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Lunar Eclipse Types Comparison of al-Dur al-Anīq with Astronomical Algorithms (Implications for the Law of Lunar Eclipse Prayers)

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Abstract

This article aims to examine the accuracy of Astronomical Algorithms and al-Dur al-Anīq lunar eclipse type calculations and their impact on the ruling of lunar eclipse prayer. This qualitative research uses descriptive and comparative approaches. This article uses lunar eclipse data from 2011 – 2050 from Astronomical Algorithms, al-Dur al-Anīq, and NASA, and 3 additional partial lunar eclipses with small umbral magnitude. This study concludes that the determination of the type of lunar eclipse al-Dur al-Anīq is more accurate than Astronomical Algorithms because the average magnitude penumbra and umbra difference is almost the same as NASA and there is no difference type of lunar eclipse with NASA. Meanwhile, Astronomical Algorithms there are differences in types of Lunar Eclipses with NASA on lunar eclipses April 4, 2015 and July 18, 2027. The different types of lunar eclipses above, do not have an impact on the difference of lunar eclipse prayer law on lunar eclipse 2011-2050 because the two eclipses differ in No Lunar Eclipse with Penumbra and Partial with Total, but it happens on lunar eclipse 24 February 2157, 16 June 2421, 22 May 2627, because the different types of lunar eclipses occur between Penumbra and Partial.

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A. Introduction

Lunar eclipse occurs when the Moon is in the middle of the Earth's shadow, so that sunlight cannot reach the Moon [1, p. 139]. Belgian astronomer Jean Meeus divides lunar eclipses into 3 types, namely total lunar eclipse, partial lunar eclipse and penumbral lunar eclipse [2, p. 43]. There is a book of Indonesian astronomers that discusses lunar eclipses and determining their types, namely al-Dur al-Anīq by KH. Ahmad Ghozali from Madura. The book is included in Tahqiqi bi at-Tadqiq calculation which has very accurate results and is included in several of his astronomy books, Among his books are Faiḍ al-Karim, Bughyat al-Rafiq, Anfa' al-Wasilah, amarat al-Fikar, Ersyadul Pupil, Taqiidat al- Jaliyah. [3]

Calculations for determining the type of eclipse are also found in Jean Meeus' book entitled Astronomical Algorithms which has high accuracy too. Jean Meeus mentioned that there are differences in the determination of the type of lunar eclipse, namely the lunar eclipse of

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November 26, 1890, which has an umbra magnitude calculation of -0.007 which shows the lunar eclipse of November 26, 1890, is a penumbral lunar eclipse, in fact the eclipse of November 26, 1890 AD is a very small partial lunar eclipse [2, p. 357].. Suppose you look at the data from NASA (National Aeronatics and Space Administration) Five Millennium Canon of Lunar Eclipses: -1999 to +3000 (2000 BCE to 3000 CE), lunar eclipse November 26. In that case, 1890 AD is a Partial Lunar Eclipse with an umbra magnitude value of 0.0017 [4, p. 470].

Based on the data above, there are differences in the determination of the type of lunar eclipse, which may make different opinions on the law of the lunar eclipse prayer. Because, Eclipse prayer announcement is based on lunar eclipse calculation. The author is interested in comparing the lunar eclipse types in the book of al-Dur al-Anīq by KH. Ghozali Madura with Astronomical Algorithms by Jean Meeus. The comparison starts from the Lunar Eclipse in 2011 AD to 2050 AD which is then validated with NASA data and the implications for the lunar eclipse prayer.

B. Method

This article is a qualitative research [5, p. 217], and is classified as literature by using descriptive and comparative analysis methods. Data collection techniques by collecting data sources (documentation) in the form of books, journals and other sources. The descriptive analysis in this study is to describe the method of determining the type of lunar eclipse and the implications of the differences in these methods in the laws of the lunar eclipse prayer and the comparative analysis in this article is to compare the results of the method of determining the type of lunar eclipse from 2011 to 2050 al-Dur al-Anīq with Astronomical Algorithms validated by NASA data.

C. Results and Discussion

Lunar Eclipse Prayer Law

The eclipse phenomenon is one of the extraordinary natural phenomena that occurs in the sky and this phenomenon had attracted people attention in ancient era, they recorded it on the inscription such as some studies claimed about 1,400 of 22,000 inscription written in Sanskrit, Kannada and Telugu referring to eclipses (both Solar and Lunar Eclipse)[6].There

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are several lunar eclipse myth around the world, Mesopotamia: the eclipse occurs because concerted attack on the moon god by an antagonistic group of deities[7], Java: the eclipse happens because the Sun or Moon is eaten by Batara Kala, a giant demon in Hindu mythology[8] and this amazing phenomena used to be interpreted as a sign of someone's death in Arab, but the Prophet Muhammad SAW. reminded that the eclipse is one of the signs of the power of Allah SWT, it is based on the hadith from Mughiroh, as follows [9, p. 316]:

حدثنا أصبغ قال: أخبرني إبن وهب قال:أخبرني عمرو عن عبد الرحمن بن القاسم حدثه عن أبيه عن إبن عمررضي الله عنهما أنه كان يخبر عن النبي صلى الله عليه وسلم: إن الشمس و القمرلا يخسفان لموت أحد ولا لحياته ولكنهما آيتان من آيات الله ,فإذا رأيتموهما فصلوا (رواه البخاري)

