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Naked eye determination of the dawn for Sinai and Assiut of Egypt

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Abstract Twilight observations were carried out by naked eye in the period (2010–2012) for north Sinai (Lat. 31°4′N, Long. 32°52′E) where the background is desert, and for Assiut (Lat. 27°10′N, Long. 31°10′E) in the period (2012–2014) where the background is agricultural land. The purpose of these observations is to calculate the depression of the sun below the horizon at which the normal eye can discriminate the dawn (morning white thread) for two sites. The results indicated that this discrimination takes place at vertical sun depression angles, D_o = 14.61° and 13.665° at Sinai and Assiut respectively.

1. 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 wide 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 field of 0.7° 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 s for very low brightness and 25 ms at higher brightness of 0.01 lumen/cm^2 (Rosenberg, 1966 and Allen, 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} W. If we consider light of wavelength, say 500 nm, the number of photons arriving at the eye each second is 250 photons. The eye's response to

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Nomenclature

φ	the latitude of the place	n	the number of the days in the year (1 to 365)
δ	the declination of the sun	m	number of month (1 to 12)
D_o	sun vertical depression angle	d	day number in the month
H	the hour through which the earth has rotated since solar noon by degree.	$k = 2$	simple years, $k = 1$ Leap year
$E.T.$	the equation of time = mean sun time – real sun time	A_r	azimuth angle of the sun at sunrise
$\Delta\lambda$	the difference of longitude (true longitude – $Z.T.$)	M_m	measured morning time (dawn measured)
$Z.T.$	zonal time	M_c	calculated morning time (dawn calculated)
Z	zenith distance	N.E.	naked eye observation
		P.E.	photoelectric observations

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 (Pirenne, 1967). The optical phenomena of twilight take 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 toward 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 (Roach and Gordan, 1973 and Donald Mc Gillivray, 1987).

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) and Richard (1946).

The intensity of the zenith skylight was measured for solar zenith angle of 90–106° for wavelengths 0.75 μm, 0.59 μm, 0.52 μm and 0.44 μm. The intensity of the zenith skylight at twilight changes by a factor of approximately 10^6 in the blue and 10^5 in the red (Ashburn, 1952).

There are six general contributors to the night sky brightness: (1) integrated light from distance galaxies; (2) integrated starlight from within our galaxy; (3) zodiacal light; (4) night airglow; (5) aurora; and (6) twilight emission lines. Night airglow, aurora, and twilight emission lines are results of planets with an 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 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 (Henden and Kaitchuck, 1982 and Benjamin Crowell, 2008).

The currently adopted rules of beginning and end of twilight in some Arabic, Islamic countries and some areas populated by some Muslims like in the U.S.A. and Europe are different. Some areas such as Pakistan and surrounding areas such as Bangladesh, Afghanistan, India and some parts of Europe fixed both twilights (Beginning and End of twilight) at 18° depression of the sun below the horizon. This value corresponds to the astronomical twilight. It should be mentioned that, when the sun 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 Beginning and End of twilight are considered. North America, Canada, parts of U.S.A. and U.K. took a value of 15°. Um Al-Qura calendar is adopting a value between 18.5° and 19° for Beginning and 22.5° for the end of twilight nowadays for the sun depression below the horizon except in Ramadan in which the value is increased to be 30°. All of the 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 beginning or the minimum red light for end of twilight). Egypt, some African countries, Syria, Iraq and Lebanon follow the published values of the Egyptian General Authority of Survey 19.5° for beginning and 17.5° for end of twilight (Hassan et al., 2009).

The authors published many articles in this field, which reported that the beginning of twilight according to the photoelectric measurements at different sites in Egypt is in the range $14 \leqslant D_o \leqslant 15°$ (Issa and Hassan (2008a,b,c) in Bahria, Issa et al. (2011) in Kottamia, Hassan et al. (2013) in Matrouh and Hassan et al. (2014a,b) in Bahria). By naked eye observations on the four locations in Egypt (Matrouh, Bahria, Kottamia and Aswan), the mean vertical sun depression for observing the dawn was found to be $D_o = 14.7°$ (Hassan et al. (2014a,b)).

Al Mostafa et al. (2005) studied the true dawn in the deep desert 170 km far from Riyadh city in Saudi Arabia (25°45′41″N, 74°12′10″E and 540 m height over the sea level) by two methods: naked eye observations and camera (of Nikon type) measurements. Both methods were carried out