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Naked eye observations for morning twilight at different sites in Egypt

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Abstract Twilight observations were carried out in the period between 1984 and 1987 in different seasons at different sites of Egypt (Baharia, Matrouh, Kottamia and Aswan) through a cooperation project between Dar El-Iftaa' and the Egyptian Academy of Scientific Research and Technology. Naked eye observations of the first light of the dawn were done in parallel to the photoelectric measurements of the twilight phenomena. The depression of the sun below the horizon corresponding to the first light was calculated from the time of observations. Our estimates show that the normal eye can just discriminate the dawn (the first white light thread) at a depression of 14.7° with a maximum value of 15.08° and a minimum value of 12.01°. This result agrees with result obtained by our previous photoelectric measurements.

1. Introduction

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.

There are six general factors contributing to the night sky brightness: (1) the integrated light from distant galaxies; (2) the integrated starlight within our galaxy; (3) the zodiacal light; (4) the night airglow; (5) the aurora; and (6) the 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 the 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 should be mentioned that normal naked eye observations and recordings have been one of the important tools for astronomical studies early in the last century and the centuries

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before. We cited before (Hassan et al., 2009) the work of Lynds (1967) as one of the important works in this field done with unaided eye. She was able to classify 1802 dark interstellar clouds into 6 – opacity classes. The opacity classes of some clouds were in full agreement with absorption in magnitudes determined by other observers using star count techniques. Typical unaided eyes were a point of research by many investigators, to determine the minimum threshold that dark adapted eyes can characterize, for instance, Knoll et al. (1946), Richard Blackwell (1946), Ashburn (1952) and Tousey and Knoll (1953). Worth to notice that, (Shariff, 2008) had carried out a comparison between the normal human eye and the electronic detectors in relation to morning and evening twilight. Recently some textbooks (Benjamin Crowell, 2008; Scott Payson, 2008) have discussed in detail the threshold of dark adapted eye against different brightness backgrounds.

Herein, the authors Hassan et al., 2009 have introduced, before, direct eye estimates of the dawn at Tubruq of Libya from recordings extended over nearly 2 years. This result insured a range of depression between 11.5° and 13.5° for the first light at the Mediterranean coast. Also, Patat et al. (2006) studied the *UBVRI* twilight brightness at dome C (Kenyon and Storey (2006)) and found that the night sky brightness levels is reached at around zenith angle $z = 105°–106°$.

The present study depends on the use of the unaided eye recordings and was carried out along 4 years of observation in some sites in Egypt (Baharia, Matrouh, Kottamia and Aswan). This work was framed by a project supported by the Egyptian Academy of Scientific Research and Technology and it was done as a cooperation with Dar El-Iftaa' in Egypt between 1984 and 1987. Therefore, many observers were sent to the observation areas to carry out the observations.

2. Observations and method

The method was mentioned in detail in Hassan et al. (2009) and Issa and Hassan (2008a,b). Here we give a brief description of the procedure. We recorded the local time t_o (time of the dawn) corresponding to what we believe to be the first light signal of early twilight. Using t_o in the following equation, we get D_o:

$$D_0 = \sin^{-1}[\sin\ \varphi\ \sin\delta + \cos\ \varphi\ \cos\delta\ \cos\ H] \tag{1}$$

$$H = \text{Noon} = t_0 \tag{2}$$

$$\text{Noon} = 12 + \frac{T}{60} - \frac{\Delta\lambda}{15} \tag{3}$$

where φ is the latitude of the location, δ is the declination of the sun, H is the hour angle of the sun, T is the equation of time (Iqbal, 1983) and $\Delta\lambda$ is the longitude difference between the standard and the local meridians.

A computer program (Moon Calculator) version 6 by Monzur Ahmed (http://www.Mozzur@bigfoot.com, and http://www.Monzur@starlight.demon.co.uk) was used to calculate the depression D_o below the horizon for the beginning of twilight. Getting the beginning of twilight time in this manner enables comparison with D_o as deduced from Eq. (1). It should be mentioned that the assumed 14.5° of the sun below the horizon is very near to a value found by Issa and Hassan (2008a,b).

