Journal of Astronomy and Sharia Applications (JASA)
Vol. 01, No. 02, July-December 2026

From *Zīj Sulṭānī* to *Sullam al-Nayyirayn*: An Epistemological Study of Solar Eclipse Calculation in the Indonesian Falak Tradition

Naili Rahmawati[1] Jauharotul Maknunah Firman[2]

[12]Universitas Islam Negeri Walisongo Semarang, Indonesia

Article Info

Article history:

Received: 07-08-2026
Revised: 11-09-2026
Accepted: 02-10-2026

***Keywords*:**

Zīj Sulṭānī; *Sullam al-Nayyirayn*; solar eclipse; epistemology; Indonesian falak; knowledge transmission.

ABSTRACT

Sullam al-Nayyirayn is one of the important works in the Indonesian falak tradition whose computational system is closely related to *Zīj Sulṭānī*, a major work of classical Islamic astronomy that influenced the development of astronomical tables and calculation methods. Nevertheless, differences can be identified in solar eclipse calculations, particularly in the parameters used to determine the type of eclipse. These differences indicate that the transmission of astronomical knowledge from *Zīj Sulṭānī* to *Sullam al-Nayyirayn* did not merely occur through direct reproduction of methods, but also involved processes of selection, adaptation, and reconstruction of knowledge. This study aims to analyze the structure and epistemological characteristics of solar eclipse calculations in *Zīj Sulṭānī* and *Sullam al-Nayyirayn*, as well as to identify the methodological transformations that occurred during their transmission into the Indonesian falak tradition. The study employs a historical-comparative approach combined with epistemological analysis of the algorithmic structure, sources of parameters, calculation stages, and procedures used to determine eclipse types in both works. The findings show that *Sullam al-Nayyirayn* essentially preserves the basic structure of solar eclipse calculations found in *Zīj Sulṭānī*, while introducing modifications at several stages, particularly in the use of parameters for classifying eclipse types. These modifications demonstrate a process of appropriation and adaptation through which classical astronomical methods were adjusted to pedagogical needs, computational practices, and the intellectual context of falak in the Indonesian archipelago. The study therefore argues that the development of Indonesian falak was not characterized by passive knowledge transmission, but by a dynamic epistemological process involving selection, simplification, adaptation, and methodological reconstruction. Accordingly, *Sullam al-Nayyirayn* may be understood as a localized transformation of the classical Islamic astronomical heritage that maintains intellectual continuity with *Zīj Sulṭānī* while simultaneously developing distinctive characteristics within the Indonesian falak tradition.

ABSTRAK

Sullam al-Nayyirayn merupakan salah satu karya penting dalam tradisi falak Nusantara yang sistem perhitungannya memiliki keterkaitan dengan *Zīj Sulṭānī*, salah satu karya astronomi Islam klasik yang berpengaruh dalam perkembangan tabel dan metode perhitungan astronomis. Meskipun demikian, dalam perhitungan gerhana Matahari terdapat perbedaan, khususnya pada parameter yang digunakan untuk menentukan jenis gerhana. Perbedaan tersebut menunjukkan bahwa transmisi pengetahuan astronomi dari *Zīj Sulṭānī* ke *Sullam al-Nayyirayn* tidak semata-mata berlangsung melalui reproduksi metode secara langsung, tetapi berpotensi melibatkan proses seleksi, adaptasi, dan rekonstruksi pengetahuan. Penelitian ini bertujuan menganalisis struktur dan karakter epistemologis perhitungan gerhana Matahari dalam *Zīj Sulṭānī* dan *Sullam al-Nayyirayn*, serta mengidentifikasi bentuk transformasi metodologis yang terjadi dalam proses transmisinya ke dalam tradisi falak Indonesia. Penelitian menggunakan pendekatan historis-komparatif dengan analisis epistemologis terhadap struktur algoritma, sumber parameter, tahapan perhitungan, serta prosedur penentuan jenis gerhana pada kedua karya tersebut. Hasil penelitian menunjukkan bahwa *Sullam al-Nayyirayn* pada dasarnya mempertahankan struktur dasar perhitungan gerhana Matahari yang terdapat dalam *Zīj Sulṭānī*, tetapi

melakukan modifikasi pada beberapa tahapan, terutama dalam penggunaan parameter untuk klasifikasi jenis gerhana. Modifikasi tersebut menunjukkan adanya proses apropriasi dan adaptasi pengetahuan yang memungkinkan metode astronomi klasik disesuaikan dengan kebutuhan pedagogis, praktik perhitungan, dan tradisi keilmuan falak di Nusantara. Temuan ini menegaskan bahwa perkembangan falak Indonesia tidak berlangsung melalui transmisi pengetahuan yang pasif, melainkan melalui proses epistemologis yang dinamis berupa seleksi, penyederhanaan, adaptasi, dan rekonstruksi metodologis. Dengan demikian, *Sullam al-Nayyirayn* dapat dipahami sebagai salah satu bentuk transformasi lokal dari warisan astronomi Islam klasik yang tetap mempertahankan kesinambungan intelektual dengan *Zīj Sulṭānī* sekaligus membentuk karakter khas tradisi falak Indonesia.

This is an open access article under the CC BY-SA license.

Corresponding Author:

Naili Rahmawati
Universitas Islam Negeri Walisongo Semarang, Indonesia
Jl. Prof. Hamka, Ngaliyan, Semarang, Jawa Tengah, 50185, Indonesia.
Email: nailirahma1@gmail.com

INTRODUCTION

Sullam al-Nayyirayn is one of the important works in the treasures of astronomy in the archipelago. This book written by Muhammad Manshur is widely used in the tradition of learning and practicing astronomical calculations, especially in determining astronomical phenomena such as the position of the Sun and Moon, the beginning of the Hijri month, and eclipses. In his preface, Muhammad Manshur mentioned that the calculation method he used was related to *Zīj-i Sultānī*, an astronomical work compiled in the environment of the Ulugh Beg observatory in Samarkand in the 15th century (Mansur, n.d.). This statement shows an intellectual relationship between the classical Islamic astronomical tradition in Central Asia and the development of astronomy in the archipelago.

