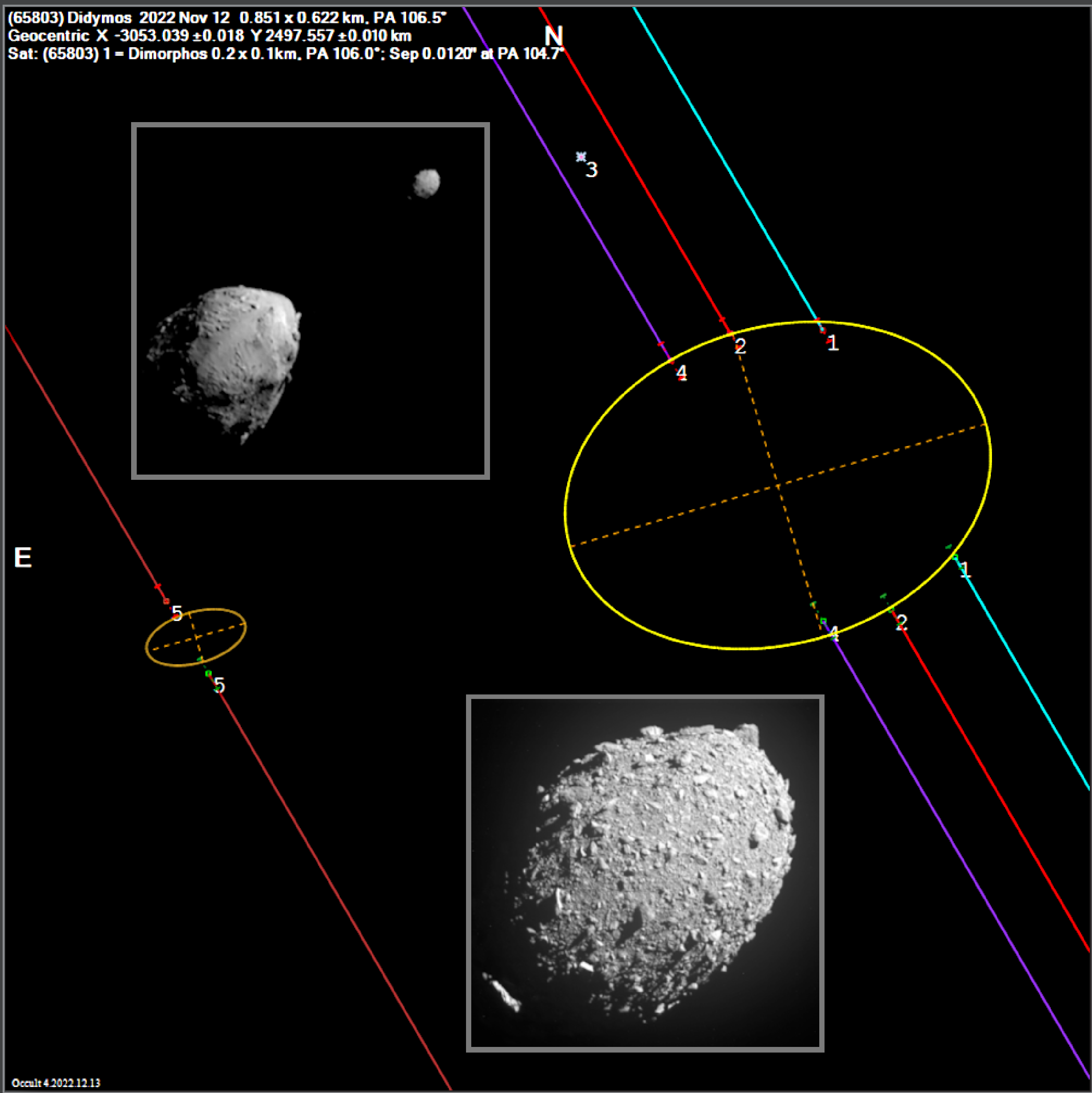
Journal for Occultation Astronomy

Volume 13 · No. 1 2023-01



After the Impact of DART - Occultation Measures the Didymos System

Dear reader,

Changes are coming up for each observer of stellar occultations in Europe. In the last 20 years we all had to send an ASCII textfile to Planoccult in order to process our observations.

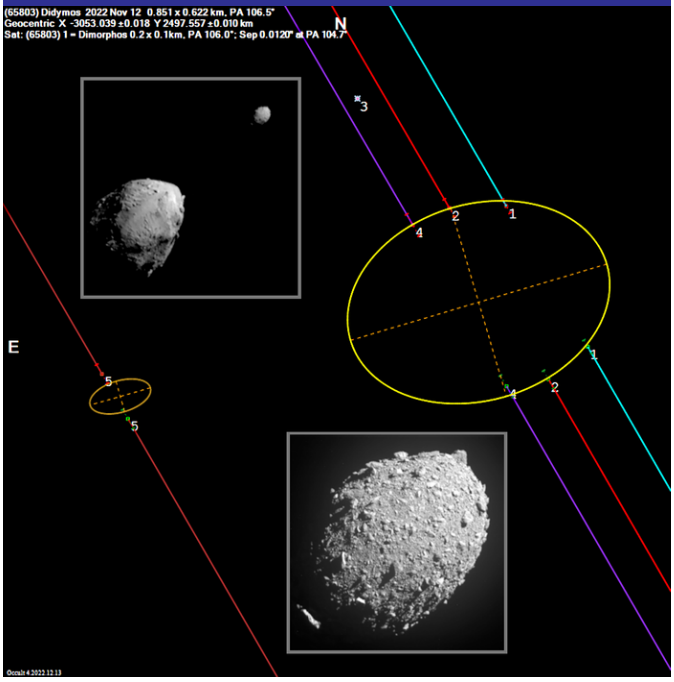
Starting with 2023 all European occultation observations will be stored not on a html website as we do it right now, but in a real database. This will be a big change for all of us, but because of the increasing number of events every year it is unavoidable. Even more, the reviewing process, up to now more or less shouldered by a single person (Eric Frappa) will be distributed to reviewer teams for groups of countries. In the last month of 2022 a testphase had been established, to see, how well this network is doing.

Occultation work over the last half century has undergone many important changes. The positions of stations are in these days measured by GPS instead of using maps, video and digital cameras have replaced the human eye, the catalogues of stars have now an unprecedented accuracy since *Gaia* catalogues became available. Occultation observers got well adjusted with all these new tools and methods I believe that we all will do well with the new Stellar Occultation Data Input System (SODIS) in 2023 and future years.

Wolfgang Beisker

Research & Development, IOTA/ES

COVER



The DRACO imager on board of NASA's *DART* mission took an image of (65803) Didymos and its moonlet Dimorphos 2.5 minutes before the impact of the probe (top left). The last full image of Dimorphos was taken at a distance of 68 kilometres (lower right). On 2022 Nov 12, observers N. Carlson, P. Maley and R. Nolthenius recorded positive chords of an occultation by (65803) Didymos, while R. Jones got a positive measurement of Dimorphos with a duration of only 0.07 s.
Images: NASA/Johns Hopkins APL   Plot: *Occult 2022.12.13*

JOA Volume 13 · No. 1 · 2023-1 $ 5.00 · $ 6.25 OTHER (ISSN 0737-6766)

In this Issue:

Copyright Transfer

Rules for Authors

In order to optimise the publishing process, certain rules for authors have been set up how to write an article for *JOA*. They can be found in "How to Write an Article for *JOA*" published in this *JOA* issue (2018-3) on page 13. They also can be found on our webpage at http://www.iota-es.de/how2write_joa.html .

Journal for
Occultation Astronomy

A Fascinating Occultation by (252) Clementina

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ABSTRACT: On 8 February 2022 I observed a positive occultation by (252) Clementina. The light curve of the event showed two successively registered drops in the combined brightness of the asteroid and the star. An initial brief occultation with a duration of 1.05 seconds was followed by a 0.70 seconds return to the previous combined brightness level before the star was occulted again for 2.46 seconds. This report describes the observation and evaluation of the event and discusses the most probable interpretations. It also demonstrates the fascinating and exciting turn that events of this kind – planned as routine observations – can take when unexpected results emerge.

Introduction

The criteria for observing the event were promising. The IBEROC prediction (OccultWatcher, [1]) gave the following: observation probability of 73%; position of the star at an elevation of 41° in the south-east. The duration of the event was predicted to be 5.0 s, a brightness drop of 0.6 to 0.8 mag, and the time of the occultation at a convenient 21:23 CET. Only the faint star and a predicted combined brightness of 13.9 to 14.1 mag increased the complexity of the observation. An exposure time of 300 to 400 ms has been estimated from similar observations in the past. My location was in the shadow path, 33 km from the central line. The crescent Moon was distant enough not to intrude, and fortunately the sky was clear with good transparency.

Figure 1 shows the predicted path over Europe from *Occult* [2] and in Figure 2 a closer look at the map is shown; the marker points to my observing position at the edge of the path.

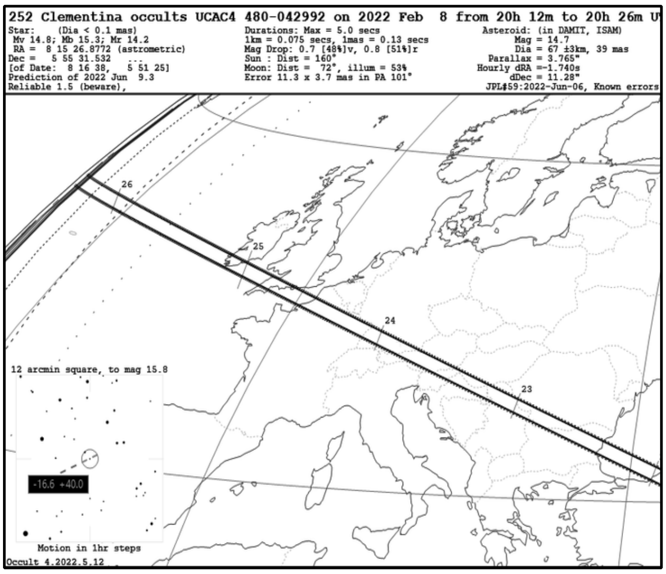

Figure 1. Path prediction, plotted with Occult v4.2022.5.12 [2]

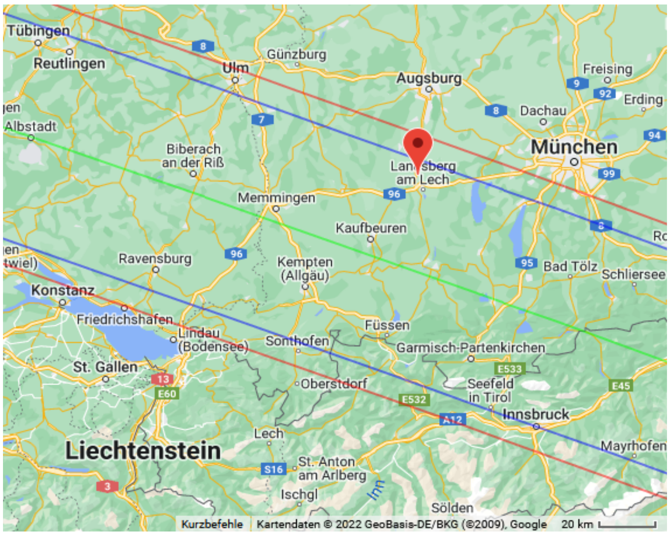

Figure 2. Path in Google Maps, the marker shows the observing position (Map data: © 2022 GeoBasis-DE/BKG (© 2009) , Google)

Star Data

The star Gaia 3096457982017961728 (UCAC4 480-042992) has a magnitude G=14.84 mag (Gaia G-band) and corresponding photometric magnitudes G_BP=15.28 mag and G_RP=14.24 mag. The re-normalized unit weight error (RUWE) value is 1.466, which indicates the reliability of the astrometric solution. There is no sign that positional errors may be larger than expected [3, 4]. No entries in the WDS and Interferometric Catalogue have been found; it is not a known double star.

It has an effective temperature of 5141 K and a surface gravity log g of 4.577 log(cm*s^{-2}). Both values have been taken from General Stellar Parametrizer from Photometry (GSP-Phot) [5].

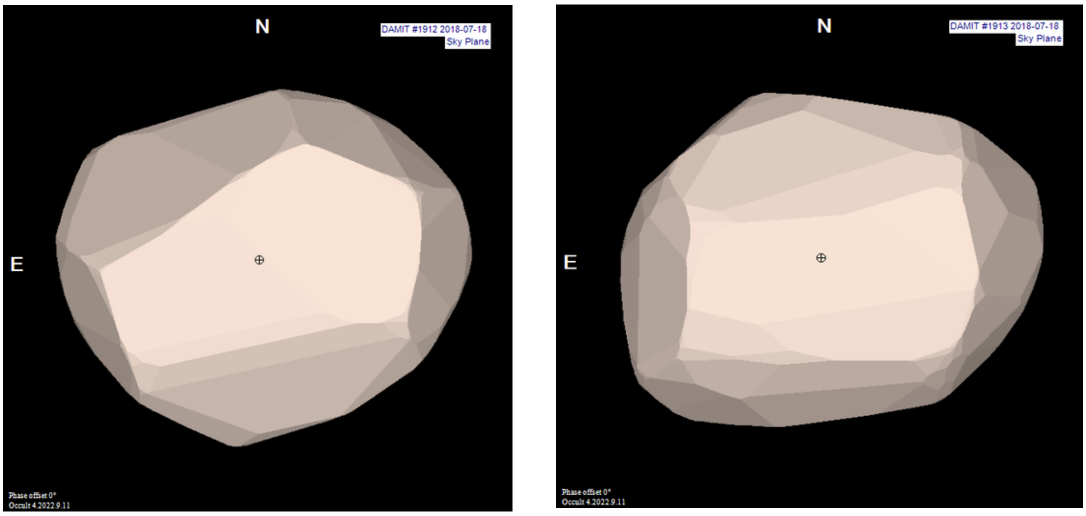

Figure 3. DAMIT models 1912 (left) and 1913 (right) at the time of occultation (source: Occult, v4.2022.9.11 [2])

Asteroid Data

(252) Clementina is a body in the main asteroid belt that was discovered by J. Perrotin in Nice, France, on 1885 October 11. The asteroid has a mean diameter of 65.3 km, a rotation period of 10.86 h and a dark surface with an albedo of 0.047 [6]. There are two DAMIT models numbered 1912 and 1913 [7], also present in the ISAM service as A252-1 and A252-2 [8]. Usually, the models have convex contours in general. According to these models the body of (252) Clementina is elongated with a maximum axis ratio of 1.35 : 1 (1912) and 1.24 : 1 (1913) and has apparently flat sides (Figure 3).

(252) Clementina is not known to be a double body and is not currently known to have a moon or rings. It has not yet been explored by a space probe, and no high-resolution images have been captured by large-scale ground-based or space telescopes. There are no radar images available, neither [9]. At time of the occultation (252) Clementina was below the ecliptic plane and had a distance from Earth of 2.34 AU (Figure 4).

There were three successful occultations and four chords in the past with (252) Clementina involved [2]:

- 2012 Apr 18 by A. Hashimoto
- 2015 Dec 16 by T. George
- 2022 Jan 17 by H. Yamamura
- 2022 Jan 17 by H. Yoshihara

But none of those observations resulted in a chord with a gap. Up to now there is no hint of a concave shape of this asteroid that would explain a grazing occultation.

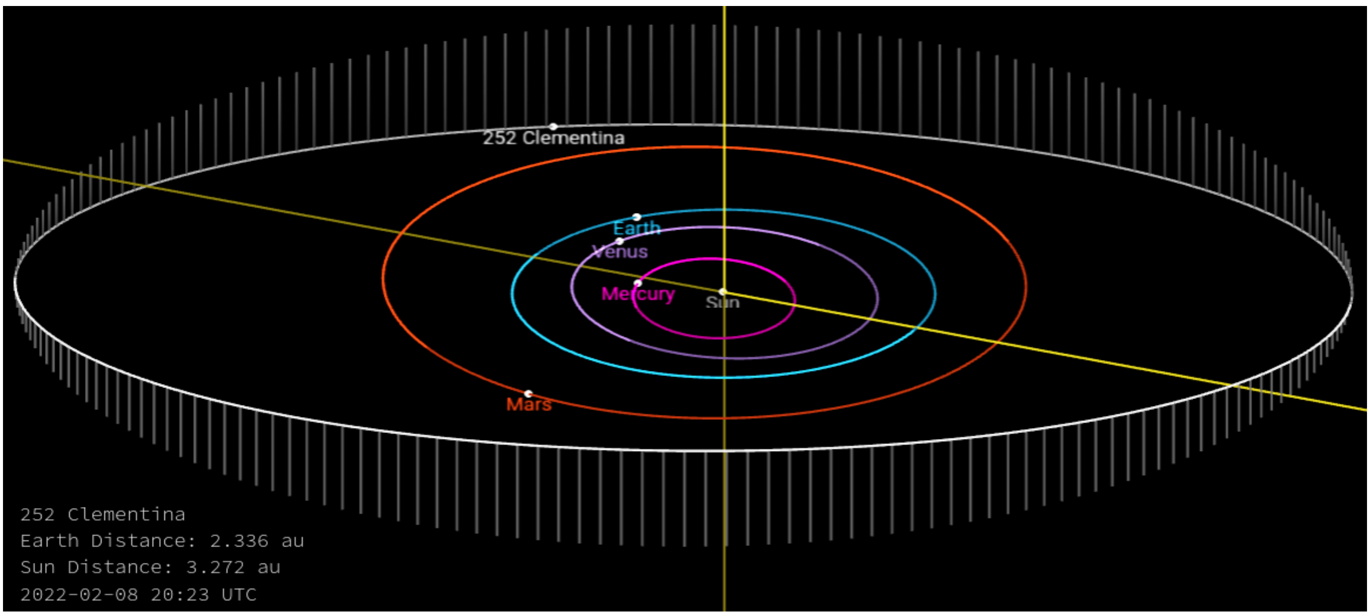

Figure 4. Orbit of (252) Clementina on the date and time of occultation (source: JPL Small Body Database [6])

Observation of the Occultation

The observation has been prepared around one hour before the event, giving plenty of time to initialize the telescope, slewing to the position of the star, setting the focus and configuring the necessary things, as well as allowing time for the telescope and camera chip to cool down. I usually take long-exposure shots before or after the event to document the surrounding stars; these images can later serve as evidence that the correct star was viewed and measured. In this case, two overview images were taken 30 and 15 minutes before the event. If an asteroid is bright enough – as (252) Clementina was in this case – it will also be recorded in these images, see Figure 5. Its motion towards the star could already be tracked live on the monitor. For this observation a 14-inch Meade telescope on a Taurus GM-60 German equatorial mount has been used. The telescope is in my observatory on the roof of my house in Kaufering [10], which saves me having to travel to a viewing location. A reducer (AstroPhysics CCDT67) is installed in the optical path of the telescope before the camera, to reduce the focal length to 2248 mm; an IR filter is used to block infrared light. Figure 6 shows the back of the telescope with the camera mounted. This system gives a field of view of 7.2 x 5.4 arc minutes with a crop section of 800 x 600 pixels. To record the progress of the occultation, *SharpCap Pro* software (Version 4.0.8655.0) [11] was used, which works smoothly with the QHY 174M-GPS camera. This camera has an integrated GPS receiver and it is able to set UTC-accurate time stamps on each frame [13]. The 2x2 binning mode is often used to increase the signal to noise ratio. Exposure time was set to 350 ms for this faint star. The three-minute recording produced 513 images in a SER[1] file [14]. See Table 1 for additional recording settings.

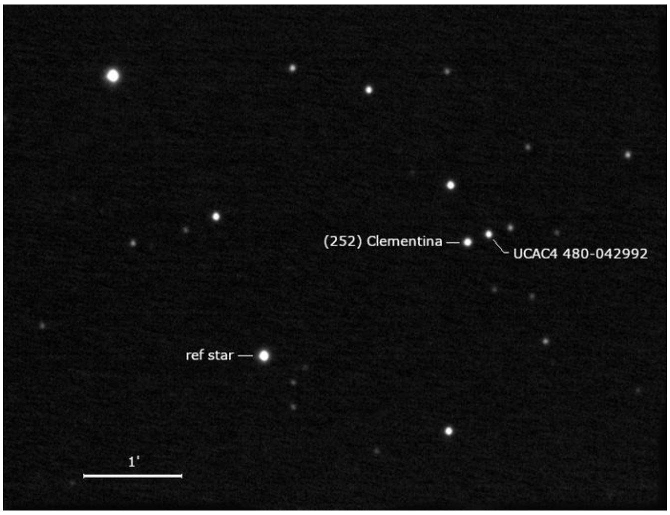

Figure 5. Positions of (252) Clementina, the occulted star UCAC4 480-042992, V=15.12 mag (UCAC4) G=14.84 mag (Gaia) and the reference star used in the Tangra light curve UCAC4 480-043008, V=12.97 mag (UCAC4) G=12.79 mag (Gaia) 30 min before event (19:53 – 19:57 UT), stacked image of 120x2 sec exposure time, Asteroid brightness: V=14.7 mag

- GPS Status: Locked
- GPS Calibration:
  Start Pos Adjust=102550, End Pos Adjust=30360
- GPS Freq Stabilization: On
- Gain: 440
- Gamma: 1
- Offset: 0
- Chip Temperature: -10° C
- Recording Start Time: 20:22:30.783 UT +/- 0.01 sec
- Recording End Time: 20:25:31.039 UT +/- 0.01 sec

Table 1. Additional recording settings

A brief dimming of the star was noticeable live on the monitor, although the start of the occultation was not clearly distinguishable visually.

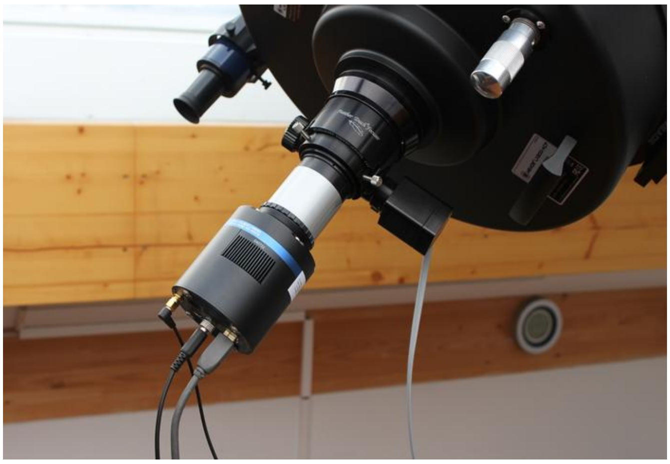

Figure 6. QHY 174M-GPS camera mounted on the telescope, the reducer is inside the draw tube.

Evaluation of Data

Tangra [15] has been used to generate a light curve. In undoubtful situations it shows in short time whether the result is positive or negative. (252) Clementina's light curve was clearly positive, and to my surprise it revealed two occultations of the star in quick succession, interspersed by a return to the original brightness level. Each of the three phases – the initial occultation, the interim brightness, and the second occultation – was documented with multiple measurement points (Figure 7). Several runs were necessary with adjustments of the aperture size to work out the drops as best as possible. As settings the Aperture Photometry method with Average Background was used with no filters.

[1] SER format for recording of occultations should be only used if all specifications are precisely known, see pitfalls with SER format [12], for scientific work the FITS file format is strongly recommended.

