



The Astrolabe as a Meeting Point of Science, Art, and Religion: An Analysis of an Instrument for Navigation, Determining Prayer Times, and the Qibla Direction

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Abstract. The Islamic Golden Age is often misunderstood through the modern lens of a science-religion conflict. The astrolabe offers a powerful counter-narrative. This complex, multifunctional instrument is not merely a technical tool, but rather material evidence of a worldview that holistically integrates rationality, spirituality, and aesthetics. This research aims to analyze the manifestation of scientific principles in the astrolabe's design, demonstrate how religious needs (*ilm al-miqat*) became the primary driver of innovation, identify its distinct artistic elements, and demonstrate how the astrolabe became a point of synthesis for science, art, and religion. The study employs a qualitative method with a material culture studies approach. Data is analyzed from high-resolution images of museum astrolabe samples and academic literature. The data analysis technique combines three approaches: functional-scientific, iconographic-artistic, and contextual-historical. The findings indicate that the need to precisely determine prayer times and the Qibla direction was the primary catalyst for mathematical and engineering innovation in the astrolabe. This scientific precision was expressed through an artistic beauty aligned with Islamic spiritual principles, as seen in the arabesque-like design of the rete and the use of beautiful calligraphy. Function, form, and purpose merge inseparably in this artifact. The astrolabe is physical proof of a synergy, not a conflict, between science, art, and religion in Islamic civilization. This artifact affirms that science can function as a means of understanding the order of God's creation, and art as a means of celebrating His beauty, both driven by the fulfilment of spiritual obligations.

Keywords: Astrolabe, Islamic Science, Islamic Art, Astronomy, Miqat.

1 Introduction

1.1 Background: The Golden Age and the Modern Dichotomy

The Islamic Golden Age, spanning primarily during the Abbasid Caliphate (750-1258 CE), was a period of extraordinary intellectual development. In cities like Baghdad, Cairo, and Cordoba, scholars not only preserved Greek, Persian, and Indian knowledge but also significantly expanded upon it [1]. One of the fields that experienced rapid

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A. Dwi Bahtiar El Rizaq et al. (eds.), *Proceedings of International Conference of Islamic Studies (ICONIS 2025)*, Advances in Social Science, Education and Humanities Research 955,

https://doi.org/10.2991/978-2-38476-464-8_13

advancement was astronomy, known in the Islamic tradition as *Ilm al-Falak*. This science was considered necessary not only for intellectual reasons but also for profound practical and religious purposes [2].

In modern discourse, the relationship between science and religion is often framed within a narrative of inherent conflict. Religion is seen as static dogma, while science is considered the realm of dynamic and progressive rationality. This narrative, rooted in specific historical experiences in Europe, is often projected universally, obscuring other, more harmonious and productive models of interaction [3]. Classical Islamic civilization offers a powerful counter-narrative to this dichotomy [4].

At the heart of this counter-narrative stands an extraordinary artifact: the astrolabe. Often described as the “analog computer” or “smartphone” of its time, the astrolabe was a highly complex, multifunctional instrument. It served as a two-dimensional model of the celestial sphere, enabling its user to perform various astronomical, astrological, land and sea navigation, and surveying calculations [5]. Its uniqueness in the Islamic context lies in its essential function in supporting religious practice [6].

Analyzing an artifact like the astrolabe is crucial for understanding how a civilization could integrate knowledge domains that modernity often rigidly separates: scientific rationality, spiritual devotion, and artistic expression. The astrolabe is not merely a product of technology; it is a window into a worldview (*weltanschauung*) that saw the cosmos as a manifestation of Divine order, where studying it was a form of worship, and depicting it beautifully was a form of praise [7].

1.2 Conceptual Framework: The Astrolabe as a Cultural Text

This research adopts a conceptual framework from material culture studies to unpack the layers of meaning contained within the astrolabe. This approach views objects or artifacts not as passive, mute things but as “texts” that can be read and interpreted to reveal the values, knowledge, beliefs, and social structures of the society that made and used them [8]. An artifact actively shapes and is shaped by its culture; it not only reflects social reality but also helps to construct it [9].

Within this framework, every aspect of an astrolabe becomes significant data. The choice of material—whether functional brass or luxurious silver-inlaid brass—reveals the patron's status and the artifact's purpose, whether for fieldwork or as a royal display piece. The precision of the engravings on its scales indicates the level of mastery in engineering and mathematics [10]. The names of cities inscribed on its plates (tympana) not only serve as latitude data but also as a map of intellectual networks, trade routes, and the reach of Islamic cultural influence at the time [11]. Even the calligraphy style and decorative motifs carry aesthetic and theological messages [12]. Thus, this analysis will go beyond merely describing technical functions to “read” the astrolabe as a rich and complex cultural narrative.

1.3 Aims of the Study and Thesis Statement

Departing from this foundation, this research is designed as a multi-layered inquiry to unpack the richness of meaning contained within the astrolabe. This inquiry begins with its functional foundation by analyzing how the principles of precision engineering and

mathematics form the basis of the instrument's workings. Subsequently, the analysis will move from the technical to the motivational aspects, to investigate the extent to which Islamic ritual obligations, encapsulated in the discipline of *ilm al-miqat* (the determination of prayer times and the Qibla direction), functioned as the primary catalyst that drove the refinement, innovation, and dissemination of the astrolabe throughout the Islamic civilization.

