LUNAR OCCULTATIONS

BY DAVID W. DUNHAM

The Moon often passes between Earth and a star, an event called an *occultation*. During an occultation, a star suddenly disappears as the east limb of the Moon crosses the line between the star and the observer. The star reappears from behind the west limb some time later. Because the Moon moves through an angle about equal to its own diameter every hour, the longest time for an occultation is about an hour. The time is shorter if the occultation is not central. Solar eclipses are actually occultations: the star being occulted by the Moon is the Sun.

Since observing occultations is rather easy, amateur astronomers should try this activity. The slow, majestic drift of the Moon in its orbit is interesting, with the disappearance or reappearance of a star at the Moon's limb a remarkable sight, particularly when it occurs as a *graze* near the Moon's northern or southern limb. During a graze, a star may disappear and reappear several times in succession as mountains and valleys in the Moon's polar regions drift by it. On rarer occasions the Moon occults a planet. There will be six in North America, but only one of Mars by a full moon on Jan. 14 will be widely visible across the continent, while another of Mars on June 30 occurs only in Hawaii. Others are in the Arctic (Feb. 1, Saturn; Feb. 9, Mars; and Sept. 19, Venus), while one of Saturn on Jan. 4 in Florida and Georgia will be too low in daylight to observe (but will be good in Europe).

In 2025, the only first mag. star occulted for us is Regulus (= α Leo = ZC 1487) on Dec. 10 in Canada, but not in most populated areas. Poorer Regulus events will occur on Aug. 23 (n.w. Alaska), Oct. 16 (e. Canada, day), and Nov. 12 (Alaska, day). 1.6-mag. El Nath (= β Tau = ZC 810) will be occulted in southern N. America on Mar. 7, Apr. 30, and Sept. 14. Check the Universal time of the event; it may occur in daylight or twilight in your area. A spectacular graze may be seen from near the northern or southern limit of the occultation that may be plotted on the map on page 173. This year, the Moon will pass over the Pleiades several times, with the best passages being on Jan. 10, Feb. 6, and July 20 (especially good with the waning Moon 24% sunlit). Occultations of stars as faint as 10^{th} mag. can be observed against the dark limb of the totally eclipsed Moon on March 14; a graze of a 9.1-mag. star will occur from B.C. to Tex.

Lunar occultation and graze observations refine our knowledge of the shape of the lunar profile and fundamental stellar data. These observations complement those made by other techniques, such as Lunar Reconnaissance Orbiter laser ranging. Especially grazing occultation observations have revealed small errors whose source is still being investigated. Occultation observations are also useful for detecting double stars and measuring their separations. Binaries with separations as small as 0.02″ have been discovered visually during grazes. Doubles with separations in this range are useful for filling the gap between doubles that can be directly resolved and those whose duplicity has been discovered spectroscopically.

Observations

The **International Occultation Timing Association (IOTA)** analyzes lunar occultation observations and is now the world clearinghouse for such observations. Anyone interested in pursuing a systematic program of lunar occultation observations should consult the lunar and grazing occultation sections of *Chasing the Shadow: The IOTA Occultation Observer's Manual* that is available as a free downloaded Acrobat (.pdf) file at **http://www.poyntsource.com/IOTAmanual/Preview.htm**. A more up-to-date source is George Viscome's primer at **http://occultations.org/documents/OccultationObservingPrimer.pdf** but it is more comprehensive about asteroidal occultations with little about lunar occultations. If you don't have your own Web access, obtain these resources online at any public library or write to IOTA's North American coordinator of lunar occultation observations, Kevin Hartnett, 21216 Denit Estates Drive, Brookeville, MD 20833, email kevin.nmi.hartnett@gmail.com; he is being helped by Derek Breit, breit_ideas@poyntsource.com, the previous coordinator, and David Dunham, dunham@starpower.net.. For more information, write to IOTA, see **http://www.occultations.org**, or contact IOTA at **P.O. Box 20313 Fountain Hills, AZ 85269, USA**; email: **business@occultations.org**. IOTA provides predictions and coordination services for occultation observers, but now, most observers can calculate their own predictions using IOTA's free Windows program Occult4; see **occultations.org/publications/rasc/2025/2025iotapredictions.pdf**. If you have difficulty generating your own predictions, we can put you in touch with one of our members in your region who can help. Most IOTA services are free, including access to our prediction software and our quarterly publication *Journal for Occultation Astronomy*, available through IOTA's main website at **www.occultations.org**. Annual IOTA membership costs $15; see **http://occultations.org/about-us/iota-membership/**. Worldwide lunar occultation predictions of the brighter objects and other useful information is at **www.lunar-occultations.com/iota**. IOTA mainly serves North America, but we have sections providing similar services in Europe, Australia, New Zealand, East Asia, India, the Middle East, and South America; links to their Web sites are at **http://occultations.org/community/international-iota-sections/.**

The main information required in a lunar occultation observation is the time of the event and the observer's location. Supplementary data include the seeing conditions, telescope size, timing method, estimate of the observer's reaction time (if visual) and the accuracy of the timing, and whether or not the reaction time correction has been applied. A shortwave radio time signal and tape recorder provide a simple, permanent time record, but a video record gives higher accuracy. The observer's longitude, latitude, and altitude should be reported to the nearest tenth of an arcsecond and 10 m, respectively, and should be accurate to at least 0.5″ or 16 m. These can be determined from either GPS measurements (5 min of position averaging and an unobstructed view of the sky above about 15° altitude are needed) or a suitable topographical map. For Canada, the maps are available from Regional Distributors, who are listed at maps.nrcan.gc.ca/distrib_centres_e.php. Email **topo.maps@NRCan.gc.ca** or call (800) 465-6277 for more information. For the United States (except Alaska), write to US Geological Survey, Map Sales, PO Box 25286, Denver

CO 80225, asking for an index to topographical maps in the desired state, or call (800) USA-MAPS. For Alaska, write to US Geological Survey, Map Sales, 4230 University Dr, Room 101, Anchorage AK 99508-4664, or phone (907) 786-7011. Parts of USGS maps can be viewed and printed at certain Web sites such as **http://nationalmap.gov/ustopo/** - enter a location or click on the USA map to zoom in and click on the Topo map tab. Detailed imagery is also available at some other Web sites, and with Google Earth. IOTA is using these resources for predictions; they are usually, but not always, accurate enough for reporting lunar occultation observations.

