AL – AFAQ
Jurnal Ilmu Falak dan Astronomi
Fakultas Syariah Universitas Islam Negeri (UIN) Mataram
P-ISSN: 2685-0176. E-ISSN: 2722-0176 Vol. 8, No. 1 Juni 2026

The Accuracy of Lunar Eclipse Calculations in *Irsyad al-Murid* Book By Ahmad Ghozali Fathulloh

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Abstract: The issue of eclipses relates to how to determine when an eclipse will occur, where it can be observed, and how to perform eclipse prayers. The book Irsyad al-Murid discusses calculation methods for determining the time of a lunar eclipse. In determining lunar eclipses, this book makes more corrections than other books. Although it does not use supporting tables or schedules, Irsyad al-Murid applies contemporary mathematical formulas. This does not reduce its accuracy, because this book is used as a reference in the study of astronomy in Madura, especially at the Lanbulan Sampang Islamic Boarding School, and is also used as a guideline for determining the beginning of the lunar month by the Calculation and Observation Agency of the Ministry of Religious Affairs of the Republic of Indonesia. The purpose of this study is to analyze the method of calculating lunar eclipses in Irsyad al-Murid and to measure its accuracy using NASA data. This is a qualitative study with the primary source being the Irsyâd al-Murîd book and secondary sources in the form of interviews and supporting literature. The analysis was conducted using content analysis and comparative methods to determine the comparison of the calculation results between the book and NASA. The results of the study show that Irsyad al-Murid uses a contemporary calculation method with complex corrections for the positions of the Moon and Earth, referring to Jean Meeus' Astronomical Algorithms. The difference lies in the use of the Hijri year, while Meeus' book uses the Gregorian year. The level of accuracy is very good, with a difference of only about one to two minutes from NASA's results.
Keywords: *Lunar Eclipse Calculation, Irsyad al-Murid, NASA*

Abstrak: Permasalahan gerhana berkaitan dengan cara menentukan kapan gerhana terjadi, di mana dapat diamati, serta bagaimana pelaksanaan salat gerhana. Kitab *Irsyad al-Murid* membahas metode perhitungan untuk menentukan waktu terjadinya gerhana Bulan. Dalam penetapan gerhana Bulan, kitab ini melakukan koreksi lebih banyak dibandingkan kitab lainnya. Meskipun tidak menggunakan tabel atau jadwal pendukung, *Irsyad al-Murid* menerapkan rumus-rumus matematika kontemporer. Hal tersebut tidak mengurangi tingkat keakuratannya, sebab kitab ini dijadikan rujukan dalam pembelajaran ilmu falak di Madura, khususnya di Pondok Pesantren Lanbulan Sampang, serta menjadi pedoman penetapan awal bulan kamariah oleh Badan Hisab dan Rukyat Kementerian Agama Republik Indonesia. Tujuan penelitian ini adalah menganalisis metode hisab gerhana Bulan dalam *Irsyad al-Murid* serta mengukur tingkat keakuratannya menggunakan data NASA. Penelitian bersifat kualitatif dengan sumber primer kitab *Irsyad al-Murid* dan sumber sekunder berupa wawancara serta literatur pendukung. Analisis dilakukan dengan metode *content analysis* dan komparatif untuk mengetahui perbandingan hasil perhitungan antara kitab dan NASA. Hasil penelitian menunjukkan bahwa *Irsyad al-Murid* menggunakan metode hisab kontemporer dengan koreksi posisi Bulan dan Bumi yang kompleks, mengacu pada *Astronomical Algorithms* karya Jean Meeus. Perbedaannya terletak pada penggunaan tahun Hijriah, sementara buku Meeus menggunakan tahun Masehi. Tingkat akurasinya sangat baik, dengan selisih hanya sekitar satu hingga dua menit dari hasil NASA.
Kata kunci: *Perhitungan Gerhana Bulan, Irsyad al-Murid, NASA*

A. Introduction

Nowadays, the issue of eclipses is rarely discussed, unlike the problem of determining the beginning of the lunar month, aligning the direction of the Qibla and so on which often receive special attention. The schools of hisab in Indonesia, when viewed from the perspective of their systems, can be divided into two large groups, namely hisab 'urfi and hisab hakiki. However, along with the development of the times, new schools of hisab have emerged that attempt to obtain more accurate calculation results such as hisab hakiki takribi, hisab hakiki tahkiki and hisab contemporary. One of the famous works among scholars of astronomy in the archipelago is the book Irsyad al-Muriid ila Ma'rifati 'Ilmi al-Falak 'ala al-Rashdi al-Jadid.[1]

The book of Irsyad al-Murid is a book written by Ahmad Ghozali which was published in 2005. In determining the direction of the Qibla, prayer times, solar and lunar eclipses, the book of Irsyad al-Murid has used modern mathematical formulas. The determination of the eclipse on June 6, 2020, the calculation produced by the book of Irsyad al-Murid was 02:25:28 WIB while NASA data was 02:24:52 WIB, then on November 8, 2022, the calculation of the book of Irsyad al-Murid was 18:00:28.1 WIB while NASA data was 18:00:22 WIB. From the two comparisons, it shows that the difference in the results of the calculation of the lunar eclipse in the book of Irsyad al-Murid with the data produced by NASA has a difference that is not too significant. The study of lunar eclipses in recent years has become one of the topics that has received quite a lot of attention among astronomers and astronomers. Since the early 2010s until now, various studies and discussions have continued to develop by reviewing this phenomenon from various perspectives, both from the perspective of modern astronomy and the study of hisab in classical books.