"*Asbagh has told us that he said: Ibn Wahb, has told me, he said: 'Amr has told me from Abdur Rahman bin Qasim that he told him from his father. From Ibn Umar R.A., that Umar received news from the Prophet SAW: Verily the Sun and the Moon do not eclipse because of someone's death or life, but they are one of the signs among the signs of Allah's greatness. If you see both, then pray."* (Al-Bukhari)

Based on this hadith the Prophet Muhammad SAW. The eclipse phenomenon is not a sign of someone's death or life but a sign of the Allah's greatness. The Prophet also ordered to perform eclipse prayers. The command of the Prophet is mandatory or sunnah. The four madhhab differ in their interpretation. The first opinion of Shafii, Ahmad, Abu Daud and Ibn Hazm and narrated by Ibn Hazm, the lunar eclipse prayer is *sunnah mu'akkad* and is carried out in congregation. The second opinion of Imam Abu Hanifah and Imam Malik, they are of the opinion that the lunar eclipse prayer is a sunnah like the usual sunnah without any additional bowing and does not need to be done in congregation. Between the two opinions, the first opinion is stronger because of the Prophet Muhammad ordering the eclipse prayer does not distinguish between a solar eclipse and a lunar eclipse, where the majority of scholars are of the opinion that the lunar eclpse prayer is a sunnah mu'akkad [10].

The Penumbral Eclipse Prayer Law according to Islamic organizations in Indonesia, as follows: Nahdhaul Ulama statedlunar eclipse prayer is not sunnah when penumbral lunar eclipse occurs, because the sunnah prayer factor for lunar and solar eclipses is the reduction in the visible circle of the sun and moon full before the eclipse. Meanwhile, Muhammadiyah

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through its majelis tarjih, it was difficult to distinguish the Penumbral Lunar Eclipse from the Full Moon because it looks the same, when viewed directly with the eyes. Observations with sophisticated tools also still look the same, only look dimmer. So that the Penumbral Lunar Eclipse is not sunnah to perform the Lunar Eclipse prayer. Persatuan Islam (PERSIS) has the same opinion regarding the phenomenon of the Penumbral Lunar Eclipse, namely that it is not sunnah to perform the eclipse prayer during the Penumbral Lunar Eclipse because there is no change in the appearance of the moon during the Penumbral Lunar Eclipse. So, the three major Muslim mass organizations agreed that the Penumbral Lunar Eclipse prayer is not sunnah to be performed [11].

The difference between the scholars regarding the implementation of prayer is that when the prayer time coincides with the times that are forbidden to perform prayer. The scholars stated that it is not permissible to perform eclipse prayers at that time because it is forbidden to pray at times that are forbidden for all prayers. Imam Shafi'i differed by stating that the eclipse prayer was still performed because this prayer was sunnah on the basis of cause. Imam Malik is of the opinion that eclipse prayers can be performed at times that are not prohibited from performing sunnah prayers. Ibn Qasim said that the provisions for the solar eclipse prayer time were the beginning of the time of Duha until the time of noon, narrated the opinion of Imam Malik. Ibn Rushd drew up a rule from the differences of the scholars, namely: Prayer is forbidden, if the times that are prohibited for prayer apply to all prayers. Prayers may be performed during forbidden times specifically for sunnah prayers. But if the eclipse prayer is classified as a sunnah prayer, then the eclipse prayer is prohibited from being performed at those times. Commenting on the history of Ibn Qasim, Ibn Rushd said the basis used was to equate the eclipse prayer with the Eid prayer [12].

Lunar Eclipse Types And Its Process

Eclipse is called eclipse (English) or ekleipsis (Greek) or eklipsis (in Latin). The term eclipse is used to describe circumstances or events in everyday life [13, p. 228]. A lunar eclipse occurs when the Sun, Earth and Moon are in one line, namely when the Moon is in opposition or when the Moon is full, so that at that time it will pass through the Earth's shadow (Umbra and Penumbra) [14, p. 107]. Lunar eclipse is is one of the ways, the Moon affects the Earth. The geometrical alignment of the Sun, the Earth and the Moon change the effective tidal force during lunar eclipse [15].The sun is a disc or extension of the light source. The sun's shadow is seen very little in the umbra, while outside the shadow, its light is fully visible and

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partially visible in the transition zone (penumbra) depending on how many degrees it is in that zone. The umbra is the cone with its apex far from the sun and the penumbra is the cone whose apex is between the sun and the moon, although the shadow will only occur at a position away from the sun. The size of the umbra depends on the size of the Earth and the distance from the Sun. Because the Earth's orbit about the Sun is not circular, the distance between the Sun and Earth varies, so the length of the shadow umbra and its cross-section varies. The average distance from the Moon to Earth is 384,000 km, so the length of the umbra is sufficient to cover it.

