NAKED EYE ESTIMATES OF MORNING PRAYER AT TUBRUQ OF LIBYA

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Abstract :

Naked eye observations at Tubruq sky (φ = 32° 05´, λ = 23° 59´) in Libya at the Mediterranean coast (see-desert background) during the two years (2008 – 2009) of morning twilight have been recorded. These observations led us to get some estimates about morning twilight, as it is necessary to determine the time of the True Dawn (Al-Fajr Prayer Time). this research aims to determine the correct time of Al-Fajr Prayer by finding the accurate angle of the sun vertical depression below the horizon that is associated with legitimate mark. The Methode used in this research was field research while the observations have been recorded by monitoring the first white thread on the eastern horizon (True Dawn) that announces the time of the Morning Prayer (Al-Fajr Prayer). The azimuthally range of observation about the solar vertical extends from 0° up to ±20°, while the phenomenon was followed from 0° up to 20° along the altitudinal range. This research gives a result that a beginning of the morning twilight is estimated to be around 13.5° depression of the sun below the horizon. This value can reach a minimum depression around 11.5° at low visibility and a maximum around 13.5° at a very god visibility.

Keywords : Naked eye, Mediterranean and desert area, beginning of twilight, True Dawn.

Abstrak :

Pengamatan mata telanjang di langit Tubruq (φ = 32° 05´, λ = 23° 59´) di Libya di pantai Mediterania (latar belakang gurun) selama dua tahun (2008 – 2009) senja pagi telah direkam. Pengamatan ini membawa kami untuk mendapatkan beberapa perkiraan tentang fajar, karena itu perlu untuk menentukan waktu fajar *shodiq* yang

Benar (Waktu Sholat Subuh). Penelitian ini bertujuan untuk menentukan waktu Sholat Subuh yang tepat dengan mencari sudut akurat lekukan vertikal matahari di bawah ufuk yang dikaitkan dengan tanda sah. Metode yang digunakan dalam penelitian ini adalah penelitian lapangan sedangkan pengamatan yang telah dilakukan dicatat dengan memantau benang putih pertama di ufuk timur (Fajar Sejati) yang mengumumkan waktu Sholat Subuh (Shalat Subuh). Rentang pengamatan azimut terhadap vertikal matahari terbentang dari 0° hingga ±20°, sedangkan fenomena diikuti dari 0° hingga 20° sepanjang rentang ketinggian. Penelitian ini memberikan hasil bahwa awal senja pagi diperkirakan sekitar 13,5° depresi matahari di bawah ufuk. Nilai ini dapat mencapai depresi minimum sekitar 11,5° pada visibilitas rendah dan maksimum sekitar 13,5° pada visibilitas sangat baik.

Kata Kunci : Mata telanjang, Mediterania dan daerah gurun, awal fajar, Fajar *Shodiq*.

A. Introduction

The human eye is a device which can receive focus and sort out the incident light, and then convert it into chemical, thermal and electrical energy which are necessary to trigger nerve propagation. About 96 % of the light falling on the cornea passes on through the lens and about 4 % is reflected. The eye behaves as an instrument, as though it had an arbitrary variable gain control capable of adjusting itself automatically to a condition under which the output signal is of comfortable strength. Its remarkable ability to adopt itself to the very range of brightness from the day to the night sky levels makes the eye a convenient device for ordinary needs of light, color and form perceptions. The focal length of the human eye is about 20 mm, and the maximum aperture under dark adaptation is about 8 mm. The fovea centralism, which is the region of highest acuity, covers a filed of 0.7o and the resolving power is about one minute of arc. At high brightness levels, where fovea vision comes into use, the threshold is determined by the minimum recognizable contrast in surface brightness. At the boundary between extended areas, this contrast is about 2 %. The time constant of the eye is a function of the brightness level. It is 0.1 sec for very low brightness and 25 m. sec., at higher brightness of 0.01 lumen/cm^2.[1]

[1] Georgij V Rozenberg, *Twilight* (New York: Plenum Press, 1966); Clabon Walter Allen, *Astrophysical quantities* (London: Athlone Press, 1973).

It has been determined experimentally that for a point source of light to be detectable, the minimum energy rate for light striking the eye must be 10^{-16} Watts. The eye's response to intensity is logarithmic. This means that the eye's response to brightness is equal to a constant multiplied by the natural logarithm of the actual change in intensity. The logarithmic response of the eye may be demonstrated by experiments in which the intensity of an observed light source is varied in relation to a background light of fixed intensity.

The optical phenomenon of twilight takes place near the time of sunset and sunrise. It occupies the time interval separating the illumination conditions of daytime from night. The appearance of the sky under both twilight and daytime conditions is wholly governed by the optical structure of the atmosphere, particularly its interaction with sunlight. As the sun sinks towards the horizon, an increase in the optical path of its rays through the atmosphere is associated with a decrease in its brightness. This leads to a weakening in the illumination of the earth's surface by both direct and scattered light in the atmosphere. The combined luminance of the daytime conditions shows a slight dependence on the sun's altitudes. A progressive drop in the luminance begins to accelerate sharply when the sun's altitude is 5 - 10°, and the twilight is considered to have set in. Sky twilight observations and measurements entail considerable troubles.[2]

There are six general factors contributing in the night sky brightness: (1) integrated light from distant galaxies; (2) integrated starlight within our galaxy; (3) zodiacal light; (4) night airglow; (5) aurora; and (6) twilight emission lines. Night airglow, aurora and twilight emission lines are the results of a planting within the atmosphere and magnetic field. Zodiacal light is a result of being within a solar system. The remaining two contributors would be present anywhere within our galaxy. Night airglow is the fluorescence of the atoms and molecules in the air from photochemical excitation. It occurs primarily in a layer about 100 km above the earth and is variable depending on sky conditions, local time, latitude, season and solar activity. There is a