Studies on the accuracy of the lunar eclipse calculation system in classical books include the book Nur al-Anwar,[2] scientific article Analysis of Rinto Anugraha's Lunar Eclipse Calculation and Accuracy Comparison.[3] *An Algorithm Analysis of The Lunar Eclipse Calculation in The Book Risalah Az Zain by Ibn Ya'qub Al-Batawy,*[4] then the Application of the Lunar Eclipse Method of the Book Al-Duru Al-Aniq.[5] There is also

[1] Ahmad Ghozali Muhammad Fathullah, *Irsyad al-Murid,* Madura: Lafal, cet III, 2005, hal.157.

[2] Ismail, *Hisab Urfi Gerhana Matahari dan Gerhana Bulan,* Al-Marshad: Jurnal Astronomi Islam dan Ilmu-Ilmu yang Berkaitan, Vol. 6, No. 1, Juni 2020, hal. 46-47.

[3] 'Alamul Yaqin dan Muhammad Farid Azmi, *Contemporary Haqiqi Calculation: Analysis of Rinto Anugraha's Lunar Eclipse Calculation Methods,* Journal of Islamic Law (JIL), Vol. 3, No. 1, 2022.

[4] Rohadatul Aisy Idra, *An Algoritm Analysis of the Lunar Eclipse Calculation in the Book Risalah Az-Zain by Ibn Ya'qub Al-Batawy,* Universitas Islam Negeri Walisongo Semarang, 2021

[5] Syikma R. Jannah, *Aplikasi Gerhana Bulan Metode Kitab Al-Duru Al-Aniq,* Universitas Islam Negeri Walisongo Semarang, 2021.

the Lunar Eclipse Calculation Method of the Book al-Manahij al-Hamidiyah.[6] Of the several studies mentioned above, there has not been a discussion that examines the accuracy of the book Irsyad al-Murid by KH. Ahmad Ghozali Fathullah in depth.

The author is interested in discussing the lunar eclipse calculation method in the book Irsyad al-Murid, because the book uses a different conceptual formulation. In the initial calculation of the month, this difference lies in the declination data and the equation of time used in the calculation that has been provided and calculated by the author, while in other modern book methods, the data used is taken from Ephemeris or Winhisab data. Another difference is in the concept of calculating the position or height of the Sun at sunrise and sunset, taking into account the horizontal correction of the Sun's parallax, while in other calculation methods, horizontal parallax does not take it into account. In determining the lunar eclipse, the book makes more corrections or penta'dilan than other books. The book Irsyad al-Murid does not use tables or schedules as support to get the time of the eclipse, but instead uses contemporary mathematical formulas, but this does not make the book inaccurate, because the book Irsyad al-Murid is not only used as a reference for learning astronomy in Madura, especially at the Lanbulan Sampang Islamic boarding school, but is also used as a guideline for determining the beginning of the lunar month by the Hisab and Rukyat Agency of the Ministry of Religion of the Republic of Indonesia.

B. Research Methods

This study employs a qualitative approach aimed at describing and analyzing the thoughts of a scholar, namely Ahmad Ghozali, regarding the method of calculating lunar eclipses as presented in the book *Irsyad al-Murid*. This approach is used to gain an in-depth understanding of the conceptual framework and intellectual construction underlying the lunar eclipse calculation method. However, in order to examine the extent to which this method aligns with the scientific principles of modern astronomy, this study is also complemented by a quantitative approach through a comparative analysis of the calculated results. Accordingly, this research adopts a mixed-method approach,[7] integrating qualitative analysis of classical texts with quantitative analysis in the form of accuracy testing of the calculation results. The purpose of this approach is to evaluate the extent to which Ahmad Ghozali's method for determining lunar

[6] Rijalul Muta Akhiri, *Hisab Gerhana Bulan Kitab al-Manahij al-Hamidiyah*, Universitas Islam Negeri Walisongo Semarang, 2021.

[7] Mendra Wijaya, *Metodologi Penelitian (Kombinasi Pendekatan Kuantitatif, Kualitatif dan Mixed Methods),* Medan: PT. Media Penerbit Indonesia, 2025, hal. 85.

eclipses can serve as a relevant guideline within the context of contemporary astronomical developments.

This study is classified as library research, as its primary focus is on textual sources, particularly the book *Irsyad al-Murid*. The data in this research are obtained from primary and secondary sources, and are further supported by interviews and relevant scientific journal publications. The primary data sources in this study consist of the book Irsyad al-Murid and interviews with individuals who possess expertise in the field of Islamic astronomy *(ʿilm al-falak)*. Meanwhile, the secondary data sources are derived from astronomy textbooks, literature on Islamic astronomy, and scholarly journals related to lunar eclipse calculations. These sources serve as the foundation for understanding and analyzing the concept of lunar eclipse calculation. The data collection techniques in this study are carried out in two stages. First, primary data collection is conducted through documentation, namely by examining and reconstructing the lunar eclipse calculation method found in the book Irsyad al-Murid. The results of these calculations are then compared with modern astronomical data, such as those provided by NASA, in order to determine the level of accuracy and deviation of the results. Second, secondary data collection is conducted through literature review, by examining various books, articles, and scientific journals related to lunar eclipses from both classical Islamic astronomy and modern astronomical perspectives. Furthermore, in the data analysis stage, this study employs a descriptive-comparative analysis, in which the calculation results derived from the classical text are compared with modern astronomical data, and are supplemented by error measurement to strengthen the validity of the research findings.