This relationship is interesting to study because there is a fairly long temporal distance between the preparation of *Zīj-i Sultānī* and the writing of *Sullam al-Nayyirayn*. The distance of about three centuries shows that the astronomical knowledge contained in *Zīj-i Sultānī* did not reach the archipelago through a simple and direct transmission process. On the contrary, it is very possible that there was an intermediate process in the form of teaching, copying, simplification, reinterpretation, and adjustment of methods to local scientific traditions. In the context of the history of science, this kind of transmission process does not always result in the reproduction of knowledge that is identical to its original source. Knowledge that moves from one intellectual environment to another can undergo selection, adaptation, and transformation according to the needs and character of the recipient community.

Indications of such transformations can be found in the calculation structure of solar eclipses. In *Sullam al-Nayyirayn*, the classification of solar eclipses is mainly directed at two categories, namely total eclipses and partial eclipses. Meanwhile, *Zīj-i Sultānī* provides a more complex classification structure and includes the possibility of *annular eclipses* (Beg, n.d.). This difference not only shows terminological variations, but also hints at differences in the use of parameters and procedures to determine the type of eclipse. Thus, the question is no longer limited to whether

Sullam al-Nayyirayn used data or tables derived from *Zīj-i Sultānī*, but also how the structure of such knowledge was received, selected, and reconstructed in the Falak tradition of the archipelago.

The study of *Zīj-i Sultānī* has developed quite extensively in Islamic astronomical historiography. A number of international studies, including the work of Kennedy and Saliba, have discussed mathematical structures, the use of geometry, astronomical tables, and the development of computational methods in the *zīj tradition*. These studies have made an important contribution to understanding the scientific character of classical Islamic astronomy. However, their attention is mainly directed to the construction of astronomical knowledge in the context of the Middle East and Central Asia, while the process of its spread and transformation to the Southeast Asian region, especially the archipelago, has not been discussed in depth.

On the other hand, research on *Sullam al-Nayyirayn* in Indonesia has tended to place the book within the framework of accuracy evaluation. Various studies have compared the results of his calculations with modern astronomy, astronomical software, or contemporary hisab systems to determine the level of accuracy of eclipse calculation results. This approach is important from a technical perspective, but it does not fully explain the origin of the algorithm structure, its epistemological relationship with *Zīj-i Sultānī*, and the forms of change that occur during the process of knowledge transmission. As a result, the historical and epistemological dimensions of the development of eclipse calculation methods in the Indonesian astronomical tradition still leave considerable research space.

This gap shows the need for a study that not only compares the level of accuracy, but also reconstructs the methodological relationship between the two works. This kind of study is important because the history of astronomy in the archipelago cannot be understood only as a process of passive acceptance of the heritage of classical Islamic astronomy. Local scientific traditions also play a role in determining the parts of knowledge that are preserved, simplified, modified, or adapted to the needs of astronomy learning and practice at a given time. With this perspective, *Sullam al-Nayyirayn* can be placed not just as a derivative work, but as an intellectual product that represents the process of appropriation and reconstruction of astronomical knowledge in the context of the archipelago.

This research departs from the argument that the relationship between *Zīj-i Sultānī* and *Sullam al-Nayyirayn* is not entirely in the form of identical algorithmic reproductions. Although *Zīj-i Sultānī* is referred to as one of the references for *Sullam al-Nayyirayn*, there are indications that some parts of its calculation structure have been modified. The absence of a ring eclipse classification in *Sullam al-Nayyirayn*, accompanied by differences in parameters in determining the type of eclipse, is an early indication of a methodological transformation. These differences need to be systematically analyzed to determine whether the changes are simply related to procedural simplification or reflect a more fundamental change in the epistemological structure of the calculation.

On that basis, this study aims to analyze and compare the calculation structure of the solar eclipse in *Zīj-i Sultānī* and *Sullam al-Nayyirayn*. The analysis was carried out on the main components of the calculation, including the determination of the time of the conjunction, the position of the Sun and the Moon, the geometry parameters of the eclipse, the procedure for determining the probability of an eclipse, and the classification of the type of eclipse. The comparison was used to identify the

elements that were retained, simplified, or modified from the calculation structure of *Zīj-i Sultānī* when applied in *Sullam al-Nayyirayn*.

Epistemologically, this study views the transmission of knowledge as a dynamic process that involves continuity as well as transformation. Astronomical knowledge is not only transferred from one text to another, but also undergoes interpretation through the choice of parameters, the rearrangement of procedures, and the adjustment of computational systems. Therefore, the comparison between *Zīj-i Sultānī* and *Sullam al-Nayyirayn* can open up space to understand how the authority of classical astronomical texts is negotiated in the Indonesian astronomical tradition.

This research is expected to make two main contributions. First, historically, this research clarifies the path of intellectual continuity between the *zīj tradition* in classical Islamic astronomy and the development of astronomy in the archipelago. Second, epistemologically, this study shows that the formation of the Indonesian astronomical tradition took place through a process of selection, adaptation, simplification, and methodological reconstruction. Thus, the calculation of eclipses in *Sullam al-Nayyirayn* can be understood not only as a legacy of *Zīj-i Sultānī*, but as a result of the transformation of Islamic astronomical knowledge that took on a new form in the intellectual environment of the archipelago.

METHOD

This research is a library-based qualitative research that focuses on the structure of the solar eclipse calculation algorithm in *Zīj-i Sultānī* and *Sullam al-Nayyirayn*. The research uses a textual-comparative approach and structural analysis with a historical-epistemological perspective. This approach is used to explore not only the similarities and differences in mathematical procedures in the two works, but also the patterns of continuity, selection, simplification, adaptation, and reconstruction of astronomical knowledge that occur in the process of transmission into the Indonesian astronomical tradition.

The primary source of the research consists of two main works. First, *Zīj-i Sultānī* by Ulugh Beg in a version that has been translated into Arabic. Second, *Sullam al-Nayyirayn* by KH. Muhammad Mansur al-Battawi which was republished by the Mahir al-Riyadl Islamic Boarding School, Kediri. The analysis is limited to the sections that specifically discuss the calculation of solar eclipses. Secondary sources in the form of scientific works on the history *of zīj*, classical Islamic astronomy, eclipse calculation methods, and the development of astronomy in the archipelago are used to provide historical and epistemological context to the results of the analysis.

