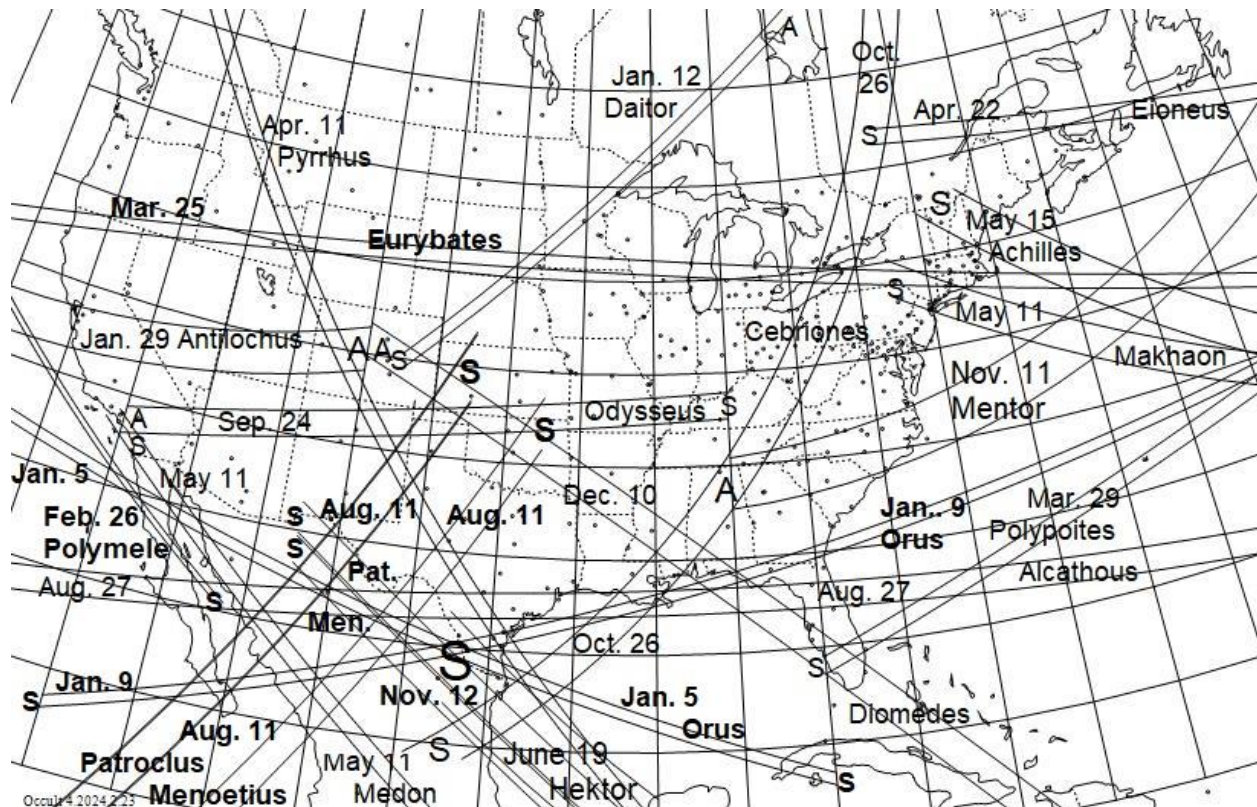


2024 Occultations by Trojan Asteroids

The Trojan asteroids formed, or were captured into, stable orbits about Jupiter's L4 and L5 triangular libration points. It is estimated that there are about a million of them larger than 1 km, about the same number as main-belt asteroids. But because they are about twice as far from the Earth, we know less about the Trojans than the main-belt objects. To learn more about the Trojans, NASA is sending its Lucy spacecraft to fly by five of them, from 2027 to 2033, to study them in detail. Three of them have known moons. Observations of occultations of stars by these asteroids will help determine the sizes, shapes, and precise orbits of the objects, information that will be valuable to the Lucy project for planning the spacecraft observations. For this reason, the Southwest Research Institute (SwRI) in Boulder, Colorado, is organizing campaigns to observe many of these occultations, and others are invited to make their own observations, to help these efforts. The Lucy mission is described in a good article, "Rock On", about it and other NASA missions to asteroids on pages 12-19 of the February 2022 issue of *Sky and Telescope*. On p. 17 is a box called "Get Involved", where SwRI asks interested amateurs to contact them, to possibly join their campaigns to observe occultations by the Lucy asteroids, and gives an example of one by (11351) Leucus that occurred in Arizona in late December, 2019; Joan and I successfully ran 4 stations for that event, obtaining the southernmost positive chord and one other, as well as the constraining miss line on the south side. Another success (Eurybates, 2021 Oct. 20) is described in an article at <https://occultations.org/publications/rasc/2022/Eurybates.pdf> that was published in the February 2022 issue of *Stardust*, publication of the National Capital Astronomers. Most future updates will not be given in this document, but more likely will be on IOTA's Trojan asteroidal occultations page for 2024 at <https://occultations.org/publications/rasc/2024/nam24Trojanoccs.htm>. That Web page also has links to some abstracts for the 2023 Asteroids, Comets, Meteors Conference with more recent results.

