Lunar occultations - prediction explanation

Example predictions

The following predicted occultations have been selected to illustrate the range of prediction outputs. [Because of this, there are far more information messages in this example than would usually occur!]

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Occultation prediction for Kambah
E. Longitude 149  3 48.9,  Latitude -35 23 49.3,  Alt.  582m;  Telescope dia 35cm;  dMag 1.0

        day  Time  P   Star   Sp  Mag  Mag    % Elon Sun  Moon   CA  PA  VA  AA Libration   A    B   RV   Cct   durn R.A. (J2000)  Dec   Mdis
 y  m  d  h  m  s   No D    v    r V  ill    Alt Alt Az   o   o   o   o   L    B   m/o m/o  "/s    o   sec  h  m  s    o  m  s   Mm
07 Aug 22  5 42 44 d    2405SA2  6.6      s  62+ 104  21 50  92  49S 137 250 129 -3.9 +6.5 +0.5-2.6 .344  -27.9    16 44 17.4 -27 27 22 393.
     2405 is triple: AB 6.58 10.15 2.03"  15.3 : AC 6.6 14.0 24.6"  195.9
     2405 = NSV 7935, 6.58, range 0.03, V, Type E:
07 Aug 22  8 41  0 d   184665 G1  8.9  8.4     63+ 105      82  18  87N  92 256  85 -4.5 +6.6 +2.5-0.2 .312    8.5    16 49  8.1 -27 34 15 391.
07 Aug 22 10 38 41 m   184699 F5  8.8  8.6     64+ 106      67 281   3S 182  68 175 -4.9 +6.6 +9.9+9.9 .000  -90.0    16 50 46.5 -27 54  7 392.
    Distance of 184699 to Terminator = 13.8"; to 3km sunlit peak = 0.0"
07 Aug 23 12 44 22 d  X145167 M0  8.6  6.9V 73+ 118      53 269  67N 65 313  64 -5.9 +6.1 +1.1+1.9 .375   13.4 .04 17 52  0.7 -28  1 21 387.
    X145167 = KW Sgr, 11.0 to 13.2, pg, Type SRC, Period 670. days
07 Aug 23 13 25 43 D   185893 A0  8.3  8.3     74+ 118      44 263  88N 86 333  85 -6.0 +6.1 +1.1+1.2 .409   -8.7    17 53 21.2 -28  3 26 388.
07 Aug 23 14 23 19 d  X145957  9.0  7.7v 74+ 119      33 257  83S 95 340  94 -6.1 +6.0 +0.8+1.0 .436  -18.0    17 55 13.2 -28  0 22 389.
    X145957 = V0776 Sgr, 10.6 to 11.1, pg, Type LB
07 Aug 25  6 38 26 m    2864dB8  4.6  4.6     88+ 140  11 28 102   8N 355 113   3 -5.0 +4.6 +9.9+9.9 .000   90.0    19 36 42.4 -24 53  1 380.
    R2864 = 52 Sagittarii
     2864 is double: AB 4.7 9.2 2.4"  173.9
    Distance of 2864 to Terminator = 6.9"; to 3km sunlit peak = 0.0"
07 Aug 25  6 39  5 Gr   2864dB8  4.6  4.6     88+ 140  11 28 **  GRAZE: CA  8.3N; Dist. 61km in az. 203deg. [Lat =-35.99-0.35(E.Long-149.06)]
    Distance of 2864 to Terminator = 12.2"; to 3km sunlit peak = 1.9"
07 Aug 27  8 54 19 d    3157cF6  7.3         99+ 167      29  90  25S 131 252 148 -4.1 +1.8 +0.6-4.4 .222  -62.8    21 33 40.2 -16 12  3 369.
     3157 is double: AB 7.33 10.00 0.90"    3.2
     3157 is a close double. Observations are highly desired
    Distance of 3157 to Terminator = 4.6"; to 3km sunlit peak = 0.0"
07 Aug 27 15 13 25 D    3177cA9  5.9  5.7     99+ 169      58 304  64N 41 265  59 -5.0 +1.2 +1.0+2.1 .429   11.8    21 43  4.4 -14 23 59 366.
    R3177 = 44 Capricorni
     3177 is double: ** 6.8 6.8 0.10"  90.0**
     3177 has been reported as non-instantaneous (OCc1608). Observations are highly desired
    Distance of 3177 to Terminator = 13.8"; to 3km sunlit peak = 4.4"
07 Aug 28  9 30 56 R   165076 G5  9.6  9.0     33E 180      23  86  44S 216 340 236 -3.1 +0.1 +0.6+0.8 .459 -153.3    22 26 25.0 -10  0  0 366.
07 Aug 28 10  2 46 D   146111 G0  7.7  7.4      0E 179      29  81  57U 109 234 129 -3.2 +0.1 +1.0-2.3 .333  -47.6    22 29  4.9 - 9 44 28 365.
07 Aug 28 10  8 56 D    3301DK0  8.8  8.0      0E 179      30  80  49U 97 222 117 -3.2 +0.1 +1.0-1.6 .396  -36.2    22 29 18.6 - 9 39 46 365.
     3301 is double: AB 8.8 11.7 9.4"  291.8
07 Aug 29 13 22 11 Gr 146693 G5  7.5  7.1     98- 164      49 **  GRAZE: CA 10.9N; Dist. 11km in az. 143deg. [Lat =-35.53+0.61(E.Long-149.06)]
    Distance of 146693 to Terminator = 2.1"; to 3km sunlit peak = 0.0"

