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DIFFERENCES IN SALAT TIME RECORDING: Analytical Method of Kitab al-Khulashah al-Wafiyyah and Contemporary

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Abstract: The discussion on calculating Islamic prayer (*salat*) times contained in the *Kitab Khulashah* has its characteristics. The calculation process of *salat* beginning times has referred to the triangular ball algorithm system. Besides, there are also *daqoiqut tamkin* corrections presented through tables and calculator calculation methods. This interesting calculation can be studied; how the transformation system of *salat* time coordinates and the accuracy level of the salat beginning times calculation results. This study uses a library research paradigm with a qualitative theory verification approach using an arithmetic approach, and the results are presented descriptively, then compared with similar methods. The results show that the coordinate transformation refers to the modern astronomical system, and the calculation system has used spherical trigonometry (spherical triangle). The calculation results differ from 0 to 3 minutes with contemporary methods. Differences in data and methods cause it. Suppose the calculation is using the contemporary method. In that case, there is a difference of 0 seconds to 12 seconds. This indicates that modifications to the contemporary calculation system will produce a more accurate calculation when the calculation is made.

Diskusi atas hisab waktu salat yang tertuang di kitab khulashah mempunyai khas tersendiri, karena dalam proses perhitungan awal waktu salat telah mengacu sistem algoritma segitiga bola, selain itu juga terdapat koreksi *daqoiqut tamkin* yang disajikan melalui tabel, dan metode perhitungan menggunakan alat bantu kalkulator. Ini sangat menarik untuk dilakukan penelitian. Terdapat beberapa hal yang dapat dikaji; bagaimana sistem transformasi koordinat waktu salat dan bagaimana tingkat akurasi hasil perhitungan awal waktu salat. Penelitian ini menggunakan paradigma *library research* dengan pendekatan verifikasi teori yang bersifat kualitatif dengan menggunakan pendekatan *arithmetic* dan hasilnya disajikan secara deskriptif, kemudian dibandingkan dengan metode yang sejenis. Hasil penelitian menunjukkan bahwa transformasi koordinat telah mengacu pada sistem astronomi modern dan sistem perhitungan telah menggunakan *spherical trigonometri* (segitiga bola). Hasil perhitungan terdapat selisih mulai dari 0 sampai 3 menit dengan metode kontemporer. Ini karena adanya perbedaan data serta cara. Jika perhitungan dengan menggunakan cara kontemporer terdapat selisih

0 detik sampai 12 detik, ini menunjukkan bahwa ketika perhitungan dilakukan modifikasi ke dalam sistem hisab kontemporer akan menghasilkan hisab yang lebih akurat.

Keywords: al-Khulashah; Salat; Accuracy

INTRODUCTION

Advances in science and technology trigger people to follow developments from all aspects of life[1]. Likewise, Indonesia's science of astronomy (*falak*) or calculation (*hisab*) has now experienced many developments.[2] This can be seen from the emergence of astronomical data in software such as Starry Night Pro 6, Jean Meeus' Astronomical algorithms, Ephemeris software Version 2.0, Salat Time, and Accurate Times, which have been tested as accurate[3] data and will continue to experience changes. Observations of the positions of celestial bodies, including the sun, moon, planets, and stars, as a reference, heavily influence these changes. Besides, there is a factor of finding astronomical instruments used to make observations accurately[4], which results in the level of accuracy of calculations (*salat* times).

The invention of modern and sophisticated *hisab* tools has implications for accuracy in calculations that are more precise and accurate. This will make it easier for users to determine the start of the *salat* time. Therefore, it is necessary to carry out a continuous study of the calculation results to be used as a reference or guideline for calculating at the *salat* beginning times, especially in the study of the classic astronomy books (*falak*)[5]. The determination of the start of the *salat* times, which is the main point of reference, is the high position of the sun when it is at the zenith, crossing the meridian, rising, setting, dawn, and dusk[6].

One kitab that examines the relation of salat times in depth is *Kitab al-Khulashatu al-Wafiyyah*. This *kitab* is a classic astronomy book that uses There is an exciting side when completing the calculation of *salat* beginning times, especially in the calculation process that uses a logarithmic system, namely by adding,

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1 Arino Bemi Sado, "Waktu Shalat Dalam Perspektif Astronomi; Sebuah Integrasi Antara Sains Dan Agama," *Muamalat Jurnal Hukum Ekonomi Syariah* VII (2015): 69–83.

2 Susiknan Azhari, "Tracing The Concept of Fajr In The Islam Mosaic And Modern Science," *Ahkam: Jurnal Ilmu Syariah* 18, no. 1 (January 12, 2018).

3 Ahmad Fadholi, "Analisis Komparasi Perhitungan Waktu Salat Dalam Teori Geosentrik Dan Geodetik" (Institut Agama Islam Negeri Walisongo Semarang, 2013).

4 Abdul Majid Amirudin et al., "Analisis Metode Hisab Kontemporer Terhadap Jam Istiwa' (Studi Penentuan Awal Waktu Salat Di Fathul Ulum Kediri)," *Antologi Hukum* 1, no. 2 (2021): 97–116.

5 Zainuddin, "Posisi Matahari Dalam Menentukan Waktu Shalat Menurut Dalil Syar'I," *Elfalaky* 4, no. 1 (2020): 36–55, https://doi.org/10.24252/ifk.v4i1.14166.

6 Haliah Ma'u, Dahliah, "Waktu Sholat Pemaknaan Syar ' I Ke Dalam Kaidah Astronomi," *Jurnal Hukum Islam* 14, no. 2 (2015): 269–85; Rizal Mubit, "Formulasi Waktu Salat Perspektif Fikih Dan Sains," *Al-Marshad: Jurnal Astronomi Islam Dan Ilmu-Ilmu Berkaitan* 3, no. 2 (December 30, 2017), https://doi.org/10.30596/jam.v3i2.1527.

subtracting, dividing, and multiplying as the calculations use the help of a calculator to make it easier to convert the log into degrees.

Based on the explanation, exciting to conduct a study of the method of *hisab* the *salat* beginning times in the classic book, *kitab Khulasah,* from the aspect of the algorithm, in terms of *Falak* science, calculation systems, sun altitude, and accuracy of calculations when juxtaposed with contemporary *hisab* "Ephemeris *Hisab Rukyat*" Ministry of Religion of the Republic of Indonesia.

Research and study of *salat* times have been carried out by previous researchers, including Ani Zaidatun Ni'mah's research.[7] The research concluded that based on the results of the verification test for the results of the calculation of the *Kitab Khulasha* by observing the position of the sun's shadow, there are 0-3 minutes. This research did not explain how the coordinate transformation system works in calculating *salat* times and the zenith position of the sun. Meanwhile, the research conducted by Ismail from his research's results, concluded that there was an effect of altitude on the results of determining the *salat* beginning time this was due to geographical differences[8]. However, this research did not describe the zenith position of the sun, as well as refraction, low horizon, horizontal parallax, and semi-diameter of the sun.

Abdul Majid Amirudin study concluded that the system for determining *istiwa'*ss time at the Islamic Boarding School Fathul Ulum Kediri differs However, there are still significant differences because the data contained in *kitab* is still in the *taqrubi* category[9].

