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Al-Biruni's Contribution To The Development Of Qibla Determination Methods: Historical Analysis And Scientific Relevance

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Abstract: Abu Raihan Muhammad bin Ahmad Al-Biruni, a prominent Muslim scholar born in 973 CE, made important contributions to the development of a more accurate method of Qibla direction determination. This Research aims to explore Al-Biruni's contribution to overcoming the limitations of traditional methods that lack precision by developing an innovative approach that combines astronomical observations and sophisticated mathematical calculations. By utilizing the positions of celestial bodies, such as the stars Canopus and Polaris, as well as the Sun's direction during the summer and winter solstices, Al-Biruni achieved a more accurate determination of Qibla. The research methodology uses a qualitative approach that includes an analysis of Al-Biruni's monumental work, Al-Qanun al-Mas'udi, especially book 5, section 5, which contains detailed calculations using spherical trigonometry and celestial sphere diagrams, as well as the application of sine and cosine rules in the process of calculating the Qibla Direction. The research findings show that Al-Biruni's method, which utilizes the positions of celestial bodies and spherical astronomical calculations, can produce a Qibla direction determination with a level of accuracy comparable to that of modern techniques. The originality of this approach lies in its systematic integration of astronomy and mathematics, which not only increases the accuracy of Qibla direction determination but also provides a basis for the development of contemporary scientific methods. The results of this research confirm the relevance and significance of Al-Biruni's method in bridging spiritual needs and scientific progress.

Keywords: Al-Biruni, Qibla Determination, Islamic Astronomy, Scientific Contribution, Historical Analysis.

Introduction

The Qibla, or the direction Muslims face during prayer, is important and deeply rooted in Islamic traditions and architecture. The change in Qibla from Jerusalem to Mecca, as commanded by the Prophet Muhammad (PBUH), marked an important historical event that influenced mosque architecture worldwide. The orientation of the mosque has been a major consideration in Islamic architecture from the beginning, as it must ensure alignment with the Kaaba in Mecca, which signifies the physical and spiritual center of Islam.[1]

Determining the correct direction for Qibla has been an interesting and evolving topic for centuries. Early Muslims used various methodologies, including astronomical observations, to ascertain the correct orientation of qibla.[2] Research shows that mosques built between 622 and 900 AD were very accurate in their Qibla direction, often only a few degrees off the actual Qibla direction, because of skillful calculations based on astronomical phenomena.[3] Scholars such as Abu Al-Wafa, Al-Biruni, and Ibn Al-Haytam significantly contributed astronomical knowledge, which became the basis for accurate Qibla orientation.[4] However, it is important to recognize that not all mosques from the early period showed the same level of precision.[5]

Abu Raihan Muhammad bin Ahmad Al-Biruni, born in the 10th and 11th centuries AD, positioned himself as one of the most influential Muslim scholars through his substantial contributions to various disciplines, including astronomy, geography, mathematics, and history.[6] Al-Biruni was not only a theoretical scientist but also an empirical researcher who emphasized observation and experimentation in scientific inquiry.[7] One of Al-Biruni's important contributions was in determining the Qibla direction that Muslims face when praying.[8] The

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[1] Saddam Hussain, Zheng Chunrou, and Fu Juan, "The Mosque's Primary Spaces and the Required Direction of the Mosque Building," *Journal of Islamic Architecture* 7, no. 4 (2023): 719–35, https://doi.org/10.18860/jia.v7i4.21497.

[2] B. Kisworo, "The Implementation of Islam as Rahmah Li Al-'alamin in Indonesia: Contributions, Challenges and Opportunities," *AJIS: Academic Journal of Islamic Studies*, 2017, https://journal.iaincurup.ac.id/index.php/AJIS/article/view/311.

[3] Walter R. Schumm, "How Accurately Could Early (622-900 C.E.) Muslims Determine the Direction of Prayers (Qibla)?," *Religions* 11, no. 3 (2020): 102, https://doi.org/10.3390/rel11030102.

[4] Reza Akbar and Asman Asman, "Social Conflict Due to the Controversy of Mosque's Qibla Direction in Sejiram Village, Sambas Regency," *Jurnal Ilmiah Al-Syir Ah* 18, no. 1 (2020): 1, https://doi.org/10.30984/jis.v18i1.926.

[5] David A. King, "The Sacred Direction in Islam A Study of the Interaction of Religion and Science in the Middle Ages," *Interdisciplinary Science Reviews* 10, no. 4 (January 1985): 315–28, https://doi.org/10.1179/isr.1985.10.4.315.

[6] Abdul Latif Samian, "Reason and Spirit in Al-Biruni's Philosophy of Mathematics," in *Springer eBooks* (Springer Nature, 2010), 137–46, https://doi.org/10.1007/978-90-481-9612-8_9.

[7] Amelia Carolina Sparavigna, "The Science of Al-Biruni," *International Journal of Sciences*, no. 12 (January 2013): 52–60, https://doi.org/10.18483/ijsci.364.

