others. The various creations and acceleration of Mamalik astronomers are manifested in the form of astronomical calculation tools and documentation (zij).

Several key figures in astronomy during the Mamluk era in Egypt and Syria played a crucial role in the development of instruments and practical astronomical practices. Ibn al-Shāṭir (Damascus, d. 1375) designed non-Ptolemaic planetary models that were mathematically close to Copernicus, yet remained geocentric, and produced highly accurate zij as well as

[25] *Ibid.*, 865.

[26] See the analysis of the manuscript *Ghunyah al-Fahīm wa al-Ṭarīq Ilā Ḥall al-Taqwīm* by Aḥmad bin Rajab al-Majdī (d. 850/1446), ed. (taḥqīq) Arwin Juli Rakhmadi (Cairo: Ma'had al-Makhṭūṭāt al-'Arabiyyah, master's thesis, 2008), 7.

timekeeping instruments (miqāt) for the Umayyad Mosque, focusing on determining prayer times and the direction of the qibla. Ibn al-Sarrāj, also from Damascus, was known as a miqāt specialist who compiled widely used tables and instruments for prayer times and qibla direction throughout the Syrian region. Meanwhile, al-Marrākushī al-Maqsī and al-Tīzīnī developed inclined sundials and coordinate tables for designing vertical sundials suitable for the latitudes of Cairo, Damascus, and Aleppo, demonstrating a shift toward highly practical falak fiziyā'ī based on spherical geometry and observation.[27]

More importantly, Mamalik's contribution to astronomy was the birth of a discipline known as mikat *(mīqāt),* which is a discipline related to *timekeeping* based on the daily rotation of the sun and stars to determine the time during the day and night by applying trigonometric formulas to data derived from the observation of the position of the sun and stars.[28]. In the Mamalik era, astronomers generally worked as *mīqātī* or *muwaqqit*, which is a professional astronomer associated with one of the mosques or religious institutions in charge of determining prayer times. In addition, there are also a number of astronomers who are not associated with one of the mosques or religious institutions.[29] This discipline had not yet emerged in pre-Islamic civilizations. Mikat is an original Islamic scientific discipline that is the result of the acceleration and creation of Muslim astronomers in the Mamalik era. Among *the muwaqqit* of the Mamalik era, among others, al-Hasan bin Ali al-Marrakusyi (d. stl. 680/1281), Syihab ad-Din al-Maqsi (d. 675/1276), Ibn Syathir (d. 777/1375), Sibth al-Mardini (d. 912/1506), and others.

[27] David A. King, "The Astronomy of the Mamluks," *Isis* 74 (1983): 531–555. M. Inayah and A. Izzuddin, "Universal Solution of Medieval Spherical Astronomy," *KULMINASI: Journal of Falak and Sharia* (2023).

[28] David A. King, "Mīqāt," in *The Encyclopaedia of Islam*, vol. VII (Leiden–New York: E. J. Brill), 27.

[29] David A. King, "The Astronomy of the Mamluks," in *Islamic Mathematical Astronomy* (London: Variorum Reprints, 1886), 534.

Astronomical Works of the 9th Century AH / 15th Century CE

Instrumental works

Instrument manuscripts are astronomical manuscripts whose descriptions contain a discussion of one or several astronomical instruments. As is understood, medieval Muslim astronomers had a high degree of innovation in creating astronomical instruments, namely by giving birth to a number of astronomical instruments as a result of translating and observing the sky and its objects.

In practice, these tools are more widely used for practical purposes, especially for determining worship times. The most popular instruments are the rubu mujayyab (Arabic: rub' al-mujayyab) and the astrolabe (Arabic: al-usthurlāb). These two instruments are in great demand because of their very applicable functions. Therefore, the works on astronomical instruments written by Muslim scientists are dominated by these two instruments.