08 Dec 29 10  6 53 D  Jupiter   -1.8 -1.8     3+  20  -9  5 248  68S 101 335 111 -3.6 +0.7 -0.1+0.9 .446  -34.0 .02 20  1 33.0 -20 55 10 403.
    Duration of planetary disk occultation: predicted time +/-33.1 secs
08 Dec 29 10 21  8 d  Callisto   6.4  6.4     3+  20 -11  3 246  62S 107 340 117 -3.6 +0.6 -0.2+0.7 .425  -39.1    20  2  2.1 -20 53 35 404.
    Duration of planetary disk occultation: predicted time +/-1.2 secs

10 Nov 29 23 41 49 r  Juno      10.2 10.2     38- 76  58 38 301  36N 346 211 323 -0.9 +6.3 +0.5-2.3 .318  136.1    11 21 19.9 - 0 52 37 365.
    Duration of planetary disk occultation: predicted time +/-0.2 secs
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Item	Meaning
Day	The day of the event. Occult searches for events on the basis of geocentric conjunctions that occur within a 24hr - with that period starting at the UT indicated in the date selection box. Users should ensure that the period starts near the middle of their day.
Time	The predicted UTC, in hours, mins and secs.
P	The Phase of the event. Values are: - D - disappearance - d - disappearance, but star is less than 1 mag brighter than the predicted visibility limit. - R - reappearance - r - reappearance, but star is less than 1 mag brighter than the predicted visibility limit. - Gr - grazing occultation at site. At mid-occultation, or closest approach, the star is less than 4" from the limb of the moon (either above or below). - gr - grazing occultation at site, but star is less than 1 mag brighter than the predicted visibility limit. - M - miss. At closest approach, the star is more than 4" above the limb of the moon - m - miss, but star is less than 1 mag brighter than the predicted visibility limit.
Star	The star identifier. Three formats are used: - nnnn - A ZC star. When reporting occultations, the catalogue is identified with 'R'. - nnnnn, or nnnnnn - An SAO star. When reporting occultations, the catalogue is identified with 'R'. - X nnnnn - an XZ star. When reporting occultations, the catalogue is identified with 'X'.
D	The double star code
Sp	Star's spectral type. Only basic spectral type information is provided
Mag v	The star's visual magnitude
Mag r	The star's red magnitude. For observers using CCD video cameras, the red magnitude provides a better indication of visibility.
D	The variable star code
% ill	the percent illumination of the moon. If followed by a +, values are for a waxing moon; - for a waning moon; and E for illumination during a lunar eclipse.
Elon	the elongation of the moon from the sun, in degrees. [Strictly, the quantity is calculated as the elongation of the star from the sun]
Sun Alt	the altitude of the sun. The field is blank if the sun is lower than -12 deg. (Nautical twilight)
Moon Alt	the altitude of the moon
Moon Az	the azimuth of the moon
	Cusp Angle - the angle of the event around the limb of the moon, measured from the nearest cusp. -'ve values indicate a bright limb event. The cusps are usually