[8] Amelia Carolina Sparavigna, "Al-Biruni and the Mathematical Geography," *SSRN Electronic Journal*, December 2014,

determination of the Qibla direction has been a major concern for Muslim astronomers since the 8th century AD and is seen as a crucial mathematical geography problem.[9]

Al-Biruni developed an innovative method for determining the Qibla direction that went beyond traditional approaches, which were often less accurate.[10] In his work, Al-Biruni utilized observations of celestial bodies, including the stars Canopus and Polaris, and the position of the Sun during the summer and winter solstices, to achieve a more precise determination of the Qibla direction.[11] His monumental work, Al-Qanun al-Mas'udi, especially book 5, section 5, contains details of Al-Biruni's calculations, which improved the accuracy of qibla determination and laid the foundations for modern calculations.[12]

Abu Raihan Muhammad bin Ahmad Biruni played a crucial role in overcoming the challenge of accurate Qibla direction measurements by introducing a method of Qibla direction determination that combined astronomical observations and sophisticated mathematical calculations.[13] Al-Biruni's integration of astronomical observation and mathematical calculation was not merely an academic exercise; it had direct implications for Islamic practices. His work on determining the Qibla, the direction of prayer towards Mecca, exemplifies this trend.[14] By applying his scientific expertise to a fundamental religious requirement, Al-Biruni demonstrated how science can serve faith.

His methods, as well as those of Abu al-Wafa, involve sophisticated mathematical techniques.[15] These methods, documented in

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https://papers.ssrn.com/sol3/Delivery.cfm/SSRN_ID2760528_code2375536.pdf?abstractid=2760528&mirid=1&type=2.

[9] David A. King, "The Sacred Geography of Islam," in *Elsevier eBooks* (Elsevier BV, 2005), 161–78, https://doi.org/10.1016/b978-044450328-2/50010-2.

[10] Andi Jusran Kasim and Muliani Muliani, "AKURASI ARAH KIBLAT MASJID DI WILAYAH KECAMATAN BANGGAE KABUPATEN MAJENE," *QISTHOSIA Jurnal Syariah Dan Hukum* 3, no. 1 (June 2022): 1–16, https://doi.org/10.46870/jhki.v3i1.227.

[11] Sparavigna, "The Science of Al-Biruni."

[12] Ali Moussa, "MATHEMATICAL METHODS IN ABŪ AL-WAFĀ'S ALMAGEST AND THE QIBLA DETERMINATIONS," *Arabic Sciences and Philosophy* 21, no. 1 (February 2011): 1–56, https://doi.org/10.1017/s095742391000007x.

[13] W. S. M. Sanjaya et al., "Determining Qibla Direction Using Al-Biruni's First Method From Kitab Tahdid Nihayat Al-Amakin With the Implementation Based on Board Arduino McU, GPS Module, and Digital Compass," 2019, 513–18, https://doi.org/10.1109/isemantic.2019.8884330.

[14] Moussa, "MATHEMATICAL METHODS IN ABŪ AL-WAFĀ'S ALMAGEST AND THE QIBLA DETERMINATIONS."

[15] Moussa.

works such as the "Kitab Tahdid Nihayat al-Amakin, use spherical trigonometry to calculate the direction of the Qibla from any location.[16] This was a significant advancement because it moved away from less accurate methods based on local traditions or simple geometric approximations.

Al-Biruni's legacy extends beyond his findings, his approach has inspired modern scientists and scholars to explore more advanced methods in various fields of research.[17] His dedication to rigorous observation, mathematical precision, and the practical application of knowledge continue to resonate in the contemporary world.[18]

This study aims to explore Al-Biruni's contribution to the development of accurate Qibla direction determination methods by analyzing their relevance in the modern scientific context.[19] By comparing Al-Biruni's method with contemporary Qibla direction determination techniques, this study seeks to highlight innovations and their impact on religious practice and scientific development.[20]

Thus, this study aims to comprehensively examine Al-Biruni's contribution to the development of accurate Qibla direction determination methods and to analyze their relevance in the modern scientific context.

Research Methods

This Research uses a qualitative approach to explore Al-Biruni's contribution to the development of accurate Qibla direction determination methods, involving a comprehensive analysis of relevant historical and scientific texts. This approach also allowed for a comprehensive assessment of Al-Biruni's thoughts and contributions to

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[16] Moussa.

[17] Y. Helena and S. T. Sumanti, "Digital Transformation in Islamic Education, Improving The Quality of Teachers in Islamic Education in Padangsidimpuan City," *AJIS: Academic Journal of Islamic …*, 2024, https://journal.iaincurup.ac.id/index.php/AJIS/article/view/12247.

[18] Sparavigna, "Al-Biruni and the Mathematical Geography," December 2014.

[19] M. K. R. Abadi and U. Saida, "Indonesian Millennialâ€™ s Financial Behaviour: The Role of Financial Literacy in Intention to Use Fintech Lending," *AJIS: Academic Journal of Islamic …*, 2024, https://journal.iaincurup.ac.id/index.php/AJIS/article/view/10050.

[20] A. D. Amda, "Science and Technology in the Islamic Perspective," *AJIS: Academic Journal of Islamic Studies*, 2016, https://journal.iaincurup.ac.id/index.php/AJIS/article/view/94.

the fields of astronomy and Qibla direction determination.[21]

The main data source was Al-Biruni's works, such as Qanun Al-Mas'udi, while the supporting data source was obtained from books, journal articles, and other scientific studies that discuss the determination of Qibla direction and Al-Biruni's contribution in the fields of astronomy, mathematics, and geography.[22]

The collected data were qualitatively analyzed through interpretation and comparison. The data analysis method used in this research involves several important steps: data reduction, data presentation, and conclusion drawing.[23] Data reduction involves filtering and focusing on the data relevant to the research questions. Subsequently, the data were presented in the form of a structured and systematic descriptive narrative, that enabled the reader to clearly understand the research findings. In the conclusion-drawing stage, in-depth interpretations were made of the data that had been presented to formulate relevant and meaningful conclusions.