In addition to these two tools, numerous others were developed, it's just that their use is not as popular as these two. Other tools can be mentioned: shundūq al-yawāqīt (time box), mīzān al-fazzary (scale of al-Fazzari), al-ālah al-muhayya'ah, mizwalah (mizwala), bushlah (compass), al-musātirah, jaib al-ghā'ib, al-murabba'ah, shafīhah az-zarqāliyyah (zarqali plate), ash-syakāziyyah, ālah ibn as-sarāj (Ibn Saraj's tool), dzāt al-halq (circle), ash-syāmilah, libnah, halqah i'tidāliyyah, dzāt ats-tsuqbatain, kurrah samāwiyyah (celestial sphere), dzat as-samt wa al-irtifā' (torquetum), dzāt al-autār, al-musyabbah bi al-manāthiq, thabaq al-manāthiq (equatoria), sudsiyyah (sect), suds al-fakhry (sect al-Fakhri), al-halqah al-ufūqiyyah as-syāmilah, and others. Many lesser-known astronomical instruments were not widely adopted due to several factors, including being highly specialized, technically complex, or serving very specific functions that did not align with everyday observational needs.

Here are some of the astronomical instrument texts that specifically deal with astrolabes: "Tuhfah ath-Thullāb fī al-'Amal bi al-Usthurlāb" by Ibn ash-Shaffar (d. 5th/11th century), "Risālah al-Mizzy fī al-Usthurlāb" by al-Mizzy (d. 690/750), "Risālah fī al-'Amal bi al-Usthurlāb wa Rub' al-Muqantharāt wa ar-Rub' al-

Mujayyab" by Ibn Syathir (d. 777/1375), "Nuzhah ath-Thullāb fī 'Ilm al-Usthurlāb" by Umayyad bin Aby ash-Shilat (d. 529/1134), and "Al-Kāmil fī al-Usthurlāb" by al-Farghany (d. 347/958).

The manuscript of the astronomical instrument discusses Rubu Mujayyab: "Kasyf ar-Raib fī al-'Amal bi Rub' al-Jaib" by Muhammad al-Mizzy (d. 750/1349), "Idhāh al-Mughib fī al-'Amal bi ar-Rub' al-Mujayyab" karya Ibn Syathir (w. 777/1375), "Al-Fathiyyah fī al-A'mal al-Jaibiyyah" karya Jamaluddin al-Mardiny (w. 809/1406), "Risālah fī al-'Amal bi ar-Rub' al-Mujayyab" karya Sibth al-Mardiny (w. 907/1501), dan "Risālah Musytamilah ''ala Qawā'id Hisābiyyah wa A'mal Handasiyyah fī al-'Amal bi Rub' al-Juyūb" karya Sibth al-Mardiny (w. 912/1506).

In addition to the astrolabe and the rubu mujayyab, there are other astronomical instrument manuscripts discussing the mizwala and the equinoctal circle, namely the manuscript "Risālah fī Dā'irah al-Mu'addil" by Abdul Aziz al-Waffa'iy (d. 879/1474) and the manuscript "Risālah al-'Azawy fī al-Mazāwil" by Khalil al-'Azawy (13th/19th century).

Table of Zij

Table manuscripts are astronomical manuscripts that in their construction are in the form of tables (columns) that contain a list of letters and numbers that indicate a certain purpose. These letters and numbers are the result of observations and calculations of the movements of celestial bodies carried out by scholars (scientists). These tables adorn many astronomical manuscripts, both in whole and in part.

Astronomical table literacy was a popular tradition among medieval Muslim astronomers. In fact, this tradition has become the standard for the scientific quality of an astronomer. This is because these tables can only be compiled based on careful and continuous observations. As is also understood, the study of astronomy – both theoretical and practical – cannot be separated from the use of tables (zij).

In practice, these tables (zij) are sometimes the result of an astronomer's observations and calculations that he writes in his work (manuscript), but sometimes he quotes from others.

However, it is worth noting, however quoting, it is accompanied by good understanding and mastery.

In general, the form and characteristics of table astronomy texts are as follows: (1) using the jumali numerical system (hisāb al-jummal), (2) in its description using the system of degrees, minutes, and seconds, (3) using special terms such as al-khāssah, al-markaz, at-ta'dīl, and others.

