Qibla Direction Calculation Methods in Islamic Astronomy References in Indonesia

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Abstrak: Penelitian ini berangkat dari fakta bahwa sebagian besar referensi ilmu falak di perguruan tinggi Indonesia masih menggunakan konsep bumi bulat dalam menjelaskan pokok bahasan arah kiblat. Padahal, berdasarkan astronomi modern, bentuk bumi tidaklah seperti bola sempurna, melainkan berbentuk elipsoid. Selain itu, terdapat pula pertentangan konsepsi deklinasi magnetik dalam persoalan penentuan arah kiblat. Penelitian ini bertujuan untuk mengkaji relevansi referensi ilmu falak terhadap konsep sains kebumian berdasarkan ketepatan penggunaan formula dan konsep deklinasi magnetik, serta juga menelaah penggunaan formula perhitungan arah kiblat berdasarkan kajian syariah. Penelitian ini termasuk penelitian kepustakaaan menggunakan pendekatan deskriptif analitik dan normatif sumber data dari berbagai referensi ilmu falak yang ada di perpustakaan digital perguruan tinggi keagamaan Islam. Berdasarkan penelitian ini, ditemukan bahwa referensi ilmu falak pada pokok bahasan arah kiblat belum relevan dengan konsep sains kebumian. Hal ini disebabkan sebagian besar referensi tersebut masih menggunakan perhitungan referensi astronomi untuk memecahkan persoalan arah kiblat. Beberapa referensi ilmu falak juga tidak mengikuti konsensus internasional mengenai konsep deklinasi magnetik. Selain itu, penelitian ini mengungkapkan bahwa seseorang yang mampu menentukan arah kiblat melalui perhitungan formula Vincenty sebaiknya menggunakannya dan meninggalkan perhitungan trigonometri bola. Hal ini disebabkan beberapa pertimbangan, yaitu pelaksanaan *ijtihād* yang mewajibkan kecakapan (*ahliyyah*) dan kesungguhan (*juhd*), pandangan Shafi'i mengenai penyelesaian *ikhtilāf* dalam *ijtihād* penentuan arah kiblat,

dan kaidah *ushūl al-fiqh* yang menyebutkan bahwa keyakinan tidak dapat dihilangkan oleh keraguan (*shakk*).

Kata kunci: ilmu falak; arah kiblat; trigonometri bola; formula Vincenty, syariah

Abstract: This research shows that most Islamic astronomy references in Islamic Universities in Indonesia still use the spherical earth concept to explain the qibla direction. However, based on modern astronomy, the earth's shape is not a perfect sphere but an ellipsoid. In addition, a contradiction occurs in the conception of magnetic declination in determining the qibla direction. This research aims to examine the relevance of Islamic astronomy reference books with the concept of geoscience based on the magnetic declination formula and concept. This research also examines the calculation methods for qibla direction based on sharia. This library research applies descriptive-analytic and normative approaches with the data originating from various Islamic astronomy references in the digital library of Islamic universities. This research finds that Islamic astronomy references about the qibla direction are not yet relevant to the concept of geoscience. Most of those references still use references astronomy for qibla calculation. There are still some references contradicting the international consensus regarding magnetic declination. In addition, this study reveals that someone who has the ability to determine the qibla direction through the Vincenty formula should use that concept instead of spherical trigonometry. This is because of skill (*ahliyyah*) and sincerity (*juhd*) requirements in ijtihad; Shafi'i's notion regarding *ikhtilāf* in *ijtihād* for qibla direction; and Islamic jurisprudence principle stating that certainty is not overruled by doubt.

Keywords: Islamic astronomy; qibla direction; spherical trigonometry; Vincenty's formula; sharia

Introduction

Islamic astronomy (in Indonesia, known as *Ilmu Falak*) occupies an important position in education at Islamic universities in Indonesia. Islamic astronomy is in the group of sharia sciences as a requirement and qualification in fulfilling the competencies of sharia and law faculty graduates. At the Faculty of Sharia, Islamic Astronomy is a compulsory subject in every department, such as the Muamalah Department (Sharia Economic Law Department), Constitutional Law Department (Siyâsah Shar'iyyah Department), Islamic Family Law Department or known as Al-Aḥwāl Al-Shakhṣiyyah Department, and Islamic Criminal Law Department. Several Islamic universities have offered Undergraduate (Strata-1/S-1) and Master (Strata-2/S-2) degree programs, majoring in Islamic Astronomy. These universities are The State Islamic University of Walisongo Semarang (bachelor and master degrees), The State Islamic University of Sunan Ampel Surabaya (bachelor and master degree), the State Islamic University of Mataram (bachelor degree), and the State Islamic Institute of Mataram (bachelor degree).

Various references have been published to facilitate learning Islamic astronomy at universities. The types of references used vary, ranging from classical to contemporary ones. Famous classical books on astronomy include the *Kitāb al-Khulāṣah al-Wafiyyah* by Zubair Umar from Salatiga, published in 1937 (Noer, 2018). There is also *Sullam al-Nayyirayn* by Muhammad Mansur, published in 1925 (Shobri, 2014). Meanwhile, there are quite a lot of books that are classified as new, for example, *Ilmu Falak: dalam Teori dan Praktik* written by Muhyiddin Khazin in 2004, *Ilmu Falak: Arah Kiblat Setiap Saat* written by Slamet Hambali, and *Kitāb Jamī'u al-adillah Ilā Ma'rifati Samti al-Qiblah* written by Ahmad Ghazali Muhammad Fatahillah published in 2017.

