I.J.S.N., VOL.9 (1) 2018: 18-24 ISSN 2229 – 6441

INTERNATIONAL JOURNAL OF SCIENCE AND NATURE

www.scienceandnature.org

STUDY OF SKY BRIGHTNESS PROFILES OF BAGHDAD AND KARBALA CITIES IN IRAQ

Ahmed Kamil Ahmed, Mohamed Ameer Sadik
Department of Astronomy and Space, College of Science, University of Baghdad, Baghdad, Iraq
Corresponding author email: ahme_jwa@yahoo.com

ABSTRACT
This study was used two detectors only *i.e*., the human eye and photometer of Sky Quality Meter (SQM-LU) during the time of sunrise and sunset. The human eye used to determine the moon's phase. The measurements of sky brightness, by using SQM-LU, performed via two locations that covered Baghdad and Karbala in Iraq from December 2016 through March 2017 intermittently. The research focused only on light perceived by detectors and not how it happens. The aim of research is to find a mathematical formula (*i.e*. brightness contrast) between the sky brightness against the solar altitude by taking moon illumination as the standard reference. Analytical software based on the Python's PyEphem astrometry library was developed to calculate the solar altitude at the two locations. Finally, the formula of sky brightness obtained from this work is an important key that contributed to finding the simulated sky brightness, when the sun's altitude is known.

KEYWORDS: Sky Brightness, SQM-LU, Brightness Contrast, and Twilight.

INTRODUCTION
The darkness, or brightness, of the night sky is a topic of interest to all amateur astronomers and astrophoto graphy's. The visibility function is defined as the magnitude difference between the excess brightness of a given object and that of the sky background. Different investigators have obtained the visibility of different-objects in the sky twilight period [1]. The light that appears before sunrise and remains after sunset, from the scientific point of view, called the twilight. In other words, twilight can be defined by the interval after sunset, or before dawn, when light from the sun is scattered towards the observer giving some local illumination, and some background light in the sky[2]. It literally means the light either between day and night or between night and day (Figure 1). The light of morning twilight gradually increases in brightness [3].

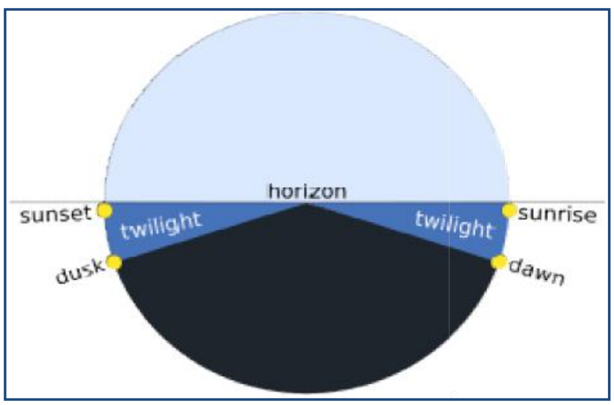

FIGURE 1: Twilight is the time between dawn and sunrise, or between sunset and dusk [4]

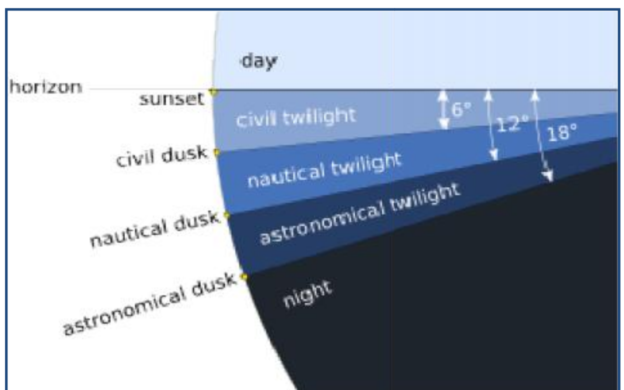

FIGURE 2: Astronomical, nautical, and civil twilight [4]

For distinguish the various phases of twilight (Figure 2). There are three types of twilight are:
1. Astronomical Twilight: This begins when the sun's centre is below the horizon at 18º.
2. Nautical Twilight: This occurs when the sun's centre is below the horizon at 12º.
3. Civil Twilight: This occurs when the sun's centre is below the horizon at 6º.

