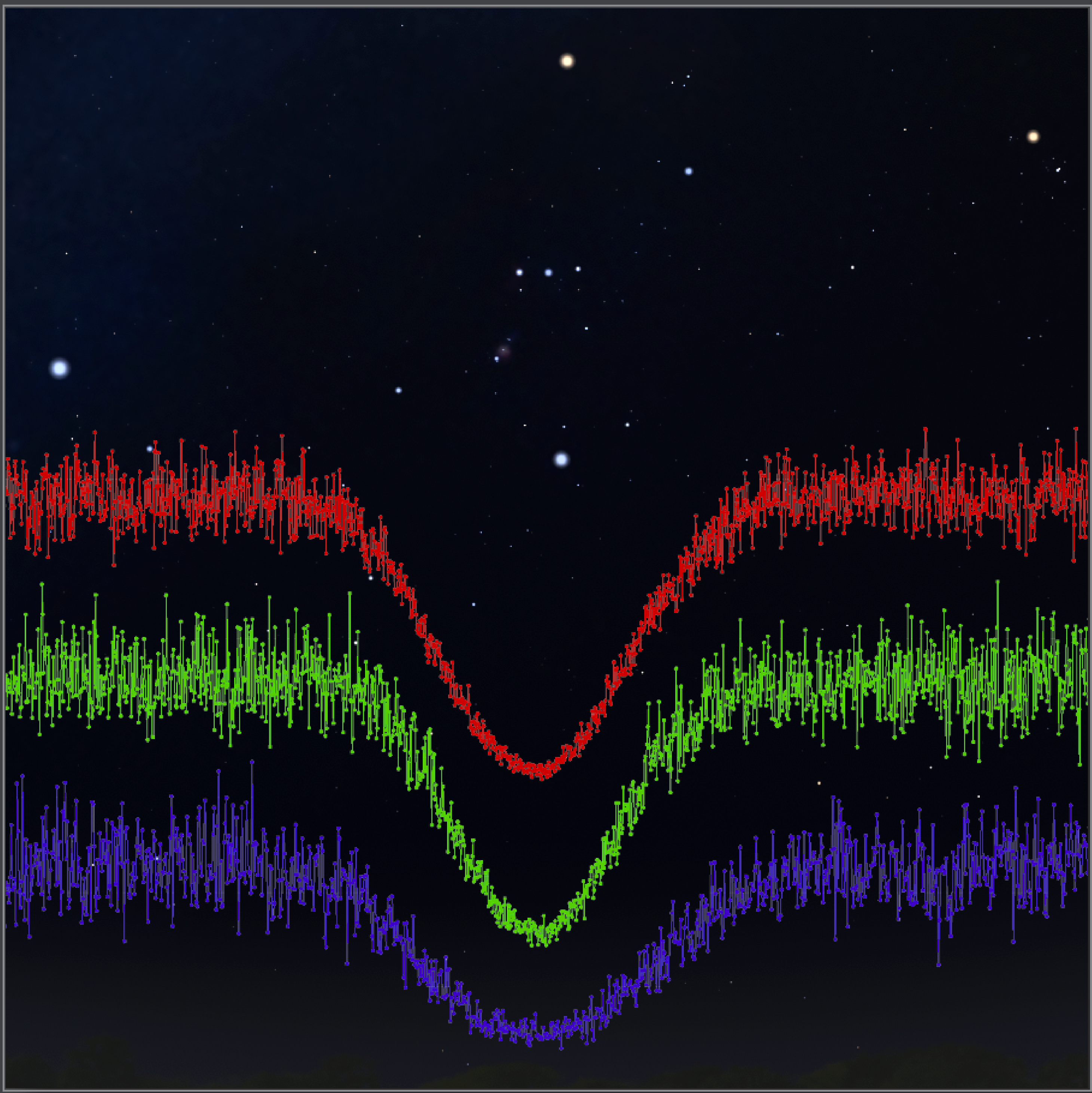
Journal for Occultation Astronomy

Volume 14 · No. 1 2024-01



Observations of the Occultation of Betelgeuse by (319) Leona

Dear reader,

Finally, the most awaited occultation arrived. The supergiant Betelgeuse was challenged by a small body in the Solar System, relegating it briefly to a humble star.

I was extremely lucky to be part of one of the observation stations in Spain. High clouds added a touch of uncertainty. In Italy clouds also caused suffering, but in the article included in this issue, the authors perfectly describe their preliminary results and also shows the feeling of great emotion, very similar to that experienced under a solar eclipse.

Calculations and models had already told us what we would see. But reality always outdoes fiction, in this case, prediction. We let the telescopes and cameras measure the photometry with different filters, taking spectra, with time controlled to a millisecond, but in that very brief time we looked directly at the star to see its light oscillate live. If a solar eclipse, which we know 100% will happen, is already exciting, what can we say about an event with an appreciable degree of uncertainty? Just the fact of seeing it was happening, was already an extraordinary event.

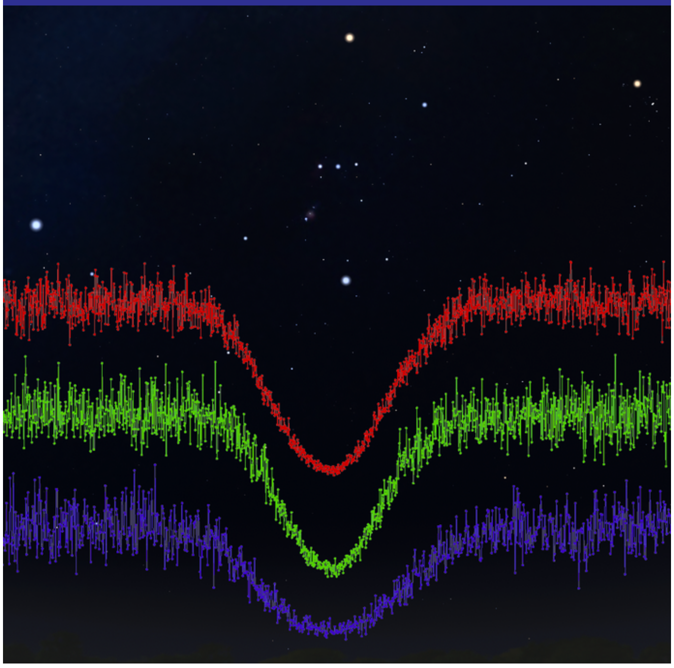
Such successful predictions were unthinkable a few years ago. It has not been only simply thanks to technology that has made it possible to obtain precise data of celestial bodies. It has also been a reward for the tireless work of the entire professional and amateur occultation community, and what a fine example of that is published quarterly in JOA. Congratulations on all the work and happy 2024!

Carles Schnabel
IOTA/ES

JOA Volume 14 · No. 1 · 2024-1 $ 5.00 · $ 6.25 OTHER (ISSN 0737-6766)

In this Issue:

COVER



Observers in several countries of southern Europe were able to measure the extraordinary stellar occultation of Betelgeuse by asteroid (319) Leona on 2023 December 12. Alfonso Noschese (AstroCampania, IOTA/ES) recorded the event in three wavelengths (see page 27 of this issue). Astronomers expect the measurements to provide new insights into the physical properties of the red giant. (Graphic: O. Klös with an image from Stellarium and data from A. Noschese)

Copyright Transfer

Any author has to transfer the copyright to IOTA/ES. The copyright consists of all rights protected by the worldwide copyright laws, in all languages and forms of communication, including the right to furnish the article or the abstracts to abstracting and indexing services, and the right to republish the entire article. IOTA/ES gives to the author the non-exclusive right of re-publication, but appropriate credit must be given to *JOA*. This right allows you to post the published pdf Version of your article on your personal and/or institutional websites, also on arXiv. Authors can reproduce parts of the article wherever they want, but they have to ask for permission from the *JOA* Editor in Chief. If the request for permission to do so is granted, the sentence "Reproduced with permission from *Journal for Occultation Astronomy, JOA*, ©IOTA/ES" must be included.

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 https://www.iota-es.de/how2write_joa.html .

Journal for Occultation Astronomy

Observing the 2023 October 14 Annular Eclipse from New Mexico

David and Joan Dunham · IOTA · Fountain Hills, Arizona · USA · dunham@starpower.net

ABSTRACT: We describe and illustrate our successful effort to record Baily's Beads during the 2023 October 14th annular eclipse from a location close to the southern limit. Some observations by others at other locations near both limits of annularity are noted. The observations will be analysed to determine a value for the solar radius that might aid predictions and planning for future solar eclipses.

Introduction

In the last issue of JOA, Konrad Guhl described his observations of the total solar eclipse of last April 20 in Australia, the latest, as of that issue, of a series of solar eclipses where IOTA observers have recorded Baily's Beads from near the edges of the path of central (total or annular) solar eclipses [1]. This continues that series of observations to the 2023 October annular eclipse, the last such eclipse that will be visible from North America until 2048 June 11.

Observation Site

We observed from the west side of Mentmore, NM, a small town near Gallup a few miles from the Arizona border. Our site very close to the southern limit of the eclipse was chosen with the aid of Xavier Jubier's interactive *Google* map for solar eclipse observers [2] and also using the various weather services, particularly the GFS cloud cover forecast from [3]. We wanted a location less than a 2-day drive from our Arizona location with a forecast of clear weather and good observing locations.

The site we selected was near a tourist gift shop currently closed for renovations. The caretaker gave us permission to observe from that location and his two puppies enthusiastically welcomed us. It was quiet, dry, away from the road, and very private. The dogs eventually were bored with our lack of attention to them and did not disturb us during the event. The coordinates were latitude 35° 30.018' N, longtitude 108° 51.478' W, altitude 1967 m.

Observation Equipment

We used a Celestron NexStar SLT 127, a 127mm Maksutov-Cassegrain with an Orion glass solar filter on a powered alt-az mount with a focal ratio of 12. We recorded the eclipse with a RunCam Astro II video camera with a 0.5× focal reducer and timing with an IOTA Video Time Inserter. The NTSC AVI video from the camera, after time insertion, was recorded using IOTA Video Capture on a *Windows 11* laptop. This is a telescope, camera, and recording system we often use for recording occultations by the Moon, and sometimes by asteroids.

Figures 1, 2, and 3 show our equipment and the observing location. As shown in Figure 3, we put the laptop in a small suitcase to make it easier to shade the screen, using a black towel and our hat brims to add more shade.

