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The Legacy of Muslim Astronomers in Medieval Maritime Supremacy and Its Importance in Today's Maritime Domain

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ABSTRACT
Muslims made unparalleled contributions to astronomy during the medieval period. The period from the 7th century to the 13th century was considered the Islamic Golden Age. Muslim scientists excelled in science and technology, especially in astronomy and other related fields. The incredible contribution of the Al-Battani and Piri Reis maps was repeatedly quoted by European astronomers, which is still considered the base of astronomy. Ahmed Ibn Majid guided Vasco da Gama (a Portuguese navigator) in achieving the first sea trade route from Europe to India in the mid-15th century. Their scientific innovation was largely transmitted to Europe through crusades and trade relations. Muslim scholars and scientists significantly influenced Western prosperity and urbanization, yet their contributions are often overlooked in favor of Greek works. This study aims to highlight the medieval scientific achievements of Muslim scholars, particularly in astronomy, which played a crucial role in medieval naval ascendancy and still holds relevance in the 21st-century maritime domain. The study relies on qualitative analysis based on secondary data.
Keywords: Medieval period, Islamic Golden Age, Astronomy, Al-Battani, Piri Reis

ABSTRAK
Umat Islam memberikan sumbangan yang tiada tandingannya kepada astronomi pada zaman pertengahan. Tempoh dari abad ke-7 hingga abad ke-13 dianggap sebagai Zaman Keemasan Islam. Para saintis Islam cemerlang dalam bidang sains dan teknologi, terutamanya dalam bidang astronomi dan bidang lain yang berkaitan. Sumbangan luar biasa peta Al-Battani dan Piri Reis telah berulang kali dipetik oleh ahli astronomi Eropah, yang masih dianggap sebagai asas astronomi. Ahmed Ibn Majid membimbing Vasco da Gama (seorang pelayar Portugis) dalam mencapai laluan perdagangan laut pertama dari Eropah ke India pada pertengahan abad ke-15. Inovasi saintifik mereka sebahagian besarnya dihantar ke Eropah melalui perang salib dan hubungan perdagangan. Cendekiawan dan saintis Muslim mempengaruhi kemakmuran dan urbanisasi Barat dengan ketara, namun sumbangan mereka sering diabaikan dan memihak kepada karya Yunani. Kajian ini bertujuan untuk menyerlahkan pencapaian saintifik zaman pertengahan para sarjana Islam, khususnya dalam astronomi, yang memainkan peranan penting dalam penguasaan tentera laut zaman pertengahan dan masih relevan dalam domain maritim abad ke-21. Kajian ini bergantung kepada analisis kualitatif berdasarkan data sekunder.
Kata kunci: Zaman Pertengahan, Zaman Kegemilangan Islam, Astronomi, Al-Battani, Piri Reis.

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1. Introduction

The word "astronomy" comes from the Greek word "astronomia," which means "law of the stars." In the 7th century, people used astronomical tools to calculate the direction of Mecca from any location and to track months (Gibson, 2016). During the Abbasid regime, Muslims excelled in astronomy, significantly contributing to the scientific and cultural advancements of their time. Caliph Al-Mansur founded Baghdad in 762 AD transforming it into a hub of science, philosophy, culture and innovation (Griffin, 2014). Islamic civilization during this period saw unparalleled growth in intellectual pursuits, with Islam and the Arabic language serving as catalysts for scientific research, especially in astronomy.

Muslim astronomers of the medieval era developed sophisticated astronomical tools that revolutionized maritime navigation. These innovations enabled extensive maritime ventures, significantly impacting global trade routes. Amir Muawiya, a commander under Caliph Umar Ibn Khattab, established the first Muslim naval force with the regime of Caliph Uthman's approval (Najeebabadi, 2001). Muawiya's successful seizure of Cyprus in 648 A.D. marked the beginning of Muslim dominance in the Mediterranean, extending trade routes from the Persian Gulf to Madagascar, China, Korea, and Japan (Yaakob et al., 2013). Key ports were established in Aden, Basra, the Red Sea and Bandar Siraf, facilitating extensive maritime trade (Yaakob et al., 2013).

The Abbasid caliphate's fall in 1258 due to the Mongol invasion led to a temporary decline in Muslim naval power, which resurged under the Ottomans. The Ottoman Empire, particularly under Sultan Muhammad al-Fatih and Sultan Suleiman the Magnificent, saw Muslim naval power and scientific achievements reach their zenith in the 16th century (Isa and Sidek, 2014; Hitti, 2002). The Ottomans controlled important maritime regions, including the Red Sea, the Mediterranean and the Indian Ocean.