Teaching materials as a source for the learning process have a very important role in achieving learning objectives in higher education (Ahmad & Lestari, 2010). One of the important parts of the curriculum is the arrangement of objectives, content, and teaching materials as described in Government Regulation (PP) No. 13 of 2015 on the Second Amendment to Government Regulation No. 19 of 2005 on National Education Standards. The teaching materials used should follow the developments of the latest science in accordance with the

expected graduate profile. For example, the graduates' profile for Islamic astronomy practitioners is to master the latest science in their expertise (Dirjen Pendis Kementerian Agama RI, 2018). For this reason, the teaching materials must consist of references relevant to the latest science.

The curriculum development has to be creative, meaning that the curriculum must adapt to the latest developments in science and technology (Alhamuddin, 2016). Meanwhile, Law No. 12 of 2012 on Higher Education Article 6 states that higher education is organized with the principle of truth-seeking by the academic community. The most advanced references in Islamic astronomy mean that the subjects presented refer to scientific concepts or international conventions. Meanwhile, the principle of truth-seeking means applying scientific concepts correctly, both theoretically and practically.

In this context, various references to Islamic astronomy still need to be examined whether they have applied the latest geoscience concepts. For example, *Ilmu Falak: Arah Kiblat Setiap Saat* written by Slamet Hambali, *Ilmu Falak*: *dalam Teori dan Praktik*, *Ilmu Falak: dari Sejarah hingga Teori dan Aplikasi*, and several other books that explain the subject of qibla direction still use the spherical trigonometry (Khazin, 2004). However, based on modern astronomy, the shape of the Earth is not a perfect sphere but an ellipsoid. Therefore, the qibla direction formula should apply the Vincenty formula instead of spherical trigonometry. Based a careful examination of the existing references, the latter concept is used in most references of Islamic astronomy used in Islamic universities in Indonesia.

In addition, there is also a contradiction in the concept of magnetic declination in determining the qibla direction using a compass. The use of magnetic declination causes the compass needle to point incorrectly towards the geographic north of the earth, so it requires correction. In the book entitled *Ilmu Falak: Arah Kiblat Setiap Saat*, on pages 25-26, it is explained that the magnetic declination to the east is negative (Hambali, 2013). Meanwhile, in the book entitled *Ilmu Falak: Rumusan Syar'I dan Astronomi*, it is stated that if the magnetic declination is positive, the north direction shown by the compass needle to the east from the true north is equal to that declination value. The two statements contradict each other.

There are two problems found in several references of Islamic astronomy on qibla direction: spherical trigonometric formulas on qibla direction and the different conceptions of magnetic declination between one reference and others. Thus, this research is focused on how relevant those references to geoscience are on the qibla direction subject. In addition, this research will also discuss the relevance or irrelevance (if so) of those concepts from sharia's perspective. However, the most important issue is the sharia perspectives on the calculation methods. This research is expected to offer recommendations regarding references used by the practitioners of Islamic astronomy (*hāṣib*) in the future to conform the qibla direction calculation method with the latest geoscience concepts.

Method

This study is library research by examining relevant references of Islamic astronomy (*Ilmu Falak*) used in Islamic universities in Indonesia. The main data source comes from the digital library database of the State Islamic University of Walisongo Semarang. Meanwhile, supporting data were obtained from the digital library database of the State Islamic University of Sunan Kalijaga.

The data acquisition in this research is a documentation technique (Gunawan, 2015). In obtaining data, the authors *first* searched the database of references at the digital library of the State Islamic University of Walisongo Semarang. Then, from that database, the authors examined all collected references, written academics and practitioners of *Ilmu Falak*. The interview technique was also used in this study for triangulation.

This research applies Miles and Huberman's technic of analysis, consisting of data collection, display, reduction, and verification (Sugiyono, 2012). In the documentary technique, the data obtained are presented systematically in a table consisting of the book title, author, city, publisher, year of publication, and references used. The Authors also provide a code for each reference to facilitate analysis because the same author writes several books. Furthermore, the data is reduced by sorting only references meeting the criteria, namely the astronomy references published after 2001.

Furthermore, this study uses inductive data analysis techniques by categorizing the data obtained (Sarwono, 2011). This is because the data obtained is not uniform, resulting in a typology of data (Afrizal, 2016). This means that the references explaining the concept of earth and magnetic declination correction differ. Besides, this study also applies content analysis to explain the characteristics of the references, which generally do not explicitly present the data (Maulid, 2021).

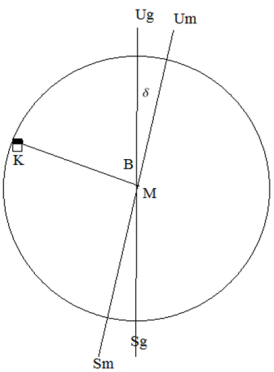
In the analysis, the compatibility of two methods of qibla direction calculation was used in the references with the sharia-based theories. These are *ijtihād* theory; solving *ikhtilāf* in *ijtihād* in Shafi'i school; and the principle of "*al-yaqīn lā yuzāl bi al-shakk*" (certainty is not overruled by doubt) in Islamic jurisprudence (*al-qawā'id al-uṣūliyyah*).