The unit of analysis in this study is each computational stage that forms the solar eclipse algorithm in both works. The first stage is carried out by reconstructing the sequence of calculations as presented in each text, starting from the conditions for the possibility of an eclipse to the determination of the characteristics and types of eclipses. Each formula, parameters, tables, and procedures are then identified and placed into the same analysis category so that the two systems can be systematically compared.

Comparisons are made based on three main groups. First, the formulation of the conditions for the occurrence of the eclipse and the determination of the timing of the conjunction, which includes the procedure for identifying the possibility of an eclipse and the relative position of the Sun-Moon. Second, the calculation of the

visible position and astronomical correction, including the parallax and other components that affect the geometry of the eclipse. Third, the parameters for determining the characteristics and classification of the type of eclipse, especially the criteria used to distinguish total, partial, and ring eclipses. This classification is used as an analytical framework to identify the parts of the algorithm that are retained, changed, simplified, or no longer used in *Sullam al-Nayyirayn*.

The analysis is not directed primarily to test the numerical accuracy of the two methods based on modern astronomy, but rather to explain the structure and transformation of the calculation method. Each equation and difference is read at two levels. At the technical level, the analysis is directed at changes in formulas, parameters, sequence of procedures, as well as the classification of eclipses. At the epistemological level, these changes are interpreted to determine the form of knowledge transmission that occurs, whether in the form of reproduction, selection, simplification, adaptation, or methodological reconstruction.

To maintain the consistency of the analysis, each stage of computation from the two sources is arranged in a comparative matrix. The matrix contains the names of the components, astronomical functions, formulas or procedures used, input parameters, calculation outputs, and forms of similarities and differences. The results of the comparison are then analyzed interpretively to assess the degree of methodological continuity between *Zīj-i Sultānī* and *Sullam al-Nayyirayn*.

The final stage of the research was carried out by placing the comparative results in the context of the historical transmission of Islamic astronomy to the archipelago. The changes found were not directly understood as errors or deviations from previous sources, but were analyzed as possible forms of adaptation to the pedagogical needs, computational practices, teaching traditions, and intellectual environment of local astronomy. With this framework, this study seeks to show how the heritage of classical Islamic astronomy underwent a process of transformation and acquired a new form in the Indonesian astronomical tradition.

RESULTS AND DISCUSSION

Structure of Solar Eclipse Calculation in *Zīj-i Sultānī*

Requirements for a Solar Eclipse

A solar eclipse can occur when the Earth-Moon-Sun is in conjunction and can be observed during the day. In *Zīj-i Sultānī,* a solar eclipse can be observed somewhere if the conjunction takes place during the day or one hour and 10 minutes before sunset or sunrise (Beg, n.d.) . Despite the occurrence of a conjunction, the Sun will only experience an eclipse if the position of the conjunction is no more than 180 14' from the node point or less than 80 39' from the node point (Beg, n.d.) .

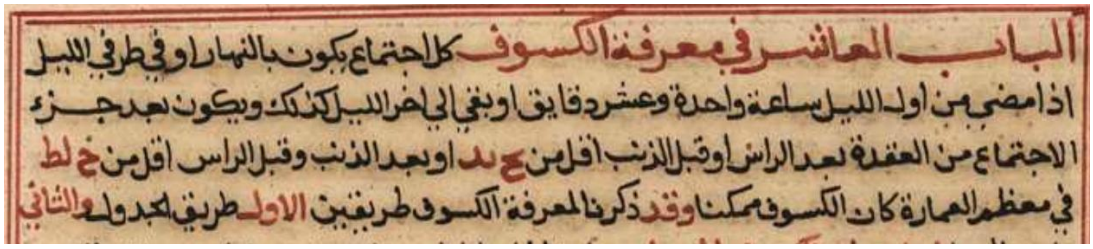

الباب العاشر في معرفة الكسوف كل اجتماع يكون بالنهار او في طرفي الليل
اذا مضي من اول الليل ساعة واحدة وعشر دقايق او بقي الي اخر الليل كذلك ويكون بعد جزء
الاجتماع من العقدة بعد الراس او قبل الذنب اقل من ح يد او بعد الذنب وقبل الراس اقل من خ لط
في معظم العمارة كان الكسوف ممكنا وقد ذكرنا لمعرفة الكسوف طريقين الاول طريق الجدول والثاني

Figure 1. *Zīj-i Sultānī text:* conditions for the occurrence of a solar eclipse based on the location of the conjunction

Based on the text in figure 1, the conditions for the occurrence of a solar eclipse can be modeled as follows:

$$t_{sunrise} - 1\ h\ 10\ m \leq t_c \leq t_{sunset} + 1\ h\ 10\ m$$
$$D = |\lambda_c - \lambda_{node}|$$

$$D < 18^o\ 14'$$
$$D < 8^o\ 39'$$

Description:
D = Distance to nodes
λ_c = Longitude of the ecliptic at conjunction
λ_{node} = Longitude Node
t_c = Conjunction Time

Furthermore, the solar eclipse event can also be known from the value of the visible latitude of the Moon. It is possible for the Sun to experience an eclipse if the latitude appears to be less than the number of qaus of the Sun and Moon.



Figure 2. *Zīj-i Sultānī text:* conditions of the solar eclipse based on the parameters of the Moon's latitude

$$|\beta_a| < r_m + r_s$$

Description:
$|\beta_a|$ = apparent lunar latitude
r_m = radius of the Moon
r_s = radius of the Sun

Visible Position of the Moon and Sun

Ulugh Beg gives two types of methods of calculating the parallax of the Moon and the Sun in *Zīj-i Sultānī*. The first method, he calls it the ancient method. According to Ulugh Beg, Ptolemy used this method to simplify the calculation process. In this method, the Moon is considered to have no latitude so in the process only the longitude of the Moon is calculated as parallax. Meanwhile, the more modern method calculates the latitude of the Moon (Beg, n.d.) .