In contrast, medieval Europe experienced a period of intellectual and scientific stagnation, referred to as the 'Dark Ages,' spanning from the end of the 5th to the mid-11th century (Russell, 1967). The dominance of the Catholic Church and various socio-cultural factors hindered scientific innovation. However, European scholars eventually absorbed the knowledge of Muslim scientists, significantly influencing modern European culture. From the 12th century onwards, the contributions of Muslim scholars were transmitted to the West through crusades and trade relations (Al-Hassan, 2006). While Greek and Roman legacies influenced the West, the comprehensive contributions of Muslim scholars were unparalleled.

This manuscript aims to highlight the profound impact of Muslim astronomers on medieval maritime supremacy and their enduring legacy in today's maritime domain. Additionally, it examines the influence of the Quran on astronomical knowledge, encouraging further research on maritime history in shaping the scientific world.

2. Research Methodology

This study adopts qualitative research method by using secondary data from books, journals, magazines, newspapers, relevant websites, E-books and E-libraries etc.

3. Golden Age: Islamic Astronomers in medieval era

A profound pursuit of knowledge was evident in Baghdad during the reign of the Abbasid Caliphate, with scholars contributing significantly to the preservation and advancement of knowledge. According to Griffin the pivotal role played by scholars residing in Baghdad, who not only preserved existing knowledge but also gave new insights that eventually disseminated to Europe (2014). Baghdad considered as the “House of Wisdom" under the patronage of Abbasid Caliph Al-Mamun in the early 8th century, signifying a flourishing center of intellectual activity. Al-Mamun's support for astronomical research was particularly notable, leading to a surge in the establishment of libraries and observatories during the Golden Age of Islam. Notably, he established the largest library in Baghdad and the first real observatory, underscoring the Abbasid Caliphate's commitment to scholarly pursuits (Mackensen, 1932).

a. Al-Khwarizmi's Astronomical Legacy

Islamic astronomy played a pivotal role in shaping the Renaissance and continues to influence modern science, particularly in the maritime domain, where many stars retain their Arabic names. In 830, the Persian mathematician Al-Khwarizmi (780–850) translated "Zij al-Sindhi," a significant astronomical work containing tables of the moon, sun, and planets (Anjum, 1997). This translation marked a milestone in Islamic astronomy, as Al-Khwarizmi synthesized knowledge from Indian Hindu astronomers and incorporated elements from Ptolemy's works (Pingree, 1978). His contributions to astronomy were substantial, particularly in the accurate calculation of celestial bodies' positions, including the sun, moon and planets (Anjum, 1997). Muslim astronomers of the 9th century engaged in primary research, translation of scholarly works, and added new insights, with Al-Khwarizmi's work encompassing spherical astronomy, eclipse calculations, and lunar visibility (Anjum, 1997).

Al-Khwarizmi's geographical contributions, notably his work "Kitab Surat al-Ard," formed the foundational basis for world map development (Schoy, 1924; Pingree, 1978). Additionally, his pioneering efforts in developing tables of sines, tangents, parallax, astrological tables and eclipse calculations further solidified his legacy in the field of astronomy (Chabás, 2012).

b. **Al-Battani: One of History’s Top Twenty Astronomers**

Al-Battani (858–929) was a brilliant Muslim scholar in astronomy in the 8th century. He lived in the era of Islamic civilization, which was very rich in science. During that regime, Muslims contributed to humanity. He worked in astronomy for over forty years, from 877 to 918 (Aktar and Dutta, no date). Al-Battani revealed that the distance varied from the sun to the earth and resulted in annular eclipses of the sun (Ikbal, 2015). He accurately determined the length of the solar year as 365 days, 5 hours, 46 minutes, and 24 seconds (Ikbal, 2015). That is the most precise calculation in history. This is the deviation from the actual modern estimation by just 2 minutes, 22 seconds (Ikbal, 2015).. In that regime, Ptolemy's theory significantly influenced a talented scientist like Al-Battani, who did not dare claim that the distance varied from the Earth to the Sun. Al-Battani's calculation differed greatly from Ptolemy’s. Al Battani, whose contributions influenced Kepler, Galileo and Tycho (Marini, 2023). He wrote astronomy-related books, his most renowned book, “Kitab al-Zij”, refining the work of Ptolemy (Ikbal, 2015). He also provided a star catalog, solar, lunar, trigonometric tables, and diagrams of planetary tables (Marini, 2023).