In addition, the method developed by Al-Biruni was compared with contemporary Qibla direction determination techniques to evaluate its accuracy and relevance in a modern context. This Research aims to highlight the innovations and accuracy introduced by Al-Biruni and their impact on religious practices and the development of science.[24]

Thus, the research method used in this study is a combination of qualitative analysis of historical and scientific texts, as well as a comparison between Al-Biruni's method and contemporary Qibla direction determination techniques.

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[21] Kasim and Muliani, "AKURASI ARAH KIBLAT MASJID DI WILAYAH KECAMATAN BANGGAE KABUPATEN MAJENE."

[22] N. Arsiti, "Application of the Principle of Al-Adah Muhakkamah in Mudharabah Practice," *AJIS: Academic Journal of Islamic Studies*, 2024, https://journal.iaincurup.ac.id/index.php/AJIS/article/view/10939.

[23] Dimas Assyakurrohim et al., "Metode Studi Kasus Dalam Penelitian Kualitatif," *Jurnal Pendidikan Sains Dan Komputer* 3, no. 1 (December 2022): 1–9, https://doi.org/10.47709/jpsk.v3i01.1951.

[24] M. Hafizh et al., "Axiological Analysis of Knowledge Cultivation and Its Contemporary Contextualization (Study of Umar Bin Khattab's Thought)," *AJIS: Academic Journal ...*, 2023, https://journal.iaincurup.ac.id/index.php/AJIS/article/view/7266.

Results and Discussions

Biography of Abu Raihan Al-Biruni

Abu Raihan Muhammad bin Ahmad Biruni was born on September 4, 973 AD, in the suburbs of Kyat, the capital of the Khorezmi feudal government, and died on December 13, 1048 AD. From Biruni's own meager story (in Chronology, said al-Mas'ud, and others), it can be known that in his childhood and adolescence, he lived in the city of Kyat, the capital of the Khorezmishyah dynasty. The conditions and circumstances of that time also played an important role in shaping Biruni's socio-political and scientific worldviews.[25]

Figure 1. Al-Biruni[26]

Khorezmi's strong scientific and cultural thinking during this time shaped Biruni's critical thinking. He studied mathematics, philosophy, and geography, and was particularly interested in astronomy.[27] Medieval Eastern astronomy gathered experimental material and theories from Ptolomeus and earlier Muslim scientists such as Al-Khwarizmi and Al-Battani.[28] Almost all Eastern feudal governments are interested in

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[25] Kh. U. Sadykov, *Abu Raihan Al-Biruni* (Jakarta: Suara Bebas, 2007), h. 12.

[26] Unesco Couries, *A Universal Genious Who Lived in Central Asia A Thousand Years Ago* (New York: H.W. Wilson Co., 1974).

[27] Mansour Ghorbani, "Al-Biruni A Scientist Beyond His Time," *Journal of Pars Arian Territories* 1, no. 1 (April 22, 2024): 1–8, https://doi.org/10.61186/jpat.2024.1.1.

[28] Kholdarov Saidbek, "ABU RAYHAN AL-BIRUNI: PIONEER OF SCIENCE AND SCHOLARSHIP," *International Journal of Advance Scientific Research* 4, no. 3 (March 1,

astronomy. Schools for astronomers were established in Kyat, Urgench, Samarkand, Bukhara, and other cities in Central Asia, and observatories were built.[29]

The most prominent astronomers in Khorezmi during Biruni's formative years were Kharadzi and Hamdaki, who prepared calendar reforms for Shah Khorezmi. There is good reason to believe that Biruni's high motivation for astronomy came from the influence of Khorezmi's scientists.[30]

Al-Biruni was an astronomer at 22 years of age. Al-Biruni also observed celestial objects based on Quranic values. This also shows that understanding work based on Quranic values is important in addressing the challenges of the modern world of work.[31] Stated that the spiritual values in the history of Sayyidina Husayn's struggle can be the foundation for building a better civilization and are coherent with maqashid principles.[32] In his early book Chronology of the Ancients, he recorded an incident from his youth. He was involved in an open debate with a famous astronomer at the time. Biruni wrote:[33]

"In the city of Rai, I met someone who was known as a famous astronomer. This astronomer studied the positions of various stars and the phases of the Moon and from that wanted to deduce a prediction of all possible air movements. I objected and said that reality did not support that."

Biruni further added:

"Indeed the phases of the Moon depend on the difference in the Sun illuminating the Moon, as the shifting positions in the sequence follow the

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2024): 189–94, https://doi.org/10.37547/ijasr-04-03-35.

[29] Xoldarov Saidbek Raxmadjon O'G'Li, "EXPLORING THE PHILOSOPHICAL VIEWS OF ABU RAYHAN AL-BIRUNI: A COMPREHENSIVE ANALYSIS," *American Journal of Philological Sciences* 4, no. 4 (April 1, 2024): 24–29, https://doi.org/10.37547/ajps/volume04issue04-05.

[30] Moiz Hasan and Pablo Olano, "The House of Wisdom: How Arabic Science Saved Ancient Knowledge and Gave Us the Renaissance," *Choice Reviews Online* 49, no. 02 (October 1, 2011): 49–0823, https://doi.org/10.5860/choice.49-0823.