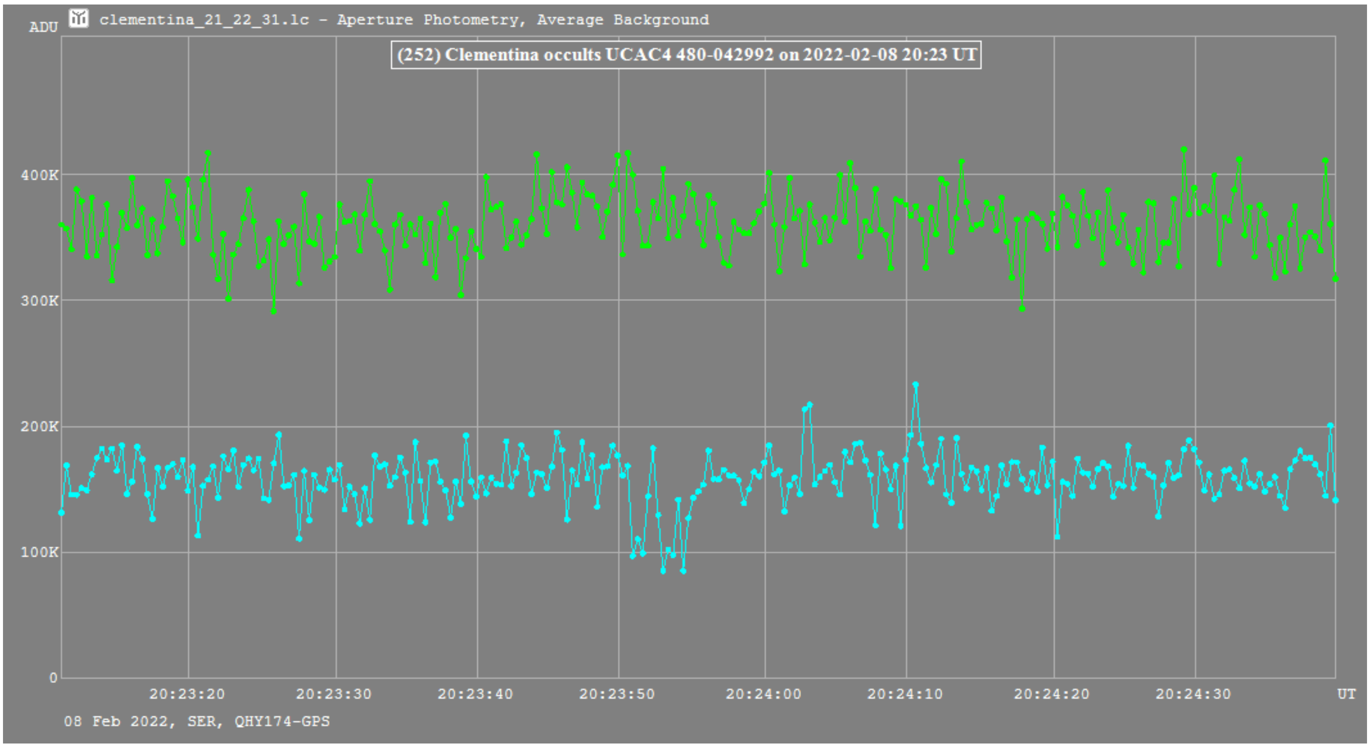

Figure 7. Tangra light curves of the double occultation by (252) Clementina (light blue) and reference star (green).

Usually, one tends to use a rather small aperture size to minimize noise, but this lowers the drop level, too.

The best values were apertures of 3.6 pixels for the occulted star and 3.1 pixels for guiding stars [16]. *PyOTE* [17] and *AOTA* [2] have been used for further evaluation of data from this event. With both software tools it was possible to identify and analyse the left and right parts of the occultation. With both tools the precise D and R times including error bars have been determined. In *PyOTE*, the trimming functionality helped to cut that part of the occultation which was not under analysis. This was done to prevent a wrong noise calculation in a region with a real drop (Figure 8).

PyOTE determined the magnitude drop to be lower than predicted (prediction: 0.6 – 0.8 mag, *PyOTE* evaluation: 0.51 mag +/- 0.29 mag left part and 0.43 mag +/- 0.15 mag right part). The prediction gives Gaia G-band magnitudes for the star brightness. This G-band ranges from 330 to 1050 nm, which includes UV and IR parts of the spectrum. But in the light path in front of the camera is a UV-IR cut filter installed to pass only visible light in the range of 400 to 700 nm. This reduces the total star brightness, especially for red stars. A recalculated magnitude drop value using the visual magnitude of UCAC4 480-042992 with V=15.1 mag from the UCAC4 catalogue gives a drop of 0.56 mag which is closer to the measured values and more realistic.

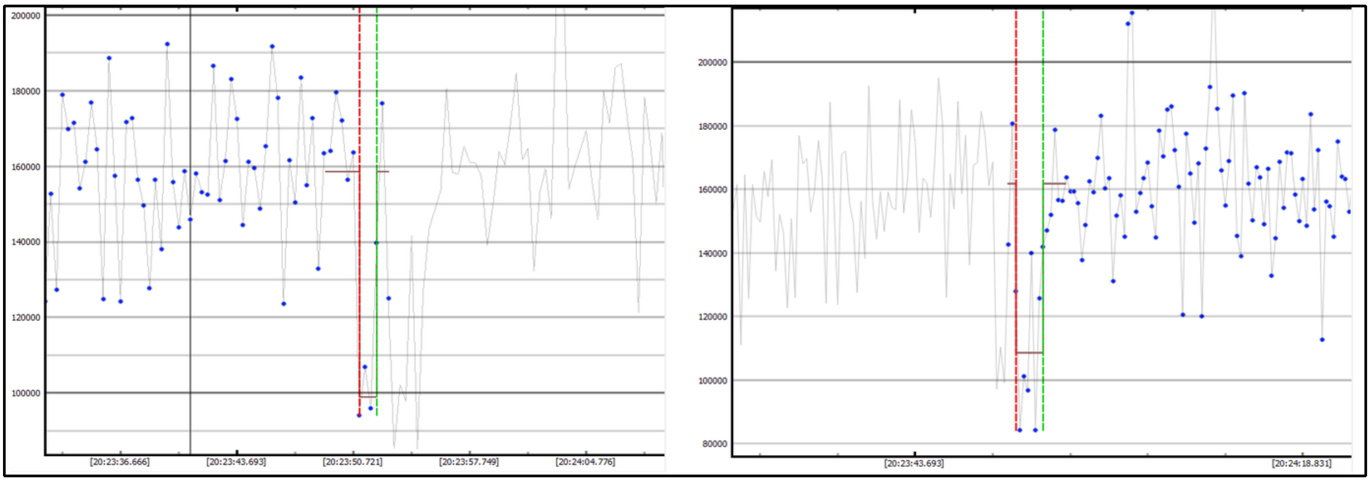

Figure 8. PyOTE plots with left and right drops analysed with trimming.

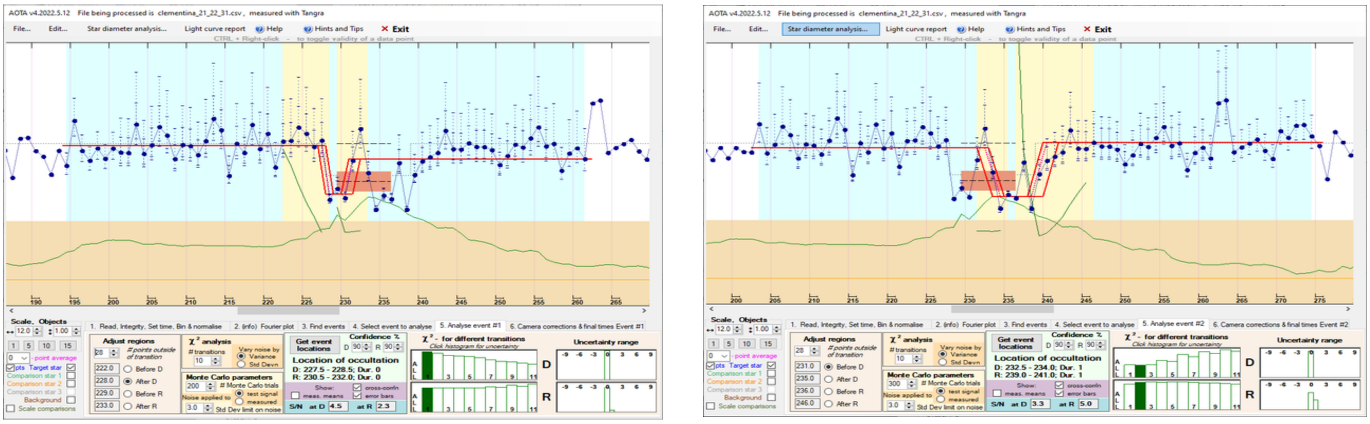

Figure 9. AOTA plots "Tab 5 Analysis" with left and right drops analysed (AOTA, v4.2022.5.12)

The evaluation delivered the following results, see Table 2. Note, that *PyOTE* uses the 0.95 confidence interval whereas *AOTA* uses 0.90. If a *Tangra* generated light curve is analysed in *PyOTE* a -1/2 integration time offset must be applied (here: -0.175 sec) to *PyOTE* results. Tangra exports mid-frame times in its csv file, whereas *PyOTE* expects start frame times.

Discussion of Results

On receipt of the report, Eric Frappa (maintainer of euraster.net [18]), did an in-depth examination of the data by himself and consulted further experts, before the event has been recognized as a possible grazing occultation [19, 20]. With respect to the measured light curve this is the most likely explanation for this event which showed a chord on the outer periphery of the asteroid body. It indicates that (252) Clementina has a possible concave shape which has not been observed yet. An effect of rotation could be excluded. The total event time is 4.22 seconds. (252) Clementina rotates only 2.33 arcmin during this time which doesn't change its silhouette in that short moment. For a grazing event both drops must have the same depth. Within the expected error limits this requirement is met.

A further discussion with Eric Frappa resulted in the statement that a weak concavity in shape is sufficient, if flat sides with some variations are present. The model 1912 shows such flat parts. The spike during the second event might be real if it's not considered as noise [19]. Figure 10 illustrates a possible grazing solution in *Occult* with my chord at the north-east edge. Indeed, the actual model doesn't match well especially for the first short drop. But the real shape of (252) Clementina isn't precisely known yet.

There are other plausible explanations of this light curve that have been taken into account:

• The intermediate return of the brightness level between the drops could be interpreted as noise. This is unlikely but it can't be ruled out. *PyOTE*'s Noise Analysis/Detectability tool calculates a base line SNR of 13.7 at a part of the light curve (left of events) and reports that an event with a duration of 1.054 s and a magnitude drop of 0.51 will be likely detectable. These values correspond to the first drop. The intermediate return of brightness level is about the same magnitude drop but shorter. If inverted, *PyOTE* would report such a drop as an undetectable event.

	Tangra > PyOTE		Tangra > AOTA	
Type	Time (UT)	Uncertainty (s), 0.95 ci	Time (UT)	Uncertainty (s), 0.90 ci
D1	20:23:50.897	+/- 0.366	20:23:50.90	+/- 0.18
R1	20:23:51.951	+/- 0.366	20:23:52.04	+/- 0.26
D2	20:23:52.654	+/- 0.425	20:23:52.74	+/- 0.26
R2	20:23:55.114	+/- 0.425	20:23:55.11	+/- 0.35
Dur1	1.054 s	+/- 0.528	1.14 s	+/- 0.38
Dur2	2.460 s	+/- 0.653	2.37 s	+/- 0.54
IDur	0.703 s	+/- 0.6 (estimated)	0.70 s	+/- 0.50 (estimated)

Table 2. Evaluation results of event by (252) Clementina (D1, D2 – disappearance of left and right drop, R1, R2 – reappearance of left and right drop, Dur1, Dur2 – duration of events, IDur – duration of intermediate brightness return; ci – confidence interval)

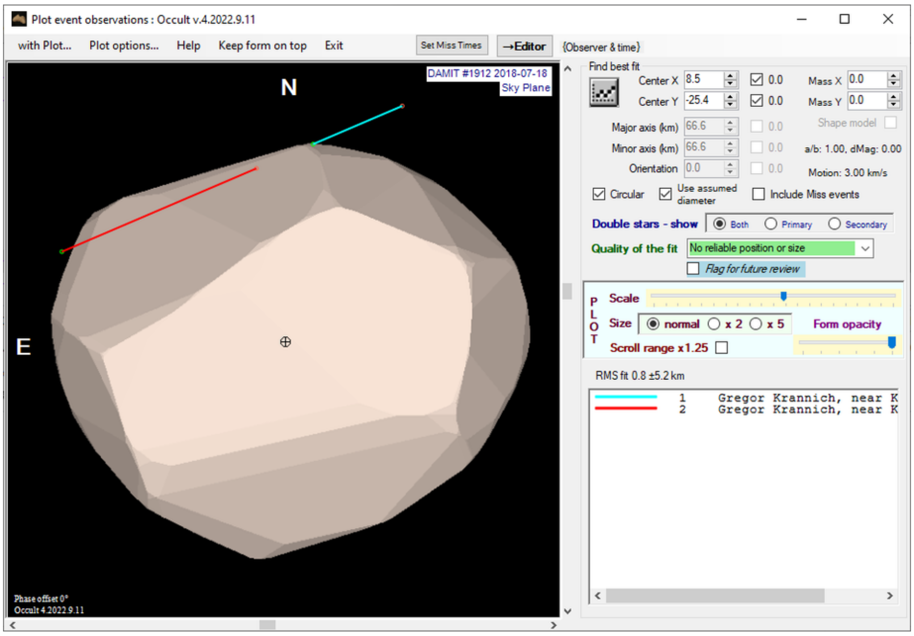

Figure 10. Possible grazing solution with measured chord (source: Occult v4.2022.9.11)

• The observed light curve can be a result of an occultation caused by a close binary star. This situation is a contradiction to the assumed grazing occultation and deserves a more detailed consideration. If we assume this as true, the star would have successively hidden its binary nature up to now, even to Gaia's astrometric measurements and evaluations recently published in Data Release 3. Several values are available in evaluated Gaia data that give indications for the existence of (close) binaries. The IPD statistics (Image Parameter Determination) is powerful to detect partially resolved binaries with elongated star images. Relevant parameters with values for the star UCAC4 480-042992 are: ipd_gof_harmonic_amplitude=0.0577, ipd_frac_multi_peak=0 and ipd_frac_odd_win=0. Additionally, from astrometric fit the RUWE value and the astrometric source noise with its significance are sensitive to photocentric motions of unresolved objects. The ratio astrometric_excess_noise/astrometric_access_noise_sig=0.0175 mas is an estimate of the uncertainty of the excess source noise, for details see chapter 5.3 Goodness-of-fit statistics in [21]. All mentioned Gaia parameters [3, 4] give no indication that the star is a partially resolved double or an unresolved close binary. Hence the binary hypothesis is unlikely from a Gaia data basis.

But from another point of view the binary hypothesis can't be discarded. This is the result of discussion with Eric Frappa. He has done manual calculations of the drops from the full signal. As a result, one can find a 0.5 magnitude drop for both of them, which gives two drops to 14.5 mag from the expected combined magnitude for star and asteroid. After removing the asteroid contribution (14.7 mag), it results in a 15.7 mag for each star, and a combined magnitude of 15.0 mag for the hypothetical double star with 14.8 mag expected. Taking into account using mean levels and G mag values from faint and bright neighbouring stars (UCAC4 480-043008 and UCAC4 480-043013), the observed combined magnitude of the target is 13.8 mag with 14.0 mag expected, and the two drops to 14.3 mag which give, after removing the asteroid contribution, a brightness of 15.6 mag for each star and a combined magnitude of 14.9 mag. Based on these considerations there is an apparent consistency for a binary star hypothesis [19].

• It is possible that (252) Clementina consists of two bodies, a main body and a moon. The duration of the first drop would lead to a rather large moon or a double asteroid with the two bodies at about the same size, which is very unlikely. This would have already been detected by signatures in rotational light curves or other occultation events.

• The intermediate return of the brightness level could be explained as a central flash, that have been detected on centre line occultations of bodies with an atmosphere like Triton (Neptune's moon) or Pluto. But this is also very unlikely, because (252) Clementina has a mass that is much too small to keep an atmosphere, even a very thin one. Furthermore, the light curve is asymmetric and the occultation at my position was not central.

Summary

The observation of the occultation by (252) Clementina yielded an unexpected result. In this case plausible explanations are a grazing occultation or an occultation caused by a previously unknown binary star. During the detailed evaluation it turned out that the grazing occultation has more convincing arguments than the double star hypothesis because of the actual missing indication from Gaia data. A clear decision for one of both explanations is not possible at this stage. There were no other observers for this event, leaving insufficient data from a single observation. A more detailed determination of (252) Clementina's shape can be provided only in future occultation observations. The methods of finding and providing binary solutions from Gaia's data are the subject of recent scientific research and will improve in future data releases.

A search for occultations by (252) Clementina within the next year shows some possibilities in Table 3 (source: *Occult*, constraints: star < 15 mag, mag drop > 0.3 mag, max. duration > 1 sec). All future observations are much appreciated to define (252) Clementina's size more precisely and to unravel its shape.

The events in Europe, the United States, Japan and Australia have chances to be observed by several observers. I would like to invite all with the right instruments to participate in these events. See Figures 11 to 14 for path maps and details.

Continent or Countries	Date / Time (UT)	Star (UCAC4)	Star (mag)	Max. Dur. (s)
China, Philippines	2023 Feb 23, 21:11	396-055200	13.2	11.7
Europe	2023 Mar 17, 02:52	403-056470	14.2	5.4
USA, Mexico, S. America	2023 Apr 13, 03:52	418-056439	14.8	4.7
China	2023 Apr 13, 14:19	418-056431	13.3	4.7
China, Japan	2023 Apr 15, 12:09	419-055757	13.3	4.8
South Korea, Japan	2023 May 03, 10:55	428-056495	14.2	6.5
Africa	2023 May 09, 02:09	434-057062	13.3	3.9
Africa	2023 Jul 18, 17:38	431-056965	14.9	3.2
Australia	2023 Aug 01, 11:25	426-057593	10.8	2.6
Middle East, India	2023 Aug 02, 16:03	426-057627	15.0	2.5

Table 3. Upcoming occultations in 2023 of target stars brighter than 15 mag by (252) Clementina. (source: Occult v4.2022.11.10)

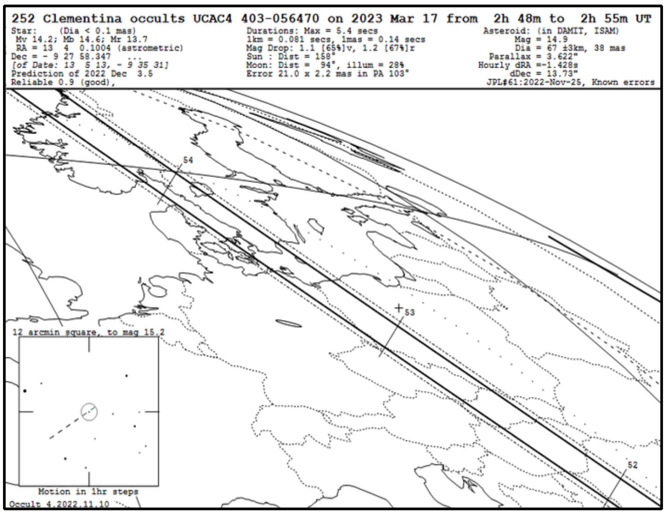

Figure 11. Path in Europe on 2023 March 17. (Occult v4.2022.11.10)

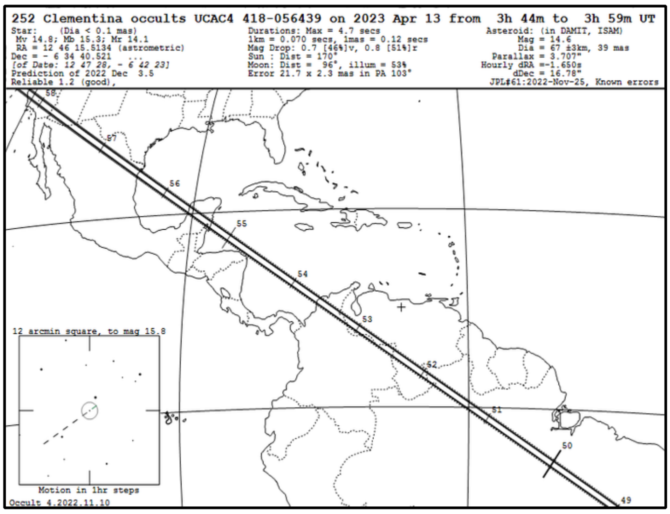

Figure 12. Path in USA, Mexico, South America on 2023 April 13. (Occult v4.2022.11.10)

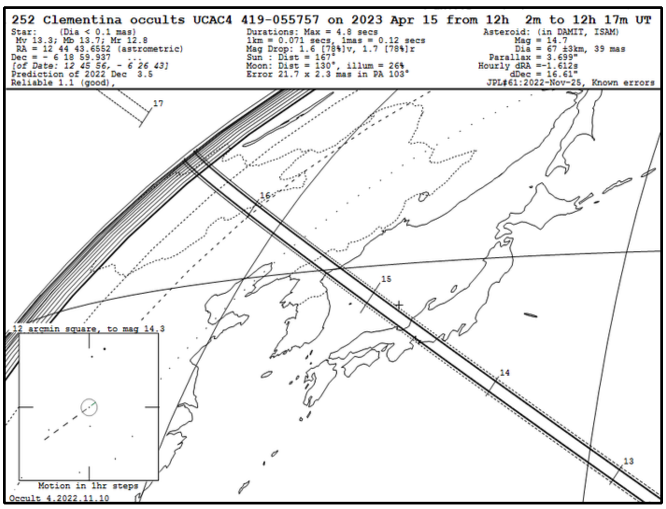

Figure 13. Path in China, Japan on 2023 April 15. (Occult v4.2022.11.10)

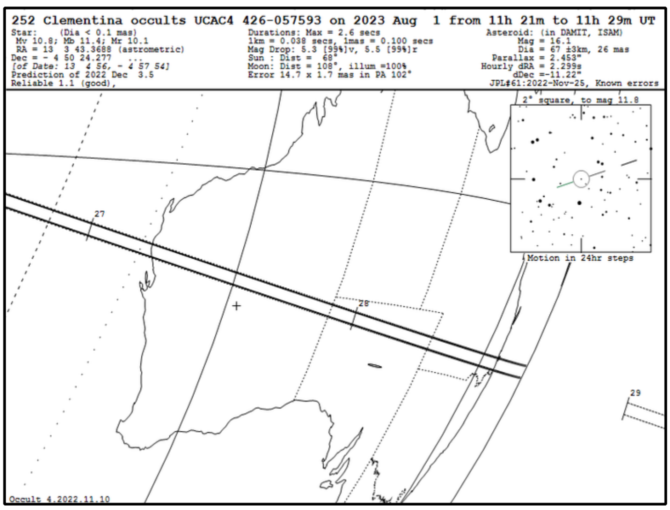

Figure 14. Path in Australia on 2023 August 1. (Occult v4.2022.11.10)

Acknowledgements

The author would like to thank Dr.-Ing. Christian Weber for reviewing this article and Konrad Guhl for valuable discussions. A special thanks goes to Eric Frappa for his patience and effort in analysis of this event and for checks and calculations of the double star hypothesis.

This work has made use of data from the European Space Agency (ESA) mission *Gaia* (https://www.cosmos.esa.int/gaia), processed by the *Gaia* Data Processing and Analysis Consortium (DPAC, https://www.cosmos.esa.int/web/gaia/dpac/consortium). Funding for the DPAC has been provided by national institutions, in particular the institutions participating in the *Gaia* Multilateral Agreement.

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30 Years Ago – Full Dedication to Observing Lunar Grazes

From *Occultation Newsletter* Vol. 6 No. 5:

- NEWS BREAK -
Astronomer Goes Belly Down!!

Yes, you read the heading correctly. On Saturday Evening January 30th, 1993, Nick Ruess, using his 3.5-inch Questar, optioned to place his *belly* down on the ground to observe the star graze of Z.C. 397! The Fahrenheit temperature was 32 degrees with a strong wind. But Nick says by observing close to the ground, he was very comfortable (covered with blankets of course) and had no tearing of the eyes during the critical moments of the graze. He also indicated this was the *second* time he's observed *belly down* to *look up*, and will use this method again if the need arises.

The next thing we'll probably see is a bumper sticker on Nick's car saying, "I DO IT BELLY DOWN!".

Other observers on the graze team were ASKC club members Rick Singmaster, Vic Winter, David Neuenschwander, and graze expedition leader, Bob Sandy.

- NEWS BREAK -
Astronomer Goes Belly Down Again!!

Yes, 3 days after the biggest snow storm in our area in quite a number of years, Marilyn Unruh, Mike Larkin, Bob Sandy, and Nick Reuss drove in a 2-car graze expedition Sunday, February 28th, to Milan, Missouri, successfully observing the moon's northern limb graze the star 39 TAURI, and for the 3rd time, Nick optioned to observe *belly down*! BUT this time lying on the large accumulation of "white stuff" on the edge of a farm road!! I guess Nick still hadn't cooled down from his timing 11 events during the graze in January!! But can you believe it? - on *this* graze *he* observed 9 disappearances and 9 reappearances of the star over a 2-minute time period using his small 3.5-inch Questar! These 18 timings set a record for "per one observer" during any past observing expeditions that the A.S.K.C. has been involved in dating clear back to 1964 (per Bob Sandy).

The old record was 14 events each seen by the late Russ Maag on September 26, 1978 and Larry McGill on September 12, 1979.

More exciting observations from the past – ***The Occultation Newsletter Heritage Project***
https://www.iota-es.de/on_heritage.html

Journal for
Occultation Astronomy

Grazing Occultations of Stars and Planets by the Moon in 2023

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ABSTRACT: The following maps and tables show this year's grazing occultations of the brightest stars and major planets by the Moon in those regions of the world where most of our observers live. The overall limiting magnitude is 5.0 except for some lunar eclipse events where it is 10.0.

Introduction

Nighttime events along the dark lunar limb are shown with a black line, whereas those events at night at the sunlit lunar limb are given in yellow. All daytime events appear in light blue. Events of stars or planets of 1.5 mag or brighter are highlighted with a bold line. Tick marks appear along the limit lines every full 10 minutes of time. The northern limb grazes show tick marks pointing downwards, whereas on the southern limb grazes they point upwards.