Figure 1. Joan (left) and David observing the eclipse.

Our Observations

One problem annular eclipse observers face is that the Sun, while slightly reduced by the eclipse, is very present, making observing more difficult and setting appropriate camera exposure to capture the bead details while avoiding over exposure. Exposing for the faintest beads risks losing other beads in overexposed images, while setting exposure to get good edges on the uneclipsed portions of the Sun can make the faintest beads nearly impossible to discern. After some experimentation, we settled on low settings of: Max gain, 2; night shutter 1; and brightness 32. That allowed us to get good focus on the Moon's edge and on sunspots; we recorded the occultation of one prominent sunspot group.

Figure 4 presents the most active parts of the second and third contact beads at 1-second intervals. At our location, the time from the first bead we recorded to the last was 7.5 minutes with approximately 21 seconds of annularity. Jubier's limb-correction was 8 s, so our beads were likely a little overexposed relative to his prediction; of course, the duration of annularity is very sensitive to location near the limit. Links to .mp4 versions of our recordings

Figure 2. Telescope and Camera Setup. The telescope, a Celestron NexStar SLT 127, has a RunCam Astro II sending NTSC AVI video to the IOTA Video Time Inserter (black box on the ground under the telescope) for GPS time insertion before capture to the laptop.

Figure 3. Laptop displaying video. The laptop is shielded from the Sun in a small carry-on suitcase with the aid of a black towel.

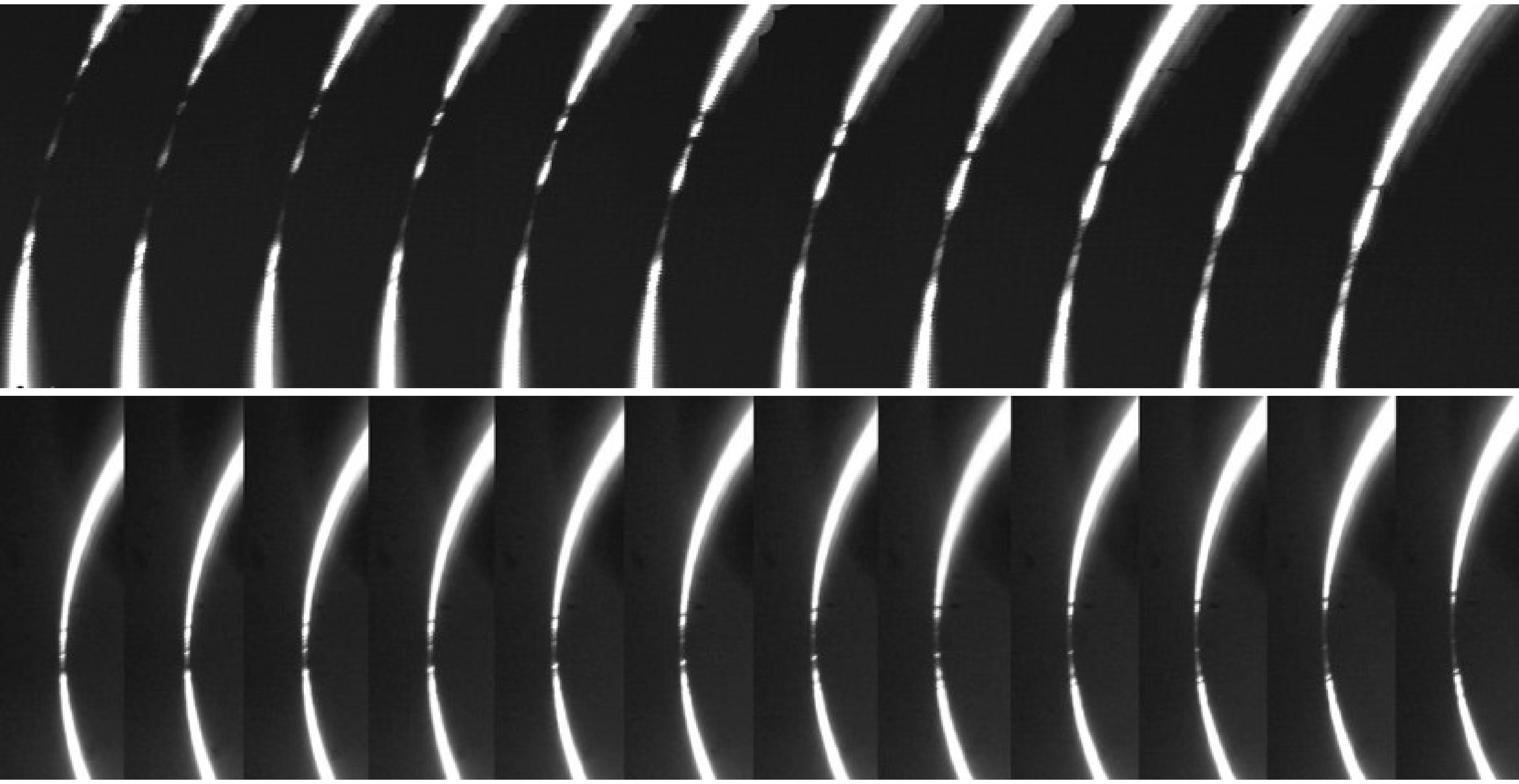


Figure 4. Baily's Beads at second (upper sequence) and third contact.

can be found in a section about the eclipse near the top of the 2023 North American grazing occultations page [4]. After the annular phase, chickens on the property noticed the increasing sunlight and announced the "second dawn".

Observations by Others

Several others recorded the eclipse near the path edges, but most of these either had lower resolution and/or lacked an accurate time base. An exception was Richard Nolthenius and Kirk Bender, who recorded the eclipse with 8-inch telescopes and IOTA-VTIs from a site about two miles inside the southern limit near Eureka, Nevada. A large group recorded the eclipse near the northern limit at Vista Grande Overlook (near Santa Fe, NM); Michael Zeiler there recorded WWV time signals with his recording available at [5] and others gave mostly anecdotal accounts on the Solar Eclipse Mailing List [6]. Luca Quaglia and John Irwin summarised northern-limit observations made from four separate locations and gave a preliminary analysis of them on SEML in an Oct. 28th message.

Luca concluded:

"As a final reminder, the eclipse solar radius is the parameter that goes into precise eclipse computations to describe the radius (at 1 AU) of the Sun, considered as a perfect sphere with a hard edge, and required to reproduce observations as best as possible. Physical reality is of course different."

Analysis

Our video is being provided to Dan McGlaun [7], and any others who may want it, for beads analysis using methods similar to those described by Guhl [1]. McGlaun's purpose is to improve the prediction for a Baily's Beads simulator used to prepare for total solar eclipse observations. Others who recorded Baily's Beads during the 2023 October eclipse are encouraged to share their observations with him. Dan's eclipse prediction web site is at [8].

References

[1] Guhl, K., Baily's Beads Observation during the Hybrid Solar Eclipse 2023 April 20, JOA 2023-4.

[2] Jubier, X., http://xjubier.free.fr/en/site_pages/solar_eclipses/ASE_2023_GoogleMapFull.html

[3] https://weather.us/model-charts/gfs

[4] Riedel, E., Dunham, D., Lunar Grazing Occultation Maps for North America for 2023, https://occultations.org/publications/rasc/2023/nam23grz.htm

[5] Zeiler, M., Video recording from the northern limit https://www.youtube.com/watch?v=22F-HNcizoQ

[6] Solar Eclipse Mailing List, SEML@groups.io

[7] dan@mcglaun.com

[8] McGlaun, M., Eclipse prediction web site, https://eclipse2024.org/

Ring of Fire - On the Annular Solar Eclipses Observed in the Past

Marek Zawilski · IOTA/ES · Polish Amateur Astronomers Society · Lodz Division · Section of Observations of Positions and Occultations · Łódź · Poland · marek.zawilski@p.lodz.pl

ABSTRACT: Recently (2023 October 14), the annular solar eclipse could be admired by observers in North and South America. Such a phenomenon still arouses interest, even though it is much less spectacular than a total solar eclipse. At present, we treat it as one type of solar eclipse, easily predictable. However, in the past this was not so obvious, and compared to the spectacular and often feared total eclipses, much fewer observations of annular eclipses have been preserved. The paper recalls these past events, as well as the evolution of views on their origins.

Early Observations of Annular Solar Eclipses

Nowadays, it is hard to believe that among the large number of observations of solar eclipses from ancient times, not one of them concerned an annular one! For example, a rich collection of Babylonian observations concerns numerous partial eclipses and one total. A similar situation occurred in China. Some eclipses observed from different places in Europe and the Middle East, were described as deep partial, although they were annular in other places not far away (for instance an observation near Chaeroneia in Greece on -393 August 14). Annular eclipses were easily remarkable near the horizon, but no such ancient report has survived [1].

We only have reliable records from the Middle Ages. The astronomer al-Iranshari in Neyshabur, Iran, noticed after sunrise on 873 July 28, that the Moon was visible against the Sun, with sunlight surrounding it on all sides (Figure 1). We owe this information to al-Biruni, who provided it in one of his works [1].

The first European reports were unclear. On 733 August 14, the Ecclesiastical History by Bede gave the information on a terrible black shield covering the Sun as seen from Jarrow, northern England, quite far from the path of annular eclipse. The annals from Brauweiler in Rhineland-Palatinate, Germany, noted that on 1147 October 26, "a circle of diverse colours and spinning rapidly" was remarked during a solar eclipse. Of course, this description, as one can assume, was a result of looking at the Sun with the unaided eye. Near the path of annularity, on 1207 February 28, many witnesses of the phenomenon in Germany (at Köln and Hirschau) reported a head was visible in the Sun. We then can analyse the description of the sighting on 1263 August 5, when it got dark while King Hakon of Norway was travelling to the Orkney Islands and a solar ring was noticed in the sky. However, since the Orkney Islands were outside the annular eclipse path, the observer must have been located somewhere in Norway and he likely could see the Sun through thin clouds. The same phenomenon was described in the Erfurt annals as a "general", and in Krakow as a great. Krakow was inside the path of annularity and Erfurt outside it but close to; apparently no more details could be seen with the naked eye from these two places.

Figure 1. Annular eclipse of 873 July 28 as seen at Neyshabur, Iran.

The only observation from China dates back to 1292 January 21, when the history of the Yuan dynasty recorded probably from Beijing that during an eclipse the Sun looked like a golden ring.