In addition, Arino Bemi Sado's research concluded that science hasan essential role in translating the Koran about the high position of the sun as determining the *salat* beginning times. Likewise, M. Basthoni's research "*A Prototype of True Dawn Observation Automation System*" concluded that there are three terms in the appearance of dawn. Astronomical dawn is when the sun is at 108° zenith, nautical dawn is when it is 102°, and civil dawn is at 96° [10]. Therefore, from the results of automatic observations of dawn occurring, it was found that the

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7 Ani Zaidatun Ni'mah, "Uji Verifikasi Perhitungan Awal Waktu Salat KH. Zubair Umar al-Jailani Dalam Kitab al-Khulasah al-Wafiyah" (Thesis, Semarang, IAIN Walisongo, 2013), http://eprints.walisongo.ac.id/id/eprint/1034/; Amirudin et al., "Analisis Metode Hisab Kontemporer Terhadap Jam Istiwa ' (Studi Penentuan Awal Waktu Salat Di Fathul Ulum Kediri)."

8 Ismail, "Metode Penentuan Awal Waktu Salat Dalam Perspektif Ilmu Falak," *ISLAM FUTURA* 14, no. 2 (2015): 218–31; ABD Karim Faiz Faiz and Wahidin Wahidin, "Prayer Time Variations: Case Study of Mosques in Parepare City in the Perspective of Contemporary Hisab and Islamic Law," *Elfalaky: Jurnal Ilmu Falak* 6, no. 2 (December 7, 2022): 207–29, https://doi.org/10.24252/ifk.v6i2.32727.

9 Amirudin et al., "Analisis Metode Hisab Kontemporer Terhadap Jam Istiwa' (Studi Penentuan Awal Waktu Salat Di Fathul Ulum Kediri)."

10 M. Basthoni and Hendro Setyanto, "Typology of Dawn Light Curves in High and Low Light Pollution Areas," *AIP Conference Proceedings* 2391, no. January (2022), https://doi.org/10.1063/5.0073949.

sidik dawn appears when the sun's altitude is -20° below the horizon[11]. Furthermore, the results of Tono Saksono's research showed that the dawn time so far in Indonesia is too early or earlier. This is based on the observations of *sidik* dawn, namely when the sun feels -14° below the horizon[12].

Some of the studies above still discuss the sun's position, especially at dawn, even though Kitab Khulasah has been explained in detail in *fiqh* and astronomy studies. Thus, it can be concluded that there is a very fundamental difference between this study and the previous one. The difference lies in calculating the data and the algorithm used to calculate the *salat* beginning times. This study is also vital in making the *kitab* a reference in calculating *salat* times and having precise accuracy.

This study is categorized as library research because it is carried out by studying *Kitab Khulasah* with a qualitative method paradigm and an arithmetic approach. This method reviews the method of *Hisab Khulasah* in calculating the *salat* beginning times. Moreover, presentation is narrative by describing and describing. This study intends to examine how to calculate the beginning of *salat* times in *Kitab Khulasah* and Contemporary books. It explains how accurate calculations are to determine the position of the sun's height at the time of *salat* and its scientific significance. It adds to the scientific treasures of astronomy in the theory and application of the calculation of *salat* beginning times.

KITAB AL-KHULASHAH AL-WAFIYYAH

The history of astronomy (ilmu falak) development in Indonesia has progressed from time to time[13]. The beginning of the emergence of *Falak* Science in Indonesia was marked by the birth of several books on *Falak* Science, including; *Mathla'u al-Sa'id, Minhaj al-Hamidiyah, Fath al-Rauf al-Mannan, Ittifaq Dzat al-Bayn, Sullam al-Nayyirain, Nurul Anwar, ad-Durus al-Falakiyyah, al-Khulashah al-Wafiyyah, at-Tibyan al-Miqat, and Syawariq al-Anwar*. This is an exciting treasure in the progress and development of *Falak* science in Indonesia. The existence of contemporary Hisab systems such as New Comb, Jean Meeus, Nautical Almanac, Ephemeris Hisab Rukyat, and Ministry of Religion of the Republic of Indonesia marked subsequent developments. In the industrial revolution era, astronomy penetrated the digital world.

Technological developments do not reduce the number of practitioners studying classical *kitab falak*. The uniqueness of the classics has its attraction to

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11 M Basthoni, "A Prototype of True Dawn Observation Automation System," *Jurnal Sains Dirgantara* 18, no. 1 (2020): 33–42, https://doi.org/10.30536/j.jsd.2020.v18.a3475.

12 Tono Saksono and Mohamad Ali Fulazzaky, "Predicting the Accurate Period of True Dawn Using a Third-Degree Polynomial Model," *NRIAG Journal of Astronomy and Geophysics* 9, no. 1 (2020): 238–44, https://doi.org/10.1080/20909977.2020.1738106.

13 H.G. Den Hollander, *Ilmu Falak* (Jakarta: J.B. Wolters., 1951); Muhyiddin Khazin, *Kamus Ilmu Falak* (Yogyakarta: Buana Pustaka, 2005).

study. *Kitab al-Khulashah al-Wafiyyah* is one of the unique and exciting classic books. This astronomy book is known for the accuracy of its calculations, even though its compilation was carried out in the 1930s by Zubair bin Umar bin al-Jaelany under the name "*al-Khulashah al-Wafiyyah Fii al-Falak Bijadawali al-Logharitmiyyah*."[14] *Kitab Khulasah* contains various discussions within the scope of astronomy that are different from other astronomical books, especially in the *hisab* of the *salat* beginning times, which in its calculation system has already used several rules in astronomy and mathematics, as well as relatively recent astronomical data.

In addition, *kitab Khulasah* has referred to the formulas for spherical geometry (trigonometry), so the results will be thorough and accurate. The calculation process still uses a straightforward method. In transforming the coordinate system, the term is still used; *bu'dul qutur, ashlul muthlaq, nishful fudllah* of the sun, *daqaiqut tamkin, ashlul muthlaq, nisfu qaus nahar wa-thuhur*. The calculation system can use the calculating tool, *Rubu' Mujayyab,* which is in the form of a quarter circle, even with a calculator as an instrument to make the process of *hisab* easier.

Calculating *kitab khulasah* at the beginning of *Maghrib* time is based on the time of 18.00, then adding *daqoiqut tamkin* and *nishful fudllah*. This is instead of refraction and semi-diameter and does not consider the altitude. For the time of *Isha'*, the sun's altitude is -17° added by the *bu'dul qutur*, while at *Subuh,* the sun's position is -19° below the horizon, and the *bu'dul qutur* is added.

The *hisab* process of *salat* times in *kitab Khulasah* is not much different from contemporary *hisab*, and it's just that *urfi* is still used to get the declination. However, *kitab Khulasah* also provides a process for obtaining true declination-*tahkiki*, with a long process. Thus, it is appropriate if there are differences with contemporary data. Besides, it has not considered the height of the place in the *hisab* process.

Apart from that, what is even more interesting to get the *daqoiqut tamkin* (refraction, low horizon, horizontal parallax, and semi-diameter of the sun) as a correction for *Maghrib, Isha'* and *Subuh* times is by looking at the table to obtain an excellent, accurate result, and still relevant and appropriate for use today. If an update is made by converting a contemporary calculation system, it will get more accurate results.