Geoscience Concept: Earth Shape and Magnetic Declination

The shift from the spherical earth theory to an ellipsoid has led scientists to find a solution, in the field of geodesy, in determining the direction (azimuth) and the distance of two points on the surface of the ellipsoid. The Vincenty formula, introduced in 1975, is a method used in geodesy to calculate the distance and azimuth between two points on the surface of the ellipsoid formulated by Thaddeus Vincenty (Vincenty, 1975). Furthermore, the formula originally applied in geodesy was developed to determine the qibla direction by Khafid, an engineer, in 2001 (Marwadi, 2014). Although the Vincenty formula has been widely used to determine azimuth (including its application in the qibla direction), many reference books still do not apply it, mainly due to the algorithm's complexity.

In addition to its geometrical problems, the earth is seen as having a giant bar magnet that extends from the earth's north pole (geographic north pole) to the earth's south pole (geographic south pole). Still, its location does not coincide with the geographic north and south points (Ta'uno, Tamuntuan, & Tongkukut, 2016). The position that has not coincided causes the compass needle not to point exactly north and south geographically. This deviation between a compass needle (magnetic north) and a point of geographic north (true north) forms a small angle known as magnetic declination.

There are two kinds of magnetic declination: positive and negative. If north is used as a reference, positive magnetic declination means that the compass needle designation is to the east of true north. Negative magnetic declination means the designation of the compass needle to the west of the true north (Zhang, Foster, Holt, Erickson, & Coster, 2012). Some references have conflicting concepts about whether a calculated qibla azimuth is reduced or increased. To be sure, a simple illustration is presented as follows.



Source: Illustrated by authors refers to the definition of positive declination
Figure 1. Illustration of the magnetic declination correction process

In figure 1, suppose that the angle B formed by KMUg is the qibla angle measured from a place (M). It is known to have a positive magnetic declination (δ) where the magnetic north (Um) is to the east (right) of the geographic north (Ug). The north direction shown when using the compass is Um. Based on the figure, for the observer to get the KM line as the qibla direction, the observer must make an angle δ + B.

Islamic Astronomy References for Qibla Calculation in Indonesia

References used in tertiary education are mentioned in Law No. 12 of 2012 Article 12 Paragraph (3), stating "Lecturers individually or in groups are required to write textbooks or teaching material published by Higher Education and/or scientific publications as one of the learning resources and for the development of an academic

culture". The Regulation of the Minister of National Education No. 2 of 2008 on Books states that textbooks are mandatory references used by educators and students in the learning process that has been tested for feasibility.

Reference is scientific writing in the form of a book whose discussion focuses on one field of science. The difference with references is that references are books whose content and presentation can be used to obtain information about science, technology, art, and culture deeply and broadly (The Regulation of the Minister of National Education No. 2 of 2008). References do not require feasibility tests from the government and are to add insight or support to textbooks. The book discusses a fairly broad topic in one field of science. The order of the material and the structure of the textbook are arranged based on the logic of the field of science (Duniadosen.com, 2016).

To clarify the meaning of the reference in Islamic astronomy, it is necessary to explain the meaning of Islamic astronomy (*Ilmu Falak*). The word *falak* means a path, orbit, or circuit (Team, n.d.). Etymologically, *Ilmu Falak* means the knowledge of the trajectories of celestial bodies such as the earth, moon, planets and stars (Salsabila, 2017). This word is mentioned twice in the Quran in *sura Al-anbiyā*' verse 33 and *Yāsīn* verse 40. In Arabic references, Islamic astronomy (*'ilmu al-falāk*) has the same meaning as astronomy in general ("Falak," 2020). In Islamic universities in Indonesia, the current use of the term *Ilmu Falak* refers to the study of celestial bodies for Muslim worship or what is known as Islamic astronomy.

From the explanation regarding the meaning of reference and *Ilmu Falak*, it can be emphasized that astronomy references in Islamic universities are books used in the process of learning astronomy in Islamic colleges, either explicitly entitled *Ilmu Falak* or not, whether written in Indonesian or other languages, as long as the book discusses issues related to the scope of astronomy or is useful as a support for Islamic astronomy learning.

The books of astronomy used in Islamic universities are generally in Arabic, Dutch, English, and Indonesian. Some Arabic books are written by Indonesian astronomers and foreign scholars. The astronomy books written by Indonesian astronomers have a distinctive feature:

their studies are directed towards worship interests. These books have often been dubbed the books of Islamic astronomy or *Ilmu Falak* by students and astronomers in Islamic universities. Meanwhile, astronomy books written by foreign authors can be in pure astronomy (general and not the realm of worship), and some are related to the realm of worship (Kholiq, 2019).

Table 1. References of Islamic Astronomy and Content Regarding Qibla Calculation

No	Book Title	Author(s)	Publisher, City, & Year	Code	Qibla direction calculation	Magnetic declination correction for qibla azimuth / qibla direction
1	Ilmu Falak: perjumpaan khazanah Islam dan sains modern	Susiknan Azhari	Suara Muhammadiyah: Yogyakarta, 2007	IF001	Spherical trigonometry	not discussed
2	Penemu ilmu falak: pandangan *Kitāb* suci dan peradaban dunia	Nur Hidayatullah	Pustaka Ilmu:Yogyakarta, 2013	IF002	not discussed	not discussed
3	Ilmu falak: menyelami makna hilal dalam al-Qur'an	Hamdani, Fahmi Fatwa Rosadi	P2U-LPPM Unisba : Bandung, 2017	IF003	not discussed	not discussed
4	Ilmu Falak: spektrum pemikiran Mohammad Ilyas	Sakirman	Idea Press: Yogyakarta, 2015	IF004	not discussed	not discussed
5	Ilmu falak: dari sejarah ke teori dan aplikasi	Siti Tatmainul Qulub	Rajawali Pers: Depok, 2017	IF005	Spherical trigonometry	Based on the illustrated image in the book, positive magnetic declination means true north is to the west of the compass needle
6	Ilmu Faak (Teori dan Aplikasi): Arah kiblat, Awal Waktu, dan Awal Tahun Hisab Kontemporer	Jamil A.	Amzah: Jakarta, 2009	IF006	Spherical trigonometry	not discussed
7	Ilmu Falak Praktis: Metode Hisab – Rukyat Praktis dan Solusi Permasalahannya	Ahmad Izzudin	Pustaka Rizki Putra: Semarang, 2012	IF007	Spherical trigonometry	not discussed