The second method, this is what *Ulugh Beg calls* the modern method. In this method, the latitude of the Moon is not always zero so it is necessary to calculate the parallax to determine the *apparent latitude* and *apparent longitude* of the Moon. The parallax value of the Moon has also been provided in the form of a table called *ikhtilaf al-manzar qamar* (Beg, n.d.) . Although the parallax table was already available in *Zīj-i*

Sultānī, *Ulugh Beg* still provided a calculation lagkah to determine the parallaxis. This calculation involved the concept of spherical trigonometry in which the results of sine and cosine had been compiled in the form of tables.

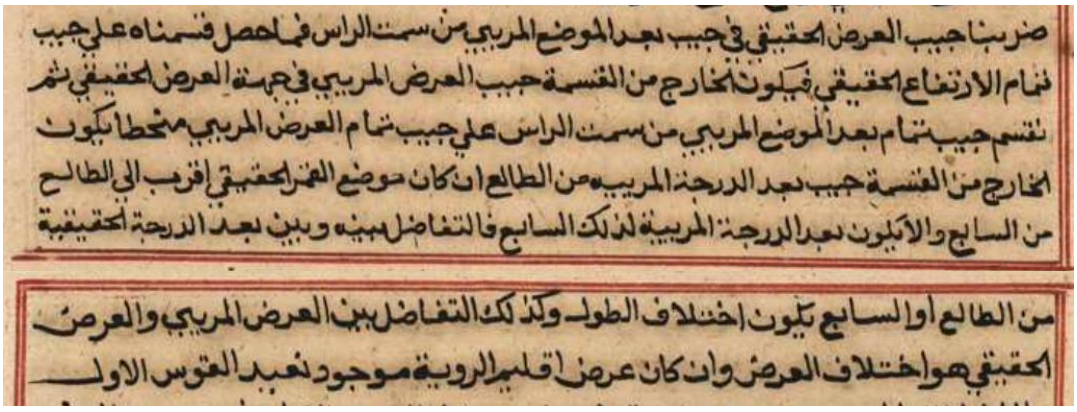


Figure 3. *Zīj-i Sultānī text: calculation* of the latitude and longitude parallax of the Moon

$$\beta' = sin^{-1}\left(\frac{\sin\beta \sin z'}{\cos h}\right)$$

Description:
β'= Visible Latitude
β = True Stars
z' = Visible zenith distance
h = True height

In the context of an eclipse, the latitude of the Moon is a parameter that determines whether or not a solar eclipse occurs (Hidayat, 2020). In addition, parallax also affects the physical nature of the eclipse.

Characteristics of Solar Eclipses

Ulugh Beg explains in detail the calculation of the solar eclipse in *Zīj-i Sultānī* regarding the physical nature of the eclipse that occurs. These physical properties include the type, magnitude, and duration of the eclipse.

The type of eclipse is determined by comparing the visible latitude of the moon (*'ardh al-mar'i*) at the conjunction with the radius of the disk (*muqawwas nisf qutr*) of the Sun and the Moon. A total eclipse occurs if the radius of the moon is greater than the radius of the Sun. Meanwhile, if the radius of the Sun is greater than the radius of the Moon and the visible latitude of the Moon is smaller than both, then what is visible is an annular eclipse. Furthermore, if the apparent latitude of the Moon is greater than the difference between the radii of the Sun and the Moon, then a partial eclipse occurs (Beg, n.d.) .

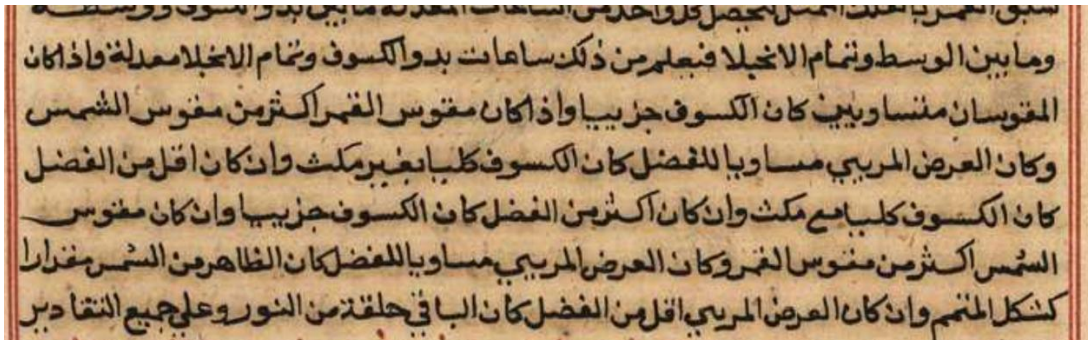


Figure 4. *Zīj-i Sultānī text:* parameters of eclipse types

Total without Mukuts

$$B_m = B_s, L = 0$$
$$B_m > B_s, L = B_m - B_s$$

Total without Mukuts

$$B_m > B_s, L < B_m - B_s$$

Partial

$$B_m = B_s, L > 0$$
$$B_m > B_s, L > B_m - B_s$$

Rings

$$L < B_s - B_m$$

Remarks:
Bs = Arc / Semidiameter of the Sun
Bm = Arc / Semidiameter of the Moon
L = Moon-Visible Latitude

Related to the magnitude of the eclipse, the size of the eclipse or the extent to which the Sun's disk is closed is expressed in *units of ashabi'* (radius/digits). The magnitude of the magnitude is obtained by comparing the part of the Sun's disk covered by the Moon's disk to the apparent diameter of the Sun. The magnitude of the eclipse is calculated after the value of the visible latitude of the Moon as well as the visible radius of the Sun and the Moon so that it can be known the size of the part of the Sun that experiences the eclipse.

The duration of the eclipse is calculated based on the time interval from the initial contact to the end of the eclipse. This time is obtained from the calculation of the visible positions of the Moon and the Sun. To obtain this magnitude, the conjunction time is first calculated, then determines the angular distance between the center of the Sun and the Moon and the daily motion value of both.