C. Result and Discussion

1. Analysis of the Lunar Eclipse Calculation Method in the Book *Irsyad al-Murid*

In calculating the lunar eclipse, we can see differences in determining it. The schools of calculation in Indonesia, when viewed from the system perspective, can be divided into two large groups, namely hisab urfi and hisab hakiki. However, along with the development of the times, new schools of calculation have emerged that attempt to obtain more accurate calculation results such as hisab hakiki takribi, hisab hakiki tahkiki and hisab contemporary.[8] The taqribi method is a simple approach based on the orbit of the Moon and the Sun with estimated numbers, while the ḥaqiqi bi at-taqrib

[8] Muhyiddin Khazin, *Ilmu Falak dalam Teori dan Praktek,* Yogyakarta: Buana Pustaka, 2004, hal, 187.

method uses basic trigonometric formulas without complex astronomical corrections.[9] The haqiqi bi at-tahqiq method is the most accurate system because it involves modern formulas, ephemeris data, and geocentric and topographical coordinate corrections. In this context, classical astronomy books in Indonesia show varying levels of accuracy, some still use the taqribi system, while others, such as Irsyad al-Murid, have switched to the more modern and precise haqiqi bi at-tahqiq method.

Based on an interview with HJ. Asma, the wife of KH. Ahmad Ghozali Muhammad Fathulloh, discussions about lunar eclipses are found in many books on astronomy in the archipelago.[10] Among them are Khulasah al-Wafiyyah by KH. Zubair Umar al-Jaelani, Nur al-Anwar by KH. Noor Ahmad from Jepara, al-Manahij al-Ḥamidiyyah by KH. Muhammad Ma'shum bin Ali, and Tibyan al-Murid by other Madurese scholars, Sullamun Nayyirain by KH. Abdul Hamid Kudus, Badi'at al-Mizan by KH. Sa'dullah As-Samarani, Fath al-Rauf al-Mannan by KH. Abdul Djalil Kudus, Each book uses a different approach and formula, adapting to the development of the science of hisab in its time. However, the book Irsyad al-Murid by Ahmad Ghozali Fathullah is one of the contemporary works that tries to bridge classical hisab and modern astronomy, especially in calculating lunar eclipses.[11]

KH. Ahmad Ghozali Fathullah is a contemporary Islamic scholar from Madura known for his contributions to the development of Islamic hisab and astronomy in Indonesia. He studied religion and astronomy at several Islamic boarding schools in Madura and actively teaches astronomy at Islamic educational institutions. As a modern Islamic figure, Ahmad Ghozali is known for his ability to combine classical Islamic boarding school hisab methods with modern mathematical and astronomical approaches, resulting in scientific works relevant to the needs of the times. Ahmad Ghozali, born in 1977, studied with KH. Maimun Zubair Sarang Rembang, and this continued for three years. Ahmad Ghozali first studied astronomy in 1995 in Mecca with his teacher, Sheikh Yasin, using the book Fathul Rouf al-Mannan.

In addition to Irsyad al-Murid, with the help of his students, Ahmad Ghozali produced a major work in Astronomy entitled Faidl al-Karim. Ahmad Ghozali Fathullah also produced several other works in the field of astronomy and Islamic mathematics, including al-Matla' al-Sa'id fi Tahqiq al-Mabadi' wa al-Ta'arif al-

[9] M. Ainul Yaqin Ahsan, *Mukhtashar Al-Durusi Al-Falakiyah,* Sleman: Penerbit Deepublish, 2024, Hal. 15-16.

[10] One of the existing sources of literature in this country is classical and Islamic astronomy, many traditional books and manuscripts, particularly those using Javanese Arabic, explain lunar eclipses and solar eclipses to teach celestial science. Texts such as *Wasilah Al Mubtadi'in* and *al-Dur al-'Aniq* discuss the scientific calculation of eclipse types.

[11] Ahmad Ghozali's Wife.

Falakiyyah, at-Taqyidat al-Jaliyah, Bugyat ar-Rafiq, Anfa' al-Wasilah, Samarat al-Fikar, ad-Durul al-Aniq and several short treatises on the direction of the Qibla and the beginning of prayer times. His works show a strong scientific tendency by showcasing the integration between traditional Islamic boarding school science and accurate astronomical computational approaches. Several books related to Astronomy have different concentrations of discussion and use different hisab methods, such as Samarat al-Fikar. The book discusses prayer times, the crescent moon, and eclipses using the hisab haqiqi tahqiqi method.[12] The book Irsyad al-Murid was compiled by Ahmad Ghozali as a refinement of his previous books, because the previous books turned out to be less precise. Many of these books still use hisab tahqiqi taqribi and hisab haqiqi tahqiqi. In the book Irsyad al-Murid Ahmad Ghozali Fathullah explains the calculation of a lunar eclipse using astronomical parameters such as ijtima', ikhtilaf al-ṭul, and ba'd baina as-sa'ah wa as-samt. This book applies spherical trigonometry formulas and ecliptic coordinate data of the Moon and the Sun to determine the moment of conjunction and opposition positions which are the basis for the occurrence of a lunar eclipse. This approach marks a shift from the traditional taqribi method to a more accurate modern calculation system.

The book Irsyad al-Murid is widely used in Islamic boarding schools (pesantren) in Madura, East Java, and parts of Central Java as a reference for learning modern arithmetic. Its influence is quite widespread because it provides formulas that are both easy to apply and accurate, making it suitable for both formal education and practical activities such as determining prayer times and predicting eclipses. Furthermore, Ahmad Ghozali Fathullah also stated that the book was compiled based on his desire to popularize astronomy among Muslims in general and students in particular. Therefore, the book is quite easy to understand and can be used with modern calculators. Several astronomy institutions in Indonesia also use this book as a comparison against the results of national ephemeris calculations. In calculating lunar eclipses, methods for obtaining lunar and solar data are already available in modern mathematical formulas that can be calculated using a calculator. The book Irsyad al-Murid is an improvement on other books. This book does not use tables in its calculations, but rather uses contemporary mathematical formulas. perform the calculation process. According to the author, this makes it easier for the public to understand. Based on an interview with Ustadh Su'udi,[13] the constant values in the

[12] Siti Makhturoh, *Ahmad Ghazali's Thoughts in The Book of Anfa' Al-wasilah on Determining 'Asr Time Prayer,* Al-Hilal: Journal of Islamic Astronomy, Vol. 4, No. 1, 2022, Hal. 83-85.