This research will also examine the artistic dimension of the astrolabe. This study will uncover how Islamic aesthetics—characterized by calligraphy, arabesque patterns, and the principle of aniconism—are inherently integrated into the instrument's design, thus making it a sublime work of art that transcends its utilitarian function. As its culmination, these three layers of analysis will be drawn together to demonstrate how the astrolabe concretely becomes a synthesis artifact, where function (science), purpose (religion), and form (art) merge into a holistic, inseparable, and mutually enriching whole.

To obtain an accurate answer, this research proposes the following main argument (thesis): The astrolabe is material evidence of a classical Islamic worldview (*weltanschauung*) that saw no ontological separation between the Divine, the rational, and the beautiful. It is an artifact wherein the need to fulfill religious obligations became the driving force for scientific innovation, and wherein scientific precision and artistic beauty merged as expressions of spiritual devotion.

2 Method

2.1 Approaches and Types of Research

This research uses a qualitative approach with a conceptual framework from Material Culture Studies. The core of this approach is to view an artifact or object not as a passive object, but as a “text” that can be “read” to reveal the values, knowledge, and beliefs of the society that made it. Every detail on the astrolabe—from the choice of material and the precision of the engravings to the style of calligraphy—is considered significant data that carries cultural, social, and intellectual messages.

2.2 Data Sources

This research relies on two types of data sources to build a comprehensive analysis. The primary data are obtained from observation of astrolabe samples from world-renowned museum collections, such as The Metropolitan Museum of Art, The British Museum, and The Khalili Collections. This analysis is conducted through high-resolution images, allowing a detailed examination of the instrument's physical features. The secondary data is sourced from an in-depth literature review covering academic books and journals on the history of Islamic astronomy (the works of science historians such as David A. King and J.L. Berggren), the principles of Islamic art, as well as ancient treatises explaining the construction and use of the astrolabe.

2.3 Data Analysis Technique: A Three-Layered Approach

The strength of this methodology lies in its analytical technique, which combines three distinct yet complementary lenses to “read” the astrolabe:

The first is Functional-Scientific Analysis. This layer of analysis dissects the astrolabe as a pinnacle of engineering. It involves explaining the workings of its parts (mater, rete, plates) and its mathematical basis, particularly the principle of stereographic projection that transforms the three-dimensional celestial sphere into a two-dimensional model. This analysis answers the question of “how” the astrolabe works as a scientific instrument [13].

The Second is Iconographic-Artistic Analysis. This layer analyzes the astrolabe as an artistic canvas. The focus is on visual elements such as calligraphic styles (e.g., Kufic or Naskh), the engraved motifs on the rete, which often resemble arabesques, and the overall design composition. This analysis answers the question of “what” the aesthetic and symbolic meaning of the astrolabe's visual form is [14].

The third is Contextual-Historical Analysis: This final layer places the astrolabe's function and design within the socio-religious context of its time. This analysis specifically connects features on the astrolabe, such as prayer-time lines and Qibla direction markers, with the demands of Islamic law (*Shari'ah*) within the discipline of *Ilm al-Miqat*. This analysis answers the question of “why” the astrolabe was developed and refined in a particular way [15].

3 Result and Discussion

This result examines the astrolabe as a scientific, artistic, and spiritual object. It highlights its historical development, technical domains, and significance within the Islamic world.

3.1 The Scientific Foundation: Projecting the Heavens onto Metal

3.1.1 Intellectual History and Evolution

The conceptual origins of the astrolabe can be traced back to Hellenistic civilization, with thinkers like Hipparchus (2nd century BCE) who developed the principle of stereographic projection and Claudius Ptolemy (2nd century CE) who detailed geocentric astronomical theory in his work, the *Almagest* [16], [17]. However, its transformation into a sophisticated and widespread instrument was a great achievement of scholars in the Islamic world.

This process began with the great translation movement in the early Abbasid period, where scientific texts from Greek, Persian, and Indian sources were translated into Arabic. This was not merely a passive transfer of knowledge but a foundation for innovation. One of the key figures in this early phase was Muhammad ibn Ibrahim al-Fazari (late 8th century), credited as one of the first Muslim scientists to construct an astrolabe. Al-Fazari played a crucial role in bridging the Indian astronomical tradition,

particularly through the translation of the *Zij al-Sindhind*, into the framework of Islamic astronomy, providing a strong mathematical basis for further development [18].