All tables and pictures in this article were created with the author's *GRAZPREP*-software. Further precise information on the local circumstances of all grazing occultations, also depending of the lunar terrain and the observer's elevation, is provided by this software which can be downloaded and installed via www.grazprep.com (password: IOTA/ES) including prediction files that are needed additionally for different regions of the world. *GRAZPREP* assists in finding and listing individually favorable occultation events and in figuring out the best observing site in advance or even under way by graphically showing the expected apparent stellar path through the lunar limb terrain. The fainter stars are calculated with their highly precise position of the *Gaia*-DR2-catalogue.

For all abbreviations in the tables and maps refer to the legend below.

Legend of Tables and Maps

Tables:

No. - Number of event corresponding the number labels on the map
M D - Month and day of the event referred to UT at the westernmost beginning of the graze limit line
USNO - Identifier in the XZ or ZC catalogue
SAOPPM - Identifier in the SAO or PPM catalogues
D - Double star code from the XZ80Q catalogue
MAG - Vmag of the star/double star system
%SNL - Percentage of sunlit lunar disc, +: waxing moon, -: waning moon, E: during lunar eclipse
L. - Limb of the Graze, N - northern limb, S - southern limb
W. UT - UT at the westernmost beginning of graze limit line
LONG LAT - Position of westernmost beginning of graze limit line
STAR NAME - Name(s) of star or planet
MAG1 MAG2 - Vmag of double star components

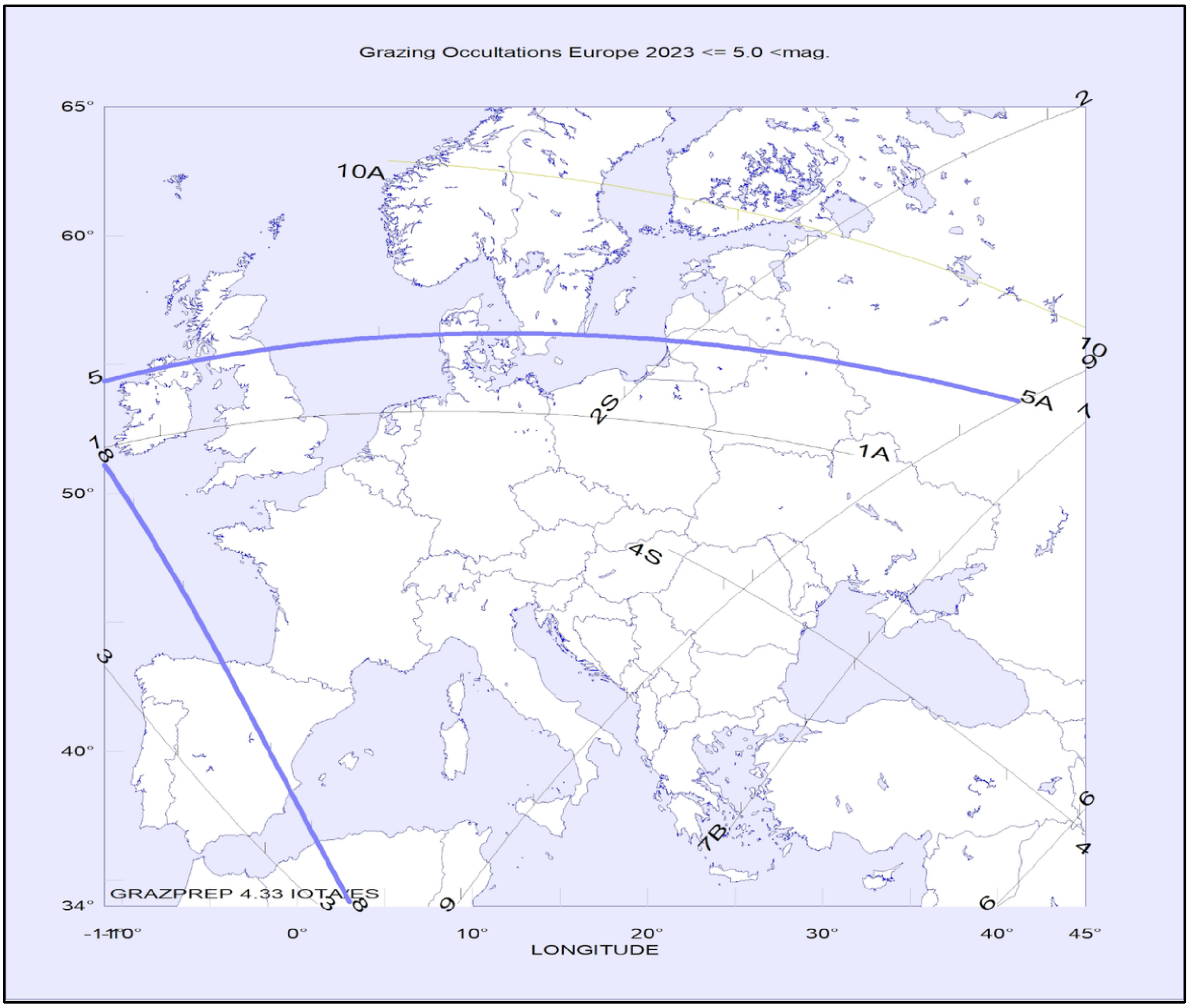
Lables on Maps:

Number - corresponding the number of the event in the table
Labels at end of graze limit lines:
A - limit line begins or ends due to altitude of moon/star
B - limit line begins or ends due to brightness of the lunar surface
S - limit line begins or ends due to bright sunlight/sky brightness
U - limit line begins or ends due to edge of umbra

Double Star Codes:

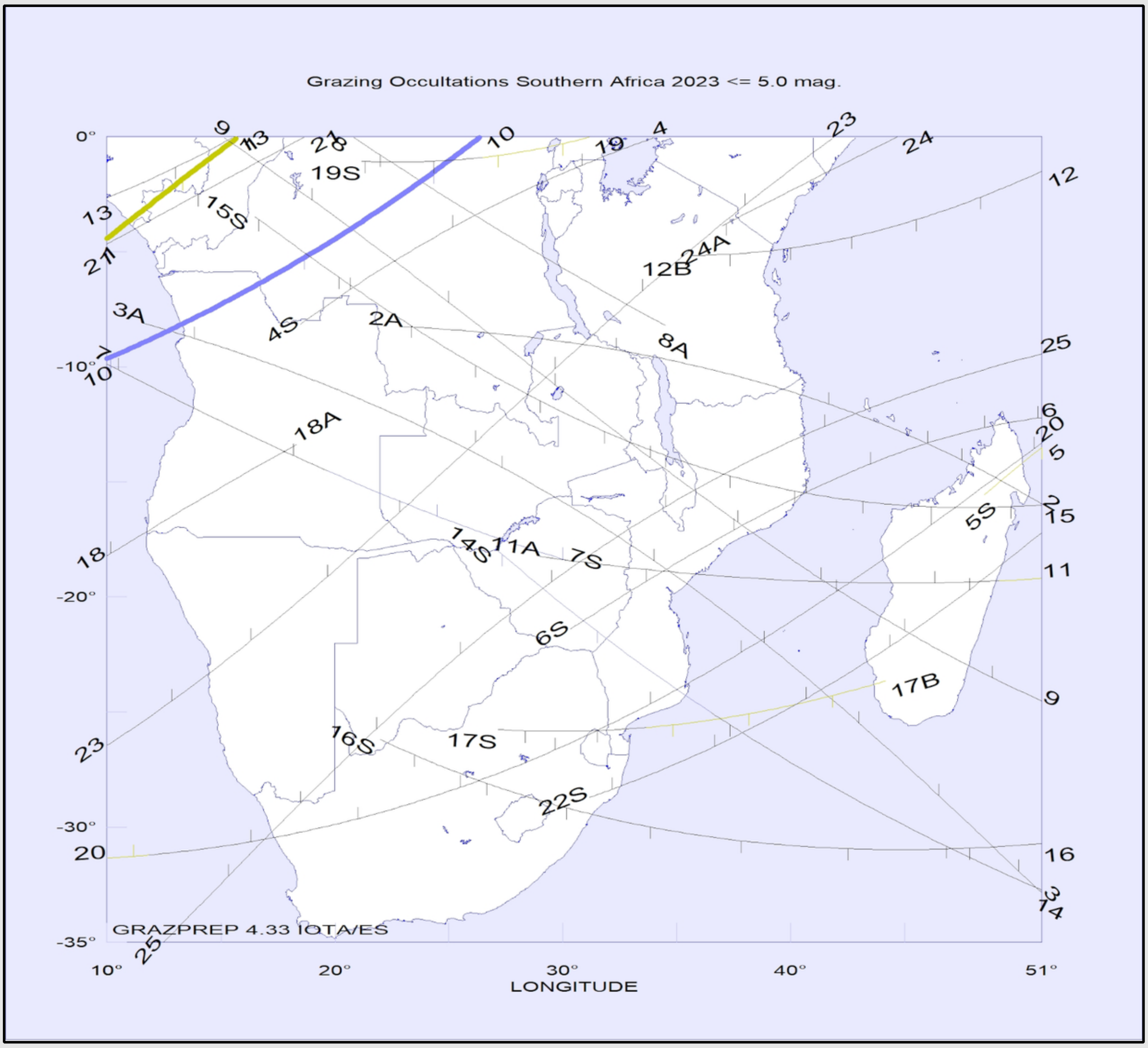
C - double, component in XZ80Q, Separation <1″
c - double, component not in XZ80Q, Separation <1″
D - double, component in XZ80Q, Separation <10″
d - double, component not in XZ80Q, Separation <10″
W - double, component in XZ80Q, Separation >10″
w - double, component not in XZ80Q, Separation >10″
M - multiple system, all components in XZ80Q
S - multiple system, some but not all in XZ80Q

Europe



2023				Grazing Occultations Europe 2023 <= 5.0 <mag.							GRAZPREP 4.33, IOTA/ES	
No.	**M D**	**USNO**	**SAOPPM D**	**MAG**	**%SNL**	**L.**	**W.UT**	**LONG**	**LAT**	**STAR NAME**	**MAG1**	**MAG2**
1	**Jan 27**	ZC 257	110110	4.3	41+	S	21 17.2	-11	52	Torcularis Septentrionalis omicron Piscium		
2	**Jan 30**	ZC 599	76430 S	4.4	70+	S	15 20.0	18	54	37 Tauri A Tauri		
3	**Apr 10**	ZC 2349	184336 L	2.9	83 -	S	2 53.1	-11	43	Al Niyat sigma Scorpii	3.3	5.3
4	**Apr 24**	ZC 890	77675 V	4.6	21+	N	17 35.9	21	48	136 Tauri NSV 02696	4.8	6.3
5	**May 17**			-2.1	5 -	S	13 47.4	-11	54	Jupiter		
6	**Sep 24**	ZC 2912	188742	4.5	71+	S	17 41.6	40	34	Terebellum 59 Sagittarii		
7	**Oct 28**	ZC 319	92812	7.7	100 E	S	19 38.4	24	37			
8	**Nov 09**			-3.9	15 -	S	10 5.1	-11	51	Venus		
9	**Nov 21**	ZC 3419	146598 A	4.2	65+	S	19 9.7	9	34	psi 1 Aquarii	4.5	8.5
10	**Dec 07**	ZC 1772	138721 Q	3.9	32 -	N	1 28.3	5	63	Zaniah eta Virginis	4.6	5.9

Southern Africa



2023			Grazing Occultations Southern Africa 2023 <= 5.0 mag.							GRAZPREP 4.33, IOTA/ES		
No.	M D	USNO	SAOPPM D	MAG	%SNL	L.	W.UT	LONG	LAT	STAR NAME	MAG1	MAG2
1	Jan 03			-1.1	91+	N	19 0.8	10	-4	Mars		
2	Jan 13	ZC 1821	138917 O	2.8	61 -	S	21 45.9	23	-8	Porrima gamma Virginis	3.5	3.5
3	Jan 15	ZC 2053	158489 U	4.5	39 -	S	23 59.4	11	-8	lambda Virginis NSV 06621	4.9	6.3
4	Jan 25	ZC 3526	147008 A	4.9	20+	S	17 14.5	18	-8	27 Piscium	5.1	10.4
5	Jan 29	ZC 465	93328	4.3	61+	N	15 21.7	48	-16	Botein delta Arietis		
6	Feb 01	ZC 890	77675 V	4.6	87+	S	16 42.9	30	-21	136 Tauri NSV 02696	4.8	6.3
7	Feb 17	ZC 2784	187683 V	3.3	13 -	S	4 29.6	10	-10	tau Sagittarii	4.2	4.2

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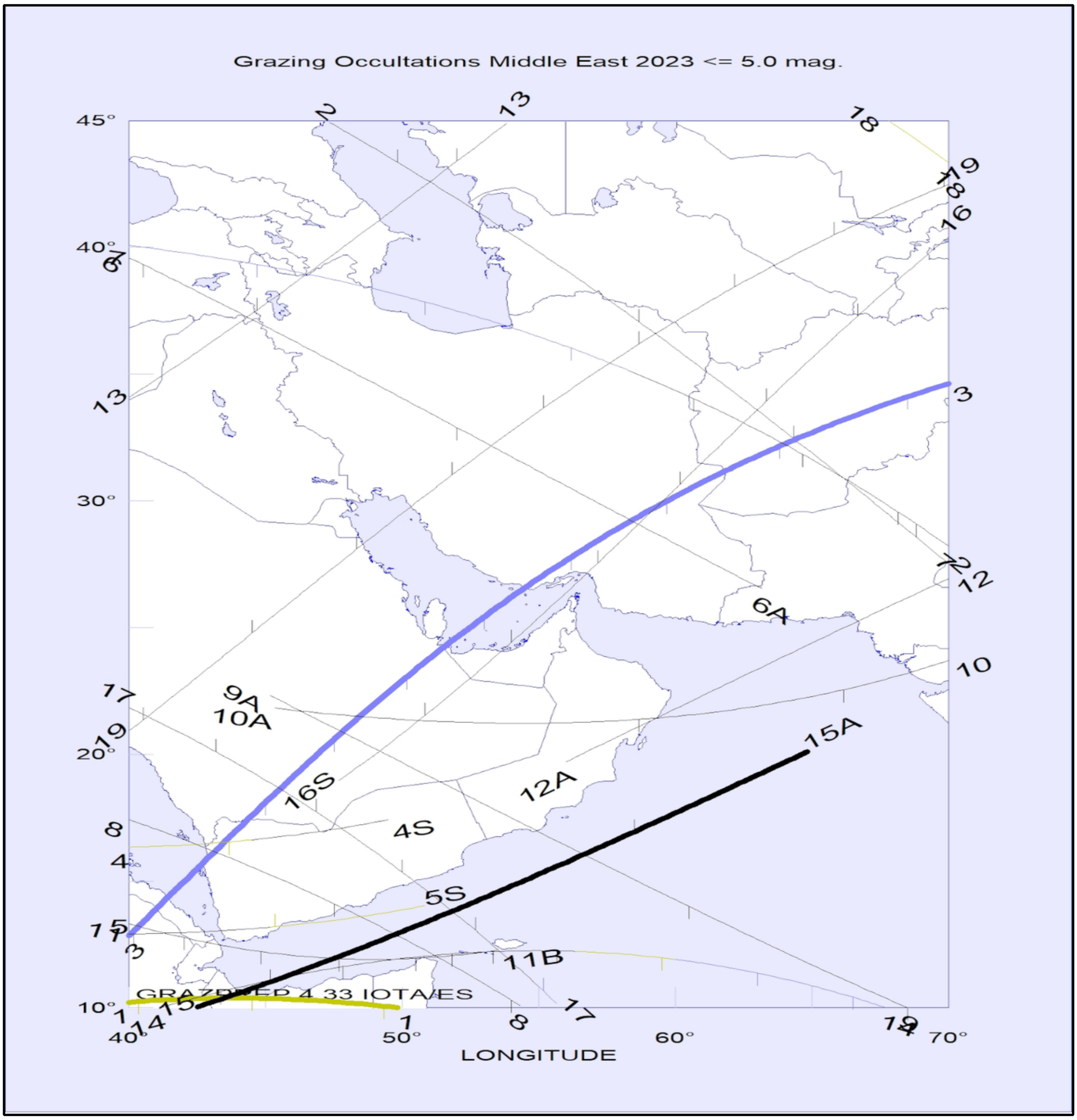
2023			Grazing Occultations Southern Africa 2023 <= 5.0 mag.							GRAZPREP 4.33, IOTA/ES		
No.	M D	USNO	SAOPPM D	MAG	%SNL	L.	W.UT	LONG	LAT	STAR NAME	MAG1	MAG2
7	Feb 17	ZC 2784	187683 V	3.3	13 -	S	4 29.6	10	-10	tau Sagittarii	4.2	4.2
8	Mar 02	ZC 1149	79533 w	4.1	82+	N	23 59.0	20	0	upsilon Geminorum NSV 03652		
9	Mar 13	ZC 2371	184429	4.8	61 -	S	23 55.1	15	0	22 Scorpii NSV 20658		
10	Mar 24			-3.5	10+	N	8 50.6	10	-10	Venus		
11	Apr 17	ZC 3425	146620 K	4.4	11 -	S	1 45.4	29	-18	psi 2 Aquarii	5.4	5.4
12	May 10	ZC 2784	187683 V	3.3	78 -	N	0 54.5	35	-5	tau Sagittarii	4.2	4.2
13	May 15	ZC 3526	147008 A	4.9	21 -	N	4 23.7	10	-3	27 Piscium	5.1	10.4
14	Jul 20	ZC 1484	98955 C	3.5	7+	N	14 40.5	27	-18	eta Leonis NSV 04738	4.1	4.6
15	Jul 28	ZC 2371	184429	4.8	79+	N	16 59.7	16	-3	22 Scorpii NSV 20658		
16	Aug 23	ZC 2172	159090 Z	4.5	43+	N	16 15.0	22	-26	iota Librae NSV 06981	5.0	6.2
17	Sep 22	ZC 2554	185755 V	4.5	49+	N	16 6.4	27	-26	X Sagittarii	5.2	5.2
18	Sep 24	ZC 2784	187683 V	3.3	62+	S	0 0.6	10	-18	tau Sagittarii	4.2	4.2
19	Sep 24	ZC 2910	188722 K	4.7	71+	N	16 30.3	21	-1	Terebellum omega Sagittarii	5.6	5.6
20	Sep 24	ZC 2914	188778 V	4.8	72+	S	17 47.8	10	-31	Terebellum 60 Sagittarii	5.8	5.8
21	Oct 07	ZC 1122	79374 K	3.8	44 -	N	0 28.4	10	-5	iota Geminorum	4.7	4.7
22	Oct 23	ZC 3164	164520 U	4.5	68+	S	16 8.2	31	-29	epsilon Capricorni	5.0	6.3
23	Oct 23	ZC 3175	164593	4.7	69+	S	19 2.4	10	-26	kappa Capricorni		
24	Nov 03	ZC 1189	79774 c	5.0	63 -	N	21 0.3	37	-4	phi Geminorum		
25	Nov 21	ZC 3421	146612 c	4.9	66+	S	20 1.5	12	-35	chi Aquarii	4.9	5.1

Middle East

2023			Grazing Occultations Middle East 2023 <= 5.0 mag.							GRAZPREP 4.33, IOTA/ES		
No.	M D	USNO	SAOPPM D	MAG	%SNL	L.	W.UT	LONG	LAT	STAR NAME	MAG1	MAG2
1	Jan 03			-1.1	91+	N	20 29.5	40	10	Mars		
2	Jan 17	ZC 2172	159090 Z	4.5	29 -	S	1 28.2	47	45	iota Librae NSV 06981	5.0	6.2
3	Mar 24			-3.5	10+	N	9 59.6	40	13	Venus		
4	Apr 17	ZC 3425	146620 K	4.4	11 -	N	2 16.2	40	16	psi 2 Aquarii	5.4	5.4
5	Apr 17	ZC 3428	146635 A	5.0	11 -	S	2 16.2	40	13	psi 3 Aquarii NSV 14491	5.2	11.2
6	Apr 24	ZC 890	77675 V	4.6	21+	N	17 59.6	40	40	136 Tauri NSV 02696	4.8	6.3
7	Apr 29	ZC 1484	98955 C	3.5	67+	N	14 13.8	40	40	eta Leonis NSV 04738	4.1	4.6
8	May 03	ZC 1891	139189 T	4.4	96+	N	15 42.4	40	17	Apami-Atsa theta Virginis	4.5	6.8
9	Jul 03	ZC 2784	187683 V	3.3	100 -	N	16 22.7	45	22	tau Sagittarii	4.2	4.2
10	Jul 07	ZC 3419	146598 A	4.2	73 -	N	19 41.7	45	22	psi 1 Aquarii	4.5	8.5
11	Aug 26	ZC 2617	186328 K	4.5	75+	N	16 13.7	40	13		5.1	5.9
12	Sep 09	ZC 1149	79533 w	4.1	21 -	N	22 11.3	56	20	upsilon Geminorum NSV 03652		
13	Sep 24	ZC 2912	188742	4.5	71+	S	17 41.6	40	34	Terebellum 59 Sagittarii		
14	Oct 07	ZC 1122	79374 K	3.8	44 -	N	1 5.5	41	10	iota Geminorum	4.7	4.7
15	Oct 18	ZC 2366	184415 O	1.1	15+	S	15 16.9	42	10	Antares alpha Scorpii	1.2	5.5
16	Nov 22	ZC 3526	147008 A	4.9	75+	S	14 11.7	47	19	27 Piscium	5.1	10.4
17	Dec 07	ZC 1772	138721 Q	3.9	32 -	S	1 42.8	40	22	Zaniah eta Virginis	4.6	5.9
18	Dec 07	ZC 1772	138721 Q	3.9	32 -	N	2 1.3	68	45	Zaniah eta Virginis	4.6	5.9
19	Dec 23	ZC 465	93328	4.3	89+	S	15 9.2	40	21	Botein delta Arietis		



India

2023			Grazing Occultations India 2023 <= 5.0 mag.							GRAZPREP 4.33, IOTA/ES		
No.	M D	USNO	SAOPPM D	MAG	%SNL	L.	W.UT	LONG	LAT	STAR NAME	MAG1	MAG2
1	Jan 13	ZC 1821	138917 O	2.8	61 -	N	21 48.9	67	16	Porrima gamma Virginis	3.5	3.5
2	Jan 17	ZC 2172	159090 Z	4.5	29 -	S	1 55.8	67	30	iota Librae NSV 06981	5.0	6.2
3	Feb 01	ZC 890	77675 V	4.6	87+	N	19 4.6	78	16	136 Tauri NSV 02696	4.8	6.3
4	Mar 24			-3.5	10+	N	11 27.2	67	34	Venus		
5	Apr 26	ZC 1149	79533 w	4.1	38+	N	14 7.9	67	35	upsilon Geminorum NSV 03652		
6	Apr 29	ZC 1484	98955 C	3.5	67+	N	15 6.7	67	30	eta Leonis NSV 04738	4.1	4.6