[13] One of the assistants of KH. Ahmad Ghozali at Pondok Pesantren Al-Mubarok Lanbulan, Sampang, Madura, East Java.

calculation of lunar eclipses in the book Irsyad al-Murid, apart from being sourced from the original thoughts of Ahmad Ghozali, also come from the thoughts of Jean Meeus and also from the thoughts of Muhammad Syaukat Odeh.[14]

Ta'dil Correction in the book of *Irsyad al-Murid* is a step used to correct the results of calculations aimed at obtaining more accurate results. As a book that uses a contemporary hisab system book of *Irsyad al-Murid* makes corrections to its calculations due to the motion and circulation of the Earth, namely rotation, revolution, precession, nutation and apsiden. Below the author provides the correction process to obtain the values of the istiqbal phases used in the book of *Irsyad al-Murid*.

T1 = -0.4065 x sin M’	T9 = 0.0012 x sin (M’ + 2 x F1)
T2 = 0.1727 x E x sin M	T10 = 0.0006 x E x sin (2 x M’ + M)
T3 = 0.0161 x sin 2M’	T11 = -0.0004 x sin 3M’
T4 = -0.0097 x sin (2 x F1)	T12 = -0.0003 x E x sin (M + 2 x F1)
T5 = 0.0073 x E x sin (M’ – M)	T13 = 0.0003 x sin A1
T6 = -0.005 x E x sin (M’ + M)	T14 = -0.0002 x E x sin (M + 2 x F1)
T7 = -0.0023 x sin (M’ – 2 x F1)	T15 = -0.0002 x E x sin (2 x M’ – M)
T8 = 0.0021 x E x sin (2 x M)	T16 = -0.0002 x sin Ω

From the example of ta'dil correction of the istiqbal phases above, the book Irsyad al-Murid can make numerous corrections. The reason for the lengthy correction process in the book Irsyad al-Murid is the existence of precession, nutation, and apsiden motion. Precession is caused by the Sun's large gravitational force, which affects the tilt of the Earth's axis. This motion is what causes the Aries point to not remain fixed at a certain point. the same place, but shifts along the ecliptic in a positive direction,[15] this movement also causes the coordinates of all celestial bodies to always change for a long period of time.[16]

2. Calculation Process Analysis

The method used in Irsyad al-Murid is a development of Jean Meeus's book Astronomical Algorithms, is one of the methods of calculating eclipses that is easy to use and has a high degree of accuracy. This calculation method is not only for calculating eclipses but can also be used to determine the distance between planets, calculate prayer times, the height of the sun, and other astronomical calculations. The

[14] Interview with Ahmad Ghozali’s Assistant, Ust. Su’udi, one of KH. Ahmad Ghozali’s assistants at the Al-Mubarok Islamic Boarding School in Lanbulan, Sampang Regency, Madura, East Java.
[15] Abu Yazid Raisal, *Sistem Koordinat Benda Langit,* Medan: Umsu Press, Cet 1, 2023, Hal. 99.
[16] Slamet Hambali, *Pengantar Ilmu Falak*, Banyuwangi: Bismillah Publisher, 2013.

AL – AFAQ
Jurnal Ilmu Falak dan Astronomi
Fakultas Syariah Universitas Islam Negeri (UIN) Mataram
P-ISSN: 2685-0176. E-ISSN: 2722-0176 Vol. 8, No. 1 Juni 2026

Jean Meeus algorithm is an algorithm derived from VSOP87[17] (Variation Seculaires des Orbites Planetaires), which is a calculation based on the movement of planets orbiting the sun, where the calculation has a high level of accuracy from thousands of correction terms, to determine the positions of celestial bodies such as the sun and moon. Ahmad Ghozali has also explained that Irsyad al-Murid is not only based on his own thoughts but also on Jean Meeus's book. Therefore, the methods used in Irsyad al-Murid and Astronomical Algorithms are related in their calculation process.[18] Proof of the relationship between Irsyad al-Murid and Astronomical Algorithms can be seen in the calculation process of both methods, as follows:

Table 1. Comparison of *Irsyad al-Murid's* Formula and Astronomical Algorithms/Jean Meeus

Perhitungan	*Irsyad al-Murid*	Astronomical Algorithms/Jean Meeus
Time in Julian Centuries (T)	K / 1200	K / 1236.85
Moon's Argument of Latitude (F)	Frac ((164.2159288 + 390.67050274 x K+ - 0.0016341 x T2 + -0.00000227 x T3) / 360) x 360	$160.7108 + 390.67050274 \times K - 0.0016341 \times T^2 - 0.00000227 \times T^2 + 0.000000011 \times T^4$
Longitude of the ascending node of the lunar orbit (Ω)	Frac ((326.4991207 + -1.5637558 x K + $0.0020691 \times T^2 + 0.00000215 \times T^3$) / 360) x 360	$124.7746 - 1.56375580 \times K + 0.0020691 \times T^2 + 0.00000215 \times T^3$
Julian Day (JD)	2447740.651689 + 29.530588853 x K +- 0.0001337 x T2 – 0.00000015 x T3	$2451550.09765 + 29.530588853 \times K + 0.0001337 \times T^2 - 0.000000150 \times T^3 + 0.00000000073 \times T^4$

From the table above, it can be seen that the calculation process used by both methods is almost the same, except for the different constant values at the end. For example, to find the value of T, the book Irsyad al-Murid uses the formula K/1200, while the book Astronomical Algorithms uses the formula K/1236.85. Another correlation can also be seen in the formula for finding the eccentricity of Earth's orbit.