No	Book Title	Author(s)	Publisher, City, & Year	Code	Qibla direction calculation	Magnetic declination correction for qibla azimuth / qibla direction
8	Ilmu Falak: Arah Kiblat Setiap Saat	Slamet Hambali	Pustaka Ilmu: Yogyakarta, 2013	IF008	Spherical trigonometry	In this book, it is stated that: If the magnetic declination is negative (E), then to get the qibla azimuth in the form of a compass is the qibla azimuth minus the magnetic declination. If the magnetic declination is positive (W) then to get the azimuth of the qibla in the form of a compass is the real qibla azimuth plus the magnetic declination. An example of magnetic declination correction is given in this book : The Azmut Qibla of IAIN Walisongo Mosque Campus I is 294°30'54.28". The magnetic declination value is -1°9'. Azimut qibla showed by compass is: 294°30'54.28"-1°9"=293°21'54.28"
9	Ilmu Falak : Metode Hisab Awal Waktu Shalat, Arah Kiblat, Hisab Urfi dan Hisab Hakiki Awal Bulan	Ahmad Musonif	Teras: Yogyakarta, 2011	IF009	Spherical Trigonometry	not discussed
10	Ilmu Falak: Arah Kiblat Rashdul Kiblat, Awal Waktu Salat, Penanggalan Kalender, Awal Bulan Qamariyah (Hisab Kontemporer)	Zainul Arifin	Yogyakarta: Penerbit Lukita, 2012	IF011	Spherical trigonometry	not discussed

No	Book Title	Author(s)	Publisher, City, & Year	Code	Qibla direction calculation	Magnetic declination correction for qibla azimuth / qibla direction
11	Ilmu Falak: dalam Teori dan Praktik	Muhyiddin Khazin	Buana Pustaka: Yogyakarta, 2004	IF012	Spherical trigonometry	For example, the magnetic declination in Yogyakarta is +0° 45' 36', which means that the true north point seen from Yogyakarta is to the east of the magnetic north (compass) that the value is 0° 45' 36.'
12	Pengantar Ilmu Falak: Pedoman Lengkap Tentag Teori dan Praktik Hisab, Arah Kiblat, Waktu Shalat, Awal Bulan Qomariah, dan Gerhana	Muhammad Hadi Bashori	Pustaka Al-Kautsar: Jakarta, 2015	IF013	Spherical trigonometri	not discussed
13	Khulasah Al-Wafiyah Fi Al-Falak Bi Jadwal Al-Lugah Al-Tamiyah	Zubair Umar Al Jailani	Menara: Kudus, 1937	IF015	not used as research data	not used as research data
14	Ilmu Falak Untuk Sekolah Menengah di Indonesia	H.G. Den Hollander	Pradnya paramita: Jakarta., 1961	IF016	not used as research data	not used as research data
15	Ilmu Falak: Rumusan Syar'I dan Astronomi	Abu Sabda	Bandung: Persis Pers, 2020	IF017	Spherical trigonometry	If the magnetic declination is positive, the north direction indicated by the compass needle to the east from true north (true north) is the value of that declination. The calculation of the magnetic declination correction is not exemplified
16	Fiqh Qiblat: Cara Sederhana Menentukan Arah Shalat agar sesuai Syariat	A. Kadir,	Yogyakarta : Pustaka Pesantren, 2012	IF018	Spherical trigonometry	If the magnetic variation is positive, the true north is to the east of the north of the compass; if the magnetic variation is negative, the true north is to the west of the north of the compass.

No	Book Title	Author(s)	Publisher, City, & Year	Code	Qibla direction calculation	Magnetic declination correction for qibla azimuth / qibla direction
17	Cara Mudah Mengukur Arah Kiblat	Muhyiddin Khazin	Buana Pustaka: Yogyakarta, 2005	IF019	Spherical trigonometry	not discussed
18	Ilmu Falak: Antara Fiqih dan Sains	Tgk. H. Abdullah Ibrahim	Fajar Pustaka Baru: Yogyakarta, 2017	IF020	Spherical trigonometry	not discussed
19	Ilmu Falak	T. Mahmud Ahmad	Yayasan Pena: Banda Aceh, 2018	IF021	Spherical trigonometry	not discussed
20	Hisab Rukyat Menghadap Kiblat	Ahmad Jaelani dkk	Semarang: Pustaka Rizki Putra, 2012	IF022	Spherical trigonometry	not discussed
21	Cepat dan Tepat Menentukan Arah Kiblat	Alifirdaus Putra	Yogyakarta: Penerbit Elmatera, 2015	IF023	Spherical trigonometry	not discussed
22	Ilmu Falak Dasar	Ahmad Fadholi	Semarang: El-Wafa, 2017	IF024	Spherical trigonometry	not discussed
23	Pengantar Ilmu Falak	Watni Marpaung	Jakarta: Prenada Media, 2015	IF025	Spherical trigonometry	not discussed
24	Ilmu Falak 1	M. Sayuthi Ali	Jakarta: RajaGrafindo Persada, 1997	IF026	Spherical trigonometry	not discussed
25	Ilmu Falak: Dalam Teori dan Praktek	Hamdan Mahmud	Banjarmasin: Diantama, 2001	IF027	Spherical trigonometry	not discussed
26	Ilmu Falak 1: Penentuan Awal Waktu Salat & Arah KIblat Seluruh Dunia	Slamet Hambali	Semarang: Pascasarjana IAIN Walisongo, 2011	IF028	Spherical trigonometry	not discussed
27	Jami'ul Adillah Ila Ma'rifati Samtil Qiblah	Ahmad Ghazali Muhammad Fatahillah	Madura: LAFAL, 2017	IF029	Spherical trigonometry & Vincenty's Formula	not discussed