The Moon orbit the Earth is also not circular like the Earth orbit the Sun, so the Moon can pass through the shadow of a cone within a certain distance. Then, as the Moon's distance from Earth increases, the Moon's cross-sections appear smaller and the Moon appears to move more slowly. The line of intersection of the cones depends on the distance from the top of the cone. The moon always approaches the shadow, coming from the west and moving east. From the eclipse process, four types of eclipses that may occur are Total Lunar Eclipse which occurs when the Moon moves through the umbra completely, Partial Lunar Eclipse occurs when the Moon passes through the umbra only partially and when the Moon does not pass through the umbra but only passes through the penumbra, a Penumbral Lunar Eclipse occurs. This eclipse is divided into two, namely a total penumbral lunar eclipse and a partial lunar eclipse [16, pp. 2–3]. The division of the type itself, the majority does not divide the Penumbral Lunar Eclipse into two, so that there are only three types of Lunar Eclipses, namely Total Lunar Eclipse, Partial Lunar Eclipse and Penumbral Lunar Eclipse [17, p. 43].

All types of lunar eclipses begin with a penumbral phase, but during this phase it will not be clearly visible until half the diameter of the Moon is covered by the penumbra. Then, the Moon looks a bit faint which is clearly visible when it enters the umbra. Entering the umbra, about 30 seconds while the Moon is still faintly visible. The Moon's disk that enters the umbra looks black because of the contrast of light, but as more of the moon's disk is covered, features begin to be visible again. During the total phase the Moon can appear red, gray and black. After the maximum eclipse phase, the process occurs in reverse during the initial process. Total Lunar Eclipse has four contacts. First, when the Moon enters the umbra. Second, when the Moon completely enters the umbra and the total phase begins. Third, when the Moon begins to emerge from the umbra and the total phase is complete. Fourth, when the Moon comes out of the umbra completely. The duration of each phase depends on the factors

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previously mentioned. However, when the Moon passes through the center of the shadow each penumbral and partial phases take a minimum of an hour and the total phases take a hundred minutes or more [16, p. 4].

Al-Dur Al-'Anīq and Lunar Eclipse Calculation Types

Al-Dur al-Anīq was written by KH. Ahmad Ghazali. He was born on January 7, 1962 AD in the village of Lanbulan, Baturasang, Tambelang, Sampang, Madura, East Java. He was born to the couple KH, Muhammad Fathullah and Hj. Zainad Khoiruddin. His father was the founder of the Al-Mubarok Islamic Boarding School Lanbulan in 1952. KH. Ahmad Ghozali is an advisor to LFNU (Lajnah Falakiyyah Nahdhotul Ulama) East Java and a member of the BHRD (Badan Hisab Rukyat) East Java and a member of the Hisab Rukyat Team of the Ministry of Religion of the Republic of Indonesia. He has many works of Falak books, including *Al-Taqyidah al-Jaliyah*, *Bugyah al-Rafīq*, *Irsyād al-Murīd*, *Al-Dur al-Anīq*, *Ṣamroh al-Fikr*[18] etc.

Al-Dur al-Anīq uses the *Tahqiqi bi at-Tadqiq* method of calculation with high accuracy. This book discusses the method of calculating the beginning of the Hijri month, calculating lunar eclipses and calculating the global and local solar eclipse. The data for calculating solar and lunar eclipses in this book comes from data from the city of Sampang, Madura, with a latitude of 7° 12' South Latitude and a longitude of 113° 15' east longitude and a height of 5 meters [19, p. 4].

There are 2 prints of the *al-Dur al-Anīq* book, the first printing was published in 2013 AD and the second printing was published in 2016 AD there was an addition to the Delta T approach formula (ΔT), which is the difference between the modern astronomical time standard (TDT) and the standard time set. based on the rotation of the Earth (UT)[16], the calculation of a global solar eclipse and the addition of new terms such as the term Total Penumbral Lunar Eclipse, Partial Penumbral Lunar Eclipse[Ghazali, Al-Dur Al-'Anīq, p.140.] etc., tables and calculation data used in calculations. The main part is divided into several parts: Chapter Calculation of the Beginning of the Moon consists of several stages: Calculation of *Ijtima'* (when the position of the Moon is in the same astronomical longitude as the Sun[20]); Calculation of Solar Data [19, pp. 14–16]; Calculation of Lunar Data [19, pp. 17–22]. Chapter Calculation of the Solar Eclipse is divided into Calculation of the Global Eclipse [19, pp. 53–67]; Local Eclipse Calculation [19, pp. 103–109]. Chapter Calculation of Lunar Eclipses [19, pp. 143–146], in the book of *al-Dur al-Anīq* There are 4 types of lunar eclipses in the book of

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al-Dur al-Anīq, namely *al-Khusūf al-Haqīqi al-Kullī* (Total Umbral Lunar Eclipse) is that all parts of the Moon are included in the shadow Earth's umbra, during the middle of the eclipse will be covered by all light from the Moon; *al-Khusūf al-Haqīqī al-Juz* (Partial Umbral Lunar Eclipse) i.e. part of the Moon enters the Earth's umbral shadow during the middle of the eclipse and the other part enters the penumbral shadow so that some of the light disappears; *al-Khusūf al-Syibhī al-Kullī* (Total Penumbral Lunar Eclipse) is that all parts of the moon fall into the Earth's penumbral shadow and no part of the Moon is included in the umbral shadow [19, p. 141]; *al-Khusūf al-Syibhī al-Juz* (Partial Penumbral Lunar Eclipse) is that part of the Moon enters the penumbral shadow during the middle of the eclipse and the other part does not enter the penumbral shadow [19, p. 142].

