Al-Hilal: Journal of Islamic Astronomy
Vol. 08, No. 01, April 2026: 61-74
DOI: 10.21580/al-hilal.2026.8.1.31866
ISSN: 2775-1236 (printed); 2775-2119 (online)

Reconstructing al-Farghānī's Southern Astrolabe: A Philological and Astronomical Study for Equatorial Observations in Indonesia

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║ *Submitted: 20-01-2026* ║ *Revised: 17-04-2026* ║ *Accepted: 28-04-2026* ║ *Published: 29-04-2026* ║

Abstract

This study reconstructs al-Farghānī's concept of the southern astrolabe through an interdisciplinary approach combining Arabic philology and computational astronomy. Focusing on the sixth chapter (*al-Naw' al-Sādis*) of *Kitāb al-Asturlāb*, the research aims to examine the technical relevance of the southern astrolabe for equatorial observations in Indonesia. The study employs philological methods, including codicological description, transliteration, textual emendation, and annotated translation, integrated with stereographic projection analysis and astronomical computation. The findings demonstrate that the conventional northern astrolabe produces severe geometric distortion when representing southern celestial objects at low latitudes, causing major navigational stars to fall beyond the instrument's physical limits. In contrast, the southern astrolabe provides a proportional projection of southern stars within the equatorial circle, making it more suitable for observers in the Indonesian archipelago. This study contributes to the historiography of Islamic astronomy by demonstrating the continued scientific relevance of al-Farghānī's geometrical framework for contemporary equatorial Islamic astronomy studies.

Keywords: al-Farghānī, southern astrolabe, philology, stereographic projection, low-latitude.

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Tulisan ini merekonstruksi konsep astrolabe selatan al-Farghānī melalui pendekatan interdisipliner yang memadukan filologi Arab dan astronomi komputasional. Dengan berfokus pada bab keenam (*al-Naw' al-Sādis*) dalam *Kitāb al-Asturlāb*, penelitian ini bertujuan mengkaji relevansi teknis astrolabe selatan bagi observasi ekuatorial di Indonesia. Penelitian menggunakan metode filologis yang meliputi deskripsi kodikologis, transliterasi, emendasi teks, dan terjemahan beranotasi, yang diintegrasikan dengan analisis proyeksi stereografis serta komputasi astronomi. Hasil penelitian menunjukkan bahwa astrolabe utara konvensional menghasilkan distorsi geometris yang signifikan dalam merepresentasikan objek langit belahan selatan pada wilayah lintang rendah, sehingga sejumlah bintang navigasi utama terproyeksikan melampaui batas fisik instrumen. Sebaliknya, astrolabe selatan menghasilkan proyeksi yang lebih proporsional bagi bintang-bintang selatan di dalam lingkaran ekuator, sehingga lebih sesuai digunakan oleh pengamat di kawasan Nusantara. Penelitian ini berkontribusi terhadap historiografi astronomi Islam dengan menunjukkan relevansi ilmiah berkelanjutan dari kerangka geometris al-Farghānī bagi kajian falak kontemporer di wilayah lintang rendah.

Kata Kunci: al-Farghānī, astrolabe langit selatan, filologi, proyeksi stereografis, lintang rendah.

To cite this article (Chicago Manual of Style 17th Edition Full-Note):
Fajrullah and Nur Faizah, "Reconstructing al-Farghānī's Southern Astrolabe; A Philological and Astronomical Study for Equatorial Observations in Indonesia", *Al-Hilal: Journal of Islamic Astronomy*, Vol. 8, No. 1 (2026): 61-74.

A. Introduction

Abū al-ʻAbbās Aḥmad ibn Muḥammad ibn Kathīr al-Farghānī (ca. 800–870 CE), known in the Latin tradition as Alfraganus, was among the most influential astronomers of the Abbasid period.[1] His work, *Kitāb fī Jawāmiʻ ʻIlm al-Nujūm*, a systematic summary of Ptolemaic astronomy, became one of the principal channels through which Islamic astronomy entered medieval Europe after its translation into Latin by Johannes Hispalensis and Gerardus Cremonensis.[2] In addition to this work, al-Farghānī also composed a treatise on the astrolabe around 856 CE in Cairo, entitled *al-Kāmil fī Ṣanʻat al-Asturlāb al-Syamālī wa al-Janūbī bi al-Handasah wa al-Ḥisāb*. The treatise is widely regarded as one of the earliest systematic works by a Muslim scholar explaining the mathematical and geometrical principles underlying the construction of the planispheric astrolabe.[3]

The astrolabe occupied a central position in Islamic scientific civilization. Beyond its role as an observational instrument, it was employed in determining prayer times, calculating the qibla direction, navigation, and astronomical computation.[4] The instrument operates through stereographic projection, a mathematical method for mapping the celestial sphere onto a flat surface while preserving angular relationships.[5] In al-Farghānī's treatise, this principle is discussed extensively, including the distinction between northern and southern astrolabe constructions. While the northern astrolabe projects the celestial sphere from the south celestial pole, the southern astrolabe reverses the projection point to the north celestial pole, thereby producing a more proportional representation of southern celestial objects.[6]

Modern scholarship on al-Farghānī's astrolabe has been shaped primarily by Richard Lorch's critical edition and translation, which remains the principal reference for contemporary studies of the text.[7] Subsequent scholarship has also highlighted the broader significance of Islamic astronomical instruments within the history of science.[8] Nevertheless, existing studies have largely concentrated on textual transmission and the general history of Islamic astronomy, while little attention has been given to the technical applicability of the southern astrolabe for low-latitude observations.[9] This issue is particularly relevant for regions near the equator, where southern celestial objects dominate the night sky.