[31] E. Elkhairati, A. Arsal, and M. Imran, "Professionalism and Religiosity: A Thematic Interpretation Study on Muslim Workers in Indonesia," *... : Academic Journal of Islamic ...*, January 2024, 118–118, https://doi.org/10.29240/ajis.v9i1.10002.

[32] F. Rahman, A. Amarulloh, and ..., "Building a Civilization Base on Spiritual Values: Learning from the Struggle of Husain," *... Journal of Islamic ...*, January 2019, 97–97, https://doi.org/10.29240/ajis.v4i2.1015.

[33] Abu Raihan Al-Biruni, *The Chronology of Ancient Nations: An English Version* (London: William H. Allen Company, 1879).

signs of the zodiac".

Biruni's favorite astronomers, except for Al-Khorezmi and Al-Battani, were Al-Fergani, Khodjandi, Abul Wefa, and Ibn Yunus. Biruni had a perfect command of Arabic and a fairly good understanding of Greek, Indian, and Syriac languages.[34]

Abu Nasir Mansur ibn-Ali Ibn-Irak was Biruni's first teacher in astronomy. He introduced Biruni to the elements of Euclidean geometry and Ptolomeus' astronomy. Biruni wrote with warmth and appreciation in his Chronology of the Ancients about this teacher, who gave high marks to the method of calculating the longitude of the Sun's apogee and other works in astronomy.[35]

The teacher of Abu Mansur Ibn-Ali Ibn-Iraq was Abu al-Wafa, Muḥammad ibn Muḥammad ibn Yaḥya ibn Ismail ibn al-ʿAbbas al-Buzjani or Abu al-Wafa Buzhjani. Abu al-Wafa was born in 940 A.D. He has been raised by a family of scientists. His brothers, Amr al-Mughazali and Abu Abdullah ibn Anbas are famous mathematicians. His geometry teachers were Abu Yahya al-Mawridi and Abu Ala ibn Karnabi. They introduced Al-Battani's astronomy work to Abu al-Wafa. Before turning 20, Abu al-Wafa moved to Baghdad and stayed there. The patient died at 58 years of age.[36]

Biruni's influence on great thinkers in the East was extensive. Several Eastern scholars have studied and developed such ideas. Among those who directly followed Biruni's ideas and scientific path were the Tajikist astronomer-scientist, writer, and philosopher Omar Khayam (1040-1123), the Azerbaijani astronomer Nasireddin at-Tusi (1201-1272), and the great 15th-century Uzbek astronomer Ulughbek (1394-1449) and others.[37]

When Omar Khayam made astronomical observations at the Merv Observatory in 1074 CE, he used Biruni's data without comments or hesitation because of his trust in Biruni's authority. It is possible that the calendar reform proposed by Khayam in 1079 was based on the analysis presented by Biruni in his book Chronology of the Ancients and the

[34] Unesco Couries, *A Universal Genious Who Lived in Central Asia A Thousand Years Ago*.

[35] Abu Raihan Al-Biruni, *The Chronology of Ancient Nations: An English Version*.

[36] A. Khan, "Al-Biruni's Astronomical Calculations: A Modern Interpretation," *International Journal of Astronomy and Astrophysics* 13, no. 1 (2023): 22–35.

[37] Amelia Sparavigna, "Al-Biruni and the Mathematical Geography" 2014 (August 7, 2019), https://doi.org/10.5281/zenodo.3362206.

Canon of Mas'ud. It is no coincidence that the 11th century is called the "Biruni century" and the second half the "Omay Khayam century".[38]

Ulughbek, the great astronomer of Uzbekistan, followed in the footsteps of Biruni, continued his scientific method, and used Biruni's work extensively. Interesting evidence of this is found in historical sources: "Ulughbek was the first to have studied the book of the Canon of Mas'ud from various aspects and wrote a commentary on it, and it was on the tables that Ulughbek expressed his admiration.[39]

Moreover, Ulughbek used data from the Canon of Mas'ud to prepare his tables. Therefore, Schoy, who studied the trigonometric part of the Canon of Mas'ud, needed an explanation, which was found in some of Ulugh Beg's tables. Schoy wrote in 1917: "On the merits of Biruni's tables of sines and tangents, it is assumed that the radius is equal to 1 and the difference in the prices of the two rows is given". Utilizing this information, I compiled a table, called the Al-Guragani Ulughbeg sine table.[40]

In the context of Falak science in Indonesia, Indonesian falak scholars have adopted Ulughbek's table. This can be seen in the opening of the monumental book Sullamun Nayyirain by Muhammad Manṣūr. It is said that the determination of ijtima' is based on the zij of Ulughbek al-Samarkand, which was summarized by the late Imam Abdul Hamid bin Muhammad Damiri al-Batawi.[41]

A slightly more detailed list of Biruni's (handwritten) works with short reviews was provided by Suter, Suter, and Wiedemann. Biruni's astronomical work is as follows:[42] 1) Al-Qanun al-Mas'udi; 2) The Chronology of Ancient Nation; 3) The Book of Instruction on the Elements of the Art of Astrology (Judul asli Tafhim li awal Al-Sina'atu Al-Tanjim); 4) An experiment that concerns the Hindu idea of the universe (holistic) regarding the problem of astronomical calculations; 5)

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[38] S Pines, "The Semantic Distinction between the Terms Astronomy and Astrology According to Al-Biruni," *Isis* 55, no. 3 (September 1, 1964): 343–49, https://doi.org/10.1086/349868.