Source: obtained by examining the books and the contents

Table 1 shows references to Islamic astronomy used in Islamic universities in Indonesia. Most books are in the Indonesian language. The Arabic book (relevant to this research) is only one, IF029 (No.27). However, it is authorized by an Indonesian author. The books used as data are those published after 2001. Two subjects to examine are the formula of qibla calculation and the correction of magnetic declination.

The Dominance of Spherical Trigonometry in Qibla Calculation

Table 1 shows that most references to Islamic astronomy in Islamic universities use spherical trigonometry in the qibla direction. The only reference (in this research) that discusses the Vincenty formula with the assumption that the earth is ellipsoid is a book with code IF027. This means that the concept of geoscience applied in the references mostly is the assumption that the earth is a sphere. Whereas according to the current concept of geoscience, the earth's shape is not perfectly spherical but ellipsoid.

According to Khafid, the level of accuracy in calculating the qibla direction includes, *first,* a low level of accuracy, in which the calculation is spherical trigonometry with geographic coordinates. The *second* is the middle level of accuracy, namely the calculation of the qibla direction using the basis of spherical trigonometry, but the coordinates used are geocentric. The *third* is a high level of accuracy, which is the calculation of the qibla direction using the Vincenty formula (Khafid, 2021). However, the three calculations do not cause a significant difference. They only differ in the order of the minute of the arc. For practical purposes, if the calculation applies spherical trigonometry, it is recommended to use a geocentric coordinate so that calculation errors are minimal (Khafid, 2001).

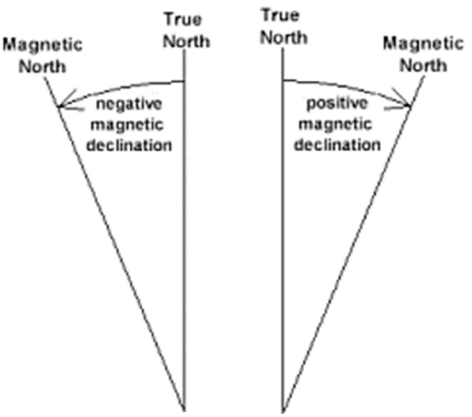
There are at least two reasons why the spherical trigonometric formula is still used today. First, based on the comparison between the spherical trigonometric formula and Vincenty's, it appears that the result gives a very small difference (Hambali, 2021). For example, with Markaz Sambas West Kalimantan, the Vincenty formula gives a qibla azimuth of 292°12'26", while with spherical trigonometric calculations, the azimuth qibla is 292°17'56". With this difference of less than 1°, spherical trigonometry is still popular among academics and practitioners. According to Gibbson (2017) and Cohen (1992) in Schumm (2020), the deviation of qibla that appears less than 2° is still accurate. However, to optimize the accuracy, it needs the best method in accordance with the true paradigm (Schumm, 2020).

Second, algorithmically, the Vincenty formula calculation is much more complicated and longer than the spherical trigonometric formula (Veness, 2021). This is because the Vincenty formula applies iterations

several times (up to 10 times), while the spherical trigonometric formula does not have iterations. Thus, calculating the qibla direction using the Vincenty formula for learning requires a longer time than spherical trigonometry.

The Concept of Magnetic Declination in Qibla Calculation

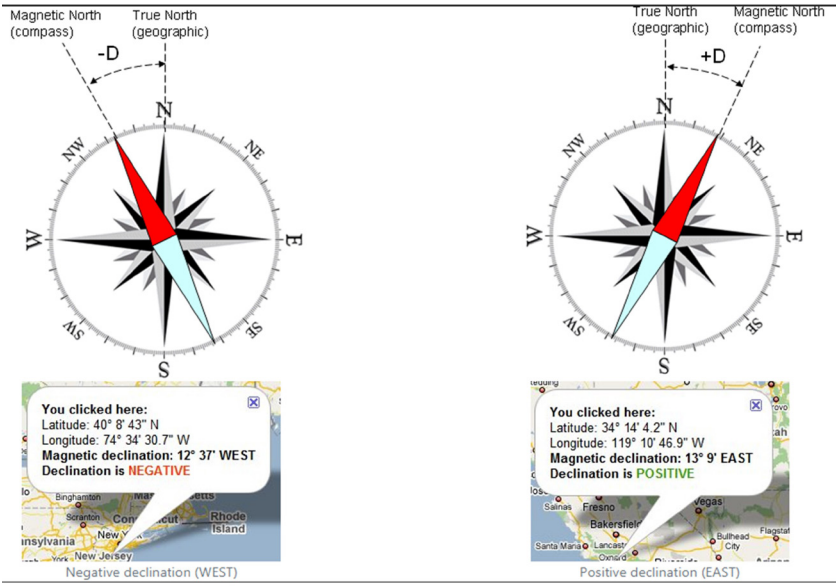
Before discussing the concept of declination in astronomical references in Islamic universities in Indonesia, an international consensus on magnetic declination is presented here.