According to the French astronomer Lalande (1732–1807), Al-Battani was one of the most influential and top twenty astronomers living in the world (Rather and Kanth, 2021). It was from the Al-Battani tables that Regiomontanus (a mathematician) constructed the Ephemerides (a kind of Astro table), which made the voyage of Columbus possible (Rather and Kanth, 2021). Muslim scholars believed that the Earth was spherical 500 years before Galileo. In the 9th century, the astronomer Ibn Hazm stated, "The sun is always vertical to a certain location on Earth (Abdulazeez and Shuriye, 2011).

c. Abu Reyhan Al Biruni: Islamic Scholar and Polymath

Over a thousand years ago, calculating the radius of the Earth needed a lot of imagination. Abu Reyhan Al-Biruni (973–1048) was the one who combined trigonometry and algebra to arrive at this exact numerical computation (Mirza, 2010). For decades, Biruni's intellectual legacy has inspired intellectuals and scientists.

In a 1975 UNESCO Courier article, the famous Tajik academician Bobojon Gafurov hailed Biruni as a world genius who "was so far ahead of his time that his most brilliant findings looked unintelligible to most of the experts of his day" (Tasci, 2020). George Sarton, the founder of the History of Science discipline, named the 11th century the Al Biruni Age (Tasci, 2020).

d. Abbas Ibn Firnas: Pioneer of Early Aviation and Astronomical Innovation

Abbas Ibn Firnas, born in Ronda in 9th century , made significant contributions to astronomy (Jamsari et al., 2013). He constructed a planetarium in his home, allowing the observation of various celestial phenomena (Neugebauer, 1949). However, his most notable achievement was his invention of a flying device, a pioneering moment in aviation history, recognized by scholars like White (1961). Western scholar Hitti highlighted Ibn Firnas as the first to pursue flight through scientific means (1964).Despite this, there is debate about his legacy, with Lienhard suggesting another figure, Armen Firman, might have influenced him, although evidence for this is limited (2003). Historical records show Ibn Firnas began experimenting with flight around 875 A.D. by using silk and eagle feathers to create a rudimentary flying apparatus (Jamsari et al., 2013). His efforts led to a significant public demonstration at age 65, despite injuries sustained during a landing. His death in 887 A.D capped a life of remarkable achievements in aviation and scientific inquiry (Jamsari et al., 2013).

e. Mirza Ulugh Beg: Star's Catalog

Mirza Ulugh Beg was a 15th-century Timurid ruler in Central Asia who was also a passionate astronomer (Abdurahmonovich, 2022). He built an observatory in Samarkand, Uzbekistan, where he conducted detailed observations of celestial bodies. Ulugh Beg's star catalog, called the Zij-i-Sultani, contained precise measurements of the positions of stars and provided valuable data for future astronomers (Abdurahmonovich, 2022).

4. Contributions of Muslim astronomers in the Medieval Era

Muslim astronomers of the Medieval Era made groundbreaking contributions to the field of astronomy. Their work remains a lasting testament to their scientific prowess, shaping modern astronomy, navigation, timekeeping and the development scientific instruments. In this study, we'll highlight the key achievements (astrolabe, mechanical lunisolar calendar, Sundial Quadrant and theory of earth rotation) of muslim astronomers and their enduring legacy around the world.

a. Astrolabe

The Greek term asturlabun, which means "star holder," is where the word "astrolabe" actually comes from (Safiai & Ibrahim, 2016). Astrolabe was an ancient analog computer that processed numerous kinds of calculations related to astronomy. The ancient astrolabe was designed by Apollonius of Perga in 225 BCE by the Hellenistic civilization (Neugebauer, 1949). Later astrolabes were further developed and introduced angular scales, which was extensively used throughout the Muslim world. Astrolabes were largely used to calculate the time of prayer, as well as the time of sunrise and sunset, the length of the day and the location of celestial objects in the sky. These technologies were used mostly by astronomers, astrologers and navigators. Arabs refined astrolabes and discovered new uses for them in various aspects of life. In the eighth century, the great Arab scientist and mathematician Muhammad ibn Ibrahim al-Fazari was the first Arab to construct an astrolabe (Pingree, 1970). In contrast, the Arab astronomer Al-Battani was the first to build the astrolabe's mathematical base (Bruin, 1977). During the Islamic era, three new types of astrolabes were developed: linear, universal and geared astrolabes (Powell, 2019). The astrolabe was introduced to the European peninsula by Arabs via Andalusia in the 11th century (Powell, 2019). This device had a profound influence on astronomy studies in medieval Europe, contributing to modern scientific growth. It's difficult to estimate the significance of this instrument in our life. While it is not extensively used today, it had an important role in the past and its impact continues to this day. Astrolabe theory strengthens GPS, space research, and navigation technologies. This is to remind us, when we travel or use modern technology; that our Arab ancestors played a key role in making this possible (Küçük, 2021). The astronomers and navigators of the Middle Ages used the astrolabe, an ancient tool, to determine latitude, longitude, and the time of day (Küçük, 2021).