[2] F Roach, *The light of the night sky*, vol. 4 (U.S.A.: Springer Science & Business Media, 1973); Donald McGillivray, *Physics and astronomy* (London: Macmillan Education LTD, 1987).

component that is present at most wavelengths, called the continuum, primarily caused by nitrous oxide and other molecules, but the major component is caused by distinct emission lines. Both components are always present, tend to increase in brightness near the horizon and are not strongly affected by geomagnetic activity.[3]

Issa and Hassan carried out photoelectric observations of twilight in 3 papers I, II and III for Bahria/Egypt. Some other studies for other sites are to follow. Taking the minimum threshold of the normal (typical) eye in the blue, visual and red colors into account, we got $D_o \approx 19^o$ for Al-Eshaa and $D_o \approx 14.5^o$ for Al-Fajr at A = 10°, a = 5°. The aim of the present work is to determine at which instant the first light of Al-Fajr (True Dawn) appears depending on the naked eye and the adjusted hand-watch.[4]

At this stage, we find it necessary to call attention to the naked eye studies of some astronomical phenomena. We believe that all the bases of the today astronomy and astrophysics owe its origin to the naked eye observations and studies. Early civilizations like the Egyptians, the Babylonians and the Chaldeans have observed the skies to develop agricultural and religious calendars. This goes back to antiquity times where no telescopes were present. We can assume that all astronomical observations before Galileo (1564 – 1642) were recorded just by naked eye.[5] Tycho Brahe (1546 – 1601) continued observing a supernova star just by his naked eye for 16 months until disappeared from naked-eye visibility.[6] Star-counting techniques in its very early times depended only on the naked eye. For more readings see (Exploration of the Universe) chapters 2 and 3. Recently, Lynds presented a catalogue of opacities of 1820 dark clouds depending only on naked eye estimations.[7] Some studies later on gave evidence

[3] Arne A Henden dan Ronald H Kaitchuck, *Astronomical Photometry* (New York: Van Nostrand Rinhold, 1982).

[4] I A Issa dan A H Hassan, "Transparency of the night sky at Bahria/Egypt. I," *NRIAG J. Astron. Astrophys.(Special Issue)*, 2008, 383–97; I A Issa dan A H Hassan, "Evening and morning twilights at Bahria/Egypt. II," *NRIAG J. Astron. Astrophys.(Special Issue)*, 2008, 399–411; I A Issa dan A H Hassan, "Eye Criteria and times of end and begin of twilights. Bahria/Egypt. III," *NRIAG J. Astron. Astrophys.(Special Issue)*, 2008, 413–23.

[5] J Rose, "Galileo Galilei (1564–1642)," *Nature* 201, no. 4920 (1964): 653–57.

[6] H Spencer Jones, "Tycho Brahe (1546–1601)," *Nature* 158, no. 4024 (1946): 856–61.

[7] Beverly T Lynds, "Catalogue of Dark Nebulae.," *The Astrophysical Journal Supplement Series* 7 (1962): 1.

a one-to-one correspondence of Lynds-opacity classes and absorption values estimated by star counting techniques.

From a scientific perspective, twilight is defined according to the position of the Sun (its centre) relative to the horizon. There are three established and widely accepted subcategories of twilight: civil twilight (brightest), nautical twilight and astronomical twilight (darkest), which correspond to D_o= 6°, 12° and 18° of the sun's depression below the horizon respectively.

Civil twilight is roughly equivalent to lighting up time. The brightest stars are visible and at sea the horizon is clearly visible. Nautical twilight happens when the horizon at sea ceases to be clearly visible and it is impossible to determine altitudes with reference to the horizon. Astronomical twilight happens when it is truly dark and no perceptible twilight remains.

Al-Fajr starts with the morning twilight (dawn) whilst Al-Eshaa starts at the end of the evening twilight (dusk). There is some debate as to which twilight angle should be used in the calculation of Al-Fajr/ Al-Eshaa. For a discussion on the subject, we refer you to Dr. Ilyas' book: (Astronomy of Islamic Times for the Twenty - first Century). Here is a brief extract from chapter five of Dr. Ilyas' book.

In modern times, astronomical twilight (18°) has come to be widely used for the determination of Al-Eshaa and Al-Fajr times. As the average intensity curve of evening twilight indicates, the flux decreases to a minimum level, and thus it would seem appropriate that even for Islamic purposes, this should indicate a reasonable starting value for the end of Astro-Islamic Twilight (AIT).[8]

According to David King, 20° and 16° were the parameters used by Ibn Yunus for morning and evening AIT respectively, whereas 19° and 17° were the parameters used by various Egyptian astronomers. King David has confirmed that although Muslim astronomers widely used 18° /l8° symmetrical values or a slight variation to 19°/17° (morning/evening)-and in a few (earlier) cases even 20°/16° values were adopted-no

[8] Mohammad Ilyas, *Astronomy of Islamic times for the twenty-first century* (London: Mansell, 1989).

record has been found of the use of a value as small as 15°. This is of specific interest to us because a few years ago, values of 15°/15° for both AITs were proposed by Bagvi on the authority of Maulana Rashid Ahmad Ludianvi of Karachi, who is reported to have made some observations personally.[9] Indeed, Ilyas himself followed Bagvi in preparing the first South Australian Islamic Time Table, although he did consider the need to examine the matter very carefully and introduced a distinct term for it. Subsequently, this 15° degrees proposition has come under criticism and is apparently not proved by others' observations made in recent years in that particular area (Karachi). Concern on this matter is obviously understandable because an erroneous delay in the beginning of Al-Fajr would have serious implications for the beginning of the Fasting. One of the useful studies arguing against this 15° depression for AIT is that of Lateef, who claims to have conducted some observational work. Unfortunately, Lateef has argued for a fixed 18°/18° case for all over the globe-no less and no more. This may not be the true situation either as there seems to be some room for geographical variability and perhaps 18° serves as a good upper limit only. The value for morning AIT has widely been used as 18°, although a practice of using 20° prevails in Egypt and Indonesia / Malaysia (under Egyptian influence, apparently owing to the concerned persons having been trained there). Possibly, 20° is taken as a safeguard because of the sanctification of the Fasting. On the other hand, the use of smaller values than 18° for India and Yemen has been reported to Ilyas in personal communications by Abdul Hafiz Maniar of Surat, India, and Qurashi of Islamabad, Pakistan, respectively.[10] However, as we have noted elsewhere, in general, at 18° depression, no detectable trace of twilight flux will be found, meaning that 18° represents an upper limit.[11] Semeida and Hassan studied the morning twilight by the naked eye observations at Wadi El Natron in Egypt. Their results indicated that the beginning of the Pseudo-Dawn (Zodiacal Light) is at *a* =-