Structure of Solar Eclipse Calculation in *Sullam al-Nayyirain*

Requirements for a Solar Eclipse

The book *of Sullam al-Nayyirain* explains that a solar eclipse only occurs at the end of the month of Kamariah, which is when the Earth, Moon, and Sun experience a

conjunction. At the time of the conjunction, the Moon is between the Earth and the Sun so that the Sun's light is potentially blocked by the Moon. However, this situation is only possible if *hissah* (the position of the Moon during ijtimak) is in one of the four zodiac signs (*constellations*) related to the equinox, namely Aries (*Haml*), Libra (*Mizan*), Pisces (*Hut*), and Virgo (*Sunbulah*). (Mansur, n.d.)

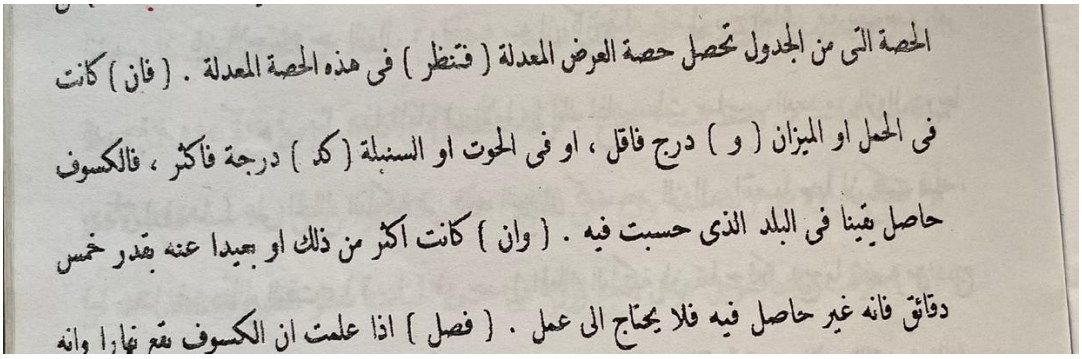

الحصة التى من الجدول تحصل حصة العرض المعدلة (فتنظر) فى هذه الحصة المعدلة . (فان) كانت
فى الحمل او الميزان (و) درج فاقل ، او فى الحوت او السنبلة (كذ) درجة فاكثر ، فالكسوف
حاصل يقينا فى البلد الذى حسبت فيه . (وان) كانت اكثر من ذلك او بعيدا عنه بقدر خمس
دقائق فانه غير حاصل فيه فلا يحتاج الى عمل . (فصل) اذا علمت ان الكسوف يقع نهارا وانه

Figure 5. Text *of Sullam al-Nayyirain*

As for determining the time of the conjunction, as in the existing method in *Zīj-i Sultānī,* the data is taken from the table. The calculation process runs in the same direction by taking variables directly from the table, such as *al-Alamah*, *al-Hishshah*, *al-Khashshah*, *al-Markaz*, and *al-Auj*. The search for the time of the true ijtimak is simply done by calculating the value of corrections such as *Ta'dil al-Khashshah* and *Ta'dil al-Markaz* to obtain *Ta'dil al-Alamah*. (Fahmy, 2019) The average *value of al-Alamah* is then subtracted by *Ta'dil al-Alamah* so that it produces *al-Alamah al-Mu'addalah* or the actual time of the essential conjunction. The final result of this calculation automatically becomes the peak or middle time of the eclipse. (Al-Battawi, 1925, p. 4)

Parallax of the Moon and Sun

The calculation of the parallax and lunar latitude values during an eclipse no longer uses spherical trigonometry formulas such as sine or cosine. *Sullam al-Nayyirain* simplified this process by providing the Rukyat Climate Latitude Table (*Ardh Iqlim ar-Ru'yah*). This table was specially created to lock the geographical location of Batavia at a South Latitude of 6 degrees (Al-Battawi, 1925). The calculation step became very mechanical. The examiner only needs to enter the location of the culmination point (*Al-Aasyir*) from the time of ijtimak into the Latitude of the Rukat Climate. (Al-Battawi, 1925) The results of the latitude are then matched with the Parallax table of the Moon (*Ikhtilaf Manzhar al-Qamar*) to obtain the value of the Difference in Longitude (*Ikhtilaf Ath-Thul*) and the Difference in Latitude (*Ikhtilaf Al-Ardh*). (Al-Battawi, 1925) The union of the parallax values of latitude and theoretical lunar latitude through ordinary addition or subtraction will directly produce a Visible Lunar Latitude (*Ardh al-Qamar al-Mar'i*). (Al-Battawi, 1925)

$$\beta' = \beta \pm \Delta\beta$$

Description:

β' = visible latitude

β = true latitude

Δβ = paralaks lintang

Characteristics of Solar Eclipses

The main characteristic of the calculation of eclipses in *Sullam al-Nayyirain* is the use of *the hisab method of haqiqi bi taqrib*. This system adapts Ulugh Beg's *Zīj-i Sulṭānī* table by simplifying the complexity of spherical trigonometry formulas. The calculation process only needs to use basic arithmetic operations to process instant data from tables such as *al-'Alamah* and *al-Hishshah* without having to master a high level of astronomy. (Fahmy, 2019)

The coordinate parameters in this book have been localized specifically for the archipelago. The calculation markup is locked in Batavia at 6 degrees South Latitude. The determination of the zero point of the longitude meridian does not refer to Greenwich, but to Jaza'ir al-Khalidat (Kenari Islands). The determination of the longitude difference of 142 degrees (equivalent to 9 hours 28 minutes) to Jakarta is very helpful to local researchers because it frees them from the complexity of converting horizon differences. This localization to Batavia is an important proof that the classical algorithm *of Zīj-i Sulṭānī* is not only transmitted in its entirety passively, but adapted to the local context to be relevant to the Muslims of the archipelago.

