The Observatory, Vol. **126**, No. 1191, pp.115-118
2006 April

"BEST TIME"

FOR THE FIRST VISIBILITY OF THE LUNAR CRESCENT

By A. H. Sultan

Physics Department, Sana'a University, Yemen

The concept of "best time" for the first visibility of the thin crescent moon developed by Bruin, Schaefer and Yallop did not consider the elevation of the site of observation. Our first estimation - after analyzing some documented observations- is that "best time" is directly proportional to site elevation and inversely proportional to moon altitude. For moderate elevation sites (less than 1000m) the crescent could be first seen shortly after sunset. However, for higher elevations (around 2000m) the crescent could be first seen shortly before moonset.

By using our first visibility photometric model, the extensive data of Blackwell 1946 experiment and the measured twilight sky brightness of our site (1990m), we find that the optimum lunar altitude for first visibility is about 2 degrees, no matter what the lunar elongation is.

Introduction

For the first visibility of the thin crescent moon, we have to know the precise point in the sky where the moon is to be looked at. We have to know also when the best time for making the observation is, i.e. when the contrast between the crescent moon and the twilight sky is becoming sufficient for the Moon to be seen.

Schaefer (1988)[1] calculated the best time from the logarithm of the actual total brightness of the Moon divided by the total brightness of the Moon needed for visibility for the given observing conditions. Based on Bruin (1977)[2], Yallop (1997)[3]found a simple formula for the "best time" in minutes, after sunset, which is equal to 4/9 × the lag time of the moon. Lag time of the moon is the length of time in minutes between the time of sunset and moon set.

Pepin (1996)[4] reported two observations: James Stamm of Tucson (Arizona), with elevation of 860m, spotted the crescent moon just 7 minutes after sunset on January 21, 1996 (Yallop's "best time" = 17 minutes). On the contrary, Dana Patchick of Mt. Wilson (California), with elevation of 1740m, spotted the same crescent on the same day, but 28 minutes after sunset (Yallop's "best time" = 18 minutes) . Al-Mostafa (2003)[5] of Laban (Saudi Arabia), with elevation of 600m, spotted the moon only 5 minutes after sunset (Yallop's "best time" = 10 minutes). All of the three abovementioned observations were done with a telescope.

The previous three observations show that "best time" depends on the elevation of observation site. When the site is at moderate elevation (less than 1000m), as it was in Stamm and Al-Mostafa observations, the crescent may be first seen shortly after sunset ("best time" is earlier than that of Yallop). When the site elevation is around 2000m, as it was in Patchick's observation the crescent must be first seen shortly before moonset ("best time" is later than that of Yallop).

Discussion

At any instant, during or after the New Moon, there is a site on the earth where it is sunset, and the sun and the moon are in perfect geometrical situation i.e. the difference in azimuth between the Sun and the Moon (DAZ) = 0°. We use standard software to locate this site and to find all parameters to be used in the six equations of our photometric model[6]. Then, we can calculate the lunar altitude at which the "Contrast Ratio" C_r, has a maximum value; C_r is defined as the ratio of the contrast C to Blackwell Contrast Threshold C_{th}[7].

The western sky twilight (L_B) was measured at Mouneef (1990-m height, 44 degree E, 13 degree N). The measurements were achieved in October 2002 using a PHYWE selenium photocell (45-mm diameter, corrected to human eye; calibration with metal filament lamp at 2850 degree K); the measurement pointing was fixed where the sun set with a depression of 0 to 8 degrees. Fig.1

……. Fig.1 …..

Example: On March 14, 2002, the instant of the New Moon was at 2h 5m UT. Using MICA and/or IMCCE software, we find the site (67S, 106W) where it is sunset at the instant of the New Moon, and at which DAZ=0°. We can also find all the quantities needed for calculating the actual luminance of the moon L_*, i.e. lunar magnitude = −4.43, semi-diameter of the lunar disk = 14.68 minutes of arc, topocentric lunar elongation = 4°, and illuminated fraction of the lunar disk = 0.19%. Taking into consideration our site elevation, we can calculate the apparent luminance of the moon L, for different moon altitudes.

Knowing the apparent luminance of the moon L, the width of the illuminated lunar disk W, and the Twilight sky luminance L_B, we can calculate the contrast between L and $L_{B.}$ To obtain Blackwell's Contrast Threshold C_{th} for disks of diameters less than 0.6 minute of arc, we extrapolated[8] the data in table VIII of Blackwell (1946).