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[9] David A King, *Islamic mathematical astronomy* (London: Variorum, 1987); David King, "In synchrony with the heavens: Studies in astronomical timekeeping and instrumentation in medieval Islamic civilization," in *2* (Leiden: E. J. Brill, 2005); David A King, *Astronomy in the Service of Islam* (Great Britain: Variorum, 1993).

[10] Abdul Lateef Bin Abdul Aziz, *Perpetual Prayer Time Table for the Whole World* (Pakistan: Abdul Majeed Qureshi, 1986).

[11] Mohammad Ilyas, *A modern guide to astronomical calculations of Islamic calendar, times and qibla.* (Kuala Lumpur: Berita Publishing Sdn Bhd., 1984); Aziz, *op. cit.*; Moulana Yakub Qasmi dan Tariq Muneer, *Prayer Times for United Kingdom & Ireland* (Dewsbury: Islamic Research Institute of Britain, 1989).

19.74°, while the end of the Pseudo Dawn is at a=-15.41° and the True Dawn announces itself at a =-14.57°. (Where $D_o \equiv -a$).[12] Here we will study about Naked Eye Estimates of Morning Prayer At Tubruq of Libya.

B. Research Methods

The methode used in this study is field research. We recorded the local time corresponding to what we believe to be the first light signal due to early twilight from a corrected hand-watch adjusted daily time signals from a radio. This time taken from the hand watch has been denoted by the hour angle H_o. Using H_o in the following equation, we get D_o:

$$D_o = \sin^{-1}(\sin\varphi \sin\delta + \cos\varphi \cos\delta \cos H_o) \qquad (1)$$

We then calculated the hour angle of the sun corresponding to the z = 104° for an observer at Tubruq from the relation:

$$H = \cos^{-1}\left[\frac{(\sin z - \sin\varphi \sin\delta)}{\cos\varphi \cos\delta}\right] \qquad (2)$$

Al-Fajr, then, is deduced from:

$$Fajr = Noon - H \qquad (3)$$

where Noon is defined by:

$$Noon = 12 + \frac{T}{60} - \frac{\Delta\lambda}{15} \qquad (4)$$

where φ is the latitude of Tubruq, δ is the declination of the sun, H is the hour angle of the sun, z is the zenith distance of the sun (z = 104°), T is the equation of time and $\Delta\lambda$ is the longitude difference between the standard and the local meridians. Equation (3) can be rewritten using Eq. (2) in the following form:

$$Fajr = Noon - \cos^{-1}\left[\frac{(\sin z - \sin\varphi \sin\delta)}{\cos\varphi \cos\delta}\right] \qquad (5)$$

[12] M A Semeida dan A H Hassan, "Pseudo dawn and true dawn observations by naked eye in Egypt," *Beni-Suef University Journal of Basic and Applied Sciences* 7, no. 3 (2018): 286–90.

The computer program (Moon calculator) version 6 delivered to us by Monzur Ahmed was used to calculate the depression below the horizon at Al-Fajr time D_o. Getting Al-Fajr time in this manner enables comparison with D_o as deduced from Eq. (1) and as given in wall calendars. The zenith distance *z* was taken to be 104° which means that the sun's depression angle was taken to be 14° below the horizon which is nearly the same value we got in Issa and Hassan from the observations.[13]

C. Discussions and Results

C.1. Al-Fajr in the Islamic Sources

The prayer is the second pillar in the Islamic religion, since the pillars of Islam are five:

1. The two testimonies
2. Prayer
3. Giving Zakat (Support of the Needy)
4. Fasting the Month of Ramadan
5. The Pilgrimage to Makkah

There are five prayers which have to be done during the day and night. Al-Fajr is one of these five prayers which are called and described as follows:

The Morning Prayer (Al-Fajr), the Noon prayer (Al-Zuhr), the Afternoon Prayer (Al-Asr), the Dusk Prayer (Al-Maghreb) and the Evening Prayer (Al-Eshaa). As we see, all prayers depend on scientific (astronomical) bases.

C.2. The Twilight in the Holy Quran

For more than a billion Moslems in the world, it is necessary to determine the prayer times according the religious texts. One of the most confidential problems nowadays is to determine the accurate time of Al-Fajr prayer as it depends upon the beginning of the morning twilight which is a very fine astronomical phenomenon.

[13] Issa dan Hassan, *op. cit.*, 2008; Issa dan Hassan, *op. cit.*, 2008; Issa dan Hassan, *op. cit.*, 2008.

C.3. The Noon

The time of Noon is considered to be the first step to calculate any prayer time. The Noon Prayer time (Al-Zuhr) begins after midday when the trailing limb of the sun crosses the meridian of the observer.

C.4. Twilight

«So I do call to witness the ruddy glow of Sunset; The Night and its Homing; and the Moon in her Fullness: Ye shall surely Travel from stage to stage» Quran (Surat Al-Ensheqaq) (84: 16 – 19).