The penultimate important pre-telescopic report again comes from Europe and is little known, perhaps because it has been included in an astronomical treatise and not in a narrative source. Namely, a Franciscan, Guy de la Marche, argued that during some solar eclipses the Sun might not be completely covered by the Moon, as it was observed (correctly!) on 1310 January 31 in Paris. The unusual phenomenon observed in Rome by Christopher Clavius on 1567 April 9 and described by him as the annular solar eclipse was in fact of another kind – this was a short total eclipse but the inner solar corona was seen as a bright ring.

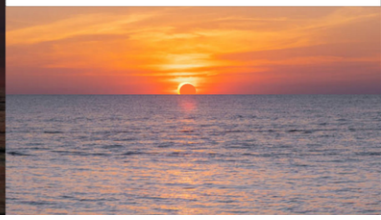
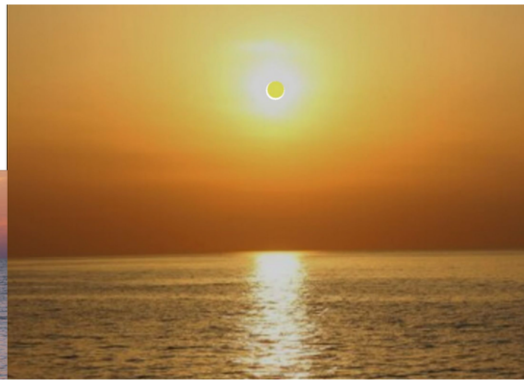




Figure 2. Annular eclipse of 1601 December 24 as seen at Bergen (left), at Trondheim (middle) and Goes (right).

In summary, early observations of annular eclipses can be considered accidental. Attempts to predict solar eclipses, if any, did not distinguish between their types, which required knowledge primarily of the angular sizes of the Sun and the Moon at the moment of the New Moon, and these were known with limited accuracy in pre-telescopic times. Besides, annular eclipses could be treated as partial ones (because no effect of a sudden darkness took place and a distinct black disk in front of the Sun was hardly seen). Better data and discussion on lunar and solar eclipses one can find later in "Astronomia Danica" (1622) by Christian Severin (Longomontanus). He also quoted an information in a report of a fisherman who saw the annular eclipse before sunset on 1601 December 24 on the sea near Bergen (Norway), while Longomontanus himself watched a deep partial eclipse on the horizon at Trondheim (Figure 2). The same eclipse was described as annular at Goes, the Netherlands, too, according to a careful observation by Philippe van Lansberge (Lansbergen), whose report, however, was not precise enough for this place. He watched the Sun through light clouds at the altitude of 11 degrees trying to measure the diameters of the Sun and the Moon. Despite this, the sunlight must have been too bright and the eclipse seemed to be annular but not a full annulus appeared at Goes in fact (Figure 2).

Finally, Johannes Kepler gave a theory of solar eclipses and methodology of their prediction in relation to "Tabulae Rudolphinae" (1627). He proposed a "projection method" i.e. calculation of the apparent position of the Sun and the Moon in the sky around the time of New Moon considering the lunar parallax and angular diameters of both bodies, stating that annular eclipses were possible in certain situations depending on the distance of the Sun and the Moon from Earth.

Observations of Annular Eclipses in the 18th Century

In the 18th century theories of eclipses were better and better as well as astronomical telescopes were in use for a longer time. And fortunately, numerous annular solar eclipses took place in this century.

So, on 1737 March 1, the annular eclipse was predicted and observed at many places, especially in Scotland (Figures 3, 4).

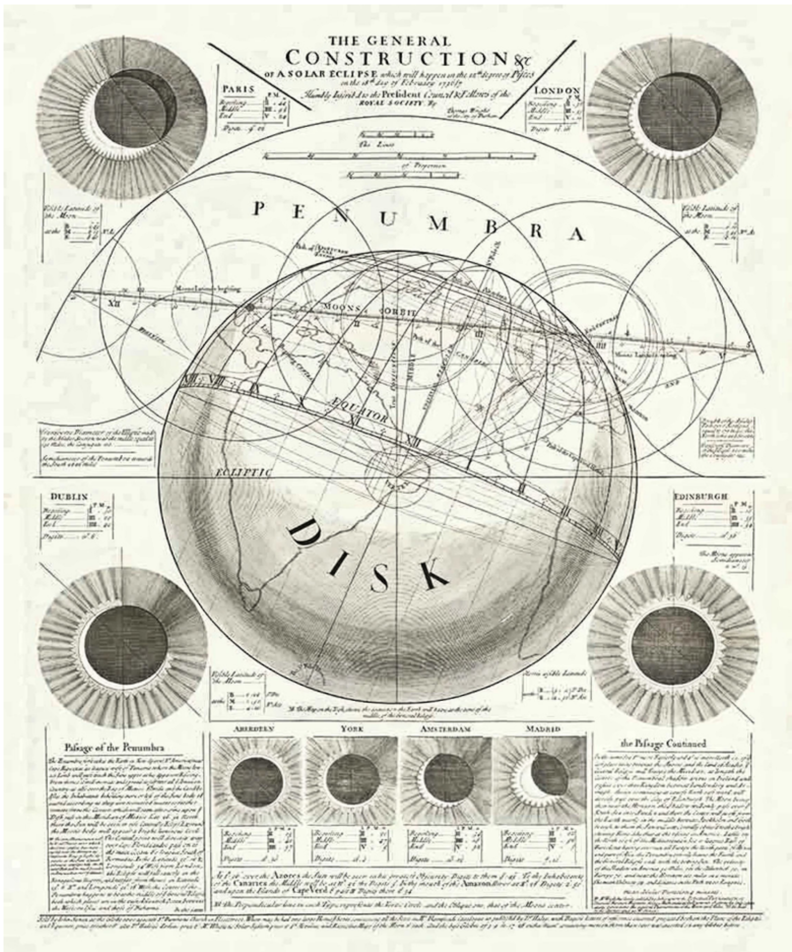


Figure 3. The prediction of the annular eclipse of 1737 March 1 by John Wright [2].

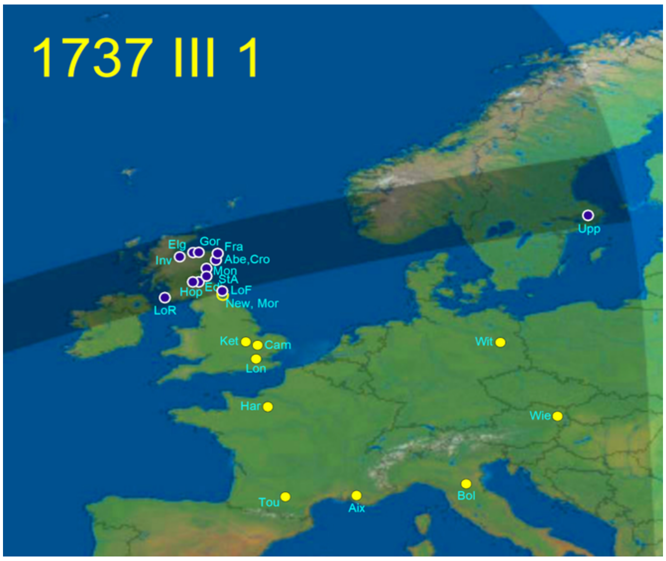


Figure 4. Annular eclipse of 1737 March 1 observed at numerous sites in Europe [3].

This was the first collection containing the precisely-timed contacts of an annular solar eclipse in the past. At Crosby and Montrose the annular phase lasted even 7 minutes and a little less at other places. Additionally, at Crosby Venus was remarked in the sky and at Edinburgh apart from Venus, Saturn and Capella were seen, too. On the other hand, at Longfarmlington, near Morpeth, Long reported only about 40 seconds of annularity; and, for instance, at Morpeth John Wilson did not record a full annulus but, according to him, the eclipse seemed to be annular while observing with the naked eye. The advantage of using telescopes was evident. Pierre Charles Lemonnier, who came to Scotland from France, observed in a group at Aberdour Castle. He carefully measured the angular diameters of the Sun and the Moon (and found them as 31′ 40″ and 29′ 47.5″, respectively); also, he tried to watch the Sun with the naked eye remarking no Moon in the Sun around the maximum phase; however, maybe because he was short-sighted. At this place, according to the report by James Short, the eclipse was not fully annular, and the solar cusps were at a distance of 1/7th of the lunar circumference to be joined; many irregularities of the lunar limb and a kind of "a brown light" was remarked which was a simplified description of the light of the chromosphere at the ends of the cusps. Uneven lunar limb was noticed by Bryce at Aldiston and Irwin at Elgin; also, at Edinburgh Colin Maclaurin collected several reports of the phenomenon called later "Baily's beads" [4].

The next opportunity to observe an annular eclipse came shortly thereafter, on 1748 July 25 and again most of the observations were made in Scotland (Figure 5).

The longest annular phase (of 6 minutes 24 seconds) was recorded this time at Dundee and the shortest one (of 1 minute and 22 seconds) at Berlin by Johann Kies and Augustin Nathanael Greschow. Venus was remarked at Aberdour Castle and Berlin (where also Mars was noticed in the sky). At Stryj, Ukraine, a naked-eye observation said about a view "as a plate rotated swiftly around"; a strange occurrence but (what is most interesting) very similar to that described 600 years ago at Brauweiler!