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[1] Pepep Puad Muslim, Tatang Farhanul Hakim, and Suparman Jassin, "Dinamika Dan Perkembangan Ilmu Falak Dari Era Pra Islam Hingga Era Kontemporer," *Al-Tsaqafa : Jurnal Ilmiah Peradaban Islam* 20, no. 1 (July 17, 2023): 14–28, https://doi.org/10.15575/al-tsaqafa.v20i1.27243.

[2] Sonja Brentjes, "Al-Farghānī On the Astrolabe," *Abstracta Iranica* 30 (2010): 1–2, https://doi.org/10.4000/abstractairanica.37981.

[3] Richard Lorch, ed., *Al-Farghānī on the Astrolabe* (Wiesbaden: Franz Steiner Verlag, 2005).

[4] David A. King, *In Synchrony with the Heavens: Studies in Astronomical Timekeeping and Instrumentation in Medieval Islamic Civilization* (Leiden: Brill, 2005), 45–87.

[5] John North, *Cosmos: An Illustrated History of Astronomy and Cosmology* (Chicago: University of Chicago Press, 2008, 2008), 178–95.

[6] Lorch, *Al-Farghānī on the Astrolabe*, 283–85.

[7] Lorch, *Al-Farghānī on the Astrolabe*.

[8] Silvia Brentje, "The Astrolabe in the Medieval Islamic World," in *Handbook of Archaeoastronomy and Ethnoastronomy* (New York: Springer, 2015), 1621–32.

[9] Mohmad Fadlilah Mamat and Mohd Sholeh Sheh Yusuff, "Astrolabe Innovation and Its Chronological Development in Islamic Astronomy: A Historiographical Perspective," *International Journal of Academic Research in Business and Social Sciences* 15, no. 9 (September 11, 2025): 459–66, https://doi.org/10.6007/IJARBSS/v15-i9/26500; Lauhatun Nashiha and Mahsun Mahsun, "Kajian Ilmu Falak Dan Astronomi Dalam Sudut Pandang Filsafat Ilmu," *Astroislamica: Journal of Islamic Astronomy* 3, no. 1 (June

From an astronomical perspective, the conventional northern astrolabe presents a significant geometric limitation when applied to low-latitude regions such as Indonesia. Since the projection is centered on the southern celestial pole, stars with high southern declinations are projected far beyond the equatorial circle, producing severe visual and mathematical distortion.[10] For observers in the Indonesian archipelago, which extends approximately from 6° N to 11° S and is largely situated within the equatorial and southern hemispheres, this configuration is technically inefficient. In contrast, al-Farghānī's southern astrolabe offers an alternative projection system better suited to representing southern celestial objects proportionally within the instrument's disk. This feature is especially relevant for the *Nusantara* region, where southern navigational stars such as Canopus and Acrux remain clearly observable throughout the year.

Recent scholarship on *Nusantara's* Islamic Astronomy manuscripts has demonstrated that the reception of Islamic astronomy in Southeast Asia involved not merely textual transmission, but also adaptation to local geographical and observational contexts.[11] However, Indonesian-language studies that combine philological analysis of classical Arabic astronomical manuscripts with technical astronomical verification remain extremely limited. Most existing studies focus either on manuscript description or on the historical development of Islamic astronomy in general, without integrating philology and computational astronomical analysis in a single framework.a[12]

This study addresses that gap by reconstructing al-Farghānī's concept of the southern astrolabe through an interdisciplinary approach combining Arabic philology and astronomical computation. Focusing on the sixth chapter (*al-Naw' al-Sādis*) of *Kitāb al-Asturlāb*, this article examines the technical relevance of the southern astrolabe for equatorial observations in Indonesia. The study applies philological methods consisting of codicological description, transliteration, textual emendation, and annotated translation, integrated with stereographic projection analysis and computational verification of southern celestial objects observed from Semarang (φ = 7°00' S). Through this approach, the article aims to demonstrate the continuing scientific relevance of al-Farghānī's geometrical framework for contemporary low-latitude astronomy and *Nusantara* astronomical studies.

B. Method

This study employs an interdisciplinary approach combining Arabic philology and computational astronomy to reconstruct al-Farghānī's concept of the southern astrolabe. The primary source examined is the sixth chapter (*al-Naw' al-Sādis*) of *Kitāb al-Asturlāb*, which

30, 2024): 29–50, https://doi.org/10.47766/astroislamica.v3i1.2645; Achmad Mulyadi, "Pemikiran Al-Khawarizmi Dalam Meletakkan Dasar Pengembangan Ilmu Astronomi Islam," *International Journal Ihya' 'Ulum Al-Din* 20, no. 1 (August 2, 2018): 63–86, https://doi.org/10.21580/ihya.20.1.2782; Iga Nur Ramdhani and Revianto Budi Santosa, "Pengaruh Astronomi Islam Pada Masa Golden Age Terhadap Arsitektur," *Al-Marshad: Jurnal Astronomi Islam Dan Ilmu-Ilmu Berkaitan* 7, no. 1 (June 30, 2021): 66–75, https://doi.org/10.30596/jam.v7i1.6888.