The twilight phenomenon occurs once the sun sets or rises behind the horizon, there must be some sunlight visible as its rays propagate in a long distance through the atmosphere. Therefore, twilight occurs due to sunlight hitting the earth's atmosphere and being scattered or its path is bent (Figure 3). The geometry of twilight allows light to reach us after the sun has dropped below the horizon. After sunset, as the depression of the sun increases the sky gets darker gradually until no scattered light reaches the observer. On the contrary, in the early-morning light starts to appear in the sky even before sunrise [5].

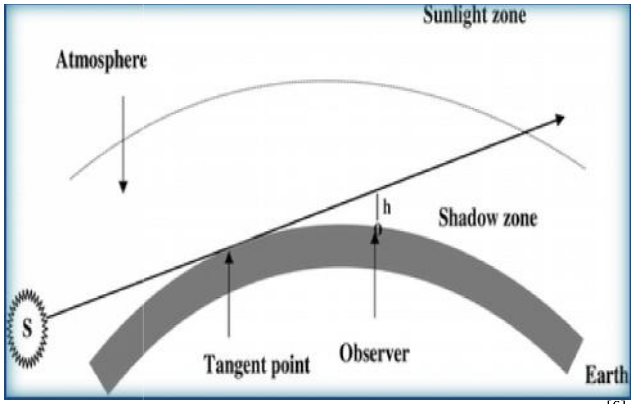

FIGURE 3: Schematic diagram of the twilight phenomena [6]

The contrast in the context of the first lunar crescent visibility is defined as the ratio of two components, the illuminance of the lunar crescent and the brightness of the sky[7]. There are effects of meteorological and atmospheric conditions on sky brightness measurements [8]. It's depends on the geometry of the sun, the earth and the moon, the distance between the moon and the sun as well as the distance between the moon and the earth. The atmospheric extinction will reduce the light or the illuminance of new moon [9]. The sky brightness due to scattered light from the sun by the earth's atmosphere in the region near the horizon will vary due to the solar depression and the distance of the sun from the earth. All factors atmospheric seeing, extinction and scattering mentioned above will reduce the quality of contrast [10].

Finally, the main factors affecting sky twilight brightness are the geographical latitude of the site, the elevation of the site above sea level, the season of measurements and aerosol pollution at the site[11]. On top of that, the sky twilight brightness provides an independent tool for probing the overhead atmosphere under much higher flux conditions, thus allowing more accurate results [12]. Our study will determined a mathematical formula of sky brightness background is correlated with the solar altitude. This formula is the key factor that contributing to measure the simulated sky brightness.

Times of Sunrise and Sunset

The hour angle and azimuth of sunrise and sunset will change because a changing declination of the sun throughout the year [13]. Sunrise is the time when the upper part of the sun is visible. On the other side, sunset is the time when the last part of the sun is about to disappear below the horizon. The time of sunrise and sunset are based on the perfect situation (clear weather conditions). There is nothing which obscures the visibility and the horizon is clear. The light coming from the sun would be refracted through the earth's atmosphere. The refraction depends on the temperature and atmospheric pressure. This would affect the rising and setting times by less than a minute. Near the north and south poles that could have a greater impact because of low temperatures and the slow rate of the sun a rising and setting.

DETECTORS & METHODS

Two detectors have used in this work, namely the human eye and the Sky Quality Meter (SQM-LU). The stimulus is, of course, light and both represent logarithmic changes. The Unihedron Sky Quality Meter has been designed by Doug Welch and Anthony Tekatch. Besides the readings, temperature, model and serial number are also displayed. It used light-to-frequency silicon photodiode; the light sensor (TSL237) provides the microcontroller with a light-level, and readings from the temperature are used to compensate the light sensor reading for various operating temperatures. The sensor is covered with an HOYA CM-500 filter to block near-infrared light [5]. The general block diagram of SQM-LU is shown in Figure (4) as well as the Figure (5) depicts the instrument of Sky Quality Meter respectively.