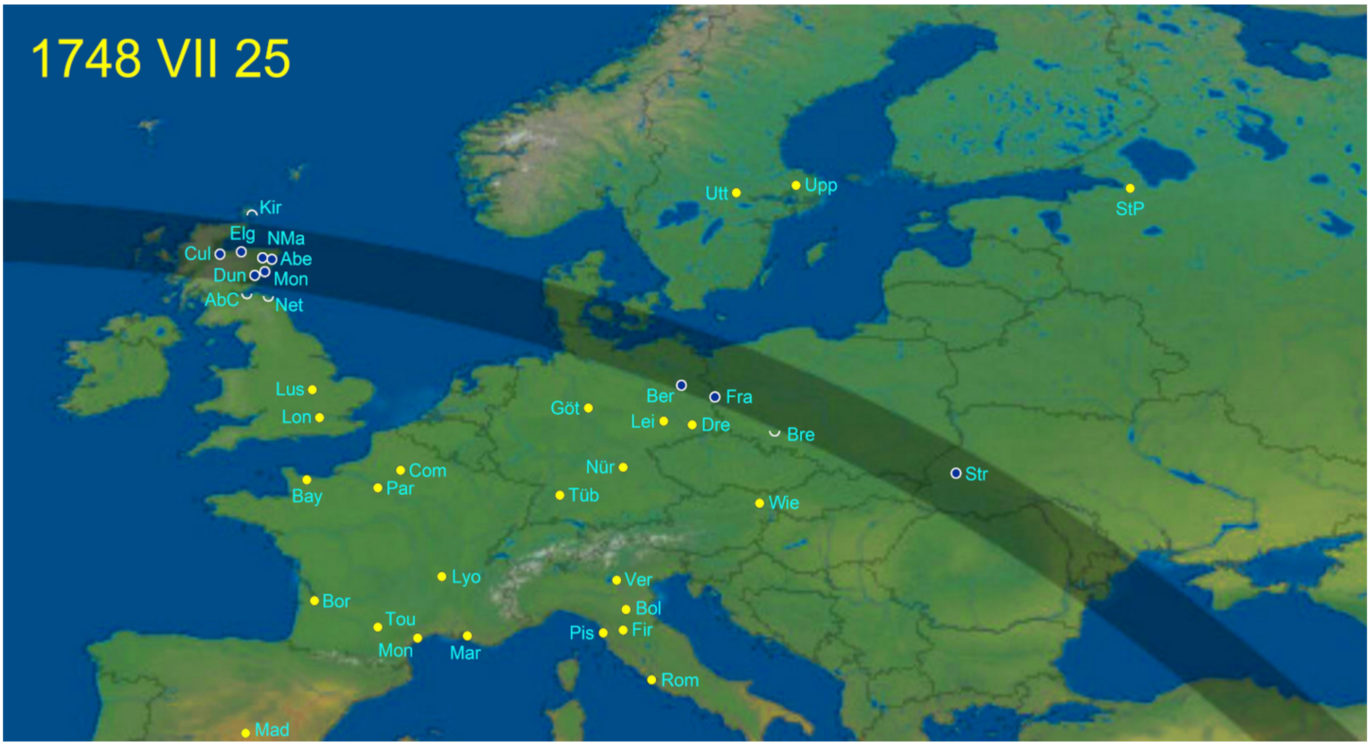


Figure 5. Annular eclipse of 1748 July 25 observed at numerous sites in Europe [3].

And again, after not a very long time, on 1764 April 1, a next annularity could be seen in Europe – from Spain to Sweden. For instance, at Calais, Vire and Caen, France, as well as at Härnösand, Torneå and Pello, Sweden, a central or almost central annular eclipse was recorded with the duration of about 6 minutes. On the other hand, at Catham, England, annularity near the limit was reported and at Oxford no formation of the annulus took place. In France, Nolon seemed to be placed at the limit of annularity whereas at Troyes, Châlons, Auxerre and Kergars no annular eclipse was noticed.

Finally, at the end of the 18th century, on 1793 September 5, the annular eclipse could be admired by the observers from Iceland through Norway, Denmark, Sweden, Germany and Poland. At Kristiansand, Norway, and Warsaw, Poland, the eclipse was recorded as central for about 6 minutes. At Königsberg, Prussia the annular eclipse was seen for 2 minutes and at Augustovo, present Belarus, close to the northern limit, the annulus did not form (despite the presence of the King of Poland among the observers...). By the way, the visibility of planets was recorded outside of the path of the annular eclipse: Venus was noticed at Enschede, the Netherlands, and Venus and Mars at Hamburg, Germany. Careful observations at Slough, England, and Lilienthal, Germany, allowed to study the inequalities of the lunar limb.

An Observation Progress in the 19th and 20th Century

At the beginning of the 19th century one annular eclipse, on 1804 February 11, could not be observed due to bad weather. But soon, on 1820 September 7, the annularity was recorded well, mainly in Germany, the Netherlands, France, Switzerland and Italy. This eclipse has been described by the author earlier [3]. The annular eclipse was longer than 5 minutes at Bremen, Göttingen, Cuxhaven, Augsburg and Frankfurt am Main, Germany, as well as at Fiume, Italy. But at Plön, Germany, the Duke of Holstein noted 55 seconds of a solar ring and at Weiningen, Switzerland, 49 seconds of annularity was recorded only! But even a shorter one was observed at Amsterdam where Greve could assess the duration of 44 seconds. At the same time, at Leyden an almost grazing annular eclipse was noted. Gruithuisen at Kuschwarta and Nicolai at Mannheim again described the phenomenon of "Baily's beads".

However, this phenomenon was analysed later by one of the observers of the next annular eclipse on 1836 May 15. On that day, a careful observation by Francis Baily at Inch Bonney, England, provided the most detailed description of it (although again similar data were collected by Henderson at Edinburgh!). At other places in England, Denmark, Germany and Poland, annularity was studied, too. And at Armagh, Ireland, the annular eclipse was recorded by Robinson for 22 seconds only but he could not assess it very precisely because of distinct irregularities of the lunar limb. Baily especially studied his "beads" during the total eclipse on 1842 July 8 at Pavia, Italy and described them again. Despite similar observations made then by other astronomers (for instance Peytal, Petit, Guérin, Airy, Zantedeschi), too, the beads phenomenon has been connected with Baily since that time.

On 1847 October 9, few observations were possible (the duration of 7 minutes at Cilly, Austria) but Baily's beads as a known phenomenon was studied at some places in France, Austria and Italy. And at Colmar, France, Parès noticed the lunar limb a little bit outside the solar disk.

A unique situation took place on 1858 March 15 in England. During this eclipse there was literally a "chasing the ring of fire", because the annular phase path was extremely narrow (less than 12 km in south-western England!) (Figure 6).

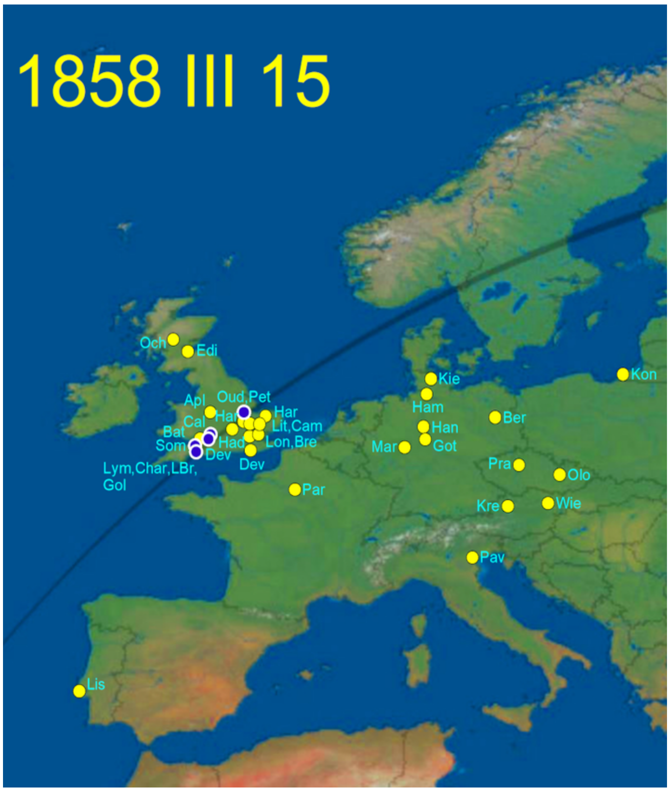


Figure 6. Annular eclipse of 1858 March 15 with the narrow path as observed across England [3].

Unfortunately, the observations usually were performed through clouds; so, a few observers achieved a success only: at Devizes the ring was noticed for 5 seconds, at Peterborough for several seconds, at Little Bridy for 7-8 seconds and at Golden Cap as if annular eclipse was seen for a while. At other places the event was described as almost annular (a rapidly transforming solar crescent), sometimes with Baily's beads and traces of the chromosphere remarked [4].

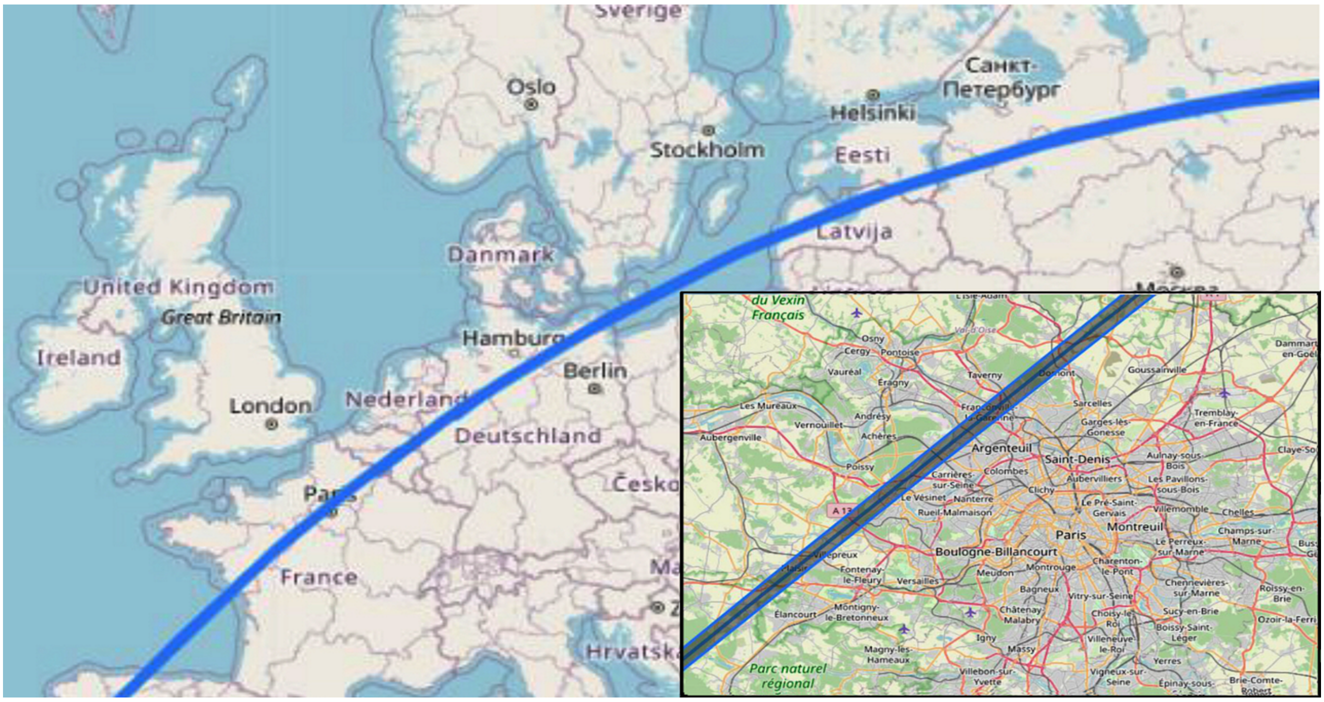


Figure 7. The path of the annular solar eclipse of 1912 April 17 across Europe and the Paris region.