The best occultations of stars by Trojan Asteroids in North America during 2024



Occultations of Stars by Trojan Asteroids in North America during 2024

Date	U.T.	Path	Diameter	Durn	Star	Mag	Elon	Star	d	Asteroid	Moon	R.A. (J2000)	Dec.
m d h m			km	sec	mag	Drop	o	No.	<1.4	No Name	Dist ill	h m s	o ' "
Jan 5	11 10	Cuba-Baja	50 0.017	3.0	14.2	2.6	175	UCAC4 541-036463	1.10	21900 Orus	105 37	7 0 15.180	18 4 8.86
Jan 9	2 16	GA-Baja	50 0.017	3.0	13.6	3.1	174	UCAC4 541-035945	1.05	21900 Orus	151 8	6 58 6.557	18 4 8.04
Jan 12	0 31	CO-ON	45 0.011	1.47	6.6	12.1	53	UCAC4 356-203001	s 1.00	16560 Daitor	44 1	23 16 58.553	-18 52 23.58
Jan 29	10 58	CO-CA	107 0.035	6.4	12.7	3.2	145	UCAC4 366-046427	0.90	1583 Antilochus	50 88	8 27 18.101	-16 49 54.00
Feb 26	13 1	Baja	21 0.007	1.38	12.2	6.6	155	UCAC4 604-046095	0.90	15094 Polymele	44 96	9 40 33.858	30 44 35.21
Mar 25	6 6	MA-CA	67 0.021	11.2	13.7	3.5	126	UCAC4 581-043505	0.95	3548 Eurybates	54 100	9 7 29.149	26 7 46.17
Mar 29	0 30	FL-Bezm.	73 0.020	3.6	10.5	6.4	81	UCAC4 471-014178	s 1.15	3709 Polypoites	136 88	5 55 55.023	4 4 19.91
Apr 11	5 35	BC-TX	54 0.016	3.8	12.9	4.4	89	UCAC4 630-041105	1.95	5283 Pyrrhus	55 8	7 40 29.446	35 56 57.48
Apr 22	1 28	QC-NS	66 0.016	2.5	13.8	3.8	64	UCAC4 529-025192	0.95	15440 Eioneus	96 97	6 22 17.272	15 43 18.24
May 11	1 31	NY	115 0.030	4.5	12.2	4.1	65	TYC 1366-01098-1	1.00	3063 Makhaon	28 11	7 46 31.630	17 31 18.99
May 11	3 46	CA-Mex	69 0.019	2.7	12.3	4.9	67	UCAC4 620-043216	1.10	4836 Medon	28 11	8 9 59.133	33 59 20.46
May 15	1 31	QC-NH	133 0.038	5.1	13.0	2.8	66	UCAC4 555-043430	1.00	588 Achilles	20 46	8 11 10.067	20 48 30.10
Jun 19	2 29	TX-Mex	250 0.058	6.8	10.8	4.6	36	TYC 1947-00163-1	0.90	624 Hektor	109 90	8 32 32.420	27 47 35.41
Aug 11	10 36	KS-Baja	113 0.041	21.9	13.4	1.9	126	UCAC4 385-001287	1.00	617 Patroclus	147 39	1 8 10.103	-13 6 28.01
Aug 11	10 37	KS-Mex	104 0.038	20.2	13.4	1.9	126	UCAC4 385-001287	1.00	Menoetius	147 39	1 8 10.103	-13 6 28.01
Aug 27	8 43	FL-Baja	116 0.035	7.6	13.9	2.3	149	UCAC4 538-152035	3.70	2241 Alcaethous	77 39	23 21 22.494	17 35 44.77
Sep 24	10 36	CA-KY	121 0.031	3.8	12.1	4.1	51	UCAC4 525-049218	1.75	1143 Odysseus	43 54	8 48 11.832	14 58 35.02
Oct 26	0 55	QC-Mex	88 0.028	4.4	13.4	2.7	176	UCAC4 513-002810	1.10	2363 Cebriones	113 33	1 45 7.084	12 33 8.68
Nov 11	0 6	VA-AL	122 0.040	7.2	13.8	2.0	156	UCAC4 425-003240	1.10	3451 Mentor	55 69	2 37 42.844	-5 7 34.64
Nov 12	1 11	Mex	104 0.038	9.2	14.9	0.9	129	UCAC4 381-000489	0.95	Menoetius	15 80	0 24 53.568	-13 57 40.11
Nov 12	1 11	NM-Mex	113 0.041	9.3	14.9	0.9	129	UCAC4 381-000489	0.95	617 Patroclus	15 80	0 24 53.568	-13 57 40.11
Dec 10	8 56	CO-Haiti	144 0.038	7.2	12.0	4.1	79	TYC 5510-01375-1	1.20	1437 Diomedes	164 69	11 39 4.274	-9 51 10.01