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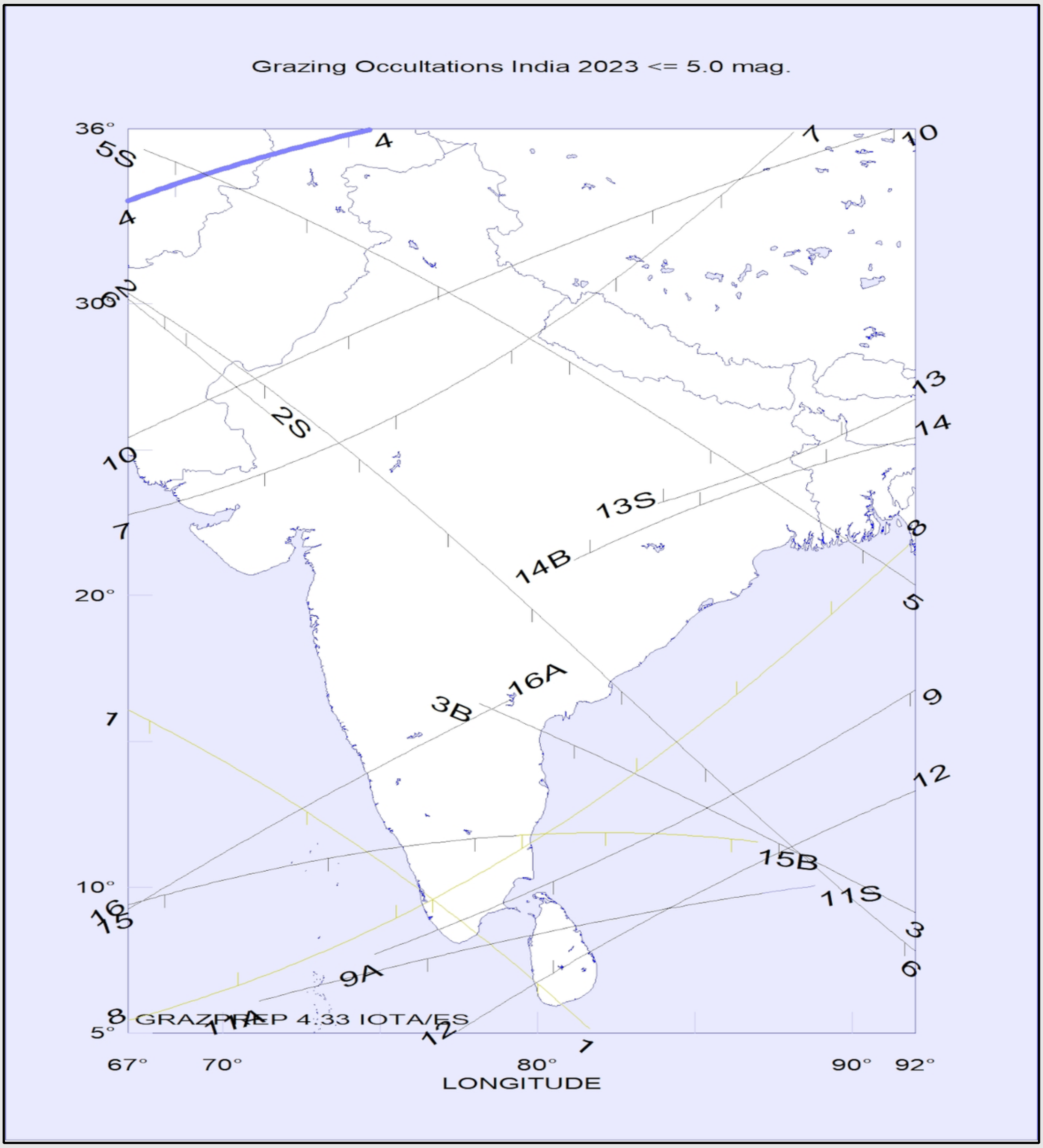
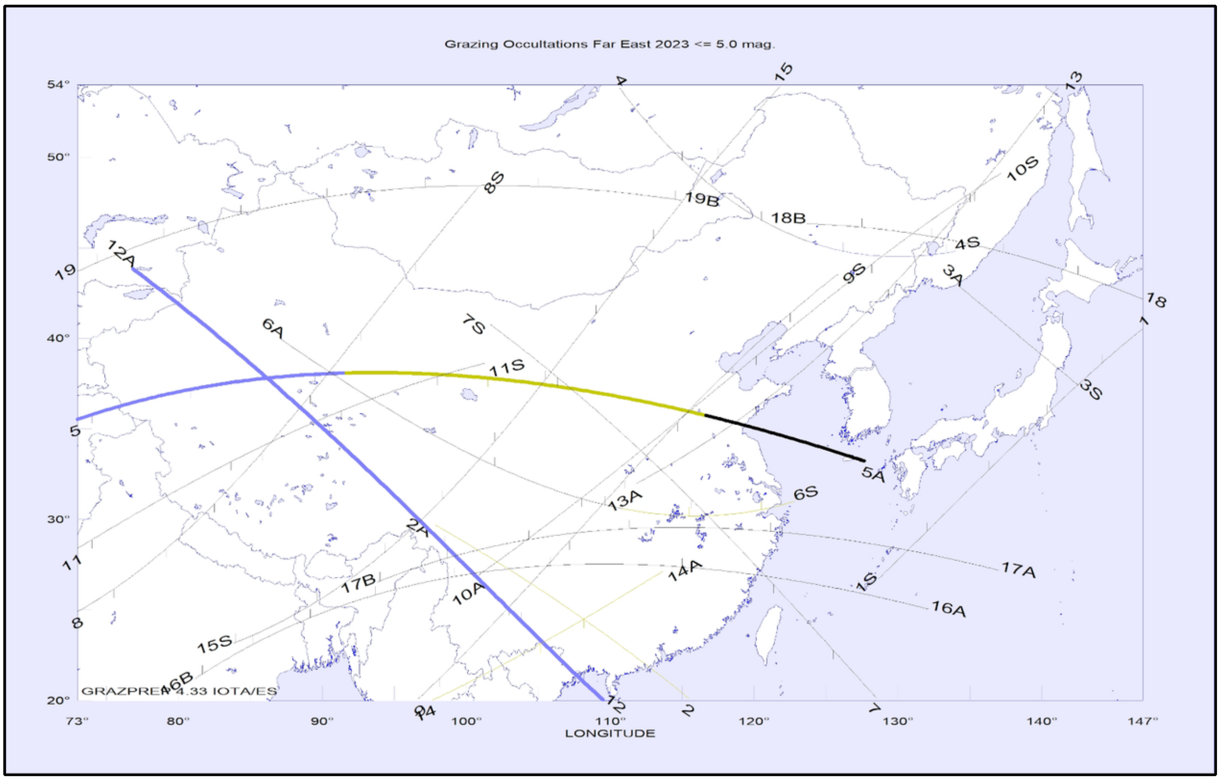
2023 — **Grazing Occultations India 2023 <= 5.0 mag.** — GRAZPREP 4.33, IOTA/ES

No.	M D	USNO	SAOPPM D	MAG	%SNL	L.	W.UT	LONG LAT		STAR NAME	MAG1	MAG2
7	Jul 07	ZC 3419	146598 A	4.2	73 -	N	20 1.7	67	23	psi 1 Aquarii	4.5	8.5
8	Jul 07	ZC 3425	146620 K	4.4	73 -	S	20 24.3	67	5	psi 2 Aquarii	5.4	5.4
9	Aug 08	ZC 465	93328	4.3	45 -	N	19 8.0	74	8	Botein delta Arietis		
10	Sep 09	ZC 1149	79533 w	4.1	21 -	N	22 15.1	67	25	upsilon Geminorum NSV 03652		
11	Sep 12	ZC 1484	98955 C	3.5	4 -	N	23 59.5	71	6	eta Leonis NSV 04738	4.1	4.6
12	Oct 23	ZC 3164	164520 U	4.5	68+	S	18 6.2	77	5	epsilon Capricorni	5.0	6.3
13	Oct 25	ZC 3425	146620 K	4.4	86+	S	11 50.3	84	23	psi 2 Aquarii	5.4	5.4
14	Oct 28	X 2909	92795	7.2	100 E	S	19 39.0	81	21			
15	Nov 03	ZC 1189	79774 c	5.0	63 -	N	21 27.9	67	9	phi Geminorum		
16	Dec 15	ZC 2914	188778 V	4.8	9+	S	14 11.1	67	9	Terebellum 60 Sagittarii	5.8	5.8

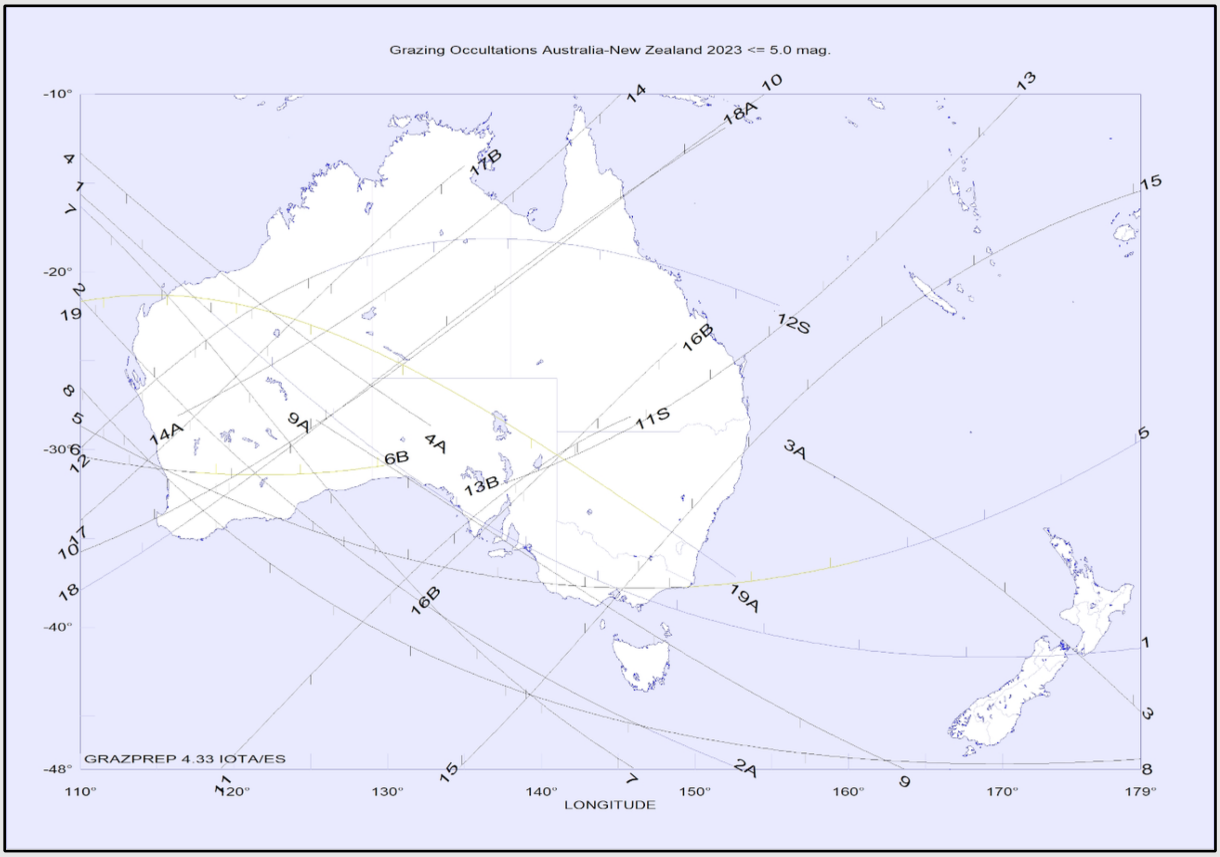


Far East



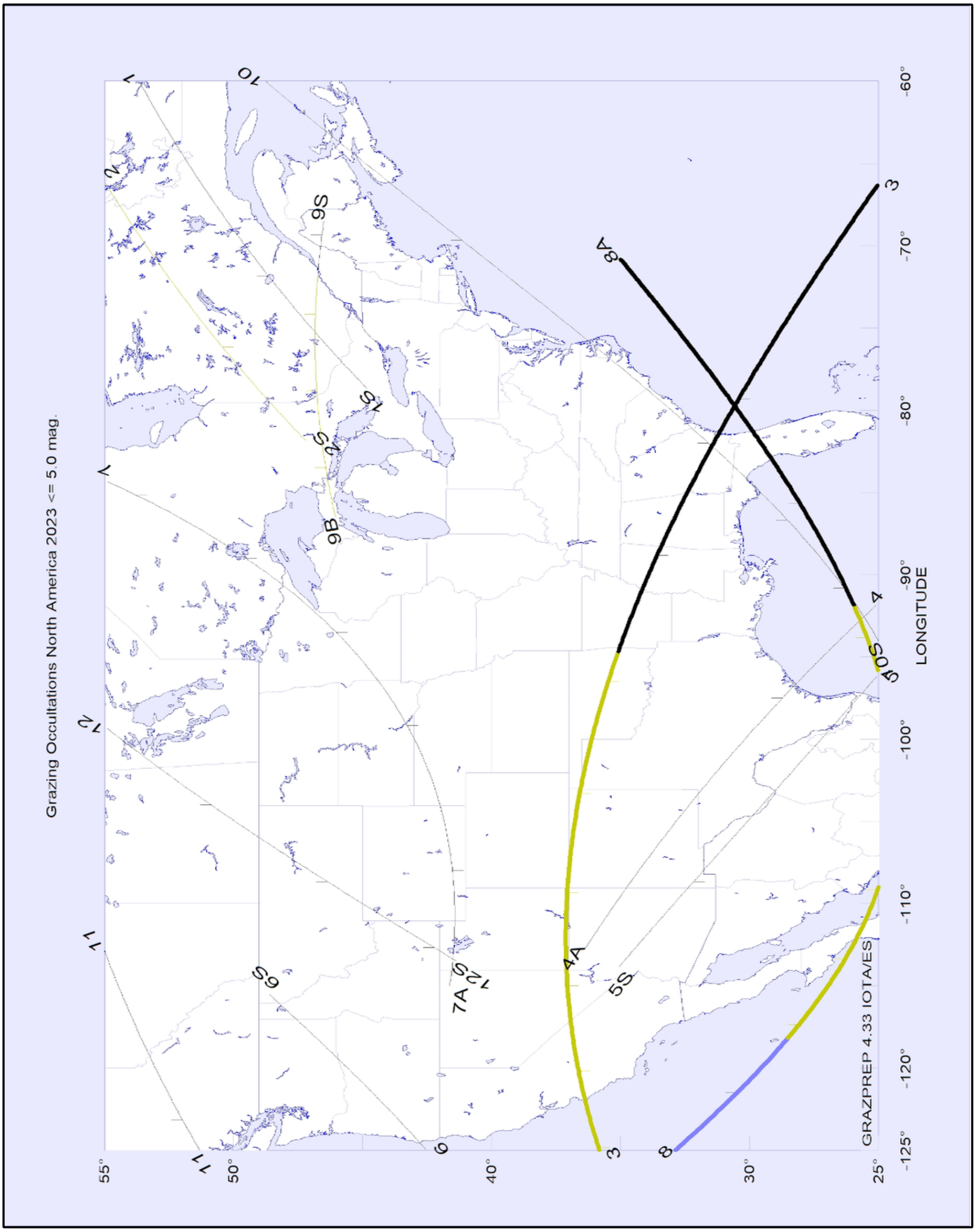
2023	Grazing Occultations Far East 2023 <= 5.0 mag.									GRAZPREP 4.33, IOTA/ES		
No.	**M D**	**USNO**	**SAOPPM D**	**MAG**	**%SNL**	**L.**	**W.UT**	**LONG**	**LAT**	**STAR NAME**	**MAG1**	**MAG2**
1	Jan 03	ZC 599	76430 S	4.4	89+	S	8 43.5	128	27	37 Tauri A Tauri		
2	Jan 17	ZC 2290	184014 L	2.3	21 -	N	20 48.4	98	30	Dschubba delta Scorpii	3.0	5.0
3	Jan 19	ZC 2617	186328 K	4.5	6 -	S	21 42.3	134	43		5.1	5.9
4	Mar 13	ZC 2349	184336 L	2.9	62 -	S	21 42.9	110	54	Al Niyat sigma Scorpii	3.3	5.3
5	Mar 24			-3.5	10+	N	11 38.3	73	36	Venus		
6	May 10	ZC 2912	188742	4.5	70 -	S	19 1.2	87	40	Terebellum 59 Sagittarii		
7	Jun 02	ZC 2172	159090 Z	4.5	97+	N	12 37.2	101	41	iota Librae NSV 06981	5.0	6.2
8	Jul 07	ZC 3419	146598 A	4.2	73 -	N	20 14.0	73	25	psi 1 Aquarii	4.5	8.5
9	Aug 08	ZC 465	93328	4.3	45 -	N	19 27.5	96	20	Botein delta Arietis		
10	Aug 11	ZC 890	77675 V	4.6	18 -	N	19 7.5	100	27	136 Tauri NSV 02696	4.8	6.3
11	Sep 09	ZC 1149	79533 w	4.1	21 -	N	22 19.2	73	28	upsilon Geminorum NSV 03652		
12	Sep 21	ZC 2366	184415 O	1.1	35+	S	7 33.0	76	44	Antares alpha Scorpii	1.2	5.5
13	Oct 02	ZC 465	93328	4.3	87 -	N	12 26.1	112	32	Botein delta Arietis		
14	Oct 18	ZC 2349	184336 L	2.9	14+	N	11 43.0	97	20	Al Niyat sigma Scorpii	3.3	5.3
15	Oct 25	ZC 3425	146620 K	4.4	86+	S	11 50.3	84	23	psi 2 Aquarii	5.4	5.4
16	Oct 28	X 2909	92795	7.2	100 E	S	19 39.0	81	21			
17	Oct 28	X 2897	92789	7.9	100 E	S	19 40.0	94	27			
18	Nov 01	ZC 890	77675 V	4.6	82 -	S	19 32.3	123	46	136 Tauri NSV 02696	4.8	6.3
19	Dec 23	ZC 465	93328	4.3	89+	S	16 37.4	73	44	Botein delta Arietis		

Australia & New Zealand



2023			Grazing Occultations Australia-New Zealand 2023 <= 5.0 mag.							GRAZPREP 4.33, IOTA/ES	
No.	**M D**	**USNO**	**SAOPPM D**	**MAG**	**%SNL**	**L.**	**W.UT**	**LONG LAT**	**STAR NAME**	**MAG1**	**MAG2**
1	**Jan 17**	ZC 2290	184014 L	2.3	21 -	S	21 21.8	110 -16	Dschubba delta Scorpii	3.0	5.0
2	**Feb 06**	ZC 1484	98955 C	3.5	99 -	S	18 37.2	110 -21	eta Leonis NSV 04738	4.1	4.6
3	**Mar 13**	ZC 2290	184014 L	2.3	68 -	S	11 23.3	157 -31	Dschubba delta Scorpii	3.0	5.0
4	**Mar 30**	ZC 1189	79774 c	5.0	65+	N	14 44.7	110 -13	phi Geminorum		
5	**Apr 12**	ZC 2784	187683 V	3.3	56 -	S	18 18.1	110 -29	tau Sagittarii	4.2	4.2
6	**May 10**	ZC 2910	188722 K	4.7	70 -	S	18 45.0	110 -30	Terebellum omega Sagittarii	5.6	5.6
7	**May 30**	ZC 1821	138917 O	2.8	77+	N	10 4.5	110 -16	Porrima gamma Virginis	3.5	3.5
8	**Jun 27**	ZC 1891	139189 T	4.4	62+	N	11 10.0	110 -27	Apami-Atsa theta Virginis	4.5	6.8
9	**Jul 03**	ZC 2721	187239 X	3.2	100+	N	8 48.9	125 -28	phi Sagittarii	4.1	4.1
10	**Aug 27**	ZC 2784	187683 V	3.3	83+	S	14 50.8	110 -36	tau Sagittarii	4.2	4.2
11	**Sep 05**	ZC 545	76172	4.1	61 -	N	19 31.7	119 -48	Merope 23 Tauri		
12	**Sep 05**	ZC 560	76228 U	3.6	60 -	N	20 59.8	110 -30	Atlas 27 Tauri	4.1	5.6
13	**Sep 26**	ZC 3175	164593	4.7	88+	S	10 40.8	137 -32	kappa Capricorni		
14	**Oct 02**	ZC 472	75810 K	4.9	86 -	N	13 53.0	116 -28	zeta Arietis	5.8	5.8
15	**Oct 25**	ZC 3421	146612 c	4.9	86+	S	12 60.0	134 -48	chi Aquarii	4.9	5.1
16	**Oct 30**	ZC 545	76172	4.1	96 -	N	14 20.9	132 -37	Merope 23 Tauri		
17	**Oct 30**	ZC 560	76228 U	3.6	96 -	N	15 20.0	110 -34	Atlas 27 Tauri	4.1	5.6
18	**Nov 17**	ZC 2784	187683 V	3.3	19+	S	10 42.9	110 -38	tau Sagittarii	4.2	4.2
19	**Nov 28**	ZC 810	77168 Y	1.6	98 -	N	17 56.4	110 -22	El Nath beta Tauri	2.6	2.6

North America



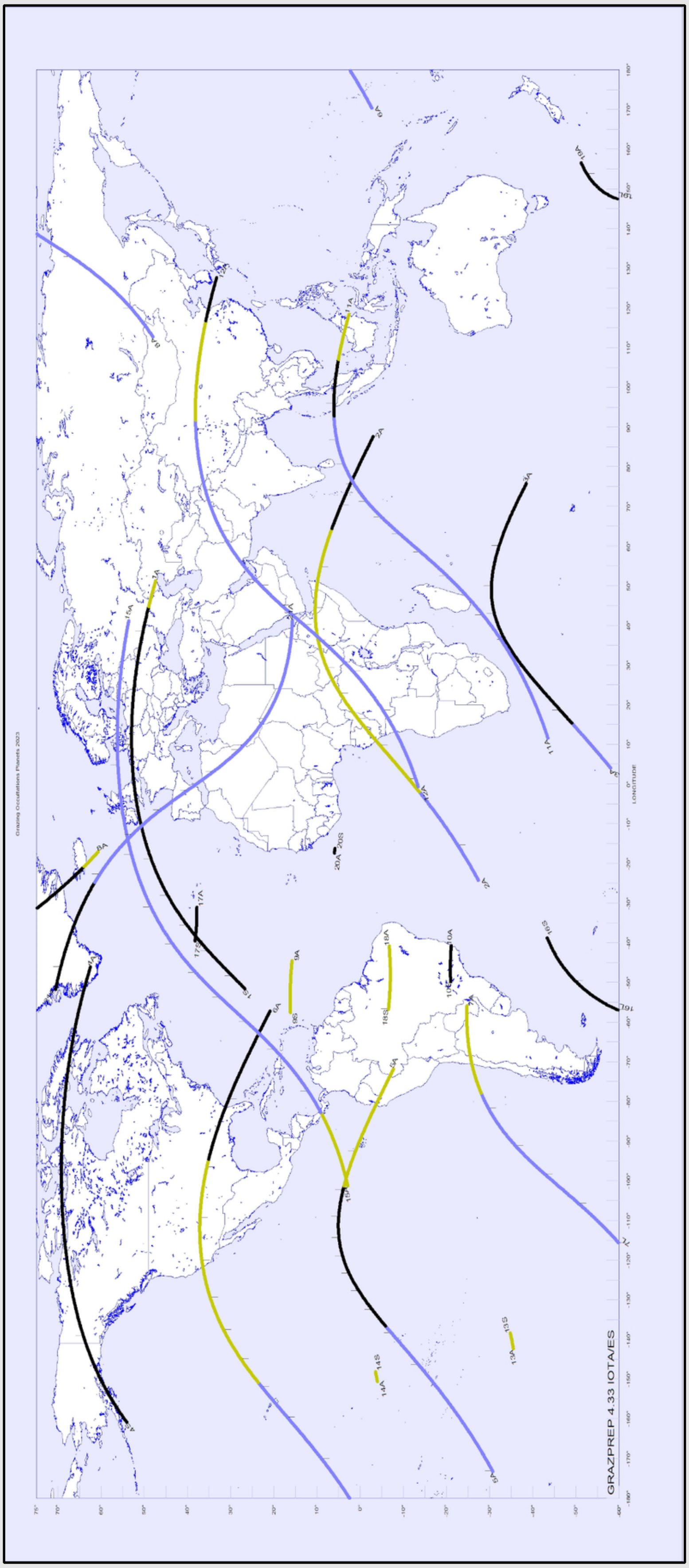
2023 — Grazing Occultations North America 2023 <= 5.0 mag. — GRAZPREP 4.33, IOTA/ES

No.	M D	USNO	SAOPPM D	MAG	%SNL	L.	W.UT	LONG LAT	STAR NAME	MAG1	MAG2
1	Jan 24	ZC 3428	146635 A	5.0	13+	S	22 12.6	-78 45	psi 3 Aquarii NSV 14491	5.2	11.2
2	Jan 24	ZC 3425	146620 K	4.4	13+	N	22 15.3	-82 47	psi 2 Aquarii	5.4	5.4
3	Jan 31			-0.3	74+	N	4 50.0	-125 36	Mars		
4	Feb 13	ZC 2172	159090 Z	4.5	54 -	S	8 32.0	-112 36	iota Librae NSV 06981	5.0	6.2
5	May 22	ZC 890	77675 V	4.6	6+	N	2 35.4	-114 35	136 Tauri NSV 02696	4.8	6.3
6	Jun 05	ZC 2617	186328 K	4.5	98 -	N	11 41.2	-125 43		5.1	5.9
7	Aug 04	ZC 3419	146598 A	4.2	91 -	N	4 56.4	-115 42	psi 1 Aquarii	4.5	8.5
8	Aug 25	ZC 2366	184415 O	1.1	57+	S	2 2.4	-125 33	Antares alpha Scorpii	1.2	5.5
9	Oct 05	ZC 890	77675 V	4.6	62 -	S	10 3.7	-86 46	136 Tauri NSV 02696	4.8	6.3
10	Oct 21	ZC 2912	188742	4.5	48+	S	23 42.5	-94 25	Terebellum 59 Sagittarii		
11	Oct 26	ZC 3526	147008 A	4.9	91+	S	8 48.7	-125 51	27 Piscium	5.1	10.4
12	Dec 19	ZC 3419	146598 A	4.2	40+	S	0 7.8	-113 41	psi 1 Aquarii	4.5	8.5

Planets Worldwide

2023 — Grazing Occultations Planets 2023 — GRAZPREP 4.33, IOTA/ES

No.	M D	MAG	%SNL	L.	W.UT	LONG LAT	STAR NAME
1	Jan 01	5.7	78+	S	20 50.7	-51 27	Uranus
2	Jan 03	-1.1	91+	N	18 16.6	-24 -27	Mars
3	Jan 03	-1.1	91+	S	18 52.1	4 -58	Mars
4	Jan 29	5.7	55+	S	3 24.9	-160 54	Uranus
5	Jan 31	-0.3	74+	S	2 40.1	-173 -31	Mars
6	Jan 31	-0.3	74+	N	2 45.0	170 -3	Mars
7	Feb 22	-2.1	10+	N	22 20.0	-115 -60	Jupiter
8	Feb 28	0.4	58+	S	3 17.2	112 48	Mars
9	Mar 22	-2.0	2+	N	21 57.3	-57 16	Jupiter
10	Mar 22	-2.0	2+	S	21 24.5	-50 -21	Jupiter
11	Mar 24	-3.5	10+	S	8 44.3	11 -44	Venus
12	Mar 24	-3.5	10+	N	8 45.5	0 -13	Venus
13	Apr 19	-2.0	0 -	S	15 42.5	-142 -36	Jupiter
14	Apr 19	-2.0	0 -	N	15 52.8	-150 -4	Jupiter
15	May 17	-2.1	5 -	S	11 6.2	-101 3	Jupiter
16	Sep 01	7.8	98 -	N	8 19.5	-57 -60	Neptune
17	Sep 16	1.7	3+	N	20 40.2	-39 38	Mars
18	Sep 16	1.7	3+	S	21 40.2	-56 -7	Mars
19	Sep 28	7.8	99+	N	18 6.8	147 -60	Neptune
20	Oct 14	-1.4	0 -	N	6 52.5	-17 6	Mercury
21	Nov 09	-3.9	15 -	S	9 17.6	-52 71	Venus


GRAZPREP 4.33 IOTA/ES

The Stellar Occultation Data Input System

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ABSTRACT: End of July 2022 the founder and manager of euraster.net, Eric Frappa, informed the European community of occultation observers about the end of his service by 2022 December 31. So Eric Frappa will take care for all observations made until end of 2022 and send the reductions in the common way. IOTA/ES will take care of the data collection in a new portal named SODIS in 2023.