Kitab Khulasah not only explains the determination of *Qibla* direction, the start of *salat* times, the beginning of the Hijri month, and eclipses but also discusses the size of the earth, moon, sun, stars, and their movements. In addition, it also explains the *dairah al-Bujri* (12 constellations), the equator, horizon, meridians, the apparent circulation of the sun, moon, and the planets Mercury, Venus, Mars,

[14] Ahmad Izzuddin, *Zubaer Umar Al-Jaelany Dalam Sejarah Pemikiran Hisab Rukyat Di Indonesia* (Semarang: DIPA IAIN Walisongo Semarang, 2002). 58

Jupiter, Saturn, and the movement of the earth's circulation, average time, and real-time[15].

The Preface of *kitab Khulasah* explains the science of astronomy. It contains the history of the first discoverer of *falak* (Prophet Idris as.), the development of astronomy, the view of the geocentric theory (Ptolomeus), the heliocentric theory[16] (Copernicus), the Kepler concept, which emphasized the heliocentric theory, to scientists like Newton, Galileo which comprehensively explained general astronomy, calculation of the motion of the planets. In addition, it also contains *falak fiqh* based on four schools of thought, supplemented by *maqayis* treatises in Islamic law, regarding measurements and weights (dinars, dirhams, liters, grams, *mizan*, kilograms *nishab*)[17]. There is a particular discussion of comets and a timetable for comets that can be seen on earth (falling) and the Milky Way, discussing how the stars form and their position[18].

In *Kitab Khulasah,* several tables still use jumali letters, such as searching for days. The *jumali* letters[19] are compilated in poetry;(أبجد هوز حطي كلمن # سعفص قرشت ثخذ ضظغ). Each letter in the poem has a numerical value from units, tens, hundreds, and thousands. The letter ا is worth 1, ب is worth 2, ي is worth 10, ق is worth 100 and غ is worth 1000, and so on. It should be noted that the table uses special symbols and abbreviations, such as (م) the symbol for *yaum*, (ت) the symbol for *sa'ah*, (ح) the symbol for degrees and the zodiac (*Buj*), (ق) the symbol for the minute (دقيقة), while (ى) second symbol, (ثوانى) ('') second (ثوالث) (“), sixty seconds (روابع), (°) degree symbol, (') minute symbol, (“) second symbol[20].

POSITION OF THE SUN AT *SALAT* TIMES

The sun every day seems to revolve around the earth. It seems to rise from the eastern horizon until it transits at the highest altitude, then sets on the western horizon. What is meant by transit is when the sun is right on the meridians. During transits, the sun has an hour angle equal to 0°, and humans can learn from this regularity[21].

At first glance, these celestial bodies appear to be in the curvature of the sky that stretches as if above us, with buildings whose shape looks like a hemispherical circle. By observing the sun, moon, and stars that appear and set regularly, which

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15 Zubair Umar Al-Jailani, *Al-Khulashah al-Wafiyah* (Surakarta: Melati, n.d.). 20-32

16 The Heliocentric theory is a theory that is the opposite of the geocentric theory. This theory posits the sun as the center of the circulation of the celestials bodies. Al-Jailani. 28

17 Al-Jailani. 199-209.

18 Al-Jailani. 170-173.

19 The jumali number is the number used for calculating by the scholars in the past as astronomical data for celestial bodies. Look Khazin, *Kamus Ilmu Falak*, 2005. 41

20 Al-Jailani, *Al-Khulashah al-Wafiyah*. 113

21 Rinto Anugraha, *Mekanika Benda Langit* (Yogyakarta: Universitas Gadjah Mada, 2012). 63.

do not experience change every day. While we seem to be in the middle, this is the celestial sphere[22].

The position of celestial bodies is always determined by the circle of the principal and origin points because the celestial sphere consists of three known circles: the horizon circle, the equator circle, and the ecliptic circle. Then celestial bodies can be expressed in a coordinate system, depending on the intended base and origin[23]. The circle of the celestial sphere is formed by the sun's annual path (apparent motion of the sun). The ecliptic is a circle drawn from the apparent yearly motion of the sun so that the sun will always appear on the ecliptic circle. In this circle, the sun will constantly shift from west to east. The sun has a delay of 36" years to arrive at the point of Aries (vernal equinox). However, because the track is not entirely flat, it results in a slight shift. Conditions like this can occur and can be seen from the latitude of the ecliptic because its value will always be close to zero.

The sun's position at *salat* times is closely related to the horizon coordinate system. This system is the primary internal reference because it is the center of the observer's position on the earth's surface[24]. The observer's position affects the position of the celestial bodies. This illustrates that we are as if we are on a large ball and form a flat plane with us. All will form the same distance from right to left, forward and backward. In this, as if heaven and earth meet[25]. The circle that passes through the UTSB is the horizon or horizon circle.

The horizon coordinate system includes azimuth, the height of the celestial bodies or stars, and the zenith distance of the stars (*bu'du as-sumti*). The zenith distance of a star is the distance from the zenith point to the star's center as measured by a vertical circle passing through the star's center. The letter Z denotes the zenith distance. The smallest zenith distance is 0° when it is at the zenith point. However, the most significant zenith distance is 180° when it is at its *nadir*.

The Azimuth star is the angle formed by the center point connecting north through east, clockwise along the horizon[26]. The azimuth is the angle formed by the observer line connecting the north point (PU line) and the line, which projects the celestial body M on the horizon (point m) or equal to the arc Um. The first measurement from north (U) to east traces the horizon from 0° to 360°. If it is 90°,

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22 Slamet Hambali, *Ilmu Falak I Penentuan Awal Waktu Salat Dan Arah Kiblat Seluruh Dunia* (Semarang: PPS. IAIN Walisongo, 2011); Encep Abdul Rojak, Ilham Mujahid, and Muhammad Yunus, "The Accuracy of Online-Based Prayer Times Applications," *Ijtihad : Jurnal Wacana Hukum Islam Dan Kemanusiaan* 21, no. 1 (June 30, 2021): 21–38, https://doi.org/10.18326/ijtihad.v21i1.21-38. 34.

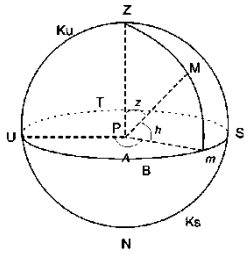
23 Anugraha, *Mekanika Benda Langit*. 53.

24 Anugraha. 53.

25 Hambali, *Ilmu Falak I Penentuan Awal Waktu Salat Dan Arah Kiblat Seluruh Dunia*. 41.

26 Djawahir Fahrurrazi, *Sistem Acuan Geodesi Dari Bigbang Sampai Kerangka Acuan Terestrial* (Yogyakarta: Gadjah Mada Universitas Press., 2011). 14.

the latitude is located on the principal vertical circle, the vertical circle that passes through the east and west points.



The star's height is the angle formed by the line that meets the center point projected by the star and the line that meets the center point of the star. The altitude (star) above the horizon is positive from 0° to + 90° and below the horizon is negative between 0° to -90°[27].