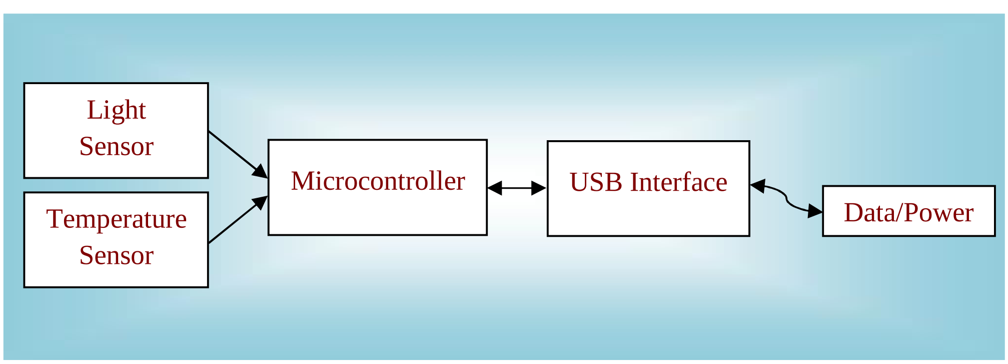

FIGURE 4: Basic elements of SQM-LU [14]

FIGURE 5: Sky Quality Meter; model LU (front and back of unit) [14]

Data Collection

The sky brightness measurements were performed via three stages is:

Pre-Observation: The photometer of Sky Quality Meter (SQM-LU) was used to measure the sky brightness variations in Baghdad and Karbala, Iraq, from December 2016 to March 2017 intermittently. Table (1) tabulates the dates. The duration of the data taking were during the time of sunrise and sunset in case of moonless and full moon. Table (2) shows the geographical coordinates of selected locations.

TABLE 2: Observation dates of sky brightness measurements with cloud classification

Date	Region	Observation	Weather
26 December 2016	Karbala	Sunset	Clear
12 January 2017	Baghdad	Sunset	Clear
27 January 2017	Karbala	Sunrise	Cloudy and Rainy
11 February 2017	Baghdad	Sunrise	Clear
01 March 2017	Karbala	Sunrise	Clear
14 March 2017	Baghdad	Sunrise	Clear
13 March 2017	Baghdad	Sunrise	Cloudy and Rainy

TABLE 2: Values of latitude and longitude of Iraq regions

Location Name	Latitude	Longitude
Baghdad	33º 19′ N	44º 25′ E
Karbala	32º 61′ N	44º 03′ E

Observation

The measurements performed several times with the aid of photometer unit. A form of scientific approach has been prepared to assist categorizing the data from different instrument. Observer requires logging swiftly any significant changes of the sky condition at a certain time on the provided form. Another item of concern to the observer is the weather type (cloud classification) at time of data taking. Preparation of laptop and also SQM-LU reader software and cleaned the optical photometer. The SQM-LU is fixing at altitude 5º±1º above the horizon; a special all-round hood placed in front of the detector for averting unwanted stray light coming from the sides. The data collected taken at each five minutes for two hours interval approximately.

Post Observation

Commercial software for the Windows (7) operating system has been selected that allowed fully automatic data processing. Thus, the input is in the form of numerical data. The Microsoft Excel software will be used to transform these data into a spread sheet after taking into account all the errors. Besides that, software based on the Python's PyEphem astrometry library is used to calculate the solar altitude at the time of sunrise and sunset for the two positions.

RESULTS & ANALYSIS

The data collected is representing the practical readings of sky brightness variations. The SQM-LU was directed at an angle whose crescent is to be observed. We have chosen the data collected on 26 December 2016 in Karbala city, Iraq, at the time of sunset as the example (Table 3) to display the sky brightness values. In addition, Figures (6 to 10) depicts the relationship between the sky brightness versus solar altitude for two regions at the time of sunset and sunrise.