al-Khusf al-Haqīqi al-Kullī (Total Lunar Eclipse) and *al-Khusf al-Haqīqi al-Juz* (Partial Umbral Lunar Eclipse) can be seen with the naked eye unless there is a partial lunar eclipse in which part of which is very little covered under observation to observe carefully. Some astronomers also call these two types of lunar eclipses the Syar'i Lunar Eclipse because they are related to the Shari'a of carrying out eclipse prayers, reading istighfar and to increase sadaqah. Whereas the last two types of eclipses cannot be observed with the naked eye, then these two types of eclipses do not pray, recite istighfar and multiply sadaqah. Fiqh scholars and astronomy scholars do not disagree about the last two types of events and do not mention them in their books [19, p. 140].

The steps to determine the type of lunar eclipse in *al-Dūr al-Anīq* are as follows: Look the *'Awāmil al-Khusf* which will be calculated in the appendix to the schedule of *'Awāmil al-Khusūf*. *'Awāmil al-Khusūf* consists of data sets including: *al-Ẓil* = x0; *Ta'dīl al-Ṭūl* = x1; *'Arḍ al-Ẓil* = y0; *Ta'dīl al-'Arḍ* = y1; *Bu'du Zawiyah al-Khusūf al-Syibhi* = L10; *Ta'dīluhu* = L11; *Bu'du Zawiyah al-Khusūf al-Ḥaqīqi* = L20; *Ta'dīluhu* = L21; *Bu'du Zawiyah al-Khusf al-Kullī*= L30; *Ta'dīluhu* = L31; *Niṣfu Quṭr al-Qamar* = sc0; *Ta'dīluhu* = sc1; *Zawiyah al-Waqti* = M0; *Ta'dīluha* = M1; *Mail al-Qamar* = dm0; *Ta'dīluhu* = dm1. Then, calculate *Sā'ah Wasaṭ al-Khusūf* with the formula: n2 = (x12 + y12); n = (n^2); T = -(x0 x1 + y0 y1) / n2; T0 UT (Central Eclipse) = TD + T – Delta T [19, p. 143].

Furthermore, calculte *Miqdār al-Khusūf al-Syibhi wa al-Khusūf al-Ḥaqīqi* with the formula: L1 = L10 + L11 x T; L2= L20 + L21 x H; L1= L10 + L11 x H; L3= L30 + L31 x H; Sc = Sc0 + Sc1 x T; M= ((x0+x1 x H)^2+(y0+y1 x H)^2); Magnitude penumbra = (L1 – m) / (2 x Sc); Umbra Magnitude = (L2 – m) / (2 x Sc). Look at the Magnitude penumbra / *Miqdār*

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al-Khusūf al-Syibhi value, if the value is negative then there is no lunar eclipse. If the value of Magnitude umbra / *Miqdār al-Khusūf al-Ḥaqīqi* is negative, then a Penumbral lunar eclipse occurs. If the value of the umbral Magnitude is positive and the value is less than one, then a partial umbral lunar eclipse occurs and if the value of the umbral Magnitude is more than 1, then a total umbral lunar eclipse occurs [19, p. 144].

***Astronomical Algorithms* and Lunar Eclipse Calculation Types**

Astronomical Algorithms is the work of a Belgian astronomer named Jean Meeus who was born in Belgium in 1928. He studied mathematics at the University of Leuven, Belgium, then graduated in 1953. He was interested in spherical astronomy and celestial mechanics. The works of Jean Meeus include *Canon of Solar Eclipses*, *Elements of Solar Eclipses 1951-2200*, *Five Millennium Canon of Lunar Eclipses: -1999 to +3000 (2000 BCE to 3000 CE), Astronomical Formulae for Calculators*, *Astronomical Algorithms*, *Transits, Astronomical Tables of the Sun*, *Moon and Planets,* .[21]

Astronomical Algorithms is a book for experts or beginners in the field of astronomy who want to practice astronomical calculations [2, p. 1] including the calculation of lunar and solar eclipses in chapter 54. This book has two editions, the first edition was printed in 1991 and the second edition was printed in 1998 which in this edition there are improvements to some writings that are misprinted and some things are wrong and there are new chapters added, namely the Jewish and Muslim Calendars, Saturn Satellites and several other additions [2, p. 2]. There are 58 chapters in this book and 4 appendices with a total of 477 pages [2, pp. 3–4].

The calculation of lunar eclipse types in the Astronomical Algorithms book consists of several steps, as follows: Calculating the Julian Day Ephemeris (JDE) instant of the average full moon, the value of k = 0.50 for the Full Moon because the lunar eclipse occurs during the Full Moon; Calculating T; calculating the value of E; Calculating the average anomaly of the Sun (M); Calculating the average anomaly of the Moon (M'); Calculating the value of F (the Moon's latitude argument) [2, pp. 349–350] ·, if the result is 180° - F degrees less than 13.9°, then an eclipse is likely will occur. If the result of 180° - F is more than 21°, it is likely that an eclipse will not occur and if the result is a value between 13.9° and 21° it cannot be determined whether an eclipse occurs or not, further steps are needed to find out[1]; continued to calculate the longitude of the Moon's rising point omega (Ω) [2, p. 380]; calculate F1;

[1] Jean Meeus, *Astronomical,…*hlm. 380.

