

# Occult for Major Planet and Lunar Occultations

## Occult 4 installation recommendations

If you currently don't have Occult 4 installed on your PC, or windows emulation on a Mac, you can obtain the software at <http://www.lunar-occultations.com/iota/occult4.htm>. Follow the instructions for installation given there. As noted there, you first should create a directory where you want to install the program; they suggest calling it "Occult 4" but I prefer names without blanks, so on my computer, it is the directory c:\Occult4\. When you first run the program, you will be prompted to download several data files, including star catalogs, planetary ephemerides, lunar limb data, and a number of others needed for the predictions. You don't need to do your own searches for occultations by major and minor planets; instead, you can just use the datasets generated by others given in the next section that include the parameters for the occultations. You don't need to download the very large Gaia14 catalog (download #40), but you may want it if you want to generate star charts for asteroidal occultations. But usually, similar or better star charts are posted on the asteroidal occultation Web sites (for each event, there's a link to that from Occult Watcher). The much smaller Gaia11 catalog (#41) is optional but recommended. You should download all of the other star catalogs and recommended files. For planetary ephemerides, you need #34, JPL planetary ephemeris. Unless you plan to work with historical observations made before the 19<sup>th</sup> century, you do not need the large #35, JPL 6000-year planetary ephemeris. First-time users need to first run "Maintenance" at the bottom left of the main page menu; on its page, click on the "User settings" button in the upper left, primarily for item 1, to specify your home location. I prefer to always set Time Zone to 0, that is, always provide predictions and work in Universal Time. In Item 3, specify your telescope aperture and travel distance for lunar grazes (use 0 if you only observe from a fixed observatory); you may want to adjust the correction to limiting magnitude later, based on your experience (if you need more predictions, set it to 1.0 or greater; if you want fewer, specify a negative number). For item 4, I didn't specify my SMTP email server name, but I recommend giving it, if you know it. Check item 6 if you have GoogleEarth; I just leave the line width defaults there (1.0 and 2.0, respectively). For the other items, leave the defaults, with some other remarks: Item 11, include the defaults, but you may want to check "Double star info" and "Add SAO #'s to Pre-point stars". For Item 12, I suggest that you include values for asteroid maps #1, with the values in degrees with west longitudes negative. For Item 13, I recommend 0.10 and 10.0 arcsec for double stars; set the graze travel distances for the brighter stars. For the graze path settings, I suggest selecting a start longitude 5 deg. west of your site (round to the nearest degree) and end longitude 5 deg. east, remembering that longitudes are negative west of Greenwich. For step interval, I recommend 0.250, and for Nominal altitude, generally you should use the altitude (above sea level) of your home. When you are done, be sure to click "Save and Exit" at the top of the page, before exiting. Then, on the Maintenance main page,

click on the “Check Installation” button on the bottom left. At the top of each of the Occult main menu pages is a Help (blue with white question mark) button, the second from the right; click it to access Occult’s extensive documentation for using the program. It will give a menu where the documentation for the current page is selected. At the top of the list of prediction/menu items is “First time user – examples” under which are step-by-step instructions for each of the main jobs for which you want to use Occult. Besides generating predictions, Occult can also be used to report your observations. Don’t hesitate to contact us if you have any questions or problems.

## Accurate coordinates for your location(s) for an Occult 4 site file

You need coordinates (longitude, latitude, and height above sea level) of your observing location. You should have already entered at least “low-precision” values for your home location, but it’s best to have rather precise values, suitable for reporting observations, that are accurate to at least the nearest second of arc, 0.01 arc minute, or 0.0001 deg. in long. and lat., and to 30m in height above sea level. There are three easy ways that accurate coordinates can be found:

**GPS Test smart phone app:** This free app gives accurate coordinates, if your location has a reasonable view of the sky, but it works even inside most frame houses. If you have an observatory with a metal dome, it will probably work if you open the slit and place the phone near it; the left of the five small menu displays at the bottom should say “3D Fix” (if not, move until it does). If you can’t get that inside your dome, stand outside right next to it, that will be good enough. Once the 3-D fix is obtained, press the world map button on the bottom right to obtain the longitude and latitude of the site. Then press the button to its right, with a large “0” (that’s your velocity, so 0 if you’re not moving); it gives your altitude above sea level in meters.

