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Astronomical Determinations for the Beginning Prayer Time of *Isha'*

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Abstract: According to *fiqh*, muslim prayer time of *Isha'* begins when *shafaq* ýphenomenon disappears at dusk. This research implements astronomical determinations to study the phenomenon and result the empirical descriptions. The observation was conducted at Tanjung Aru, Sabah, East Malaysia. Based on suitability, the disappearance of *shafaq al-abyad* is applied for Malaysia locality condition. The research has employed SQM-LE meter to collect sky brightness data. According to the results, the sky brightness magnitude for the disappearance of *shafaq al-abyad* is obtained averagely at 20.79 ± 0.36 mag/arcsec^2 with mean solar depression angle at 107.99° ± 0.16°. The results are considered to be still consistent with the theoretical value of 108° which marks the beginning of night time and the disappearance of daylight.

Key words: Muslim prayer time % Sky brightness % Sky quality meter % *Isha'* % *fiqh al-salat*

INTRODUCTION

The determination of Muslim prayer times are discussed in Islamic jurisprudence studies namely *fiqh*. It covers the injunctions from the Quran and the Hadith (the prophetic tradition) with views from Islamic jurists namely *fuqaha'* related to the obligation of Muslim prayer and its prescribed times. The studies provide only qualitative descriptions. On that reason, this research attempts to explain quantitatively when is the beginning time of *Isha'* by using astronomical methods.

Methodology

Theory: In *fiqh* perspective, *shafaq* literally means reddening and contextually is remarked as the sky condition at western horizon related to the determination of the ending time of *Maghrib* and the beginning time of *Isha'*. The sky changes slowly from reddening, followed yellowing and lastly whitening before it appears completely dark. Islamic jurists agree *salat* of *Maghrib* ends and *Isha'* begins when the phenomenon of *shafaq* is set in but they have different views in explaining the sky condition of *shafaq*ý. The phenomenon is comprehended from the verses of Quran and the text of Hadtith in which must occur during dusk [1-10].

The dusk phenomenon can be observed after the sun has set at western horizon. The observer on the earth receives light at the time of sunset. It is scattered and reflected by earth's atmosphere. The intensity of light diminishes as the sun sinks further below the horizon. The intensity spectrum ranges from 100 nm to 22.5 ìm. It is category in three conditions as civil, nautical and astronomical dusk correspondingly based on sky brightness condition and solar depression angle [11-14].

There are two types of sky condition of *shafaq* have been defined by *fuqaha'* i.e. *shafaq al-ahmar* and *shafaq al-abyad*. The descriptions distinct in terms of sky brightness level at western horizon after sunset. *Maghrib* is started after sunset. It will ends following *Isha'* begins either at the end of *shafaq al-ahmar* or at the end of *shafaq al-abyad*. The period of *Isha'* ends at the beginning of dawn [1-10].

According to *fiqh* explanations, the condition of sky reddening at dusk can be noted as *shafaq al-ahmar* and it occurs before *shafaq al-abyad*. The disappearance of sky whitening when the sky is almost dark marked as

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Table 1: The disappearance of *shafaq al-abyad* by Islamic organizations [11-14]

Islamic Organization	Solar Depression Angle
Western Islamic Organizations	105°
Muslim World League	107°
Egyptian General Authority of Survey	107.5°
‘Aisya Charity, City of Montreal Canada	107.5°
University of Islamic Sciences, Karachi	108°
JAKIM, Malaysia and Badan Hisab and Rukyat Dep.	
Agama Indonesia	108°
Umm Al-Qura of Saudi Arabia	110°

Table 2: The disappearance of *shafaq al-abyad* by

Scholars	Solar Depression Angle
Al-Marrakushi	106°
Al-Qayini, Ibn Yunus, Ibn al-Shatir, al-Khalili,	
al-Tusi, Sibt al-Maridini, Muwaqits of Syria,	
Morocco, Egypt, Turkey since 15th CE	107°
Habash, al-Nayrizi, al-Biruni, Ibn Al-Haytham, Ibn Mu’adh	108°
Abu ‘Abdullah ibn Ibrahim ibn Riqam	109°
previous scholars [11-14]	

shafaq al-abyad. It is permitted either to use the disappearance of *shafaq al-ahmar* or the disappearance of *shafaq al-abyad* for determining the ending time of *Maghrib* and the beginning time of *Isha’*. The disappearance of *shafaq al-abyad* is used widely in present condition includes in Malaysia because it is more convenience and compatible for the country in equatorial region [11-14].