From these initial adaptations, Muslim scholars quickly moved to pure innovation. They refined designs, improved accuracy, and added new functions specifically relevant to the needs of their civilization. The pinnacle of this evolution can be seen in the work of Abu Ishaq Ibrahim al-Zarqali (known in the West as Arzachel) in Andalusia in the 11th century. Al-Zarqali created the *Safiha al-Zarqaliyya* (the Zarqali plate), a revolutionary universal astrolabe. Unlike the standard astrolabe, which required a separate plate for each geographical latitude, the *safiha* could be used anywhere on earth, an engineering breakthrough that demonstrated a conceptual leap from mere adaptation to original innovation [19]. Here are some images of astrolabes:



Fig. 1. Planispheric Astrolabe by Muhammad Zaman al-Munajjim al-Asturlabi, in The Metropolitan Museum

This planispheric astrolabe, a functional work of art, was crafted by Muhammad Zaman al-Munajjim al-Asturlabi and is attributed to Mashhad, Iran, dating between 1654–55 CE (1065 AH). Made from brass and steel using casting, hammering, piercing, and engraving techniques, this instrument measures 21.6 cm in height, 17.1 cm in width, and 5.7 cm in depth. Its creation highlights the maker's metallurgical expertise and Iran's rich scientific and artistic heritage during that period.



Fig. 2. Astrolabe by ‘Umar ibn Yusuf ibn ‘Umar ibn ‘Ali ibn Rasul al-Muzaffari, in The Metropolitan Museum

This remarkable astrolabe, crafted by the Yemeni ruler 'Umar ibn Yusuf ibn 'Umar ibn 'Ali ibn Rasul al-Muzaffari in 1291 CE (690 AH), stands as a rare testament to the artistic and scientific achievements of Yemen. Fashioned from brass through casting, hammering, piercing, chasing, and adorned with silver inlay, this astrolabe measures 15.6 cm in diameter and 0.6 cm in thickness. Its various components, including the bar with an attached nail, the net, plates, and pin, all showcase exceptional metallurgical skill. More than just a complex scientific instrument, this astrolabe is tangible evidence of Yemen's rich cultural and intellectual legacy in the 13th century.



Fig. 3. Planispheric Astrolabe in the Khalili Museum

This 9th-century CE planispheric astrolabe, originating from North Africa, is a significant artifact measuring 18.5 x 13.2 cm. Crafted from cast brass, the instrument features an intricate fretwork rete and detailed surface engraving. With Accession Number SCI 430, this astrolabe stands as an early example of the scientific and artistic advancements in the region.



Fig. 4. A monumental planispheric astrolabe made for Shah Jahan, in the Khalili Museum

This monumental planispheric astrolabe, custom-made for Shah Jahan in Lahore, Punjab, between 1648 and 1658, is a masterpiece of metalwork. Crafted from cut and engraved sheet and cast brass, its rete is intricately adorned with silver inlay, showcasing an extraordinary level of skill and luxury. With a diameter of 52.6 cm and a height of 60.2 cm (excluding the shackle and suspension ring), this instrument, with Accession Number SCI 53, stands as significant evidence of the scientific and artistic prowess during the Mughal Empire.



Fig. 5. Planispheric Astrolabe Inscribed in Judaeo-Arabic, in the Khalili Museum

This rare planispheric astrolabe, likely crafted around 1300 in Spain, is a significant artifact adorned with Judaeo-Arabic inscriptions. Made from cast and sheet brass, which has been cut and engraved, this 22 cm tall astrolabe (excluding the shackle and suspension ring) features a rete set with silver studs, though some are now missing. Bearing Accession Number SCI 158, this astrolabe is valuable evidence of the intersection of scholarship, culture, and religion in the Iberian Peninsula during the Middle Ages.



Fig. 6. Astrolabe-Quadrant in the Khalili Museum

This astrolabe-quadrant, originating from Ottoman Turkey and dated 1256 AH (1840–41 AD), is a unique instrument crafted from solid walnut. Its surface is adorned with inscriptions in red and black ink beneath a yellowish varnish, giving it a distinctive appearance. Equipped with a brass socket for the plumb-line and a lead weight housed within the instrument, this astrolabe measures 16.8 x 12.8 x 3 cm, with a quadrant radius of 12.5 cm. This artifact, with Accession Number SCI 40, reflects the woodworking skill and scientific practices of the late Ottoman period.



Fig. 7. Astrolabe by al-Misri, in the British Museum

This Ayyubid astrolabe, crafted by Abd al-Karim al-Misri in Cairo in 1236 CE (633 AH), is a masterpiece showcasing intricate inlay techniques. Made from copper alloy, silver, and copper, it measures 21.31 cm x 30.48 cm and reflects the scientific and artistic advancements of the Ayyubid period.

3.1.2 The Mathematical Heart: Stereographic Projection and Spherical Trigonometry

The "magic" of the astrolabe lies in its ability to model the vast, three-dimensional celestial sphere onto a flat, handheld metal disc. This capability is made possible by an elegant mathematical principle: stereographic projection. This projection is a method of mapping points on the surface of a sphere onto a flat plane from a single pole point. Its main advantage is that it is conformal, meaning it preserves angles and maps circles on the sphere to circles (or straight lines) on the flat plane. This allows for the accurate representation of the paths of celestial bodies (like the sun's ecliptic) and celestial coordinates (like altitude circles or *almucantars*) on the astrolabe's plate [16].