TABLE 3: Sky brightness recorded on 26 December 2016 in Karbala, Iraq

Local Time (Hour: Minute)	Sky Brightness (magnitude/arcsecond^2)	Solar Altitude (degree)
17:01	7.93	-0.127
17:06	8.46	-1.059
17:11	9.10	-1.998
17:16	9.95	-2.941
17:21	11.03	-3.890
17:26	12.13	-4.844
17:31	13.31	-5.803
17:36	14.50	-6.766
17:41	15.41	-7.734
17:46	16.18	-8.706
17:51	16.57	-9.683
17:56	16.77	-10.664
18:06	17.17	-12.637
18:11	17.23	-13.629
18:16	17.27	-14.625
18:21	17.29	-15.624
18:26	17.45	-16.626
18:31	17.43	-17.632
18:36	17.37	-18.641
18:41	17.40	-19.652
18:46	17.40	-20.667
18:51	17.40	-21.684
18:56	17.40	-22.704
19:01	17.40	-23.726
19:06	17.40	-24.751
19:11	17.40	-25.778

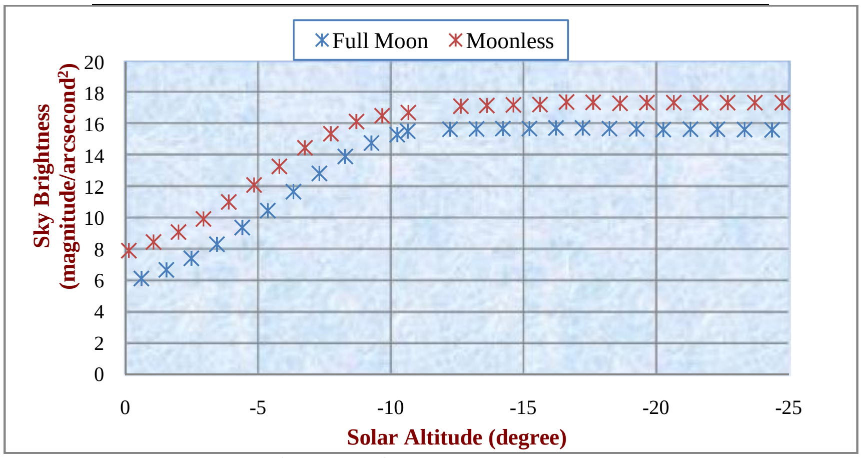

FIGURE 6: Background sky brightness as function of the solar elevation angle on 26 December 2016 and 12 January 2017 in Karbala and Baghdad, Iraq, respectively at the time of sunset

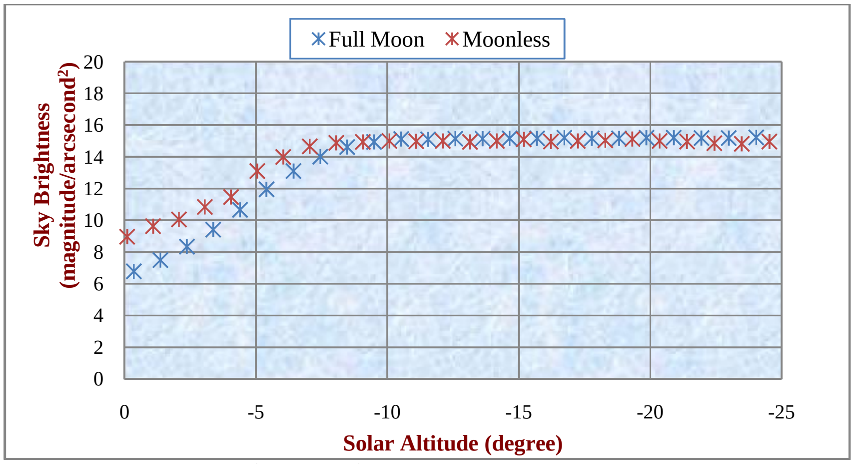

FIGURE 7: Background sky brightness as function of the solar elevation angle on 27 January 2017 and 11 February 2017 in Karbala and Baghdad, Iraq, respectively at the time of sunrise