[39] Ghorbani, "Al-Biruni A Scientist Beyond His Time."

[40] Benno Van Dalen, "World-Maps for Finding the Direction and Distance to Mecca. Innovation and Tradition in Islamic Science. By David A. King (Islamic Philosophy, Theology and Science, Text and Studies 36). Pp. Xxviii, 638. Leiden and London, Brill and al-Furqan Islamic Heritage Foundation, 1999.," *Journal of the Royal Asiatic Society* 12, no. 3 (October 31, 2002): 371–73, https://doi.org/10.1017/s1356186302260368.

[41] Muhammad Mansur, *Sullamun Nayyiran*, 1925, h. 1.

[42] Ghorbani, "Al-Biruni A Scientist Beyond His Time."

Fergani's astronomical investigations; 6) Simplification of solving trigonometric functions.

Al-Biruni produced many written works, but only about 200 books are known. Among these is Tarikh al-Hindi (History of India), the first and best work ever written by a Muslim scholar in India.[43]

In addition, he also wrote about other general knowledge such as the book Al-Jamahir fi Ma'rifati al-Juwahir (Mining science), As-Syadala fi al-Thib (pharmacy in medical science), Al-Maqalid Ilm Al-Hai'ah (about astrology) and the book Al-Kusuf wa Al-Hunud (a book about the Indian view of the eclipse of the Moon).[44]

This is only a small part of al-Biruni’s books. In addition, many other books can be used as references, but unfortunately, al-Biruni's great works are not as influential in the Western region because his books were only translated into Western languages in the 20th century.

History of the Development of Qibla Direction Determination Methods

In the early development of Islam, determining the Qibla Direction did not cause problems because the Prophet was with the Companions and the Prophet himself pointed toward Qibla when he was outside Mecca. However, when the Companions started traveling to develop Islam, the problem of determining the Qibla direction became more complicated. First, they referred to the position of the stars and the sun, which could indicate the direction of the Qibla. In Arabia, the main star that was used as a reference in determining the direction was the Qutub star (Qutbi/Polaris), which is the only star that points exactly to the north of Earth. Based on this star, the inhabitants of Arabia and neighboring areas can determine the Qibla direction.[45]

One significant problem in astrology is integrating this knowledge with the daily practice of worship, such as determining the qibla direction, prayer times, and the beginning of the lunar month. People are often trapped in traditions that are not aligned with technological and scientific advances.[46] Another major challenge in integrating astrological

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[43] Abu Raihan Al-Biruni, *The Chronology of Ancient Nations: An English Version*.

[44] Saidbek, “ABU RAYHAN AL-BIRUNI: PIONEER OF SCIENCE AND SCHOLARSHIP.”

[45] Baharuddin Zainal, *Ilmu Falak Teori, Praktek Dan Hitungan* (Malaysia: Yayasan Islam Terengganu, 2003), h. 61.

[46] Y. Yusefri, “The Law of Polygamy in Islam: A Methodological Review of Siti Musdah Muliaâ€™ s Legal Thought,” *AJIS: Academic Journal of Islamic Studies*, January

into the daily practice of Muslims is bridging scientific understanding with existing beliefs and traditions.[47] This indicates that cultural factors strongly influence astrology acceptance. Therefore, teaching solid religious values can improve our understanding of the relationship between astrology and religious practice.[48] The social and historical context is crucial in building this understanding and needs to be maintained so that phallic science serves not only as a practical tool but also as a spiritual foundation.

When the Prophet was in Medina, he prayed facing the south. The position of Medina, which is north of Mecca, makes Kaaba face south. Therefore, the Prophet said in a hadith that "Between East and West lies the Qibla (Kaaba)". This south-facing reference was used as a benchmark for the Qibla direction by Muslims in various regions.[49]

In Andalusia, Syria, and Palestine, the southern direction was the main reference for the Qibla direction. The al-Aqsa mosque (founded in 715 AD) was built almost south. The mosque lasted for several centuries. Even though research and calculations of Falak practitioners with the contribution of geographical data, it has been proven that the Qibla direction in Quds (Palestine) is located approximately 45^0 east longitude towards the west.[50]

The first mosque to stand in Egypt was the Amru bin Ash mosque located in Fusthath, guided by the direction of sunrise on the winter solstice (inqilab suitably), which survived and developed during the medieval period. The Al-Khalifah al-hakim Mosque and Al-Azhar Mosque were counted as the first mosques built during the Fatimid dynasty, which were 10 degrees off. An Egyptian astrologer, Ibn Yunus, discovered that the Qibla was actually at 37^0 south latitude towards the east based on astronomical mathematics.[51]

In Iraq, mosques were built facing the direction of sunset on the

2017, https://journal.iaincurup.ac.id/index.php/AJIS/article/view/312.

[47] L. Shesa and A. R. Oktori, "Traditional Impacities in the Frame of Worship: A Study of Fidyah Semyang Ritual in Suka Datang Village, North Curup Sub-District," *AJIS: Academic Journal of Islamic ...*, January 2022, 93–93, https://doi.org/10.29240/ajis.v7i1.3443.

[48] Rahman, Amarulloh, and ..., "Building a Civilization Base on Spiritual Values: Learning from the Struggle of Husain."

[49] Ahmad Izzuddin, *Kajian Terhadap Metode-Metode Penentuan Arah Kiblat Dan Akurasinya* (Jakarta: Kementerian Agama RI, 2012).

[50] A David King, *Astronomy In the Service of Islam* (USA: Variorum Reprints, 1993), h. 253.