Table 2. Comparison of Finding the Value of E

Irsyad al-Murid	*Astronomical Algorithms* /Jean Meeus
E = 1 – 0.002516 x T + - 0.0000074 x T2	E = 1 – 0.002516 x T – 0.0000074 x T2

[17] VSOP is an algorithm with a high degree of accuracy from thousands of correction terms, used to determine the position of the sun.

[18] Baiq Anggi Andini, *Implementasi Algoritma Jean Meeus dalam Penentuan Gerhana Bulan dan Matahari,* Jurnal Al-Afaq: Jurnal Ilmu Falak dan Astronomi, Vol. 5, No. 1, Juni 2023, hal. 58-59.

E stands for eccentricity, eccentricity is an astronomical term meaning oblong. The oblong in question is the Earth's orbit, namely the eccentricity or oblongness of the Earth's orbit. Because the Earth's orbit is elliptical, and the elliptical path of the Sun and Earth always changes in circulation with the distance of the perihelion point (closest point) and the aphelion point (farthest point) being 5,000,000 km. With a tilt of 23 degrees 27 minutes.[19] The method used to find the value of the Earth's orbital eccentricity between the book Irsyad al-Murid and the book Astronomical Algorithms is almost the same, only differing in addition and subtraction. After the number 1 is subtracted by the value 0.002516 then multiplied by the value T, in the book of Irsyad al-Murid then added with the value (-0.0000074), while in the book of Astronomical Algorithms it is subtracted with the value 0.0000074.

The ecliptic limit value is greatly influenced by the elliptical shape of the Earth's orbit. The ecliptic limit value in the book Irsyad al-Murid and the book Astronomical Algorithms in determining the probability of an eclipse refers to the value of F. In the book Astronomical Algorithms, if the value of F is greater than 21.0, or the value of sin F is greater than 0.36, then there will be no lunar eclipse. Therefore, a lunar eclipse occurs when the value of F is less than 21.0. The relationship between the methods in the book Irsyad al-Murid and the book Astronomical Algorithms in determining the possibility of a lunar eclipse in the book Irsyad al-Murid is that if the ecliptic limit value is used as (sin), then these values are not greater than 0.36. Please refer to the table below. The book Irsyad al-Murid uses an ecliptic limit value of 12^0. This value is very different from the ecliptic limit value used by its source, namely the book Astronomical Algorithms, which uses an ecliptic limit value of 13^0 9'. The difference between the two ecliptic limits is not too far apart, only around 1^0 9', which proves that the data used in the book Irsyad al-Murid can be used as a reference and its values can be accounted for astronomically.

[19] The Earth's axis is tilted 23 degrees 27 minutes from the perpendicular line of the ecliptic plane (the Earth's orbit around the Sun). Scientists believe this is due to a violent collision that occurred about 4.6 billion years ago during the formation of the solar system. This major event permanently altered the orientation of the Earth's rotational axis. This tilt has remained constant as the Earth has evolved, which is the main cause of seasonal changes and differences in the intensity of sunlight in various parts of the Earth throughout the year. Visit the website *Earth, Orbit and Rotation,* *https://science.nasa.gov/earth/facts/#:~:text=Earth%20is%20composed%20of%20four,of%20iron%20and%20nickel%20fluids*

Table 3. Data on the correlation between the probability of a lunar eclipse occurring in the book Irsyad al-Murid and Astronomical Algorithms

0°	Sin (0°) = 0
12°	Sin (12°) = 0.2079
168°	Sin (168°) = 0.2079
192°	Sin (192°) = - 0.2079
348°	Sin (340°) = - 0.3420
360°	Sin (360°) = 0

Another difference is that to find the smallest distance from the center of the Moon to the Earth's shadow axis, both the book Irsyad al-Murid and the book Astronomical Algorithms use the letter Y to represent it.

Table 4. Comparison of Finding the Value of Y

Irsyad al-Murid	**Astronomical Algorithms/Jean Meeus**
Y = S x sin F1 + C x cos F1 x (1 – 0.0048 x W)	Y = (P x cos F1 + Q x sin F1) x (1 – 0.0048 x W

From the above formula, we can see that there is a similarity between the formula used by Ahmad Ghozali in his book Irsyad al-Murid and that used by Jean Meeus in his book Astronomical Algorithms.[20] To calculate the time of a lunar eclipse, the concept used in the book Irsyad al-Murid is quite simple, and the method used is not much different from other contemporary books. The general steps for determining a lunar eclipse in the book Irsyad al-Murid are as follows:

a. Find the probability of a lunar eclipse occurring.
b. Find the midpoint time of the lunar eclipse.
c. Convert the Hijri day to the Gregorian day.
d. Find the time of the lunar eclipse.

3. Analysis of the Accuracy of the Method Used by Ahmad Ghozali in the Book *Irsyad al-Murid*

[20] *Astronomical Algorithms* by Jean Meeus (published by Willmann-Bell, 2nd ed. 1998) is a foundational, widely acclaimed text for calculating celestial positions and phenomena. It provides practical, high-precision mathematical formulas for solar, lunar and planetary positions, covering topics like eclipses, planetary stations, and coordinate transformations, primarily intended for computational implementation. Susan Venia, *Implementation of The Jean Meeus Algorithm in Calculating New Moon and Full Moon Data,* Al-Hilal: Journal of Islamic Astronomy, Vol. 6, No. 1, 2024, hal. 56-57.