Functionally, the astrolabe is a graphical calculator capable of solving complex problems in spherical trigonometry visually and mechanically. Calculations such as determining the time from the sun's altitude, or vice versa, which mathematically require complex formulas, could be solved simply by rotating the astrolabe's components. These main components work in synergy.

Mater (Mother) or the main hollow body of the astrolabe, with a rim (limb) engraved with degree and hour scales, forms the base of the instrument. Inserted into the Mater is the Plate (Tympanum), a flat disc; each plate is engraved with a stereographic projection of the local celestial coordinates (horizon, zenith, almucantars, and azimuth lines) for a specific geographical latitude. The Rete (Network/Spider) is positioned above the plate, a perforated framework that rotates over the plate. The rete functioned as a star map, with its sharp pointers marking the positions of the brightest fixed stars, and it also has an eccentric circle representing the ecliptic, the sun's annual path through the zodiac. On the back of the astrolabe is the Alidade (Sighting Rule), a rotating ruler with two sighting vanes, used to measure the altitude of a celestial body [20].

By measuring the altitude of the sun or a star with the Alidade, then rotating the rete until the position of that sun or star aligns with the corresponding altitude circle on the plate, the user could directly read the time on the hour scale on the mater's edge. This process effectively turns a complex trigonometric problem into a simple mechanical procedure [5].

3.1.3 Non-Religious Applications

Although the religious impetus was a primary catalyst for its development in the Islamic context, the astrolabe's advanced technology had broad universal applications. These non-religious uses show how integral the instrument was to various aspects of life in its time. These secular functions include *Navigation*. The astrolabe was a vital tool for sailors and trade caravans to determine their latitude by measuring the altitude of the North Star or the sun's altitude at midday. This allowed for more accurate long-distance travel across oceans and deserts [20].

The second secular function is *Land Surveying*. Using the Alidade and simple trigonometric principles, the astrolabe could be used to measure the height of mountains, towers, or buildings, as well as the depth of wells or the width of rivers without direct measurement [21]. The third function is *Astrology*. Astrology was a widespread practice in the Middle Ages, in both the Islamic world and Europe. The

astrolabe was an essential tool for astrologers to cast horoscopes, which were maps of the sky at the time of a person's birth, believed to be useful for predicting their fate [22]. The fourth is *Education*. The astrolabe served as a highly effective teaching aid to demonstrate the movement of celestial bodies and the basic principles of astronomy to students [23]. This diversity of functions underscores the astrolabe's status as a versatile scientific instrument, a “smartphone” of its time whose applications transcended any single domain.

3.2 The Spiritual Impetus: *Ilm al-Miqat* as the Engine of Innovation

3.2.1 Theological Basis

If science was the mechanical heart of the astrolabe, then religion was the soul that gave it purpose in Islamic civilization. The obligation of daily worship created a pressing and constant *technical need* that could not be met by mere estimation. Two primary obligations were the driving force: determining the times for the five daily prayers and determining the direction of the Qibla (the direction of the Kaaba in Mecca) [2].

The theological basis for these obligations is firmly rooted in the primary sources of Islam. The Qur'an explicitly commands Muslims to turn their faces towards the Sacred Mosque (Masjid al-Haram) during prayer: “*So from wherever you go out, turn your face toward al-Masjid al-Haram.*” (Qur'an 2:150). This command, which marked the shift of the Qibla from Jerusalem to Mecca, became a definitive moment that demanded a precise geographical and astronomical solution [11]. The hadiths (sayings) of the Prophet Muhammad also reaffirmed this obligation, making it a condition for the validity of prayer.

Similarly, the prayer times are defined by astronomical phenomena related to the sun's position: its decline from the meridian (Dhuhr), the length of shadows (Asr), sunset (Maghrib), the disappearance of twilight (Isha), and the appearance of dawn (Fajr). As implied in Qur'an 17:78, these commands demanded careful and continuous observation of the sky. From these religious requirements arose the specific disciplines known as *Ilm al-Falak* (theoretical astronomy) and *Ilm al-Miqat* (the applied science of determining worship times) [24].

3.2.2 Analysis of Religious Features on the Astrolabe

These theological needs were directly translated into physical features on the astrolabe. The instrument was explicitly designed to solve the problems of *ilm al-miqat*. One major application was in *Determining Prayer Time*. Many Islamic astrolabe plates not only contain the standard altitude circles but also special lines or curves that mark the beginning of prayer times. For example, the curve for the Asr prayer time was often specifically drawn. Some astrolabes even had two different Asr curves to accommodate different jurisprudential interpretations (e.g., the Shafi'i, Maliki, and Hanbali schools defining Asr time when an object's shadow length equals its height, versus the Hanafi school defining it when the shadow length is twice the object's height). This is an extraordinary example of an Islamic legal debate being directly engraved into the design of a scientific instrument [2].

Another essential function was *determining the Qibla Direction*. The back (*dahr*) of the astrolabe often served as an information hub for determining the Qibla direction. This could be a table listing the geographical coordinates of major cities along with their Qibla azimuth, or more sophisticated graphical methods. A standard method involved a sine/cosine quadrant engraved on the back, which allowed the user to solve the spherical trigonometry problem to find the Qibla direction from any location with known coordinates. The names of cities engraved on the plates (e.g., Baghdad, Damascus, Cairo, Isfahan) not only indicated for which latitude the plate was made but also served as a “market map,” showing the centers of civilization where there was high demand for this advanced instrument [25].

