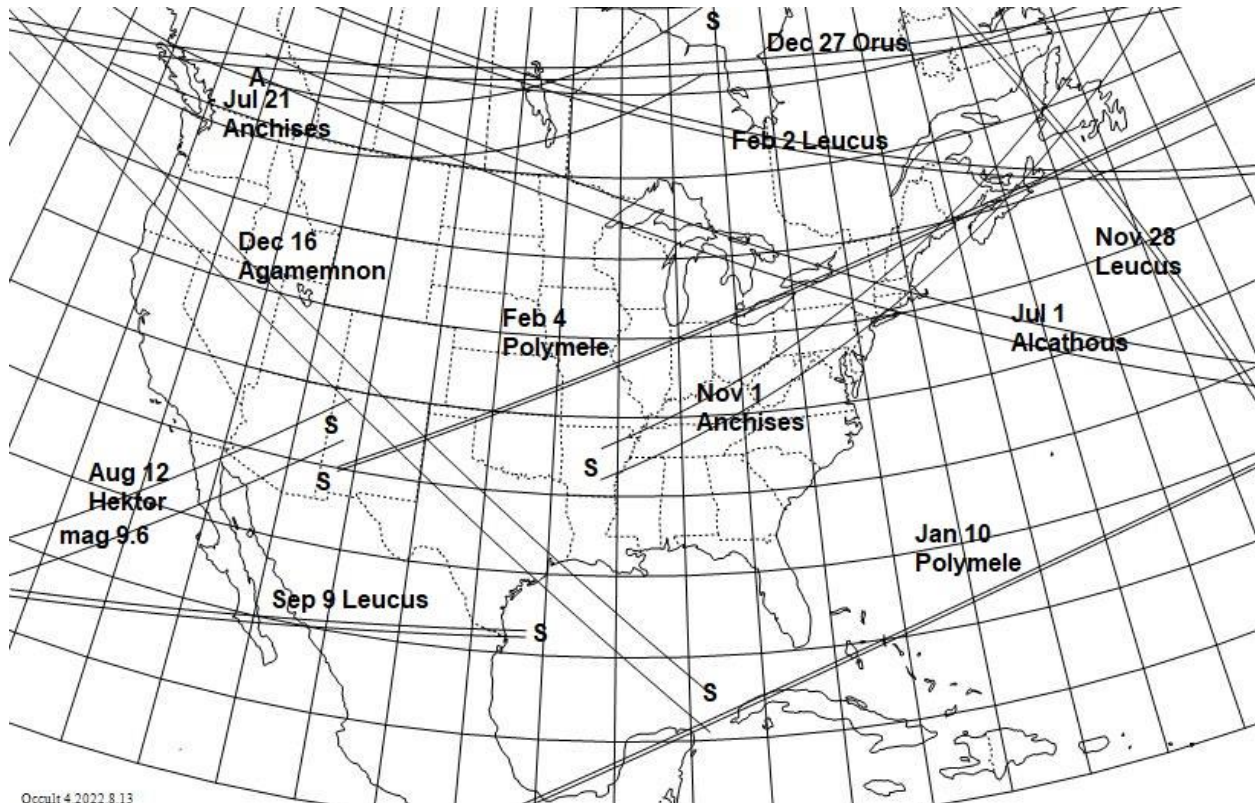


2023 Occultations by Trojan Asteroids

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 2023 at <https://occultations.org/publications/rasc/2023/nam23Trojanoccs.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 2023



2023 OCCULTATIONS BY TROJAN ASTEROIDS

Date	UT	Occulting Body	Star	Mag.	RA (2000) h m s	Dec ° ' "	ΔMag.	Dur. s	Path
Jan. 10	01:50	15094 Polymele	UCAC4 630-037427	12.8	06 53 22.1	+35 52 58	5.6	1.3	BS-Mex
Feb. 2	06:26	11351 Leucus	UCAC4 535-023400	14.0	06 05 56.5	+16 59 57	4.1	3.7	NS-AK
Feb. 4	01:43	15094 Polymele	UCAC4 631-037227	13.3	06 38 54.7	+36 01 27	5.5	2.0	NS-NM
Jul. 1	06:03	2241 Alcahous	UCAC4 464-127791	11.2	21 44 08.5	+02 40 08	5.0	11.6	MA-BC
Jul. 21	07:06	1173 Anchises	UCAC4 364-177314	12.9	20 12 04.4	-17 20 56	2.4	7.5	ON-BC
Aug. 12	11:41	624 Hektor	UCAC4 627-040447	9.6	07 34 34.7	+35 18 58	5.7	4.8	Baja-NM
Sep. 9	11:09	11351 Leucus	UCAC4 509-045671	13.2	08 23 22.7	+11 43 06	5.6	1.0	Baja-TX
Nov. 1	00:15	1173 Anchises	UCAC4 364-176248	12.9	20 02 18.5	-17 12 23	3.4	5.7	AR-NL
Nov. 28	06:32	11351 Leucus	UCAC4 483-047928	13.5	08 58 22.4	+06 33 35	5.1	5.5	QC-NL
Dec. 16	11:26	911 Agamemnon	UCAC4 642-044054	13.2	08 29 48.3	+38 16 06	2.2	13.3	TX-OR
Dec. 27	06:39	21900 Orus	UCAC4 541-037650	13.5	07 05 38.8	+18 05 05	3.4	3.0	ON-BC