[10] Lorch, *Al-Farghānī on the Astrolabe*, 283–85.

[11] Arwin Juli Rakhmadi and Muhammad Hidayat, "Falak Manuscripts: Windows into the Intellectual and Cultural History of Southeast Asia," *KARSA Journal of Social and Islamic Culture* 33, no. 2 (October 31, 2025): 508–35, https://doi.org/10.19105/karsa.v33i2.21576.

[12] Arwin Juli Rakhmadi Butar-Butar, "Historiografi Ilmu Falak Di Nusantara; Sejarah, Motivasi Dan Tokoh Awal," *Journal of Contemporary Islam and Muslim Societies* 2, no. 2 (February 12, 2019): 156–73, https://doi.org/10.30821/jcims.v2i2.2928.

discusses the geometrical construction of the southern astrolabe. The philological stage included codicological description, Arabic text transliteration, textual emendation through comparison with Richard Lorch's critical edition, and annotated translation.[13] The second stage involved astronomical and geometrical analysis of the manuscript's technical content. To evaluate the relevance of the southern astrolabe for low-latitude observations, stereographic projection ratios *(r/R)* were analytically computed using the projection formulas described in al-Farghānī's treatise for both northern and southern astrolabe constructions. The calculations were applied to selected southern stars observable from Semarang (φ = 7°00' S), including Canopus, Acrux, and Alpha Centauri, in order to compare the geometric performance of both projection systems under equatorial observational conditions.[14] Through this combined philological and computational framework, the study aims to demonstrate the continuing scientific relevance of al-Farghānī's geometrical model for contemporary low-latitude astronomy.

C. Result and Discussion

1. Al-Farghānī and the Theoretical Foundations of the Southern Astrolabe

The astrolabe was among the most sophisticated astronomical instruments developed in the ancient and medieval world. The term "astrolabe" derives from the Greek astrolabos (*αστρολάβος*), meaning "star-taker," and was later absorbed into Arabic as *al-asturlāb* (الأسطرلاب).[15] The mathematical principle underlying the instrument namely stereographic projection can be traced back to the Greek astronomical tradition, particularly to Hipparchus of Nicaea (ca. 190–120 BCE), who first applied projection methods for representing the celestial sphere on a flat surface.[16] This principle was later elaborated by Claudius Ptolemy in the Planisphaerium and subsequently transmitted into the Islamic world through the large-scale translation movement of the Abbasid period.[17]

Within Islamic civilization, the astrolabe evolved beyond a mere adaptation of Greek astronomy. Muslim astronomers transformed it into a highly developed scientific instrument used for astronomical observation, navigation, determination of prayer times, and qiblah calculation.[18] Among the scholars associated with this development, al-Farghānī occupies a particularly important position. His treatise *al-Kāmil fī Ṣan'at al-Asturlāb al-Syamālī wa al-Janūbī bi al-Handasah wa al-Ḥisāb*, composed around 856 CE in Cairo, is widely regarded as one of the earliest

[13] Oman Fathurrahman, *Indonesian Philology: Theory and Method* (Jakarta: Kencana, 2015), 75–95; Edwar Djamaris, *Methods of Philological Research* (Jakarta: Manasco, 2002), 7–12.

[14] Lorch, *Al-Farghānī on the Astrolabe*, v–viii.

[15] Emilia Calvo, "Astrolabe," in *Encyclopaedia of the History of Science, Technology, and Medicine in Non-Western Cultures*, ed. Helaine Selin, 3rd ed. (New York: Springer, 2016), 1–8.

[16] North, *Cosmos: An Illustrated History of Astronomy and Cosmology*, 178–95.

[17] Lorch, *Al-Farghānī on the Astrolabe*, 1–3.

[18] King, *In Synchrony with the Heavens: Studies in Astronomical Timekeeping and Instrumentation in Medieval Islamic Civilization*; Moh. Fadllurrahman and Moh. Ilham Wahyudi, "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," in *Proceedings of International Conference of Islamic Studies (ICONIS 2025)*, ed. Agung Dwi Bahtiar El Rizaq (Amsterdam: Atlantis Press SARL, 2025), 173–91, https://doi.org/10.2991/978-2-38476-464-8_13; Ahmad Izzuddin, Muhammad Habibur Rahman, and Muhammad Himmatur Riza, "Teleskop Ioptron Cube II Dalam Penentuan Arah Kiblat," *Al-Afaq: Jurnal Ilmu Falak Dan Astronomi* 3, no. 1 (July 19, 2021): 25–40, https://doi.org/10.20414/afaq.v3i1.2776.

systematic works by a Muslim scholar to explain the mathematical and geometrical foundations of astrolabe construction.[19] Unlike earlier practical manuals, al-Farghānī's work presents the astrolabe as a theoretically grounded scientific instrument based on demonstrable geometrical principles.

Recent scholarship has shown that earlier Arabic astrolabe treatises, particularly those attributed to al-Khawārizmī, were predominantly procedural in nature, focusing on the operation and construction of the instrument rather than on its mathematical foundations.[20] Al-Farghānī adopted a markedly different approach. Beginning with the geometrical principles of stereographic projection, he systematically explained the projection of celestial circles, the mathematical relationships between declination and projected radius, and the construction of astronomical tables required for instrument making.[21] In this respect, his contribution did not lie in inventing the astrolabe itself, but in transforming astrolabe construction from a practical craft (*ṣināʿah*) into a mathematically organized discipline.