On the bottom of the previous page is the map of 2024 Trojan asteroidal occultations that's in the Handbook, and the corresponding table of information about each of the plotted occultations is at the top of this page. Below it is another table that has additional information, including the expected diameter of the asteroid, the Elongation from the Sun, and the event distance from the Moon, whose percent illuminated is in the last column. The orbital elements are all from the NASA JPL Horizons Web site at <https://ssd.jpl.nasa.gov/horizons.cgi> and the stellar data are from the Early third release (EDR3) of the European Space Agency's Gaia mission, as implemented with UCAC4, Tycho, and Hipparcos catalog identifiers with IOTA's free *Occult* software.

On the map, labels for the occultations involving the Lucy Trojan targets are highlighted in bold type, to emphasize their importance. The paths for the occultations by (617) Patroclus and its nearly-as-large satellite Menoetius are not accurate; the actual paths for them are about a path-width in error, according to predictions by the Southwest Research Institute (SwRI) and confirmed by their occultation campaigns for NASA's Lucy mission; see <https://lucy.swri.edu/occ/predictions/> for SwRI's interactive Google maps. More about the Lucy mission occultations is below.

The European Lucky Star project is also interested in several other large Trojan objects, and is also encouraging observations of occultations by them. Many of the non-Lucy paths shown are of interest to Lucky Star, especially occultations by Hektor, the largest Trojan and an interesting contact binary object (the two lobes have different spectra, indicating different compositions), as well as having a significant moon.

The successive columns in the top table list: The successive columns in the table list: (1) the date and central time of the event; (2) the path location specified by the lands crossed by the eastern and western ends of the path shown on the map; (3) the diameter of the occulting body; (4) the duration of the central occultation; (5) the star's apparent visual magnitude; (6) the expected magnitude change from the combined brightness; (7) the elongation of the star from the Sun; (8) the catalogue and number of the occulted star, a code indicating possible stellar duplicity, and its Gaia Renormalized Unit Weight Error (RUWE; if it's 0 or blank, there is no proper motion or parallax, and the star's current position will be greatly in error; if it is >1.4, the Gaia solution is probably poor and the actual path errors are likely to be larger than the formal errors show); (9) the number and name of the occulting body; (10) the elongation (Dist) of the star from the Moon in deg.; (11) the percent sunlit (ill) of the Moon; and (12) the star's J2000 right ascension and (13) declination. For the path location, the two-letter postal abbreviations for the US States and Canadian Provinces are given, with the order indicating the direction of motion of the shadow.

“Baja” is Baja California (Norte and Sur), “Mex” is the rest of Mexico, and “Berm” is Bermuda. The times are for the center of the path; for any specific location in North America, the event time can be a few minutes earlier or later depending on the direction of motion of the shadow.

Special interactive Google maps and other details for the SwRI curated events is at <https://lucy.swri.edu/occ/predictions/>. Similar information is given for the other occultations at the Lucky Star prediction Web site at <https://lesia.obspm.fr/lucky-star/predictions.php>. It’s worth checking these Web sites a week or two before an occultation that you might observe, since both SwRI and Lucky Star update their predictions with the help of earlier occultation observations which can shift the paths from what we show on our maps.