C.5. Night sky

«So (give) glory to ALLAH when ye Reach eventide, and when ye rise in the morning» & «Yea, To Him be praise, in the Heavens and on earth; and in the Lat afternoon, and when the day begins to decline» Quran (Surat Al-Room) (30: 17 – 18).

C.6. Al-Eshaa (Night Prayer)

«That is because ALLAH merges night into day, and He merges day into night, and verily it is ALLAH who Hears and Sees (all things) » Quran (Surat Al-Hajj) (22: 61).

Most of Islamic scholars agree to adopt the beginning time of Salat Al-Eshaa at the disappearance of the red – glow sky of the evening twilight in the western horizon (Do = 17.5°, 18°, 15° or 12°, see Table (2). This differs, however, from our finding that Al-Eshaa begins at the threshold of the eye in the red.

C.7. Al-Fajr (True Dawn)

Al-Fajr (the twilight begins), which depends mainly on normal (typical eye verification, has been mentioned in Holy Quran six times in five Surahs namely:

1. Surah Al Bakara (The Cow) in (2:187)
2. Surah Al-Israa (The Night Journey) in (17:78) (twice)
3. Surah Al Nour (The Light) in (24:58)
4. Surah Al-Fajr (The Dawn) in (89:1)
5. Surah Al-Qadr (The Fate) in (97:5)

The beginning of Salat Al-Fajr is strictly determined in the Holy Quran:

«...And eat and drink, until the white thread of dawn appears to you distinct from the black thread» Quran (Surah Al Bakara) (2:187).

Those who are in touch with nature know the beautiful appearance of dawn lights. First, a weak thin thread of a fluorescent light appears along the eastern horizon extending on both sides of the solar vertical direction. Only experts can distinguish this light. This light is followed directly by a black thread and then the dawn. We believe that the black thread is the horizon of the observer, since before dawn the sky and the horizon are black. When the dawn announces itself as a white light, the horizon stays black making this contrast. This will be followed by a pinkish white light zone clearly distinguishable in the dark. Some areas define this dark when the sun is of a depression angle 19.5° below the horizon, while some others take it at 18° and others believe that it is at 15° or 12° below the horizon. Our value in the present work is inherited with some bias, since the first co-author of the present work is affected by the results of the project of photoelectric observational verification of the Al-Fajr and Al-Eshaa prayers executed by the National Research Institute of Astronomy and Geophysics (NRIAG) in the period 1983 – 1985. This is the true dawn as defined in Holy Quran, when fasting begins directly.

C.8. The Site of the Observations

Watching the morning sky twilight was carried out at Tubruq city in Libya on the two years, (Dec. 2007- Sep. 2009, except August in each). The observers (Hassan, A. H. and Rahoma, U. A.) carried out the observations on cloudless selected days directly by naked eyes.

Table (1) shows the geographical latitude (φ) and longitude (λ) of the site which were determined astronomically, besides the elevation (h) above sea level in meters and the topographic nature of the site (N. L.).

Latitude (φ)	Longitude (λ)	h	N. L.
32° 5'	23° 59'	10 m	Sea – desert area

Table 1. The geographical data of the Tubruq site.

C.9. Al-Fajr and Al-Eshaa in Some Countries

Table (2) Summaries times of Al-Fajr and El-Eshaa in some Arabic, Islamic countries for some areas which happens to be populated by some Muslims like in the U.S.A. and Europe. From this table, we find that there is a great discrepancy of the adopted sun vertical depression Do below the horizon for the True Dawn in most Islamic countries, which reaches more than 7 degrees from Do=12^o to 19.5^o. Some areas like Pakistan and surrounding areas like Bangladesh, Afghanistan, India and some parts of Europe fixed both twilights (of Al-Fajr and Al-Eshaa) at 18° depression of the sun below the horizon. This value corresponds to the astronomical twilight. It should be mentioned that, when the suns depression is 18° below the horizon, the eye receives the least possible non-perceptible light in all wavelengths from the twilight. This does not enable the normal eye to distinguish any horizon. So, people in the sea depend totally on stars of the sky to find their directions. No religious signs for Al-Fajr and Al-Eshaa are considered. North America, Canada, parts of U.S.A. and U.K. is adopting the value of 15° for the sun vertical depression of Al-Fajr and Al-Eshaa Prayers which lies somewhere in between the nautical and the astronomical twilights. Um Al-Qura calendar is adopting a value between 18.5° and 19 for Al-Fajr and 22.5° for Al-Eshaa nowadays for the sun depression below the horizon except in Ramadan in which the value is increased to be 30°. All the Arabian Gulf countries follow Saudi Arabia in this regard. It should be mentioned also that Um Al-Qura calendar does not follow the religious signs (e.g. the twilight thread for Al-Fajr or the minimum red light for Al-Eshaa). Egypt, some African countries, Syria, Iraq and Lebanon follow the published values of the Egyptian General Authority of Survey (19.5° for Al-Fajr and 17.5° for Al-Eshaa). The Federation of Islamic Organizations in France adopted the Eshaa and the true dawn at Do=12^o. On the other hand, the field measurements show that the deviation of the sun vertical depression (Do) for the True Dawn is about one degree between the deep desert (Do=14.7^o) and the agriculture background (Do=13.5^o). Table (3) summarizes the degree of sun vertical depressions (Do) for True Dawn from previously published research. The summary of these previous research shows that the range of the True Dawn is at Do ≈13.5° for agriculture and Do ≈14.5° for desert background.

Organization	Angle of the sun below the Horizon (Beginning) *Do* (Degrees)	Angle of the sun below the Horizon (Evening), *Do* (Degrees)	Region
University Of Islamic Sciences, Karachi	18°	18°	Pakistan, Bangladesh, India, Afghanistan, Parts of Europe
North America	15°	15°	Parts of the USA, Canada, Parts of the UK
Muslim World League	18°	17°	Europe, The Far East, Parts of the USA
Umm Al-Qura Committee	18.5° (19° degrees before 1430 hijri)	90 minutes after the Sunset Prayer 120 minutes (in Ramadan only)	The Arabian Peninsula
Egyptian General Authority of Survey	19.5°	17.5°	Africa, Syria, Iraq, Lebanon, Malaysia, Parts of the USA
Federation of Islamic Organizations in France	12°	12°	France, Britain, and most of northern Europe

Table 2. the basis of calculated of the beginning (Al-Fajr) and evening (Al-Eshaa) twilight for the Islamic regions in the world as the sun vertical depression (D_o).