2023 Trojans North America L following date is a Lucy mission target

Date	U.T.	Diameter	Durn	Star	Mag-Drop	Elon	%	Star	d Rely	Planet	Min	Moon
m d	h m	km "	sec/m	mag	V	R	* o	No.	<1.4	No Name	D	Error Dist ill
Jan 10	L 1 50	21 0.008	1.31s	12.8	5.7	5.7	165	UCAC4 630-037427	1.05	BS-Mex15094 Polymele	0.15 ±0.03	42 91
Feb 2	L 6 26	36 0.012	3.7s	14.0	4.2	4.3	138	UCAC4 535-023400	1.05	NS-AK 11351 Leucus	0.62 ±0.01	11 89
Feb 4	L 1 43	21 0.007	1.97s	13.3	5.5	5.4	141	UCAC4 631-037227	0.95	NS-NM 15094 Polymele	0.17 ±0.03	11 93
Jul 1	6 3	116 0.034	11.6s	11.2	5.0	5.4	128	UCAC4 464-127791	1.10	MA-BC 2241 Alcahous	0.36 ±0.01	82 93
Jul 21	7 6	111 0.043	7.5s	12.8	2.4	2.6	176	UCAC4 364-177314	1.10	ON-BC 1173 Anchises	0.92 ±0.01	144 11
Aug 12	11 41	181 0.041	4.7s	9.6	5.8	5.8	33	UCAC4 627-040447	W 1.15	Baja-NM 624 Hektor	0.32 ±0.02	16 14
Sep 9	L 11 9	36 0.008	1.01s	13.2	5.6	5.6	42	UCAC4 509-045671	0.95	Baja-TX11351Leucus	0.04 ±0.01	24 26
Nov 1	0 15	111 0.033	5.7s	12.9	3.4	3.5	81	UCAC4 364-176248	0.95	AR-NL 1173 Anchises	0.73 ±0.01	126 95
Nov 28	L 6 32	36 0.010	5.5s	13.5	5.1	5.1	110	UCAC4 483-047928	0.95	QC-NL 11351 Leucus	0.29 ±0.01	60 99
Dec 16	11 26	157 0.051	13.3s	13.2	2.2	2.3	140	UCAC4 642-044054	1.00	TX-OR 911 Agamemnon	0.12 ±0.01	163 16
Dec 27	6 39	50 0.017	3.0s	13.4	3.4	3.4	169	UCAC4 541-037650	1.00	ON-BC 21900 Orus	0.58 ±0.01	12 100

On the bottom of the previous page is the map of 2023 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.

In the table at the top of this page, occultations involving the Lucy Trojan targets are highlighted in bold type, to emphasize their importance. The paths for the Polymele occultations on the map are not accurate; the actual paths are a few path-widths farther north, according to predictions by the Southwest Research Institute (SwRI) and confirmed by IOTA's observations for their occultation campaigns for NASA's Lucy mission; see <http://lucy.swri.edu/occultations.html> for SwRI's interactive Google maps. Maps and 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. The non-Lucy paths shown are all 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: (1) the date and central time of the event; (2) the name of the occulting body; (3) the catalogue and number of the occulted star; (4) the star's apparent visual magnitude; (5) the star's right ascension and (6) declination; (7) the expected magnitude change from the

combined brightness; (8) the predicted maximum duration of the occultation in seconds; and, (9) the path location specified by the lands crossed by the eastern and western ends of the path shown on the map. The two-letter 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, either Norte or Sur, while “Mex” denotes the rest of Mexico. The times are for a point near the middle of the plotted path; for any specific location in North America, the event time can be a few minutes earlier or later.