Introduction

euraster.net collected observations of occultations by minor planets since 1996 for European observers [1]. All observation reports were carefully reviewed and their results published on an event-by-event basis. At the same time, the reductions were shared with the global networks. For this tireless work, Eric Frappa was awarded the *Homer F. DaBoll Award* by IOTA in 2017 [2]. We would like to take this opportunity to thank Eric once again.

The Database

Service for Unregistered Users

IOTA/ES starts SODIS (Stellar Occultation Data Input System) as a system to collect the observation results of the European observers. In the web based system SODIS, observers can collect and report all observations, also the negative results. During the development of SODIS it had to be considered that data collection, reviewing and reporting have the highest priority. Other functions, like comparisation chords versus modelation of minor planets will be possible, but have not yet been realised.

Unregistered users can see all observations collected in the system of SODIS [3]. You can reach this sub-domain via the webpage of IOTA/ES [4]. In this window the user can see all observations in the database. On the upper part (Figure 1) users see some statistic and can search for different criteria (star, planet, observer, country etc.). The search area is the top part of the start screen, the database is visible after a scroll down (Figure 2).

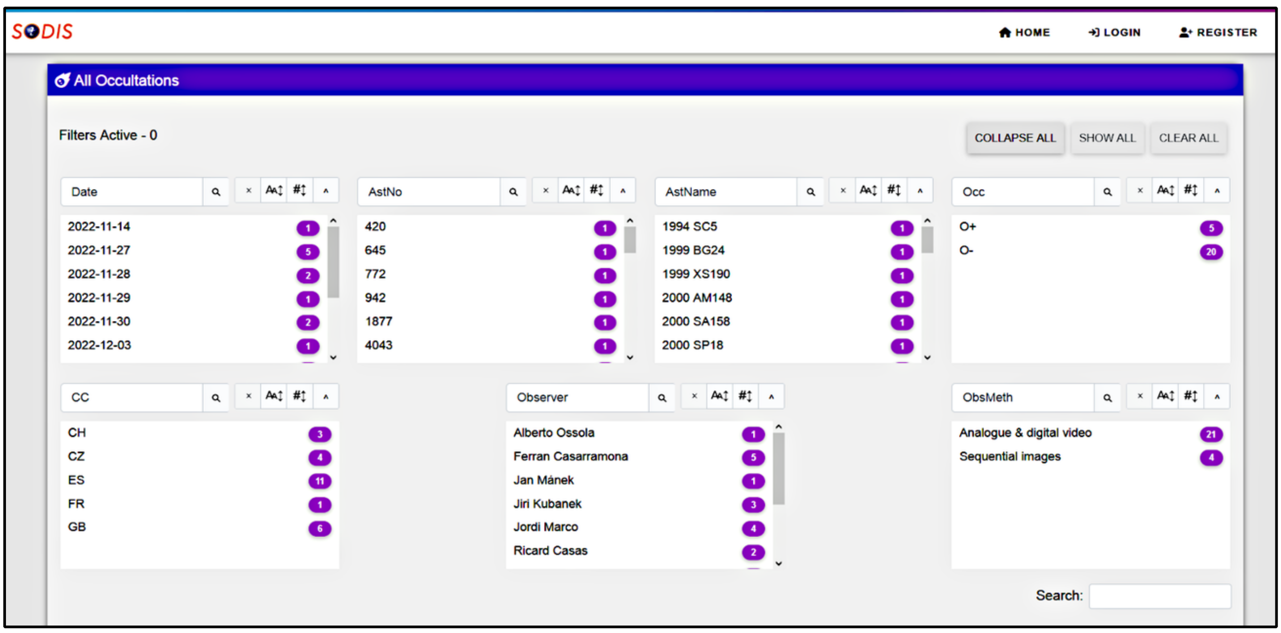


Figure 1. Upper part of the home screen. The database collects all reports and is an archive for all observations made in Europe.

SODIS — HOME — LOGIN — REGISTER

Search:

ID	Date	Predicttime	AstNo	AstName	Occ	Duration	CC	Observer	ObsMeth	Review Status
132	2022-12-06	2022-12-06, 22:39:06	942	Romilda	O-		CH	Alberto Ossola	Analogue & digital video	⌛
131	2022-12-07	2022-12-07, 22:01:21	392224	2009 US106	O-		GB	Tim Haymes	Analogue & digital video	⌛
130	2022-12-06	2022-12-06, 23:30:45	135547	2002 EN14	O-		GB	Tim Haymes	Analogue & digital video	⌛
128	2022-12-06	2022-12-06, 22:30:10	103416	2000 AM148	O-		GB	Tim Haymes	Analogue & digital video	⌛
127	2022-12-06	2022-12-06, 20:12:58	196103	2002 TX133	O-		ES	Ferran Casarramona	Analogue & digital video	✓
126	2022-12-05	2022-12-05, 22:04:00	1877	Marsden	O+	2.5	GB	Simon Kidd	Analogue & digital video	⌛
124	2022-12-05	2022-12-05, 23:28:04	24290	1999 XS190	O+	1.87	GB	Simon Kidd	Analogue & digital video	✓

Figure 2. Lower part of the home screen. The entries in the database are visible for unregisterd observers.

The Database

Service for Registered Users

After a one-time registration, observers can fill or upload their observation results. A registration is prefered to minimise the workload of the SODIS team. Occasional observers, who rarely observe stellar occultations, can send their observation data to sodis@iota-es.de. The SODIS team will take care for these observations.

Together with the reporting form, observers can submitt some data for the reviewing process. Figure 4 gives an overview which data are requested. The full set of data is requested for a positive observation only. In case of reporting a negative observation the event file with the path map and the light curve are sufficient. For visual observations the personal equation must be reported instead of a lightcurve.

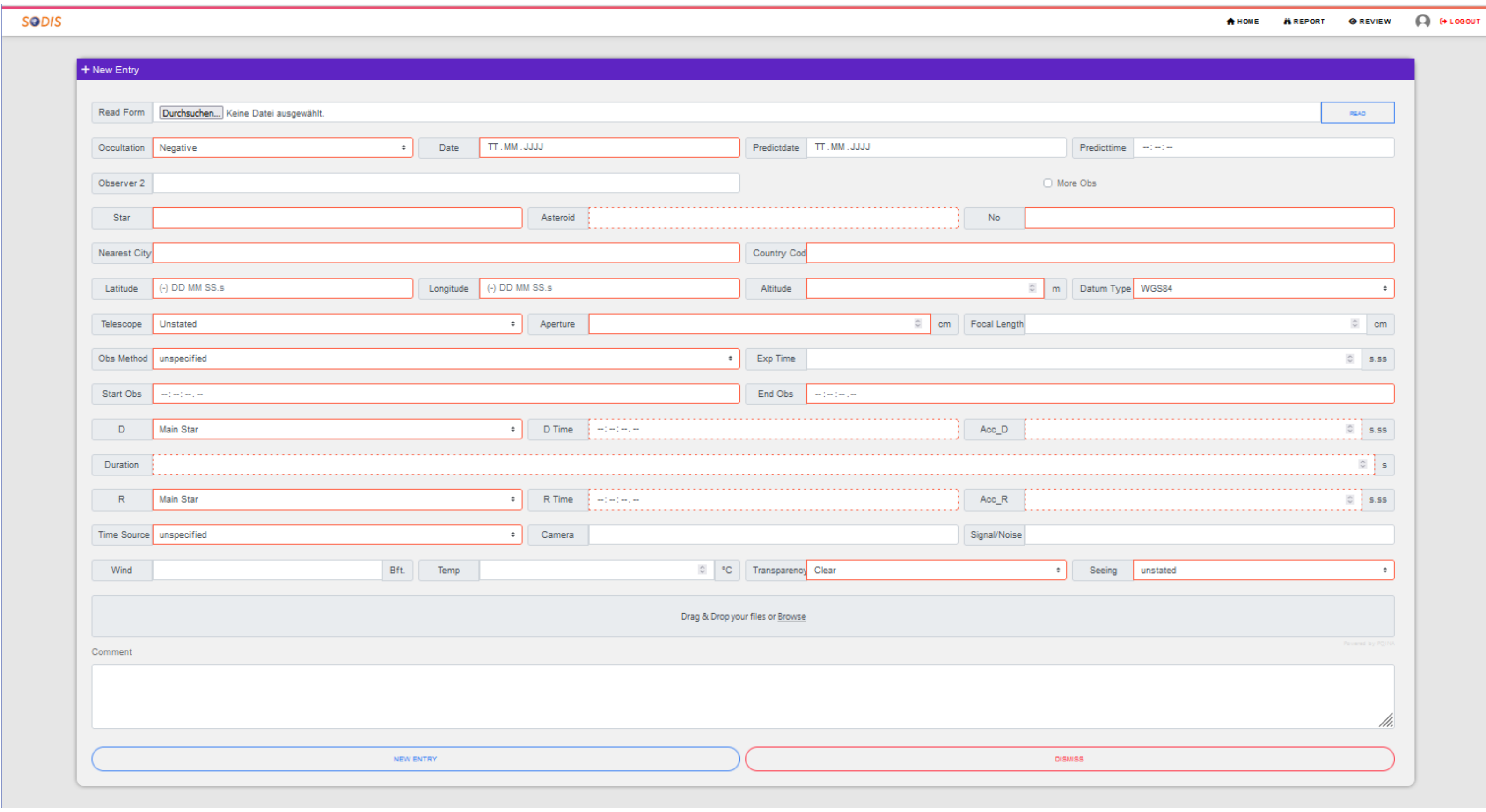


Figure 3. Report screen after log in.

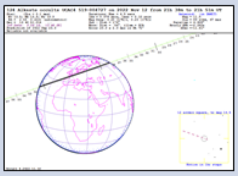
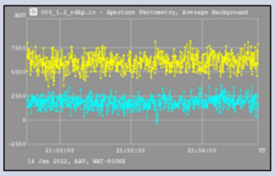
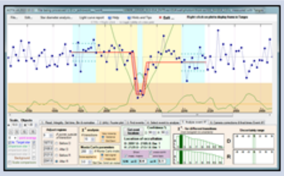
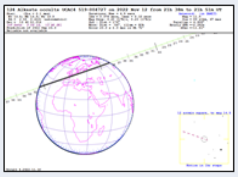
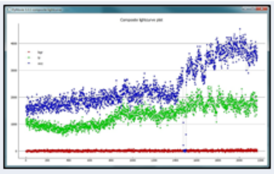
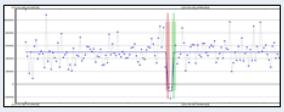
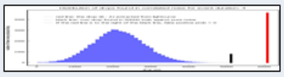
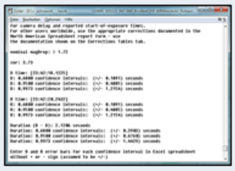
Pipeline	Event	Overview	Reduction	Log
Tangra, AOTA	 PNG-Image from Occult-Watcher: „Open Event in Occult“	 PNG-Image from Tangra: „Export lc / Save as Image File“	 PNG-Image from AOTA: „tab 5“	 Textfile („… AOTA_ Report.txt“) from AOTA „tab 6“: „Save Report“
Py-Movie, PyOTE	 PNG-Image from Occult-Watcher: „Open Event in Occult“	 PNG-Image from PyMovie: „Plot“ („Composite Lightcurve Plot“)	 Image from PyOTE: („… PYOTE.png“)  Image from PyOTE: („… false-positive.PY-OTE.png“)	 Textf. („… PYOTE.log“) from PyOTE
Other (SORA, Li-movie, ...)	Please provide similar information as described above.			

Figure 4. Requested additional information for review process. (Graphic: Christian Weber)

A group of local reviewers will check the plausability of the data. The reviewer may communicate with the observer in the reviewing process to discuss unclear information or special events during the occultation. The status of data as reviewed or unreviewed is shown for all users. The results will be compiled by event from a second reviewer and forwarded in blocks to the *Occult* database. Figure 5 shows the current regions of local reviewers – there are some gaps in the coverage of countries and we do need reviewers for these areas (Table 1).

The new report form and the working instructions are available on IOTA/ES website [5]. There is also a forum for exchanging information or reporting problems [6]. Observer can create the report form in different ways: Text-editor, using *Occult Watcher* [7], or using the occultation event dialog in the control software of the DVTI-camera [8].

Summary

The ever-increasing accuracy of astrometry of stars and minor planets has expanded the possibilities for observing stellar occultations in recent years. Whether distant TNOs, near-Earth objects, comets, main-belt asteroids or future targets of space probe missions, our observing tasks are diverse and will still increase in number. Therefore, it is necessary to gradually automate the collection of observational data in Europe and to distribute the review of these data among several shoulders. Observations of stellar occultations with only negative chords will also be stored in the new database for possible future evaluations. No observation should have been carried out in vain any more.

In order to lead this project successfully into the future, your cooperation is needed. Report your observations on your own into SODIS by creating an account. Please submit your data completely to keep the workload of the reviewers on a low level. The SODIS team is looking forward to your cooperation, criticism and suggestions. Especially additional local reviewers for European countries not yet covered are welcome.

The team of SODIS works very hard to meet the launch date of 2023 January 1. If you can provide support and want to join the team, please contact us via sodis@iota-es.de.

Let us take this step into the future together.

Region	Reviewer
CH	Jonas Schenker, Stefan Meister
CZ+SK	Jan Mánek, Jiří Polak, Karel Halíř
DE+AT+NL	Wolfgang Beisker, Gregor Krannich
ES+PT	Carlos Perelló, Ricard Casas, Carles Schnabel
FR	Thierry Midavaine, Arnoud Leroy, Pierre le Cam, Matthieu Conjat
GB+IR	Tim Haymes, Alex Pratt, Simon Kidd, William Stewart
IT	Stefano Sposetti, Claudio Costa
PL	Wojciech Burzyński, Daniel Błażewicz
Other countries [1)]	Christian Weber, Sven Andersson, Konrad Guhl

[1)] The backup team takes care of reports from European countries not listed on this table until local reviewers for these countries are selected.

Table 1. Reviewers for observation reports submitted to SODIS in Europe.

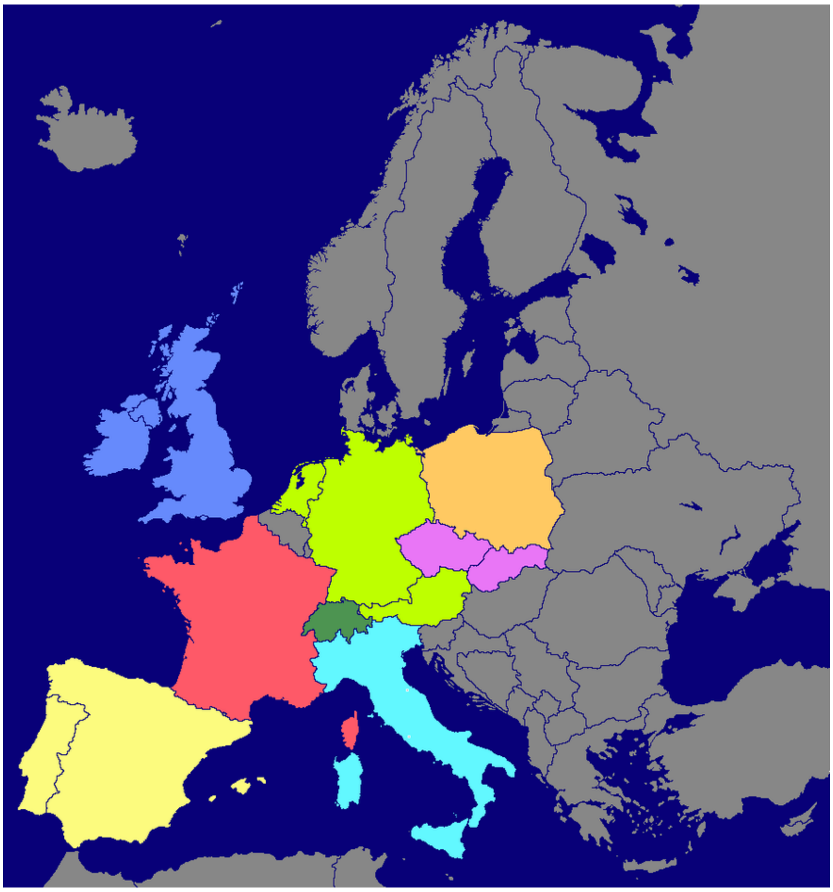


Figure 5. Local reviewers will take care of reports from observers all over Europe. Some reviewers will handle reports from several countries. Their areas are marked in different colours on the map. The grey areas have not an own reviewer yet. Their reports will be checked by the SODIS backup team. The SODIS team looks forward to find local reviewers for more areas.

References

[1] Frappa, E., euraster.net - European Asteroidal Occultation Results https://www.euraster.net/results/index.html

[2] The Homer F. DaBoll Award of the International Occultation Timing Association, 2017 Award Recipients, Regional Coordinators for Asteroidal Occultations https://www.asteroidoccultation.com/observations/Awards/Coordinators.htm

[3] SODIS, https://sodis.iota-es.de/

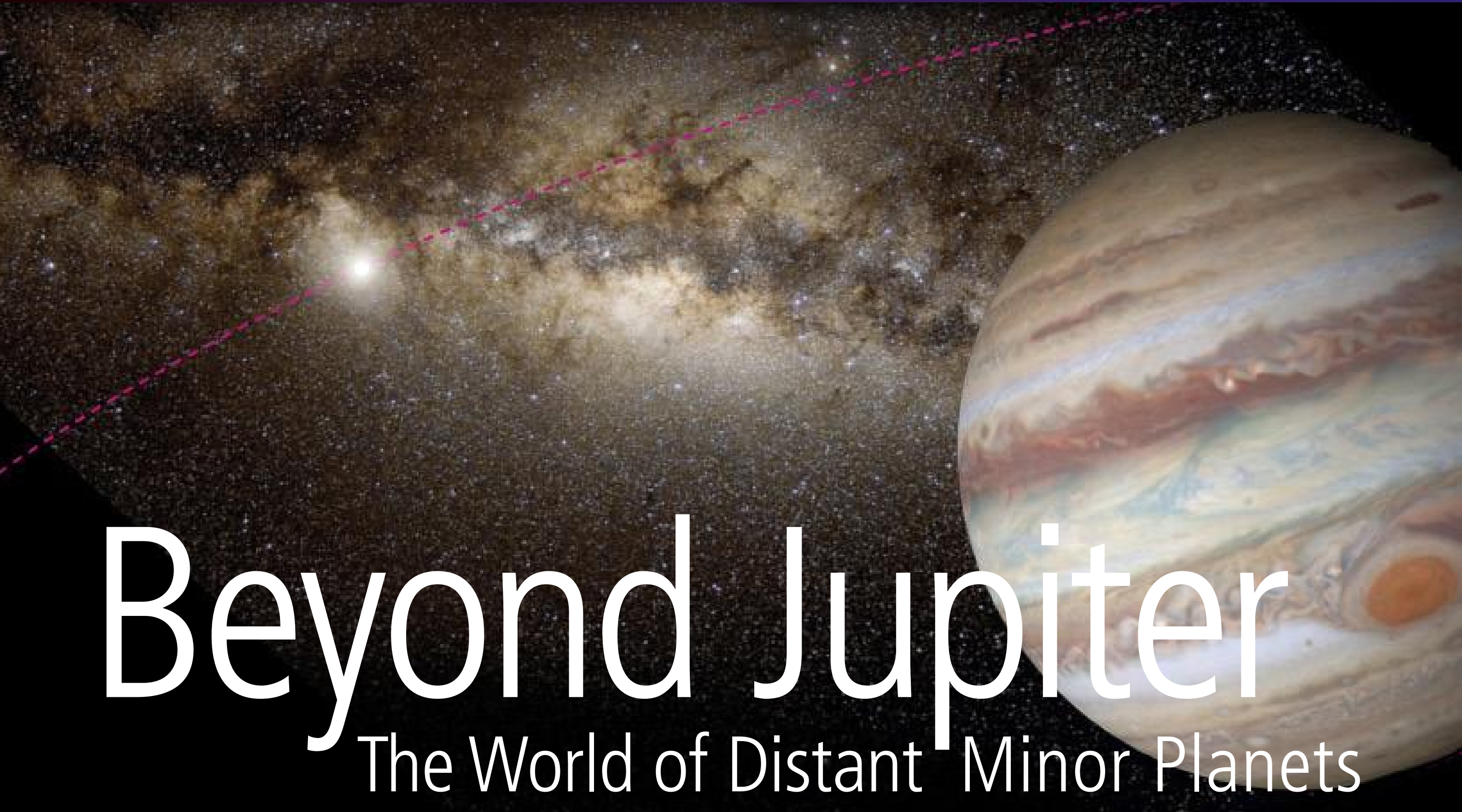
[4] Homepage of IOTA/ES, https://www.iota-es.de

[5] Manuals and report form of SODIS https://www.iota-es.de/sodis/sodis_docu.html

[6] SODIS forum, https://forum.iota-es.de/

[7] Pavlov, H., Occult Watcher, https://www.occultwatcher.net

[8] DVTI+Cam support, https://dvticam.com/support



Beyond Jupiter

The World of Distant Minor Planets

Since the downgrading of Pluto in 2006 by the IAU, the planet Neptune marks the end of the zone of planets. Beyond Neptune, the world of icy large and small bodies, with and without an atmosphere (called Trans-Neptunian Objects or TNOs) starts. This zone between Jupiter and Neptune is also host to mysterious objects, namely the Centaurs and the Neptune Trojans. All of these groups are summarised as "distant minor planets". Occultation observers investigate these members of our solar system, without ever using a spacecraft. The sheer number of these minor planets is huge. As of 2022 December 15, the *Minor Planet Center* listed 1450 Centaurs and 2934 TNOs.
In the coming years, JOA wants to portray a member of this world in every issue; needless to say not all of them will get an article here. The table shows you where to find the objects presented in former JOA issues. (KG)

In this Issue:

(32532) Thereus

Konrad Guhl · IOTA/ES · Berlin · Germany · kguhl@astw.de

ABSTRACT: The centaur (32532) Thereus was discovered in 2001 orbiting the Sun every 34.5 years. Its orbit lies relatively close to Saturn, with its aphelion and perihelion located either side of the planet's orbit. The diameter of Thereus is approximately 60 – 88 km. Some measurable rotational light curves have been published, but no moons have yet been detected. A favourable occultation is predicted for 2024.