**Google Earth:** For most regions of the world, you can obtain accurate-enough coordinates from Google Earth by zooming in on your location and placing the cursor there, but be careful, if you do that and then move the cursor off of the display to access Occult or another app on your computer, the coordinates displayed at the bottom of the Google Earth display will be for a place where the cursor left the edge of the display, not for your location. To avoid that problem, I leave the cursor right at the location whose position I want, then obtain a screen view (PrtScr button on most PC’s) and paste that into any image program such as Paint; then you can read the coordinates at the bottom of that display. Google Earth has the advantage that you don’t need to physically be at the location to obtain coordinates, but if you are observing, you’re there, anyway (unless you observe remotely). Google Maps and some other mapping software can also be used to find coordinates, but I prefer Google Earth.

**GPS-based Video Time Inserter:** The coordinates obtained with GPS-based (using 1PPS) time inserters, such as the IOTA-VTI, Kiwi, and the GPSBOXSPRITE2 by Blackboxcamera (<http://www.blackboxcamera.com/pic-osd/sprite.htm>) can also be used. They should be operating at the location for 15 minutes or more, to be sure the latest GPS satellite ephemerides and time corrections have been obtained. The same is true for the GPS system used by the QHY 174M GPS camera.

It's always a good idea to use two of these methods at a site, for verification. Once you have accurate coordinates, it's best to enter them as a station in one of the site files provided with Occult. You can do that from the Occult Maintenance page, click the "Edit SITE files" button on the upper right, then select the site file (upper right of the Site Editor page) you want to use, generally the one for your continent (but the USA Short one can be used for those in the USA), and click the "Open site file" below it. Then, all of the sites in the file will be displayed in a large box to the left; click on the button "Add new site" below it. Enter the site name, coordinates, and other information; for the coordinates, you can enter either deg., min., & sec. of arc; or deg. min. & decimals of min. of arc; or degrees and decimals; if you have the coordinates to a precision of 0.1 arc second, 0.001 arc minute, or 0.00001 deg. (that's to about 3m), enter all of those numbers, even though the accuracy may be a little greater. Once you are done, click on the "Accept" button at the bottom left, and then (this is important), you must click the "Save" button below the "Open site file" button on the upper right. If you prefer, you can save the edited site file with a new name using the "Save as" button instead.

## Using Occult 4 for exploring predictions by major and minor planets

First, you need the prediction datasets. The yearly dataset for occultations of stars by major planets and their satellites is posted to the predictions page of the IOTA website (<http://occultations.org/observing/occultation-predictions/major-planet-occultation-predictions/>). On this page you will find a link for downloading an Occult data file for all the major planet events for the year. When you click on that link, you obtain a file (e.g. Planets2019.zip) that you need to unzip into any directory on your hard drive, forming the actual planets/satellites occultation input file, Planets2019.xml. You can then open this file in Occult via as follows. From the main Occult menu, select the "Asteroid predictions" menu. On the middle right of that page, click on the "List & Display occultations" button. Click on "File" in the upper left and select "Open". Then navigate to the directory where you stored the Planets2019.xml file and select this file. At the top of the page are several "Selection filters" that you need to select, as desired. Check the box just to the left of "Visible from:" in the yellow box, then enter your coordinates, or better, click on the "Select site" button to obtain your station from the appropriate site file. You need to generate two lists from this page, with the first one leaving both of the distance boxes unchecked; that's needed to obtain the predictions of all of the occultations by major planets that will be visible from your location. You will probably want to check the box for "Local altitude" with 5 deg., but you can select a higher or lower value, with 1 deg. being the lowest possible. In the orange box, leave the "Magnitude drop" unchecked (for most major planets, the "mag. drop" is likely to be near 0, but one of the contacts might be observable against the dark side of the planet), check a Star mag. limit appropriate for your telescope (you might leave it at 11 for this first major planets run; there has already been a filtration by magnitude for the major planets in the event selection used when creating the input file), and you also should check the "Solar elongation >" box, with the default value 20 deg. being good for most (you can adjust it up or down). I recommend leaving the last three boxes all unchecked (no filtration). Then, click on the "List events" button just