Figure 1: The medieval Astrolabe Quadrant (British Museum, 2008)

b. Mechanical Lunisolar Calendar

Abu Rayhan al-Biruni, a pioneering scholar of the 11th century, devised a remarkable device known as the "Box of the Moon." This sophisticated lunisolar calendar utilized an intricate gear mechanism composed of eight gearwheels (Marchant, 2006). Notably, it represents an early example of a fixed-wire processing machine. Al-Biruni's innovative work with this calendar instrument drew upon gear trains reminiscent of those found in a 6th-century Byzantine portable sundial, highlighting the diverse history of mechanical inventions across different cultures and periods (Marchant, 2006).

c. Sundial

The first sundial was used in Ancient Egypt around 1500 BC (Plantić, 2019). The Greeks later contructed sundials, aligning the gnomon with the Earth's axis and using their geometry expertise to create more complex designs (Evans, 1998). During the medieval period, Muslim scholars and scientists made significant advancements in the field of sundials (Turner, 2010). They refined and expanded upon the knowledge of sundials inherited from earlier civilizations, such as the Greeks and Egyptians (Turner, 2010).

Figure 2: Bibury St. Mary, Mass Dial (Longbottom, 1975)

Muslim scientists like Al-Biruni and Al-Zarqali played a crucial role in improving the accuracy and design of sundials (Turner, 2010). They introduced innovations like the astrolabe, a sophisticated instrument that incorporated sundial features, enabling more precise timekeeping and astronomical measurements. Khwarizmi developed tables for these devices, greatly reducing the time required to perform specific calculations (Campbell-Kelly, 2003). These advancements in sundial technology by Muslim scholars during the medieval period not only enhanced timekeeping but also contributed to the development of astronomy and navigation, making them important figures in the history of science and technology. A sundial operates by tracking the movement of the sun across the sky and its effect on shadow casting (Marini, 2023). The Earth's rotation causes the Sun to shift its position, casting shadows from various objects (Marini, 2023). The gnomon, a raised structure on the sundial's surface, creates a shadow that moves as the sun changes position.

By observing where the shadow falls to these markers, one can determine the current time. In essence, the sundial acts as a solar clock, offering a simple and reliable way to keep track of time during daylight hours. It highlights the intricate relationship between the Earth's rotation, the Sun's path in the sky, and the resulting shadow patterns that enable timekeeping. Sundials underwent significant advancements under Muslim scholars, building upon the knowledge inherited from Greek predecessors. A remarkable illustration of this practice can be seen in the 14th century, when Ibn al-Shatir, the timekeeper of the Umayyad Mosque in Damascus, constructed an impressive sundial (King, 2019).

d. Quadrant

Muslim scholars made significant contributions to the development of various types of quadrants. One notable example is the sine quadrant, designed specifically for astronomical calculations. Additionally, they crafted several variations of the horary quadrant, which were instrumental in determining time, particularly for prayer schedules, through observations of the sun and stars. The city of Baghdad in the 9th century served as a hub for the advancement of these quadrant instruments. A noteworthy figure in this context is Abu Bakr ibn al-Sarah al-Hamawi, a Syrian astronomer who, in the 14th century, introduced a unique quadrant known as the "al-muqantarat al-yusra”(Al-Hassani, 2012). His innovative work further exemplifies the rich history of quadrant development.

e. Earth rotation

In historical Islamic astronomy, there were differing views on whether the Earth rotated and orbited the Sun. Abu Rayhan Biruni believed the Earth was stationary at the center of the universe (Kirby, 2018). His contemporary, Abu Sa'id al-Sijzi, accepted Earth's rotation (Baloch, 1990). Scholars at observatories like Maragha and Samarkand, including Tusi and Qushji, discussed Earth's rotation using arguments similar to Copernicus (Bennett, 2012). However, they didn't fully embrace heliocentrism, as Copernicus later did (Bennett, 2012). Islamic astronomy thus had varying perspectives on the Earth's motion during this period.