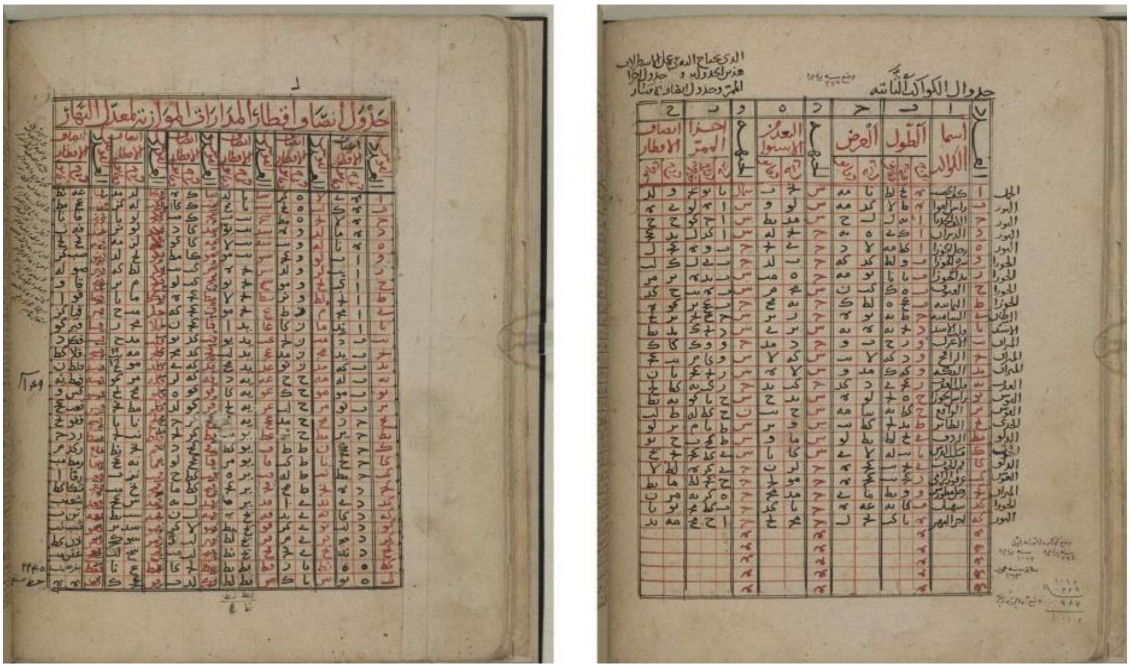

Figure 1. Tables of orbital half-diameters (*anṣāf aqṭār al-madārāt*) and fixed stars (*al-kawākib al-thābitah*) in al-Farghānī's manuscript.

[19] Brentjes, "Al-Farghānī On the Astrolabe."

[20] François Charette and Petra G. Schmidl, "Al-Khwārizmī and Practical Astronomy in Ninth-Century Baghdad. The Earliest Extant Corpus of Texts in Arabic on the Astrolabe and Other Portable Instruments," *CIAMVS: Sources and Commentaries in Exact Sciences* 5 (2004): 101–198; Slamet Hambali, "Astronomi Islam Dan Teori Heliocentris Nicolaus Copernicus," *Al-Ahkam* 23, no. 2 (October 21, 2013): 225–36, https://doi.org/10.21580/ahkam.2013.23.2.24; Robert G. Morrison, "The Cambridge History of Science," in *The Cambridge History of Science: Medieval Science*, ed. David C. Lindberg and Michael H. Shank, 2nd ed. (Cambridge: Cambridge University Press, 2013), https://doi.org/10.1017/CHO9780511974007; Stefan Zieme, "Gerard of Cremona's Latin Translation of the Almagest and the Revision of Tables," *Journal for the History of Astronomy* 54, no. 1 (February 4, 2023): 3–33, https://doi.org/10.1177/00218286221140848; Mamat and Yusuff, "Astrolabe Innovation and Its Chronological Development in Islamic Astronomy: A Historiographical Perspective."

[21] Lorch, *Al-Farghānī on the Astrolabe*, 16–30.

A major component of al-Farghānī's treatise is the integration of astronomical tables directly into the instrument's geometrical design. The fourth chapter contains tables of orbital half-diameters (*anṣāf aqṭār al-madārāt*) and fixed stars (*al-kawākib al-thābitah*), which functioned as computational references for constructing the astrolabe disk and rete.[22] The coordinates contained in these tables determined the placement of star pointers and celestial circles on the instrument, thereby linking theoretical astronomy with practical instrument fabrication. Richard Lorch therefore characterizes the treatise not merely as a descriptive text, but as a computational guide directly applicable in astrolabe workshops.[23]

Figure 2. The rete (*'ankabūt*) in al-Farghānī's manuscript showing stellar positions and the ecliptic circle.

More importantly, al-Farghānī extended the theoretical framework of the astrolabe by discussing the southern astrolabe (*al-asturlāb al-janūbīyah*) in the sixth chapter (*al-Naw' al-Sādis*). While the standard northern astrolabe projects the celestial sphere from the south celestial pole, the southern astrolabe reverses the projection point to the north celestial pole, thereby producing a more proportional representation of southern celestial objects.[24] This innovation is particularly significant for observers located in low-latitude and southern regions, where southern stars dominate the night sky. In this sense, the southern astrolabe reflects an advanced geometrical awareness of observational differences across geographical regions within the Islamic astronomical tradition.