The initial prediction of the eclipse is confirmed quickly through the reading of the zodiac points or *constellations*. An eclipse is only possible if the *value of hishshshah mu'addalah* is in the zodiac signs of Aries or Libra (worth 6 degrees or less), and Pisces or Virgo (worth 24 degrees or more). The observer is advised to immediately stop the calculation if the value is outside this limit, because the eclipse will certainly not be visible. (Al-Battawi, 1925)

The measurement of the magnitude of the eclipse is carried out using a constant standard. The Sun's disk is absolute standardized to 12 fingers (*ishba'*). The determination of the type of eclipse is purely based on the final value of the Visible Lunar Latitude: the number zero indicates a total eclipse, the number 31 minutes or less indicates a partial eclipse, and a number above 35 minutes means that the eclipse cannot be observed visually. (Al-Battawi, 1925)

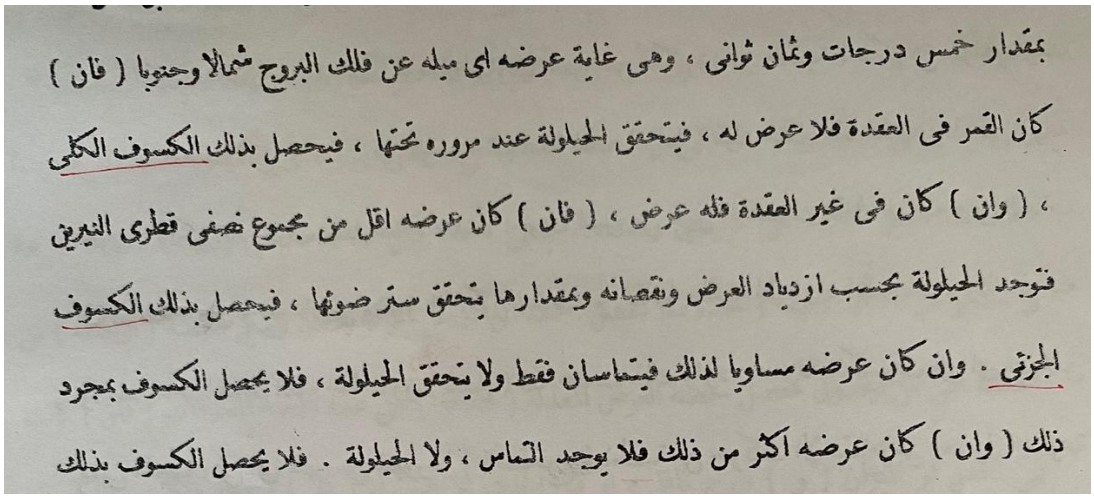

بمقدار خمس درجات وثمان ثوانى ، وهى غاية عرضه اى ميله عن فلك البروج شمالا وجنوبا (فان)
كان القمر فى العقدة فلا عرض له ، فيتحقق الحيلولة عند مروره تحتها ، فيحصل بذلك الكسوف الكلى
، (وان) كان فى غير العقدة فله عرض ، (فان) كان عرضه اقل من مجموع نصفى قطرى النيرين
فتوجد الحيلولة بحسب ازدياد العرض ونقصانه وبمقدارها يتحقق ستر ضوئها ، فيحصل بذلك الكسوف
الجزئى . وان كان عرضه مساويا لذلك فيتماسان فقط ولا يتحقق الحيلولة ، فلا يحصل الكسوف بمجرد
ذلك (وان) كان عرضه اكثر من ذلك فلا يوجد التماس ، ولا الحيلولة . فلا يحصل الكسوف بذلك

Figure 6. Text *of Sullam al-Nayyirain*

KH. Muhammad Manshur's awareness of the dynamics of astronomical science is shown through the embedding of a warning (*Tanbih*) at the end of the treatise. The researcher is required to align the results of theoretical calculations (papers) with the results of empirical observations in the field. This calibration is emphasized because the primary data of Ulugh Beg's legacy is a classic product whose accuracy level will naturally shift with the changing times. (Al-Battawi, 1925)

Comparison of the Two Books

Based on the data that has been obtained, it can be seen that there are several things that can be discussed.

Table 1. Comparison of *Zīj-i Sultānī and Sullan nayyirain*

	Zīj-i Sultan	***Sullam al-Nayyirain***
Eclipse conditions	Based on precise calculation of the degree of the node point and the numerical limit of the space.	Based on the position of the Moon in certain zodiac signs (Aries, Libra, Pisces, Virgo)
Parallax of the Moon and Sun	Using spherical trigonometry and mathematical iteration	Using tables (schedules) that are calibrated specifically for the Batavia region
Classification of eclipses	Describe the three parameters of the eclipse type: Total, Partial and Ring	Simplification becomes a Total and Partial eclipse.
Calculation Location (Markaz)	Universal by converting calculations adjusts the position of the observer	Localization specific to the Batavia region

It can be seen that there are several differences between the calculations of the eclipse version of *Zīj-i Sultānī* and *Sullam al-Nayyirain.* First, the conditions for the eclipse to occur are explained in *Zīj-i Sultānī* in detail, this shows that at that time the understanding of the position of celestial bodies was very good. Furthermore, when this knowledge reached the archipelago, with the traditions, culture, and social and intellectual life of the Islamic archipelago, these calculations were adapted. In the book *Sullam al-Nayyirain, the* conditions for a solar eclipse to occur are explained in a more easily understood way that a solar eclipse is possible if the conjunction takes place in one of the 4 zodiac signs, namely Aries, Libra, Pisces, and Virgo. These zodiac signs are the position of the node points formed between the ecliptic line and the equator.