Some of the works of Zij are popular in Islamic civilization including: (1) Zij al-Hakimy. Zij al-Hakimy or Kitab az-Zaij al-Kabir al-Hakimy is the work of Ibn Yunus (d. 399 H). The preparation of this zij was originally a request from King Fatimiah Al-Aziz, but it was only completed in the time of King Al-Hakim, so this zij was named Zij al-al-Hakimy. This is Ibn Yunus's best contribution in the field of astronomy. In general, these pages contain the results of eclipse observations and other astronomical phenomena.[30]

(2) This "Zij al-Khawārizmī" is also called the "Kitāb az-Zaij" (Table Book) by Abu Ja'far Muhammad bin Musa al-Khawarizmi (d. 232/848). This zij consists of two parts, so it is sometimes called the First Zij (az-Zaij al-Awwal) and the Second Zij (az-Zaij ats-Tsāny). In its compilation, Al-Khawarizmi quoted many schools of Indian and Persian astronomy, so that sometimes this is also known as as-Sindhind ash-Shaghir (Little Sindhind). However, in the calculation of interpolation (at-ta'ādīl) and declination (al-mail) it is different from the Indian zij-zij. Interpolation is based on the Persian school and the declination of the Sun is based on the Ptolemaic school.[31]

(3) "Zij Abu Ma'syar" Abu Ma'syar (d. 272/885) was a popular astronomical figure in Islamic civilization. According to al-Qifthi, in the field of zij, Abu Ma'syar is recorded to have several collections of zij. Among others, Zij al-Kabīr (Big Table) and Zij ash-Shaghīr (Small Table), the latter of which is also called Zij al-Qirānāt (Conjunction Table) which incorporates knowledge of the

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[30] Ibn Khallikān, *Wafayāt al-A'yān wa Anbā' Abnā' al-Zamān*, jil. 3, ed. Iḥsān 'Abbās (Beirut: Dār al-Thaqāfah, t.t.), 429.

[31] Arwin Juli Rakhmadi Butar-Butar, *Khazanah Astronomi Medieval Islam* (Purwokerto: UMP Press, cet. I, 2016), 439.

planets in relation to the timing of the conjunction of Saturn and Mustary that occurred since the era of hurricanes.[32]

(4) "Zij ash-Shāby'". This zij is the work of Al-Battani (d. 317/929), with the full title "az-Zaij ash-Shāby' fī Hisāb an-Nujūm wa Falak al-Burūj wa Mawādhi' al-Kawākib wa Ghairihā" (Sabean Table on the Calculation of the Stars and Orbits of the Zodiac, Position of the Planets and Others). This is al-Battani's best work in astronomy. This zij was written based on Zij al-Mumtahan (Verification Table) by Yahya bin Abi Manshur. According to the researchers, this book is the first to discuss azimuths, nadir points, the closest and farthest points of the Sun from Earth, and spherical trigonometry. This Zij consists of 57 chapters discussing the motion of celestial bodies (especially the Sun, Earth and Moon), discussion of astronomical tools and the process of making them, description of the division of the celestial sphere into zodiac signs and their degrees.

(5) "Zij ad-Durr al-Yatīm". The full title of this page is "ad-Durr al-Yatīm fī Shinā'ah at-Taqwīm" by Ibn Majdi (d. 850/1446), an Egyptian astronomer. This Zij contains tables of celestial bodies, especially the Moon and the Sun. King and Kennedy have done research and wrote this paper under the title "Ibn al-Majdi's Table for Calculating Ephemerides". As the second narration says, this zij was once given by Ibn Majdi himself, then it was given by 'Izzuddin al-Wafa'i (d. 874/1469), Ibn al-Fath al-Shufi (d. 883/1478), Hasan bin Khalil al-Karadisi (d. 887/1482), Ahmad al-Kutubi al-Kharfani, Salim bin Hamzah bin Bakhsy, Ahmad bin Musa, Yahya bin Muhammad al-Khattab, and Uthman bin Shalih al-Wardani. The number of lectures on it actually shows the depth and excellence of this Zij.[33]