Location	Lat. N	Long. E	Elev. (m)	N. L.	Method	D_o, *True Dawn*	Authors
Aswan, Egypt	24° 6’	30° 45’	160	Desert	Camera	14.25°	Miethe and Lehmann 1909

Riyadh (Saudi Arabia)	25° 46′	74° 12.16′	540	Desert	N.E & Camera	14.6° ± 0.3	Al Mostafa et al. 2005
Bahria (Egypt)	28° 42.9’	29° 59.82’	150	Desert	P. E.	15.5°	Issa and Hassan 2008,II
Bahria oasis, (Egypt)	28° 42.9’	29° 59.82’	150	Desert	P. E.	14° ▯ 0.5	Issa and Hassan 2008,III
Matrouh (Egypt)	31° 0.2’	27° 51’	75	Sea-Desert	P. E.	14.5°	Hassan et al. 2009
Kottamia (Egypt)	29° 55.9’	31° 49.5’	470	Desert	P. E.	14.5°	Issa et al. 2011
Matrouh (Egypt)	31° 0.2’	27° 51’	75	Sea-Desert	P. E.	15° ± 1	Hassan et al. 2013
Bahria (Egypt)	28° 42.9’	29° 59.82’	150	Desert	P. E.	≤15°	Hassan et al. 2014, "b"
Bahria Egypt	28° 42.9’	29° 59.82’	150	Desert	N.E	14.7°	Hassan et al. 2014, "a"
Matrouh, Egypt	31° 0.2’	27° 51’	75	Sea-Desert	N.E	14.5°	Hassan et al. 2014, "a"
Kottamia, Egypt	29° 55.9’	31° 49.5’	470	Desert	N.E	14.66° ± 0.2	Hassan et al. 2014, "a"
Aswan, Egypt	23° 48.22’	32° 29.5’	210	Desert	N.E	13.96°	Hassan et al. 2014, "a"
Tubruq1 (Libya)	32° 4.7´	23° 59´	40	Desert	N.E	14.7°	Hassan and Abdel-Hadi 2015
Sinai, Egypt	31° 04´	32° 52´	10	Desert	N.E	14.61°	Hassan et al. 2016
Assiut, Egypt	27° 10´	31° 10´	52	Agricultural	N.E	13.48°	Hassan et al. 2016

Hail, Saudi Arabia	25° 46′	47° 12′	540	Desert	N. E	14.66°	Khalifa, et al., 2018
Wadi El Natron, Egypt	30° 30´	30° 09´	30	Desert	N.E	14.57°	Semeida and Hassan, 2018
Depok, Indonesia	-6° 27´	106° 48´ E	50 -140	Sea - Desert	SQM	14° ±0.6	Tono Saksonoa and Mohamad Ali Fulazzaky, 2020

Table 3. Summarization of the published work of observing twilight using naked eye (N.E), photoelectric (P. E) and Sky Quality Meter (SQM) for the true dawn.

To distinguish between the True Dawn and the False Dawn, Table (4) shows the characteristics and features of each of them. These features can help the observers and the normal people who are seeking the legitimistic signs for Al-Fajr prayer to decide the beginning of its time. This table summarized the differences between the concept and definitions of the False Dawn (Pseudo-Dawn) and the True Dawn.[14]

No.	True dawn	False dawn (Pseudo-dawn)
1	It begins as a strong light at Do≈14.5° after the disappearance of the false dawn, extending horizontally and continuing to appear as a wide and relatively intense light.	It begins as a pyramid of light at Do≈18.5° that changes its axis with the seasons, a perpendicular cone rises high in the sky. It appears about 4° before the true dawn and is followed by the darkness for about one degree.
2	It is resulted from the refraction of sunlight in the Earth's atmosphere.	It is resulted from the reflection of sunlight on interplanetary matter, especially from the asteroid belt between Mars and Jupiter.
3	It is not affected by moonlight because it is much stronger than	It is affected by moonlight as it is hardly visible in

[14] Sulidar, "The Review of Some Hadiths in Praying Shubuh and Astronomy Observation," *IOSR Journal Of Humanities And Social Science (IOSR-JHSS)* 22, no. 11 (2017): 40–47, doi:10.9790/0837-2211054047; Semeida dan Hassan, *op. cit.*

	it.	its presence.
4	Ibn Umm Maktum's Athzan.	Bilal's Athzan.
5	It is a part from the day	It' is a part from the night
6	Its shortest time interval is in the two equinoxes, its longest time interval is in summer, while it is intermediate time interval is in winter.	The distance from its beginning to its end is about 4 degrees.
7	It can be shown every day in the absence of clouds.	The best time to see it monthly is one or two days after the beginning of the lunar month, and the best time to see it is throughout the year is around the spring and autumn equinoxes.
8	The beginning of the true dawn is a strong transverse light that increases gradually with time.	The end of the false dawn is like a transverse light that remains constant for a period of time and then disappears.

Table 4. The difference between the False Dawn (Pseudo-Dawn) and the True Dawn (Sulidar 2017& Semeida and Hassan 2018).