Second, the apparent position of the Moon and the Sun is an important aspect in determining the observed timing of the solar eclipse. This is related to the handling of parallax (*ikhtilaf al-manzar*). Parallax is a correction that is needed because the position of the Moon observed from the Earth's surface (topocentric position) is different from the position of the Moon calculated from the center of the Earth (geocentric position) (Meeus, 1998). This correction determines whether an eclipse is really observed somewhere, when it is, and how much coverage it has. *Zīj-i Sultānī* provides two ways to determine the timing of a solar eclipse, namely the tabular method and the calculation. In addition, *Zīj-i Sultānī* offers a more modern method of calculation if a higher level of accuracy is desired. This method applies the concept of spherical trigonometry, in which the parallax values of the latitude and longitude of the Moon are calculated directly based on the distance of the zenith, declination, and latitude of the observer. Meanwhile*, Sullam al-Nayyirain* contains parallax calculations using the table method only. This approach will simplify the calculation process because the data of celestial bodies that require trigonometry calculations have been provided in the table. Therefore, the logic of calculation in *Sullam al-Nayyirain* simply uses arithmetic such as addition, subtraction, division, and multiplication. However, with the available celestial body data, the resulting data tends to be static even though some corrections *(ta'dil) have been made.* In other words, the parallax table in *Sullam al-Nayyirain* is actually the result of the trigonometric calculations of *Zīj-i Sultānī.*

Third, in terms of the classification of eclipse types, *Zīj-i Sultānī* seems to distinguish solar eclipses into three more detailed categories. This category includes differences in the degree of coverage of the Sun's disk, namely partial, ring eclipses and total duration and without duration (*mucus*). This shows that the importance of astronomy at that time was to achieve the most accurate description possible. For example, distinguishing between total duration and non-duration indicates that *the preparation of Zīj-i Sultānī* paid attention to the distance between the Earth-Moon-Sun at the time of conjunction (ijtimak) which affects the magnitude of the diameter of the disks of the Moon and the Sun, so that the duration can also vary. *Sullam al-Nayyirain* simplified this classification into a more concise category, namely total and partial

eclipses. This simplification of classification seems to prioritize practicality, so that the calculation is easier to apply by the Muslims of the archipelago.

The meaning of these three differences shows that the development of astronomy in the archipelago is oriented towards practical values. Astronomical knowledge was initially explained in a complex way packaged into calculations that are easier to understand. This proves the independence of local scholars in adapting complex classical astronomical algorithms, becoming a functional and easy-to-apply typical Hisab method of the archipelago.

Benefits and Implications

The study of the structure and logic of the solar eclipse hisab in classical books has had a significant impact on the development of astronomical treasures in Islamic civilization in Indonesia. The *Zīj-i Sultānī* calculation method is not applied in its entirety as it is, but involves an adaptation process. This adaptation can be seen from the adjusted aspects, namely the use of the zodiac to mark the possibility of an eclipse. This can make it easier for the Muslim people of the archipelago to remember when a solar eclipse will occur. Furthermore, the data in the *'ard al-rukyat climate table* has been calculated based on Betawi coordinates. By understanding the way of thinking of previous Muslim scientists, the research was not only able to reconstruct the calculation procedures they used, but also uncovered the epistemological foundations behind parameter selection, algorithm simplification, and method adaptation at the time. This understanding shows that the development of astronomy in the archipelago is the result of a dynamic transformation process. Specifically, this transformation is evidenced through: the basic structure of the ijtimak time-determination algorithm that is maintained, the complexity of parallax trigonometry and simplified eclipse classification, as well as coordinate reference points tailored specifically for the Batavia region. By detailing the transformation pattern, this study provides a new perspective for the historiography of astronomy in Indonesia.

CONCLUSION

This study shows that the structure of the solar eclipse calculation in *Sullam al-Nayyirayn* has a strong epistemological continuity with *Zīj-i Sultānī*, especially in the basic structure of determining ijtimak or conjunction and the use of astronomical parameters that are the basis for eclipse prediction. However, this relationship is not entirely reproductive. Comparative analysis shows that there is a methodological reconstruction in *Sullam al-Nayyirayn*, especially in the formulation of eclipse conditions, the processing of parallax and the apparent position of the Sun–Moon, as well as the simplification of parameters to determine the characteristics and types of eclipses. The most notable difference is seen in the classification of eclipses, when *Zīj-i Sultānī* provides a mechanism for distinguishing partial, total, and ring eclipses, while *Sullam al-Nayyirayn* uses a simpler classification structure.

These findings show that the transmission of astronomical knowledge from the *Samarkand zīj* tradition to the archipelago falak tradition did not take place as a passive transfer of the method. *Sullam al-Nayyirayn* retained the fundamental

elements of the previous astronomical system, while at the same time selection, simplification, and adaptation to its computational procedures. This transformation can be seen, among other things, in the shift from relatively complex geometric and trigonometric calculations to the use of astronomical tables that are more operational and adapted to the needs of local calculations, including parameters related to Batavia.

This simplification is therefore more appropriately understood as a form of methodological adaptation than intellectual regression. Changes in the computational structure allow classical astronomical knowledge to be used more practically in the educational and practice environment of astronomy in the archipelago without having to reproduce all the mathematical complexity of its source of origin. From an epistemological perspective, *Sullam al-Nayyirayn* represents an active process of knowledge transmission, namely through selection, appropriation, simplification, and reconstruction of methods.

Thus, the relationship between *Zīj-i Sultānī* and *Sullam al-Nayyirayn* shows a continuity as well as a transformation in the history of Indonesian astronomy. *Sullam al-Nayyirayn* is not just a local reproduction of *Zīj-i Sultānī*, but a form of localization of classical Islamic astronomical knowledge that maintains its epistemic structure while adapting its computational methods to the intellectual context and practical needs of the archipelago's astronomical society. These findings strengthen the understanding that the development of Indonesian astronomy was formed through a creative process in accepting and processing the heritage of classical Islamic astronomy.

ACKNOWLEDGEMENTS

The author expresses his highest appreciation to all parties who have provided intellectual support and research room facilities during the preparation stages of this research. Special gratitude is addressed to the leaders of the institution and colleagues who always open a productive discussion space related to the transmission of archipelago falak literature.

REFERENCES

Al-Battawi, M. M. (1925). *Sullam al-Nayyirain*. Al-Falah Ploso.

Azhari, S. (2005). *Ensiklopedi hisab rukyat*. (Query date: 2023-08-24 21:20:11).

Azhari, S. (2018). *Tracing the Concept of Fajr in the Islam Mosaic and Modern Science*. Syarif Hidayatullah State Islamic University Jakarta. https://garuda.kemdikbud.go.id/documents/detail/2173858

Azhari, S., & Wardan, H. (2007). Hisab dan Rukyat, Wacana untuk Membangun Kebersamaan di Tengah Perbedaan, Yogyakarta: Pustaka Pelajar, Cet. *Ke I*. (Query date: 2023-08-24 21:20:11).