[51] King, h. 253.

winter solstice, by making the northeast wall of the Kaaba pillar in the same direction as the northeast wall of the Kaaba, so that if one stood facing the pillar, one would be looking exactly at the direction of sunset in that season.[52]

In northwestern Africa, the Qibla direction is based on the rising sun of the equinox (I'tidalayn/syarq haqiqy). In Yemen, the Qibla is determined based on the direction of the north wind or the direction of the north pole star (najm quthby); in Syria, it is based on the rising of the Canopus star; and in India, it is based on the direction of sunset on the equinox (I'tidalayn / gurb haqiqy).[53]

In Turkey, the Hagia Sophia church in Constantinople (now Istanbul), which was built during the era of Emperor Justinian I, for five years and inaugurated in 537, was then converted into a mosque by Sultan Mehmed II, which did not change the Qibla direction. The former church altar was replaced with the mosque mihrab without considering the Qibla direction.[54]

In medieval times, the Qibla direction was generally determined using the following guidelines:[55]

1. Four patterns of wind movement
2. Directions for the appearance of the star Canopus (najm suhyl), which mostly rises in the southern hemisphere.

The canopus is the brightest star in the constellation Carina and the second brightest star in the night sky after Sirius, with an apparent magnitude of -0.72. It has a declination of -52° 41' 44'' and an axis of 6°23'57''. The Qibla direction determination using the appearance of this star can be performed when the Qibla direction is equal to the declination of the Canopus star.

3. Sunrise direction on summer solstice (inqilab as-shayfy)

The Qibla direction can be determined using the sunrise guideline in summer if the Qibla direction is equal to the value of solar declination and the longitude of the place is smaller than the longitude of Ka' bah.

4. Sunset direction on summer solstice

[52] King, "The Sacred Direction in Islam A Study of the Interaction of Religion and Science in the Middle Ages."

[53] King, *Astronomy In the Service of Islam*.

[54] King.

[55] King, h. 254.

The Qibla direction can be determined using the sunset guideline in summer if the Qibla direction is equal to the value of solar declination and the longitude of the place is greater than the longitude of the Ka' bah.

5. Sunrise direction on the winter solstice

The Qibla direction can be determined using the guideline of sunrise in summer if the Qibla direction is equal to the value of solar declination and the longitude of the place is smaller than the longitude of the Ka' bah.

In the case of calculating the Qibla direction of the Mosque in Egypt, Masjid al-Khalifah al-Hakim deviated by 10 °. This is because the Qibla direction for Egypt is approximately -32°9'44.27'' east-south. The coordinates of Egypt are 26.8206 LU and 30.8025 BT. The difference was approximately 10° with the maximum declination of the sun during winter.

6. Sunset direction on the winter solstice

The Qibla direction can be determined using the sunset guideline in summer if the Qibla direction is equal to the value of solar declination and the longitude of the place is greater than the longitude of the Ka' bah.

7. Maps qiblah[56]

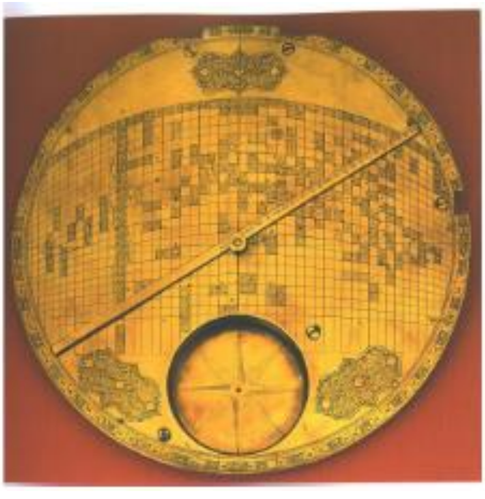

Figure 2. ***Miscellaneous***

This instrument is called the World Maps For Finding Qibla or

[56] Van Dalen, "World-Maps for Finding the Direction and Distance to Mecca. Innovation and Tradition in Islamic Science. By David A. King (Islamic Philosophy, Theology and Science, Text and Studies 36). Pp. Xxviii, 638. Leiden and London, Brill and al-Furqan Islamic Heritage Foundation, 1999."

World Maps to determine the Qibla direction. This tool is called a world map because 150 cities between Spain and China were already included in its preparation. This tool is used to calculate the Qibla angle. The Kaaba is positioned at the center. Muslims were interested in calculating the distance and direction during the time of al-Biruni and al-Habash.[57]

This tool consists of three parts: rulers, Axes (axis or cardinal), and plate (field/slope). This ruler shows the distance from Mecca to the other cities. The process of determining the Qibla direction using this tool is shown in the figure below.[58]

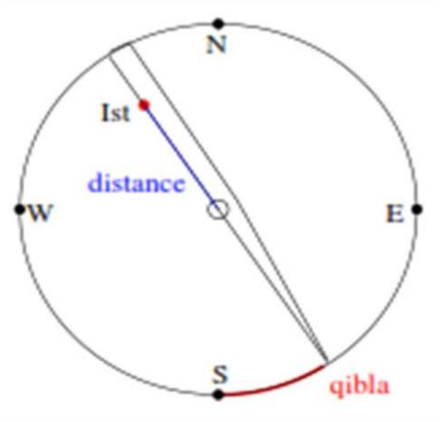

Figure 3. The Qibla direction of Istanbul and its distance from Mecca using the Qibla Maps tool

The problem of Qibla direction is a Muslim problem related to Geographic Mathematics. In its development, medieval Muslims used several calculation models, as follows:[59] 1) The method used by Al-Khwarizmi and Al-Battani used geometry rules; 2) The method used by Habash al-Hasib and Ibn Haytam used graphical/geographical rules; 3) The method used by Ibn Yunus al-Nayrizi, and al-Biruni uses the rule of the spherical triangle.