3.2.3 Critical Discussion: Considering the Views of David A. King

In the study of Islamic instruments, the views of the preeminent historian of science, David A. King, cannot be ignored. King has made the provocative argument that “*the popular notion that Islamic astrolabes were used for regulating the times of prayer... is to be abandoned for lack of evidence* [26].” This statement, at first glance, undermines the central thesis of this research. However, a more nuanced analysis actually strengthens it.

King's argument must be understood in its context. The astrolabe was an expensive, complex instrument that required a high degree of mathematical skill to use effectively. It was not a tool that every Muslim owned for personal daily use, like a modern watch. In this respect, King is correct; evidence for the mass use of astrolabes by individuals for prayer is indeed scarce.

However, this does not negate the astrolabe's central role in regulating worship times. Instead, it highlights the role of a very important professional figure in major mosques: the *muwaqqit*. The *muwaqqit* was a professional astronomer officially employed by a religious institution (a mosque or madrasa) with the specific task of performing astronomical calculations to determine the accurate prayer times for the entire community. They were the ones who would then signal the *muezzin* to make the call to prayer [18].

Within this framework, the astrolabe functioned not as a personal devotional “watch” but as a precision scientific instrument in the hands of experts. The religious needs of the *community* created a *scientific profession* (the *muwaqqit*), and this profession, in turn, demanded and drove the development of sophisticated instruments like the astrolabe, quadrants, and complex sundials. King's own monumental work, *In Synchrony with the Heavens*, extensively documents the vast corpus of astronomical tables (*zij*) created by *muwaqqits* for this purpose, confirming the intimate relationship between mathematical astronomy and Islamic worship practices.

Thus, King's view does not weaken but clarifies and strengthens the main thesis. The astrolabe was indeed crucial for determining prayer times, not as a mass-produced tool, but as a pinnacle technology that was the working instrument of specialists whose role was created by the needs of Islamic law [24].

3.3 The Cosmic Canvas: Artistic Manifestation on a Precision Instrument

3.3.1 Principles of Islamic Art and the Spirituality of *Tawhid*

Islamic art is fundamentally shaped by its primary theological principle: *Tawhid*, the absolute and transcendent Oneness of God. This principle gives rise to a unique aesthetic character. Because God cannot be represented in material form, Islamic art generally avoids the figurative depiction of living beings (humans and animals), a principle known as aniconism. This is intended to prevent idolatry and to preserve the purity of the concept that only God is the Creator [27].

Instead, Muslim artists developed rich forms of abstract expression to convey spiritual truths. Three main elements are dominant. First, Geometric Patterns—Intricate, interlocking, and endless geometric patterns became a visual metaphor for the order, harmony, and unity underlying God's creation. The mathematical regularity in this art was seen as a reflection of the order of the Divine cosmos. Second, Arabesque. Composed of stylized and rhythmic patterns of plant tendrils, growing and spreading endlessly, symbolize the infinite nature of creation and its dependence on the one Divine Source. Third, Calligraphy emerged as the highest Islamic art form since the Qur'an is considered the word of God revealed in the Arabic language, and the Arabic script itself acquired a sacred status. Calligraphy became the highest art form, transforming writing into a visual expression of Divine truth [28].

According to thinkers like Seyyed Hossein Nasr, this aesthetic is not mere decoration but a means of contemplation. The order of geometric and arabesque patterns guides the soul from the particular and chaotic to the universal and harmonious, while the *void* that often serves as a background in the design symbolizes the indescribable and infinite transcendence of God [29].

3.3.2 Artistic Analysis of Astrolabe Samples

These principles of Islamic art were not only applied to mosque architecture or manuscript illumination but were also seamlessly integrated into the design of scientific instruments like the astrolabe.

Table 1. Comparative Analysis of Astrolabe Samples from Museum Collections

Artifact	Maker/ Period	Noteworthy Artistic Features
Astrolabe of 'Umar ibn Yusuf (The Met)	'Umar ibn Yusuf ibn 'Umar ibn 'Ali ibn Rasul al-Muzaffari, Yemen, 1291 CE	Made by a Sultan. Features very fine calligraphic inscriptions, including the sultan's name and titles, as well as poetic verses. Its <i>rete</i> is elegant with dagger-shaped star pointers.
Astrolabe of al-Misri (British Museum)	Ahmad ibn Khalaf (attributed), Iraq, c. 900 CE	It is one of the oldest surviving examples. Though earlier and simpler, it shows elegance in its

		Kufic calligraphy and the balanced design of its <i>rete</i> .
Astrolabe (Khalili, SCI 430)	Abd al-A'emma, Isfahan, 1712 CE	An example from the later Safavid period, made by one of the most famous astrolabe makers. It displays very dense and intricate engravings, including zodiac figures and floral decorations typical of Persian art.
Astrolabe (Khalili, SCI 161)	Muhammad Mahdi al-Yazdi, Persia, 1659/60 CE	In addition to beautiful calligraphy, this astrolabe is decorated with complex cloud patterns and medallions, showing the evolution of artistic styles over time while retaining core principles.