More than 50 years later, on 1912 April 17[1], a similar occurrence took place, when a short annular eclipse could be observed in Europe (and it was hybrid for the terrestrial globe) when the width of the path strongly depended on the location and the coordinates of the central line were not known with full accuracy (Figure 7).

[1] The eclipse occurred 2 days after the sinking of "Titanic"!

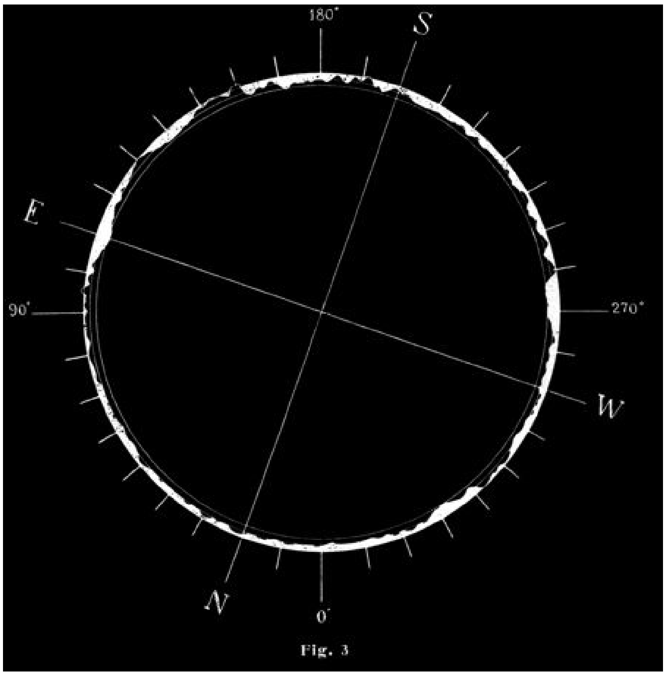


Figure 8. Lunar circumference as seen in the Sun on 1912 April 17 [6].

In such situations, some mass observations have been arranged. For instance, between Trappes and Neauphle, west of Paris, about 400 pupils were deployed perpendicularly in relation to the predicted path and some of them reported either a short annularity or a deep partial eclipse only (at present, we know that the width of the annularity path was merely about 2 kilometres in that region!). At many other places along the path in France, Belgium and Germany, an annular eclipse for several seconds have been recorded and photographed. In some places in Russia the annular phase lasted much longer (up to 20-30 seconds). Baily's beads for the first time were noticed on the whole circumference of the Moon (Figure 8) and the eclipse had even been filmed (for instance at St.Germain-en-Laye and Grand-Croix, France, Namur, Belgium, and Hagenow, Germany) [6].

References

[1] Stephenson, F.R., Historical Eclipses and Earth's Rotation. Cambridge University Press, 1997.

[2] https://www.etsy.com/in-en/listing/1174236817/old-solar-eclipse-chart-1737-by-john

[3] Zawilski, M., A Catalogue of Historical Solar Eclipses. Journal for Occultation Astronomy, vol.10, no.3, 2020-03, p.3-7.

[4] A Collection of the Observations of the Solar Eclipse, Feb. 18. 1736-7 sent to the Royal Society. Philosophical Transactions of the Royal Society of London, 40, 1738.

[5] Observations of the Annular Solar Eclipse of March 14–15, 1858. Monthly Notices of the Royal Astronomical Society, 18, 1858, p.183-250.

[6] Jubier, X., Hybrid Solar Eclipse of 1912 April 17 over Europe http://xjubier.free.fr/en/site_pages/solar_eclipses/HSE_19120417_pg01.html

Journal for Occultation Astronomy

Grazing Occultations of Stars and Planets by the Moon in 2024

Eberhard Riedel · IOTA/ES · München · Germany · e_riedel@msn.com

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.

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 mag 1.5 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 figures in this article were created with the author's *GRAZPREP*-software. Further precise information on the local circumstances of all grazing occultations, also depending on 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 favourable occultation events and in figuring out the best observing site in advance or even underway by graphically showing the expected apparent stellar path through the lunar limb terrain. The fainter stars are calculated with their highly-precise position from 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 to 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 to 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

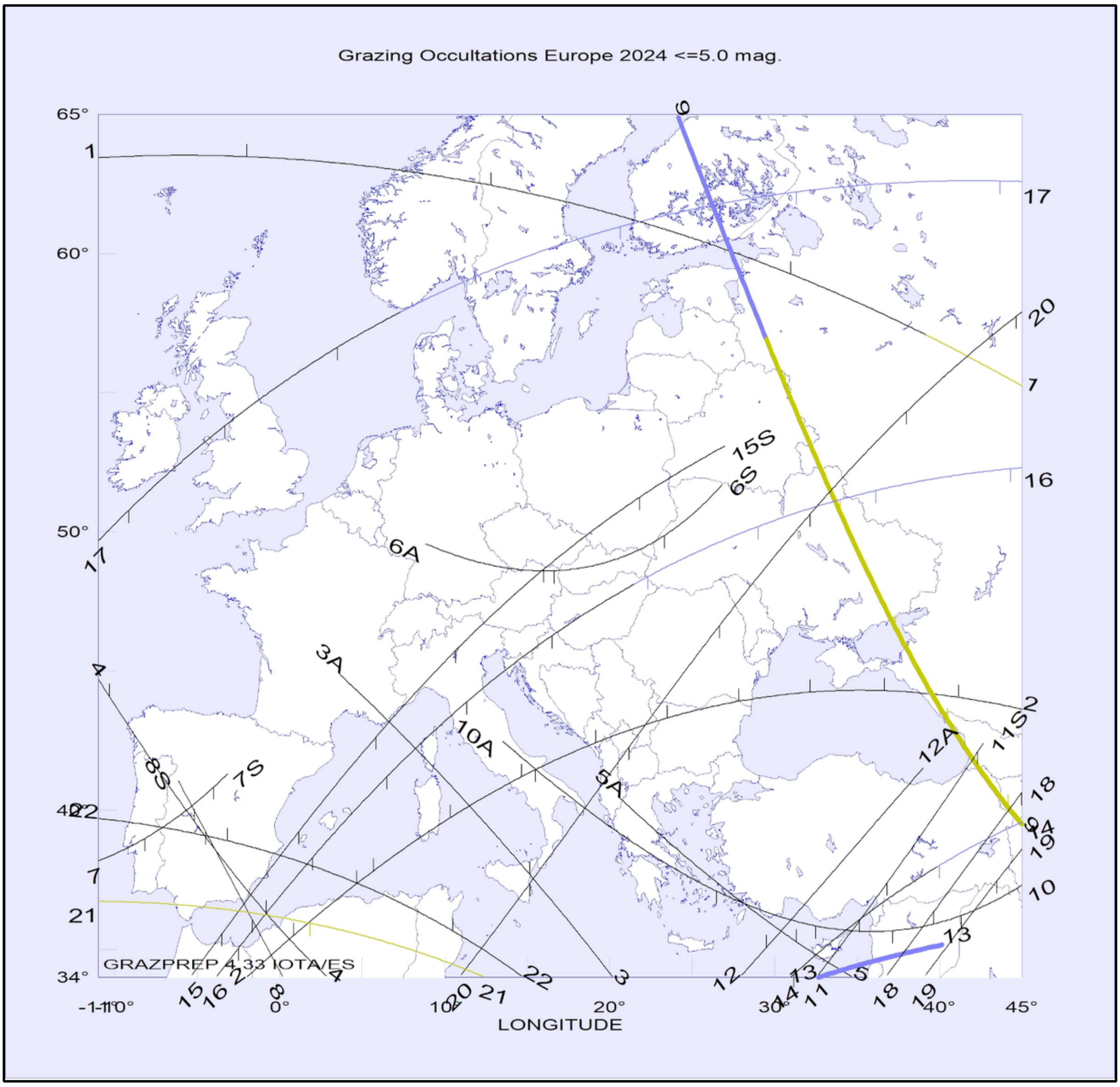
Double Star Codes:

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

2024	Grazing Occultations Europe 2024 <= 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 19**	ZC 465	93328	4.3	68+	S	22 43.1	-11 63	Botein delta Arietis		
2	**Jan 22**	ZC 890	77675 V	4.6	92+	S	18 24.7	-2 34	136 Tauri NSV 02696	4.8	6.3
3	**Feb 04**	ZC 2237	183686	5.0	38 -	S	2 44.0	3 45	42 Librae NSV 20363		
4	**Mar 30**	ZC 2298	184068	5.0	79 -	S	3 29.1	-11 45			
5	**Apr 03**	ZC 2912	188742	4.5	39 -	S	1 54.8	20 40	Terebellum 59 Sagittarii		
6	**May 02**	ZC 3164	164520 U	4.5	42 -	N	2 23.7	8 50	epsilon Capricorni	5.0	6.3
7	**May 02**	ZC 3175	164593	4.7	41 -	N	4 54.4	-11 38	kappa Capricorni		

(Continued on next page)