The Trojan asteroids considered in our searches for 2024 include all of the Lucy Trojan targets: (617) Patroclus, (3548) Eurybates, (11351) Leucus, (15094) Polymele, and (21900) Orus. The other Trojan asteroids that we selected are:

#	Name	#	Name	#	Name	#	Name	#	Name
588	Achilles	1208	Troilus	2207	Antenor	3317	Paris	5027	Androgeos
624	Hektor	1404	Ajax	2241	Alcathous	3451	Mentor	5283	Pyrrhus
659	Nestor	1437	Diomedes	2357	Phereclos	3709	Polypoites	5440	Eioneus
884	Priamus	1583	Antilochus	2363	Cebriones	3793	Leonteus	16560	Daitor
911	Agememnon	1647	Menelaus	2797	Teucer	4063	Euforbo	58931	Palmys
1143	Odysseus	1749	Telamon	2920	Automedon	4543	Phoinix	100624	1997 TR28
1172	Aneas	1867	Deiphobos	3063	Makhaon	4709	Ennomos		
1173	Anchises	1873	Agenor	3240	Laocoon	4836	Medon		

Information about some of the occulting Trojans portrayed above is given below; some past occultations are on the map and events table above, due either to their importance or to observations made of them. **(617) Patroclus:** Patroclus is about 113 km across, but its large (104 km) moon Menoetius is almost as large, so this is a binary pair with a separation of about 680 km in a nearly circular orbit, known well enough that we can predict separate paths for the two objects. However, our paths for these objects are not accurate; for the best predicted paths for them, you need to consult SwRI’s predictions, see above, and on the next page for their map of the important August 11th occultation.

(911) Agamemnon: This is not a Lucy target, but it is the second or third largest Trojan asteroid. A 2012 occultation showed a size of about 160 km, but more well-observed events are sought to better determine its size and shape. The 2012 event also revealed a satellite, ~10 km across with a separation of 278 km.

(624) Hektor: This is the largest Trojan and a contact binary object; Lucky Star is very interested in it.

(1173) Anchises: Lucky Star has a better orbit to improve this path.

(2241) Alcathous: Lucky Star has a better orbit to improve this path, as shown by a 2022 Aug 11 UK occultation.

(11351) Leucus: Previous occultations show that Leucus has an unusual, elongated shape.

(15094) Polymele: A 5km moon, about 200 km away, was discovered with 2 chords during a 2022 Mar. 27th occultation. In Feb. 2023 SwRI led a massive campaign that defined well another profile of Polymele and recorded another occultation by the moon, informally named “Shawn”.

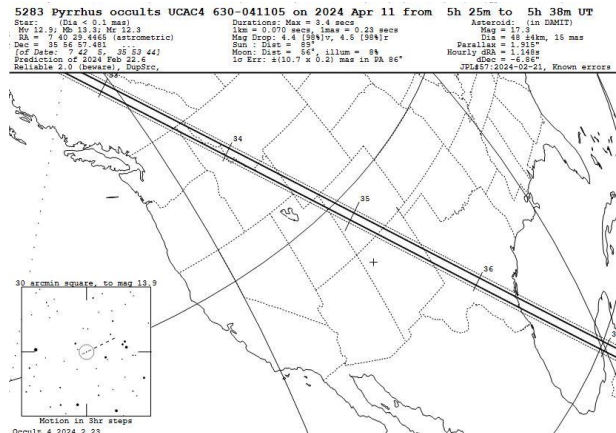
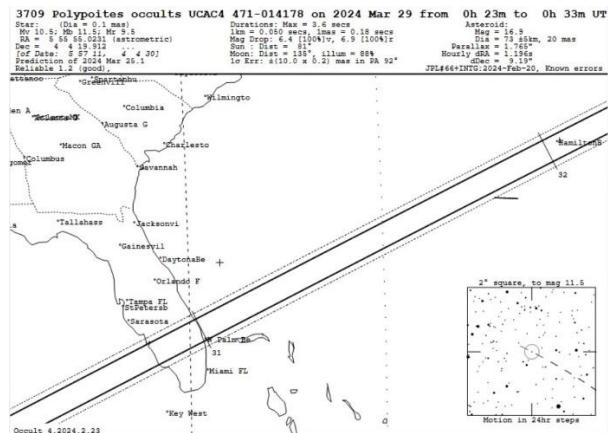
(21900) Orus: This is another Lucy target.