Abu Raihan Al-Biruni's Qibla Direction Determination Method

The new author finds the concept of calculation used by al-Biruni with the rule of the spherical triangle, so that, al-Biruni is known as the first person to calculate the Qibla direction accurately. Al-Biruni's method of calculating the Qibla can be found in Book 5, Section 5 of al-

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[57] A David King, *World Maps for Finding the Direction and Distance to Mecca* (Leiden: Boston, 1999).

[58] King.

[59] S. Kamal Abdali, "The Correct Qibla," 1997, https://geomete.com/abdali/papers/qibla.pdf.

Qanun al-Mas'udi.[60] Al-Biruni uses a diagram of the celestial sphere from the outside, with the observer's zenith in the center and his horizon on the periphery. In Figure 3, Z and M are the zenith of the observer and Mecca, respectively, and ZPN and MPL are their meridians, respectively, with P being the celestial pole. MZQ is the great circle through the zenith, with the pole at G, and JLG and JHM are the M and F horizons, respectively. It is assumed that we already know the latitude of the observer and Mecca, as well as their longitude difference; these are measured by PN = ϕz, PL = ϕm, and MPZ = ΔL. The Qibla measured from the observer's southern meridian was q = ∠SZM = SK.[61]

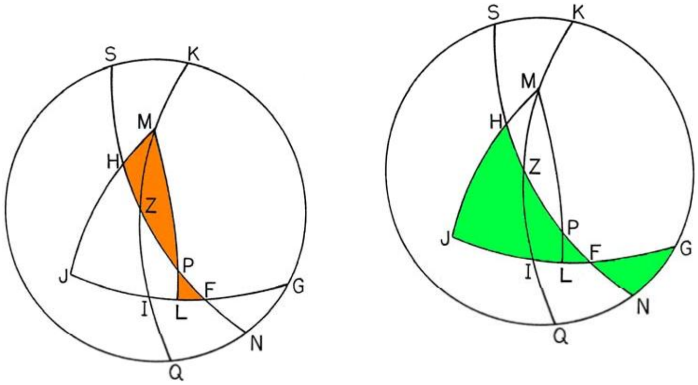

Figure 4. Segitiga Bola digunakan oleh Al-Biruni yang pertama di sebelah kiri dan yang final di sebelah kanan

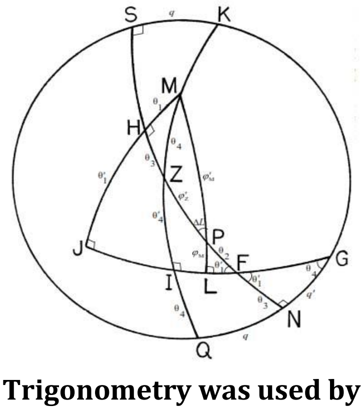

Figure 5. Trigonometry was used by Al-Biruni

In Figure 4, Randy K. Schwartz adds a king diagram with symbols θ_1 θ_4 for the arc of a great circle determined by successive calculations, where prim (‘) denotes the complement. This labeling can be performed

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[60] Abu Raihan Al-Biruni, *Al-Qanun al-Mas’udi*, vol. 2, 1955.

[61] Randy K. Schwartz, “Al-Qibla and the New Spherical Trigonometry: The Examples of al-Bīrūnī and al-Marrākushī” (Tenth Maghrebian Colloquium Pada History of Arabic Mathematics (COMHISMA10), Tunis, Tunisia, 2010).

before invoking the trigonometric theorems. This makes it easier to understand al-Biruni's solution and see the outline of the method known as the zījes method.

In conclusion, al-Biruni's calculation has four stages:[62][63]

a. Using the sine rule with ΔMHP to determine θ_1 From θ_M and ΔL

$$\text{Sin } \theta_1 = (\text{Sin } \Delta L)(\sin \phi'_m)$$
$$\text{Sin } \theta_1 = (\text{Sin } \Delta L)(\text{Cos } \phi_M)$$

b. Using the sine rule with ΔPFL to determine, θ_2 From θ_1 and θ_M:

$$\text{Sin } \theta_2 = \frac{\text{Sin } \phi_M}{\text{SIn } \theta'_1}$$
$$\text{Sin } \theta_2 = \frac{\text{Sin } \phi_M}{\text{Cos } \theta_1}$$

c. With arc θ_3 determined by

$$\theta_3 = \phi_z - \theta_2$$

Use the rule of four sums with ΔHJF and ΔZIF to determine θ_4 from θ_1 and θ_3:

$$\text{Sin } \theta'_4 = (\text{Sin } \theta'_1)(\text{Sin } \theta'_3)$$
$$\text{Cos } \theta_4 = (\text{Cos } \theta_1)(\text{Cos } \theta_3)$$

d. The sine rule with ΔFGN is used to determine *q* from $\theta_1, \theta_3, \textit{ and } \theta_4$:

$$\text{Sin } q' = (\text{Sin } \theta'_1)(\text{Sin } \theta_3) / \sin \theta_4$$
$$\text{Cos } q = (\cos \theta_1)(\text{Sin } \theta_3) / \sin \theta_4$$

The solution that al-Biruni described in his book Maqalid, which had been written three decades before al-Qanun, was different in the last stage. Here, he used:

$$\text{Sin } q = \sin \theta_1 / \sin \theta_4$$

If we look at ΔFGN in Figure 4, we see that this is the case

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[62] Schwartz.