No.	Name	Author	Link to Issue
944	Hidalgo	Oliver Klös	JOA 1 2019
2060	Chiron	Mike Kretlow	JOA 2 2020
5145	Pholus	Konrad Guhl	JOA 2 2016
8405	Asbolus	Oliver Klös	JOA 3 2016
10370	Hylonome	Konrad Guhl	JOA 3 2021
10199	Chariklo	Mike Kretlow	JOA 1 2017
15760	Albion	Nikolai Wünsche	JOA 4 2019
15810	Awran	Konrad Guhl	JOA 4 2021
20000	Varuna	Andre Knöfel	JOA 2 2017
28728	Ixion	Nikolai Wünsche	JOA 2 2018
38628	Huya	Christian Weber	JOA 2-2021
47171	Lempo	Oliver Klös	JOA 4 2020
50000	Quaoar	Mike Kretlow	JOA 1 2020

No.	Name	Author	Link to Issue
54598	Bienor	Konrad Guhl	JOA 3 2018
55576	Amycus	Konrad Guhl	JOA 1 2021
60558	Echeclus	Oliver Klös	JOA 4 2017
90377	Sedna	Mike Kretlow	JOA 3 2020
90482	Orcus	Konrad Guhl	JOA 3 2017
120347	Salacia	Andrea Guhl	JOA 4 2016
134340	Pluto	Andre Knöfel	JOA 2 2019
136108	Haumea	Mike Kretlow	JOA 3-2019
136199	Eris	Andre Knöfel	JOA 1 2018
136472	Makemake	Christoph Bittner	JOA 4 2018
174567	Varda	Christian Weber	JOA 2 2022
208996	2003 AZ_{84}	Sven Andersson	JOA 3 2022
341520	Mors-Somnus	Konrad Guhl	JOA 4 2022
-	2004 XR_{190}	Carles Schnabel	JOA 1 2022

The Discovery

This object was discovered on 2001 August 9 during the Near-Earth Asteroid Tracking program (NEAT) at *Palomar Observatory*. NEAT ran from December 1995 until April 2007, at Hawaii (Haleakala-NEAT; 566), as well as at *Palomar Observatory* in California (Palomar-NEAT; 644). A picture of the telescope used for NEAT is given in [1]. The object was given the provisional designation 2001 PT_{13} [2].

A single pre-discovery observation from Siding Spring, Australia in 1983 (published in 2020) [3] and as objects 1995 MM_6 and 1999 NE_2 helped to refine the orbit. The planet was assigned its final name in MPC Circular 49102 on 2003 June 14 [4].

The Name

The object was identified as a member of the Centaur family of solar system bodies, namely objects for which the semi-major axis of the orbit lies between that of Jupiter and Neptune. It was named in 2003 as Thereus (Greek: Θηρεύς), a centaur from Greek mythology, one of the hunters. He captured bears and carried them home, alive and struggling. The French sculptor Emmanuel Frémiet (1824 – 1910) is known for his perfect animal sculptures. With his Thereus bronze, he created a representation of a horse and man (centaur) and a bear as shown in Figure 1.

The name Thereus is also used for a South American butterfly. Here the name was given by the Augsburg painter and entomologist, Jacob Hübner [5].

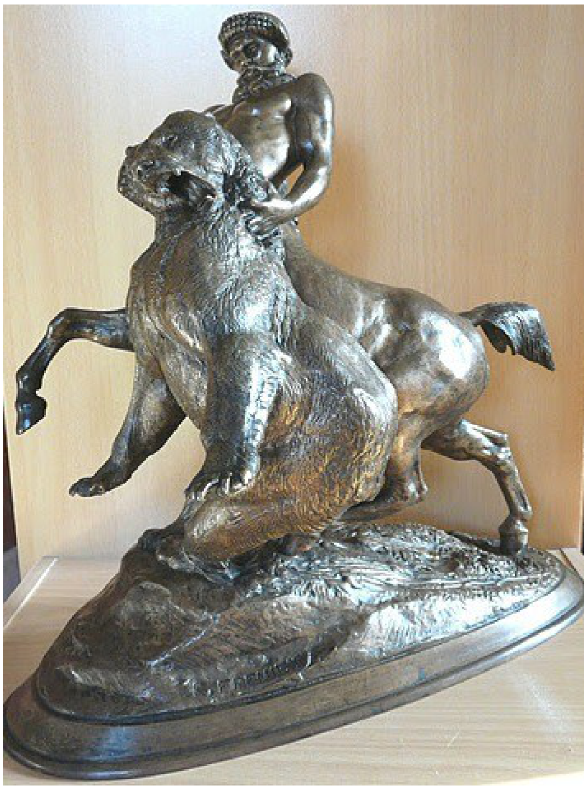


Figure 1. Thereus catching a bear, bronze anima sculpture by Emmanuel Frémiet.
(Source: http://colcombet.com/la-valeur-dun-bronze-centaure-et-ours-de-e-fremiet/)

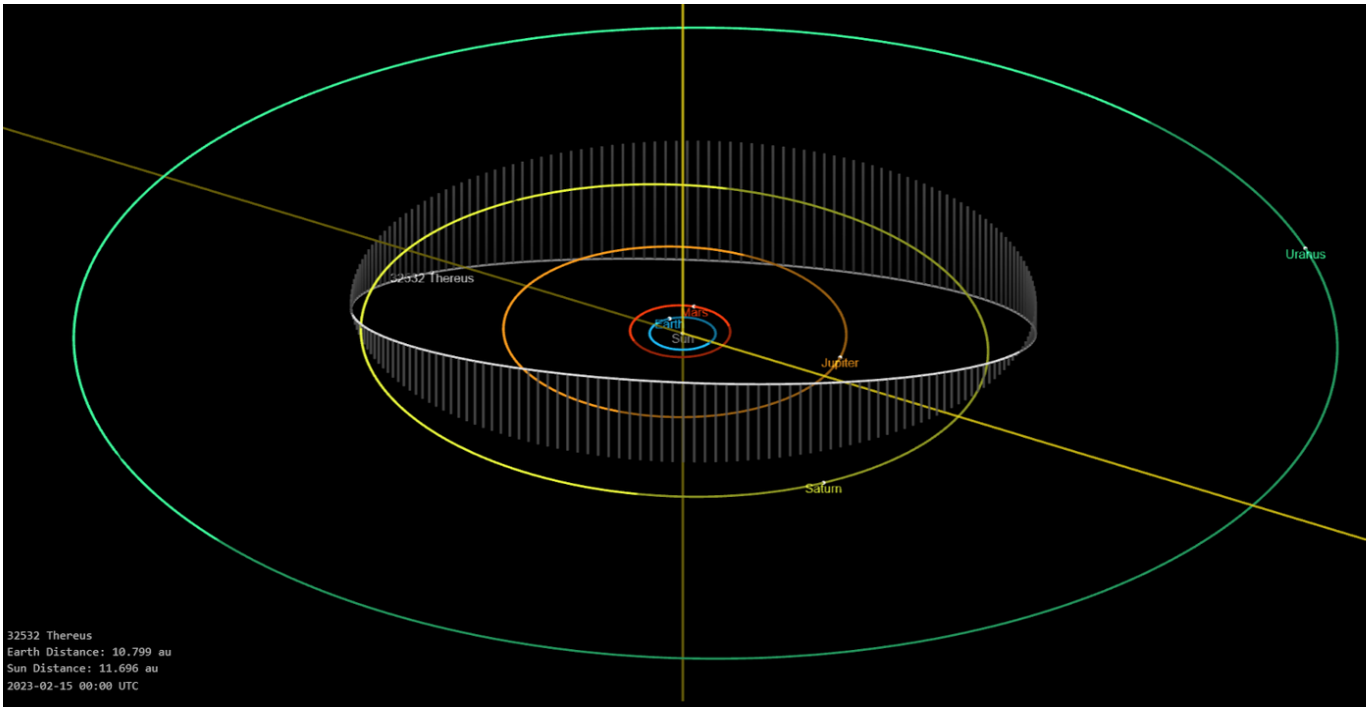


Figure 2. Orbit diagram and position for 2023 February 15.
(Source: https://ssd.jpl.nasa.gov/tools/sbdb_lookup.html#/?sstr=32532&view=VOP)

Orbit and Classification

The current orbit in the JPL Small-Body Database is based on 640 observations spanning the interval 1983 January 13 to 2022 March 28, the discovery astrometry having been excluded owing to residuals in excess of 2" [6]. The orbit (Figure 2) has an eccentricity of 0.1998 and is inclined to the ecliptic by 20.38°. With a semi major-axis of 10.6 AU, the distance from the Sun varies between 8.49 AU and 12.72 AU and so is classified as a Centaur.

At present, Thereus' position lies outside of Saturn's orbit in the direction of the constellation Sextans (until 2023 August).

Physical Characteristics

Stansberry et al. published in Reference [7] two different diameters, namely about 60.8 ± 12.6 km and 87.8 ± 9.5 km. Both values are calculated from observations by the *Spitzer Space Telescope* and based on the Standard Thermal Model (STM). The observations were made at wavelengths near 24 µm and 70 µm in 2008. Both measurements were obtained at different distances from the Sun and the *Spitzer Space Telescope*. Later, in 2018, Duffard et al. observed the object with the *Herschel Space Observatory*. Using these observations and data from Ref. [7] they calculated a diameter of 62 ± 3 km [8]. The absolute magnitude according to the Minor Planet Center is H = 9.22 [9].

According to the Asteroid Lightcurve Database (LCDB) the rotational period is 8.335 h (based on 5 references) and exhibits an amplitude ranging between 0.16 – 0.38 magnitudes [10].

Figure 3 is described in reference [11] as "Image of Thereus, a magnitude 20.4 centaur, taken from *Oukaïmeden Observatory*, Morocco, on the evening of 2013 January 31 with a 50-cm aperture, f/3 telescope, obstruction 35%, STL 11000 camera, pixel size of 1.24 arcsec, and a measured seeing of about 3 arcsec" (credit C. Rinner). The image is the shifted sum of 25 x 120 s exposures. The images were stacked at the object's motion of 5.82 arcsec/h in position angle 292° (from North, positive to East). Thereus is the point-like source in the middle of the frame, while the stars appear trailed.

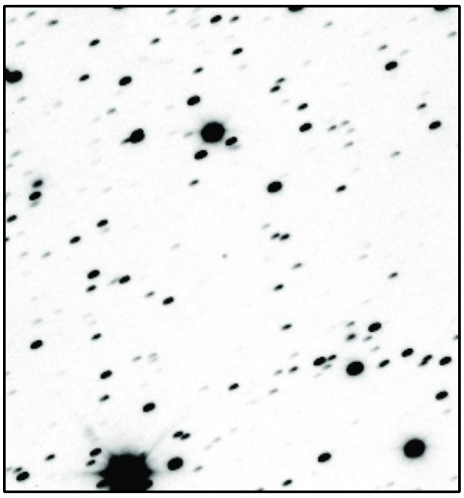


Figure 3. Stacked and tracked image of (32532) Thereus. Credit: C. Rinner

Future Stellar Occultations

Using Dave Herald's *Occult 4* software [12] only two observable events could be found up to the end of 2025, notably that of 2024 March 21 and 2025 March 10. Figure 4 shows the track crossing east Europe as depicted with the *Occult* software. Let's hope to have observers in this region to the date. Sure, it is a long time to

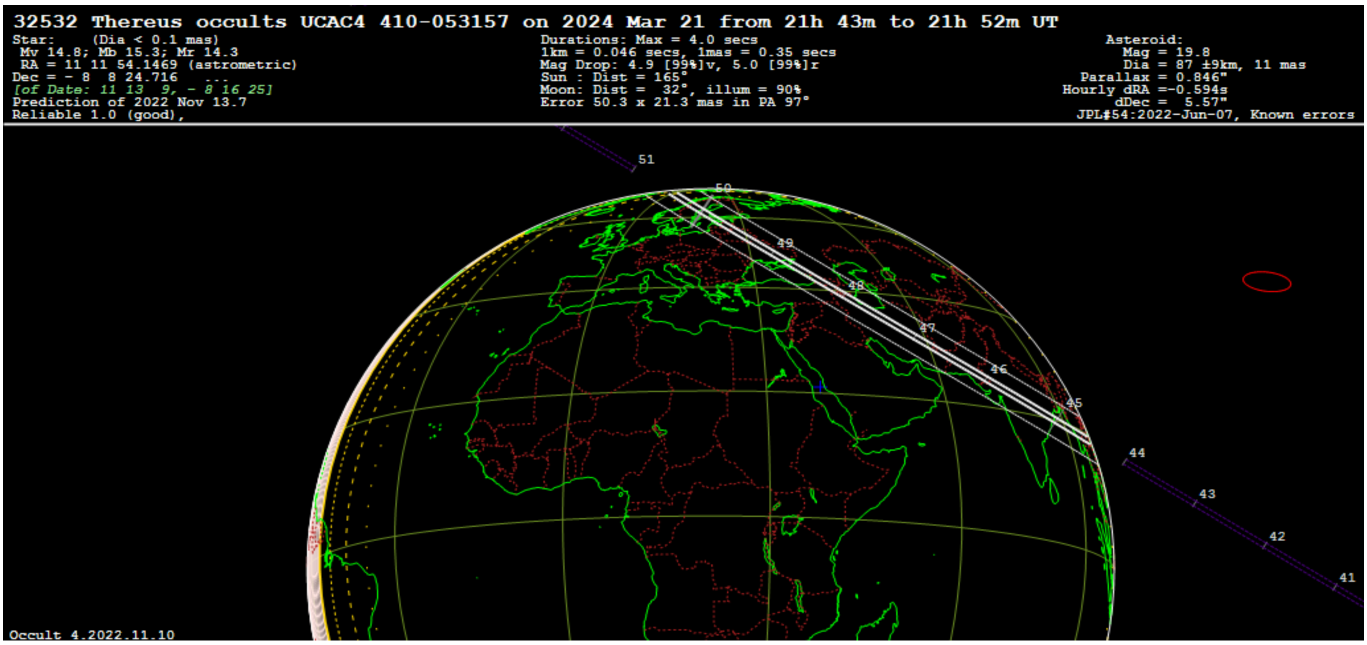


Figure 4. Occultation of UCAC4 410-053157 by (32535) Thereus in 2024. Calculated with Occult Ver. 4.2022.11.10

go yet and the ephemeris is possibly not exact enough to plan an observation, but the circumstances are promising. The stars magnitude is within the range of small and middle-sized instruments and it's in the late evening.

Figure 5 shows a prediction in 2025 for a really bright star in a region with experienced observers. Like explained above – it's a long time and some path shifts are possible.

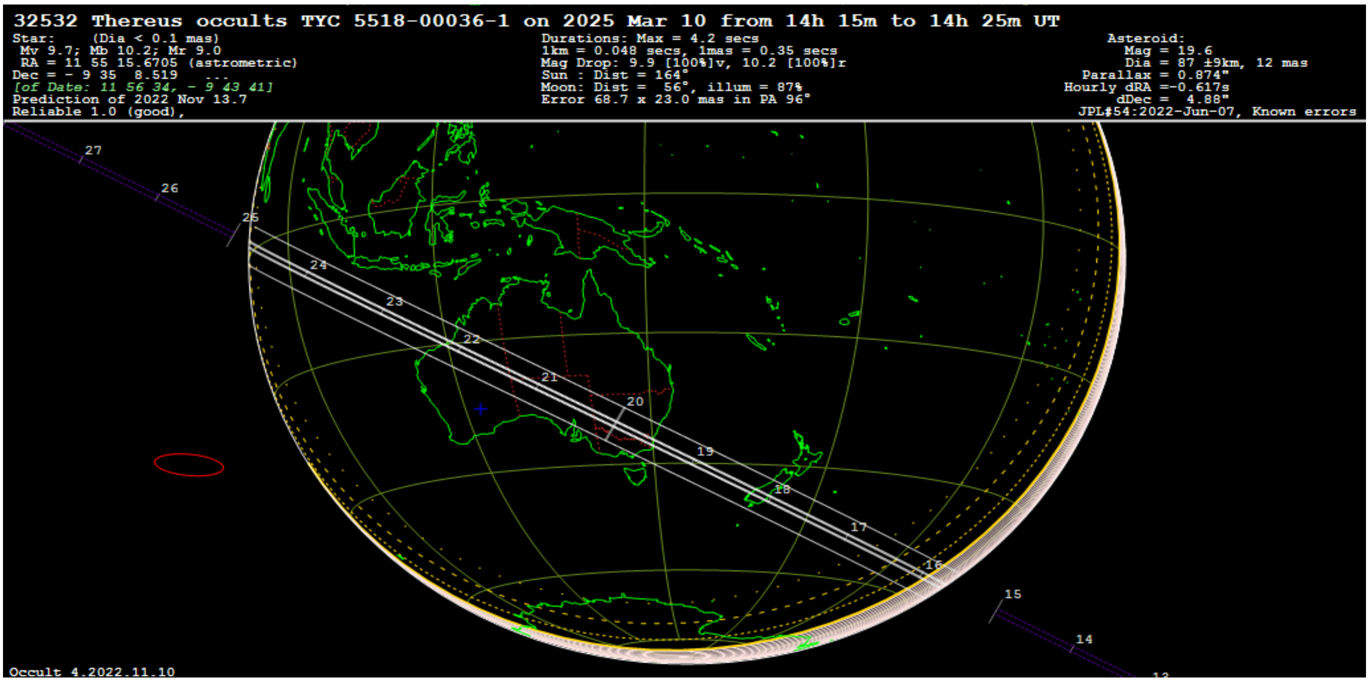


Figure 5. Occultation of TYC 5518-00036-1 by (32532) Thereus in 2025. Calculated with Occult Ver. 4.2022.11.10

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[4] Minor Planet Circulars M.P.C. 49102
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http://www.lunar-occultations.com/iota/occult4.htm

Further Reading

"The Trans-Neptunian Solar System" edited by D. Prialnik, M.A. Barucci and L.A. Young, Elsevier Science, 478pp. (2019)

Useful links about objects like Centaurs:
http://ssd.jpl.nasa.gov/sbdb.cgi
http://spacewatch.lpl.arizona.edu
http://www.minorplanetcenter.org

IOTA/ES-Workshop Tangra & AOTA, Berlin, Germany, 2022 November 5

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ABSTRACT: After the recording of a stellar occultation follows the work on the computer. The softwares Tangra and AOTA help to create and analyse a light curve. At the Archenhold Sternwarte in Berlin, Germany, participants were trained in this task in-person and virtually.

Introduction

Recording a stellar occultation with a camera is only the first step to determ the profile and a position of an asteroid. A light curve must also be made from the recording and the exact times of the occultation by the asteroid must be determined with the help of an evaluation software. One program for creating a light curve is Hristo Pavlov's *Tangra* [1]. The light curve obtained in *Tangra* can then be used to reliably determine the times of a stellar occultation in Dave Herald's *AOTA* [2]. Especially the analysis with *AOTA* is always a challenge for the users and often their first results have to be checked and corrected.

IOTA/ES offered a workshop on these two important tools to give observers more confidence in using these analysis softwares and to make the work of reviewers easier.

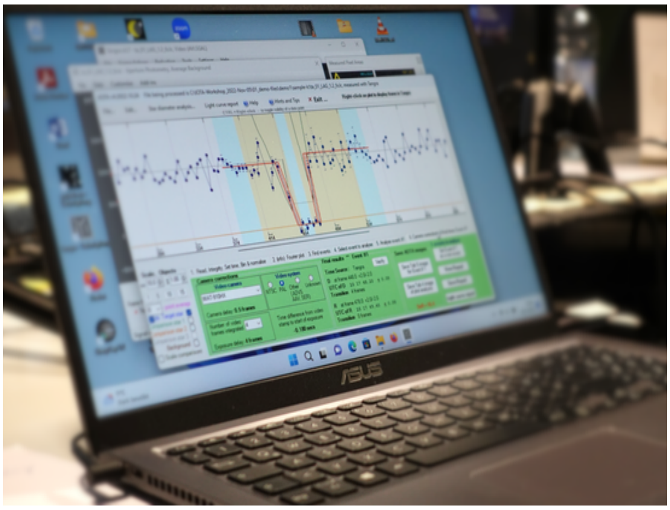

Figure 2. Training session on AOTA.

In-Person and Virtual

Back in February 2020, IOTA/ES had organised a workshop on the camera QHY174M-GPS at the *Archenhold Sternwarte* in Berlin-Treptow, Germany (Figure 1), [3]. At that time, eleven participants met in-person [4]. Since the Covid-19 pandemic, streaming possibilities have rapidly developed to offer such a meeting also virtually and thus to allow members of IOTA/ES who cannot travel to Berlin to participate in such an exchange of knowledge. For members of IOTA/ES, the participation of this workshop was free of charge, others could join for a small fee in-person or virtually.

Figure 1. Main building of the Archenhold Sternwarte with the legendary large refractor on the roof top.

Figure 3. Presenter Christian Weber (right) discusses with Stefan Meister, SOTAS, some software settings.

The Workshop

On Saturday 2022 November 5th, eight participants gathered in-person in the lecture room of the 5 metre dome (Figure 4). More than 40 participants from all over Europe joined via *Zoom*. Among the participants were 14 paying guests.

IOTA/ES member Christian Weber, who had already held the workshop in February 2020, explained the use of the *Tangra* software in the morning session (Figure 3). He demonstrated how to create a light curve with live presented examples. The participants in Berlin were able to use their own computers to follow the individual steps in a practical session and were able to ask questions to Christian. Virtual participants also took advantage of the chat function in *Zoom* for their comments and questions.

After the lunch break, Christian taught the further processing of the light curve in *AOTA*. For this purpose, he had meticulously followed and evaluated e-mails about problems with the use of *AOTA* on the PLANOCCULT [5] mailing list. Even experienced users of this software could gain new insights here.

The day ended with a guided tour of the *Archenhold Sternwarte* for the participants by the President of IOTA/ES, Konrad Guhl.

Conclusion

The workshop in Berlin showed that many users have the same problems with evaluations of light curves and that these can be solved together in a working session, in-person or virtually. Since the collected knowledge should also be accessible to other interested observers, the workshop was recorded by the author of this report. A video tutorial on *Tangra* and *AOTA* will be made from these recordings.

IOTA/ES plans to offer further workshops in the future and invites the worldwide community of occultation observers to join. The topics and schedules will be announced in time.

Figure 4. The workshop in the lecture room of the 5 metre dome still continued at sunset.

Acknowledgements

Special thanks to Christian Weber for his conscientious preparation of the complex topics of the workshop, as well as to the LOC at *Archenhold Sternwarte*, Berlin, for their renewed hospitality.

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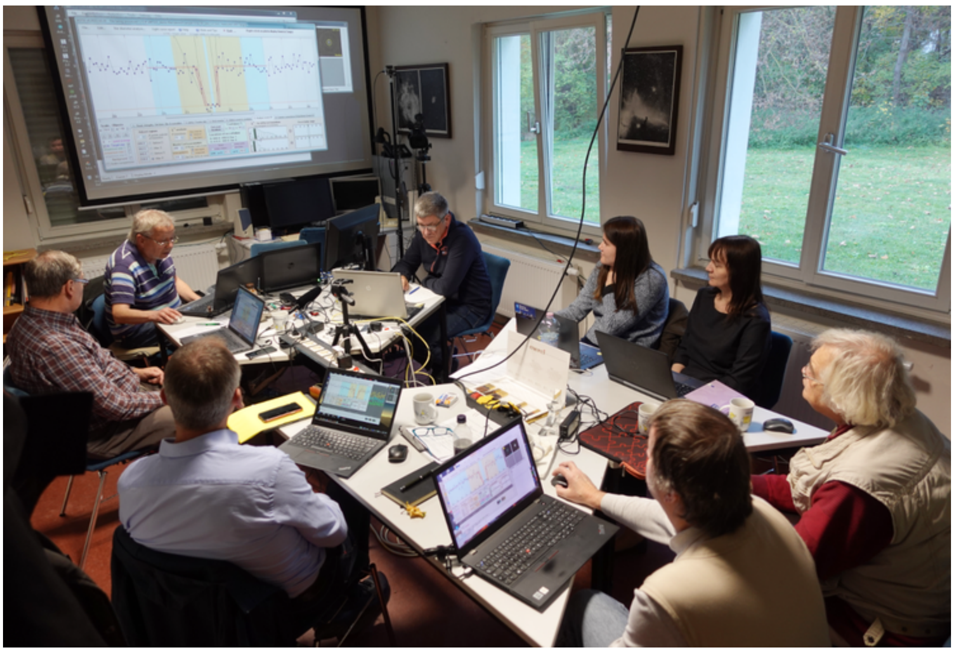

Figure 5. At the lecture room during the afternoon session on AOTA.
From top, clockwise: Nikolai Wünsche, Julia Perla, Anna Marciniak, Eberhard Bredner, Sven Andersson, Stefan Meister, Konrad Guhl and Christian Weber

Paul D. Maley receives Gordon Myers Amateur Achievement Award

The *Gordon Myers Amateur Achievement Award* recognises significant observational or technological contributions to astronomy by an individual not employed in a professional capacity. The 2022 recipient Paul D. Maley, IOTA, was awarded during a gala held by the Astronomical Society of the Pacific (ASP) on November 19th in Burlingame, California, USA. The laudation was given by ASP Board member John Keller.