C.10. Results

These include exact at which the first light of the morning twilight was noticed by one of us (Hassan, A. H.). It should be mentioned that the hand-watch was adjusted daily to the radio time signal. Watching the sky was carried out by the observer from the balcony of his apartment directly on the shore of the Mediterranean Sea in Tubruq. The horizon is directly open everywhere one looks (except backwards). City lights have a little effect. Table (5) shows the average depression of the sun below the horizon as determined from Eq. (1) corresponding to the recorded time to. This average is 12.38° ± 0.402° in a range between maximum depressions of 13.5° to minimum at 11.5°. This average is so small compared to the adopted value of 18.25° below the horizon. It should be mentioned that a value of 12.38 is very near to a value about 15° deduced observationally for some 5 sites in Egypt using a well-calibrated photoelectric photometer and taking into account the religious conditions for Al-Fajr (white thread, threshold of the eye, suitable light filter, etc.) (Issa and

Hassan, (2008)). We can say that an average value of the sun depression angle Do = 12.38° ± 0.402° suffers a bias and some errors due to the fact that the eyes of the observer are not typical and the hand-watch, although adjusted every day to the radio signals, still must suffer from some error. The two authors of the 2008 paper (Issa and Hassan) must be affected by their long term observations done photoelectrically on 5 sites in Egypt following the religious statements regarding Al-Fajr and Al-Eshaa. This could be the main cause of the bias. Column 3 in Table (5) shows the differences in degrees between the adopted depression (Do = 19.5°) and the calculated depressions, while column 4 gives this difference in time measure.

Results	D_o (degree)	Gape (hour)	Gape (minute)
Maximum	13.5	0.7	42
Minimum	11.5	0.4	25
Mean	12.38	0.526	32
Median	12.41	0.516	31
Rang	2	0.3	18
Variance	0.234	0.0041	0.246
Dispersion	0.402	0.052	3.12
SD	0.483	0.064	3.84
Standard error	0.0233	0.00316	0.2

Table 5. The statistical results of the sun vertical depression D_o of Al-Fajr (True Dawn) and the gap between the False and the True Dawns (minutes) over 429 days.

Table (6) represents the beginning of twilight (Al-Fajr (True Dawn)) in Tubruq in hours and minutes depending on the zonal time of Libya (UT + 2 hours), according to the applied Al-Fajr (at sun depression of 18.25o, the suggested mode Fajr 14o, the nearest of true (15o at North America organization) and the sunrise at four seasons (the equinox and the inverse seasons) in the zonal time (Z.T.). From this table, we notice that the difference between the mode of Al-Fajr of 14o sun depression and the now applied Al-Fajr is about 4.25o (22 to 34 minutes), while the difference between it and the 15o mode of sun depression which is applied in the north American is relatively small (about 1o).

Table (7) represents the monthly mean variation of the sun vertical depression (Do), the standard deviation and the dispersion of the values.

Date	Fajr 18.25° H:mm	Fajr 14° H:mm	Fajr 15° H:mm	Sunrise H:mm
21 March	5:03	5:25	5:19	6:26
21 June	3:36	4:02	3:58	5:18
21 September	4:48	5:08	5:06	6:11
21 December	5:51	6:13	6:09	7:20

Table 6. The times of the beginning of twilight (Al-Fajr) for the adopted sun vertical depression now (Fajr 18.25°), Fajr 14°, Fajr 15° and sunrise at different seasons for Tubruq.

Numbered of days	Month	Mean of Do Degree	S.D Degree	dispersion degree
29	Jan.	12.562	0.409	0.409
31	Feb.	12.33	0.363	0.294
38	Mar.	12.407	0.611	0.466
32	Apr.	12.359	0.466	0.389
40	May	11.892	0.331	0.287
41	June	12.572	0.277	0.228
44	July	12.388	0.459	0.413
------	Aug.	-------	----	---

39	Sep.	12.406	0.406	0.295
54	Oct.	12.029	0.41	0.346
46	Nov.	12.626	0.468	0.514
35	Dec.	12.69	0.403	0.322
Mean		12.39	0.418	0.360

Table 7. The monthly mean of the observation days, sun vertical depression (*D_o*), The standard deviation (S.D) and the average deviation (dispersion).

Table (8) represents the statistical classification of the sun vertical depression Do according to the variation of the visibility from 5 to 8, where the range of the visibility (from 5 to 8 Okta) corresponds with the rang of Do, as Visibility 5 means (11.5o ≤ Do ≤ 12o), visibility 6 means (12o ≤ Do ≤ 12.5o), visibility 7 means (12.5o ≤ Do ≤ 13o) and visibility 8 means (13o ≤ Do ≤ 13.5o). From this table, the majority of the relative number of days lays in the visibility 6 (35%), while 62 days lay in the visibility 8 representing about 15% (very good visibility) from the total days. This leads to the values of Do = 13.5o which represents the ideal value and that it is considered to be the adopted value. The Correlation Coefficient between the visibility and the sun vertical depression (Do) over the total days (429 days) is very significant (0.948) and Standard error is relatively small (0.312).

Statistical Parameters	Visibility 5 Do (11.5-12°)	Visibility 6 Do (12-12.5°)	Visibility 7 Do (12.5-13°)	Visibility 8 Do (13-13.5°)
Number of days	96 (22%)	153 (35%)	116 (27%)	62 (15%)
Number of missing values	13	20	8	6
Minimum	11.5	11.95	12.5	12.9
Maximum	11.94	12.52	12.94	12.5
Range	0.44	0.57	0.44	0.6
Mean	11.725	12.26	12.703	13.123

Median	11.71	12.3	12.69	13.035
Standard error	0.0132	0.0134	0.0113	0.0222
Variance	0.0166	0.027	0.0147	0.0306
Dispersion	0.1119	0.145	0.1049	0.1544
Standard deviation	0.129	0.166	0.1214	0.175

Table 8. Statistical classification of the sun vertical depression Do (from 11.5° to 13.5°) according to the visibility range (from 5 to 8 Okta).