Beg, U. (n.d.). *Zīj-i Sultānī*. https://archive.org/details/ldpd_15264398_000/mode/2up

Bin Jani, M. F., bin Sulong, J., & Aziz, A. H. A. (2016). Sumbangan Kitab Sullam Nayyirain dalam Hitungan Gerhana di Nusantara. *Journal of Al-Tamaddun*, *11*(1). https://doi.org/10.22452/JAT.vol11no1.3

Fahmy, S. R. (2019). *Pengaruh Pemikiran Ulugh Beg (Zij as-Sulthoni) Terhadap Hisab Awal Bulan dalam Kitab Sullamun Nayyraen*. Universitas Islam Negeri Walisongo Semarang.

Fatoohi, L. J., Stephenson, F. R., & Al-Dargazelli, S. S. (1998). The Danjon limit of first visibility of the lunar crescent. *Observatory*, *118*(1143), 65–72. Scopus.

Fazlioğlu, İ. (2008). The Samarqand Mathematical-Astronomical School: A Basis for Ottoman Philosophy and Science. *Journal for The History of Arabic Science*, *14*, 3–68.

Ghanbari, J., Karimian, M., Babaeian, I., & Motiei, M. (2013). Study of meteorological parameters effects on lunar crescent visibility using a genetic algorithm. *Journal of the Earth and Space Physics*, *38*(4), 259–271. Scopus.

Hidayat, E. (2020). Penentuan Jumlah Gerhana Matahari dengan Argumen Lintang Bulan dan Teori Aritmatika. *Miyah*, *16*. https://doi.org/10.33754/miyah.v16i1.139

Hj Wan Yussof, W. N. J., Man, M., Umar, R., Zulkeflee, A. N., Awalludin, E. A., & Ahmad, N. (2022). Enhancing Moon Crescent Visibility Using Contrast-Limited Adaptive Histogram Equalization and Bilateral Filtering Techniques. *Journal of Telecommunications and Information Technology*, *2022*(1), 3–13. Scopus. https://doi.org/10.26636/jtit.2022.155721

Izzuddin, A. (2007). *Fiqh Hisab Rukyat*. Erlangga.

Judhistira, J., Indonesia, U. P., Ramalis, T., & Indonesia, U. P. (2016). *Parameter-Parameter Fisis Visibilitas Hilal (Contribution of Some Factors to the Sky Twilight Brightness and Their Influences on Minimum Value of the Physical Parameters of the Lunar Crescent Visibility)*. (November 2014).

Kalu, C. O., Chidi-Kalu, E. I., & Mafe, T. A. (2021). Research data management in an academic library. In *Handbook of Research on Information and Records Management in the Fourth Industrial Revolution*. https://doi.org/10.4018/978-1-7998-7740-0.ch003

Kennedy, E. S. (1956). Parallax Theory in Islamic Astronomy. *Isis*, *47*(1), 33–53. https://doi.org/10.1086/348454

Lewis, M. (2018). Libraries and the management of research data. In *Envisioning Future Academic Library Services*. https://doi.org/10.29085/9781856048750.011

Li, L. (2019). New Astronomy in Service of Old Astrology: Close Planetary Conjunctions in Pre-Modern China. *Journal for the History of Astronomy*, *50*(4), 411–427. Scopus. https://doi.org/10.1177/0021828619866328

Mansur, M. (n.d.). *Sullam al-Nayyirain*. Ma'had Al-Islam Al-Salafi Mahir al-Riyadl.

Meeus, J. (1998). *Astronomical Algorithm* (2nd ed.). Wilmann-Bell.

Mikhail, J. S., Asaad, A. S., Nawar, S., & Hassanin, N. Y. (1995). Visibility of the new Moon at two sites I: Maryland situated at northern geographical latitude. II: Sacramento peak situated at high altitude above sea level. *Earth, Moon, and Planets*, *70*(1–3), 93–108. Scopus. https://doi.org/10.1007/BF00619454

Rahmawati, N., Nurussaadah, A., Firman, J. M., & Aliyah, F. N. (2026). Transmission of Eclipse Calculation Science: From the Wabkanawi Annular Eclipse Prediction to Adaptation of Calculation in the Archipelago. *Proceedings of International Conference on Islamic Civilization and Humanities*, *4*, 500–511. https://proceedings.uinsa.ac.id/index.php/iconfahum/article/view/4773

Ridwan. (2022). *Kontestasi Mazhab Hisab dan Rukyat di Indonesia*. Pustaka Ilmu.

Ridwan, I. (2020). Harmoni, Disharmoni, dan Integrasi Antara Sains dan Agama. *Jurnal Filsafat Indonesia*. (Query date: 2024-09-15 11:23:26).

Said, S. S., & Stephenson, F. R. (1991). Accuracy of Eclipse Observations Recorded in Medieval Arabic Chronicles. *Journal for the History of Astronomy*, *22*(4), 297–310. https://doi.org/10.1177/002182869102200403

Sakirman, S. (2018). Konstruk Sosial dalam Konvergensi Hisab dan Rukyat. *NUANSA: Jurnal Penelitian Ilmu Sosial Dan Keagamaan Islam*, *14*(2), 275. https://doi.org/10.19105/nuansa.v14i2.1636

Sakunov, G. G., Timirev, A. A., & Barteneva, O. D. (1990). Aerosol optical characteristics of the Arctic atmosphere. *Sov. Meteorol. Hydrol.*, *2*, 53–58.

Saliba, George. (1987). Theory and Observation in Islamic Astronomy: The Work of Ibn al-Shātir of Damascus. *Journal for the History of Astronomy*, *18*(1), 35–43. https://doi.org/10.1177/002182868701800102

Shobri, M. T. (2014). Kitab Sullam an-Nayyirain dalam Tinjauan Astronomi Modern. *An Nisa'a*, *9*(2), 43–60.

Thomas Djamaluddin. (2005). *Menggagas Fiqih Astronomi*. Kaki Langit.

Van Dalen, B. (1993). *Ancient and Mediaeval Astronomical Tables: Mathematical Structure and Parameter Values*. Universiteit Utrecht, Faculteit Wiskunde en Informatica.