(6) "Zij Ulugh Bek" (Zij Jadīd Sulthāny). Some sources say that this zij consists of several titles, including: Zij Kūrkāny, Zij Jadīd Sulthāny, and Zij Ulugh Bek. This zij is the work of an astronomer

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[32] 'Abd al-Amīr al-Mu'min, *Qāmūs Dār al-'Ilm al-Falakī* (Beirut: Dār al-'Ilm li al-Malāyīn, cet. I, 2006), 232.

[33] David A. King and E. S. Kennedy, "Ibn al-Majdī's Table for Calculation of Ephemerides," in *Islamic Mathematical Astronomy* (London: Variorum Reprints, 1886), 49–68.

named Ulugh Bek (d. 853/1449). This Zij consists of four parts, the first part is about the calendar (consisting of the preamble and 5 chapters). The second part is about knowing the time of the rising of celestial bodies (al-mathāli') at all times (consists of 22 chapters). The third part is about the circulation of the planets and their positions (consists of 13 chapters). The fourth part is about the position of the 'fixed' stars. According to Hajji Khalifah, these zij are very good and very detailed. This zij was once lectured by Maryam Jalbi, Ali al-Qusyji, and once summarized by al-Shufi.[34]

Commentary Works

A commentary (*al-makhthūthāt asy-sharihah*) is a manuscript written by a scholar and subsequently received comments (*syarh*) from disciples or scholars (astronomers) who came afterwards. In the study of classical manuscripts, manuscripts with the genre of commentary (*syarh*) have an important position. The urgency of the commentary manuscript is to show that it has depth and detail in its discussion. In addition, he can explain difficult and complicated things in a text (*matan*). The commentary script also functions to criticize the opinions and thoughts of a character (author) in the matan manuscript.

To a certain extent, commentary manuscripts have a higher popularity and urgency than matan texts (manuscripts). In his tradition, commentary texts have more than one commentary (syarh) which shows that he is in great demand. This also shows the connection of thoughts in it.

Commentary manuscripts adorn the writing of astronomical works by Muslim astronomers. Some of the commentaries in the field of astronomy can be mentioned, including Ptolemeus "al-Majisthy" manuscript . This manuscript has many sharh in a fairly long period of time. This manuscript was translated from Greek to Arabic at least four times throughout the 2/8 and 3/9 centuries. The figures who have commented on this work include: Ibn Haitsam (d. 430/1038) in the 10th century AD and Nashiruddin al-Thusi (d. 672/1273) in the 7th/13th century. Next is the lecture on the

[34] Qadrī Ḥāfiẓh Thu'qān, *Turāth al-'Arab al-'Ilmī fī al-Riyāḍiyyāt wa al-Falak* (Cairo: al-Hay'ah al-'Āmmah li Quṣūr al-Thaqāfah, cet. I, 2008), 228.

manuscript "al-Ushūl" by Euclid, where the most important lecture (commentary) is the manuscript entitled "Sharh Mashādirāt Kitāb Euclid" by Ibn Haitsam (d. 430/1038).

Furthermore, the manuscript of Syarh Qadhi Zadah against the manuscript "al-Mulakhkhash fī al-Hai'ah al-Basīthah" by al-Jighminy. The manuscript "al-Mulakhkhash" is recorded to have been lectured by Abdurrahman as-Suwaidi, Fadhlullah al-'Ubaidy, as-Syarif al-Jurjani, Muhammad bin Zadah ath-Thayyib, and Kamaluddin at-Turkmany.

"Al-*Mulakhkhash*" by al-Jighminy itself is an educational book that contains various important discussions of astronomy and geography. Some of the discussions in it include the earth, the motion of the earth, and the discussion of the planets. This book is an important source of reference in astronomy and geography. According to Nillino, this book is one of the important books in the history of Arabic astronomy, studying it is a requirement to obtain a diploma in astronomy and geography. This book can be seen as a basic astronomy education book in the history of science. The book was translated into German in 1893.