From the explanation above, the sun's height is a component of the parameters determining *salat* times. If the zenith distance is > 90°, then the height of the celestial body is < 0°, or the celestial body is below the horizon. For example, a distance of 108° equals an altitude of -18° (90+18), and a distance of 110° equals an altitude of -20°. When a celestial body sets, the height of the celestial body is, 0° or the zenith distance is 90°. However, when observing the phenomenon of setting celestial bodies, such as the sun and moon, it is necessary to correct refraction with an average of 34'. The semi-angular diameter of the sun and moon is 16'[28]. The low horizon (*ikhtilaf* horizon. This occurs due to the altitude position of the geographical location of the observation that affects the horizon (*ufuk*)[29]. There are three horizons, namely *Cakrawala Sejati* or true horizon (*ultimate horizon*), *Cakrawala Palsu* or false horizon (*ufuk hissi*), *Cakrawala Pandang* atau horizon viewing (*ufuk mar'i*)[30]

FORMULATION OF *SALAT* TIMES

There are several stages in calculating the *salat* beginning times in *kitab Khulasah*, including;

1) *Thulu syamsi* (*ecliptic longitude)*
   Thulu syamsi is the calculated distance from 0[b]=(0°) until the sun passes through the ecliptic circle counterclockwise. The determination of the *sun's constellation is* expressed by the constellation ([b]) and degrees (°). Every 1[b] is worth 30°, every 1° is worth 60', and every 1' is worth 60' because the longitude of the sun (BM) starts from 0[b] 0°, then the order of *asad* (Leo) constellation means BM 4[b] 10°, and so on[31].

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27 Simamora, *Ilmu Falak Kosmografi* (Jakarta: CV. Pustaka Bangsa, 1985). 8.

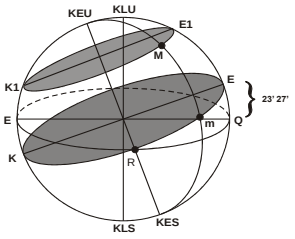
28 Jean Meeus, *Astronomical Tables of the Sun, Moon and Planets* (Virginia: Williamn-Bell Inc, 1983). 101

29 Imam Qusthalaani, "Kajian Fajar Dan Syafaq Perspektif Fikih Dan Astronomi," *Mahkamah : Jurnal Kajian Hukum Islam* 3, no. 1 (2018): 1, https://doi.org/10.24235/mahkamah.v3i1.2744.

30 Khafid, "Modul Kuliah Astronomi Dan Hisab Kontemporer" (Semarang: Pascasarjana IAIN Walisongo, 2012); Nailur Rahmi and Firdaus Firdaus, "An Analysist of Sa'adudin Djambek's Hisab Method About All The Time of Praying Schedule," *Al-Hilal: Journal of Islamic Astronomy* 2, no. 1 (April 30, 2020), https://doi.org/10.21580/al-hilal.2020.2.1.5588.

31 Hambali, *Ilmu Falak I Penentuan Awal Waktu Salat Dan Arah Kiblat Seluruh Dunia*. 84

Thulu Syamsi is related to the ecliptic coordinate system, which explains the position of celestial bodies, including ecliptic longitude and ecliptic latitude[32]. Look at the following picture:



Information; E-R-Q is the celestial equator, K-R-m-E is the ecliptic which forms an angle of 23° 27' with the equator, K1-M-E1 is the ecliptic latitude circle., KEU-M-m-KES is the ecliptic longitude circle, R is the aries point, R-m is the ecliptic longitude, m-M is the ecliptic latitude.

Ecliptic longitude is known as astronomical longitude, or *takwim* or *thul*. The data is the longitude of the sun or *thulu asy-shams*, which is the distance from the sun starting at the Aries point (vernal equinox), measured as far as the ecliptic circle with the direction of the ecliptic arrow to the star projection at the ecliptic 0-360°.[33]

Ecliptic latitude, known as astronomical latitude or known as *ardhu syams*, is the distance from the sun's center point to the ecliptic circle. This is the annual apparent motion of the sun. The arc distance in the astronomical latitude that passes between stars whose projection is on the ecliptic is 0°-90° to the north or 0°-90° to the south.[34]

The sun's journey on the ecliptic is uneven. It moves north and south and will always be close to 0°. The ecliptic latitude circle is obtained by making a large circle, connecting KEU and KES through a star.[35]

On March 21, the longitude of the sun = 0^{b} 0°, and on June 21, the sun's longitude is 3^{b} 0°. On the 23rd of September, the sun's longitude is 6^{b} 0°, and on the 22nd of December, the sun's longitude is 9^{b} 0°. Then, in addition to 4 dates, the following way is to determine the sun's longitude[36].

For example, determining the *salat* beginning times, the headquarters of Sayung Sub-District, Demak district, Central Java, coordinates = -6° 52' South Latitude and = 110° 31' East Longitude. On June 26, 2022 AD, to get *thul asy-syams* using the formula[37];

June 26 (6)

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32 Kementerian Agama, *Ephemeris Hisab Rukyat 2021* (Jakarta: Direktorat Urusan Agama Islam Dan Pembinaan Syariah Direktorat Jenderal Bimbingan Masyarakat Islam, 2021). 1

33 Muhyiddin Khazin, *Kamus Ilmu Falak* (Yogjakarta: Buana Pustaka, 2005). 84

34 Agama, *Ephemeris Hisab Rukyat 2021*.

35 Slamet Hambali, *Pengantar Ilmu Falak: Menyimak Proses Pembentukan Alam Semesta* (Banyuwangi: Bismillah Publisher, 2012), 237; Lidya Safrida and Machzumy Machzumy, "Analisis Astronomical Twilight Sebagai Tanda Penentuan Awal Waktu Salat Isya," *Astroislamica: Journal of Islamic Astronomy* 1, no. 1 (June 30, 2022): 47–72, https://doi.org/10.47766/astroislamica.v1i1.687.

36 Hambali, *Ilmu Falak I Penentuan Awal Waktu Salat Dan Arah Kiblat Seluruh Dunia*. 87

37 Hambali. 91

$$\begin{array}{l} +9° \ -4^b/+8^b \\ 35° \ \ 2^b/14^b - 12^b = 2^b \\ -30° \qquad +1^b \\ \hline 5° \qquad 3^b \end{array}$$

Thus, *thul asy-syams* is 3^b 5° (95° difference in sun longitude). The results of thul asy-syams are used to determine *daqoiq ta'dil zaman* or time aggregators, to get *mail asy-syams* by connecting 3^b with 5°, and the result is -0^h 3^m. Next is to determine the *mail asy-syams*[38].

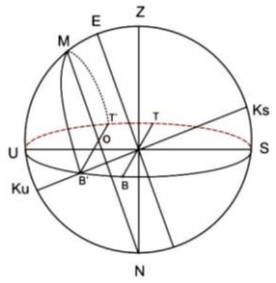
2) *Mail asy-Syams*

Nisbah Jaib Mail = Nisbah Jaib Bu'di Juz . Nisbah Jaib Mai 'Adom[39]

Nisbah Jaib Bu'di Juz (95°)	= 9.9983 –10
Nisbah Jaib Mai 'Adom (23° 27')	= 9.5998 –10 +
Nisbah Jaib Mail	= 9.5981 –10
Mail asy-Syams	= 23°21'19.65"

3) *Bu'dul Qutur*[40]

Bu'dul qutur is the distance of the arc or span calculated from the horizon from where the sun rises or sets to the midline of the sun's trajectory into two equal parts up and down[41]. Look at the picture below:



If EZ is the latitude (*'ard al-balad*), then EM is the sun's declination (*mail asy-syams*), and UM is the height of the sun (*irtifa' asy-syams*), ZM is the zenith distance and MB'T' is half an arc noon (*nisfu qausi nahar*), Mo is *bu'du al-qutur*.