below “File” in the upper right. Click the button under it, “Save listed events”. With this first run, you’re interested only in the few occultations by major planets; ignore all of the satellite occultations. While in Occult, if you click on any line, a map of the event will be displayed; the first time you do that, I suggest, at the top of the map, click on “Redraw” and change the setting there from “1” to “2”. With “1”, a full-world view is given with only the coastlines drawn. With “2”, you have a more zoomed-in (centered on your location) view that now includes country boundaries, and for the USA, Canada, and Australia, the state or provincial boundaries. If you click on “with this Event”, there are many things you can do, including saving the map by clicking on “Save” at the bottom.

The first run is only for the major planets. For occultations by their satellites, which are all much smaller, you should make a 2<sup>nd</sup> run, checking one of the distance criteria. Some of the satellites are larger than 1500 km radius, so you might not want to click on the distance in km, but check instead the distance of “asteroid from star” to, perhaps, 0.5”, to ensure catching all occultations by the large satellites. You might even want to make another pass with a smaller setting, such as 0.2”, for the many smaller satellites, or use instead the distance from path in km; due to errors in the satellite ephemerides, I would use at least 200 km for that distance. The smaller satellites are like asteroids, so you should set the other parameters in the orange box, such as “mag. drop >” 0.1 (if you observe visually, you might want 0.5; 0.1 is reasonable for analysis of a video recording). The star mag. should be checked and set to a value appropriate for your telescope and camera; with the Runcam astro camera with integration, you should be able to reach at least mag. 12 with a 20cm telescope, 13 with a 25cm telescope, and 15 with a 40cm telescope, but you should experiment with your equipment; local light pollution might force you to set brighter limits. I would leave max. duration and diameter unchecked.

For occultation by minor planets, the primary source of predictions is OccultWatcher. You can download OccultWatcher via the software page on occultations.org (<http://occultations.org/observing/software/>). With OccultWatcher you can browse all predictions from a variety of sources. But you can also view the predictions from asteroidoccultation.com by downloading the FutureAll file via Occult. From the Occult main menu, select Asteroid Predictions, then download the FutureAll file in the “Download Predictions” section of the dialog. Occult will place the FutureAll file in the /Generated Files subdirectory under the main Occult directory.

### **Using Occult 4 for computing predictions of lunar total occultations**

From the Occult main menu page, click on the “Lunar predictions” icon to get the “Lunar Occultation predictions” menu page. On it, click on the “Predictions for single sites” button to obtain the prediction menu page. For item 1 at the top, select your .site file, and your station within that .site file. For 2, select “XZ” at the top. For 3, check Stars, Planets, and Asteroids. For 4, select the Start as 2019 Jan 01 and End as 2019 Dec 31; under “Starting at”, select “0 hrs” if you are in Asia east of long. 120 E, Australia, and the Pacific Ocean west of long. 130 W; for the rest of the Americas, select -6 hrs; for Europe and Africa, select +12hrs; and for Asia west of long. 120 E, select +6 hrs. The predictions will be filtered with a variable magnitude limit based

on your telescope size (and lunar phase, twilight, etc.) for a visual observer; using a sensitive camera like the Runcam, Watec, or PC164C-EX2, you may want to select “1” or even “2” from the “Mag limit adjustment” at the top, to add to the calculated mag. limit. Then press the “Occultations” button under item 5 and your predictions will be generated. Once that’s done, you can click on “with Prediction” at the top left to save the prediction list to a plain text file. A plain text file for the whole year is useful mainly for long-range planning. For actually observing occultations tonight (i.e., sometime during the next few to 18h or so in the future), it’s useful to generate the predictions for just that night with Occult, then with the list in Occult, you can click on a line to select an occultation, then right-click on it for a menu of further options, the most useful of which is “Moon map”. That generates a view of the Moon showing the maria and many craters, and where on the Moon’s limb the event will occur. If that’s done for the first event of the night, you can right-click anywhere on the Moon map to plot more events. The Moon map is a little counter-intuitive in that the darker shaded area is sunlit, while the lighter-shaded area is dark (illuminated by Earthshine).