Most of previous studies have used the measurement of solar depression angle to explain the disappearance of *shafaqý*. The value ranges from 102° to 105° of solar depression angle to define the disappearance of *shafaq al-ahmar*, which occurs nearly at the stage of nautical dusk. Meanwhile, the disappearance of *shafaq al-abyad* is estimated to parallel with the end of astronomical dusk for which different value of solar depression angle is used relatively on different location as shown in Table 1 and Table 2 [11-14].

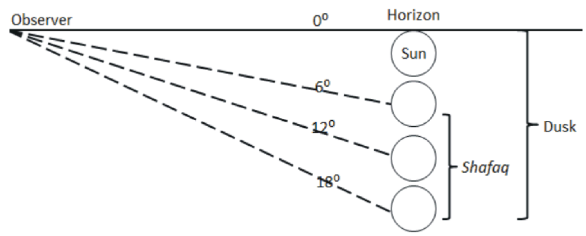


Fig. 1: *Shafaq* and dusk (Illustrated by author)

The sky brightness condition for the disappearance of *shafaq al-abyad* at western horizon essentially underlies the value of solar depression. It is significantly implemented to provide accurate prayer timetable for civil use and to regulate the timetable. As the phenomenon occurs at dusk (Figure 1), thus the condition tends to vary considerably caused by several influencing factors: (1) the geographical latitude and the season of the site; (2) the elevation of the site above sea level; (3) the atmospheric or meteorological conditions such as clouds, haze, aerosol, air pollution and dusts, this factor causes the sky gets darker earlier than usual; (4) the local conditions such as light pollution from the ground topography and the nearby trees and buildings; (5) other astronomical factors such as thunder, moon brightness and zodiacal light. The atmospheric and meteorological factors are essentially responsible affecting the brightness condition. The sky brightness is also so different during cloudy sky and clear sky as the cloud affects it strongly [12, 14-16].

The sky brightness conditions of dusk stages are given in luminance unit (lux) as presented in Table 3. In expecting the lower limit of sky brightness at dusk stages, we consider to use the relation between luminance, L (cd/m^2) and incident illuminance, I (lux) for a perfect diffuse reflector with reflectivity at 1. The relation formula is employed to generate the expected value for lower limit of sky brightness [17-19].

$$\text{Luminance } (cd/m^2) = 1/\pi \times \text{Illumination (lux)} \times \text{Reflectivity} \quad (1)$$

Table 3: Sky brightness conditions [17-19]

Dusk Stages	Illuminance	Luminance	Expected Value for Lower Limit of Sky Brightness
Civil Dusk	3.4 lux	1.08 cd/m^2	12.42 $mag/arcsec^2$
Nautical Dusk	8.31×10^{-3} lux	2.64×10^{-3} cd/m^2	19.03 $mag/arcsec^2$
Astronomical Dusk	6.52×10^{-4} lux	2.08×10^{-4} cd/m^2	21.79 $mag/arcsec^2$

From cd/m^2 to $mag/arcsec^2$:

$$x = 12.58-2.5 \text{ Log } (y) \qquad (2)$$

From $mag/arcsec^2$ to cd/m^2:

$$y = 10^{(12.58-x)/2.5} \qquad (3)$$

According to equation (1), 3.4 lux is equivalent to 1.08 cd/m^2 from a perfect reflector and 1.08 cd/m^2 is equivalent to 12.42 $mag/arcsec^2$ based on equation (2) [17-19].

For general guide, dusk is categorized into three types of stage relatively depends on solar depression angle irrespective of the influencing factors. Civil dusk is refers to the ending time of evening after sunset until solar depression is geometrically 6 degrees below the horizon. During civil dusk, terrestrial objects and the horizon is clearly can be distinguished, the brightest stars are visible to the naked eye as well as the extended sources of planets such as Venus and Saturn, thus, outdoor activities still can be carry on during this civil dusk without any artificial sources of light [11, 12, 15].