Therefore, for the high position of the sun, *mar'i* and *hakiki* for the beginning and end of the *salat* time are measured from the horizon, height of the sun at noon time when the position of the sun culminates.[42] To determine when

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38 Mail al-Syamsi, that is when the sun is most northerly 23° 27' this is the maximum declination, known as the summer point, this occurs on June 22 and is in the constellation Cancer. Conversely, when the sun is most southerly -23° 27', it is called the winter point, this occurs on December 22, which is in the constellation Capricornus.Kementerian Agama, *Ephemeris Hisab Rukyat* (Jakarta: Direktorat Jenderal Bimbingan Masyarakat Islam Kementerian Agama Republik Indonesia, 2013). 1

39 Nisbah Jaib Mai 'Adom (23° 27'). Al-Jailani, *Al-Khulashah al-Wafiyah*. 81

40 An arc that stretches along a perpendicular (vertical) circle on a celestial body that is calculated from the center line of that object's path to the horizon. Look Khazin, *Kamus Ilmu Falak*, 2005. 14

41 Al-Jailani, *Al-Khulashah al-Wafiyah*. 89

42 Ahmad Fadholi, "Analisis Komparasi Perhitungan Waktu Salat Dalam Teori Geosentrik Dan Geodetik" (Master Thesis, Semarang, IAIN Walisongo, 2013), http://eprints.walisongo.ac.id/id/eprint/40/.

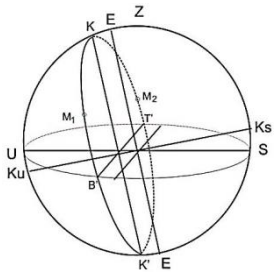
the sun culminates, use the formula: h_m = 90°-(φ-δ)—the sun at 90° culmination[43].

Nisbah Jaib Bu'dul Qutur = Nisbah Jaib Mail . Nisbah Jaib 'Ard Balad

Nisbah Jaib Mail (23° 21'19.65")	= 9.5981 –10
Nisbah Jaib 'Ard} Balad (-6° 52')	= 9.0776 –10 +
Nisbah Jaib Bu'dul Qutur	= 8.6757 –10
Bu'dul Qutur	= -2°43'0.08"

4) *Ashlul Muthlaq* atau *Ashlul Haqiqi*

Ashlul muthlaq is the distance calculated from the culmination point to the meeting point between the horizon line that connects the midline of the sun's trajectory at the upper culmination point with the lower culmination point. *Ashlul muthlaq* is always positive[44]. Look at the picture as follows;



Information: Circle T' K B' K' is the daily path of the sun will always be parallel to the equator, this shows the mail *asy-syams* (declination of the sun) at sunrise at "T" and peaks (culminates) at "M_1" so KM is the angle of time

The sun's time angle is usually marked as t, the distance from the sun starting at the culmination point, measured as far as the daily trajectory. When measured from the west, the time angle is + (positive), and vice versa. When measured from the east, the value is - (negative).

Nisbah Jaib Ashlul Muthlaq = Nisbah Jaib Tamam Mail. Nisbah Jaib Tamam 'Ard Balad.

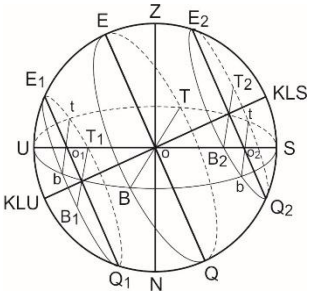
Nisbah Jaib Tamam Mail (23°21'19.65")	= 9.9629 -10
Nisbah Jaib Tamam Ard} Balad (-6° 52')	= 9.9968 -10 +
Nisbah Jaib Ashlul Muthlaq	= 9.9597 -10
Qous Ashlil Mutlaq	= 65°42'37.4"

5) *Nishful Fudllah*

[43] Fadholi; Rojak, Mujahid, and Yunus, "The Accuracy of Online-Based Prayer Times Applications."

[44] Al-Jailani, *Al-Khulashah al-Wafiyah*. 89-90

Nishful fudllah is a calculation of half of the actual noon arc[45]. *Nishful fudllah* has an average position of 90 or a count of 6 hours from half of the noon arc[46]. Thus, the *nishful fudllah* is between 0° to 90°, both positive and negative. *Nishful fudllah* is positive if the day is longer than the night. Conversely, *nishful fudllah* is negative if the night is longer than the day[47]. Look at the image illustration as follows.



EZ shows the magnitude of the latitude of the place, when the sun crosses EBQT, *bu'dul qutur* is absent (0°) and OE is *ashlul muthlaq*. When the sun crosses E_1 b B_1 Q_1 T_1 and t, then *Bu'dul Qutur* is b B_1 or t T_1 (negative because it is below the horizon). O_1 E_1 is *ashlul muthlaq*. When the sun crosses E_2 B_2 b Q_2 t and T_2, then *Bu'dul Qutur* is B_2 b or T_2 t (positive because it is below the horizon). E_2 O_2 is *ashlul muthlaq*.

For areas located on the equator, the *nishful fudllah* worth is always 0°. Meanwhile, for areas outside the equator except for the polar regions on March 21 and September 22, *nishful fudllah* worth= 0°. Moreover, areas at the poles and areas outside the poles will experience continuous daylight, so *nishful fudllah* worth= +90°. Otherwise, the polar and outer polar regions will experience continuous night conditions, so *nishful fudllah* value = -90°[48].

To get the angle of time first, determine nishful fudllah, bu'dul qutur, ashlul muthlaq because all of them are part of the elements of the time angle. To determine nishful fudllah, the solution has two kinds of formulas.

Nisbah Jaib Hisful Fudllah = Nisbah Jaib Bu'dul Quthur ÷ Nisbah Jaib Ashlul Muthlaq

Nisbah Jaib Bu'dul Quthur (-2°43'0.08")	= 8.6757 -10
Nisbah Jaib Ashlul Muthlaq (65°42'37.4")	= 9.9597 -10
Nisbah Jaib Hisful Fudllah	= 8.7160 -10
Hisful Fudllah	= -2°58'50.73" (-11^m 55^s.38)

6) Daqoiqut Tamkin

[45] declination and latitude of the place. See Hambali, *Ilmu Falak I Penentuan Awal Waktu Salat Dan Arah Kiblat Seluruh Dunia*. 68

[46] Al-Jailani, *Al-Khulashah al-Wafiyah*. 91

[47] The distance along the trajectory of a celestial body calculated from the bright circles or to the horizon. See Agama, Ephemeris *Hisab Rukyat*. 295

[48] Hambali, *Ilmu Falak I Penentuan Awal Waktu Salat Dan Arah Kiblat Seluruh Dunia*. 68

Daqoiqut tamkin is minutes that are always included in the calculating (*hisab*) for specific times, including sunset times for *Maghrib, Isha', and Fajr*. To get *daqoiqut tamkin*[49].