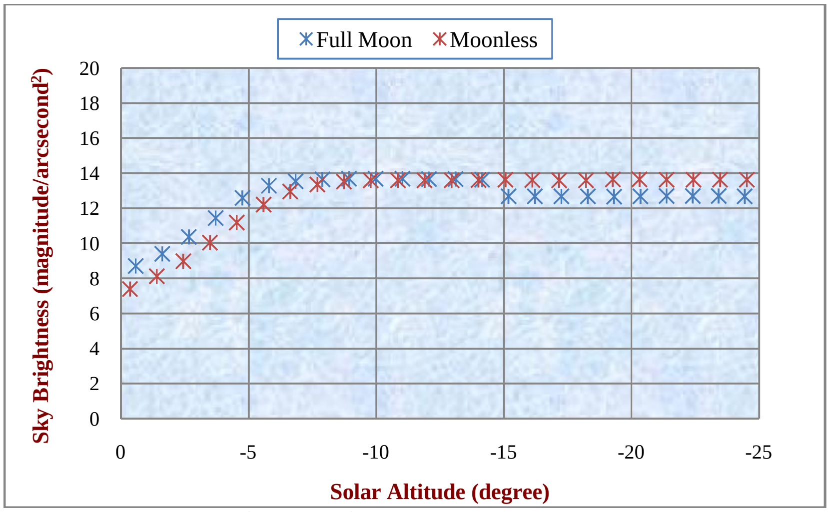

FIGURE 8: Background sky brightness as function of the solar elevation angle on 01 March 2017 and 13 March 2017 in Karbala and Baghdad, Iraq, respectively at the time of sunrise

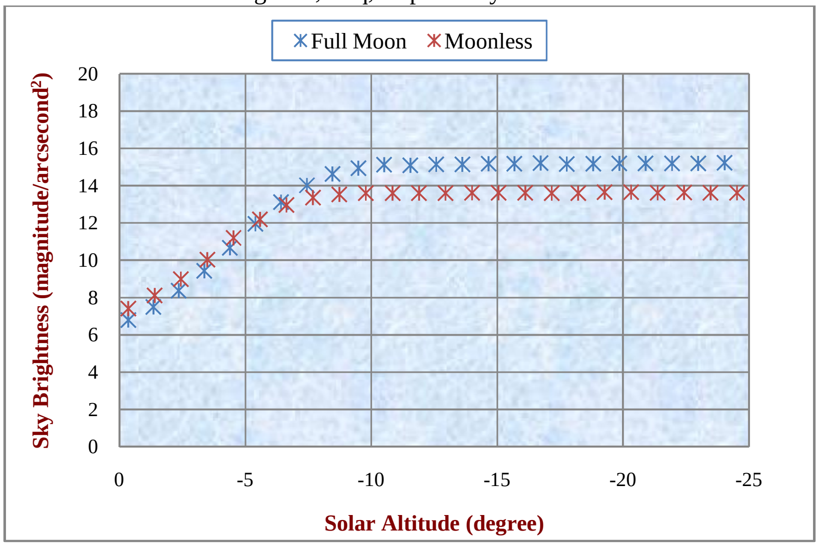

FIGURE 9: Background sky brightness as function of the solar elevation angle on 11 February 2017 and 01 March 2017 in Baghdad and Karbala, Iraq, respectively at the time of sunrise