(100624) 1997 TR28: Found to be binary from a 2024 Jan 23 occultation with 2 chords on the 4km satellite in JP, while the main 10km object was recorded by Jiri in CZ; on the sky plane, the separation was 23 km.

Better maps and more information about some of the predicted occultations in our list

March 29, (5283) Polypoites, April 11, (5283) Pyrrhus, and April 22, (15440) Eioneus:

Information about these events were distributed by e-mail to the IOTAoccultations list, and to #iota on Lucyocc.slack.com, about a day before each event; Occult maps with the latest JPL prediction were included and are shown for the first two below.



The first involved the brightest star occulted by our selected Trojans in North America during the rest of this year, with the occultation of a 10.2-mag. star in Orion. The fainter second event crossed a good part of the continent from British Columbia to Texas, but the star had a high Gaia RUWE, meaning that the path likely had an error significantly larger than the formal error. As far as I know, neither event was observed; nobody signed up for them with OW. Most, including us, were preoccupied with the April 8th total solar eclipse around the dates of these events. The April 22nd event is still in the future, but I noted it by email and on #iota on Lucyocc slack on April 16, and its Occult map is on the Trojans Web page.

Earlier past events

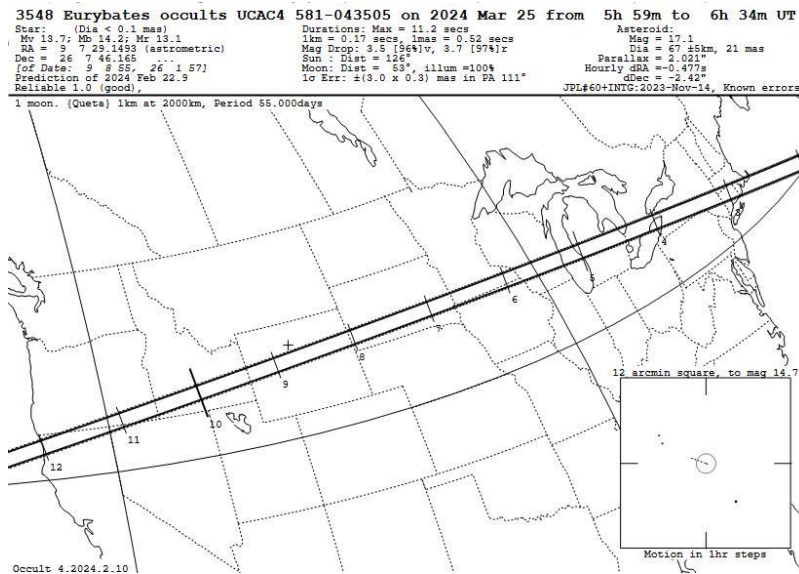
Like the two events noted above, the important earlier Lucy occultations were widely promoted by e-mail, but with the predictions and coordination done by SwRI via Lucyocc.slack.com.

Jan. 5, (21900) Orus: This Lucy occultation, whose path crossed northern Mexico and the Rio Grande Valley of southernmost Texas, was only used (in Baja California Norte) for training of Mexican student observers by SwRI and senior Mexican observers; I have not heard if any useful observations of the event were obtained.

Feb. 26, (15094) Polymele: this was the most important Lucy Trojan occultation in North America this year. SwRI worked with some experienced American, and many Mexican, observers, to try to record the occultation from 50 parallel fence lines about 3 km apart (see their interactive map at <https://lucy.swri.edu/occ/predictions/20240226Polymele/>) across northern Baja California, to obtain another profile of Polymele, and 2 chords across Shawn, the Polymele moon discovered during the 2021 campaign. Some IOTA observers in California and s. Arizona hoped to extend the SwRI coverage northward, just in case (mainly for a possible second moon), but our El Niño winter sent an atmospheric river with thick clouds over the whole area; only 3 stations of the 50 that SwRI deployed, near the southernmost part of the coverage area, recorded the target star at the right time, but apparently they were misses (they were well outside the predicted path for Polymele).