The issue of the accuracy of a newly published book is a very urgent matter. This is particularly urgent because the book Irsyad al-Murid is one of the reference books used to determine matters of worship by the Ministry of Religious Affairs of the Republic of Indonesia, the East Java and Madura Falakiyah Council. The results of these calculations are very decisive in matters of eclipse prayer. Although eclipse prayer is a sunnah prayer, it is better if we perform it at the right time.[21] The book Irsyad al-Murid classifies lunar eclipses into only two criteria, namely partial and total lunar eclipses. The book does not classify penumbral eclipses as lunar eclipses. Penumbral eclipses can only be seen using a telescope specifically designed for viewing celestial objects.[22] This is why the book Irsyad al-Murid does not consider penumbral eclipses to be lunar eclipses. As written in the schedule in the book, which is the schedule of eclipses during the time of the Prophet Muhammad after his migration, the schedule of these eclipses can be seen below.

Table. 5 : List of types and years of lunar eclipses according to the book Irsyad al-Murid

Selesai Penumbra	Selesai Umbra	Selesai Gelap	Tengah Gerhana	Mulai Gelap	Mulai Umbra	Mulai Penumbra	Jenis Gerhana	Tanggal	Hari
4:38	3:44	2:47	1:57	1:08	0:11	23:16	Total	2/2/622	Senin
Di bawah ufuk	Di bawah ufuk	Di bawah ufuk	Di bawah ufuk	Di bawah ufuk	Di bawah ufuk	5:25	Total	28/7/622	Rabu
1:59	0:24	-	23:24	-	22:23	20:48	Sebagian	30/11/624	Jumat
22:38	21:41	20:37	19:57	19:18	Di bawah ufuk	Di bawah ufuk	Total	27/5/625	Senin
6:50	5:49	4:48	3:58	3:09	2:08	1:06	Total	20/11/625	Rabu
Di bawah ufuk	Di bawah ufuk	-	Di bawah ufuk	-	4:42	3:35	Sebagian	17/5/626	Sabtu
22:22	20:53	-	19:51	-	18:50	Di bawah ufuk	Total	25//3/628	Jumat
7:04	6:07	5:08	4:18	3:28	2:29	1:32	Sebagian	15/3/629	Rabu

According to the book Irsyad al-Murid, during the time of the Prophet Muhammad SAW after his migration, only total and partial lunar eclipses occurred, while penumbral eclipses were not considered lunar eclipses. The data on the

[21] Nurmila, *Analisis Awal Waktu Salat Gerhana Menurut Imam Malik dan Imam Syafi'I Perspektif Ilmu Falak,* Hisabuna, Vol. 3, No. 3, 2022, Hal. 133-138.

[22] A penumbral lunar eclipse takes place when the Moon moves through the faint, outer part of Earth's shadow, the penumbra. This type of eclipse is not as dramatic as other types of lunar eclipses and is often mistaken for a regular full Moon. Visit the website https://science.nasa.gov/moon/eclipses/

occurrence of lunar eclipses in the table above refers to lunar eclipses in the region of Madinah al-Munawwaroh because Ahmad Ghozali stated that this data is a list of eclipses that occurred during the time of the Prophet SAW after his migration. Therefore, in the calculation of the lunar eclipse, it is mentioned in the last method that W1 is ibtida al-khusuf al-syibhi. The meaning of ibtida al-khusuf al-syibhi does not mean the beginning of a penumbral lunar eclipse, but the time when the Moon begins to enter the Earth's penumbral shadow. Similarly, the meaning of the word intiha al-khusuf al-syibhi is the time when the Moon begins to exit the Earth's penumbral shadow. The issue of accuracy in the book Irsyad al-Murid is that because it is a contemporary book, the calculation system used as a benchmark to determine its accuracy is also a contemporary calculation system. The book Irsyad al-Murid also does not provide criteria for the color of eclipses during lunar eclipses, as stated by KH. Noor Ahmad SS, in his book entitled Nur al-Anwar.

Table. 6 : Interval criteria for determining the color of eclipses in the book *Nur al-Anwar*

Lintang Bulan	**Warna**	**Lintang Bulan**	**Warna**
Derajat		**Derajat**	
00^0 – 00^0 10’	Hitam Pekat	00^0 30’ – 00^0 40’	Hitam Kekuningan
00^0 10’ – 00^0 20’	Hitam Kehijauan	00^0 40’ – 00^0 50’	Kedebuan
00^0 20’ – 00^0 30’	Hitam Kemerahan	00^0 50’– 00^0 60’	Kedebuan

The table above explains that the book Nur al-Anwar provides criteria for eclipse colors by referring to the Moon's latitude or ard al-qomar. In this study, the author will compare the results of the Irsyad al-Murid book with NASA data. The National Aeronautics and Space Administration (NASA)[23] is a United States government agency responsible for the US space program and long-term general space research. This organization is responsible for space research programs for civil society,[24] aeronautics, and aerospace programs (nasa.gov, 2025). This is why NASA is highly trusted by many people around the world. NASA's official website for searching for

[23] NASA (National Aeronautics and Space Administration) is a United States government agency established in 1958, tasked with managing space exploration programs, aeronautics research, and aerospace science. NASA focuses on solar system exploration, Earth studies, and the development of space technology for both civil and commercial purposes.

[24] Alfan Maghfuri, *Akurasi Perhitungan Gerhana Matahari dengan Data Ephemeris Hisab Rukyat,* Al-Afaq: Jurnal Ilmu Falak dan Astronomi, Vol. 2, No. 1, 2020, hal. 3-4.

lunar eclipses can be accessed at http://eclipse.gsfc.nasa.gov/lunar.html.[25] The following table presents a comparison of the results of the Irsyad al-Murid book calculations and NASA's calculations. The following table compares the mid-eclipse times between the results of the Irsyad al-Murid book calculations and NASA data:

Table 7. Comparison of Differences in Results between *Irsyad al-Murid* and NASA

No	Time	Types of Eclipse	*Irsyad al-Murid*	NASA	Difference
			Mid-Eclipse		
1	28-Aug-2026	Partial	4:14:24	4:14:04	0:00:20
2	12-Jan-2028	Partial	4:14:38	4:14:13	0:00:25
3	6-Jul-2028	Partial	18:21:42	18:20:57	0:00:45
4	31-Dec-2028	Total	16:53:06	16:53:15	0:00:09
5	26-Jun-2029	Total	3:24:05	3:23:22	0:00:43