1. Half the sun's diameter = +16′
2. Refraction at sunset = +34′
3. Low horizon = +11′
4. Horizontal parallax = - 8′ 48″–
   Total = +51′12″(3^m 25^s)

To get *daqoiqut tamkin*, you can also connect or bring together the degree of declination and the closest degree of latitude, as follows;

Mail Al-Syams = 23°21′19.65″kelompok derajat 25
Ardu Balad = -6° 52 kelompok derajat 5
Daqoiqut Tamkin = 3^m $27^{s.}$[50]

7) *Ta'dil Zaman*
Ta'dil zaman is another name for the time averaging or equation of time, namely the difference between the actual (essential) solar culmination time and the average solar time.[51] *Ta'dil zaman* (PW) = 0^h 3^m, obtained from *thul asy-syams* is 3^b 5° by connecting in the table. *Ta'dil zaman* change every day. For; 7 - 17 Feb = - 14^m, on 15 and 16 April = 01^s. , on 15 July - 6 August = -06^m, on 19 - 21 November = +06^m, and on 26 October - 11 November = +16^m[52].

8) *Bu'du as-Sumti* (zenith distance)
Bu'du as-sumti is the distance span from the zenith point of a celestial body to the culmination point along the meridian circle. In astronomical terminology, this is known as the zenith distance. The initial calculation of the *Asar* time that must be considered is to determine the zenith distance[53]. At the same time, the formula is the zenith distance + culmination height, while to determine which side the sun's zenith is by using the formula Zm = declination - latitude of the place.

Zm = *Mail Syamsi – 'Ard Balad*
Zm = 23°21′19.65″ – (-6° 52′)
= 30°13′19.65″

9) The height of *Asar* (ha)

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49 Hambali. 78
50 See table جدول اختلاف الافاق بدقائق وثوان الساعة. Al-Jailani, *Al-Khulashah al-Wafiyah*. 222
51 Agama, *Ephemeris Hisab Rukyat 2021*. 2
52 Al-Jailani, *Al-Khulashah al-Wafiyah*. 217
53 Khazin, *Kamus Ilmu Falak*, 2005. 14

The height of *Asar* is related to the sun's position. That is, when the sun's shadow has passed its culmination point, the shadow will get longer until it is the same as the object, then add the *Zuhr* time. To get the height with the formula:

Dhil Tamam ha	= *Dhil* Zm + 1
Dhil Zm 30°13'19.65"	= 0.5825
	+1
Dhil Tamam ha	= 1.5825
	= 32°17'21.53

HISAB OF *SALAT* BEGINNING TIMES

An example of calculating the *salat* beginning times on June 26, 2022 AD, Sayung Sub District, Demak district, Central Java and coordinates = -6° 52' South Latitude and = 110° 31' East Longitude.

1. *Zuhr* Beginning Time

WIB = WH – PW + (BD-BT)
WIB = 12.00 – (-0^h 3^m) + (105° – 110° 31') ÷ 15
= 11:40.56 WIB

2. Early Beginning Time

In determining the *hakiki Asar* time, there are 3 stages

1). X = ha – BQ
= 32°17'21.53"- (-2°43'0.08")
= 35°00'19.61"

2). *Nisbah Jaib Tamam* A = *Nisbah Jaib* ÷ *Nisbah Jaib* QAM

Nisbah Jaib X (35°00'19.61")	= 9.7586 - 10
Nisbah Jaib QAM (65°42'37.4")	= 9.9597 - 10 -
Nisbah Jaib Tamam A	= 9.7989 - 10
A	= 50°59'47.57"

3). *Asar* Beginning Time (WH) = 12 + A
= 12:00 + 50°59'47.57"
= 12:00 + 3°23'59.17"
= 15:23:59.17 (WH)
WIB = WH – PW + (BD-BT)
= 15:23:59.17 – (-0^h 3^m) + (105° – 110° 31') ÷ 15
= 15:04:55.17 (WIB)

3. *Maghrib* Beginning Time

WH = 18:00 + (DT+NF)
= 18:00 + (03^m 27^s + (-11^m 55^s.38))
= 17:51:21.62 (WH)
WIB = WH – PW + (BD-BT)
WIB = 17:51:21.62 – (-0^h 3^m) + (105° – 110° 31′) ÷ 15
= 17:32:17.62 WIB

4. *Isha's* Beginning Time

There are 3 formulas for determining *Isha's* time

1). X = 17 + BQ
= 17 + (-2°43′0.08″)
= 14°16′59.92″

2). *Nisbah Jaib* I = *Nisbah Jaib* ÷ *Nisbah Jaib* QAM

Nisbah Jaib X (14°16′59.92″)	= 9.3922 – 10
Nisbah Jaib QAM (65°42′37.4″)	= 9.9597 – 10 -
Nisbah Jaib I	= 9.4325 – 10
I	= 15°42′16.56″

3). *Isha'* beginning time WH
WH = 18:00 + I+DT
= 18:00 + 15°42′16.56″+03^m 27^s
= 18:00 + 1^h 02^m 49^s.1 + 03^m 27^s
= 19:06:16.1 (WH)
WIB = WH – PW + (BD-BT)
WIB = 19:07:16.1 – (-0^h 3^m) + (105° – 110° 31′) ÷ 15
= 18:47:12.1 WIB

5. *Shubuh* Beginning Time

There are 3 formulas for determining the time of *Isha'*

1). X = 19 + BQ
= 19 + (-2°43′0.08″)
= 16°16′59.92″

2). *Nisbah Jaib Tamam* S = *Nisbah Jaib* ÷ *Nisbah Jaib* QAM

Nisbah Jaib X (16°16′59.92″)	= 9.4477 – 10
Nisbah Jaib QAM (65°42′37.4″)	= 9.9597 – 10 -
Nisbah Jaib Tamam S	= 9.4880 – 10
S	= 72°5′3.31″

3). *Shubuh* Beginning Time WH

WH = S – DT
= 72°5′3.31″ – 03^{m} 27^{s}
= 72°1′36.31″
= 4:48:6.42 (WH)
WIB = WH – PW + (BD-BT)
WIB = WH – PW + (BD-BT)
= 4:48:6.42 – (-0^{h} 3^{m}) + (105° -110° 31′) ÷ 15
= 4:29:2.42 (WIB)

6. Sun Rising Time

WH = 06.00 – (DT+NF)
= 06.00 – (03^{m} 27^{s} + (-11^{m} 55^{s}.38))
= 06: 08:28.38 (WH)
WIB = WH – PW + (BD-BT)
WIB = 06: 08:28.38 – (-0^{h} 3^{m}) + (105° – 110° 31′) ÷ 15
= 05:49:24.38 (WIB)

The phenomenon of the twilight dawn sunrise is related to the distance of the sun's zenith[54]. Thus, to explain the position of the sun during the *salat fiqh*, it provides a limit, the time for the noon prayer, that is, when the sun slips (*zawal*)[55], meaning that there is a change in the position of the sun passing the zenith point, namely the dividing line between the western and eastern sky. At that time, the sun is at *zawal* point at 12.00 WH.