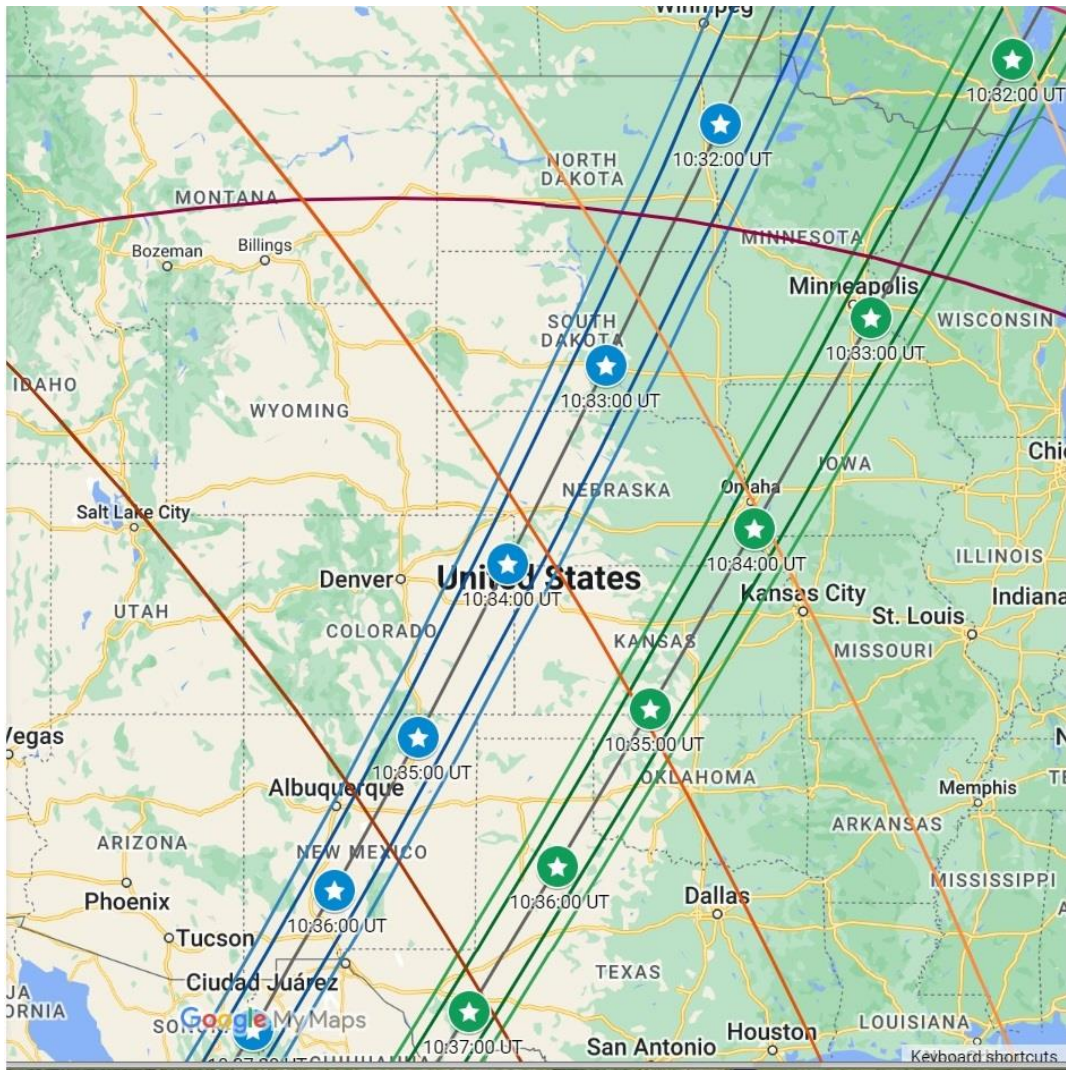
Mar. 25, (3548) Eurybates: We had high hopes for a SwRI/IOTA unfunded campaign for this trans-continental occultation (see the Occult map below, but for the most accurate path, the SwRI zoomable

map at <https://lucy.swri.edu/occ/predictions/20240325Eurybates/> was used for site selection. Unfortunately, widespread thick clouds covered the path across Wyoming to Michigan, causing SwRI to cancel their observational effort from Colorado, and similarly for IOTA observers hoping to see it from n.w. California or s. Oregon. There were thinnings in the clouds over southern Idaho, and Vadim Nikitin found one to record the occultation there. But the only really clear sky was over south-central and south-eastern New York; Steve Conard and Roxanne Kamin recorded the occultation with their QHY cameras from observatories on opposite sides of Ithaca, NY while Phillip Oakey, a student from the University of Virginia, travelled with one of their mobile systems to New York to also record the occultation. Buie posted a preliminary sky plane plot on the event channel on Lucyocc.slack.com. The more accurate SwRI path was about 10 miles from the IOTA/JPL path shown in the small scale Occult map below:



Large SwRI effort planned for important Aug. 11th occultations by Patroclus and Menoetius

The next large SwRI campaign will be for the occultation on the morning of August 11th by (617) Patroclus and its large moon Menoetius. These objects are of most interest to NASA and SwRI since they will be the last flyby targets of Lucy, and they are the largest Trojans of the Lucy targets. The SwRI map is at <https://lucy.swri.edu/occ/predictions/20240811Patroclus/> showing the path for Patroclus with blue lines and circled stars, while those for Menoetius are green (see top of next page for a screen view of it). The UT of the occultation is given under the circled stars. A static view of the map is at the top of the next page; from it, you can see that the SwRI paths are a little more than a path-width west of the ones I plotted using Occult4 on the map at the bottom of p. 1; the SwRI map is the more accurate one, updated with the results of the 2022 campaigns for occultations by these objects in Australia. Another curious problem is the mag. of the occulted star, given as 8.4 (G* at the top of the SwRI page), but Occult and AAVSO APASS all agree that the Gaia G mag. (without the “*”) is 13.4; the prominent G* value of 8.4 is quite misleading, if true, the event could be recorded with mighty mini’s, while 13.4 will need at least an 8-inch scope. If you have such a scope, and want to participate in the Aug. 11th campaign, send a message to Brian Keeney, email bkeeney at gmail dot com asking that you be added to the lucyocc.slack.com channel to receive important communications from SwRI about plans for the event.



2024 Aug. 11 occultation paths by (617) Patroclus (blue) and Menoetius, see previous page.

Another occultation on our map on p. 1 will occur on Nov. 12, with the side-by-side paths for Patroclus and Menoetius in n. Mexico, just south of Texas. But the paths extend farther northwest, into central Arizona, where some observers have good enough equipment to record the events in the evening twilight that will occur there. Consequently, we will request SwRI to generate path predictions for Nov. 12 (actually, the evening of Nov. 11 local time).

SwRI has some plans to predict and encourage observation of occultations by non-Lucy Trojan asteroids; we look forward to that, to supplement this document and corresponding Web page.

The maps were produced with IOTA's free *Occult* software; see <http://www.lunar-occultations.com/iota/occult4.htm>. You can download and use this software and use it to compute your own local lists and information about these and many other occultations. The information for doing this is at <http://www.lunar-occultations.com/iota/2024iotapredictions.pdf>. This describes a

prediction input file for planetary and asteroidal files called **All2024.xml**. You can use that file to generate local predictions, but you can replace it with the other files listed below to generate predictions for more Trojan occultations, mainly of fainter stars than shown on the maps, or for other parts of the world:

Nam24Trojans.xml – This is the input for the 22 Trojan occultations for North America shown on the map at the bottom of p. 1.

2024WorldLucyOccsToMag16.xml – This is the input for 194 occultations by the Lucy Trojans (6 objects, counting Menoetius separately) worldwide to mag. 16 in 2024, but the Patroclus/Menoetius events are off by a path-width or more; if you plan to observe occultations by any of the Lucy Trojans and your event is not on the SwRI prediction site at <https://lucy.swri.edu/occ/predictions/>, you should send a message to Brian Keeney, email bkeeney at gmail dot com, giving the date, asteroid, and general area, and he can prepare and post a Google map for the event. SwRI's prediction site should always be consulted since its path predictions are better than ours on OW generated from JPL Horizons, which does not have access to the many observations that SwRI has collected in recent years, but has not yet had time to publish (Leucus is an exception, since the SwRI data for it were published and used by JPL).

2024restWorldTrojansToMag14.xml – This is the worldwide input for all of our selected Trojans, 339 occultations to mag. 14 for the rest of 2024. These include a selected subset of the non-Lucy Trojans. Many of them have better path predictions by the Lucky Star Project; for them, see <https://lesia.obspm.fr/lucky-star/predictions.php>. There is also a North American subset of this file.

For worldwide occultations by major and all types of minor planets (mainly main-belt) worldwide for the whole year, fairly comprehensive only to about mag. 12, use the **All2024.xml** file noted above, but even more occultations can be found with Occult Watcher, IOTA's free Windows software for finding and coordinating observations of asteroidal occultations, available free at <http://www.occultwatcher.net/>.

David and Joan Dunham, dunham@starpower.net, cell 301-526-5590, 2024 April 17