Nautical dusk is defined as the ending time of evening when solar depression is geometrically between 6 to 12 degrees below the horizon. At the time of nautical dusk, the horizon is clearly not distinguishable to the naked eye, general outlines of some terrestrial objects still can be discerned but some of smaller ground objects no longer can be recognized. Any outdoor activities therefore required artificial sources of light [11, 12, 15].

When center of the sun is geometrically between 12 to 18 degrees below the horizon, it is defined as astronomical dusk. End of astronomical dusk is remarked as the beginning of night. At the stage of astronomical dusk in the evening, the sky is mostly dark and the sunlight is so faint that it is practically imperceptible to the naked eye due to the sun does not contribute to sky brightness. During this astronomical dusk, the point sources like the stars and zodiacal light are perceptible to the naked eye. Instead, faintest and dimmest objects such as nebulae, galaxies and the stars above the sixth magnitude only visible to the naked eye when solar depression angle is above 18 degrees, which is after the astronomical dusk [11, 12, 15].

Current implementation by Malaysia Department of Islamic Development (JAKIM) refers the 108° of solar depression as fixed value on its calculation to define the disappearance of *shafaq al-abyad* as stated in equation (4) [20].

$$t_I = \cos^{-1} (\cos 108° - \sin \delta_I \sin \phi_L / \cos \delta_I \cos \phi_L) \qquad (4)$$

Isha' time = LST + t_I

Where, Z_I = 108° of zenith distance/solar depression for *Isha'*/ the disappearance of *shafaq ý* ý al-abyad; t_I = hour angle; δ_I = declination; ϕ_L = latitude; LST = Local Standard Time

Instrumentation: We have used SQM-LE to obtain the parameter of sky brightness. The Unihedron SQM is robust devices and sensitive used specially for measuring the darkness of the sky. The device measures the darkness of the sky in the unit of magnitudes per square arcsec ($mag/arcsec^2$). Magnitudes per square arcsec are a logarithmic measurement to describe the brightness of an object. These meters are operated using a quantum detector that responds to the rate of incidence of photons on the detector thereby making the SQM reading is indicative of the sky brightness within its field of view. Small numerical changes in SQM reading represent large changes in sky brightness [21].

The absolute precision is believed to be ±10% (±0.10 $mag/arcsec^2$). The difference in zero point is typically ±10% (±0.10 $mag/arcsec^2$). The sensitivity to a point source 19° off-axis is a factor of 10 lower than on-axis. A point source 20° and 40° off-axis would register 3.0 and 5.0 magnitudes fainter, respectively. Specific indication for the measurement of SQM is tested and checked by Cinzano respective of acceptance angle, linearity and spectral response [22]. The initial calibration of SQM covers light calibration offset (19.90 $mag/arcsec^2$) with temperature 28.0°C, dark calibration time period (300.000 seconds) with temperature 36.7°C and calibration offset (8.70 $mag/arcsec^2$) [18, 22].

Simple programming using JAVA has to be used in order to set the IP address of the SQM-LE through laptop to enable the device collects data [23]. Knightware SQM Reader is installed allows to take the readings of the meter either on-demand or automatically reading [24].

The instrumentation also includes other complimentary equipments such as a simple circuit to provide power source to the meter consist of 1A fuse, four 1.5 Volts batteries, battery casing, connectors, tripod, cardboard and a black paper are needed to support and focused the same spot of the sky on the meter while taking readings.