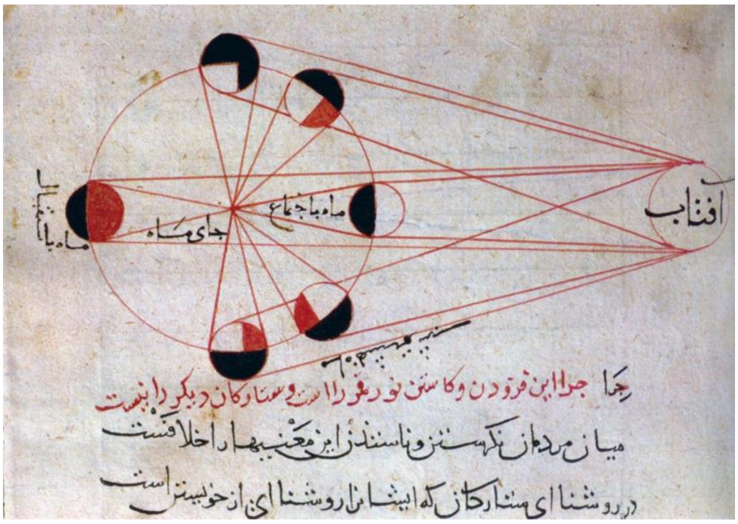

Figure 3: Al-Biruni's illustration depicts lunar phases relative to the sun (Al-Hassani, 2012)

5. Islamic Astronomy's Impact on Medieval Navigation and Cartography

The medieval era witnessed significant contributions from Muslim astronomers in the development of navigational instruments and the advancement of cartography. Islamic scholars played a pivotal role in refining navigational tools, notably the astrolabe, which facilitated celestial navigation by determining the altitude of celestial bodies (Renima et al., 2016). Their meticulous calculations and improvements in geographical coordinates, including longitudes and latitudes, greatly enhanced the accuracy of navigational charts and maps (King, 2021). Their calculations and understanding of these coordinates helped cartographers create more accurate maps. Muslim scholars like Ibn Battuta, who was not an astronomer but a renowned traveler, provided detailed accounts of their journeys (Speake,2014). These accounts contained geographical information, and they often encountered various maps during their travels (Speake,2014). This knowledge was invaluable for cartographers, helping them create more accurate and comprehensive maps. Many Muslim libraries and centers of learning, such as the House of Wisdom in Baghdad, played a pivotal role in preserving astronomical and geographical knowledge (Lyons, 2008).This facilitated the transmission of knowledge from the Islamic world to other cultures and civilizations, including Europe.

Islamic astronomy in the medieval period profoundly influenced navigation and cartography. The knowledge of Islamic astronomers was seamlessly integrated into map-making, as exemplified by the advanced "Tabula Rogeriana" (Roger's Map) crafted by the Muslim cartographer Al-Idrisi (Al-Hassani, 2012). This map combined astronomical data with geographical information, resulting in a highly accurate representation of the known world.