[22] Lorch, 126–27.
[23] Lorch, *Al-Farghānī on the Astrolabe*.
[24] Lorch, 283–85.

2. Stereographic Projection and the Geometry of the Southern Astrolabe

The fundamental principle underlying the planispheric astrolabe is stereographic projection (*al-isqāṭ al-mustawī*), a geometrical method used to represent the three-dimensional celestial sphere on a two-dimensional plane.[25] In al-Farghānī's treatise, this principle is discussed extensively in the opening chapters as the mathematical foundation of astrolabe construction.[26] The stereographic projection employed in the astrolabe possesses two essential properties: it preserves angular relationships (conformal projection) and projects every circle on the celestial sphere whether great circles or small circles as circles on the projection plane.[27] These properties enabled medieval astronomers to map celestial coordinates onto a flat instrument without losing the geometrical relationships required for astronomical observation and calculation.

In the conventional northern astrolabe, the stereographic projection is constructed from the south celestial pole onto a plane tangent to the north celestial pole or, equivalently, onto the equatorial plane.[28] Under this system, celestial objects located near the southern celestial pole are projected increasingly farther from the center of the instrument. Al-Farghānī mathematically expressed this relationship through the projection equation:

$$r = R\ x \tan\left(\frac{90 -\ \delta}{2}\right)$$

where *r* represents the projected radius on the astrolabe disk, *R* denotes the reference radius of the celestial sphere, and δ refers to stellar declination.[29] The equation demonstrates that the farther a celestial object lies from the projection pole, the larger its projected radius becomes on the instrument plane.

This geometrical consequence becomes particularly significant for southern celestial objects observed from low-latitude regions. Stars with large southern declinations produce projection radii that extend far beyond the equatorial circle, resulting in disproportionate representation and practical limitations for astrolabe construction.[30] In classical northern astrolabes, many southern navigational stars consequently fall outside the physical boundary of the instrument plate, reducing their usefulness for observers located near the equator or in the southern hemisphere.

Al-Farghānī addressed this limitation through the concept of the southern astrolabe (*al-asturlāb al-janūbīyah*), discussed in the sixth chapter (*al-Naw' al-Sādis*) of his treatise.[31] Unlike the northern construction, the southern astrolabe reverses the projection point to the north celestial pole. The projection relationship therefore becomes:

$$r = R\ x \tan\left(\frac{90 +\ \delta}{2}\right)$$

This reversed projection produces a more compact and proportional representation of southern celestial objects within the equatorial circle.[32] Geometrically, the southern astrolabe does

[25] North, *Cosmos: An Illustrated History of Astronomy and Cosmology*, 178–95.
[26] Lorch, *Al-Farghānī on the Astrolabe*, 16–30.
[27] Lorch, 18–22.
[28] Lorch, 23–28.
[29] Lorch, 23–28.
[30] Lorch, 283–85.
[31] Lorch, 283–84.
[32] Lorch, 284–85.

not alter the principles of stereographic projection itself, but rather changes the orientation of the projection system to accommodate different observational environments.

From the perspective of equatorial astronomy, this modification represents a significant technical innovation. Regions such as the Indonesian archipelago, situated largely within low latitudes and partially within the southern hemisphere, observe a night sky dominated by southern celestial objects.[33] Under these conditions, the southern astrolabe provides a geometrically more efficient representation of navigational stars such as Canopus (*Suhayl*) and Acrux (*al-Ṣalīb al-Janūbī*). Al-Farghānī's discussion therefore demonstrates an advanced awareness of the relationship between astronomical instrumentation and geographical latitude within the medieval Islamic scientific tradition.

3. Philological Reconstruction of *al-Naw' al-Sādis*

This section presents the philological reconstruction of the opening passage of the sixth chapter (*al-Naw' al-Sādis*) of al-Farghānī's *Kitāb al-Asturlāb*, which specifically discusses the southern astrolabe (*al-asturlāb al-janūbīyah*). The reconstruction process involved transliteration of the Arabic manuscript, textual emendation through comparison with Richard Lorch's critical edition, and annotated translation of technical astronomical terminology.[34] The manuscript examined in this study dates to 691 AH/1292 CE and preserves the chapter in relatively stable textual condition, with only minor orthographic variations that do not substantially affect the meaning of the text.[35]

The opening sentence of the chapter is particularly significant because it explicitly distinguishes between the conventional northern astrolabe and the southern astrolabe construction. The manuscript reads:[36]

النّوع السّادس في صف تخطيط الاسطرلاب الجنوبيّة .أما ما عمل عليه الأولون من هيئة الأسطرلاب على جهة القطب الشمالي للعلة التي قدمناها فهو ما قد وصفنا وقد يجب لتمام العمل بما قدمنا من الملة أن نصف كيف نعمل الأسطراب على جهة القطب الجنوبي

The passage may be translated as follows:

"*The sixth chapter: concerning the construction of the southern astrolabe. As for the astrolabe constructed by earlier scholars according to the orientation of the northern pole, for the reasons previously explained, it is as we have described. However, for the completion of this discipline, it is necessary to explain how the astrolabe may be constructed according to the orientation of the southern pole.*"

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[33] Indonesia geographically extends from approximately 6° N to 11° S, with most major islands located within the southern hemisphere.