[63] Abu Raihan Al-Biruni, *Al-Qanun al-Mas'udi*.

where one "leg" and all three angles are known and the task is to find the "leg" q'. Formula Cos q = (cos θ_1) (Sin θ_3) / sin θ_4 is derived ignoring right angles and using the sine rule, while al-Biruni derived the formula Sin q = sin θ_1 / sin θ_4 in Maqalid by using right angles, specifically applying the rule of the Four Quantities to the ΔSZK:

$$\frac{SIN\ HM}{SIN\ MZ} = \frac{SIN\ SK}{SIN\ KZ}$$

$$\frac{\text{SIN } \theta_1}{\text{SIN } \theta_4} = \frac{\text{SIN q}}{1}$$

Description:

θ_1 = the difference in longitude between M and Z, the great arc from M to Z's meridian orthogonal to point H

θ_2 = latitude Z

θ_3 = Altitude difference between M and Z, Arc From H to Z

θ_4 = Arc Distance From M and Z, the angle between the observer and Mecca.

e. Contoh perhitungan arah kiblat metode al-Biruni :

Venue Data:

- Latitude of Place ϕz = 6° 59' LS
- Longitude of Place = 110° 24' BT
- Latitude of Mecca ϕm = 21° 30' LU
- Longitude of Mecca = 39° 54' BT
- Longitude Difference ΔL = 110° 24' - 39° 54' = 70° 30' 00"

Calculation Result

- Sin θ_1 = (Sin ΔL) (Cos ϕ_M) → θ_1 = 61° 17' 18.79"
- Sin θ_2 = $\frac{Sin\ \phi_M}{Cos\ \theta_1}$ → θ_2= 49° 43' 15.53"
- θ_3 = ϕ_z - θ_2 → θ_3 = -56° 42' 16"

- Cos θ_4= (Cos θ_1) (Cos θ_3) → θ_4 = 74° 42’ 33.1”
- Cos Arah Kiblat = (cos θ_1) (Sin θ_3) / sin θ_4 → Arah Kiblat = 114° 35’ 59.1” (The Qibla direction of this method does not take into account the right angle so it is reduced by 90°.) Thus, Qibla Direction = 114° 35’ 59.1” - 90° = 24° 35’ 59” (B-U)

Sin Qibla Direction = sin θ_1 / sin θ_4 → Qibla Direction = 65° 24’ 0.9” (U-B), The last formula used by al-Biruni.

Conclusion

Abu Raihan Muhammad bin Ahmad Biruni, who was born on September 4, 973 AD in the suburbs of Kyat, the capital of Khorezmi's feudal government, and died on December 13, 1048 AD, was one of the most influential scientists in Islamic history. The rich intellectual and cultural environment of Khorezmi shaped Biruni's critical and curious character. He has mastered various disciplines, such as mathematics, philosophy, and geography, with a special interest in astronomy. Biruni was admired and inspired by prominent astronomers such as Al-Khorezmi, Al-Battani, Al-Fergani, Khodjandi, Abul Wefa, and Ibn Yunus. His extensive linguistic abilities, including mastery of Arabic and a good understanding of Greek, Indian, and Syriac, enriched his scientific perspective.

In Islamic history, the Kaaba has deep spiritual significance as the first house of worship on Earth. According to the Dictionary of Islam, Prophet Adam (peace be upon him) laid the foundation of the Kaaba, which was later rebuilt by Prophet Ibrahim and Prophet Ismail. In the early days of the ordination of prayer by Prophet Muhammad, Muslims faced the Baitul Maqdis (Jerusalem). However, after the hijra to Medina, the Qibla direction moved back to Kaaba, marking an important change in Muslim religious practice.

The history of Qibla direction determination involved the observation of celestial bodies, such as the Canopus and Polaris, as well as astronomical phenomena such as solstices. However, these early methods often lacked accuracy and reliability. A significant breakthrough occurred in the 9th century AD when Abu Raihan Al-Biruni introduced a more accurate calculation of the Qibla direction using spherical trigonometry. Al-Biruni is known as the first person to calculate the Qibla direction with high precision, documented in the 5th book, 5th section of Al-Qanun al-Mas'udi. In his work, Al-Biruni used a diagram of the celestial sphere with the observer's zenith at the center and the horizon at the periphery and applied the sine and cosine rules of spherical trigonometry in four stages of calculation.

Al-Biruni's contribution to Qibla's direction determination not only demonstrates his intellectual excellence but also marks a significant advance in astronomy and mathematics. Using spherical trigonometry, Al-Biruni overcame the limitations of traditional methods and provided a more scientific and reliable solution. His systematic and data-driven approach reflects the advanced scientific thinking of his time, and these methods remain relevant today.

Al-Biruni's work shows how science can serve as a bridge between spiritual and technological needs. By integrating astronomical observations and mathematical calculations, Al-Biruni not only enriched religious practices but also pushed the boundaries of science. His intellectual legacy continues to resonate with the contemporary world, inspiring generations of scientists and scholars the explore and develop more advanced methods in various fields of science.

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