CA	N (north) or S (south), but near full moon can be E (East) or W (west). If a lunar eclipse is in progress, CA gives is the % distance from the centre of the umbra, and is followed by a 'U'. Values up to 103% are possible. Where an event occurs more than 103% of the umbral radius, the usual Cusp Angle value is displayed.
PA	Position Angle - the angle of the event around the limb of the moon, measured from true north
VA	Vertex Angle - the angle of the event around the limb of the moon measured anticlockwise from the vertex of the lunar limb - i.e. the point on the limb highest from the horizon
AA	Axis Angle - the angle of the event around the limb of the moon, measured eastward from the moon's north pole. Essential for reappearance, as it locates the event with reference to lunar features. To use, mark a map of the moon around the circumference at 10 deg intervals, starting at the north pole. Mare Crisium is at about 300 deg. [Note - the so-called Watts Angle differs from the Axis Angle by 0.21 deg. The term Watts Angle is limited to the context of accessing the Watts Charts. In all other situations, the term Axis Angle is preferred.]
Libration L	the libration of the moon in longitude, as seen from the site at the time of the event
Libration B	the libration of the moon in latitude, as seen from the site at the time of the event
A	coefficient for correcting the prediction for changes in site location. The units are minutes of time per degree (or seconds of time per minute of arc). The correction to the prediction for a change in site, in seconds of time, is found by multiplying A by the change in site longitude (+'ve for changes towards the East) from the prediction site.
B	same as for A, but for changes in latitude (+'ve to the north).
RV	Radial Velocity - the radial rate of motion of the star relative to the lunar limb, in arcsecs per second.
Cct	Contact Angle - the difference between the normal to the lunar limb and the direction of lunar motion. values range between -180 and +180. Disappearance have values in the range +90 to -90; reappearances are in the range 90 to 180, or -90 to -180. The sign of Cct indicates whether the star is to the north (+'ve) or south (-'ve) of the direction of motion.
durn	Some stars have an appreciable diameter, such that the occultation will not be instantaneous. When this is likely, this column gives an estimate of the duration. [Note: the value is an estimate only, with the diameter being calculated on the basis of the star's magnitude and colour.]
RA	The J2000 RA of the star. For planets and asteroids, the position is for an integral hour closest to the time of geocentric conjunction - although the prediction includes full allowance for the object's motion... **NOTE**: The 'Apparent position' of a star can be displayed instead of the J2000 position. Go to the **Maintenance Tab**, **User settings**, **Lunar Occultation Predictions...** box, and check the item **In lunar predictions, display Apparent star....**
Dec	The J2000 Declination of the star.- as for Right Ascension.
Mdist	The distance of the lunar limb from the observer - in mega-meters. [Multiply by 1000 to give the distance in km.]
SV	The Shadow Velocity of the moon's shadow relative to the observer - in the direction of the moon's apparent motion - in metres/sec.

The following messages can appear

Item	Meaning
Star name	If the star is brighter than 5.0, and has a proper name, Bayer letter or Flamsteed number, this is given in a line like: R2864 = 52 Sagittarii
Double star details	If the star is a double star, the details are given in a line like: 2405 is triple: 6.7 10.1 2.0" 15.3 : 6.6 14.0 21.4" 197.0 The information provided for each pairing is the magnitude of each component, the separation and the PA, with pairings being separated by colons. Where an orb available for the pairing, the separation and PA are computed for the date of the occultation. Where there is no orbit, the separation and PA are estimated by linear extrapolation of the values in the double star catalogue.

Close and suspected Double stars	Two additional message lines may appear for double stars. If the star is a close double, with a separation less that 2.0" and greater than 0.01", an alert line will app
	
	`3157 is a close double. Observations are highly desired`
	
	Where there are observations which suggest that a star *might* be a double star, an alert line will appear like:
	
	`3177 has been reported as non-instantaneous (OCc1608). Observations are highly desired`
	
	The OCC number in brackets gives the identification of the star in the file XZDoubles Discoveries. This message is generated for all double stars where the doubl identifier is one of 'OCc', ' ', '---', 'S ' and 'GC '.

Variable star details	If the star is a variable star, the details are given in a line like: X145167 = KW Sgr, 11.0 to 13.2P, Type SRC, Period 670. days For regular variables with a known epoch, the phase in the current cycle is also provided.
Object diameter	For planets, moons and asteroids, the prediction is for the center of the object. The prediction also includes a line like: Duration of planetary disk occultation: predicted time +/-33.1 secs To indicate the time difference from the start and end of the occultation of the object's disk. In this example, it will take 66 secs for the moon to cover the disk of t *Note: the displayed value assumes a circular object. No correction for the oblateness of Jupiter or Saturn is included.*

Graze nearby	Where an 'observable' grazing occultation occurs within the graze travel distance for the site, a separate prediction line appears - like:
	
	`07 Aug 29 13 22 10 Gr 146693 G5  7.5  7.1  98- 164     49 ** GRAZE: CA 10.9N; Dist. 12km in az. 143deg. [Lat =-35.53+0.61(E.Long-`
	
	The first part of the line is the same as for any other prediction line. The additional information provided is:
	• Cusp angle at mid-graze
	• the distance from the site to the closest point on the graze path (in km)
	• the azimuth of the direction to the graze path
	• a simple formula to give the latitude of a point on the graze path for a specified longitude. In this example, you get the following latitudes by inserting the longi the formula
	
	   • E. Longitude = +149.06 => latitude = -35.53
	   • E. Longitude = +150.06 => latitude = -34.92
	
	For observers in US/Canada, remember that your longitude is -'ve.

Terminator distance	If a dark-limb occultation occurs less than 20" from the terminator, the distance to the terminator, and to a theoretical 3" high mountain beyond the terminator whi be sunlit, is given in a message like: Distance of 2864 to Terminator = 12.2"; to 3km sunlit peak = 1.9" The distance to the terminator is calculated on an assumption that the moon is perfectly smooth. The distance to a 3km sunlit peak indicates a 'worst-case' scenario effect of a high mountain (which could be on the near or far side of the moon).