Here are some of the commentary texts: *"Syarh li Mulakhkhash fī al-Hai'ah al-Basīthah"* by Musa bin Muhammad Qadhi Zadah ar-Rumi (d. 1436 AD) and *"Taudhīh at-Tadzkirah fī 'Ilm al-Hai'ah li ath-Thusy"* by Nizhamuddin al-Hasan bin Muhammad.

Mikat Works

Mikat (Arabic: al-mīqāt and al-mawāqīt), in language means time allocated as an activity. The terminology mīqāt has been popular among medieval Muslim astronomers. In its development, the discipline of mikat is an independent discipline that is different from the science of zij and observation. According to Al-Akfani (d. 749/1348), the science of mikat is a branch of astronomy that plays a role in knowing and studying the position of celestial bodies starting from their shape, location, size, distance, and motion.[35] Meanwhile, Al-Qalqasyandi (d. 821/1418)

[35] Muḥammad bin Ibrāhīm al-Akfanī, *Irshād al-Qāṣid Ilā Asnā al-Maqāṣid*, ed. ʻAbd al-Munʻim ʻUmar (Cairo: Dār al-Fikr al-ʻArabī, n.d.), 202.

in "Shubh al-A'syā fī Shinā'ah al-Insyā" expressly places the science of al-mawāqīt as one of the branches of astronomy.[36]

Mikat as a branch of astronomy is more oriented to the study related to practical aspects of Muslim worship, such as the determination of prayer times, the direction of the qibla, and the rukyatul hilal. Therefore, the pattern and or type of mikat texts here are scripts written with the theme of prayer time, qibla direction, and rukyatul hilal.

Some of the popular mikat figures in Islamic civilization include: Sibth al-Mardiny (d. 912/1506) with his work "Wasīlah ath-Thullāb wa Nuzhah al-Albāb Ila Ma'rifah al-Auqāt bi al-Hisāb" by Sibth al-Mardiny (d. 912/1501) and Ahmad bin Rajab al-Majdy (d. 850/1446) with his work "Khulāshah al-Aqwāl fī Ma'rifah al-Waqt wa Ru'yah al-Hilāl" by Ibn al-Majdy (d. 850/1446)

The mikat texts that discuss the direction of the Qibla include: "Qaul fī Samt al-Qiblah bi al-Hisāb" by al-Hasan bin al-Hasan bin al-Haitsam (w. 430/1038), "Risālah fī Ma'rifah Samt al-Qiblah by Ali bin Muhammad al-Bazdawi (w. 482/1089), "Qaul fī Samt al-Qiblah bi al-Hisāb" by Ibn al-Haitsam (w. 430/1038), "Tuhfah al-Ahbāb fī Nashb al-Badzāhanj wa al-Mihrāb" by Ahmad bin Rajab al-Majdy (d. 850/1446), "Al-Hidāyah Min adh-Dhalālah fī Ma'rifah al-Waqt wa al-Qiblah wamā Yata'allaqu bihimā Min Ghair Alah" by Syihabuddin al-Qalyubi (d. 1069/1658), and "Kitāb Tahdīd al-Qiblah" by Ibn al-Banna' al-Marrakusyi (d. 740/1339).

Manuscrips mikat in rukyatul hilal: "Risālah fī Isti'māl Jadwal li Hisāb Ru'yah al-Hilāl" by Ahmad bin Rajab al-Majdy (w. 850/1446), "Al-Manhal al-'Adzb az-Zulāl fī Hall at-Taqwīm wa Ru'yah al-Hilāl" by Ahmad bin Rajab al-Majdy (w. 850/1446), and "'Iqd ad-Durar fī al-'Amal bi al-Qamar" by Ahmad bin Rajab al-Majdy (w. 850/1446), "Risālah fī 'Amal al-Ahillah bi Tharīq al-Jadāwil" by Hasan bin Khalil al-Karadisy (d. 887/1482), "Risālah fī 'Amal al-Ahillah bi al-Hisāb" by Hasan bin Khalil al-Karadisy (d. 887/1482), and "Barā'ah al-Istihlāl wamā Yata'allaqu bi asy-Syahr wa al-Hilāl" by Abdurrahman bin Isa al-'Umry (d. 1037/1627).