This comparative analysis shows that the astrolabe was consistently treated as more than just a tool. It was an object of patronage, a symbol of knowledge, and a canvas for artistic and spiritual expression.

3.3.3 The Rete as Arabesque, Inscriptions as Calligraphy

Two elements of the astrolabe particularly demonstrate the fusion of function and art. The first is *Rete* (*Spider's Web*). The perforated design of the *rete* is fundamentally functional; it must allow the user to see the coordinate map on the plate beneath it. However, Muslim craftsmen transformed this functional necessity into an artistic opportunity. The metal framework connecting the star pointers was often shaped into flowing, elegant tendril patterns, resembling an arabesque. The cold, mathematical star map was transformed into a beautiful, organic web, as if the night sky itself were an orderly celestial garden [5].

The second is *Inscriptions and Calligraphy*. All writing on the astrolabe—the names of stars, the names of months on the calendar, the names of cities on the plates, the maker's signature, and other quotations—was executed to a high calligraphic standard. The formal, angular Kufic style, or the more cursive and legible Naskh style, were often used. Precision in calligraphic writing was considered as important as precision in placing mathematical scales. A beautiful script not only beautified the instrument but also showed respect for the knowledge it contained and, often, the spiritual purpose it served. On the astrolabe, scientific truth and calligraphic beauty were two sides of the same coin [12], [30].

3.4 The Grand Synthesis: The Harmonious Meeting Point of Science, Art, and Religion

The separate analysis of the scientific, religious, and artistic dimensions of the astrolabe has shown the richness of each aspect. However, the true power of this artifact lies in the synthesis of all three. The astrolabe is not an object where science, art, and religion are merely placed side-by-side; it is an artifact where the three merge organically, mutually informing each other, and becoming inseparable. This chapter is the culminating argument demonstrating how this fusion occurs.

This process of synthesis can be understood through a coherent causal flow, moving from need to beauty through the medium of precision. At the root of this flow lies *The Root (Religion)*. The starting point of the entire process is the *need* created by Islamic law (Shari'ah). The obligation to perform prayers at the correct times and face the correct direction of the Qibla was the *prime mover*. This is the “why” behind the urgency to develop sophisticated astronomical instruments. Without this constant and universal religious impetus, the development of applied astronomy might not have reached the same scale and level of sophistication [2].

From this root grows *The Stem (Science)*. This religious need could not be met with rough estimates. It demanded *precision*. Determining the Qibla direction from thousands of kilometers away or calculating the time for the Asr prayer based on shadow length required accurate calculations. This demand for precision was the catalyst for the development and application of advanced mathematics, particularly spherical trigonometry, and precision engineering in metalworking and engraving. Science became the answer to the question of “how” to meet the demands of religion [16]. Finally, the third process is called *The Flower (Art)*. The process of creating an object with such high mathematical precision, for a purpose considered noble and sacred (worship of God), naturally demanded beauty in its execution. In the Islamic worldview, beauty (*ihsan*, perfection) is one of the Divine attributes and is an integral aspect of any well-done act. Therefore, scientific precision and artistic beauty were not seen as separate things. An engraving that was mathematically precise also had to be aesthetically beautiful. The calligraphy marking a star's name had to be astronomically accurate and visually elegant. The design of the *rete* had to be functional for mapping the sky, and at the same time resemble an eye-pleasing arabesque. Art manifested “what” is produced when science is used for a spiritual purpose [29].

On the astrolabe, there is no separation between the functional, the beautiful, and the spiritual. Scientific accuracy is a form of beauty because it reflects the order of God's created cosmos. Artistic beauty is a form of reverence for the noble spiritual purpose of the tool. The most concrete example of this synthesis can be found on each star pointer on the *rete*. Its sharp tip must be placed in the exact position corresponding to the coordinates of the star it represents—a strict demand of science. The name of the star engraved near it must be written in a correct and beautiful calligraphic style—an unavoidable demand of art. This entire mechanism, when combined, can be used to determine the time of prayer, an act of devotion to God, and the ultimate purpose of religion. In one small point on a metal disc, these three dimensions of civilization meet and merge harmoniously [31].

Table 2. Synthesis of the Three Dimensions in the Astrolabe

Astrolabe Feature / Component	Dimension of Science (Knowledge)	Dimension of Art (Beauty)	Dimension of Religion (Faith)
Star Pointer on the Rete	Its tip's position is precisely determined by the astronomical coordinates of a star.	The pointer's shape is stylized (leaf, dagger). The star's name is engraved with aesthetic calligraphy.	Used as a reference for navigation (Hajj pilgrimage) and for calculating worship times.
Latitude Plate (Tympan)	Engraved with lines for altitude, azimuth, and hours based on complex stereographic projection for a specific location.	Visual balance and symmetry in the layout of the lines. City names are written in clear and neat calligraphy.	Features special curved lines to determine Prayer (Salah) times (Dhuhr, Asr) and a line indicating the Qibla direction.
Inscriptions (Back/Throne)	Often includes mathematical scales like sine/cosine quadrants and calendars for conversion.	The maker's and patron's names are beautifully engraved. Empty space is filled with intricate geometric or arabesque patterns.	Contains Qur'anic verses (e.g., the Throne Verse), prayers, or praises to God as a sign of piety and blessing.
Overall Function	Functions as an "analog computer" to solve dozens of astronomical and trigonometric problems.	It is a luxury object and status symbol, showcasing the pinnacle of metalworking skill and design.	Serves as a fundamental tool for performing the pillars of Islam, especially the five daily prayers and the Ramadan fast.