The table above explains the average difference in the mid-time of a lunar eclipse between the Irsyad al-Murid book and data obtained from NASA, referring to five eclipses. The maximum difference between the Irsyad al-Murid book and NASA[26] data occurred on July 28, 2028, with a value of 00 minutes 45 seconds. The minimum difference occurred on December 31, 2028, with a value of 00 minutes 09 seconds. The average difference in the mid-time of an eclipse between the Irsyad al-Murid book and NASA data is 00 degrees 00 minutes 20.00 seconds. Based on the calculations and the table above, it can be understood that the difference between the Irsyad al-Murid book and NASA data each year is not too significant and is still tolerable.

The comparison above explains that the difference in the lunar eclipse calculation results between the Irsyad al-Murid book and NASA data is very small. Although NASA's results are considered more accurate, the Irsyad al-Murid book also has a very high level of accuracy because it uses astronomical data that corresponds to the development of changes in the distance and speed of celestial bodies. Irsyad al-Murid still uses geocentric position parameters with simple corrections, while NASA uses high-precision ephemeris data with global topographic corrections. It should be noted that the method NASA uses to calculate lunar eclipses is based on numerical calculations using high-precision ephemeris data that account for the dynamic positions and motions of celestial bodies. The calculation process involves determining the

[25] eclipse.gsfc.nasa.gov/lunar.html.
[26] eclipse.gsfc.nasa.gov/lunar.html

positions of the Sun and Moon, identifying the full moon phase, analyzing proximity to the orbital nodes, and calculating the geometry of the Earth's shadow with various astronomical corrections such as ΔT.[27] Therefore, this method no longer relies on simple formulas but instead employs complex mathematical simulations that yield a very high level of accuracy. Nevertheless, the very small difference indicates that the method used by Ahmad Ghozali Fathullah has a level of accuracy approaching modern astronomical standards.

Based on the author's analysis of several chapters discussed, the author offers several conclusions regarding the lunar eclipse calculation method used in Ahmad Ghozali's book, Irsyad al-Murid, to address the main issues. These conclusions are as follows:

a. The book of Irsyad al-Murid uses a contemporary hisab method. It is said to be a contemporary book because the book of Irsyad al-Murid in calculating the position of the Moon and Earth has used quite careful corrections for the irregular movements of the Moon and Earth. The data used in the book of Irsyad al-Murid in calculating the time of the lunar eclipse comes from a book by Jean Meeus entitled Astronomical Algorithms. The steps used in the book of Irsyad al-Murid in calculating the time of the lunar eclipse are four steps, namely: finding the probability value of the lunar eclipse, finding the mid-time value of the lunar eclipse, converting Hijri days to Gregorian days and finding the time of the lunar eclipse.
b. The accuracy of the lunar eclipse calculation results in Ahmad Ghozali's book Irsyad al-Murid is considered very accurate and can be used as a guideline in determining eclipse times. The author has proven this by comparing the calculation results of the book with NASA's results. The results of the book are not far apart, with the average difference between the books of Irsyad al-Murid and NASA only differing by 1-2 minutes. The lunar eclipse calculation method used in the book Irsyad al-Murid is a method that can be used throughout time, without being limited to certain years.

The Irsyad al-Murid book is one of the great works of the Islamic boarding school world that demonstrates remarkable achievements in the field of astronomy. This book proves that Islamic boarding school scholars have a high level of scientific ability in understanding and calculating astronomical phenomena. In terms of determining the

[27] In lunar eclipse calculations is the time difference between Terrestial Time (TT/TD) and Universal Time (UT), it serves as a correction for the Earth's irregular rotational movement, ensuring that the predicted eclipse time (ephemeris) aligns with the actual observation time. *Delta T and Universal Time*, https://eclipse.gsfc.nasa.gov/SEhelp/deltaT.html

time of a lunar eclipse, the calculations contained in Irsyad al-Murid show a very high level of accuracy. The difference with modern data, such as that released by NASA, is minimal, and often very close. This confirms that the traditional methods used by scholars remain relevant and scientifically accountable. Through this book, the world of Islamic boarding schools shows that they are not lagging behind the modern academic world in terms of rational and analytical thinking skills. This achievement also illustrates the harmonious blend of religious knowledge and general knowledge. Thus, Irsyad al-Murid is clear evidence that the scientific heritage of Islamic boarding schools has made an important contribution to the development of science, particularly in the field of Islamic astronomy.[28]

4. Conclusion

Based on the author's analysis of several previously discussed chapters, the author concludes several points regarding the lunar eclipse calculation method used in Ahmad Ghozali's book, Irsyad al-Murid, as answers to the main research questions. These conclusions can be outlined as follows:

a. The Irsyad al-Murid book uses a contemporary hisab method. It is called contemporary because in calculating the positions of the Moon and Earth, this book has applied very precise corrections to the irregular movements of the Moon and Earth. The data used to determine the time of the lunar eclipse comes from the book Astronomical Algorithms by Jean Meeus. The steps in calculating the lunar eclipse in the Irsyad al-Murid book include four stages: determining the probability of a lunar eclipse, calculating the mid-time of the lunar eclipse, converting the Hijri date to the Gregorian date, and calculating the exact time of the lunar eclipse.
b. The accuracy of the lunar eclipse calculations in Ahmad Ghozali's book, Irsyad al-Murid, is considered very high and is worthy of being used as a guideline for determining eclipse times. This has been proven by comparing the results with NASA data, where the average difference between the two is only around 1–2 minutes. The lunar eclipse calculation method used in Irsyad al-Murid is universal and can be used throughout time, regardless of a specific year.
c. The accuracy of the lunar eclipse calculations in Ahmad Ghozali's book, Irsyad al-Murid, is considered very high and is worthy of being used as a guideline for determining eclipse times. This has been proven by comparing the results with NASA data, where the average difference between the two is only around 1–2

[28] Ahmad Ghozali Muhammad Fathulloh, *Irsyad Al-Murid.*

minutes. The lunar eclipse calculation method used in Irsyad al-Murid is universal and can be used throughout time, regardless of a specific year.