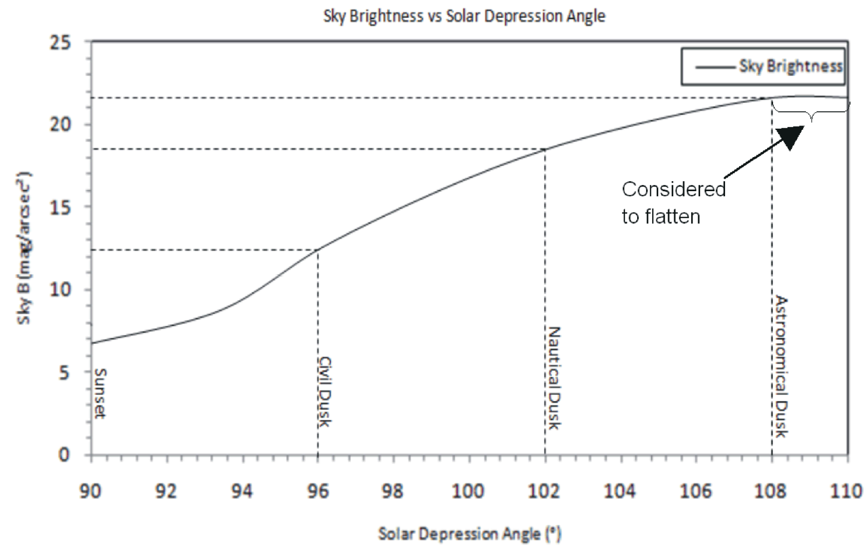


Fig. 2: Example of plotted graph to determine the disappearance of *shafaq al-abyad*

Observation: The selected location is Pantai Tanjung Aru, Kota Kinabalu, Sabah, Malaysia for observation in June 2009. The coordinates for Pantai Tanjung Aru are latitude, M: 5° 57' N; longitude, 8: 116° 02' E; time zone: +8 h; elevation above sea level: 3.695 m. It is chosen since there is no sky brightness data being obtained from the location and the previous study only covers on Peninsular Malaysia region.

For the observational technique, the SQM is pointed 15° above the horizon and the data is taken in 1-minute interval time contrary from previous research, which is obtained in 2 minutes interval time. Temperature and humidity data were manually written into the specific form while data reading of SQM-LE was automatically saved into computer through its proprietary software Knightware SQM Reader.

Analysis: The analysis process consists of the determination of sky brightness condition at dusk and the determination of sky brightness for the disappearance of *shafaq al-abyad*. MoonCalc V.6 is used to compute solar depression angle at the specific time for the location, as the parameter is essential to plot the graph.

Each stage of dusk theoretically is identified based on solar depression where the value for civil, nautical and astronomical dusk is 96°, 102° and 108° respectively. In order to examine the lower limit magnitude, therefore, the sky brightness at civil and nautical dusk is determined considerably by selecting the highest magnitude from the stage. The disappearance of *shafaq al-abyad* is considered to present the lower limit of astronomical dusk.

The disappearance of *shafaq al-abyad* is conceptually similar to the end of astronomical dusk i.e. remarks the horizon sky begins to dark completely. Hence, the disappearance of *shafaq al-abyad* is determined when sky brightness graph and data readings are showing start to flatten as shown in Figure 2.

Figure 2 presents the relation between sky brightness and solar depression angle. The observation is carried out from sunset until 110° of solar depression. The increasing value of the magnitude presents the decreasing of sky brightness, which is the sky becomes darker as the sun sinking below the horizon.

The pattern of the curve indicates in three stages by plotting the sky brightness versus solar depression. The first pattern shows distribution of data slowly grows which means the western sky horizon is still bright and it is very slowly getting dark. It is particularly can be seen at the stage of civil dusk (90° to 96° of solar depression) and at the beginning of nautical dusk (96° to 102° of solar depression).

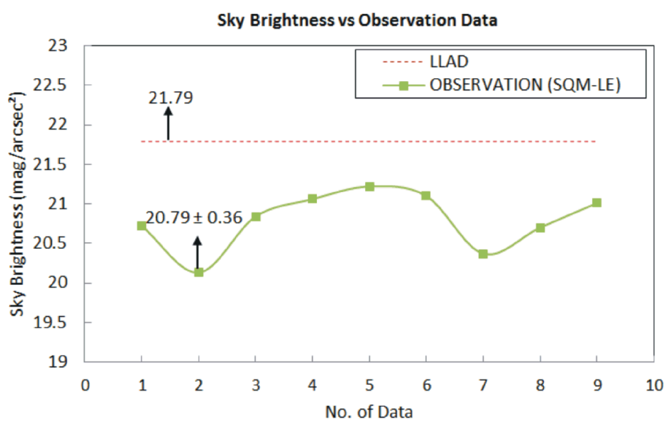
Next, there is a small increase gradually in the sky brightness magnitude occurs at the end of nautical dusk and at the beginning of astronomical dusk (102° to 108° of solar depression). The sky is rapidly become darkened and the disappearance of sky reddening qualitatively can be observed.