3. Results and discussion

It should be mentioned that all of our observations and eye recordings were done along the last week of each Hijri month and the first week of the next Hijri month (Arabic months depending on the lunar calendar). In this time, moon light and moon twilight are at their minimum, so their effect is least. Worth to notice, also, that the four sites are very far away from metropolitan. We took into account that the sites of observations also must be very far from big cities, far away in the desert, in which we can take the best observations. For instance, Kottamia 74 inch telescope is one of these sites. It is about 70 km far from the red sea, from Suez, and from Cairo and about 250 km far from the White Sea. Kottamia, where the 74 inch telescope is installed, is about 470 m above the sea level. The geographical information about the sites in Table 1 indicates also that they were far from aerosol pollution of the industrial centres and posses clear extended horizons. The observers who did these recordings were all about 35 years old and were inspired by their self intension to solve the problem. Table 1 shows the geographical data of the four locations (Baharia, Matrouh, Kottamia and Aswan) in Egypt.

In Table 2, columns 1–7 include date, site (location), observed time (h:m) of the beginning of twilight, calculated time assuming $D_o = 14.5°$ (M14.5°) below the horizon as the standard reference according to five published work by the photoelectric observations in different locations at Egypt, difference (Diff.) between observed (Obs.) and calculated (M14.5°) times in (minutes), computed D_o and sunrise (SR) time respectively.

The time of observation does not represent the effulgence of light but what we believe to be the faint white light thread that can be characterized by the normal eye. Table 3 summarizes the results of our records. The first raw contains the number of recorded times of the first light thread observed by one of us. In the second and third rows, we give the minimum and maximum values of D_o. The range between the minimum and maximum depression is shown in the fourth row followed by the mean depression determined from the recorded data altogether. Variance, standard deviation and coefficient of variation follow in the next rows successively. The morning twilight occurs at 14.7° ($D_o = 13.642° + 1.054°$). It falls in the range of $D_o = 13.642° \pm 1.054°$ with maximum depression at $D_o = 15.08°$ and a minimum at $D_o = 12.01°$. It deserves to notice that the weighted average is nearly equal to the average value of $D_o = 14.5°$ deduced from photoelectric studies at Bahria (Issa and Hassan (2008a)), (Issa et al. at Kottamia (2010)), (Hassan et al. at Matrouh (2013)) and from the naked eye estimations by Hassan et al. at Tubruq (2009). The standard deviation around the mean is relatively big because eye conditions cannot be assumed the same at different times

Table 1 Geographical data of the four locations in Egypt.

Location In Egypt	Latitude. (N)	Longitude. (E)	Elevation. (m)	N. L.
Baharia	28° 42.9′	29° 59.82′	150	Desert
Matrouh	31° 00.2′	27° 51′	75	Sea-Desert
Kottamia	29° 55.9′	31° 49.5′	470	Desert
Aswan	23° 48.22′	32° 29.5′	250	Desert

Table 2 Recordings and calculated items, see the text.