Special interactive Google maps and other details for the SwRI campaign events is at <http://lucy.swri.edu/occultations.html>. 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 substantially from what we show on our maps.

Some information about some of the occulting Trojans portrayed above is given below:

(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, which is known well enough that we can predict separate paths for the two objects. But there are no occultations by the pair in N. America brighter than mag. 14 during 2023, and only a few in other parts of the world.

(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) Alcahous: 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.

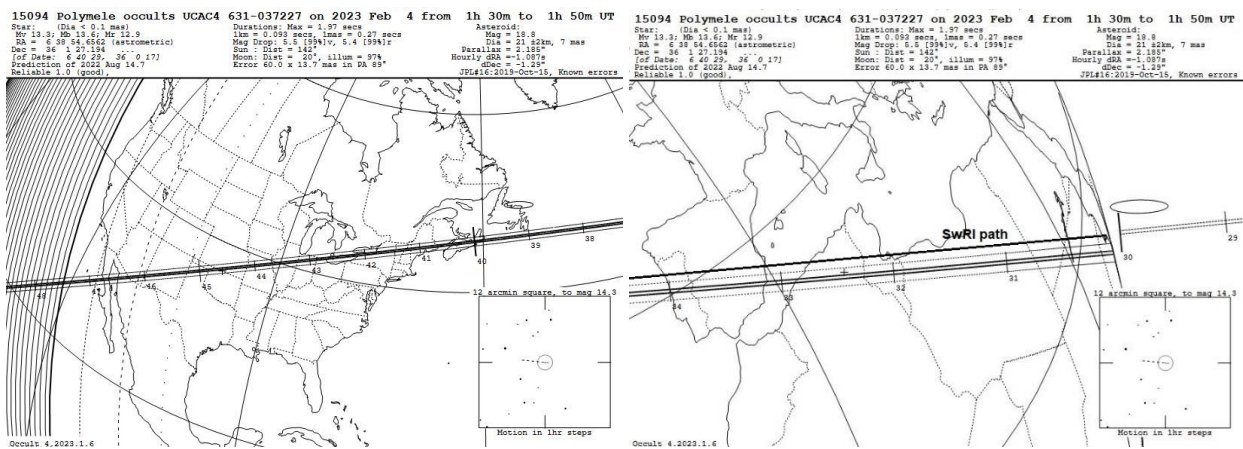
(15094) Polymele: A 5km moon, about 200 km away, was discovered with 2 chords during a 2022 Mar. 27th occultation. See below about SwRI’s massive Feb. 4th campaign that defined well another profile of Polymele and recorded another occultation by the moon, informally named “Shawn”.

(21900) Orus: This is another Lucy target.

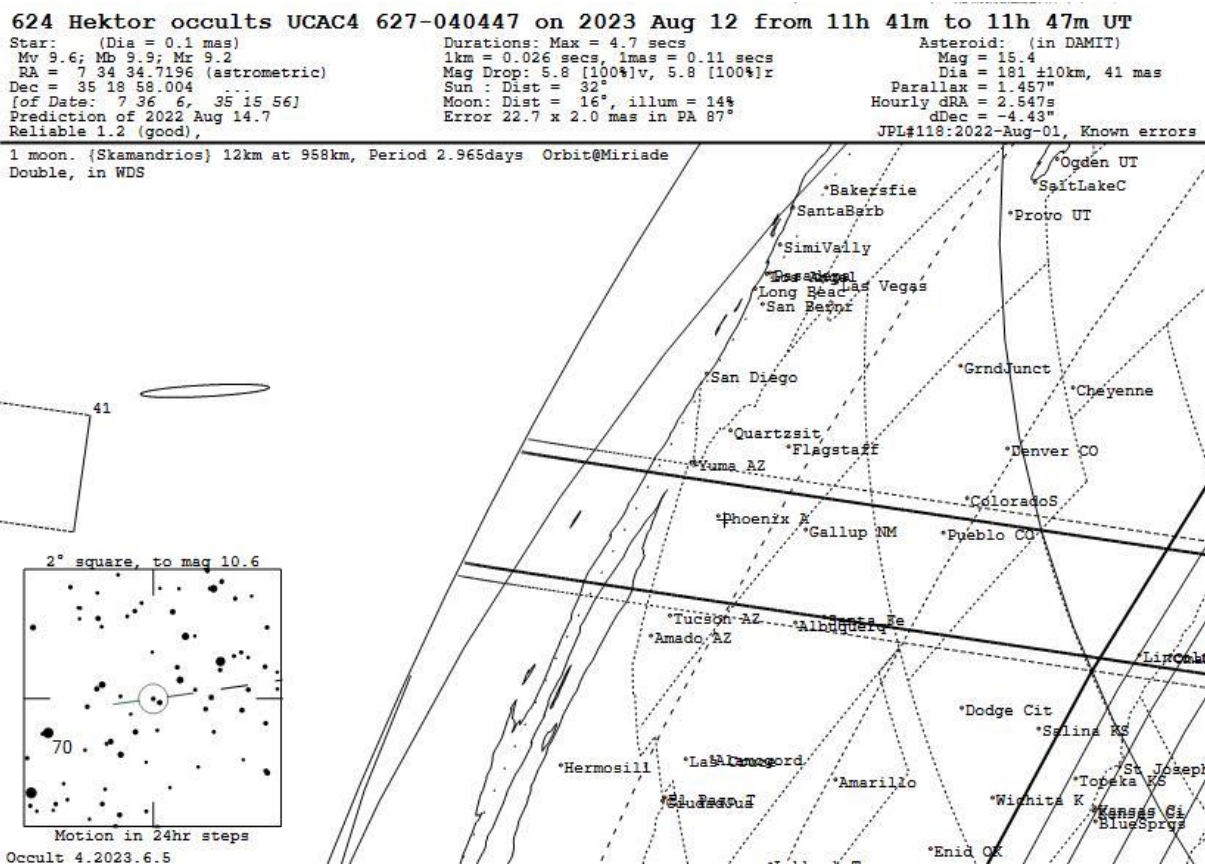
Occultation of 13.1-mag. star by Polymele, Feb. 4 UT (Feb. 3 pm local time in N. America)