Fig. 1 shows the monthly average of the sun depression below the horizon (Do). The squares stand for the year 2007, the circles stand for the year 2008, while the triangles-up stand for the year 2009. Accordingly, the upside-down triangles stand for the average of the monthly averages of the sun depression. As it is shown, a distorted wave–like structure appears with a minimum at May and a maximum at June followed by another minimum at October. The highest peak lies between November and December. The distortion can be due to the uncertainty, the error of the hand–watch of the observer and the turbulence of the atmosphere.

Fig. 2 displays the monthly average of the white thread (Al-Fajr) begins along the time interval from December 2007 to December 2009. The squares represent the hand–watch observations, the circles represent times according the wall–calendar (Do = 18.25°)), while the triangles stand for a constant depression of 14°. A sinusoidal wave–like structure assumes itself. A maximum time at January followed by a minimum at June and repeated afterwards to the end of the period can be easily shown.

Fig. 3 shows the correlation between the true Fajr and Fajr 14o over 429 days. The fitting curve gives the relation of Eq. (6):

$$\text{Fajr } 14 = 1.021925508 \text{ (Fajr true)} - 0.2696218835 \quad (6)$$

The correlation coefficient of this curve is 0.998, while the standard error is 0.0436. As we see, the results indicate high correlation values and accordingly we can consider that the mode of D_o = 14° (Fajr 14°) as the basis of calculating Al-Fajr at this region is more suitable.

Fig. 4 represents the relative abundance of the days for the sun vertical depression. We can note that sun depression values which lay in the interval $11.5° \le D_o \le 13.5°$ take place in the visibility range of $5 \le$ visibility ≤ 8, as visibility 5 represents ($11.5° \le D_o \le 12°$), visibility 6 represents ($12° \le D_o \le 12.5°$), visibility 7 represents ($12.5° \le D_o \le 13°$) and visibility 8 represents ($13° \le D_o \le 13.5°$).

According to the Tables (3, 4, 5 and 6) and Figs. (1, 2, 3, 4, 5, and 6), we can suggest that the beginning of twilight (Al-Fajr) is at D_o = 14°.

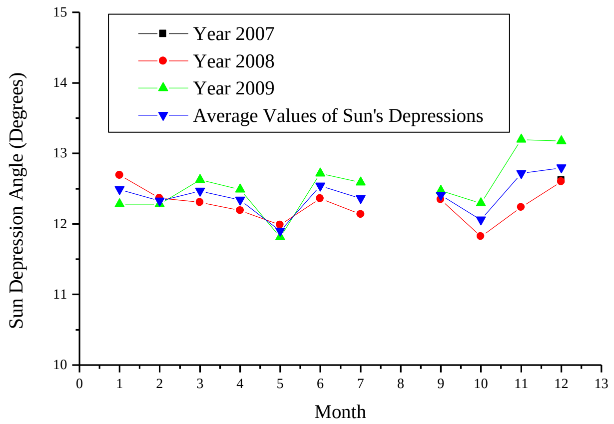

Fig. 1 The monthly average of the sun depression below the horizon (D_o).

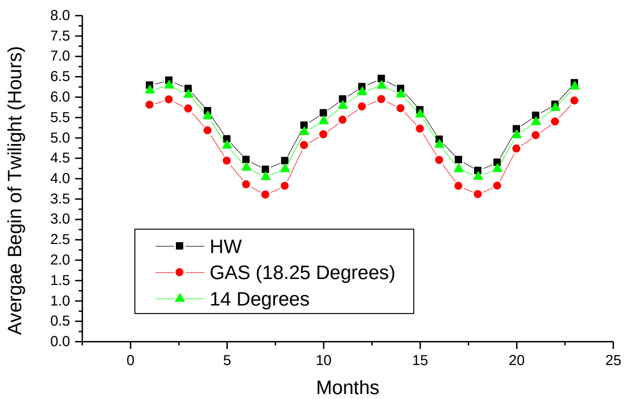

Fig. 2. The monthly average of the twilight thread (Al-Fajr) begins along the time interval from December 2007 to December 2009.

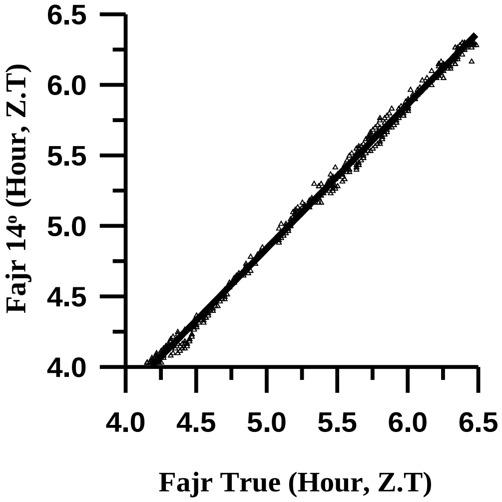

Fig. 3 The correlation between the true Fajr and Fajr 14° over 429 days.

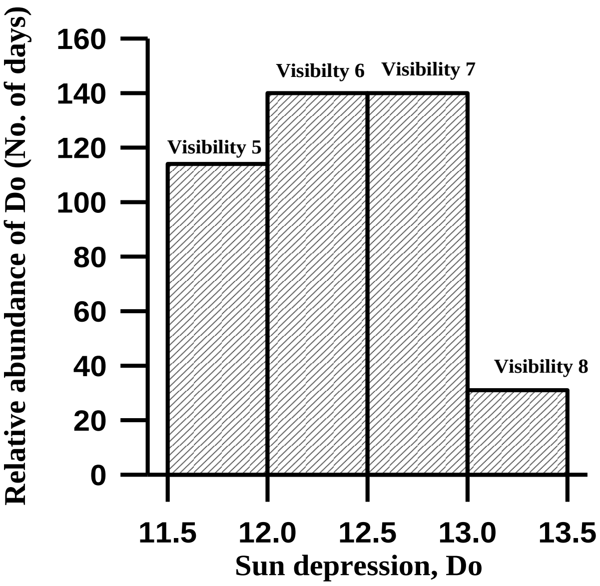

Fig. 4 The relative abundance of days for the sun vertical depression.