The third pattern shows the small numerical change in magnitude reading which happens at the end of astronomical dusk. At this stage, the disappearance of *shafaq ýal-abyad* or the end of astronomical dusk, when the curve starts to flatten and the data reading are almost constant for a period. It is essential to note that the obtained solar depression from graph is the observational value respective of the influencing factors such as weather and local condition.

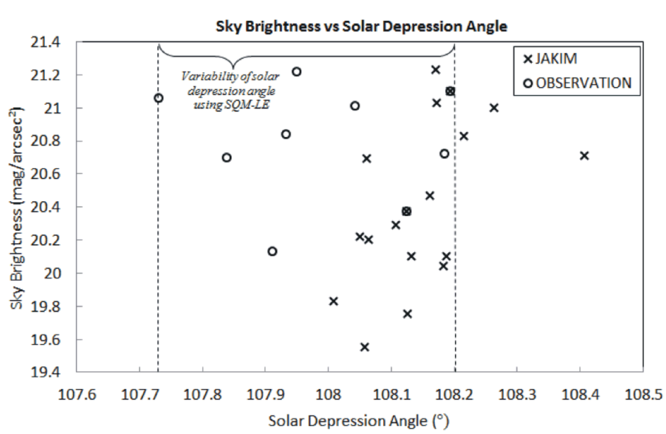
RESULTS AND DISCUSSION

Graph 1 presents the results of sky brightness measurement at astronomical dusk. The graph is an improved version of the previous article especially in term of data selection and graph analysis [25]. Accorging to the graph, the results increasing and decreasing in different value of sky brightness are presented by the fluctuated curve while the straight dashes line shows the expected value of sky brightness. The difference between the expected value for lower limit of dusk stages and the observation is essentially believed due to atmospheric and meteorological factors as the reason strongly influence the sky brightness.

Graph 2 shows sky brightness distribution for the disappearance of *shafaq al-abyad* at different solar depression. The time of *Isha'* according to JAKIM is employed to obtain solar depression angle through sky brightness data. Thus, the generated value of solar depression for JAKIM as presented in Figure 4 is 108.15° ± 0.09° (108.01°-108.41°). The difference value of solar depression between JAKIM and the observation using the meters is due to the value of JAKIM which initially based on equation 4 with 108° of solar depression to derive the time of *Isha'* is used uniformly to indicate end of astronomical dusk for general guide irrespective of atmospheric factors and local condition. While, the results of observation have fluctuated value of solar depression between 107 to 109 degrees because the measurement is conducted at the real time respective of atmospheric factors and local condition.



Graph 1: Sky brightness distribution for the disappearance of *shafaq al-abyad*



Graph 2: Sky brightness distribution for the disappearance of *shafaq al-abyad* at different solar depression

CONCLUSIONS

According to the results, the lower limit of sky brightness condition for astronomical dusk is averagely at 20.79 ± 0.36 mag/arcsec^2, whereas expected values calculated was 21.79 mag/arcsec^2. The percentages of difference between the expected value of sky brightness with the observational value is 4.5%. The results show that observational values seem higher than the expected values indicating that atmospheric and local conditions affect the reading. From the sky brightness value, mean solar depression for the disappearance of *shafaq al-abyad* as the lower limit of astronomical dusk is at 107.99° ± 0.16.