[34] Lorch, *Al-Farghānī on the Astrolabe*; A. King David, "Some Remarks on Islamic Scientific Manuscripts and Instruments and Past, Present, and Future Research," in *The Significance Of Islamic Manuscripts Proceedings Of The Inaugural Conference Of Al-Furqān Islamic Heritage Foundation, 30th November - 1st December 1991 - English Version* (Al-Furqān Islamic Heritage Foundation, 1992), 115–43, https://doi.org/10.56656/100130.10.

[35] The manuscript examined in this study is dated 691 AH/1292 CE according to the colophon preserved in the final folio

[36] Lorch, *Al-Farghānī on the Astrolabe*, 283.

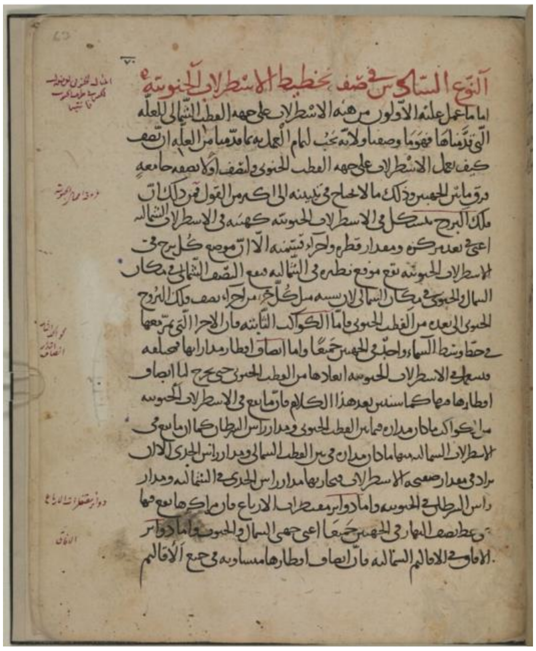

Figure 3. Opening page of *al-Naw' al-Sādis* in al-Farghānī's *Kitāb al-Asturlāb* (folio 63r), discussing the construction of the southern astrolabe.

Several philological observations emerge from this passage. *First*, the expression *al-awwalūn* ("the predecessors") refers to earlier astrolabe makers whose instruments were primarily oriented toward northern latitudes. This statement corresponds closely with the historical context of medieval Islamic astronomy, whose principal scientific centers such as Baghdad, Damascus, and Cairo were located in the northern hemisphere. *Second*, the terms *jihat al-quṭb al-shamālī* and *jihat al-quṭb al-janūbī* indicate two distinct stereographic projection orientations rather than merely geographical directions.[37] In the context of astrolabe geometry, the "northern orientation" refers to projection from the south celestial pole, whereas the "southern orientation" reverses the projection point to the north celestial pole.

The textual reconstruction further demonstrates that the sixth chapter was not intended as a minor technical appendix, but rather as an integral component of al-Farghānī's broader astronomical system. His insistence on explaining the southern astrolabe "for the completion of the discipline" (*li-tamām al-'amal*) suggests a conscious attempt to formulate a geometrical framework applicable to multiple observational environments.[38] In this respect, the southern astrolabe reflects not only technical innovation, but also a broader epistemological awareness of geographical variation within medieval Islamic astronomy.

From a codicological perspective, the manuscript section examined in this study remains relatively well preserved. The principal text is written in black ink, while chapter headings appear in red ink, a common feature in scientific Arabic manuscripts of the medieval Islamic period.[39]

[37] Lorch, 284–85.
[38] Lorch, 285–90.
[39] Fathurrahman, *Indonesian Philology: Theory and Method*, 75–95.

Although minor damage appears along the margins of several folios, the core text remains legible and largely consistent with Lorch's critical edition. The limited number of textual variants indicates a relatively stable transmission history for this section of the manuscript.

4. Equatorial Application of the Southern Astrolabe; The Case of Semarang

The geometrical principles discussed by al-Farghānī in the sixth chapter (*al-Naw' al-Sādis*) acquire particular significance when applied to equatorial and low-latitude regions. This study examines the practical relevance of the southern astrolabe through a computational case study based on the geographical coordinates of Semarang *(φ = 7°00' S, λ = 110°24' E)*, one of the important centers of contemporary Islamic astronomy studies in Indonesia.[40] Located within the southern hemisphere and close to the equator, Semarang provides an appropriate observational context for evaluating the effectiveness of southern astrolabe projection systems in representing southern celestial objects.

Using the stereographic projection formulas described in al-Farghānī's treatise, projection radius ratios *(r/R)* were analytically computed for five major southern stars recorded in the manuscript's astronomical tables: Canopus (*Suhayl*, *α Car*), Achernar (*α Eri*), Acrux (*α Cru*), Mimosa (*β Cru*), and Alpha Centauri (*α Cen*).[41] The calculations demonstrate a substantial geometrical contrast between northern and southern astrolabe constructions. Under the conventional northern projection system, all five stars produce projected radii ranging from 2.96 to 4.18 times the equatorial radius, placing them far beyond the physical limits of a standard astrolabe plate.[42] In practical terms, these stars cannot be accurately represented within the instrument.

Table 1. Analytical computation of stereographic projection ratios *(r/R)* for selected southern stars observed from Semarang *(φ = 7°00' S)*.