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calculate A1; calculating JDE corrections; calculate the corrected JDE when a maximum eclipse occurs, the corrected JDE formula; calculate JDE at maximum eclipse; calculate P; Calculating Q; calculate W; calculate γ; calculate u [2, p. 381]; calculate the magnitude of the penumbral eclipse, calculate the magnitude of the umbral eclipse [2, p. 382]; calculate Pu; calculate T1; calculate H Count n; calculate the Semi duration of the penumbral phase: calculate the Semi duration of the partial phase; calculates the Semi total phase duration.

If the value of magnitude penumbra is negative, then there is no lunar eclipse. If the magnitude value of the umbral eclipse is negative, then a penumbral lunar eclipse occurs. If the value of semi total duration is negative, then a partial lunar eclipse occurs, otherwise if the value of semi total duration is positive, then a total lunar eclipse occurs [2, p. 383].

Earth's Shadow Enlargment

In 18th and 19th century, there were several values of umbral enlargement from 1/40 to 1/65 [22, pp. 247–253]. History of enlargement of earth's shadow was begun in 1700 by French Astronomer Philippe de La Hire earth's umbra observation. The result is to fit timing made during a lunar eclipse observation, the predicted shadow radius needed to be enlarged by 1/41. According to Chauvenet (1891) by his observation result, the shadow enlargement was variable among a lunar eclipse. He adopted 1/50, which was used by many international worldwide to be the standard enlargement factor for lunar eclipse [4, p. 7]. Andre Danjon (1951) though Chauvenet was not closely correct to apply to the entire expression for geometric radius [22].He stated the only understandable procedure of accounting for a layer of opaque air surrounding Earth is to raise the planet's radius by the altitude of the layer. This can be accomplished by proportionally raising the parallax of the Moon. The radii of the umbral and penumbral shadows are then subject to the same absolute correction and not the same relative correction employed in the traditional Chauvenet 1/50 convention. Danjon guess the thickness of the occulting layer to be 75 km and this results in an enlargement of Earth's radius and the Moon's parallax of about 1/85 [23].

Link (1969) found a mean shadow enlargement of 2.3% from his research in 57 eclipses among 150 years. Additionally, crater entrances timings and exits through the umbra when four lunar eclipses from 1972 to 1982 closely backing the Chauvenet shadow enlargements value of 2%. there is no abrupt boundary between the umbra and penumbra from a physical point of view. The shadow thickness actually varies continuously as a function of radial distance from the central axis out to the extreme edge of the penumbra. However, the

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thickness variation is most rapid near the theoretical edge of the umbra. Kuhl's (1928) contrast theory demonstrates that the edge of the umbra is perceived at the point of inflexion in the shadow density. This point appears to be equivalent to a layer in Earth's atmosphere at an altitude of about 120 to 150 km. The net enlargement of Earth's radius of 1.9% to 2.4% corresponds to an umbral shadow enlargement of 1.5% to 1.9%, in reasonably good agreement with the conventional value.

In the *Five Millennium Canon of Lunar Eclipses: -1999 to +3000 (2000 BCE to 3000 CE)*, Espenak and Meeus use Danjon's enlargement method to calculate Earth's penumbral and umbral shadow sizes. Other canons using Danjon's method include Meeus and Mucke (1979), Espenak (2006) and *Connaissance des Temps*. Several canons using Chauvenet's method are Espenak (1989), Liu and Fiala (1992), and *Astronomical Almanac* [4, p. 8].

Comparison of Types of Lunar Eclipses *Al-Dur al-Anīq* with *Astronomical Algorithms* From 2011 – 2050 Ad

There are 3 types of lunar eclipses in *Astronomical Algortihms*, namely Total Lunar Eclipses, Partial Lunar Eclipses and Penumbral Lunar Eclipses. *al-Dur al-Anīq* divides lunar eclipses into 4 types, namely *al-Khusūf al-Haqīqi al-Kullī* (Total Umbral Lunar Eclipse), *al-Khusūf al-Haqīqi al-Juz* (Partial Umbral Lunar Eclipse), *al-Khusūf al -Syibhī al-Kullī* (Total Penumbral Lunar Eclipse) and *al-Khusūf al-Syibhī al-Juz* (Partial Penumbral Lunar Eclipse) such as Bao Lin Liu and Alan D. Fiala in Canon of Lunar Eclipses 1500 BC-AD 3000, but in data from the calculation of the lunar eclipse, both of them only classify lunar eclipses into three types. According to the author, the division into 4 types is based on the position of the Moon when the Lunar Eclipse moves into the shadow of the Penumbra or reaches the Umbra. Thus, the Lunar Eclipse is broadly divided into two, namely the Umbral and Penumbral Lunar Eclipses, then each is divided into two. The Umbral Lunar Eclipse is divided into two, namely the Total Umbral Lunar Eclipse (Total Lunar Eclipse and Partial Umbral Lunar Eclipse). However, due to the appearance of the eclipse It is difficult to see the changes in the penumbral moon directly, so the penumbral lunar eclipse is not classified into two like the umbral lunar eclipse in the calculation results of the lunar eclipse.