Source: illustrated by authors from NOAA, NCEI, Wildwolks, Wikipedia, and Others
Figure 2. Illustration of definitions of positive and negative magnetic declination

In Figure 2, magnetic declination is classified into positive and negative. According to the definition given by NOAA (National Oceanic and Atmospheric Administration), magnetic declination is positive if the magnetic north is east of the true north point. In contrast, magnetic declination is negative when magnetic north is to the west of true north ("Magnetic Declination (Variation) | NCEI," n.d.). Likewise, the definition stated on the Barcelona Field Studies Center website. The website explains that if magnetic north is to the west of the true north. It is said that the magnetic variation is negative. Meanwhile, if the magnetic north is to the east of the true north, it is said that the magnetic declination value is positive ("How to Adjust for Magnetic Declination or Variation," n.d.). So is the definition provided by

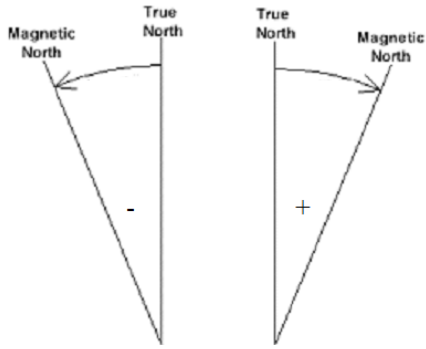
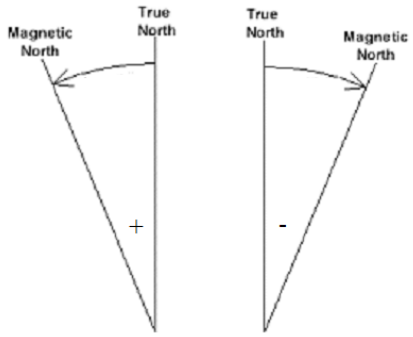
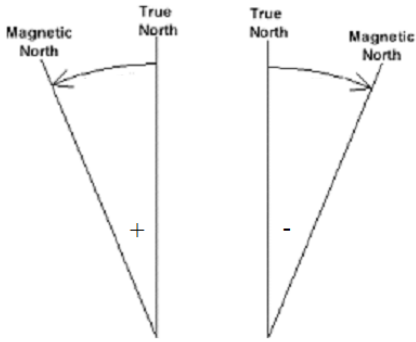
https://www.magnetic-declination.com/, http://www.wildwalks.com/, and others.

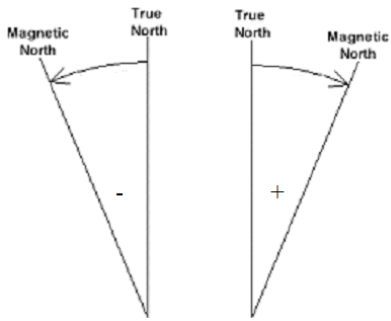
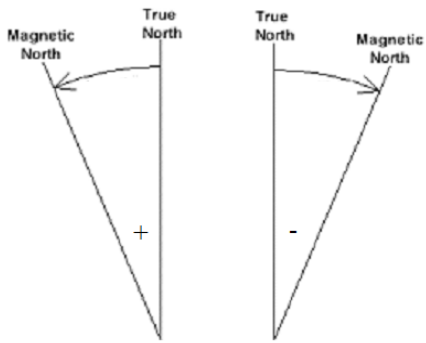


Source: https://www.magnetic-declination.com, 2021
Figure 3. Illustration of positive and negative magnetic declination and the examples

Figure 3 shows two locations where the magnetic declination differs positively and negatively. The negative declination occurs when the magnetic north (shown by the compass) deviates to the east of the true north (or the true north is to the west of the magnetic north). The positive magnetic declination is vice versa. In the references to Islamic astronomy in Indonesia, it is found that the concept of magnetic declination is not explained completely. Even many references do not discuss magnetic declination at all. Moreover, only a few books provide examples of calculations that apply magnetic declination as a correction in calculating the qibla direction. The followings are summarized reference books of Islamic astronomy that discuss the concept of magnetic declination.

Table 2. Magnetic declination concept in reference books of Islamic astronomy

No	Code of Books	Illustration of Magnetic Declination Concept Refers to International Consensus
1	IF005	
2	IF008	
3	IF012	

No	Code of Books	Illustration of Magnetic Declination Concept Refers to International Consensus
4	IF017	
5	IF018	

Source: Illustrated by authors from examining the book content

Table 2 shows five references that explain the concept of magnetic declination. It appears that there are two conflicting concepts. First, in IF005 and IF017, positive magnetic declination is defined as the deviation of the compass needle direction where the compass needle is to the east of true north, and vice versa for the meaning of negative magnetic declination. Whereas in IF008, IF012, and IF018, the magnetic declination is positive when the compass needle deviates to the west from the true north and vice versa for the definition of negative magnetic declination.