Date dd-mm-yyyy	Location	Obs. h:m	M14.5° h:m	Diff. m	D_o Obs.	SR h:m
3-7-1984	Baharia	3:52	3:52	0	14.5	5:04
4-7-1984	Baharia	3:52	3:53	−1	14.7	5:05
3-11-1986	Baharia	5:06	5:09	−3	15.08	6:14
4-11-1986	Baharia	5:07	5:10	−2	15.00	6:14
6-11-1986	Baharia	5:08	5:11	+3	15.07	6:16
7-11-1986	Baharia	5:09	5:12	+3	15.00	6:17
29-1-1987	Baharia	5:52	5:44	−8	12.89	6:49
30-1-1987	Baharia	5:55	5:44	−11	12.17	6:48
31-1-1987	Baharia	5:55	5:43	−12	12.01	6:48
1-2-1987	Baharia	5:52	5:43	−11	12.63	6:47
2-2-1987	Baharia	5:54	5:42	−12	12.1	6:47
3-2-1987	Baharia	5:41	5:42	+1	14.91	6:46
4-2-1987	Baharia	5:44	5:41	−3	14.15	6:46
5-2-1987	Baharia	5:48	5:41	−7	13.18	6:45
26-2-1987	Matrouh	3:36	6:34	−2	14.33	6:38
27-2-1987	Matrouh	3:35	5:33	−2	14.33	6:37
28-2-1987	Matrouh	3:41	5:32	−9	12.82	6:36
1-3-1987	Matrouh	3:43	5:31	−12	12.16	6:35
8-10-1987	Kottamia	4:45	4:46	+1	14.86	5:50
10-10-1987	Kottamia	4:47	4:47	0	14.5	5:51
11-10-1987	Kottamia	4:47	4:48	+1	14.81	5:51
12-10-1987	Kottamia	4:48	4:49	+1	14.49	5:52
2-12-1986	Aswan	5:10	5:13	+3	14.97	6:17
3-12-1986	Aswan	5:21	5:14	−7	12.72	6:17
4-12-1986	Aswan	5:18	5:14	−4	13.5	6:18
5-12-1986	Aswan	5:24	5:15	−9	12.72	6:19
6-12-1986	Aswan	5:21	5:15	−6	13.12	6:20
7-12-1986	Aswan	5:25	5:16	−9	12.39	6:20
8-12-1986	Aswan	5:24	5:17	−7	12.74	6:21
2-1-1987	Aswan	5:34	5:28	−6	13.29	6:32
3-1-1987	Aswan	5:33	5:28	−5	13.56	6:33
4-1-1987	Aswan	5:37	5:29	−8	12.78	6:33
5-1-1987	Aswan	5:38	5:29	−9	12.62	6:33
6-1-1987	Aswan	5:30	5:29	−1	14.41	6:20
7-1-1987	Aswan	5:37	5:29	−8	12.95	6:20

Table 3 Statistics deduced from the recordings by the normal eye in Egypt, No = Number of recordings, SD = Standard deviation and CV = Coefficient of variation.

Location In Egypt	Baharia	Matrouh	Kottamia	Aswan	Total
No.	14	4	4	13	35
Minimum	12.01	12.16	14.49	12.39	12.01
Maximum	15.08	14.33	14.86	14.97	15.08
Range	3.07	2.17	0.37	2.58	3.07
Mean	13.814	13.41	14.665	13.213	13.642
Variance	1.547	1.201	0.039	0.561	1.111
SD	1.244	1.096	0.1974	0.749	1.054
CV	0.09	0.0817	0.0135	0.0567	0.077

because of different atmospheric circumstances (from stable, calm to turbid and very turbid at these very different sites). The standard deviation at Kottamia is very small compared to the same values in other sites. These results agree with the study done by Patat et al. (2006) which reports that the night sky brightness levels are reached at around zenith angle z = 105°–106°. This means that the dawn declares itself at sun vertical depression $D_o \leqslant 15°$. Although they are naked-eye estimates, a comparison with photoelectric observations indicates that the observers were very serious and aware of their problem.

4. Conclusion

The results indicate that the dawn (first light) occurs according to normal eye estimates at Egypt (as an average of the four chosen locations) at sun depression angle $D_o = 14.7°$ ($D_o = 13.642° + 1.054°$) with a maximum depression at $D_o = 15.08°$ and a minimum at $D_o = 12.01°$. These results agree well with the results of the observations carried out by the photoelectric technique, (Issa and Hassan at Baharia, 2008a,b), (Issa et al. at Kottamia (2010)), (Hassan et al. at Matrouh (2013)) and by the naked eye at Tubruq (Hassan et al., 2009).

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