The author compares the penumbra and umbra magnitudes in al-Dur al-Anīq, Astronomical Algorithms and NASA from 2011 to 2050 AD.:

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Table 1. Magnitude Penumbra and Umbra Comparison

No.	Calculation	Penumbra Magnitude	Umbra Magnitude
1	*A Algorithms & al-Dur al-Anīq*	0.0044	0.0048
2	*A Algorithms & NASA*	0.0044	0.0049
3	*al-Dur al-Anīq & NASA*	0.0002	0.0002

Table 1 shows a comparison of the magnitudes of the penumbra and umbra. First, the comparison of the magnitude of the penumbra. The average difference between is *al-Dur al-Anīq* 0.0044 larger than *Astronomical Algorithms*, the largest difference in the Penumbral Lunar Eclipse May 5, 2023 is 0.0116 and the smallest difference in the Total Lunar Eclipses of March 13, 2044 and September 19, 2044, which is 0.0001. Then the difference in the average comparison of *Astronomical Algorithms* with NASA is 0.0044 (NASA has larger penumbral magnitude), the largest difference in magnitude is 0.0111 in the Penumbral Lunar Eclipse May 5, 2023 and there is the same penumbral magnitude value in the Total Lunar Eclipse September 19, 2044. The average difference comparison of *al-Dur al- Anīq* with NASA is 0.0002 (*al-Dur al- Anīq* has larger penumbral magnitude), the largest difference between the two Penumbral Lunar Eclipses on August 17, 2027 and July 18, 2027, is 0.0009 and there are 14 eclipses with the same magnitude.

Second, the comparison of the magnitude of the umbra. The average difference between *al-Dur al-Anīq* and *Astronomical Algorithms* is 0.0049 (*al-Dur al- Anīq* has larger umbral magnitude), the largest difference in the Penumbral Lunar Eclipse 5 May 2023 is 0.0122 and the smallest difference is 0.0001 in three eclipses, namely the Total Lunar Eclipse 27 July 2018, 8 November 2022 and 18 November 2040. The average difference between *Astronomical Algorithms* and NASA is 0.0048 (*NASA* has larger umbral magnitude), the largest difference in the Penumbral Lunar Eclipse 5 May 2023 is 0.0115 and the smallest difference is in the Total Lunar Eclipse 8 November 2022. The average difference comparison of *al-Dur al-Anīq* with NASA is 0.0002 (*al-Dur al- Anīq* has larger umbral magnitude), the largest difference is 0.0011 in the Penumbral Lunar Eclipse of July 18, 2027 and 15 eclipses have same umbral magnitude value.

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The author then presents the types of lunar eclipses of al-Dur al-Anīq, Astronomical Algorithms and NASA from 2011 to 2050 AD. The following table lists the types of lunar eclipses for each calculation:

Table 2. Lunar Eclipse Type Comparison

No.	Types	NASA	*al-Dur al-Anīq*	*A Algorithms*
1	Penumbra	33	33	32
2	Partial	20	20	21
3	Total	37	37	36
	Total	90	90	89

Table 2 shows that the types of lunar eclipses from 2011 to 2050 AD *Astronomical Algorithms* and NASA are the same, namely 90 lunar eclipses of 33 penumbral, 20 partial and 37 total. Meanwhile, *Astronomical Algorithms* have 89 lunar eclipses with 32 penumbra, 21 partial and 36 total. Differences occurred in 2 lunar eclipses on April 4, 2015 and July 18, 2027, NASA and *al-Dur al-Anīq* classified the April 4, 2015 lunar eclipse as a total lunar eclipse, while the Astronomical Algorithms for a partial lunar eclipse. Meanwhile, the lunar eclipse of July 18, 2027, was classified as a penumbral lunar eclipse by NASA and *al-Dur al-Anīq* and Astronomical Algorithms based on their calculations that there was no lunar eclipse on that date. Based on table 1, the April 4, 2015 lunar eclipse has a penumbra magnitude difference of 0.0034 with *al-Dur al-Anīq* and 0.0036 with NASA, while the umbra magnitude has a difference of 0.0052 both with *al-Dur al-Anīq* and NASA. Lunar eclipse of 18 July 2027 has a penumbral magnitude difference of 0.0023 with *al-Dur al-Anīq* and 0.0014 with NASA, while the umbra magnitude has a difference of 0.0094 with *al-Dur al-Anīq* and 0.0083 with NASA. The difference that has been mentioned is still below the average difference between the magnitudes of the penumbra and umbra, except for the difference in the magnitude of the umbra for the lunar eclipse of July 18, 2027, but the difference is not the largest difference, so it does not cause a difference in the type of eclipse. The factor that causes the different types of the 2 lunar eclipses is the small magnitude value and is at the classification limit between eclipse types.