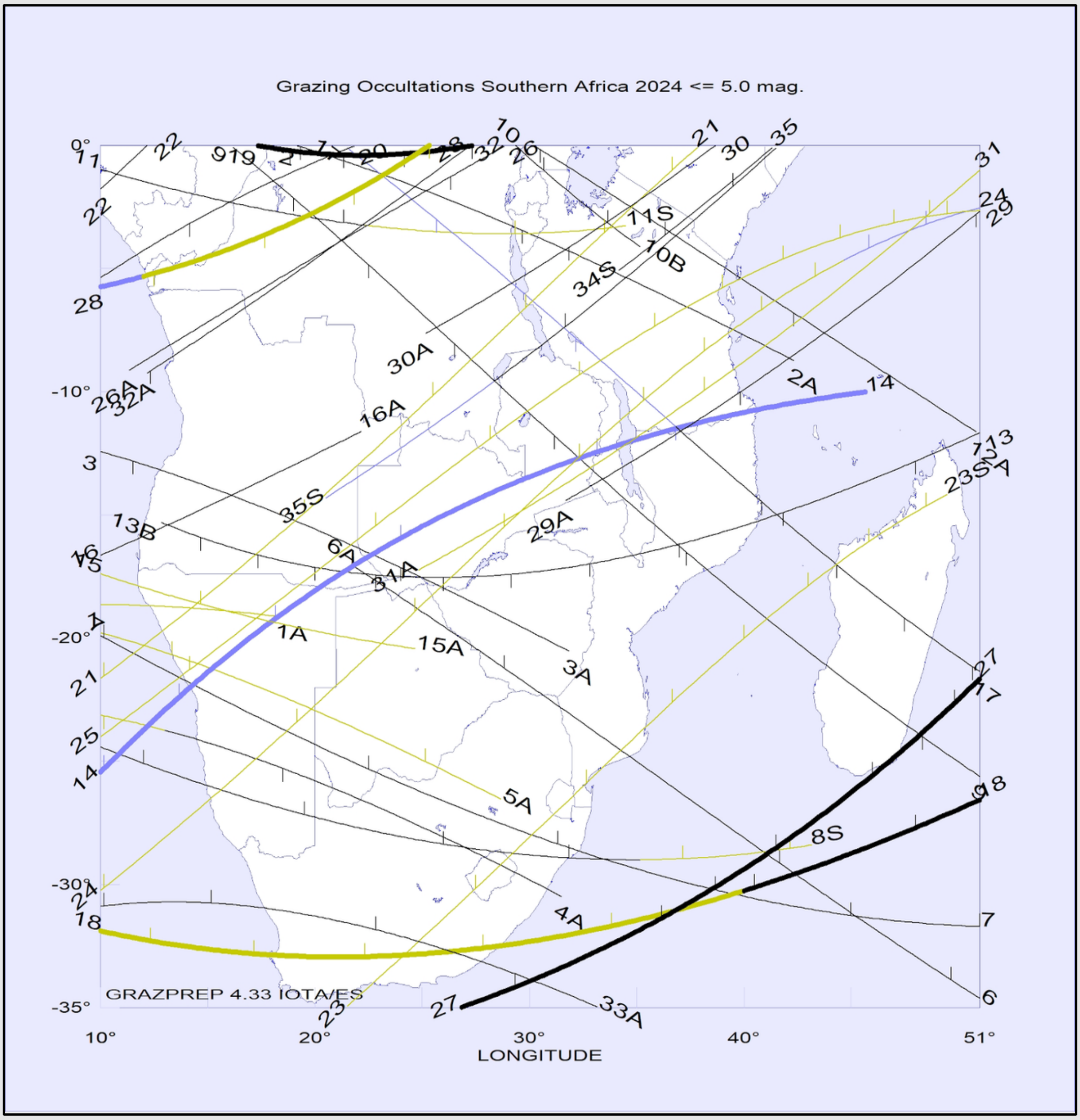


2024			Grazing Occultations Europe 2024 <= 5.0 mag.								GRAZPREP 4.33, IOTA/ES	
No.	**M D**	**USNO**	**SAOPPM D**	**MAG**	**%SNL**	**L.**	**W.UT**	**LONG**	**LAT**	**STAR NAME**	**MAG1**	**MAG2**
8	**Jun 13**	ZC 1644	118804	4.0	46+	N	19 54.7	-6	41	Shang Tseang sigma Leonis		
9	**Jun 16**	ZC 1925	157923 Z	1.0	74+	S	18 35.3	24	65	Spica alpha Virginis	1.3	4.5
10	**Jun 23**	ZC 2914	188778 V	4.8	95-	N	21 9.3	13	42	Terebellum 60 Sagittarii	5.8	5.8
11	**Jul 02**	ZC 472	75810 K	4.9	16-	N	1 24.0	32	34	zeta Arietis	5.8	5.8
12	**Aug 15**	ZC 2609	186237 V	4.7	81+	S	21 18.8	28	34	W Sagittarii	5.1	5.1
13	**Aug 21**			0.9	97-	S	4 14.8	32	34	Saturn		
14	**Aug 26**	ZC 537	76131 U	3.7	53-	N	2 30.5	31	34	Electra 17 Tauri	3.9	7.0
15	**Aug 26**	ZC 545	76172	4.1	53-	N	2 16.3	-5	34	Merope 23 Tauri		
16	**Aug 26**	ZC 552	76199 K	2.9	52-	N	2 57.0	-4	34	Alcyone eta Tauri	3.0	4.6
17	**Aug 26**	ZC 560	76228 U	3.6	52-	N	3 56.8	-11	50	Atlas 27 Tauri	4.1	5.6
18	**Oct 19**	ZC 545	76172	4.1	91-	N	19 15.1	36	34	Merope 23 Tauri		
19	**Oct 19**	ZC 552	76199 K	2.9	91-	N	19 51.5	39	34	Alcyone eta Tauri	3.0	4.6
20	**Oct 19**	ZC 560	76228 U	3.6	91-	N	20 14.2	11	34	Atlas 27 Tauri	4.1	5.6
21	**Oct 28**	ZC 1644	118804	4.0	15-	N	4 24.6	-11	37	Shang Tseang sigma Leonis		
22	**Nov 24**	ZC 1609	118648 C	4.6	39-	S	3 2.7	-11	40	chi Leonis	4.7	11.0

Southern Africa

2024			Grazing Occultations Southern Africa 2024 <= 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	**Feb 13**	ZC 146	109627 K	4.3	20+	N	19 51.7	10	-19	epsilon Piscium	5.2	5.2
2	**Feb 16**	ZC 537	76131 U	3.7	52+	N	20 30.4	19	0	Electra 17 Tauri	3.9	7.0
3	**Feb 16**	ZC 541	76155 V	3.9	52+	N	20 48.2	10	-12	Maia 20 Tauri	4.4	5.4
4	**Feb 16**	ZC 539	76140 V	4.3	52+	N	20 20.7	10	-23	Taygeta 19 Tauri	4.6	6.1
5	**Feb 16**	ZC 545	76172	4.1	52+	S	20 45.2	10	-20	Merope 23 Tauri		
6	**Mar 04**	ZC 2617	186328 K	4.5	35-	S	23 27.8	22	-17		5.1	5.9
7	**Apr 03**	ZC 2910	188722 K	4.7	39-	S	1 0.8	10	-20	Terebellum omega Sagittarii	5.6	5.6
8	**Apr 03**	ZC 2914	188778 V	4.8	38-	S	2 27.6	10	-24	Terebellum 60 Sagittarii	5.8	5.8
9	**Apr 15**	ZC 1189	79774 c	5.0	50+	N	18 21.6	16	0	phi Geminorum		
10	**Apr 25**	ZC 2237	183686	5.0	96-	S	22 46.0	29	0	42 Librae NSV 20363		
11	**May 02**	ZC 3164	164520 U	4.5	42-	S	1 21.4	10	-1	epsilon Capricorni	5.0	6.3
12	**May 10**	ZC 810	77168 Y	1.6	8+	N	15 59.9	30	0	El Nath beta Tauri	2.6	2.6
13	**May 23**	ZC 2349	184336 L	2.9	100-	N	23 33.5	12	-15	Al Niyat sigma Scorpii	3.3	5.3
14	**May 31**			1.3	43-	S	9 0.3	10	-25	Saturn		

(Continued on next page)



2024			Grazing Occultations Southern Africa 2024 <= 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
15	Jun 13	ZC 1644	118804	4.0	46+	S	21 48.2	10 -17	Shang Tseang sigma Leonis		
16	Jul 17	ZC 2237	183686	5.0	77+	S	0 31.3	10 -17	42 Librae NSV 20363		
17	Jul 17	ZC 2349	184336 L	2.9	84+	N	14 55.5	21 0	Al Niyat sigma Scorpii	3.3	5.3
18	Jul 17	ZC 2366	184415 O	1.1	85+	S	20 35.1	10 -32	Antares alpha Scorpii	1.2	5.5
19	Jul 17	ZC 2366	184415 O	1.1	85+	N	20 34.7	17 0	Antares alpha Scorpii	1.2	5.5
20	Aug 21	ZC 3412	146585	4.2	97 -	N	4 14.7	10 -5	phi Aquarii NSV 26044		

(Continued on next page)

2024 — Grazing Occultations Southern Africa 2024 <= 5.0 mag. — GRAZPREP 4.33, IOTA/ES