Maghrib time is when the entire sun disk sets below the horizon, while the sun's diameter is 32', so the zenith distance from the horizon is 90°[56]. The *Isha's* beginning time, as mentioned in a hadith that *Isha'* beginning time is when the clouds disappear (*syafaq ahmar* or red light)[57]. According to the above statement, there are several opinions, including Imam Hanafi, who argues that the clouds mentioned are white, so the sky is dark. In astronomy, the sun's position is below the horizon -19°.[58]

Unlike Imam Hanafi, Imam Syafi'i stated that what is meant by the loss of *Syafaq Ahmar* is when the sun is -17° below the horizon. If the point of view is based on the opinion of Imam Hanafi, then by using -17° below the horizon added

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54 Thomas Djamaluddin, "Lokakarya Imsakiyah Ramadhan 1432 H" (Semarang: PPM IAIN Walisongo Semarang, 2011), 2.

55 Imam Muslim, *Sahih Muslim* (Beirut: Dar al-Kutub al-Ilmiah, n.d.). 95

56 Abd Rachim, *Ilmu Falak* (Yogyakarta: Liberty, 1998). 26

57 A hadith narrated by Abdullah bin Amr Ra.
عَنْ عَبْدِ اللَّهِ بْنِ عَمْرٍو أَنَّ رَسُولَ اللَّهِ صَلَّى اللهُ عَلَيْهِ وَسَلَّمَ قَالَ وَقْتُ الظُّهْرِ إِذَا زَالَتِ الشَّمْسُ وَكَانَ ظِلُّ الرَّجُلِ كَطُوْلِهِ مَا لَمْ يَحْضُرِ الْعَصْرُ وَوَقْتُ الْعَصْرِ مَا لَمْ تَصْفَرَّ الشَّمْسُ وَوَقْتُ صَلاَةِ الْمَغْرِبِ مَا لَمْ يَغِبِ الشَّفَقُ وَوَقْتُ صَلاَةِ الْعِشَاءِ إِلَى نِصْفِ اللَّيْلِ الْأَوْسَطِ وَوَقْتُ صَلاَةِ الصُّبْحِ مِنْ طُلُوعِ الْفَجْرِ مَا لَمْ تَطْلُعِ الشَّمْس (رواه مسلم)
Imam Muslim, *Sahih Muslim*. 96

58 Al-Jailani, *Al-Khulashah al-Wafiyah*. 97

by *qous bu'du qutur*, it will produce -19° below the horizon[59]. Fajr's beginning time is when the dawn appears, as white clouds on the eastern horizon before sunrise. This occurs when the sun is -19° below the horizon and added *qous bu'du qutur*. Meanwhile, for *imsak*, some astronomers use the *Fajr* time reduced by 8 minutes to 15 minutes, but what is widely used is 10 minutes and 12 minutes[60].

Table of comparison of the calculation results of *Kitab Khulasah* with the results of calculation of contemporary *hisab* [61] (Ephemeris *Hisab Rukyat*) on June 26, 2022[62], Declination; 23°21'28", equation of time; –00^h 2^m 49^s" (12 GMT/5 WIB), with an altitude of 0 M.

Time	*Khulashah*	Ephemeris	Deviation
Imsak	04:19:2.42	4:18:18.16	0^h 0^m 44^s.26
Subuh	4:29:2.42	4:28:18.16	0^h 0^m 44^s.26
Sunrise	05:49:24.38	05:49:00.83	0^h 0^m 24^s.55
Zuhr	11:40.56	11:40.45	0^h 0^m 11^s
Asar	15:04:55.17	15:02:09.49	0^h 2^m 45^s.68
Magrib	17:32:17.62	17:32:29.17	0^h 0^m 11^s.55
Isha'	18:47:12.1	18:44:30.05	0^h 2^m 42^s.05

Meanwhile, a comparison table of calculation results using data *mail as-syamsi* (23°21'19.65") and *daqoiq ta'dil zaman* (-0^h 3^m) in *kitab al-Khulashah al-Wafiyyah*, on June 26, 2022, using a contemporary *hisab* system.

Time	*Khulashah*	Ephemeris	Deviation
Imsak	04:18:29.17	4:18:18.16	0^h 0^m 11^s.01
Subuh	4:28:29.17	4:28:18.16	0^h 0^m 11^s.01
Sunrise	05:49:11.75	05:49:00.83	0^h 0^m 10^s.92
Zuhr	11:40.56	11:40.45	0^h 0^m 11^s
Asar	15:02:20.52	15:02:09.49	0^h 0^m 11^s.03
Magrib	17:32:40.25	17:32:29.17	0^h 0^m 11^s.08
Isha'	18:44:41.5	18:44:30.05	0^h 0^m 11^s.45

It can be concluded that from the above calculations, there are differences between *khulashah* and contemporary *hisab* (ephemeris *hisab rukyat*), but they are not quite significant. The difference occurs because of astronomical data such as data of *mail al-syams* (declination) 23°21'19.65"/ 23°21'28" and *daqoiq ta'dil zaman*

[59] Al-Jailani. 97

[60] Al-Jailani. 96-100

[61] Contemporary Calculation is a calculation system using a computer and using algorithmic formulas, always making corrections to the latest data findings. Amirudin et al., "Analisis Metode Hisab Kontemporer Terhadap Jam Istiwa ' (Studi Penentuan Awal Waktu Salat Di Fathul Ulum Kediri)."

[62] Ephemeris hisab rukyat. Agama, *Ephemeris Hisab Rukyat 2021*. 205

(equation of time) or known as the Average Time (PW) -00^h 3^m and -00^h 02^m 49^s. Algorithmically, *Kitab Khulasah* has used a modern algorithm. This can be seen when calculating *salat* beginning times involves several components, including *bu'dul qutur*, *ashlul muthlaq*, and *nishful fudllah*. Nevertheless, because the calculations do not consider the height of the place, it makes a difference. The difference can be seen in the position of the sun at *Asar* time, while *Maghrib, Isha'*, and *Shubuh* have considered refraction by adding *daqoiqut tamkin* to the calculation process. Thus, this method will produce accurate calculations.

CONCLUSION

Kitab Khulasah is a classical book that has considered and calculated the sun's position in applying a *hisab* of *salat* times. Apart from that, *kitab Khulasah* also uses the formula for spherical triangles (trigonometry) so that the calculation results are not too different from current data (contemporary) to get the sun angle using the following formula; Cos t = sin h ÷ cos φ^x ÷ cos δ – tan φ^x x tan δ. δ is the declination of the Sun, and φ is the geographic latitude for which it is to be calculated.

The calculation process has calculated refraction, horizontal parallax, and low horizon (*daqoiqut tamkin*) by connecting *mail al-syams* and *ard al-balad* from the table. The current *salat* times calculation process has considered the height of the place with the formula ku = 1.76 √h. This formula is used as a correction for the height of the place, as the formula used; -(ku + ref + sd). Meanwhile, the formula = 0.0167 ÷ tan (h + 7.31 ÷ (h + 4.4)) is used to get refraction. Thus, the correction shows that based on the table data, there is no significant difference between *kitab khulashah* and contemporary *hisab.* There is a difference of 0 seconds to 12 seconds. This indicates that the calculation system *kitab Khulasah* is very accurate.