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[36] Aḥmad al-Qalqashandī, *Ṣubḥ al-A'shā fī Ṣinā'at al-Inshā'*, jil. 1 (Cairo: Maṭba'ah Dār al-Kutub al-Miṣriyyah, 1340/1922), 476–477.

Typology, Content, Characteristics

Astronomical typologies emerged through systematic study and observation of celestial phenomena with various social settings and objectives that surround them. These various social settings and diverse goals ultimately lead to these typologies. In addition, astronomical typology also emerged as a response to previous astronomical ideas that were generally theoretical-astrological.

Theoretical Astronomy

Theoretical astronomy is illustrated in its theories that focus on the study of the universe (al-kawn) as illustrated by the apparent motion of celestial bodies. In history, the pioneer of this field is none other than Ptolemeus from Yunani, in his work Almagest.[37] The object of study in theoretical astronomy in general is celestial bodies that appear from the earth.[38] Another characteristic of theoretical astronomy is the weighting of mathematical and astronomical calculations and their compatibility with empirical observations. Among the Muslim astronomers who developed many astronomical models was Ibn Majdi (d. 850/1446) in his work "Ghunyah al-Fahīm wa ath-Tharīq Ilā Hall at-Taqwīm" (Comprehensive Understanding and Methods of Solving Calendars), among others. In its development, Muslim astronomers conducted research on Ptolemy's theories, so that works in the form of revisions, criticisms and corrections were born, both in terms of theory, observation and philosophical foundations.

Among others, Ibn Haitsam (d. 430/1038) in his work "asy-Syukūk 'alā Bathlamiyūs" (Doubts on Ptolemy) contains 16 criticisms of Ptolemy's astronomical theories. Next in the 7th/13th century Nashiruddin al-Thusi (d. 672/1273) with his comprehensive correction known as "muzdawijah ath-thūsy" (al-Tusi's Couple) explained the various contradictions between

[37] **See** the introduction by Aḥmad Fu'ād Bāshā in *Ishāmāt al-Ḥaḍārah al-'Arabiyyah wa al-Islāmiyyah fī 'Ulūm al-Falak* (Iskandariyyah: Maktabah al-Iskandariyyah, 2006), 9.

[38] *Ibid.9*

Ptolemy's theories and empirical observations. Next came other critics such as Muhyiddin al-'Urdhi (d. 1266 AD) and Ibn Syathir (d. 777/1375), both of whom came from the astronomical madrasah of Maragha, Iran.[39]

Practical Astronomy

Practical astronomy (falak tathbīqy) is astronomy that focuses on the study and observation of celestial bodies and formulating them in a number of astronomical instruments. In practice, various activities in this field are documented in a number of records called zij (astronomical tables). This model of astronomy has a distinctive Islamic character because it is related to the system and timing of Muslim worship acts, especially the determination of the direction of Mecca (qibla), the determination of prayer times, and the determination of the visibility of the hilal. In addition to worship, practical astronomy also plays a role in practical aspects of daily life such as observing the stars in the sky to determine (predict) the seasons and crops, estimating routes and travel times for trade, determining the time of certain worship rituals, and others. Some of the astronomical figures who wrote and studied the practical aspects of astronomy were Ibn Majdi (d. 850/1446) with his work "ad-Durr al-Yatīm"[40].

For the sake of the worship system and timetable, this astronomy is definitely related to geographical-mathematical aspects, especially in the context of determining latitude and longitude coordinate points. Determining the direction of the qibla, for example, requires an understanding of the spherical triangle to determine three points: the point (region) of a place, the point of Mecca, and the north pole. In its development, the methods used are very diverse, ranging from estimation methods to complex mathematical methods. The practice of the early

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[39] Arwin Juli Rakhmadi Butar-Butar, *Khazanah Astronomy of Medieval Islam* (Purwokerto: UMP Press, cet. I, 2016), 57–58.

