# How to plot accurate paths for (90) Antiope occultations using Occult

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Antiope is a binary asteroid, with roughly equal-size components, so the usual techniques applicable for most asteroids with roughly ellipsoidal shapes can not be used. I give the steps below for determining how far one should be from the central line, in order to see occultations by one or by both components. Often, the geometry is such that the components are widely separated from the center perpendicular to the direction of motion, so that no occultation will occur from the predicted central line for the center of mass of the system that is used for predictions. A good example is the 2011 July 19th occultation of LQ Aquarii by Antiope, with Dave Herald's fit to the observations, and the current ISAM shape model, is:
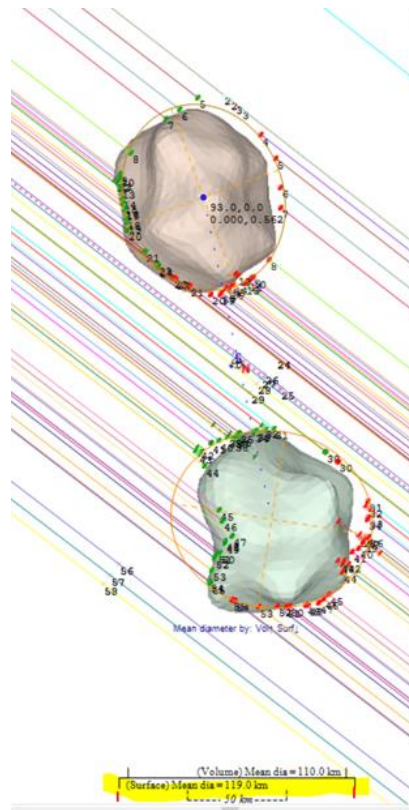
The 2011 observations show a good fit with size 120 km for Antiope, which is close enough to the surface mean diameter of 119 km. 120.1 km is the default size of Antiope (assumed as a single object) used for predictions computed by Occult. Wikipedia says that the mean diameters of the components are 88 km for (90) Antiope [the primary component] and 84 km for S/2000 (90) 1 [the secondary component], separated by 171 km in a nearly circular orbit.

Occult generates a plot of the path for one (assumed) object of diameter 120.1 km. But observers want a map showing the paths of each component. I go through the steps to obtain that on the next page, illustrated with the occultation of 9.2-mag. TYC 6343-01777-1 = SAO 189554, spectral type K5, visible from s. Quebec to w. Texas, Baja California, and Hawaii from 7:14 to 7:27 UT of 2022 August 8. Others can follow these steps for future Antiope occultations so I don't have to, but I will give advice to others who try. You may have tips to improve these instructions.

*1. Get the Occult "occelmnt" .xml input file from the prediction page for the event. For this IOTA event, that's from Steve Preston's page at

https://www.asteroidoccultation.com/2022_08/0808_90_76800.htm . Click on "Detailed Info" below the small-scale black world map; from the bottom of that, copy the lines between "- - - occelmnt file for Occult BEGIN - - -" and the similar one "Occult END", being careful not to include any part of those lines. Copy those lines (from <Occultations> to </Occultations>) and paste them into a new Notepad file, and save that as yyyymmddAntiope.xml (in Notepad, don't save as a .txt file, but at the bottom right, click on the arrow so you can select "All files", and then you can include the ".xml" so it won't be just a plain text file. The file I obtained this way for this event is 20220808Antiope.xml that you can get from the main "Special Main Belt asteroids" page at

https://occultations.org/publications/rasc/2022/nam22MBspecialoccs.htm – other files mentioned below are also available there. For non-IOTA events, you can get the occelmnt file the same way from the Occult Watcher Cloud page for the occultation. On that page, click on "JPL#xxx" in the "Orbit Date" column, Horizons/GaiaEDR3 line, of the small table to the left of the small world map. That opens a new page, and the occelmnt information is at the bottom of that page.