This difference in the concept of magnetic declination raises further questions: Does the difference in the concept of magnetic declination impact the results of the calculation of the qibla direction? Of the five reference books discussing the concept of magnetic declination, only

one book presents an example of the calculation, namely the IF008 book. In the book, it is written:

"The magnetic declination around the mosque of IAIN Walisongo Campus I is negative, namely 1°9' E. Therefore, the qibla azimuth of the mosque in the form of a compass is obtained by means of the qibla azimuth, reduced by the magnetic declination value, namely 294°30'54,28" – 1°9' = 293° 21' 54,28".

A conceptual framework that has been prepared previously is used to prove whether the statement is true or false.

Table 3. Conceptual framework of magnetic declination correction

No	Value to calculate / Stated in form of	Qibla direction angle	Magnetic declination	Qibla angle from compass needle
1	From north to West	B	D	B + D
2	Azimuth (from north to east)	A	D	A – D

Source: determined by authors from definitions/theories

Because the statement relates to the correction of qibla azimuth, the conceptual framework used is point 2 from Table 3. If the value of the direction of the qibla is A (from north to east), then with a declination of D, the azimuth is corrected to A - D. Logically, the value of A could be greater or less than A - D. It depends on the value of D which is the magnetic declination. If D is positive, then A <A - D. If D is negative, then A> A – D.

In the example presented in the book IF008, although the value of D is negative, in its application, the author of IF008 does not write 294°30'54,28"- (-1°9'), but writes 294°30'54,28" - 1°9'. This means, in IF008, if the magnetic declination to the east (for example, presented in IF008 is 1°9'E), then it applies that the azimuth value of the qibla A> A - D. This is proven that the value of A changes from 294°30'54,28" to 293°21'54.28". It can be ascertained that the value

of D substituted in the correction is positive, not negative, as stated in IF008. Thus, in IF008, the concept of magnetic declination differs from the concept of magnetic declination based on the international consensus regarding positive and negative declination. However, this difference in concept does not cause a difference in the final result in calculating the qibla direction.

The Relevance of Islamic Astronomy References with Geoscience on the Subject of Qibla

From various astronomical references used in Islamic universities in Indonesia, it appears that the qibla direction presented in these books is still not relevant to the geoscience concept. This irrelevance is strengthened followings:

Most of the references of Islamic astronomy still use the concept of a perfectly spherical earth, which applies spherical trigonometry to solve the problem of qibla's direction. However, according to science, the shape of the Earth is not perfectly spherical but an ellipsoid. Thus, the formula that should be used is Vincenty's formula. However, according to Slamet Hambali, spherical trigonometry and the Vincenty formula differ only in the use of latitude. This means that the spherical trigonometric formula is relevant to use as long as the latitude coordinates used are geocentric latitude coordinates (not geographic). Therefore, a geocentric GPS is needed to get these geocentric latitude coordinates, not regular one (geographic GPS). Meanwhile, there is no difference in the geocentric and geographic longitude values (Hambali, personal communication, 3 November 2021).

Meanwhile, according to Ahmad Fadholi (2021), practically (to determine the qibla direction in the field), the use of the spherical trigonometry formula and the Vincenty formula is not significantly different because the difference in the calculation results is only a few arc minutes, not in the order of degrees. Thus, using the spherical trigonometric formula to solve the qibla direction problem can still be used for practical purposes (Fadholi, personal communication, 22 March 2021).

There are contradictory concepts in several reference books of Islamic astronomy related to the discussion of magnetic declination,

namely the meaning of positive and negative magnetic declination. This contradictory concept is partly consistent with international consensus. Still, it does not explain its application deeply in magnetic declination correction to the calculated qibla direction/azimuth. Meanwhile, some others do not comply with the international consensus. However, although the concept of magnetic declination contradicts the international consensus, the final result of the corrected direction/azimuth values is the same as the international consensus. The concept of positive or negative magnetic declination may differ depending on the reference used (the zero-point used as the reference) and whether magnetic north is relative to true north or vice versa. This is not a problem as long as it does not affect the calculation results (Hambali, personal communication, 3 November 2021).

Sharia Perspective on the Calculation Methods

Determining the qibla direction for people away from the Kaaba is an effort of *ijtihād* (Tanjung, 2017). In the principle of Islamic jurisprudence, the implementation of science in the context of conducting *ijtihād* for worship is not firmly ruled. The difference in the concept of magnetic declination correction does not bring any legal consequences because it only differs in definition, not in principle. However, the difference in calculation methods between spherical trigonometry and Vincenty's formula brings a legal impact in principle. In this research, the urgent issue is how sharia views the difference regarding the *ijtihād* in determining the qibla direction between spherical trigonometry and Vincenty's formula calculation. Should Vincenty's formula be applied while the spherical trigonometry formula is abandoned? Although this issue may be debated later, the authors believe that people who use the correct scientific method should use Vincenty's formula method and abandon the spherical trigonometry method to determine the qibla direction. This is based on the following considerations.

The first, facing the qibla in performing prayers, is a definitive matter (*qaṭ'ī*) as described in the Quran and hadith. However, how to face the qibla for people who cannot see the Kaaba is an uncertain matter (*ẓannī*) in which Muslim scholars agree that, in this matter, there is an opportunity for *ijtihād*. One of the principles in *ijtihād* is

proficiency (*ahliyyah*). Khallaf (2004) asserts that proficiency cannot be divided. That is, a pious person who meets the requirements of *ijtihād* in one field (e.g. divorce law) may not perform *ijtihād* in another field (e.g. the law of transaction) unless he has the proficiency in that field (Khallaf, 2004).