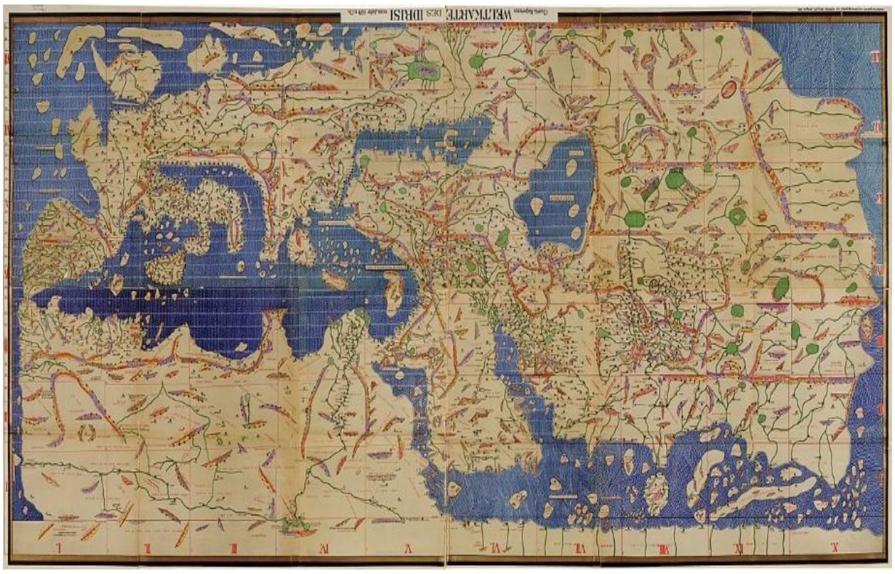

Figure-4: Al-Idrisi's 1154 World Map for Roger II of Sicily (Miller, 2021).

Ahmet Mohiuddin Piri (Piri Reis) was a fascinating admiral, geographer and cartographer. He wrote "The Book of Bahriye," related to navigation (Yilmaz, 2010). Moreover, Piri Reis drew from the expertise of medieval Muslim astronomers and navigators. Their understanding of celestial navigation, astronomical principles and mapmaking traditions influenced his work, enabling him to create the Piri Reis Map—a representation of the world that reflected the collective knowledge of the time.

Figure 5: 1513 Piri Reis Map Fragment-A Glimpse of the Early World (Harvey, 2018)

Figure 6: Piri Reis's Historic Map of the American Coast, Venezuela and Brazil (Harvey, 2018)

Muslims demonstrated expertise in navigation as well. Throughout centuries, they fearlessly journeyed across the Indian Ocean to engage in trade with India and the eastern coastline of Africa. Their dominance extended to the Mediterranean Sea for approximately five hundred years (Al-Monaes, 1991). They exhibited foresight akin to Columbus by exploring the Atlantic, potentially reaching distant points like the Azores, and conceivably arriving in America prior to his own voyage. It's reasonable to assert that Columbus would not have mustered the courage to embark on his expedition, nor would he have conceptualized such a journey, without the skill inherited from Muslims and the understanding of the Earth's spherical nature they imparted (Selin, 2013). Ahmad Ibn Majid was the master navigator in the Ottoman Empire. His nickname was "Lion of the Sea (Tolmacheva, 2021). He played a pivotal role in facilitating Vasco da Gama, a Portuguese navigator, in navigating the inaugural sea trade route from Europe to India during the mid-15th century (McIntyre & McIntyre, 2013).

6. Influences of Islamic Astronomy Across Regions and Eras

Astronomy has had a profound and enduring influence across various regions and historical periods. In Africa, it significantly shaped Malian astronomy (Holbrook et al., 2008). In Europe, the translation of Islamic astronomical works into Latin during the 12th century greatly impacted European astronomy (Eshkevari, 2014). Prominent Islamic astronomers such as al-Battani left a lasting legacy, referenced by figures like Copernicus, Kepler, and Tycho Brahe (Marini, 2023). The Al-Battani model, which provided an alternative to Ptolemy's, gained popularity in 13th-century Europe and was made more accessible through Michael Scot's Latin translation (Holbrook et al., 2008). Copernicus also cited Islamic astronomers when discussing planetary order theories (Ragep, 2007).

In China, Islamic astronomy influenced the Song dynasty, with a Hui Muslim astronomer introducing the concept of a seven-day week (Mak, 2022). Islamic astronomers were invited to China during the Mongol and Yuan dynasties, contributing to calendar-making and the construction of astronomical instruments. Chinese astronomers at the Maragheh observatory in Persia benefited from Islamic astronomy, particularly in planetary latitudes and eclipse predictions (Guessoum, 2013). Chinese instruments and spherical trigonometry showed traces of Islamic influence. The Hongwu Emperor of the Ming dynasty embraced Islamic astronomy, translating works and creating the Huihui Lifa calendrical system (Engelfriet, 1998).

In Korea, the accuracy of the Islamic calendar was pivotal in early Joseon Korea's calendar reform (Shi, 2021). Islamic astronomy's contributions enhanced astronomical understanding and practice across regions, facilitating the transmission of knowledge and ideas across cultural boundaries and leaving a lasting imprint on astronomy's development.