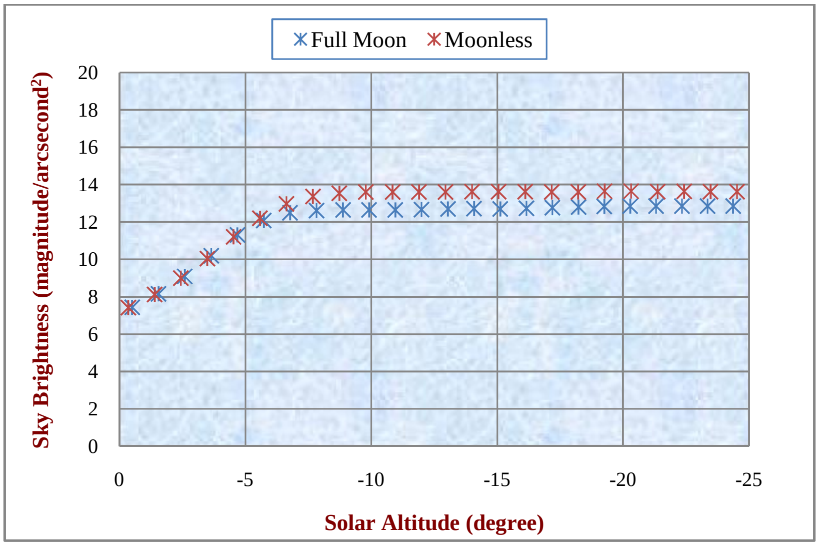

FIGURE 10: Background sky brightness as function of the solar elevation angle on 01 March 2017 and 14 March 2017 in Karbala and Baghdad, Iraq, respectively at the time of sunrise

Finally, Figure (6) shows the averaged measured light curve of sky brightness from sunrise and sunset to astronomical twilight in Baghdad and Karbala locations.

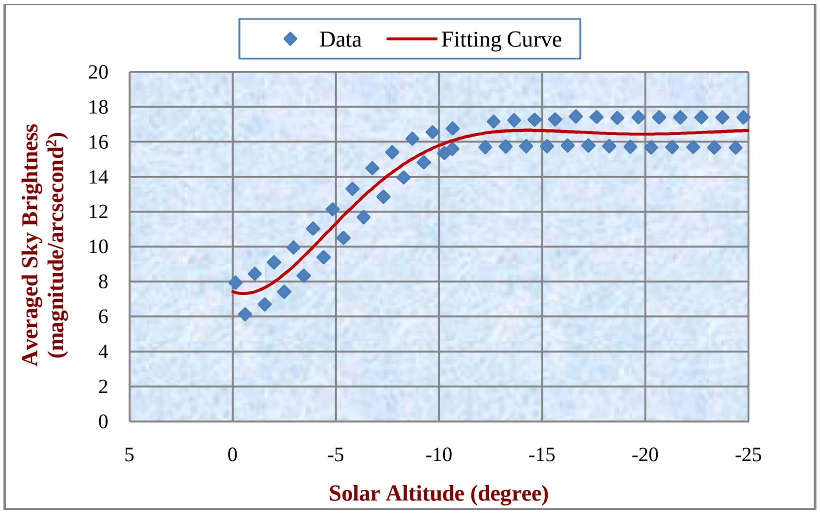

FIGURE 11: Fitting curve between averaged SQM-LU versus solar altitude in Baghdad and Karbala regions

The polynomial function of fitting fourth degree has been deduced for least square-approximation. It has been used to calculate the simulated sky brightness (magnitude/arcsecond^2). The polynomial function is obtained from least-squares fit as follows:

$$Y=0.0006\times X^4+0.0272\times X^3+0.3266\times X^2+0.2546\times X+7.4053 \quad \text{-----------------------------} \quad (1)$$

Where X is the sun's altitude in degree and Y is the simulated sky brightness in magnitude/arcsecond^2. The coefficient of determination, R^2, obtained is 0.9108.

DISCUSSION

The sky brightness does not suddenly turn to dark immediately after sunset due to atmospheric scattering but changes with time as the sun descends below the horizon, be rapidly initially and then more slowly until it reaches a constant brightness (or rather constant darkness)**.** On a moonless night, this marks the end of the sun’s influence on the sky brightness even though, on a clear night, the sky is not totally dark due to light from the stars, planets, the Milky Way and others. Also, there was effect on sky brightness measurements due to full moon (the values are less than in case of moonless). In modern times, terrestrial light sources also contribute to sufficient sky brightness, collectively known as sky glow.

Whenever sun's altitude is lower, the sky brightness readings by SQM-LU gave a higher value, vice versa, due to the magnitude scale. The sky brightness is affected greatly by sunlight. Therefore, the crescent sighting is more likely when the sky brightness readings on the photometer are high. The sky brightness depends on the geometry of the sun, the earth, and the moon as well as the distance between the moon and the sun. Furthermore, it depends on the distance between the moon and the earth.