Observers are encouraged to learn how to videotape occultations in order to obtain reliable and accurate timings. Inexpensive yet sensitive video cameras are now available. Visual timings must be accurate to ±0.2 s to be good enough for further improvement of the lunar profile and other parameters, except for grazes, where ±0.5 s is adequate. Information about videorecording occultations is in the Observing section of IOTA's main website and in its manual given above. Forms and reporting procedures are at **http://occultations.org/observing/reporting-observations/.** If you have questions, correspond with the North American coordinator specified on the previous page.

Pages 165–170 of the *RASC Observer's Handbook2025* give tables of occultation predictions, and a table and a map of northern or southern limits for the brighter grazing occultations is on pages 174-175.

TOTAL LUNAR-OCCULTATION PREDICTIONS

By David Herald and David W. Dunham

The total occultation predictions, as given in the tables on pp. 165–170 of the *RASC Observer's Handbook2025* are for the 18 standard stations identified on the map on p.164; the longitudes and latitudes of these stations are given in the table headings. The predictions were computed for IOTA as plain text files by David Herald in Murrumbateman, Australia; a .zip file of them, **DHtotalsRASCC2025.ZIP**, is available on IOTA's lunar occultations page at **http://www.lunar-occultations.com/iota/index.htm.** The predictions in the Handbook are limited to stars of magnitude 5.8 at the best phases and brighter otherwise; for some stations, brighter limits had to be used. Herald's original file, (the posted zip file, has a few more events to 6th magnitude. The first five columns give for each occultation the date, the Zodiacal Catalogue (ZC) number of the star, its magnitude, the phenomenon, and the percent illumination (% of the disk that is sunlit) of the Moon, with "+" indicating waxing and "-" showing waning phases; if the occultation occurs during a lunar eclipse, "E" is used and the value is the percent of the Moon's disk not in the umbral shadow (no eclipse lunar occultations occur during 2025). Under each station are given the Universal Time of the event, factors *A* and *B* (see below), and the cusp angle *CA* (measured around the Moon's limb from the North or South cusp, positive on the dark side, negative on the sunlit side, to the point of occurrence of the phenomenon); during a lunar eclipse, the fractional distance of the star from the center of the Moon's umbra (0) to its edge (100) is given with "U" instead of "N" or "S". If no data are given for an occultation for a given station, it is due to no occultation, below the horizon, or sunlight there. If *A* or *B* have values larger than 5, as can happen in the case of near grazes, they will not give a reliable prediction for other places.

The terms *A* and *B* are for determining corrections to the times of the events for stations within 300 km of the standard stations. If Lo* and La* represent the longitude and latitude of the standard station, and Lo and La those of the observer, then for the observer,

UT of event = UT of event at the standard station + A(Lo – Lo*) + B(La – La*),

where Lo, etc., are expressed in degrees, and *A* and *B* are in minutes of time per degree. Longitude measured *west* of Greenwich is assumed to be *negative* (which is now the IAU convention and that used by IOTA's *Occult* software). Due regard must be paid to the algebraic signs of the terms. To convert UT to the standard time of the observer, see the section STANDARD TIME ZONES on page 45 of the *RASC Observer's Handbook 2025*..

As an example, consider the occultation of 4.3-mag. ZC 146 (= ε Piscium) on 2025 Jan. 7 (see p. 169) as seen from Phoenix, Arizona. For Phoenix, Lo = –112.1° and La = 33.4°. The nearest standard station is New Mex., Ariz. for which Lo* = –109.0° and La* = 34.0°. Therefore, the UT of the disappearance at the dark limb (DD) is 1:27.8 + 2.3 × (–112.1° +109.0°) min + 0.5 × (33.4° – 34.0°) min = 1:20.4. The % illumination of the Moon is 51+, showing the Moon is very close to first quarter. The cusp angle of disappearance is approximately 81° from the southern cusp on the Moon's dark limb, so just south of the center of the dark side. The local time is 6:20.4 p.m. MST of the **previous day** (Jan. 6) since Mountain Standard Time is 7h behind UT (that is, MST = UT –7 hours). With the bright star, the event should be readily observable with any small telescope, if the sky is clear. The reappearance is not given since it is unobservable on the sunlit limb.

The number of events observable from any location increases *rapidly* as predictions are extended to fainter stars. Observers who wish to pursue such work can compute their own more extensive predictions using IOTA's free Occult program (preferred; see above) or ask for more extensive lists from Walter Robinson, 515 W Kump, Bonner Springs KS 66012–1439, USA, by providing accurate geographical coordinates, your largest telescope aperture, and a long, self-addressed envelope (with postage); or, better, email him at webmaster@lunar-occultations.com. or compute your own using the Occult4 program as described at **http://www.lunar-occultations.com/iota/2025iotapredictions.pdf** . For tables of star names and double stars occulted by the Moon during 2025 in North America, see IOTA's 2025 North American lunar grazing occultation document at **https://occultations.org/publications/rasc/2025/nam25grz.pdf** and its associated Web page at **https://occultations.org/publications/rasc/2025/nam25grz.htm** .