Finally, we calculate C_r, for different moon altitudes. We find that C_r has a maximum value when the Moon altitude is about two degrees. The following table summarizes the above example:

Table I …………………………………….

By repeating the steps of the above example for lunar elongations of 5, 6, 7, and 8 degrees, we get the same result. That is, C_r has a maximum value when the Moon altitude is about two degrees, no matter what the lunar elongation is, Fig.2

……. Fig.2 …..

Conclusions

From the discussion above, we may conclude that “best time” for the first visibility of the thin crescent moon is directly proportional to site elevation and inversely proportional to moon altitude, at site elevation of 1000m or less the crescent could be first seen 5 to10 minutes after sunset, where at site elevation of around 2000m the crescent couldn’t be first seen until about 30 minutes after sunset. We also conclude that, at site elevation of around 2000m the optimum lunar altitude for first visibility is about 2 degrees.

References

(1) B. E, Schaefer, *QJRAS*, **29**, 511, 1988.

(2) F. Bruin, *Vistas Astron.*, **21**, 331, 1977

(3) B. D. Yallop, *Tech. Note 69*, RGO NAO, 1997

(4) M. B. Pepin, *Sky & Telescope*, **92**, 104, 1996.

(5) Z. A. Al-Mostafa and M. N. Kordi, *Observatory*, **123**, 49, 2003.

(6) A. H. Sultan, *Observatory,* **124**, 390, 2004.

(7) H. R. Blackwell, *JOSA*, **36**, 624, 1946.

(8) A. H. Sultan, *Observatory,* **125**, 227, 2005.

Figure Captions

FIG. 1: This figure shows Mouneef western sky twilight luminance in nL as a function of sun depression in degrees.

FIG. 2: At site elevation of around 2000m, the optimum altitude of the lunar crescent to be first seen is about 2 degrees.

Table I

The Relative Contrast Cr depends on moon altitude
(Site elevation = 1990 m)

Obs. time UT Date h m	Ph.angle o	R ′	Mag	Elon o	% ill	L_* (nl)	L (nl)	W ′	L_B (nl)	C_{th}	C	Cr
14 3 2002 2 5	175	14.68	-4.43	4	0.19	4.3×10^8						
Moon altitude = 3 degrees, Sun altitude = -1degree							4.5×10^7	0.06	3×10^7	46	0.5	0.011
Moon altitude = 2 degrees, Sun altitude = -2 degrees							2.4×10^7	0.06	1.2×10^7	60	1	0.017
Moon altitude = 1degree, Sun altitude = -3 degrees							8.4×10^6	0.06	4.5×10^6	67	0.9	0.013

Note for Table I

Obs.time: Observation time in UT.

Ph.angle: phase angle in degrees.

R: Semi-diameter of the lunar disk.

Mag: lunar magnitude.

Elon: elongation in degrees (taking account of lunar parallax), DAZ=0°, and site elevation = 2000m.

%Ill: illuminated fraction of the lunar disk.

L_*: actual (extra-atmospheric) luminance of the moon.

L: The apparent (ground-observed) luminance of the moon (nL).

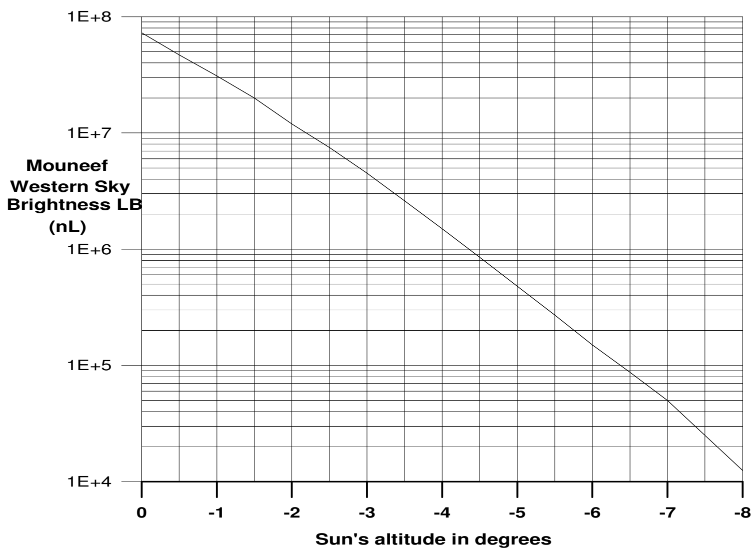
W: Topocentric width of the illuminated lunar disk in minutes of arc.