*2. Using Occult, select the "Asteroid predictions" menu at the top, and on that, click on the "List & Display occultations" box on the upper right. In the new page that opens up, in the upper left, click on "File…" to open the Antiope occelmnt file above, then click on "List events". There should be a line only for the event in question, leaving all of the Selection filters off. Click on the event line; that opens a new page with the familiar Occult map, but it will be a small-scale world map. You want a larger-scale map of the region of interest; to get that, double-click on the map or edit the Site longitude and Latitude and change the plot scale to 16 or even 32. Then, click on "with this Event" in the upper left to get the pull-down menu. At the bottom of the menu, click on "Save" to save the Occult map as an image file with a name of your choice; I saved it as 20220808AntiopeCenUSA.jpg in the folder for the event that I had created earlier on my computer.

*3. From the same pull-down menu of the Occult map page used above (by clicking on "with this Event"), go about 3/4ths of the way down to select "Open link to DAMIT & ISAM shape models". It will display the one ISAM model, ISAM A90-1, for Antiope, showing the configuration at the date and U.T. of the occultation. Click on "with Model image…" and select "Draw mean Diameter on image", "Plot on White background", and "Plot on Earth Plane"; these all must be selected. Then at the bottom, click on "Save". I called my version of it 20220808AntiopeISAM.jpg. While you are here, use the same menu to save a Google map file; that option is the 5th from the bottom, "Save as GoogleMaps HTM file". I called it 20220808Antiope.htm. It will be needed for some of the last steps.

*4. Next, you will want to overlay the ISAM model on the Occult map with the proper position, orientation, and scale. I use Power Point to do that, with a file I call 20220808AntiopeCenUSA.pptx. First step of this is to start a new file with one blank slide and save it with the desired name. Select "Design" (5th item from the left at the top) and there, select "Slide Size" (3rd item from the right end of the design page menu line at the top). Click on it to select "Standard (4:3)". Then, select "Insert" (3rd item from the left at the top), select "Pictures", and insert the 20220808AntiopeCenUSA.jpg map from Step 2. Be careful to NOT change the shape of the picture file, but move and expand it (pulling only diagonally on the corners) to fill as much of the slide as you can; if you fit the left and right sides of the map picture to very close to the left and right sides of the slide, there should be narrow strips of blank on the slide at the top and bottom of the picture; that is, the map will not fill the slide vertically.

*5. Insert the ISAM model picture from Step 3. With the ISAM model image selected in PowerPoint, right-click on it and select "Format picture" at the bottom of the resulting menu. Click on the 3rd rightmost ("picture") Icon, select "Picture Transparency", and use the sliding bar to select a value near 40%, so you can see both the model and the map underneath it. Next, select the "size" icon to the left of the picture icon and select "Size". Be sure to keep the aspect ratio locked. Rotate the ISAM image with either the circular arrow at the top, or changing the Rotation angle, until the scale at the bottom of the ISAM image is perpendicular to the occultation path on the map. For this, you can move the image until one of its sides is as coincident as possible with one of the limits on the map. I found the rotation angle for this was 74°. Now, grab one of the corners of the ISAM image, and shrink and move it, so the FULL LENGTH of the scale line at the bottom of the image extends from one limit to the other in the path. I found, in this case, that it occurred when the shrink factor was 35% (or size of the ISAM image sides 1.6 in.); this is all you want from this step, the size of the ISAM model.

*6. Set the rotation angle back to 0 so the ISAM image has the right orientation. Then, if necessary, move the ISAM image up or down (selecting Position and changing the vertical position number to the nearest 0.01 in.) until the small red "x" marking the center of mass is on the central line. Since the Occult map shows the limits and not the center, this is not real precise, but can be done to the accuracy of the prediction (the ISAM model is good, but not perfect; that's why we are observing these occultations, to improve it). But I found, that apparently from Step 5, the ISAM image was already centered on the path as well as I could tell, so no vertical adjustment was needed. I do not know if this will always be the case.

*7. Determine how far, in km, the edges of each of the projected components are from the limits. There's probably some measuring tool that can measure such distances (like on Google Earth), but I don't know it, so I just printed the Power Point slide and measured it with a ruler. It just happens that on my printed map, 1 path-width is 1.71 cm; since from Steve Preston's details page, the path-width is 171 km, the scale on my printed Occult map is 1 cm = 100 km. Another coincidence is that the distance between the two objects in their orbit is also 171 km. I was also able to measure the scale at the bottom of the ISAM diagram: 1.82 cm, so that's too large by 0.09 cm. It's a good check, and shows that, for the most accuracy, the final values in km from the center for the component edges should be shrunk by a factor of 0.94.