REFERENCES

Al-Jailani, Zubair Umar. *Al-Khulashah al-Wafiyah*. Surakarta: Melati, n.d.

Amirudin, Abdul Majid, Ahmad Junaidi, Fakultas Syariah, and Iain Ponorogo. "Analisis Metode Hisab Kontemporer Terhadap Jam Istiwa' (Studi Penentuan Awal Waktu Salat Di Fathul Ulum Kediri)." *Antologi Hukum* 1, no. 2 (2021): 97–116.

Anugraha, Rinto. *Mekanika Benda Langit*. Yogyakarta: Universitas Gadjah Mada, 2012.

Azhari, Susiknan. "Tracing The Concept of Fajr In The Islam Mosaic And Modern Science." *Ahkam: Jurnal Ilmu Syariah* 18, no. 1 (January 12, 2018). https://journal.uinjkt.ac.id/index.php/ahkam/article/view/9819.

Basthoni, M. "A Prototype of True Dawn Observation Automation System." *Jurnal Sains Dirgantara* 18, no. 1 (2020): 33–42. https://doi.org/10.30536/j.jsd.2020.v18.a3475.

Basthoni, M., and Hendro Setyanto. "Typology of Dawn Light Curves in High and Low Light Pollution Areas." *AIP Conference Proceedings* 2391, no. January (2022). https://doi.org/10.1063/5.0073949.

Djamaluddin, Thomas. "Lokakarya Imsakiyah Ramadhan 1432 H," 2. Semarang: PPM IAIN Walisongo Semarang, 2011.

Fadholi, Ahmad. "Analisis Komparasi Perhitungan Waktu Salat Dalam Teori Geosentrik Dan Geodetik." Master Thesis, IAIN Walisongo, 2013. http://eprints.walisongo.ac.id/id/eprint/40/.

Fahrurrazi, Djawahir. *Sistem Acuan Geodesi Dari Bigbang Sampai Kerangka Acuan Terestrial*. Yogyakarta: Gadjah Mada Universitas Press., 2011.

Faiz, ABD Karim Faiz, and Wahidin Wahidin. "Prayer Time Variations: Case Study of Mosques in Parepare City in the Perspective of Contemporary Hisab and Islamic Law." *Elfalaky: Jurnal Ilmu Falak* 6, no. 2 (December 7, 2022): 207–29. https://doi.org/10.24252/ifk.v6i2.32727.

Hambali, Slamet. *Ilmu Falak I Penentuan Awal Waktu Salat Dan Arah Kiblat Seluruh Dunia*. Semarang: PPS. IAIN Walisongo, 2011.

———. *Pengantar Ilmu Falak: Menyimak Proses Pembentukan Alam Semesta*. Banyuwangi: Bismillah Publisher, 2012.

Hollander, H.G. Den. *Ilmu Falak*. Jakarta: J.B. Wolters., 1951.

Ismail. "Metode Penentuan Awal Waktu Salat Dalam Perspektif Ilmu Falak." *Islam Futura* 14, no. 2 (2015): 218–31.

Izzuddin, Ahmad. *Zubaer Umar Al-Jaelany Dalam Sejarah Pemikiran Hisab Rukyat Di Indonesia*. Semarang: DIPA IAIN Walisongo Semarang, 2002.

Kementerian Agama. *Ephemeris Hisab Rukyat*. Jakarta: Direktorat Jenderal Bimbingan Masyarakat Islam Kementerian Agama Republik Indonesia, 2013.

———. *Ephemeris Hisab Rukyat 2021*. Jakarta: Direktorat Urusan Agama Islam Dan Pembinaan Syariah Direktorat Jenderal Bimbingan Masyarakat Islam, 2021.

Khafid. "Modul Kuliah Astronomi Dan Hisab Kontemporer." Semarang: Pascasarjana IAIN Walisongo, 2012.

Khazin, Muhyiddin. *Kamus Ilmu Falak*. Yogyakarta: Buana Pustaka, 2005.

Ma'u, Dahliah, Haliah. "Waktu Sholat Pemaknaan Syar ' I Ke Dalam Kaidah Astronomi." *Jurnal Hukum Islam* 14, no. 2 (2015): 269–85.

Meeus, Jean. *Astronomical Tables of the Sun, Moon and Planets*. Virginia: Williamn-Bell Inc, 1983.

Mubit, Rizal. "Formulasi Waktu Salat Perspektif Fikih Dan Sains." *Al-Marshad: Jurnal Astronomi Islam Dan Ilmu-Ilmu Berkaitan* 3, no. 2 (December 30, 2017). https://doi.org/10.30596/jam.v3i2.1527.

Ni'mah, Ani Zaidatun. "Uji Verifikasi Perhitungan Awal Waktu Salat KH. Zubair Umar al-Jailani Dalam Kitab al-Khulasah al-Wafiyah." Thesis, IAIN Walisongo, 2013. http://eprints.walisongo.ac.id/id/eprint/1034/.

Qusthalaani, Imam. "Kajian Fajar Dan Syafaq Perspektif Fikih Dan Astronomi." *Mahkamah : Jurnal Kajian Hukum Islam* 3, no. 1 (2018): 1. https://doi.org/10.24235/mahkamah.v3i1.2744.

Rachim, Abd. *Ilmu Falak*. Yogyakarta: Liberty, 1998.

Rahmi, Nailur, and Firdaus Firdaus. "An Analysist of Sa'adudin Djambek's Hisab Method About All The Time of Praying Schedule." *Al-Hilal: Journal of Islamic Astronomy* 2, no. 1 (April 30, 2020). https://doi.org/10.21580/al-hilal.2020.2.1.5588.

Rojak, Encep Abdul, Ilham Mujahid, and Muhammad Yunus. "The Accuracy of Online-Based Prayer Times Applications." *Ijtihad : Jurnal Wacana Hukum Islam Dan Kemanusiaan* 21, no. 1 (June 30, 2021): 21–38. https://doi.org/10.18326/ijtihad.v21i1.21-38.

Sado, Arino Bemi. "Waktu Shalat Dalam Perspektif Astronomi; Sebuah Integrasi Antara Sains Dan Agama." *MUamalat Jurnal Hukum Ekonomi Syariah* VII (2015): 69–83.

Safrida, Lidya, and Machzumy Machzumy. "Analisis Astronomical Twilight Sebagai Tanda Penentuan Awal Waktu Salat Isya." *Astroislamica: Journal of Islamic Astronomy* 1, no. 1 (June 30, 2022): 47–72. https://doi.org/10.47766/astroislamica.v1i1.687.

Saksono, Tono, and Mohamad Ali Fulazzaky. "Predicting the Accurate Period of True Dawn Using a Third-Degree Polynomial Model." *NRIAG Journal of Astronomy and Geophysics* 9, no. 1 (2020): 238–44. https://doi.org/10.1080/20909977.2020.1738106.

Simamora. *Ilmu Falak Kosmografi*. Jakarta: CV. Pustaka Bangsa, 1985.

Zainuddin. "Posisi Matahari Dalam Menentukan Waktu Shalat Menurut Dalil Syar'I." *Elfalaky* 4, no. 1 (2020): 36–55. https://doi.org/10.24252/ifk.v4i1.14166.