CONCLUSION

SQM-LU is able to assist the process of estimating values of sky brightness due to its precision. Additionally is no substitute for human eye since SQM-LU just give numerical result rather than human eye which give almost immediate result. So, we could deduce that the human eye and SQM-LU correct each other and both approaches proved to be good in determining the simulated sky brightness. In conclusion, equation (1) represents the important key to finding the simulated sky brightness, when the sun's altitude is known.

ACKNOWLEDGMENTS

We would like to deeply thank College of Science in University of Karbala as well as University of Baghdad to help us during data collection of sky brightness by using SQM-LU unit.

REFERENCES

[1]. Mikhail, J.S., Asaad, A.S., Nawar, S. and Hassanin N.Y. (1995) Visibility of the New Moon at Two Sites I: Maryland Situated at Northern Geographical Latitude. II: Sacrmaento Peak Situated at High Altitude above Sea Level. Earth, Moon and Planets, Vol. 70, pp. 93-108.

[2]. Kitchin, C.R. (2002) Illustrated Dictionary of Practical Astronomy. London:Springer.

[3]. Rizvi, S.M. (1991) Beliefs & Practices “Al-Fajr As-Sadiq: A New Perspective” [Online]. Available from World Wide Web: http://www.al-islam.org/ beliefs/ practices/fajr.

[4]. Ahmed, A.K. (2014) New Criteria for Crescent Visibility Based on Sky Brightness Leading to Global Lunar Calendar Development. PhD thesis, Universiti Sains Malaysia (USM).

[5]. Shariff, N.N. (2008) Sky Brightness at Twilight: Detectors Comparison between Human Eye and Electronic Device for Isha’ and Subh from Islamic and Astronomical Considerations. MSc thesis, University Malaya.

[6]. Kumari, B.P, Kulkarni, S.H., Jadhav, D.B., Londhe, A.L. and Trimbake, H.K. (2008) Exploring Atmospheric Aerosols by Twilight Photometry. Journal of Atmospheric and Oceanic Technology, Vol. 25, pp. 1600-1607.

[7]. Hoffman, R.E. (2003) Observing the New Moon. Mon. Not. R. Astron. Sco., Vol. 340, pp. 1039-1051.

[8]. Ahmed, A.K. (2017) New Moon's Visibility Criterion Based on Photometric Data. International Journal of science and Research (IJSR), Vol. 6, Is. 12, pp. 1855-1858.

[9]. Raharto, M., Arumaningtyas, E.P. and Sopwan, N. (2010) Theoretical Contrast for Hilal Visibility Prediction at Pelabuhan Ratu. AIP Conf. Proc. Vol. 1325, pp. 105-108.

[10]. Arumaningtyas, E.P. and Raharto, M. (2010) Contrast Threshold of Lunar Crescents Visibility for Ramadan and Syawal 1431 H at Bosscha Observatory. AIP Conf. Proc. Vol. 1325, pp. 117-120.

[11]. Mikhail, J.S., Asaad, A.S., Nawar, S. and Hassanin N.Y. (1995) Improving the Crescent Visibility Limits Due to Factors Causing Decrease in the Sky Twilight Brightness. Earth, Moon and Planets, Vol. 70, pp. 109-121.

[12]. Patat, F., Ugolnikov, O.S. and Postylyakov, O.V. (2006) UBVRI Twilight Sky Brightness at ESO-Paranal. Astronomy & Astrophysics manuscript No. MS4992, pp. 1-10.

[13]. Roy, A.E. and Clarke, D. (2003) Astronomy: Principles and Practice. 4th Edition, Bristol and Philadelphia: Institute of Physics Publishing.

[14]. Ahmed, A.K. and Abdul Aziz, A.H. (2014) Young Moon Visibility Criterion Based on Crescent Illumination and Sky Brightness Contrast Model. Middle-East Journal of Scientific Research, Vol. 21, No. 9, pp. 1641-1644.