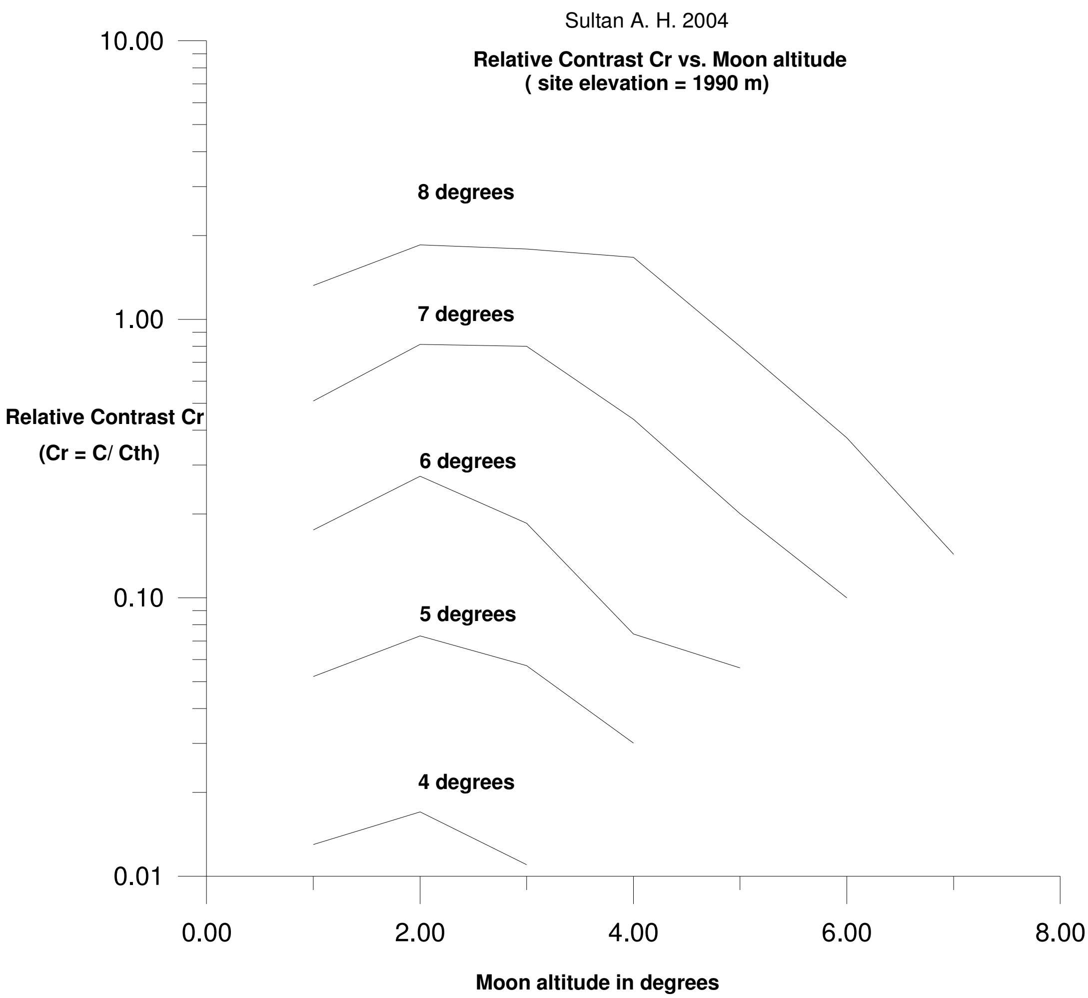
L_B: Twilight sky luminance (nL).

C_{th}: Blackwell Contrast Threshold C_{th}.

$C = (L - L_B)/ L_B.$

$C_r = C/C_{th}$.


1E+8
1E+7
1E+6
1E+5
1E+4
Mouneef
Western Sky
Brightness LB
(nL)
0
-1
-2
-3
-4
-5
-6
-7
-8
Sun's altitude in degrees


Sultan A. H. 2004
Relative Contrast Cr vs. Moon altitude
(site elevation = 1990 m)
8 degrees
7 degrees
6 degrees
5 degrees
4 degrees
10.00
1.00
0.10
0.01
Relative Contrast Cr
(Cr = C/ Cth)
0.00
2.00
4.00
6.00
8.00
Moon altitude in degrees