This table visually summarizes the main thesis of the research, showing how three often-separated domains—science, religion, and art—actually converge and manifest in the concrete features of an astrolabe. It is a powerful framework for understanding the astrolabe not as an object with many functions, but as an object with a single, holistic function expressed in three interrelated dimensions.

4 Conclusion

This research has conducted an in-depth analysis of the astrolabe as a holistic cultural artifact, answering four main research questions. From scientific foundation, it was found that the principles of precision engineering and mathematics, particularly stereographic projection and spherical trigonometry, form the functional backbone of the astrolabe. This method allows for modeling the 3D cosmos onto a 2D instrument that can mechanically solve complex astronomical calculations. It also functions as Religious Motor. It was proven that Islamic ritual obligations (*ilm al-miqat*) served as the primary catalyst driving the innovation and dissemination of the astrolabe. The need to accurately determine prayer times and the Qibla direction created a scientific profession (the *muwaqqit*). It demanded the development of sophisticated instruments, making the astrolabe an essential tool in institutional religious practice. From the Artistic Expression, it was identified that Islamic aesthetics (calligraphy, arabesque, geometric patterns) are inherently integrated into the astrolabe's design. These principles, rooted in the spiritual concept of *Tawhid*, transform a functional instrument into a work of art rich with meaning, where beauty and precision are inseparable. Holistic Synthesis: It was concluded that the astrolabe concretely becomes an artifact of synthesis where function (science), purpose (religion), and form (art) merge harmoniously. It is the material evidence of a civilization that viewed science as a way to understand the order of God's creation, and art as a way to celebrate His beauty, with both serving as means to facilitate devotion to the Creator.

This research has significant implications for contemporary discourse. The astrolabe proves that religion and science can be in harmony, even mutually inspiring and driving scientific advancement, challenging the narrow view that sees them as an eternal conflict. This model of productive integration is highly relevant in an increasingly polarized world. Furthermore, this research enriches our understanding of Islamic material culture. By treating the astrolabe as a “cultural text,” this study shows how an artifact can be a rich primary source for reconstructing the intellectual history, social networks, religious practices, and aesthetic values of a civilization, encouraging an interdisciplinary approach to understanding history. While this research greatly benefited from high-resolution digital imagery, direct observation and physical analysis of the artifacts remain irreplaceable, and the scope of the astrolabe samples analyzed is still limited. Based on these limitations, future research can focus on comparative regional studies of astrolabes from various regions, metallurgical analysis to identify workshops or schools of instrument makers, and systematic analysis of ancient manuscript treatises on the making and use of astrolabes. These approaches will deepen our understanding of the astrolabe and the civilization that produced it.