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REFERENCES

1. Al-Syirbini, M., 1997. Mughni al-Muhtaj. Beirut: Dar al-Ma'rifah, 1: 190.
2. Aal-Qarafi, A., 1994. al-Dhakhirah. Beirut: Dar al-Gharb al-Islamy, pp: 16-18.
3. ‘Anas, M., 1994. al-Mudawwanah al-Kubra. Beirut: Dar al-Kutub al-‘Ilmiyyah, 1: 156-157.
4. Ibn A’bidin, M., 2003. Rad al-Mukhtar ‘Ala al-Dur al-Mukhtar. Riyadh: Dar ‘Alim al-Kutub, 2: 17.
5. Ibn al-Humam, K., 2003. Syarh Fath al-Qadir ‘Ala Hidayah Syarh Bidayat al-Mubtadi'. Beirut: Dar al-Kutub al-‘Ilmiyyah, 1: 23.
6. al-Nawawi, Y., 2003. Raudah al-Talibin. Riyadh: Dar ‘Alim al-Kutub, 1: 292-293.
7. al-Syirazi, I., 1995. al-Muhadhdhab fi Fiqh al-'Imam al-Syafi’i. Beirut: Dar al-Kutub al-Ilmiyyah, 1: 102-103.
8. Ibn Qudamah, A., 1999. al-Mughni. Riyadh: Dar Alim al-Kutub, 2: 25-27.
9. Ibn Qudamah, A., 2001. al-Kafi. Beirut: Dar al-Kutub al-‘Ilmiyyah, 1: 207.
10. al-Zuhaili, W., 1985. Fiqh al-Islam wa Adillatuh. Damascus: Dar al-Fikr, 1: 511-513.
11. Ilyas, M., 1999. Astronomy of Islamic Times for the Twenty-first Century. Kuala Lumpur: A.S. Noordeen, pp: 64.
12. Yallop, B.D. and C.Y. Hohenkerk, 1996. A Note on Sunrise, Sunset and Twilight Times and on The Illumination Conditions During Twilight. RGO Astronomical Information Sheet No. 7. HM Nautical Almanac Office, Royal Greenwich Observatory, Madingley Road, Cambridge.
13. Miftahi, Y.A., 2005. Fajar and Isha’. London: Hizbul Ulama.
14. Katiya, S., 2007. Explanation of Muslim Prayer Timing. Montreal: ‘Aisha Charity.
15. Schmeidler, F., 1993. The Terresterial Atmosphere and Its Effects on Astronomical Observation. Compendium of Practical Astronomy. 4th Edition. Edited by Roth, G.D. Springer-Verlag: Berlin, 2: 331-335.
16. Mikhail, J.S., A.S. Asaad, S. Nawar and N.Y. Hassanin, 1995. Improving The Crescent Visibility Limits Due to Factors Causing Decrease in The Sky Twilight Brightness. Netherlands: Springer, 70: 1-3.
17. Electro-optics Handbook, N.D., Retrieved August 15, 2012, from www.photonis.com/attachment.php?id_attachment=95
18. Gibson, D., 2001. Foot-Candles: Photometric Units. CREG Journal. Retrieved August 15, 2012, from http://www.dfisica.ubi.pt/~hgil/FotoMetria/SI_Units/PhotoMetry-Units.pdf
19. Jan van Gastel, N.D., 2012. Formulae for Converting to and from Astronomy-Relevant Units. Retrieved August 15, 2012, from http://members.ziggo.nl/jhm.vangastel/Astronomy/Formules.pdf
20. Unit Falak, J.A.K.I.M., 2001. Buku Panduan Kaedah Ilmu Falak Syarie. Jabatan Kemajuan Islam Malaysia.
21. Unihedron website. Retrieved August 15, 2012, from http://www.unihedron.com/projects/sqm-l/, http://www.unihedron.com/projects/sqm-le/
22. Cinzano, P., 2005. Night Sky Photometry with Sky Quality Meter, Istituto di Scienza e Tecnologia dell'Inquinamento Luminoso, Thiene. Retrieved August, 15 2012, from http://www.lightpollution.it/download/sqmreport.pdf

23. Java website. Retrieved August, 15, 2012, from http://www.java.com/en/download/chrome.jsp?locale=en/
24. Knightware website. Retrieved August 15, 2012, from http://knightware.biz/sqm/
25. Niri, M.A., M.Z. Zainuddin, S. Man and M.S.A.M. Nawawi, 2012. The Disappearance of Shafaq al-Abyad at Dusk at Tanjung Aru, Sabah, Malaysia. In Transformation of Research in Islamic Studies, Eds., F.A.F. Hamid, W.A.W. Ramli and S.H. Abdullah, Kuala Lumpur: Postgraduates Division, Academy of Islamic Studies, University of Malaya, pp: 105-113.