In addition to proficiency, another important aspect of conducting *ijtihād* is totality (*juhd*). This is based on the definition of *ijtihād*, namely the exerting totality (*badhlu al-juhd*) to yield Islamic law (jurisprudence) from detailed sharia proposition (Khallaf, 2004). What is someone's totality in determining the qibla direction? One's efforts represent this totality until he can no longer exert addition at the limit of his ability (Miswanto, 2018). If one can still improve the truth or quality of the results of his *ijtihād*, one must do so to the extent of his ability, not based on the ease and conciseness of a method.

Based on the rules of *ijtihād*: proficiency and totality, the person who is entitled to conduct *ijtihād* in the matter of the qibla direction is the one who has the ability to determine the qibla direction and the ability to the extent that he is no longer able to improve the truth of the results of the *ijtihād*. Thus, for a person who is only able to determine the qibla direction by spherical trigonometry methods, then the *ijtihād* is legitimate so long as exerting the totality and its ability limit. Likewise, for one who is able to use the Vincenty'formula, the result of *ijtihād* is legitimate so long as it is carried out with total ability. However, for someone who is able to use Vincenty's formula, but uses spherical trigonometry calculations, this is not legitimate because it does not meet the rule of totality (*al-juhd*).

The second, according to Shafi'i in his book *al-Umm*, if people outside Mecca conduct *ijtihād* in finding the qibla direction and there is a difference (*ikhtilāf*) in the results of their *ijtihād*, then one of them may not follow the results of someone else's *ijtihād*. This is true even if that person knows that the other person is more competent until the other person (his friend) can show evidence of a fault or weakness in the *ijtihād* (Shafi'i, 1990). This means that if there is a difference in the results of *ijtihād* between two people regarding the direction of the qibla determination, then the solution is by showing evidence of weaknesses in the results of each other's *ijtihād*, not by *taqlīd* to the person who is considered more expert between the both.

In our discussion, the question is which one is better, whether to use Vincenty's formula or spherical trigonometry? If we refer to Shafi'i's notion, the way out is to show evidence of weaknesses in each calculation method. Assume that the two methods of calculating qibla direction by Vincenty's formula and spherical trigonometry have been carried out carefully according to the calculation rules. Which of the two is better to use? One proof of weakness in spherical trigonometry calculations that can be proposed is that the method (with spherical trigonometry) is an old paradigm. Meanwhile, the current scientific paradigm is that the Earth is an ellipsoid. This ellipsoidal earth has been proved by experiments, one of which was carried out by The French Academy of Science at the north pole area (Lapland) in 1736-1737 and around the equator (Peru) in 1735-1743 using the gravity method (Smith, 2002).

Thus, the theory used in determining the qibla direction, in principle, must refer to the consensus of science. Scientists agree that the Earth is not a perfectly spherical celestial body but rather an ellipsoidal one. This means that if the earth is spherical then the correct calculation to determine the qibla direction is spherical trigonometry. However, if the shape of the earth we assume is an ellipsoid then the Vincenty's formula is the correct one. These different paradigms bring an impact on other theories. The reasoning above shows that a theory will bind other theories. In determining the qibla direction, referring to Shafi'i's notion, facing the qibla directly towards the Kaaba is a must. Therefore, inaccuracy in using a theory will impact inaccuracy in facing the qibla.

The third, in the principle of Islamic jurisprudence (*uṣūl al-fiqh*), there is a proposition that states " certainty is not overruled by doubt: *al-yaqīn lā yuzāl bi al-shakk*)". This general principle (kulliyy) prevails in many aspects. Certainty means firm or absolute belief. In comparison, doubt (*shakk*) is a conjecture between two equal or balanced sides. If the conjecture is strong, then it is an assumption (*ẓann*); if it is weak, it is an illusion. If a conviction stands and doubt appears, what remains is the conviction (Hashaniy, 1997).

The ellipsoidal Earth occupies a more trusted position in scientific circles than was assumed to be spherical. This has been

proved scientifically by research and observation. Indeed, there is no rule in the principles of Islamic jurisprudence which states that the correct calculation of qibla direction is to use Vincenty's formula. However, the calculation of qibla's direction cannot be separated from scientific principles. Thus, the rule of science must be used to solve this problem. Although, once again, the authors state that the results of both calculations only bring a minor difference, even insignificant in practice. So, in this problem, it is not a matter of small or large differences in calculations between Vincenty's formula and spherical trigonometry but rather whether the method used is correct. The accuracy of the true scientific method brings conviction to the calculation results.

Conclusion

This study concludes that the references to Islamic astronomy used in Islamic universities in Indonesia are still largely not relevant to the concept of geoscience on the subject of qibla direction. This is indicated by the widespread use of spherical trigonometry, based on the assumption of the spherical shape of the earth, despite the ellipsoid shape of the earth. In addition, there are still references that contradict international consensus on the meaning or concept of magnetic declination but do not contradict in principle. The other important finding in this research is that the legitimate method of calculating Qibla direction is Vincenty's formula instead of spherical trigonometry. This notion is based on the rules of *ijtihād* that consist of proficiency (*ahliyyah*) and totality (*juhd*). In addition, according to Shafi'i, the alternative solution of *ikhtilāf* in qibla direction *ijtihād* is by denoting the weakness or fault in the *ijtihād*. The spherical trigonometry calculation has a weakness because of its old scientific paradigm. Another consideration of why Vincenty's formula is better to apply in qibla calculation is based on the principle of Islamic jurisprudence that asserts "certainty is not overruled by doubt ". It means that the scientific circle believes that the true scientific paradigm regarding the earth's shape is ellipsoidal instead of spherical.

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