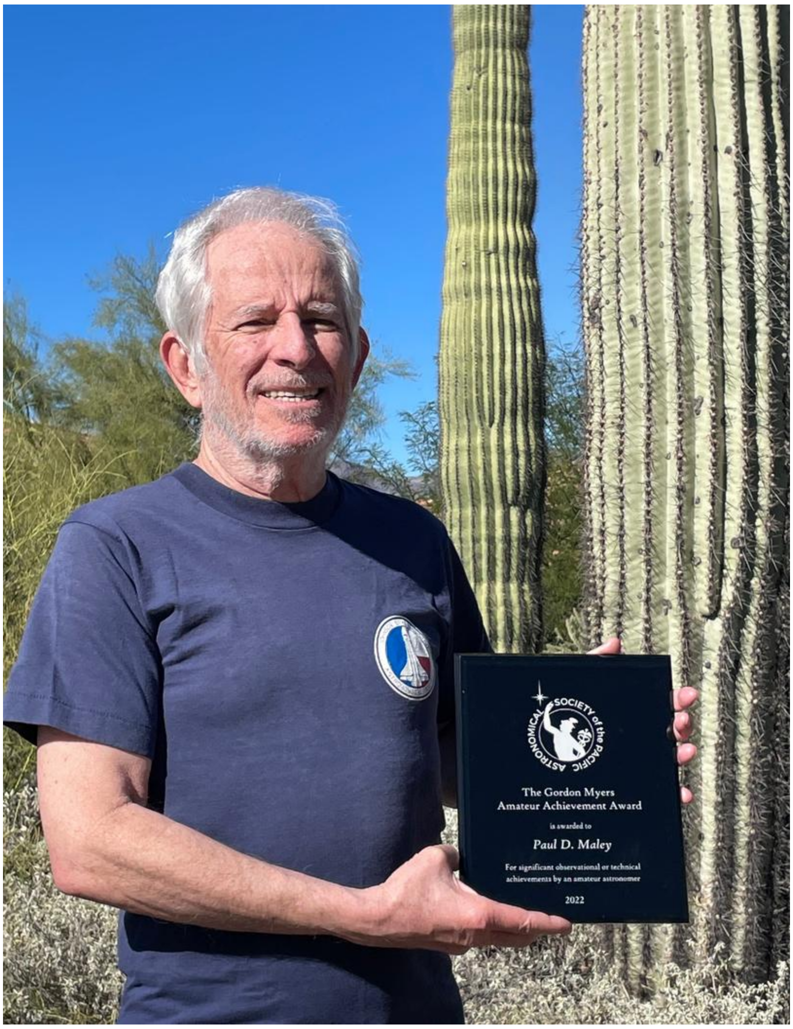

Figure 1. Paul D. Maley presents the plaque of the Gordon Myres Amateur Achievement Award. Photo: Lynn Palmer

"The 2022 recipient is Paul D. Maley who has demonstrated an extraordinary record of accomplishment for an amateur astronomer, contributing serious professional quality work at the highest levels.

Dedicating nearly 60 years of his life to his craft, Maley is a passionate amateur astronomer, not just in his love for observing, but also traveling around the world encouraging, advising, and enabling others to chase solar eclipses, stellar occultations, and the Northern Lights.

Maley's tireless efforts include his commitment to public outreach as a longtime member of the Johnson Space Center Astronomical Society (JSCAS). He has organized almost 50 solar eclipse expeditions around the world, two Transit of Venus expeditions, three Transit of Mercury ventures, and personally observed 80 solar eclipses of all types through 2022. He planned these trips generally several years in advance looking at the history of weather records and assessing possible hazards to select the highest probability of success and safest locations for viewing. His work supporting the JSCAS has also included training international amateurs in the art of making grazing lunar occultation and minor planet occultation measurements. As one nominator expresses "Before anyone had heard the term Citizen Science he was out there, organizing it...". His travels and observational trips have taken him to places like Saudi Arabia and Iraq, to Cuba and India. He has created official historical markers for the location of lesser known but important astronomical events such as expeditions in the 18th and 19th century for Transits of Venus; also for the residence of Asaph Hall, the discoverer of Mars' two satellites in Washington, DC.

A major part of Maley's life has also been spent observing and documenting sky phenomena concentrating on artificial earth satellites, spacecraft reentries and asteroids. A fellow nominator and JSCAS member noted that Maley "observed over 500 minor planet occultations from six continents in an ongoing effort to measure shapes and sizes of minor planets." His most notable contribution was the possible first observation of an occultation of a star by an asteroid moon in 1977—a type of body never before known to exist. Although not confirmed, the subsequent report spurred professionals and amateurs to observe asteroid occultations until the first confirmed asteroid moon was imaged by the Galileo spacecraft in 1993. Additional work in this field included observations of grazing occultations at the edges of the predicted path to improve the polar diameter of the Moon, and observations from the edges of solar eclipse paths to attempt to determine changes in the Sun's polar diameter. Several new double stars were discovered as a result of his occultation activity.

Maley's astronomical work separately resulted in the discovery of intense flashes of light occurring when the Sun's light glints from inactive earth satellites - originally mistaken for novel astronomical phenomena in the 1980s and 90s. This gave fair warning of the amount of space debris humans had created, but also demonstrated how inactive Earth satellites could create some 'false' professional astronomical discoveries. There is no doubt Maley has made use of his skills as an amateur astronomer, shared this enthusiasm with the public through his solar eclipse, occultation travels, viewing the Northern Lights, and ultimately through discovery, observation, and collaboration impacted the professional world of astronomy."

Figure 2. John Keller, member of the Board of ASP, honours Paul D. Maley during the gala in Burlingame, California, USA. Photo courtesy of the Astronomical Society of the Pacific.

Paul D. Maley has been observing occultations since the late 1960's and is most noted for having made an observation of (6) Hebe occulting a 3.6 magnitude star and reporting a brief occultation from Texas in 1977 prior to David Dunham receiving reports of 3 chords from Mexico. In attempting to understand the situation Paul suggested to David whether this could be the result of a satellite of (6) Hebe. This was all initially documented in Occultation Newsletter [1] and from there stemmed the search for minor planet satellites which continues to this day.

In addition to having made 554 separate successful asteroid occultations (hundreds more misses) and driven nearly 100,000 miles since moving to Arizona 7 years ago. Paul was a principal in helping IOTA incorporate in Texas in 1983, served as Vice President of IOTA for 30 years, took the first photo of an asteroid occultation in 1980 as well as the first (and perhaps only photo) of a complete grazing lunar occultation during a total lunar eclipse from the very site where Gen. McArthur landed on his return to help liberate the Philippines in 1982. He has attempted minor planet occultations from six continents and specifically from Iraq, Moldova, Saudi Arabia, Tanzania, South Africa, Lord Howe Island, Australia, French Guiana, Indonesia, Japan, Taiwan, Guyana, Brazil, Greece, Bosnia-Hercegovina, France and other locations although mainly observes in Arizona, USA now.

In 1983 he was the principal organiser of the observation campaign for an occultation by (2) Pallas, the most productive minor planet occultation recorded to date [2, 3], participated in lunar polar diameter expeditions to Sudan and Mexico, and facilitated others to observe from the edges of solar eclipse paths on some of his 80 solar eclipse attempts. His biggest failure was a 300 station graze in the early 1980's due to weather.

He created the *W. J. Merline Award for Discovery of an Asteroid Moon by Occultation* (MADAMO) award in 2013 [4]. He keeps in contact with observers in India on their minor planet occultation activities and has sent them timing hardware.

Among other honours, he was elected a Fellow of the RAS (nominated by B. G. Marsden in 1975), became a Fellow of the Explorers Club in 2021 because of his worldwide travels to over 300 countries and territories, received the *IOTA Lifetime Achievement Award* in 2019 [5], and the binary asteroid 1981CH was named (27675) Paulmaley on 2019 September 3 during the 5th Workshop on Binaries in Ft. Collins, Colorado USA. In 2021 he also received the *G. Bruce Blair Gold Medal* from the Western Amateur Astronomers for his public outreach work on behalf of the NASA Johnson Space Center Astronomical Society from 1969 to the present. (OK)

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ESOP XLI

Report of the 41st European Symposium on Occultation Projects

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Oliver Klös · IOTA/ES · Eppstein-Bremthal · Germany · pr@iota-es.de

ABSTRACT: The 41st European Symposium on Occultation Projects (ESOP) took place at the Instituto de Astrofísica de Andalucía, Granada, Spain, during the weekend of September 10 – 11 and it was a hybrid event held simultaneously as an in-person meeting and an online video conference. A total of 40 delegates attended the meeting and a similar number participated via Zoom, together representing Algeria, Argentina, Belgium, Brazil, China, Czechia, France, Germany, Greece, Ireland, Italy, Netherlands, Poland, Portugal, Spain, Switzerland, Turkey, the United Kingdom and the USA. The science meeting was followed by social excursions on the Monday and Tuesday.

Friday 9th September 2022

Early on Friday evening the participants met for the traditional welcome by the Local Organising Committee (comprising José Luis Ortiz, Pablo Santos-Sanz and others), held at the central patio of the Instituto de Astrofísica de Andalucía (IAA), Spanish national Research Council (CSIC), which was also the location for our Symposium. This informal event often includes local regional catering and we were treated to drinks and a tapas buffet, the numerous tasty little snacks and appetisers so popular in Spain. It was also an opportunity to register our attendance at ESOP where the LOC handed out conference badges, abstracts booklets and tourist information material to the delegates.

Saturday 10th September 2022

Konrad Guhl, the IOTA/ES President, opened the proceedings by welcoming everyone in the lecture room and others viewing online to the 41st ESOP; he thanked the LOC for organising the meeting and everyone who travelled to Granada and the online attendees.

José Luis Ortiz (IAA) thanked IOTA/ES for their support, the IAA for providing the resources to host this year's ESOP and the LOC volunteers for the Friday buffet and the catering during the breaks. Local astronomical societies and Sababell amateur astronomers contributed much assistance, and in particular Mike Kretlow and

Figure 2. Entrance of the Instituto de Astrofísica de Andalucía in Granada (O. Klös)

Pablo Santos-Sanz put a lot of work into delivering ESOP. Pablo and Mike said a few words about daily logistics for lunchtimes, the Symposium dinner and the social excursions. René Duffard and Mike explained the protocol for speakers – how to deliver their talks to the meeting and online, and to conduct question and answer sessions.

ESOP XLI was held in September for the generally cooler temperatures and to precede the Europlanet Science Congress also in Granada a week later. It was unseasonably warm with temperatures up to 35°C but the lecture room had good air conditioning.

Session 1 - Observations and Results
chaired by Mike Kretlow

José Luis Ortiz - Some results from occultations by TNOs and Centaurs and prospects for the future.

José Luis outlined how the team at IAA contribute to and collaborate with the international Lucky Star project to determine the physical characteristics of Centaurs and in particular trans-Neptunian objects (TNOs), intriguing primordial bodies in the outer solar system. Their angular diameters are small, their orbits aren't very well defined, so observing them is challenging.

Figure 3. Salon de Actos - the lecture room of the Instituto de Astrofísica de Andalucía. José Luis Ortiz presents results from occultations by TNOs and Centaurs. (O. Klös)

He showed some of the key results from this work, such as Eris, Makemake, Quaoar and Chariklo, and compared their diameters measured by occultations and by thermal imaging.

Pablo Santos-Sanz - Physical properties of the trans-Neptunian object (38628) Huya from a multi-chord stellar occultation

Pablo spoke about how a prediction of an occultation of a bright mag. 10.6mv star by Huya, which had a most favourable track across Europe and Asia, resulted in a network of pro-am observers recording 21 well-separated chords across this ~400 km-wide TNO. From this quality dataset it was possible to fit an ellipse to the body with small residuals, and to derive estimates of Huya's dimensions. No satellite, rings or debris were detected in the data, although it placed constraints on their presence, including an upper limit on any Pluto-like atmosphere.

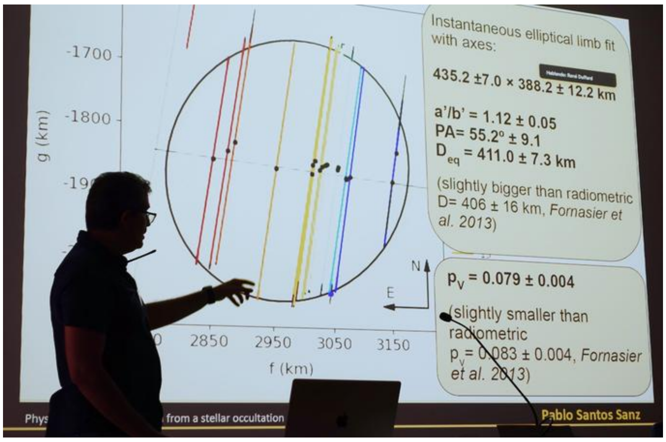

Figure 4. Pablo Santos-Sanz shows the measured shadow profile of the occultation by Huya. (O. Klös)

Bruno Sicardy - The search for material around (50000) Quaoar

Bruno leads the Lucky Star team and he described the 1,100 km diameter TNO (50000) Quaoar whose orbit lies beyond that of Pluto and it could also be categorised as a dwarf planet. (50000) Quaoar has a moon, Weywot, almost 100 km across. Bruno discussed the results from previous occultation campaigns to observe the Quaoar-Weywot system and he theorised on the likelihood of a probable ring system or debris around (50000) Quaoar.

During the coffee breaks the participants had the chance to take a look at a poster by Chrystian Luciano Pereira et al. about topographic evidence in the Trojans (3451) Mentor, (2207) Antenor, and (58931) Palmys from Stellar Occultations. The light curves and preliminary analyses of occultation observations of these Trojans suggest evidence of interesting topography or a binary nature.

Javier Flores presented a poster about an expedition to observe an occultation by the Near Earth Object (65803) Didymos on 2022 August 24 in southern Spain. After being contacted by the ACROSS team the Sociedad Astronomica Granadina (SAG) monitored this event with 7 telescopes. The poster described their campaign and the analysis of their observations.

Session 2 - Observations and Results

chaired by José Luis Ortiz

Alex Pratt – Experiences of observing the 2017 October 5 Triton occultation

The Lucky Star team publicised a major pro-am campaign to observe this occultation. It was an opportunity to remotely study Triton's atmosphere, to probe for changes in its structure, density and winds since previous observations in 2008. Alex was one of 90 or so observers who submitted light curves and several contributors recorded its bright central flash. A definitive paper was published by the Lucky Star team. He described his participation in the project and proposed some recommendations to improve data quality for future campaigns.

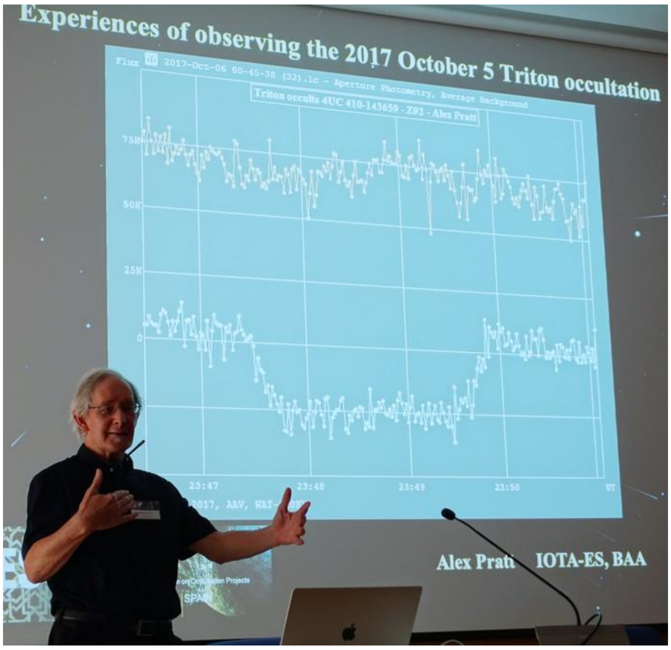

Figure 5. Alex Pratt reports about his experiences of observing the Triton occultation on 2017 October 5. (O. Klös)

João F. Ferreira - ACROSS: The Campaign for occultations by DART target Didymos (and other NEAs)

João explained that thanks to the Gaia Data Releases we have much improved occultation predictions, even for small and fast-moving Near-Earth Asteroids (NEAs) such as (3200) Phaethon and (99942) Apophis. The ACROSS project (Asteroid Collaborative Research via Occultation Systematic Survey) supports NASA's DART mission – asteroid Didymos and a planned spacecraft collision with its satellite Dimorphos - and ESA's Hera mission, and ACROSS will select other NEAs for study. The ACROSS team obtain high-quality ground-based astrometry of NEAs and generate predictions for pro-am observers of NEAs' short-duration occultations.

Session 2 - Observations and Results
chaired by Konrad Guhl

Session 2 continued after the group photo (Figure 1) and the lunch break.

Costantino Sigismondi (via Zoom) - Refraction at the horizon measured by sunrise and sunset timing

Costantino presented his studies of the effect of refraction when timing sunrise and sunset, such as against a sea horizon. The airmass extinction, humidity, ambient temperature, and gradients in temperature and atmospheric pressure influence the phenomenon and differential refraction compresses the image of the Sun vertically, producing chromatic splitting into bands of colour. He demonstrated some of his videos and timing technique, and his analysis methods using *Stellarium* software.

Session 3 - Predictions & Upcoming Events
chaired by Konrad Guhl

Jiří Kubánek - Occultations by Asteroids - Highlights for Europe in 2023

In part 1 of his talk Jiří outlined his selection criteria for the 20 most observable events in 2023. These included stars brighter than mag. 12, durations >10 s and favourable drops > 1 mag. The major event of the year is the *annular occultation of Betelgeuse* by mag. 14 (319) Leona, on 2023 December 12 across Mediterranean latitudes. Jiří discussed this special case where asteroid and star have similar apparent diameters. In part 2, he presented 10 events for asteroids with known satellites, including (216) Kleopatra, 3 Jupiter Trojan events, also (624) Hektor and other asteroids of special interest.

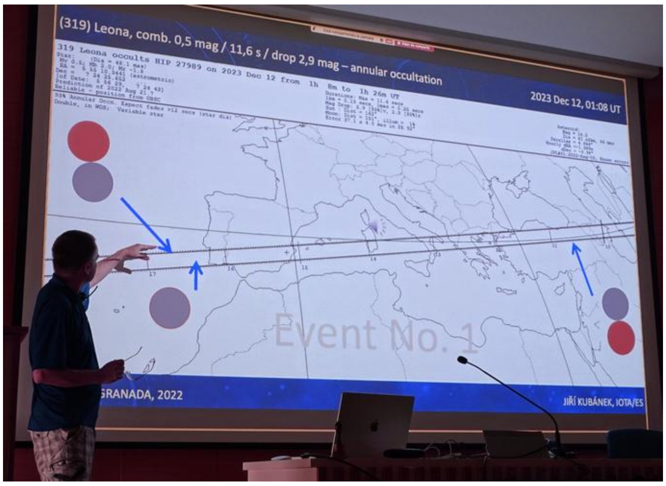

Figure 6. Jiří Kubánek explains the special case of the occultation of Betelgeuse by (319) Leona on 2023 December 12. (O. Klös)

Konrad Guhl - Future occultation observation reporting and archiving in Europe – open discussion

Konrad gave an overview of the current system, where we submit our report files to the Planoccult list server, they are reviewed by Eric Frappa and if they are accepted, he adds them to the online Euraster database. Negative observations are also stored by him. Checking reports and replying to observers with advice / corrections is time-consuming and Eric has done this alone for many years. He now wishes to step down from this demanding role. Konrad discussed the current systems in use, e.g., IOTA/USA, Trans-Tasman, Japan, to consider the way forward for IOTA/ES in 2023. The delegates debated whether a reporting tool could be added to OWCloud by Hristo Pavlov or to adopt the IOTA/USA workflow with regional reviewer teams.

The meeting of the first day closed with the IOTA/ES General Assembly. Results of the member survey and membership statistics were reported by Secretary Nikolai Wünsche. Wolfgang Beisker talked about scientific results and projects with special thanks to Eric Frappa, euraster.net for his work. Oliver Klös gave an overview of printed and digital publications and public relations attempts by members of IOTA/ES. Andreas Tegtmeier explained the details of the treasurer's report. The assembly closed with a discussion about future projects.

In the evening we met at the Plaza Nueva where local people were enjoying traditional entertainment, including a flamenco dancer accompanied by a guitar player, then we walked through the busy streets and up narrow winding alleyways to the restaurant Mirador de Morayma. The climb was worth it because from our outdoor tables we had wonderful views overlooking the Alhambra Palace in the evening light. Konrad Guhl gave a brief speech before our dinner.

Sunday 11th September 2022

Session 4 - Observations and Results
chaired by Alex Pratt

Julia Perła (via Zoom) - Analysis of stellar occultations by asteroids observed from station in Borowiec

Julia explained that her talk was based on her work for her bachelor's thesis at the Astronomical Observatory Institute, Adam Mickiewicz University in Poznań, Poland. She used a 40 cm telescope at Borowiec equipped with an Andor Zyla camera to observe 10 asteroidal occultations, measured the instants of D and R for her positive events, fitted an ellipse or shape model to the chords, derived a lower limit for the asteroid's sizes and compared these with satellite data.

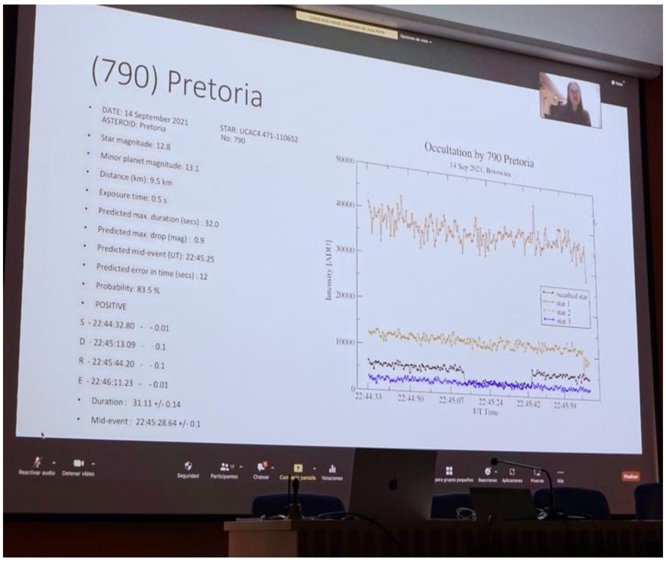

Figure 7. Julia Perła joined ESOP via Zoom. Here she presents her recording of a light curve of the occultation by asteroid (790) Pretoria on 2021 September 14. (O. Klös)

Anna Marciniak - First results from stellar occultation campaign on slow rotators

Anna is a senior staff member at the Astronomical Observatory Institute in Poznań and she investigates slowly rotating asteroids with small light curve amplitudes by using photometric observations and their stellar occultation data. Combining these datasets reveals their shape profiles, dimensions, angles of spin and rotation periods. Anna manages the Slow Rotators feed in *OWCloud* which has a growing number of observers and she presented examples of how this work is improving our knowledge of these somewhat neglected asteroids.

Session 5 - Predictions & Upcoming Events chaired by Carles Schnabel

Djounai Baba Aissa (via Zoom) - Observation of relevant future stellar occultations by NEAs in Algeria in 2022

Djounai summarised the involvement of Algiers Observatory in occultation work by its Small Bodies solar system team including national meetings and observer recruitment. He led the Algerian team to observe an occultation by the NEA (65803) Didymos on 2022 August 25, and colleagues attempted the event by Skamandrios, (624) Hektor's moon, on August 30. His group is now equipped with three 28-cm aperture SCTs, each with an IOTA-VTI GPS time inserter and Watec 910HX video camera in readiness for recording short-duration stellar occultations by NEAs.

Konrad Guhl - Plans for the 2023 total solar eclipse in Australia

The timings of Baily's Beads during solar eclipses are used by IOTA and IOTA/ES to measure the radius of the Sun. Konrad presented the circumstances of this hybrid solar eclipse (annular-total) on 2023 April 20 and described his plans to observe it from Western Australia, although it only just touches the Australian mainland at the town of Exmouth where overnight accommodation is 'astronomically' expensive. He will test and calibrate his established IOTA/ES method alongside observers using a new flash spectrum technique.

Session 6 - Hardware, Software & Procedures - chaired by Wolfgang Beisker

Konrad Guhl - News about the (IOTA/ES) M2 expedition telescope

The 50 cm Dobsonian *M2* telescope evolved from the work of Michael Busse and Michael Dohrmann (hence '*M2*') There is a User Handbook (English and German versions). Its first success was a Pluto occultation, then Chariklo in Namibia (by Mike Kretlow) and Quaoar, followed by observing Polymele and Didymos. *M2* is transportable in three boxes, it can be assembled by two people and is available to IOTA/ES members for approved projects.