The Penumbral Lunar Eclipse of July 18, 2027 AD and the Total Lunar Eclipse of April 4, 2015 M are included in the category of Penumbral Lunar Eclipse with extreme magnitude in the *Five Millennium Canon of Lunar Eclipses: -1999 to +3000 (2000 BCE to 3000 CE)* by Fred Espenak and Jean Meeus. The book classifies extreme magnitude values of

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12,064 Lunar Eclipses (2000 BCE to 3000 CE) for each type of Lunar Eclipse from such as Penumbral Lunar Eclipse (penumbral magnitude 0.0020 and 1.0080), Partial Lunar Eclipse (umbral magnitude 0.0020 and 0.9980) and Total Lunar Eclipse (umbra magnitude 1.0020 and 1.8700).**Espenak and Meeus, Five Millennium Canon of Lunar Eclipses: -1999 to +3000 (2000 BCE to 3000 CE), p. 32-34.**

The Penumbral Lunar Eclipse July 18, 2027 AD is among the 7 Penumbral Lunar Eclipses with an extreme magnitude ≤ 0.0020. The eclipse with the smallest penumbral magnitude on December 13 -780 with a penumbral magnitude of 0.0004. The following is a list of the 7 eclipses:

Table 3. Penumbral Lunar Eclipse with Magnitude ≤ 0.0020 [4, p. 32]

No.	Date	Saros	Gamma	Penumbra Magnitude	Duration
1	13 December -780	61	-1.5529	0.0004	5.2 minutes
2	23 January -411	27	1.5791	0.0013	11 minutes
3	7 May -311	74	1.5502	0.0008	7.8 minutes
4	7 February -103	80	1.5540	0.0019	12 minutes
5	20 May 859	112	1.5700	0.0007	8.1 minutes
6	18 July 2027	110	-1.5758	0.0014	11.8 minutes
7	11 February 2791	175	-1.5670	0.0006	7.4 minutes

Table 3 shows the Penumbral Lunar Eclipse July 18, 2027 is one of the lunar eclipses with the smallest magnitude from 2000 BCE to 3000 CE. The small magnitude results in the duration of the lunar eclipse getting shorter, the lunar eclipse of July 18, 2027[24], with a duration of 11 minutes 48 seconds. This lunar eclipse is included in the 110 saros series. Saros is a periodization and repetition of eclipses (Moon or Sun) with 1 period of about 18 years 11 days 8 hours. All 110 saros lunar eclipses occur at the ascending node of the moon and the moon moves to the southward and there are 72 lunar eclipses consisting of 13 total, 43 partial and 16 penumbral in this series, starting with a penumbral lunar eclipse on 28 May 747 and the last eclipse is penumbral lunar eclipse on 18 July 2027. All eclipses in table 3 are the beginning and end of each saros series respectively [4, p. 32]. The occurrence of different types of eclipses that have been discussed previously is normal for this lunar eclipse because the very small penumbra magnitude value is less than 0.0044 (the average difference in the penumbra magnitude of the Astronomical Algorithms & NASA) and is between the determination of the type of penumbral eclipse and no lunar eclipse occurs.

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Total lunar eclipse of April 4, 2015 is also one of 12 total lunar eclipses with an umbra magnitude ≤ 1.0020, the smallest magnitude occurring on a lunar eclipse of 17 October 1529. The following is a table of 12 lunar eclipses with an umbra magnitude ≤ 1.0020:

Table 4. Total Lunar Eclipse with Magnitude ≤ 1.0020 [4, p. 34]

No.	Date	Saros	Gamma	Umbra Magnitude	Duration
1	31 January -1573	18	0.4776	1.0008	4.2 minutes
2	9 Juny -1338	28	0.4662	1.0012	5.5 minutes
3	10 August -318	62	0.4474	1.0009	4.9 minutes
4	30 March -200	48	-0.4790	1.0019	6.6 minutes
5	19 April 767	92	0.4581	1.0002	2.4 minutes
6	3 December 792	96	0.4413	1.0004	3.1 minutes
7	17 October 1529	109	0.4775	1.0001	1.7 minutes
8	4 April 2015	132	0.4460	1.0008	4.7 minutes
9	11 September 2155	130	-0.4752	1.0003	2.6 minutes
10	25 May 2366	146	0.4871	1.0007	3.9 minutes
11	11 September 2565	156	0.4700	1.0009	4.6 minutes
12	8 June 2905	164	0.4748	1.0018	6.5 minutes

From the table data above, it can be concluded that the Total Lunar Eclipse of April 4, 2015 M is one of the 12 total lunar eclipses with the smallest umbra magnitude in a span of approximately 5000 years. This small magnitude causes the eclipse to be one of the lunar eclipses with the shortest duration of 4 minutes 42 seconds. This eclipse is included 132 saros series that occurs at the ascending node of the Moon and the Moon moves to the southward, starting at the Penumbral Lunar Eclipse May 12, 1492 AD and ending with the Penumbral Lunar Eclipse June 26, 2754 AD with a total of 71 eclipses consisting of 12 Total, 32 Partial, 27 Penumbral. Table 4 supports the difference type of lunar eclipse because the small umbra magnitude is less than 0.0049 (the average difference in the umbra magnitude of Astronomical Algorithms & NASA) and is between the determination of the type of partial and total lunar eclipse.