#### **Using Occult 4 for computing predictions of lunar grazing occultations**

This starts with the same “Lunar Occultation predictions” menu page as for total lunar occultations in the section above. But Occult won’t let you predict grazes for a single site for multiple dates, as you can do for total occultations; you can only do that for one date at a time. So for grazing occultation predictions for a year, you need to click on “Predictions of Multiple objects for Multiple sites” at the upper right. Then under Item 1, select your site file, and then check the box under it for your station; at the bottom, it should then say “1 sites selected”. Then under Item 2, you should select the 3rd option, “XZ < mag 9” (or even the 4th option, “XZ < mag 7” if you have only a small portable telescope) as almost nobody these days is interested in observing grazing occultations of very faint stars. The cusp angles for grazing occultations are usually quite small, much smaller than for most total occultations, making them generally more difficult to observe, due to glare from the (closer) sunlit part of the Moon. Since there is now less scientific value in observing grazing occultations than there used to be, perhaps a main attraction of them is their spectacular nature that can be useful for publicity and education; see, for example, the video of the spectacular 2017 March Aldebaran grazing occultation at <https://vimeo.com/209854850>. You may want to check the “XZ < mag 4” button, to get predictions for only the most spectacular grazes, but these are quite rare; a small telescope can give a very good view of a crescent-Moon graze of a star of mag. 7 or less. For Item 3, Options for grazes, under “Set output files”, check all of the items “for individuals” and only “No spaces in filenames” under “for web sites”. Under “Profile options”, the GIF format gives the smallest file sizes, and under “Plot”, select “Medium” (good enough) and B&W (the color option, with its black background, is very printer-unfriendly). Under “Kaguya/LOLA profile data”, select LOLA and check “HiRes” and “Number of events indicator”. Leave “Observed data” at None; that was useful in the old days with the inaccurate Watts profiles, but just adds clutter with the detailed LOLA profiles we have now. Item 4 has no settings for grazes, while Item 5 is like for total

occultations, select 2019 Jan 1 for the first date and 2019 Dec 31 for the last date. Then just click on the “Compute Grazes” box on the middle right side. It may take a few hours to generate the predictions for all of 2019, if you have a travel radius larger than 150 km; the calculation of the detailed profiles is computer-intensive. You can follow the progress of the calculations as the date of the current calculation is given under the date range; when it reaches the end date, the calculations are done. Then, using File Explorer, display the “AutoGenerated Grazes” Occult folder; it should show 4 folders, named “\_Predictions”, “tmp”, “GoogleMap files”, and “[name of your station]”. The last two of these should be empty and can be deleted. The “tmp” folder should contain 2 files that are duplicated in the last folder, so it should also be deleted. The folder “\_Predictions” should contain one .zip file that will unzip to give all of the prediction files. Before clicking on the .zip file with File Explorer to unzip it, I suggest that you first create a folder with a short name such as YourCity2019 and then unzip the files to that folder, rather than to the default folder, which will have a very long name as a subdirectory of the \_Predictions folder and hence will be less easy to access. Once the file is unzipped to the YourCity2019 (or whatever you name it) folder, you can delete the .zip file. The .zip file is like the graze .zip files distributed to IOTA members in previous years, including a small map and summary list of the grazes, and for each graze, a .txt file with the graze path information, the predicted profile, a Google Map .htm file that you can use with your browser to plot the path with offsets determined from the profile to show the graze zone, and a .kmz file that can be used to plot the graze limit line with Google Earth.

Good luck with predicting AND OBSERVING occultations.

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