Andreas Schweizer (via Zoom) - DVTI camera project status update and kickstarter campaign kickoff

Andreas gave an overview of the DVTI project, an occultation camera with GPS time inserter developed by him and Stefan Meister, comparable to the QHY174M-GPS camera but without active cooling. They have also written *DVTI Cam Control*, which is comprehensive digital camera control software. Their project supports the IMX174 sensor (same as the QHY model) and the newer IMX430 with other sensors being tested. The hardware (image sensor) and firmware are user upgradeable. They now have a batch of cameras ready for purchase.

Roman Kostenko – Eclipse trips in 2020–2022 during the "Covid era"

Roman is a keen eclipse observer and he attempted to travel to shadow tracks during the Covid lockdowns. He couldn't get flights to countries in the Middle East for June 2020 so he observed a

Figure 8. Roman Kostenko reports about his attempts to observe solar eclipses during the Covid pandemic. (O. Klös)

partial eclipse from Europe, then South America was inaccessible to him in December 2020. In June 2021 Canada was closed to travellers, then he finally had a successful trip to Argentina in April 2022 where he saw a partial eclipse at sunset.

Bruno Morgado (via Zoom) - SORA: Stellar Occultation Reduction and Analysis

Bruno is a member of the team who developed *SORA*, a comprehensive Python-based open-source program suite for predicting occultation events through to reducing and analysing their shapes, sizes and astrometric positions. It is designed to deal with the rapid increase in occultation observations made possible by the *Gaia* Data Releases and the high volumes expected from the 'inventory of the solar system' by the *Vera Rubin Observatory* – big data! Bruno explained the functionality of *SORA* and he gave an overview of its latest features. Please look at *SORA* and participate in its development.

Andreas Schweizer (via Zoom) - DVTI Cam Control software

Andreas gave a brief demonstration of the DVTI+Cam for *MS Windows* camera control software, its integration with *Occult Watcher* predictions, generation of the report form, *ASCOM* telescope control and event selection and its recording scheduler.

Session 7 - Observations and Results
chaired by Pablo Santos-Sanz

Bernd Gährken - Diffraction effects at eta Leonis' occultation in May 2022

When the point source of a star is occulted by the lunar limb it produces diffraction effects. Bernd described his observation of the lunar occultation of eta Leonis on 2022 May 9, where he used an ASI290 colour webcam running at over 500 fps by selecting a tiny region of interest on the chip. He combined this with a dual

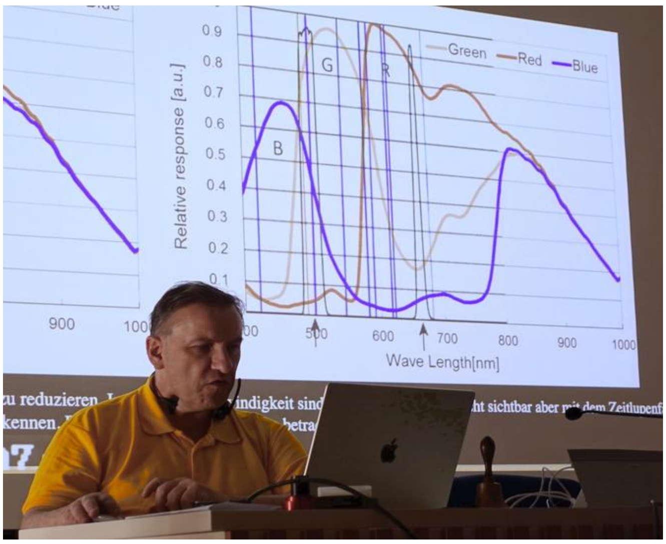

Figure 9. Bernd Gährken shows the transmission curves of the filters he had used for his observation. (O. Klös)

band filter (used to image the OIII and HII lines) and obtained Fresnel diffraction light curves in these two wavelengths. He discussed his results and explained that red giant stars display longer fading rather than diffraction effects.

Apostolos Christou (via Zoom) - Extraterrestrial occultations: the Beagle 2 experiment

Beagle 2 was a British-designed Mars lander for conducting astrobiology experiments. It landed on Mars on Christmas Day 2003 but it didn't open all its solar panels, so communication with it was lost. Tolis described his innovative proposal to use its onboard UV photometer to capture light curves of annular solar eclipses by Phobos and Deimos to measure the location of *Beagle 2*. He presented details of this technique and the results expected if it had been successful.

Mike Kretlow - On the stellar occultations by comets 28P/Neujmin 1 and 430P/Scotti

Mike discussed the challenges of predicting stellar occultations by comets, but unlike asteroids, inactive Centaurs and TNOs, comets incur non-gravitational effects (e.g., outgassing) and their photo centre can be offset from the centre of mass, affecting the astrometry and orbital calculations. Occultations by comets are of high scientific value but are elusive. Cometary nuclei are small, so dimming during an appulse is more likely than an occultation by the nucleus. Mike presented details of recent occultations by comets 28P/Neujmin 1 and 430P/Scotti, and predictions for the active Centaur 29P/Schwassmann-Wachmann 1.

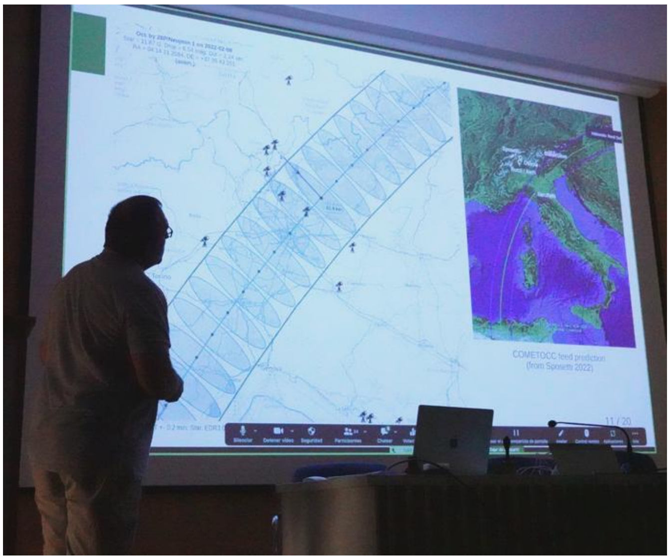
Figure 10. Mike Kretlow presents the locations of observing stations for the occultation by comet 28P/Neujmin 1. (O. Klös)

Robert Purvinskis - Baltic Adventure: Hyperborea, 23 Aug 2022

Robert talked about his collaboration with observers in the Baltic States to prepare for the occultation of a mag. 9 star by mag. 15 asteroid (1309) Hyperborea. The event was monitored by three observers from Latvia and one from Lithuania. All were negative observations but they gained valuable experience and hopefully they will attempt more events.

Session 8 - Predictions & Upcoming Events
chaired by René Duffard

Altair Ramos Gomes Júnior (via Zoom) - Prediction of stellar occultations by the space telescope CHEOPS

Space probes travelling to the outer solar system have observed stellar occultations during a flyby phase, and the *Hubble Space Telescope* had serendipitous success from Earth orbit. Altair said that an occultation by Quaoar in 2020 was the first TNO event to be predicted then observed from orbit, by the space telescope *CHEOPS*. The precise location of *CHEOPS* at any instant is affected by the irregular distribution of Earth's mass and he described how high-quality predictions can be generated and submitted to mission planners. It was hoped to observe the Triton occultation on 2022 October 6.

Pablo Santos-Sanz - Stellar occultations by TNOs from JWST?

Pablo described his Target of Opportunity (ToE) programme which aims to utilise the *James Webb Space Telescope* (*JWST*) to monitor occultations by the 40 largest Centaurs and TNOs. *JWST* moves around the Lagrange 2 point which adds to the difficulties, so predictions have to be frequently revised and aided by high-quality ground-based astrometry. He showed some predictions for 2022 and 2023. If an event meets various selection criteria a ToE observing request can be submitted to the *JWST* staff.

Figure 11. Pablo Santos-Sanz talks about occultation observations with the James Webb Space Telescope. (LOC ESOP)

Konrad Guhl, Carles Schnabel, José Luis Ortiz, Bruno Sicardy – Discussion panel – introduced by Mike Kretlow - Pro-Am collaboration: status and future; what is good, what is not so good?

Amateur (unpaid) astronomers enjoy working with professional astronomers in this field and contribute more than basic 'citizen science'. Amateurs can announce their raw results immediately, whereas professionals have a responsibility to their academic institutions and research funding / grants to publish scientific papers in peer-reviewed journals. Hence, the publishing timeline and information embargo affect which professional results can be made publicly available in the short term. This can be decided on a case-by-case basis.

Figure 12. Discussion panel with René Duffard, Mike Kretlow, Konrad Guhl, Carles Schnabel, José Luis Ortiz and Bruno Sicardy. (LOC ESOP)

Apostolos Christou (via Zoom) – AOP proposal to hold the 2023 ESOP at Armagh, Northern Ireland, UK

Tolis submitted the proposal from *Armagh Observatory and Planetarium* (AOP) to host ESOP XLII in Armagh, Northern Ireland on 2023 September 15 – 19. *Armagh Observatory* has a long history of astronomical research dating back to 1790 and in 1968 its Planetarium was established for public education and outreach. He showed Armagh's location in the UK, it Is served by airports in Belfast and Dublin (Republic of Ireland) and there are sites of historical and astronomical interest within Armagh, across Northern Ireland and also nearby in the Republic.

Konrad Guhl thanked all the delegates for attending ESOP in Granada and the online attendees for joining us via Zoom. He also expressed his thanks to the members of the LOC and for the IT support enabling and maintaining our hybrid meeting.

Monday 12th September 2022

On Monday morning we met in the grounds of the IAA and boarded our bus for the 2-hour drive through the arid, semi-desert landscapes of the Sierra de Los Filabres - where some Spaghetti Westerns were filmed - and up to *Calar Alto Observatory*, Almeria province, at an altitude of 2,168 m. The observatory is the Spanish Centre for Astronomy in Andalucia (Centro Astronómico Hispano en Andalucía, CAHA) and is managed by the Council of Andalucia and IAA-CSIC. During our private visit, support astronomer Stefan

Figure 13. Stefan Cikota (centre, with papers) answered many questions. (O. Klös)

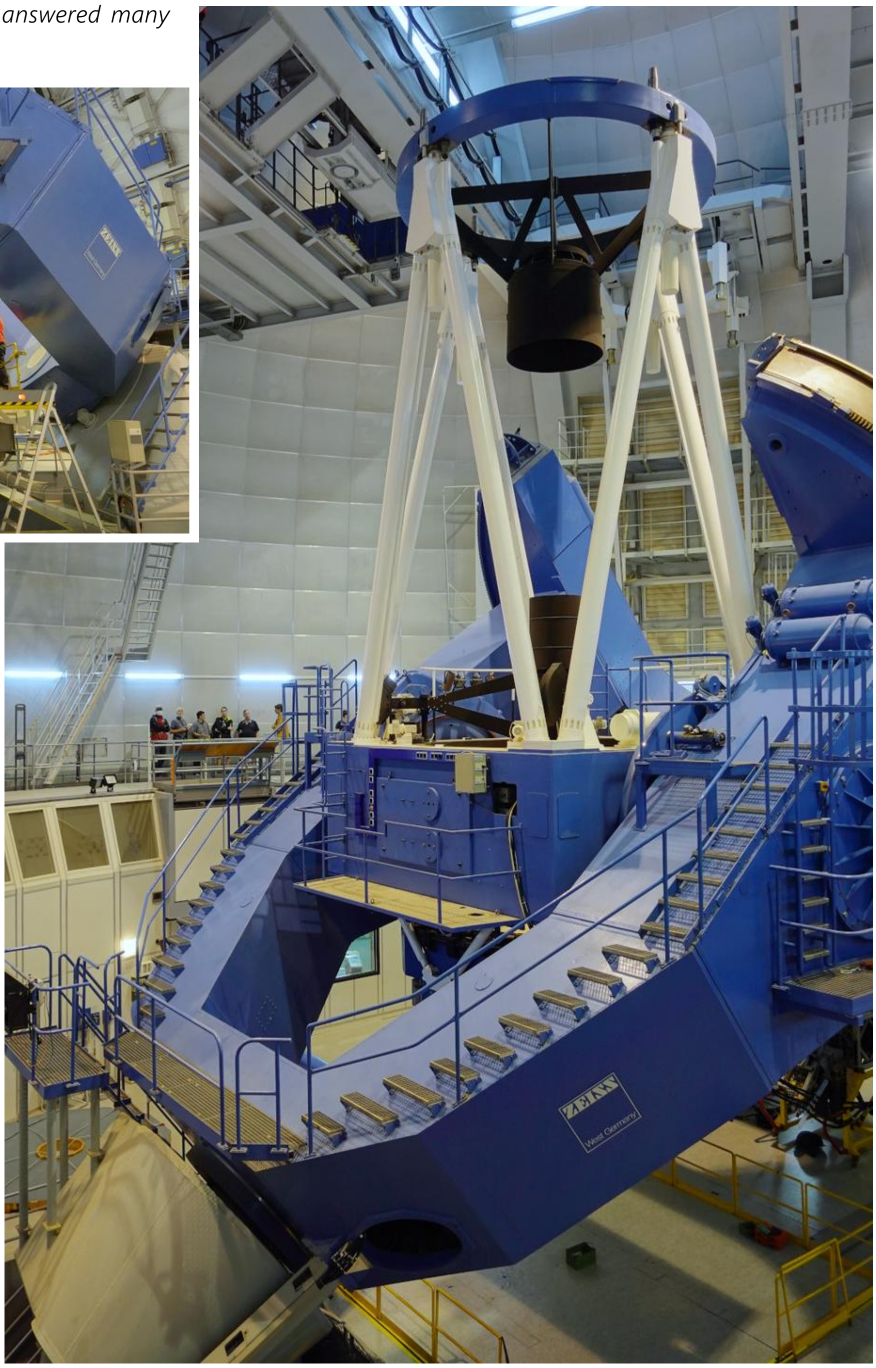

Figure 14, 15. The technicians are ready to remove the primary mirror of the 3.5-m telescope. (O. Klös)

Cikota guided us around the various telescopes on site which are used for a wide range of observations, from solar system bodies to galactic surveys (Figure 13).

Housed in a 40-m high building, the 3.5-m is the largest equatorially mounted reflecting telescope in western Europe (Figure 14). It is used for wide-field spectroscopy of galaxy clusters. We were fortunate to see its huge primary mirror being removed by technicians to be recoated onsite (Figure 15). A relatively smaller structure nearby houses the 2.2-m telescope (Figure 19), then another dome contains a 1.23-m instrument (Figure 18) and a short distance away is a 0.8-m Schmidt. There is a lot of additional equipment in other domes and buildings across the site, including meteor and fireball cameras mounted on the breezy outer gantry of the 2.2-m telescope, from where we could see the Mediterranean Sea and the distant coast of north Africa.

It was a sunny day with wisps of high thin cloud and at 2,000 m it was comfortably cooler than the 34°C in Granada. Our excursion included a leisurely lunch in a local village a short drive from Calar Alto, and we returned to Granada in the early evening.

Figure 16. The group on the walk to the next dome. (O. Klös)

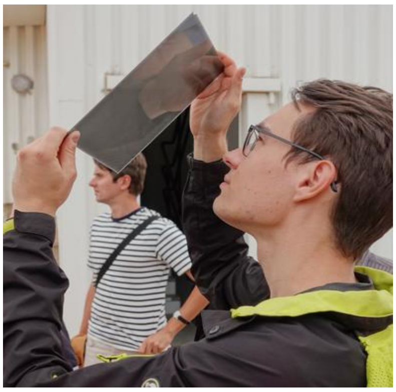

Figure 17. Maciej Borowski inspects an original glass plate taken at Calar Alto. (O. Klös)

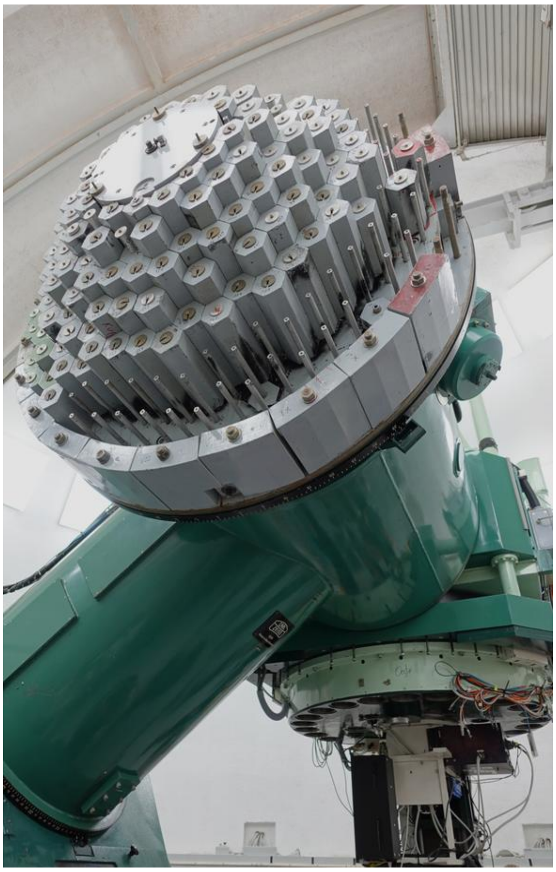

Figure 18. Counterweights on the 1.2-m telescope. (O. Klös)

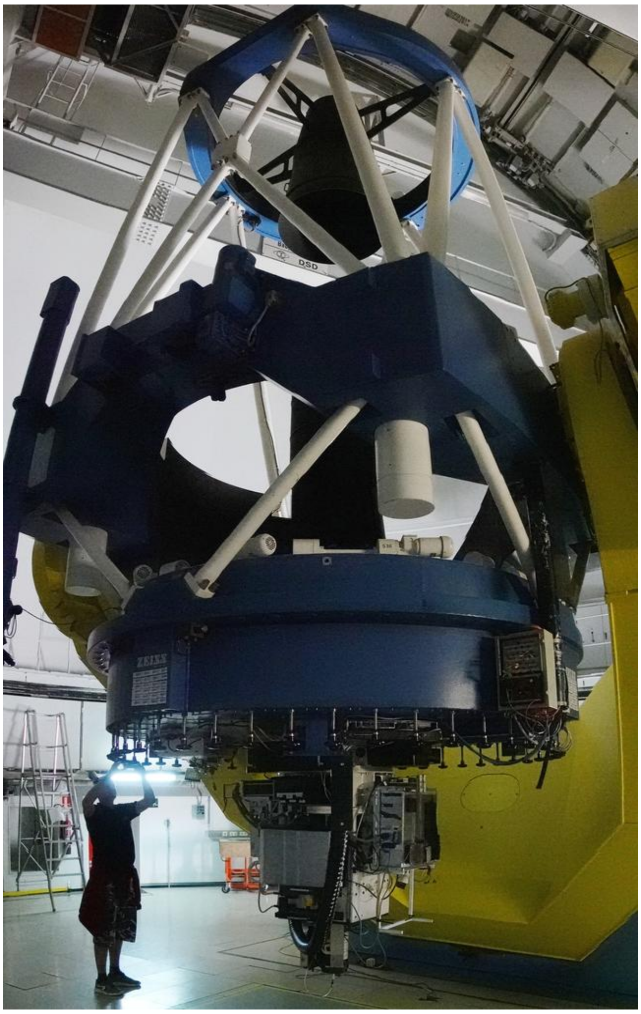

Figure 19. Wojciech Burzyński takes a photo of a detail of the 2.2-m telescope. (O. Klös)

Tuesday 13th September 2022

On Tuesday morning we gathered at the entrance to the Alhambra (Arabic for 'red palace') and were given a guided tour of the site including audio handsets. This building complex lies on a promontory overlooking Granada and has a long history of being a fortress and palace since the Middle Ages when the region was an Islamic state. For over two hours we were shown its Islamic architecture, including its gateways, courtyards, decorative tiled walls and ceilings, ornamental fountains and landscaped gardens.

After leaving the Alhambra a few of us went to the Parque de las Ciencias (Science Park) assisted by the LOC who booked taxis for us. It is a science museum covering 70,000 square metres comprised of museum exhibition halls, a biodome which recreates the natural habitats for wildlife across our planet and a planetarium and astronomy sections. We purchased tickets for the areas we wished to see then took lunch in the Via Lactea café. As well as general science exhibits, our visit included a wander around the astronomy garden to see the gnomons, sundials and celestial spheres, etc explaining the movements of the Sun, Moon and Earth, then we enjoyed a show in the planetarium.

Full details of the Symposium can be found here:
https://iota-es.de/esop41/

including the list of registered participants, speakers' abstracts (including their affiliations) and the programme timetable with links to speakers' PDFs (where available) and to YouTube recordings of each session.

Figure 20. Inside the Alhambra. (J. Kubánek)

Figure 21. Fantastic craftsmanship from the past inside the Alhambra. (J. Kubánek)

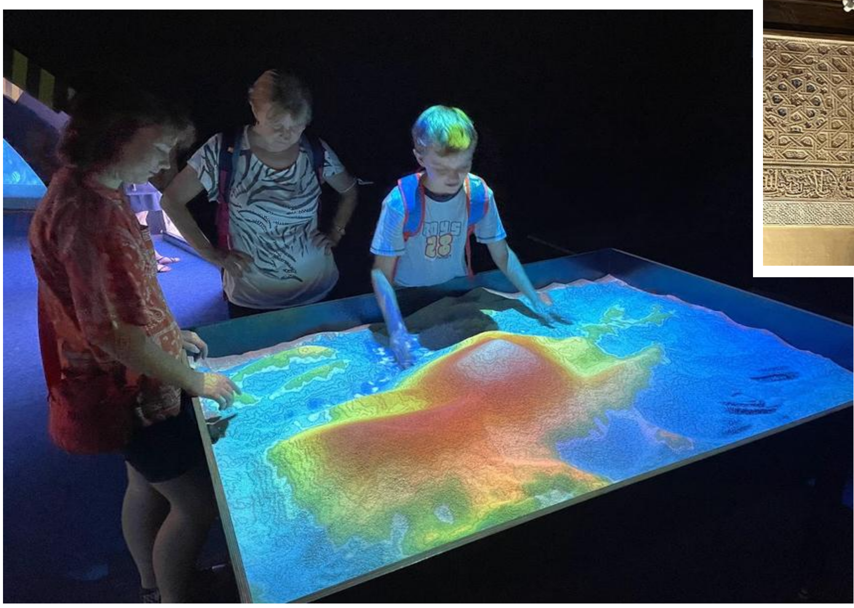

Figure 22. Simona Kubánková, Milena Kubánková and Martin Kubánek explore the Parque de las Ciencias. (J. Kubánek)

Journal for
Occultation
Astronomy

IOTA's Mission

The International Occultation Timing Association, Inc was established to encourage and facilitate the observation of occultations and eclipses It provides predictions for grazing occultations of stars by the Moon and predictions for occultations of stars by asteroids and planets, information on observing equipment and techniques, and reports to the members of observations made.

The Journal for Occultation Astronomy (JOA) is published on behalf of IOTA, IOTA/ES and RASNZ and for the worldwide occultation astronomy community.

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Imprint

Publisher: International Occultation Timing Association/European Section e.V.
Am Brombeerhag 13, D-30459 Hannover, Germany
Responsible in Terms of the German Press Law (V.i.S.d.P.): Konrad Guhl
Editorial Board: Wolfgang Beisker, Oliver Klös, Alexander Pratt, Carles Schnabel, Christian Weber
Additional Reviewers: Richard Miles — Contact: joa@iota-es.de
Layout Artist: Oliver Klös — Original Layout by Michael Busse (†) — Webmaster: Wolfgang Beisker
JOA Is Funded by Membership Fees (Year): IOTA: US$15.00 — IOTA/ES: €20.00 — RASNZ: NZ$35.00
Publication Dates: 4 times a year

Submission Deadline for JOA 2023-2: February 15

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www.occultations.org
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These sites contain information about the organisation known as IOTA and provide information about joining.

The main page of occultations.org provides links to IOTA's major technical sites, as well as to the major IOTA sections, including those in Europe, Middle East, Australia/New Zealand, and South America.

The technical sites hold definitions and information about all issues of occultation methods. It contains also results for all different phenomena. Occultations by the Moon, by planets, asteroids and TNOs are presented. Solar eclipses as a special kind of occultation can be found there as well results of other timely phenomena such as mutual events of satellites and lunar meteor impact flashes.

IOTA and IOTA/ES have an on-line archive of all issues of Occultation Newsletter, IOTA'S predecessor to JOA.

Journal for Occultation Astronomy

(ISSN 0737-6766) is published quarterly in the USA by the International Occultation Timing Association, Inc. (IOTA)
PO Box 20313, Fountain Hills, AZ 85269-0313

IOTA is a tax-exempt organization under sections 501(c)(3) and 509(a)(2) of the Internal Revenue Code USA, and is incorporated in the state of Texas. Copies are distributed electronically.

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