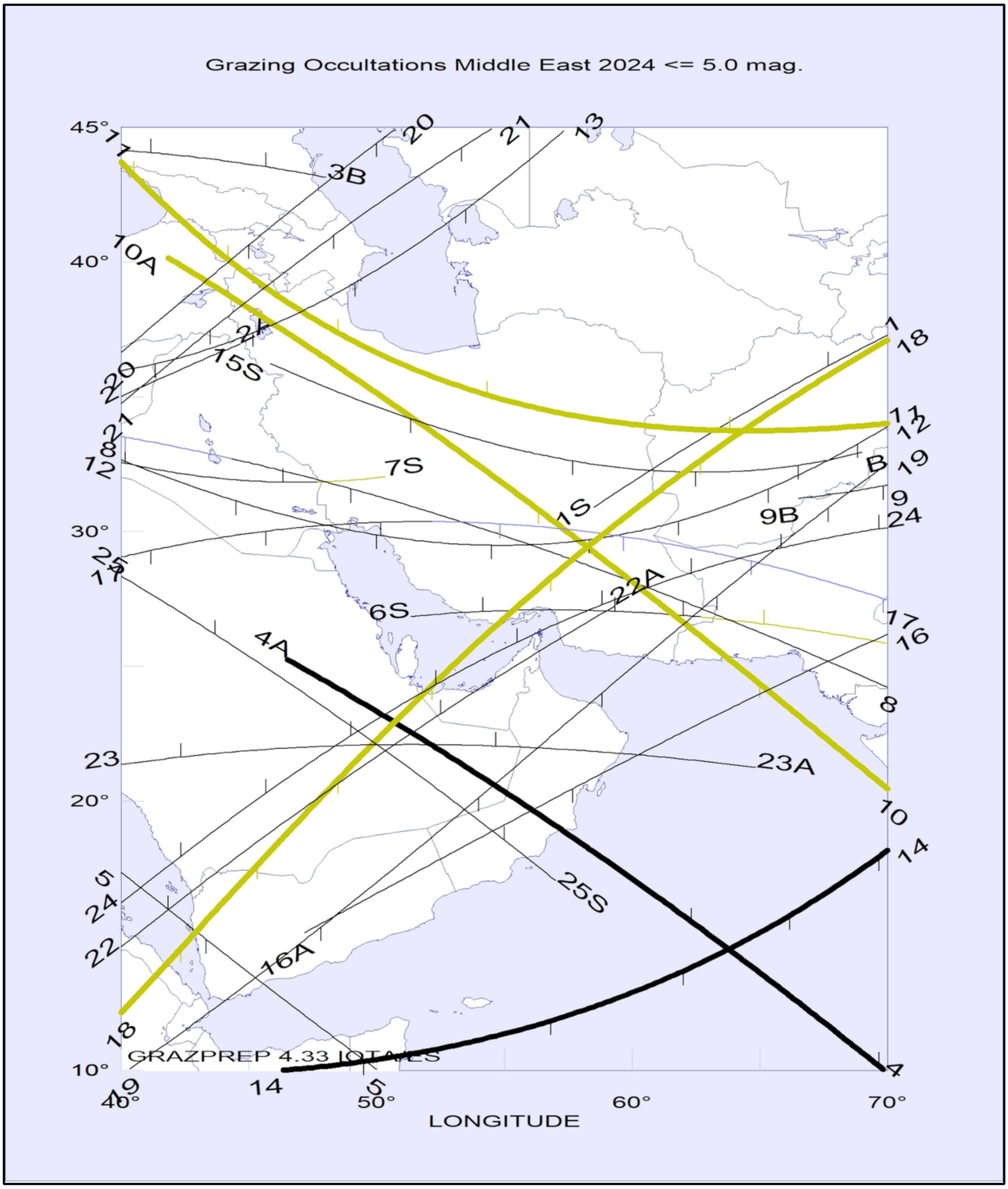
No.	M D	USNO	SAOPPM D	MAG	%SNL	L.	W.UT	LONG LAT	STAR NAME	MAG1	MAG2
21	Aug 26	ZC 537	76131 U	3.7	53 -	S	1 0.7	10 -22	Electra 17 Tauri	3.9	7.0
22	Aug 26	ZC 539	76140 V	4.3	53 -	N	1 45.3	10 -2	Taygeta 19 Tauri	4.6	6.1
23	Aug 26	ZC 539	76140 V	4.3	53 -	S	1 42.2	21 -35	Taygeta 19 Tauri	4.6	6.1
24	Aug 26	ZC 541	76155 V	3.9	53 -	S	1 39.9	10 -30	Maia 20 Tauri	4.4	5.4
25	Sep 24	ZC 810	77168 Y	1.6	57 -	S	0 37.4	10 -24	El Nath beta Tauri	2.6	2.6
26	Sep 26	ZC 1122	79374 K	3.8	36 -	N	0 52.8	11 -9	iota Geminorum	4.7	4.7
27	Oct 14			1.0	90+	S	16 56.9	26 -35	Saturn		
28	Oct 14			1.0	90+	N	16 55.9	10 -6	Saturn		
29	Oct 19	ZC 539	76140 V	4.3	91 -	N	18 26.9	31 -14	Taygeta 19 Tauri	4.6	6.1
30	Oct 19	ZC 541	76155 V	3.9	91 -	N	18 37.8	25 -8	Maia 20 Tauri	4.4	5.4
31	Oct 19	ZC 552	76199 K	2.9	91 -	S	18 56.5	24 -17	Alcyone eta Tauri	3.0	4.6
32	Nov 17	ZC 810	77168 Y	1.6	94 -	N	19 20.0	12 -9	El Nath beta Tauri	2.6	2.6
33	Dec 12	ZC 440	75673 M	4.7	92+	S	23 30.4	10 -31	epsilon Arietis	5.2	5.6
34	Dec 13	ZC 545	76172	4.1	96+	S	15 48.1	34 -5	Merope 23 Tauri		
35	Dec 13	ZC 552	76199 K	2.9	97+	S	16 13.2	20 -14	Alcyone eta Tauri	3.0	4.6

Middle East

2024 — Grazing Occultations Middle East 2024 <= 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 3164	164520 U	4.5	6+	S	13 23.3	58 31	epsilon Capricorni	5.0	6.3
2	Jan 13	ZC 3175	164593	4.7	6+	S	15 54.8	40 35	kappa Capricorni		
3	Jan 22	ZC 890	77675 V	4.6	92+	S	19 57.6	40 44	136 Tauri NSV 02696	4.8	6.3
4	Feb 04	ZC 2366	184415 O	1.1	29 -	S	23 31.1	46 25	Antares alpha Scorpii	1.2	5.5
5	Feb 20	ZC 1149	79533 w	4.1	88+	N	22 34.0	40 17	upsilon Geminorum NSV 03652		
6	Mar 14	ZC 472	75810 K	4.9	24+	S	14 43.8	51 27	zeta Arietis	5.8	5.8
7	Apr 03	ZC 2912	188742	4.5	39 -	S	2 9.8	40 33	Terebellum 59 Sagittarii		
8	Apr 11	ZC 560	76228 U	3.6	11+	N	15 20.3	40 34	Atlas 27 Tauri	4.1	5.6
9	Apr 25	ZC 2237	183686	5.0	96 -	N	23 44.0	66 31	42 Librae NSV 20363		
10	Apr 26	ZC 2366	184415 O	1.1	91 -	N	19 15.2	42 40	Antares alpha Scorpii	1.2	5.5
11	Jun 16	ZC 1925	157923 Z	1.0	74+	S	19 18.5	40 44	Spica alpha Virginis	1.3	4.5

(Continued on next page)



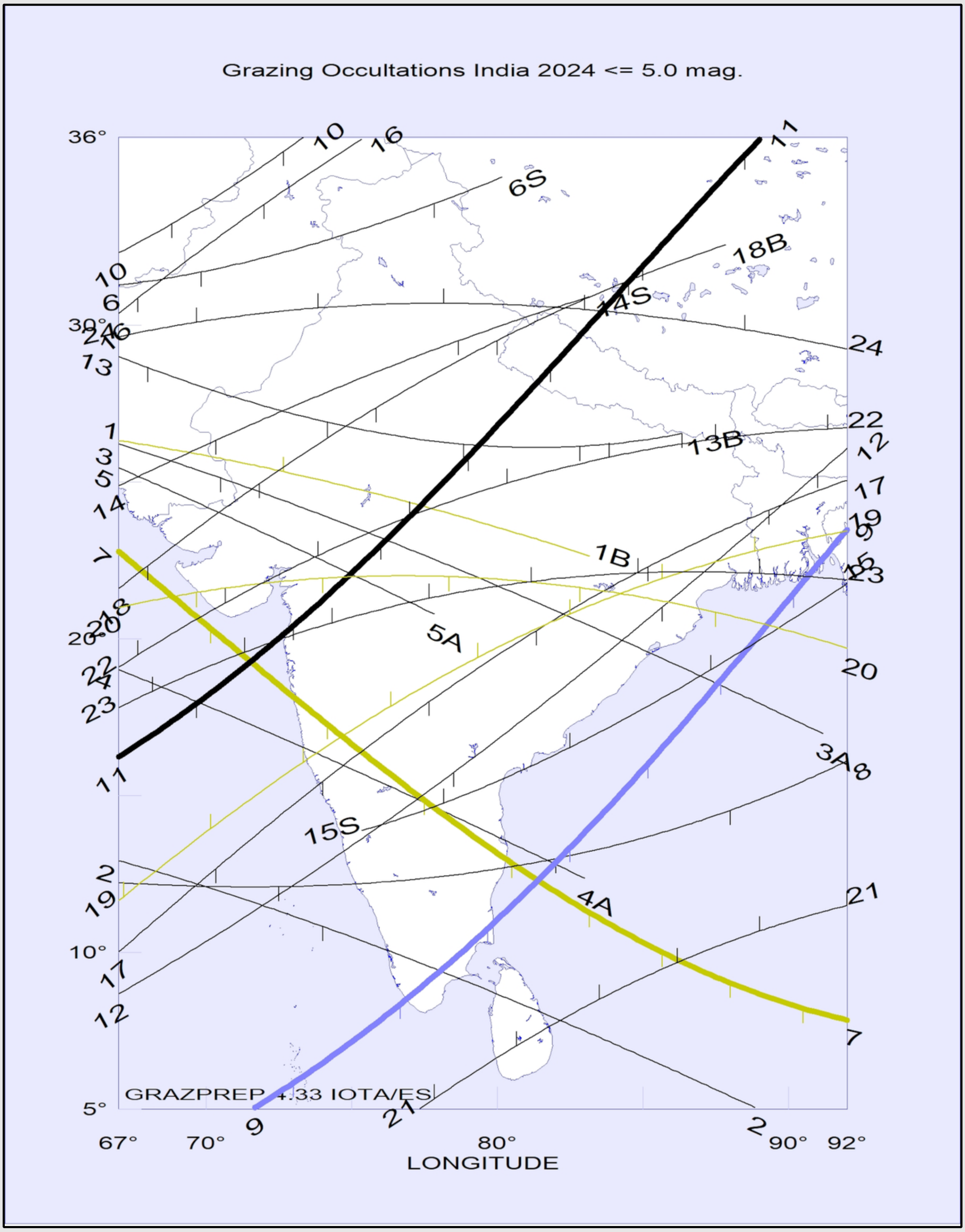
Grazing Occultations Middle East 2024 <= 5.0 mag.
45°
40°
30°
20°
10°
40°
50°
60°
70°
LONGITUDE
GRAZPREP 4.33 IOTA/ES