Arabic Name	Desig.	*δ*	*r/R North*	*r/R South*	*h Semarang*
Suhayl	*α Car*	-52.7°	2.96	0.34	44.3°
Ākhir al-Nahr	*α Eri*	-57.24°	3.40	0.29	39.8°
Al-Ṣalīb al-Janūbī (α)	*α Cru*	-63.1°	4.18	0.24	33.9°
Al-Ṣalīb al-Janūbī (β)	*β Cru*	-59.69°	3.69	0.27	37.3°
Rijl al-Qanṭūris	*α Cen*	-60.84°	3.84	0.26	36.2°

The southern astrolabe produces markedly different results. By reversing the projection point to the north celestial pole, the same stars yield projection ratios between 0.24 and 0.34, positioning them comfortably within the equatorial circle of the instrument.[43] This proportional representation allows southern celestial objects to be displayed more accurately and efficiently for observers located in low-latitude regions. The computational results therefore provide

[40] Semarang was selected as the observational reference point due to its geographical location within the equatorial region and its role in contemporary Indonesian Islamic astronomy studies.

[41] Lorch, *Al-Farghānī on the Astrolabe*, 126–27.

[42] King, *In Synchrony with the Heavens: Studies in Astronomical Timekeeping and Instrumentation in Medieval Islamic Civilization*, 349.

[43] Lorch, *Al-Farghānī on the Astrolabe*, 283–85.

mathematical verification of al-Farghānī's argument that the southern astrolabe constitutes an essential complement to conventional northern astrolabe construction.

The relevance of these findings becomes clearer when considered within the broader observational context of the Indonesian archipelago. All five stars examined in this study culminate at elevations between approximately 33° and 44° above Semarang's southern horizon, making them clearly visible throughout much of the year.[44] Among these stars, Canopus (*Suhayl*) holds particular historical significance, having served as a major navigational reference for *Arab-Hadhrami* sailors traveling across the Indian Ocean and the *Nusantara* region since the medieval period.[45] The southern astrolabe therefore reflects not only a geometrical innovation, but also an astronomical framework potentially compatible with historical navigational practices in maritime Southeast Asia.

The computational analysis presented in this study demonstrates that al-Farghānī's ninth-century geometrical framework retains scientific relevance for contemporary low-latitude astronomy studies in Indonesia. Although the present research remains theoretical and philological in character, the projection calculations confirm that the southern astrolabe offers a mathematically more suitable representation of southern celestial objects for equatorial observers. In this respect, the study contributes to the growing interdisciplinary scholarship connecting Islamic manuscript studies, history of astronomy, and computational astronomical analysis within the context of the *Nusantara*.[46]

D. Conclusion

This study has reconstructed al-Farghānī's concept of the southern astrolabe through an interdisciplinary approach combining Arabic philology and computational astronomy. The philological analysis of the sixth chapter (*al-Naw' al-Sādis*) demonstrates that the southern astrolabe constituted an integral component of al-Farghānī's geometrical framework rather than a marginal technical addition. Through transliteration, textual emendation, and annotated translation, the manuscript reveals a conscious attempt to formulate an astronomical projection system adaptable to different geographical environments. The computational analysis further confirms that the southern astrolabe provides a geometrically more proportional representation of southern celestial objects for observers in low-latitude regions such as Indonesia. In contrast to the conventional northern astrolabe, which projects major southern stars beyond the physical limits of the instrument, the southern projection system accommodates these stars within the equatorial circle more accurately and efficiently.

Nevertheless, this study remains limited in several respects. The philological analysis relies primarily on a single manuscript witness collated with Lorch's critical edition, while the astronomical verification is confined to analytical projection calculations for selected southern stars observed from Semarang. The research therefore remains theoretical and geometrical in

[44] Culmination altitude was calculated using the formula $h = 90° - |\varphi - \delta|$, where $\varphi = -7°00'$ for Semarang

[45] Paul Wheatley, *The Golden Khersonese: Studies in the Historical Geography of the Malay Peninsula before A.D. 1500* (Kuala Lumpur: University of Malaya Press, 1961), 128–33.

[46] Rakhmadi and Hidayat, "Falak Manuscripts: Windows into the Intellectual and Cultural History of Southeast Asia."

character and does not yet include physical reconstruction or observational testing of a functioning southern astrolabe calibrated for equatorial latitudes. Future studies may expand this research through comparative multi-manuscript analysis, digital reconstruction of southern astrolabe models, and experimental verification using contemporary observational data. Further interdisciplinary work integrating manuscript studies, history of science, and practical astronomical instrumentation would also contribute significantly to the development of *Nusantara* astronomy studies and the broader historiography of Islamic astronomy.

BIBLIOGRAPHY

Brentje, Silvia. "The Astrolabe in the Medieval Islamic World." In *Handbook of Archaeoastronomy and Ethnoastronomy*, 1621–1632. New York: Springer, 2015.

Brentjes, Sonja. "Al-Farghānī On the Astrolabe." *Abstracta Iranica* 30 (2010): 1–2. https://doi.org/10.4000/abstractairanica.37981.

Calvo, Emilia. "Astrolabe." In *Encyclopaedia of the History of Science, Technology, and Medicine in Non-Western Cultures*, edited by Helaine Selin, 3rd ed. New York: Springer, 2016.

Charette, François, and Petra G. Schmidl. "Al-Khwārizmī and Practical Astronomy in Ninth-Century Baghdad. The Earliest Extant Corpus of Texts in Arabic on the Astrolabe and Other Portable Instruments." *CIAMVS: Sources and Commentaries in Exact Sciences* 5 (2004): 101–198.