The precise astronomical knowledge developed by medieval Muslim astronomers remains relevant today. While modern navigation heavily relies on GPS, celestial navigation techniques based on celestial bodies remain valuable for backup in cases of system failure. Navigators can use stars, the moon, and the sun to determine their position accurately. The astrolabe, quadrant, and sextant, developed or improved by Muslim scholars, laid the foundation for modern navigational instruments. Though contemporary technology has largely replaced these tools, they are still taught and used in maritime education and training programs as backup methods, highlighting the importance of knowledge of Islamic civilizations in shaping maritime practices.

7. Astronomy and Quran

Astronomy and the Quran have been subjects of interest and discussion among scholars and individuals for many years. The Quran, the holy book of Islam, contains various verses that touch upon natural phenomena, including celestial bodies and astronomical concepts. One of the most cited verses states, "Do not those who disbelieve see that the heavens and the earth were a closed-up mass, then We opened them out?" (The Quran, 21:30). This verse is a reference to the Big Bang theory, which is the prevailing scientific explanation for the origin of the universe.

The Quran also mentions the concept of celestial bodies moving in orbits, which states: "It is He who created the night and the day and the sun and the moon; all [heavenly bodies] swim along, each in its own orbit" (The Quran, 21:33). This verse is sometimes cited to suggest that the Quran recognizes the motion of celestial bodies in space, which aligns with our modern understanding of planetary orbits. The Quran uses the imagery of stars for guidance and navigation. It stated, “And landmarks. And by the stars, they are also guided" (The Quran, 16:16). The Quran mentions the moon and its phases in various verses and states, "It is He who made the sun a shining light and the moon a derived light and determined for its phases" (The Quran, 10:5). This verse acknowledges the changing phases of the moon, which is a well-known astronomical phenomenon, and it is mentioned: "And the heaven we constructed with strength, and indeed, we are [its] expander” (The Quran, 51:47). In Surah Ya Sin, it states: "It is not allowable for the sun to reach the moon, nor does the night overtake the day, but each, in an orbit, is swimming" (The Quran, 36:40). This verse is often seen as an acknowledgment of the orbits and movements of celestial bodies. Muslim scholars and scientists have historically explored the intersection of religious teachings and scientific discoveries, seeking harmony between the two.

8. Islamic Golden Age: Factors Behind the Decline

Islamic astronomy experienced a decline in the aftermath of the flourishing period known as the Islamic Golden Age, characterized by significant advancements across various disciplines, notably astronomy and navigation. This decline can be attributed to several factors, including political fragmentation, external pressures, geographical vulnerability, the collapse of the Ottoman Empire, and natural disasters.

Political fragmentation ensued with the weakening of the Abbasid Caliphate and the emergence of independent states, resulting in political instability and internal conflicts. Consequently, resources were redirected away from intellectual pursuits towards military and political endeavours, leading to a decline in scholarly activities (Obaidullah, 2007).

Simultaneously, external pressures from the Mongol invasions and the Crusades inflicted severe damage on cities, including the destruction of libraries and centres of learning. These invasions disrupted trade routes, resulting in the loss of valuable resources and intellectual capital (Obaidullah, 2007).

Geographical vulnerabilities, particularly evident in regions such as Iraq, Syria, and Egypt, made them susceptible to external attacks over the centuries. This geographical disadvantage hindered scientific and technological progress, further exacerbating the decline of Islamic Golden Age (Obaidullah, 2007).

Furthermore, the collapse of the Ottoman Empire, which had previously supported economic prosperity in its conquered territories, contributed to the decline. The loss of Ottoman patronage dealt a significant blow to scientific endeavours within the Islamic world.

Natural disasters, including famines and plagues, further compounded the challenges faced by Islamic astronomers. These calamities led to catastrophic depopulation in regions like Egypt, Syria, and Iraq, resulting in a significant loss of life and impeding scientific advancement (Obaidullah, 2007).

In summary, the decline of the Islamic Golden Age was a gradual process influenced by a combination of political, external, geographical and environmental factors. This decline marked a transition from a vibrant center of knowledge and culture to a period of relative stagnation in the Islamic world.

9. Conclusion

Muslim scientists made invaluable contributions to astronomy. Their pioneering concepts and innovations that still influence the maritime domain today. While Western scholars further developed these ideas, their legacy modernized maritime technologies, leaving a lasting impact on civilization. Their advancements in science, technology and culture continue to shape the modern world. Muslim scholars were pioneers in astronomy, navigation, and other maritime technologies which playing a vital role in the fields of science and technology. Their contributions to Western civilization are well-documented, serving as inspiration for future developments in modern science and technology, particularly in the maritime domain.

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