So, the authors conclude that *al-Dur al-Anīq* has better accuracy compared to the *Astronomical Algorithm*, because it has an average difference between the penumbra and umbra which is almost close to the NASA data, there are even 14 penumbra magnitudes and 15 for the same lunar eclipse magnitude as NASA. and there is no difference between the eclipse of the Moon *al-Dur al-Anīq* and NASA. Meanwhile, Astronomical Algorithms has

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different types of lunar eclipses with NASA on 2 lunar eclipses on April 4, 2015 and July 18, 2027.

Potential Differences Opinion on the Law of Lunar Eclipse Prayer

According to Imam 4 madzhab, the lunar eclipse prayer is divided into several opinions. The first opinion is that the lunar eclipse prayer is sunnah *mu'akkad* and is performed in congregation from Imam Shafii, Ahmad, Abu Daud and Ibn Hazm narrated by Ibn Hazm. The second opinion, the lunar eclipse prayer is a *sunnah* like the usual sunnah of Imam Abu Hanifah and Imam Malik, they argue that it is legal [10]. Meanwhile, according to several mass organizations in Indonesia, Nahdhatul Ulama, Muhammadiyah and PERSIS are not sunnah [11]. KH. Ahmad Ghazali also mentions in his book *al-Dur al-Anīq* that the Penumbral Lunar Eclipse is not a Syar'i Eclipse according to some astronomers because the eclipse prayer is not performed during the Penumbral Lunar Eclipse [19, p. 140].

Eclipse prayer announcement is based on lunar eclipse calculation in Indonesia. In this case, the lunar eclipse of 2011 to 2050, based on the comparison of the types of lunar eclipses of *al-Dur al-Anīq*, *Astronomical Algorithms* and NASA, there were differences in partial and total lunar eclipse on April 4, 2015 (Total = *al-Dur al-Anīq* and NASA, Partial = *Astronomical Algorithms*) and the Lunar Eclipse of July 18, 2027 (Penumbra Type according to *al-Dur al-Anīq* and NASA, there is no Lunar Eclipse according to *Astronomical Algorithms*). So, the different types of the two lunar eclipses do not cause different opinion on the law of the lunar eclipse prayer, because there are not differences on penumbra and partial lunar eclipse. Based on data penumbral and umbral magnitude between NASA, *al-Dur al-Anīq*, and *Astronomical Algorithms*. *Astronomical Algorithms* has the smallest magnitude than others. So that, if the difference type of lunar eclipse that cause the difference of lunar eclipse prayer between penumbra and partial types, partial lunar eclipses with the small magnitude that may cause the difference. To track the lunar eclipses Authors uses the NASA data of partial lunar eclipse with magnitude $\leq$ 0,0020 from after from -1999 to 3000 that contain 11 lunar eclipses and choose 3 lunar eclipses that happen after 2050 AD. ie. 24 February 2157, 16 June 2421 and 22 May 2627 to be compared with Astronomical Algorithms [4, p. 33]. The result shows Astronomical Algorithms differs with NASA. Lunar eclipses: 24 February 2157, 16 June 2421 and 22 May 2627 are penumbral eclipse based on Astronomical Algotihms and partial lunar eclipse based on NASA.

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The difference opinion on the law of the eclipse prayer happens only in several lunar eclipses i.e. 24 February 2157, 16 June 2421 and 22 May 2627 AD., moreover there is no different that cause different opinion between 2011-2050 based on the lunar eclipse calculation comparison. So, It is different with the beginning of Lunar/Hijri month[25] that happen frequently and involve the largest islamic organization in Indonesia and cause on obligatory worship.

D. Conclusion

Comparison of *al-Dur al-Aniq's* Lunar Eclipse Type with *Astronomical Algorithms* validated by NASA data from 2011 to 2050 AD shows that *al-Dur al-Anīq* has better accuracy than *Astronomical Algorithms* because of the magnitude value of the Penumbra and Umbra *al-Dur al-Anīq* is only slightly different from NASA and there is no difference in the type of lunar eclipse between *al-Dur al-Anīq* and NASA. Meanwhile, there are differences in determining the type of lunar eclipse between the *Astronomical Algorithms* and NASA, namely April 4, 2015 AD (*Astronomical Algorithms* = Partial Lunar Eclipse, *al-Dur al-Anīq* and NASA = Total Lunar Eclipse) and July 18, 2027 AD (*Astronomical Algorithms* = No Lunar Eclipse, *al-Dur al-Anīq* and NASA = Penumbral Lunar Eclipse). This difference occurs because the two eclipses have a small magnitude value, less than the average difference between the *Astronomical Algorithm's* magnitude value and NASA and are within the classification boundary between types of lunar eclipses. The difference in the types of lunar eclipses among 2011-2050 AD. do not cause the difference opinion on the law of lunar eclipses prayer because the differences occur in lunar eclipses (no eclipse - penumbra) and lunar eclipses (partial - total), not between partial lunar eclipse – penumbra lunar eclipse. The difference types of eclipses that have an effect on the difference of lunar eclipse prayer is an eclipse with small umbra magnitude value such as the lunar eclipses of February 24, 2157, June 16, 2421 and May 22, 2627.

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