Although the lunar eclipse calculation method in Irsyad al-Murid is quite easy to understand, it would be beneficial for this book to provide a more detailed explanation of the symbols and terms used in the calculation process. This explanation would help beginners understand and develop the lunar eclipse calculation method in this book, while also expanding the knowledge of astronomical science to increase its appeal to the wider public. Accurately calculating the timing of a lunar eclipse is crucial, as knowing the exact time allows Muslims to perform the eclipse prayer on time. Therefore, the author hopes that astronomers in Indonesia will continue to develop their knowledge by compiling contemporary Indonesian-language books. This way, the public can independently determine the timing of a lunar eclipse without relying solely on information from the BMKG, NASA, or other institutions.

Bybliography

Ahsan, M. Ainul Yaqin, *Mukhtashar Al-Durusi Al-Falakiyah,* Sleman: Penerbit Deepublish, (2024)

Andini, Baiq Anggi, *"Implementasi Algoritma Jean Meeus dalam Penentuan Gerhana Bulan dan Matahari,*" Jurnal Al-Afaq: Jurnal Ilmu Falak dan Astronomi, Vol. 5, No. 1, (2023)

Azhari, Susiknan, *Ensiklopedi Hisab Rukyat*, II (Pustaka Pelajar, 2008)

Delta T and Universal Time, https://eclipse.gsfc.nasa.gov/SEhelp/deltaT.html

Earth,*https://science.nasa.gov/earth/facts/#:~:text=Earth%20is%20composed%20of%20four,of%20iron%20and%20nickel%20fluids.*

Eclipse.gsfc.nasa.gov, https://eclipse.gsfc.nasa.gov/lunar.html

Fathulloh, Ahmad Ghozali, *Irsyad al-Murid* , Lafal, (2005)

Hambali, Slamet, *Pengantar Ilmu Falak: Menyimak Proses Pembentukan Alam Semesta,* Bismillah Publisher, (2012)

Idra, Rohadatu Aisy, *An Algorithm Analysis of The Lunar Eclipse Calculation in The Book Risalah Az Zain by Ibn Ya'qub Al-Batawy.* Semarang: Universitas Islam Negeri Walisongo, (2021)

Interview with Ustad Su'udi, Assistant to K.H. Ahmad Ghozali

Interview with Hj. Asma, Wife of K.H. Ahmad Ghozali

Izzuddin, Ahmad, *Ilmu Falak Praktis: Metode Hisab Rukyah dan Solusi Permasalahannya,* Pustaka Al-Hilal, (2024)

Jannah, Syikma Riyadil *"Aplikasi Gerhana Bulan Metode Kitab al-Duru Al-Aniq,"* Universitas Islam Negeri Walisongo Semarang, (2021)

Khazin, Muhyiddin, *Ilmu Falak dalam Teori dan Praktik*, Buana Pustaka, (2008)

Maghfuri, Alfan, *Akurasi Perhitungan Gerhana Matahari dengan Data Ephemeris Hisab Rukyat,* Al-Afaq: Jurnal Ilmu Falak dan Astronomi, Vol. 2, No. 1, (2020)

Makhturoh, Siti, *Ahmad Ghazali's Thoughts in The Book of Anfa' Al-wasilah on Determining 'Asr Time Prayer,* Al-Hilal: Journal of Islamic Astronomy, Vol. 4, No. 1, (2022)

Meeus, Jean, *Astronomical Algoritms,* Willmann Bell. Inc, (1991)

Muhajir*, "Hisab Gerhana Bulan dalam Kitab Nur Al-Anwar (Analisis Pemikiran KH. Noor Ahmad SS),"* Jurnal Islam Nusantara, vol. 03, no. 02, (2019)

Nurmila, *Analisis Awal Waktu Salat Gerhana Menurut Imam Malik dan Imam Syafi'I Perspektif Ilmu Falak,* Hisabuna, Vol. 3, No. 3, (2022)

Prayogi, Lalu Adam, *"Studi Komparatif Perhitungan Gerhana Bulan Astronomical Algorithm Jean Meeus dan Textbook On Spherical Astronomy W.M Smart,"* Universitas Islam Negeri Mataram, (2022)

Raisal, Abu Yazid, *Sistem Koordinat Benda Langit,* Medan: Umsu Press, Cet 1, (2023)

The Moon and Eclipses, https://science.nasa.gov/moon/eclipses/

Venia, Susan, *Implementation of The Jean Meeus Algorithm in Calculating New Moon and Full Moon Data,* Al-Hilal: Journal of Islamic Astronomy, Vol. 6, No. 1, (2024)

Wijaya, Mendra, *Metodologi Penelitian (Kombinasi Pendekatan Kuantitatif, Kualitatif dan Mixed Methods),* Medan: PT. Media Penerbit Indonesia, (2025)

Yaqin, Alamul dan Azmi, Muhammad Farid *"Lunar Eclipse Types Comparison of al-Dur al- Anīq with Astronomical Algorithms (Implications for the Law of Lunar*

Eclipse Prayers)," Al-Marshad: Jurnal Astronomi Islam dan Ilmu-Ilmu Berkaitan, vol. 11, no. 1, (2025)