*8. The different measurements I made are as follows; the predicted limits are half the path-width from center, or 85.5 km:

Component edge	cm on map	km from limit	From map, km from center	applying the 0.94 factor adjusted km from center	x 1.02 G. Map factor
Green north	0.75 n. of n. lim.	75 km n. of n.	160.5 n.	151 n.	+154 (n.)
Green south	0.63 s. of n. lim.	63 km s. of n.	22.5 n.	21 n.	+21 (n.)
Brown north	0.45 n. of s. lim.	45 km n. of s.	40.5 s.	38 s.	-39 (s.)
Brown south	0.88 s. of s. lim.	88 km s. of s.	173.5 s.	163 s.	-166 (s.)

See Step 9 for the explanation of the Google map factor (last) column.
The occultation's rank is 100 and the 1-sigma path-width error is only 0.03 path-width or 5 km. But we don't have such estimates for the shape model; I think errors twice as large, or about 10 km, are possible from their errors, but they could be more. I don't know which component, the green or brown one, is the "main" Antiope component, and which is considered the satellite, S/2000 (90) 1. But this time, on Aug. 8th, the components are reversed from what they were for the 2011 July occultation, as can be seen by comparing the figure for 2011 on p. 1 with the plot on the PowerPoint file.

*9. Use the numbers in the last column of Step 8 with the Google map file, which allows you to draw two dark gray lines with values in km from center specified in boxes just above the interactive map. As a check, first put in 85.5 and -85.5; those should land on the blue limit lines on the map. When I did this for the Aug. 8 event, they did not; the best match came with 87.1 rather than 85.5, so further scaling is recommended. The 87.1 value was not a perfect match, with offsets of up to several tenths of a km (but always less than 1.0 km) at different places along the path. I'm not sure, but I think this is due to different interpolation intervals or formulae for the limits than for the gray lines. We can live with these errors of the order of 1-km errors since the 1-sigma error of the prediction is 5 km, and likely significantly more for the shape model. In the Step 8 table, I've added a column to increase the distances by a factor of 1.02, the ratio of 87.1 divided by 85.5 (actually, 1.0187, so 1.02 is good enough).

The Google map file uses the right-hand rule, positive values are on your right if you look down the path in the direction of the shadow motion. On Aug. 8, that is from east to west, so positive values are north of center, and negative ones are south of it; that's the reason for the signs on the numbers of the last column of the Step 8 table. Since the Google map file can draw only two user-specified lines at a time, maps for each component need to be generated separately. In a separate file, 20220808AntiopeMaps.pdf, I show the paths for each component in a series of maps covering parts of the path that observers might travel to. They should allow positioning to about 1 km accuracy, when compared to more detailed maps, or Google Earth views.

Change to Google Maps in August 2022?

You can use the Google Map file to generate your own more detailed maps, and can zoom in and switch to satellite and street views to select sites (which you should then also enter on Occult Watcher for the overall coverage). However, I'm not sure that you will be able to do that after August 1 (that is, during the week before the event) since with the Google maps used by OW, a message appears (with my use of Chrome) saying "You are using a browser that is not supported by the Google Maps JavaScript API. Please consider changing your browser. Learn more Dismiss". Clicking on "Learn more" goes to https://developers.google.com/maps/documentation/javascript/error-messages#unsupported-browsers , especially the section (about 2/3rds way down) called "Handling unsupported browsers". Perhaps switching to Edge, or updating to Windows 11 (which I haven't done), may solve that problem. But there are other issues related to Internet Explorer 11 – the following applied to Google Maps:

" The last version of the Maps JavaScript API to support Internet Explorer 11 is v3.47. Support for Internet Explorer 11 will be entirely discontinued in August 2022. This also applies to the IE mode in Edge." I don't know if this affects only Occult Watcher, or all Google map files; we'll find out in a couple of days. Hristo Pavlov has developed an alternative Google Maps-like system in Occult Watcher Cloud; maybe we'll need to do something similar for future Antiope occultations, if the .htm files produced by Occult no longer work.

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