References

- [1] G. Saliba, *Islamic Science and the Making of the European Renaissance*. Cambridge: MIT Press, 2007.
- [2] D. A. King, *In Synchrony with the Heavens: Studies in Astronomical Timekeeping and Instrumentation in Medieval Islamic Civilization*. Leiden: Brill, 2014.
- [3] J. H. Brooke, *Science and Religion: Some Historical Perspectives*. Cambridge: Cambridge University Press, 1991.
- [4] A. Dallal, *Islam, Science, and the Challenge of History*. New Haven, CT: Yale University Press, 2010.
- [5] E. Savage-Smith, "The Astrolabe: An Object of Beauty and Utility," in *The Genius of Arab Civilization: Source of Renaissance*, J. R. Hayes, Ed., New York: New York University Press, 1992.
- [6] D. A. King, "The Sacred Geography of Islam," in *Mathematics and the Divine: A Historical Study*, T. Koetsier and L. Bergmans, Eds., Amsterdam: Elsevier Ltd, 2005, pp. 161–178.
- [7] S. H. Nasr, *Science and Civilization in Islam*, 2nd ed. Cambridge: Islamic Texts Society, 1987.
- [8] J. D. Prown, "Mind in Matter: An Introduction to Material Culture Theory and Method," *Winterthur Portf.*, vol. 17, no. 1, pp. 1–19, Accessed: Jul. 16, 2025. [Online]. Available: <https://www.jstor.org/stable/1180761>
- [9] A. Appadurai, *The Social Life of Things: Commodities in Cultural Perspective*. Cambridge: Cambridge University Press, 1986.
- [10] S. Ackermann, "Material and Craftsmanship," in *The Astrolabe: An Object of Beauty and Scientific Precision*, S. Ackermann, R. L. Kreme, and E. Savage-Smith, Eds., Oxford: Oxford University Press, 2024, pp. 45–62.
- [11] D. A. King, *World-Maps for Finding the Direction and Distance to Mecca: Innovation and Tradition in Islamic Science*. Leiden: Brill, 1999.
- [12] S. S. Blair, *Islamic Calligraphy*. Edinburgh: Edinburgh University Press, 2006.
- [13] M. F. Yanto, "Penentuan Waktu Rasdul Qiblat Harian dengan Menggunakan Astrolabe RHI," UIN Walisongo, 2019.
- [14] M. R. H. Pratama, A. M. Afsal, and S. S. Hasanah, "Perpaduan Harmonis antara Arabesque dan Geometri: Sebuah Studi tentang Tema-tema Dekoratif Seni Islam," *Priangan J. Soc. Sci. Humanit.*, vol. 3, no. 2, pp. 39–50, 2024.
- [15] I. Hadi and L. Karina, "Studi Analisis Akurasi Perhitungan Awal Waktu Shalat Menggunakan Universal Astrolabe," *AL - AFAQ J. Ilmu Falak dan Astron.*, vol. 4, no. 1, pp. 129–156, Jun. 2022, doi: 10.20414/afaq.v4i1.5154.
- [16] J. L. Berggren, *Episodes in the Mathematics of Medieval Islam*. New York: Springer, 2016.
- [17] F. Rausi, "Astrolabe; Instrumen Astronomi Klasik dan Kontribusinya dalam Hisab Rukyat," *ELFALAKY*, vol. 3, no. 2, pp. 120–137, Dec. 2019, doi: 10.24252/ifk.v3i2.14149.
- [18] D. A. King, "The Astronomy of the Mamluks," *Isis*, vol. 74, no. 4, pp. 531–555, 1983, doi: <https://www.jstor.org/stable/232211>.
- [19] J. Samsó, "Al-Zarqālī, Abū Ishāq Ibrāhīm ibn Yaḥyā al-Naqqāsh," in *The Biographical*

- Encyclopedia of Astronomers*, T. et al. Hockey, Ed., New York: Springer, 2007, pp. 1258–1260.
- [20] J. E. Morrison, *The Astrolabe*. Rehoboth Beach, DE: Janus, 2007.
- [21] K. Van Cleempoel, “Astrolabes and the Creative Process,” in *Astrolabes in Medieval Cultures*, J. P. Hogendijk and K. Van Cleempoel, Eds., Leiden: Brill, 2021, pp. 294–298.
- [22] T. Y. Arslan, “The Astrolabe as a Textbook: The Case of al-Mawṣilī’s al-Durr al-naẓīm fī ‘ilm al-taqwīm,” *Suhayl J. Hist. Exact Nat. Sci. Islam. Civilis.*, vol. 19, pp. 41–45, 2021.
- [23] J. Ros-Santaella and A. Hernández, “The Astrolabe as a Nexus of Knowledge: Revisiting its Pedagogical and Astrological Functions in Pre-Modern Iberia,” *J. Hist. Astron.*, vol. 54, no. 2, pp. 160–165.
- [24] T. Y. Arslan, “A Mīqāt Zīj by al-Mawṣilī: The Work of a Mamluk Practitioner Astronomer,” *Suhayl J. Hist. Exact Nat. Sci. Islam. Civilis.*, vol. 21, pp. 81–118, 2013.
- [25] M. Rius, “Finding the Qibla with an Astrolabe in the Field,” *Suhayl J. Hist. Exact Nat. Sci. Islam. Civilis.*, vol. 20, pp. 45–73, 2022.
- [26] D. A. King, “The Culmination of Greek and Arabic Astronomy in the Astrolabe and Universal Quadrant,” in *Astrolabes in Medieval Cultures*, J. P. Hogendijk and K. Van Cleempoel, Eds., Leiden: Brill, 2021.
- [27] T. Burckhardt, *Art of Islam: Language and Meaning*, Trans. J. London: World of Islam Festival Trust, 1976.
- [28] H. Şen, “The Geometric Language of Unity: Revisiting the Metaphysics of Pattern in the Great Mosque of Córdoba,” *Int. J. Islam. Archit.*, vol. 12, no. 1, pp. 45–68, 2023.
- [29] S. H. Nasr, *Islamic Art and Spirituality*. Albany, NY: State University of New York Press, 1987.
- [30] V. Gonzalez, “The Conception of the Astrolabe in the Writings of al-Bīrūnī: A Study in Science, Epistemology and Aesthetics,” *J. Soc. Arab Islam. Stud.*, vol. 45, no. 1, pp. 65–72, 2021.
- [31] S. Babaie, “The Astrolabe’s Aura: Craft, Cosmology, and Devotion in Safavid Iran,” *Ars Orient.*, vol. 52, pp. 85–110, 2022.

Acknowledgments. Since this research was self-funded, we would like to express our gratitude to the former Head of Lajnah Falakiyyah Annuqayah and astronomy student, Moh. Ilham Wahyudi, for providing extensive information regarding astrolabes.

Disclosure of Interests. The authors have no competing interests to declare that are relevant to the content of this article.

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