[40] So far, research on *al-Durr al-Yatīm* has been carried out by David A. King and E. S. Kennedy in the article "Ibn al-Majdī's Table for Calculation of Ephemerides"; **see** David A. King, "Ibn al-Majdī's Table for Calculation of Ephemerides," in *Islamic Mathematical Astronomy* (London: Variorum Reprints, 1886), 49–68.

Islamic generation, the direction of the Qibla in various regions was determined based on the position of the mosque mihrabs built and determined by the Companions, such as the Amru bin Ash Mosque in Egypt and the Great Mosque of the Umayyad in Syria. However, as Dallal stated, the determination of the direction of the Qibla with this method has many errors and inaccuracies in the direction.[41]

The most concrete form of practical astronomy is the emergence of a branch of astronomy called mikat (al-mīqāt, timekeeping). Historically, the emergence of mikat science is a response as well as a socio-religious demand to the importance of accurately determining the times of worship. This science began to develop and became popular in the 6th/13th century, and it is thought that the main pioneer was Ibn Yunus (d. 399/1008).

Observational Astronomy

Observational astronomy is astronomy that is based on observation in the formulation of theories and their applications. Basically, both theoretical and practical astronomy, even astrology, is entirely based on the observation of celestial bodies. However, in observational astronomy, observation without theoretical study of the observation results is emphasized. Likewise, there is no purpose in applying the results of the observations in the interests of daily life, both related to worship rituals and civic activities.

Observational astronomy is solely limited to the observation of celestial bodies. As is understood, through serious and careful observation of celestial bodies, all creations and contributions in the field of astronomy are found. However, in the pre-Islamic era, the activity of observation was popular in society but it was still biased against mystical and mythical elements.

In contemporary studies, observational astronomy is closely related to other types of astronomy (theoretical, practical, and astrological), all complementing each other. Theoretical astronomy seeks to explain observations, while observations are used to

[41] Aḥmad Dallal, "Science, Medicine, and Technology and the Creation of a Scientific Culture," in *Islamic Sciences*, ed. John L. Esposito, trans. M. Khoirul Anam (Jakarta: Initiation Press, cet. I, 2004), 38.

confirm theoretical results, and are subsequently applied in everyday life. Even the practice of astrology – in the Middle Ages – could not be separated from these elements. In fact, the presence of astrology is actually an attempt to translate the life of a person or a group of people in the present and in the future, no matter how forbidden. In its development, although observational astronomy is more focused on observation alone, for the present era these observation results are very urgent for practical research purposes. The rapid development of cosmic objects along with the sophistication of celestial body detection technology requires comprehensive and continuous study. Therefore, observation results are absolutely necessary.

Conclusion

Astronomical manuscripts from the 9th century Hijri (15th century CE) in Cairo, particularly those preserved in Dar al Kutub al Mishriyyah, the Al Azhar Library, and the Library of the Arab Manuscript Institute, exhibit distinctive typologies, contents, and characteristics, reflecting the advanced and dynamic nature of astronomical science that developed during this period.

The typology and pattern of astronomical manuscripts (works) in the genre of astronomical instruments, zij, commentary works, and mikat works show the growth of the study of astronomy in this century, which sociologically the manuscripts of Muslim astronomers appeared driven by the socio-religious-intellectual activity that developed at that time, among which was driven by the practical needs of society as well as intellectual development.

In the Indonesian context, the works of Muslim astronomers of the 9th century Hijri (15th century CE) share typological and thematic similarities with Nusantara astronomical manuscripts, while differing in the depth of scholarly discussion. Islamic astronomy of this period generally emphasized complex mathematical calculations and instruments, whereas Nusantara scholars focused on more practical approaches adapted to local needs. Further systematic comparative studies are required to clarify these distinctions.

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