This was the most important Lucy Trojan occultation in North America this year. Four of the other Lucy event paths all miss the territory of the “lower 48” United States, and the other one, by Leucus on Sep. 9, only crosses the southernmost part of Texas in morning twilight. Because this was our only good opportunity this year, SwRI and IOTA made a maximum effort to observe it, and SwRI, using their NASA funds, paid the travel expenses of most of the observers. Occult maps of the occultation are below, with the path across N. America on the left, and across Iberia and Algeria on the right. SwRI’s Marc Buie describes the campaign’s goals at <https://occultations.org/publications/rasc/2023/BuieGoalOnly.pdf> and updated information about the campaign is at <https://occultations.org/publications/rasc/2023/Jan21updateForTheSwRICampaign.pdf>.

The maps at the top of the next page give information about the occultation in the header, and portray the path approximately across North America on the left, and across Iberia and northern Africa on the right. But for the best predicted path, use SwRI’s Google map at <http://lucy.swri.edu/occ/20230204Polymele.html>.



Occultation of 9.6-mag. SAO 60194 by (624) Hektor, Sat. morning, August 12



This is the brightest Trojan occultation in North America during 2023. Hektor is the largest Trojan asteroid and, as noted on p. 3, is an interesting contact binary object. More about this important occultation is in the associated IOTA Trojans occultation Web page (link in 1st paragraph of the first page); let us know if you might be interested in helping us record this occultation.

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/2023iotapredictions.pdf> . This describes a prediction input file for planetary and asteroidal files called **All2002.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 occultations, mainly of fainter stars than shown on the maps, or for other parts of the world:

2023namTrojansFinal.xml – This is the input for the 11 Trojan occultations for North America shown on the map at the bottom of p. 1.

2023LucyTrojansToMag16.xml – This is the input for the occultations by the Lucy Trojans (6 objects, counting Menoetius separately) worldwide to mag. 16, but the Polymele and Patroclus/Menoetius events are off by a few path-widths; if you plan to observe occultations by any of the Lucy Trojans [except Leucus, which has an accurate orbit in our system], you should send a message to Brian Keeney, email bkeeney@gmail.com, giving the date, asteroid, and general area, and he can prepare and post a Google map for the event. SwRI's prediction Web site is at <http://lucy.swri.edu/occ/predictions.html> but currently it only has information about future occultations by Polymele; predictions for some of the events by other Lucy mission targets will likely be added during the next few months.

2023worldTrojansToMag14.xml – This is the worldwide input for all of the Trojans we've considered (Lucy and Lucy Star) occultations to mag. 14. These include a selected subset of the non-Lucy Trojans covered by the Lucky Star Project; better paths are usually available for them at <https://lesia.obspm.fr/lucky-star/predictions.php> .

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. 12.5, use the **All2002.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, 2023 June 7