Djamaris, Edwar. *Methods of Philological Research*. Jakarta: Manasco, 2002.

Fadllurrahman, Moh., and Moh. Ilham Wahyudi. "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." In *Proceedings of International Conference of Islamic Studies (ICONIS 2025)*, edited by Agung Dwi Bahtiar El Rizaq, 173–91. Amsterdam: Atlantis Press SARL, 2025. https://doi.org/10.2991/978-2-38476-464-8_13.

Fathurrahman, Oman. *Indonesian Philology: Theory and Method*. Jakarta: Kencana, 2015.

Hambali, Slamet. "Astronomi Islam Dan Teori Heliocentris Nicolaus Copernicus." *Al-Ahkam* 23, no. 2 (October 21, 2013): 225–36. https://doi.org/10.21580/ahkam.2013.23.2.24.

Izzuddin, Ahmad, Muhammad Habibur Rahman, and Muhammad Himmatur Riza. "Teleskop Ioptron Cube II Dalam Penentuan Arah Kiblat." *Al-Afaq: Jurnal Ilmu Falak Dan Astronomi* 3, no. 1 (July 19, 2021): 25–40. https://doi.org/10.20414/afaq.v3i1.2776.

King, David A. "Some Remarks on Islamic Scientific Manuscripts and Instruments and Past, Present, and Future Research." In *The Significance Of Islamic Manuscripts Proceedings Of The Inaugural Conference Of Al-Furqān Islamic Heritage Foundation, 30th November - 1st December 1991 - English Version*, 115–43. Al-Furqān Islamic Heritage

Foundation, 1992. https://doi.org/10.56656/100130.10.

King, David A. *In Synchrony with the Heavens: Studies in Astronomical Timekeeping and Instrumentation in Medieval Islamic Civilization*. Leiden: Brill, 2005.

Lorch, Richard, ed. *Al-Farghānī on the Astrolabe*. Wiesbaden: Franz Steiner Verlag, 2005.

Mamat, Mohmad Fadlilah, and Mohd Sholeh Sheh Yusuff. "Astrolabe Innovation and Its Chronological Development in Islamic Astronomy: A Historiographical Perspective." *International Journal of Academic Research in Business and Social Sciences* 15, no. 9 (September 11, 2025): 459–66. https://doi.org/10.6007/IJARBSS/v15-i9/26500.

Morrison, Robert G. "The Cambridge History of Science." In *The Cambridge History of Science: Medieval Science*, edited by David C. Lindberg and Michael H. Shank, 2nd ed. Cambridge: Cambridge University Press, 2013. https://doi.org/10.1017/CHO9780511974007.

Mulyadi, Achmad. "Pemikiran Al-Khawarizmi Dalam Meletakkan Dasar Pengembangan Ilmu Astronomi Islam." *International Journal Ihya' 'Ulum Al-Din* 20, no. 1 (August 2, 2018): 63–86. https://doi.org/10.21580/ihya.20.1.2782.

Muslim, Pepep Puad, Tatang Farhanul Hakim, and Suparman Jassin. "Dinamika Dan Perkembangan Ilmu Falak Dari Era Pra Islam Hingga Era Kontemporer." *Al-Tsaqafa : Jurnal Ilmiah Peradaban Islam* 20, no. 1 (July 17, 2023): 14–28. https://doi.org/10.15575/al-tsaqafa.v20i1.27243.

Nashiha, Lauhatun, and Mahsun Mahsun. "Kajian Ilmu Falak Dan Astronomi Dalam Sudut Pandang Filsafat Ilmu." *Astroislamica: Journal of Islamic Astronomy* 3, no. 1 (June 30, 2024): 29–50. https://doi.org/10.47766/astroislamica.v3i1.2645.

North, John. *Cosmos: An Illustrated History of Astronomy and Cosmology*. Chicago: University of Chicago Press, 2008, 2008.

Rakhmadi, Arwin Juli, and Muhammad Hidayat. "Falak Manuscripts: Windows into the Intellectual and Cultural History of Southeast Asia." *KARSA Journal of Social and Islamic Culture* 33, no. 2 (October 31, 2025): 508–35. https://doi.org/10.19105/karsa.v33i2.21576.

Rakhmadi Butar-Butar, Arwin Juli. "Historiografi Ilmu Falak Di Nusantara; Sejarah, Motivasi Dan Tokoh Awal." *Journal of Contemporary Islam and Muslim Societies* 2, no. 2 (February 12, 2019): 156–73. https://doi.org/10.30821/jcims.v2i2.2928.

Ramdhani, Iga Nur, and Revianto Budi Santosa. "Pengaruh Astronomi Islam Pada Masa Golden Age Terhadap Arsitektur." *Al-Marshad: Jurnal Astronomi Islam Dan Ilmu-Ilmu Berkaitan* 7, no. 1 (June 30, 2021): 66–75. https://doi.org/10.30596/jam.v7i1.6888.

Wheatley, Paul. *The Golden Khersonese: Studies in the Historical Geography of the Malay Peninsula before A.D. 1500*. Kuala Lumpur: University of Malaya Press, 1961.

Zieme, Stefan. "Gerard of Cremona's Latin Translation of the Almagest and the Revision of Tables." *Journal for the History of Astronomy* 54, no. 1 (February 4, 2023): 3–33. https://doi.org/10.1177/00218286221140848.

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