C.11. The problem

The problem is that all Arabic regions and many Islamic countries are adopting the sun vertical depression $D_o \geq 18^o$ (the Egyptian General Authority of Survey 19.5°) for calculating Al-Fajr Prayer Time. The observations assure that it is a wrong value. The observations showed that the correct sun depression angle of Al-Fajr Prayer Time is around D_o =14.7° in Bahria (Issa and Hassan 2008, I, II, III, and Hassan and Abdel-Hadi 2015) and around 13.5° in this study. As we see, the adopted mode now at Libya

(D_o = 18.25°) is far away from the true value D_o = 13.5° at the sea coast or D_o = 14.7° in the deep desert. Therefore, we can say that the value D_o = 18.25° is impractical.

D. Conclusion

The beginning of twilight (Al-Fajr) at this region (Tubruq - Libya) takes place when the sun vertical depression angle reaches the value of 13.5° (with the sea and desert background observation).

The error in the beginning of twilight (Al-Fajr) in the sun vertical depression is 4.25° ± 0.5° between the true depression angle (D_o = 13.5°) and the false depression angle (D_o = 18.25°). The minimum error between the true and false twilight is 25 minutes and takes place in the equinoxes (March and September months) while the maximum error is 42 minutes and takes place in June and July months. The error in the naked eye observation is found to be around 0.5° ≈ 2 minutes.

The sun depression angle (D_o) adopted by the Islamic Society of North America (ISNA) (D_o = 15°) is the nearest value adopted for calculating Al-Fajr. These results agree with the results from the naked eye observations taken in Assiut of Egypt (Hassan et al., 2016), which indicate that the dawn shows itself at sun depression angle D_o = 13.5°. It is important to mention here that the climatic and environmental condition in Tubruq is a coastal area (Mediterranean), while the condition in Assiut is an agricultural land. It is already well-known that the high water vapor content in the coastal and agricultural land surfaces cause low visibility in both sites.

Most of the Islamic countries now are adopting Al-Fajr Prayer time for the false dawn. The nearest society to the correct time of this prayer is the Islamic Society of North America (ISNA) (see Table 2, D_o=15° for both Fajr and Eshaa).

E. Invitation

We would like to invite all astrophysicists who are interested in the rightness of Al-Fajr Prayer in the world and especially in the Arabic and Islamic world to observe Al-Fajr (the beginning of twilight according the eye criteria in the visual light) by the naked eyes over a long period (one year or more), where this method doesn't need any instruments. But only some astrophysical knowledge such as, the direction of the sunrise, the different between the false of Al-Fajr and the true of Al-Fajr, the back ground of the night sky, the degree of the visibility (okta

0 - 8 km) are needed to be learned ((and we shall help them, yasser_hadi@yahoo.com and ahhassan210@yahoo.com). The observer has to observe the twilight apart from the cities and the human activities to avoid the parallax in the observations.

F. Bibliography

Allen, Clabon Walter. *Astrophysical quantities*. London: Athlone Press, 1973.

Aziz, Abdul Lateef Bin Abdul. *Perpetual Prayer Time Table for the Whole World*. Pakistan: Abdul Majeed Qureshi, 1986.

Henden, Arne A, dan Ronald H Kaitchuck. *Astronomical Photometry*. New York: Van Nostrand Rinhold, 1982.

Ilyas, Mohammad. *A modern guide to astronomical calculations of Islamic calendar, times and qibla.* Kuala Lumpur: Berita Publishing Sdn Bhd., 1984.

——. *Astronomy of Islamic times for the twenty-first century*. London: Mansell, 1989.

Issa, I A, dan A H Hassan. "Evening and morning twilights at Bahria/Egypt. II." *NRIAG J. Astron. Astrophys.(Special Issue)*, 2008, 399–411.

——. "Eye Criteria and times of end and begin of twilights. Bahria/Egypt. III." *NRIAG J. Astron. Astrophys.(Special Issue)*, 2008, 413–23.

——. "Transparency of the night sky at Bahria/Egypt. I." *NRIAG J. Astron. Astrophys.(Special Issue)*, 2008, 383–97.

Jones, H Spencer. "Tycho Brahe (1546–1601)." *Nature* 158, no. 4024 (1946): 856–61.

King, David. "In synchrony with the heavens: Studies in astronomical timekeeping and instrumentation in medieval Islamic civilization." In 2. Leiden: E. J. Brill, 2005.

King, David A. *Astronomy in the Service of Islam*. Great Britain: Variorum, 1993.

——. *Islamic mathematical astronomy*. London: Variorum, 1987.

Lynds, Beverly T. "Catalogue of Dark Nebulae." *The Astrophysical Journal Supplement Series* 7 (1962): 1.

McGillivray, Donald. *Physics and astronomy*. London: Macmillan Education LTD, 1987.

Qasmi, Moulana Yakub, dan Tariq Muneer. *Prayer Times for United Kingdom & Ireland*. Dewsbury: Islamic Research Institute of Britain, 1989.

Roach, F. *The light of the night sky*. Vol. 4. U.S.A.: Springer Science & Business Media, 1973.

Rose, J. "Galileo Galilei (1564–1642)." *Nature* 201, no. 4920 (1964): 653–57.

Rozenberg, Georgij V. *Twilight*. New York: Plenum Press, 1966.

Semeida, M A, dan A H Hassan. "Pseudo dawn and true dawn observations by naked eye in Egypt." *Beni-Suef University Journal of Basic and Applied Sciences* 7, no. 3 (2018): 286–90.

Sulidar. "The Review of Some Hadiths in Praying Shubuh and Astronomy Observation." *IOSR Journal Of Humanities And Social Science (IOSR-JHSS)* 22, no. 11 (2017): 40–47. doi:10.9790/0837-2211054047.