2024			Grazing Occultations Middle East 2024 <= 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
12	Jun 23	ZC 2910	188722 K	4.7	95 -	N	19 54.1	40	33	Terebellum omega Sagittarii	5.6	5.6
13	Jun 23	ZC 2914	188778 V	4.8	95 -	N	21 46.9	40	36	Terebellum 60 Sagittarii	5.8	5.8
14	Jul 24			1.0	84 -	N	19 16.9	46	10	Saturn		
15	Aug 17	ZC 2914	188778 V	4.8	94+	N	15 44.3	46	36	Terebellum 60 Sagittarii	5.8	5.8
16	Aug 29	ZC 1149	79533 w	4.1	15 -	N	23 36.7	47	15	upsilon Geminorum NSV 03652		
17	Sep 24	ZC 810	77168 Y	1.6	57 -	N	1 57.7	40	29	El Nath beta Tauri	2.6	2.6
18	Oct 14			1.0	90+	N	18 21.8	40	12	Saturn		
19	Oct 19	ZC 537	76131 U	3.7	92 -	N	18 21.1	40	10	Electra 17 Tauri	3.9	7.0
20	Oct 19	ZC 545	76172	4.1	91 -	N	19 20.7	40	37	Merope 23 Tauri		
21	Oct 19	ZC 552	76199 K	2.9	91 -	N	19 53.2	40	35	Alcyone eta Tauri	3.0	4.6
22	Nov 07	ZC 2910	188722 K	4.7	34+	S	17 17.6	40	15	Terebellum omega Sagittarii	5.6	5.6
23	Dec 10	ZC 146	109627 K	4.3	74+	S	21 7.4	40	21	epsilon Piscium	5.2	5.2
24	Dec 13	ZC 560	76228 U	3.6	97+	S	17 33.9	40	16	Atlas 27 Tauri	4.1	5.6
25	Dec 28	ZC 2298	184068	5.0	8 -	S	2 28.5	40	28			

India

2024			Grazing Occultations India 2024 <= 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	Mar 14	ZC 472	75810 K	4.9	24+	S	15 12.7	67	26	zeta Arietis	5.8	5.8
2	Apr 11	ZC 537	76131 U	3.7	11+	N	13 53.2	67	13	Electra 17 Tauri	3.9	7.0
3	Apr 11	ZC 545	76172	4.1	11+	N	14 27.2	67	26	Merope 23 Tauri		
4	Apr 11	ZC 552	76199 K	2.9	11+	N	15 3.9	67	19	Alcyone eta Tauri	3.0	4.6
5	Apr 11	ZC 560	76228 U	3.6	11+	N	15 42.6	67	25	Atlas 27 Tauri	4.1	5.6
6	Apr 25	ZC 2237	183686	5.0	96 -	N	23 45.0	67	31	42 Librae NSV 20363		
7	Apr 26	ZC 2366	184415 O	1.1	91 -	N	19 33.6	67	23	Antares alpha Scorpii	1.2	5.5
8	May 03	ZC 3421	146612 c	4.9	22 -	N	22 36.9	67	12	chi Aquarii	4.9	5.1
9	May 05			1.1	12 -	N	1 16.7	71	5	Mars		
10	Jun 23	ZC 2910	188722 K	4.7	95 -	N	20 55.2	67	32	Terebellum omega Sagittarii	5.6	5.6
11	Jul 24			1.0	84 -	N	19 52.5	67	16	Saturn		
12	Jul 29	ZC 560	76228 U	3.6	30 -	N	21 11.4	67	9	Atlas 27 Tauri	4.1	5.6

(Continued on next page)

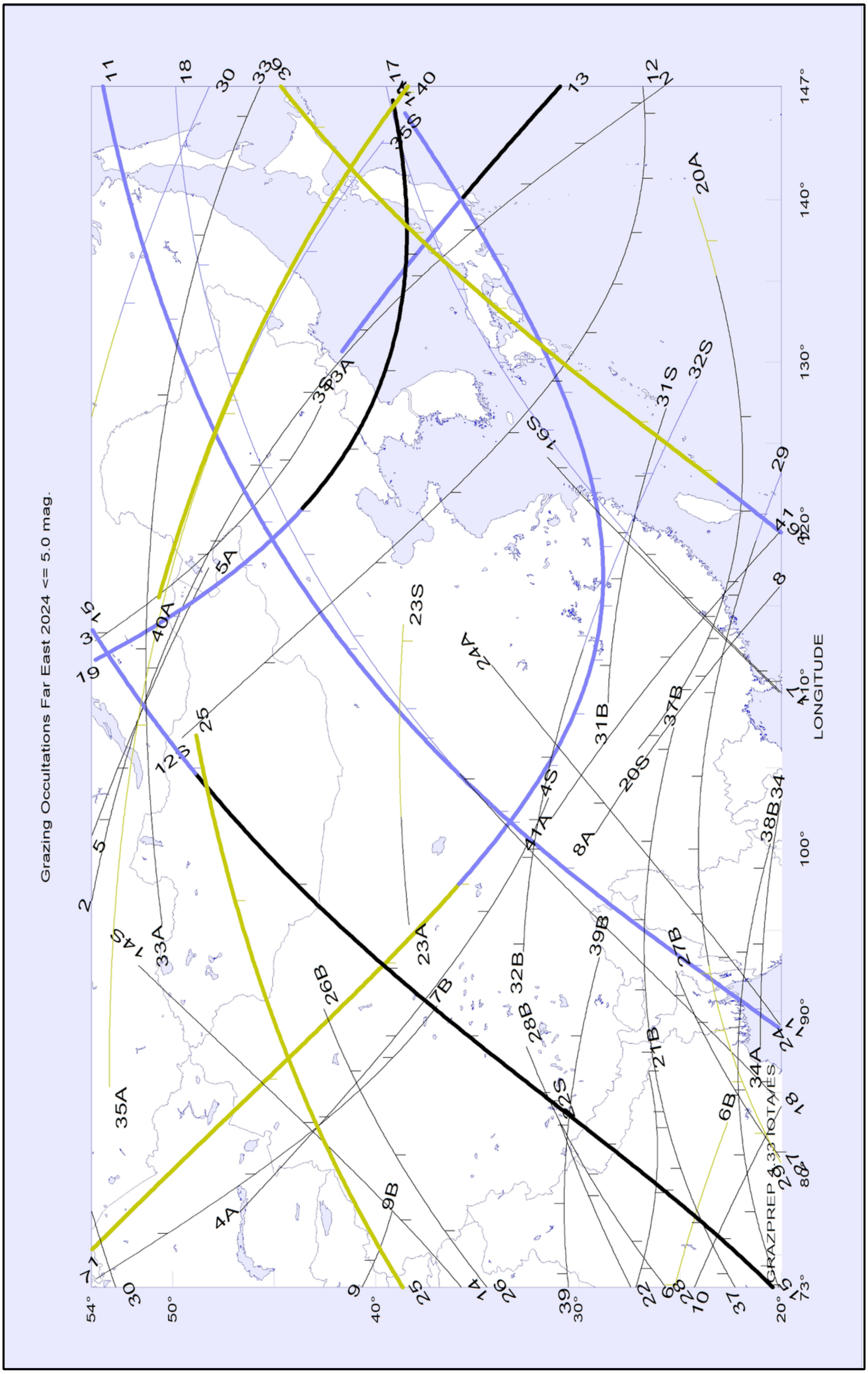

Grazing Occultations India 2024 <= 5.0 mag.
GRAZPREP 4.33 IOTA/ES
LONGITUDE
36°
30°
20°
10°
5°
67°
70°
80°
90°
92°

2024				Grazing Occultations India 2024 <= 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
13	Aug 17	ZC 2910	188722 K	4.7	94+	N	14 28.7	67	29	Terebellum omega Sagittarii	5.6	5.6
14	Aug 29	ZC 1149	79533 w	4.1	15 -	N	23 46.8	67	25	upsilon Geminorum NSV 03652		
15	Oct 09	ZC 2609	186237 V	4.7	38+	S	12 43.0	75	14	W Sagittarii	5.1	5.1
16	Oct 19	ZC 537	76131 U	3.7	92 -	N	19 8.6	67	30	Electra 17 Tauri	3.9	7.0
17	Oct 19	ZC 539	76140 V	4.3	91 -	N	19 11.6	67	10	Taygeta 19 Tauri	4.6	6.1
18	Oct 19	ZC 541	76155 V	3.9	91 -	N	19 37.6	67	22	Maia 20 Tauri	4.4	5.4
19	Oct 19	ZC 552	76199 K	2.9	91 -	S	19 50.3	67	12	Alcyone eta Tauri	3.0	4.6
20	Nov 17	ZC 810	77168 Y	1.6	94 -	N	20 44.0	67	21	El Nath beta Tauri	2.6	2.6
21	Dec 13	ZC 537	76131 U	3.7	96+	S	16 28.6	77	5	Electra 17 Tauri	3.9	7.0
22	Dec 13	ZC 545	76172	4.1	96+	S	16 58.4	67	19	Merope 23 Tauri		
23	Dec 13	ZC 552	76199 K	2.9	97+	S	17 46.1	67	18	Alcyone eta Tauri	3.0	4.6
24	Dec 13	ZC 560	76228 U	3.6	97+	S	18 53.2	67	30	Atlas 27 Tauri	4.1	5.6

Far East

2024				Grazing Occultations Far East 2024 <= 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	Feb 05	ZC 2366	184415 O	1.1	29 -	N	0 4.6	75	54	Antares alpha Scorpii	1.2	5.5
2	Feb 25	ZC 1644	118804	4.0	99 -	S	14 55.9	96	54	Shang Tseang sigma Leonis		
3	Mar 02	ZC 2298	184068	5.0	57 -	S	21 39.3	112	54			
4	Mar 04	ZC 2609	186237 V	4.7	35 -	S	23 3.1	77	47	W Sagittarii	5.1	5.1
5	Mar 14	ZC 472	75810 K	4.9	24+	N	15 8.7	100	54	zeta Arietis	5.8	5.8
6	Mar 14	ZC 472	75810 K	4.9	24+	S	15 20.4	73	25	zeta Arietis	5.8	5.8
7	Mar 27	ZC 2029	158401	4.9	94 -	S	21 23.5	73	54	ET Virginis	4.9	5.0
8	Mar 29	ZC 2237	183686	5.0	82 -	S	15 45.3	101	29	42 Librae NSV 20363		
9	Mar 29	ZC 2268	183896 H	4.5	80 -	S	23 46.8	73	41	2 Scorpii	5.6	5.6
10	Apr 11	ZC 545	76172	4.1	11+	N	14 32.0	73	24	Merope 23 Tauri		
11	May 05			1.1	12 -	N	2 15.6	89	20	Mars		
12	Jun 19	ZC 2237	183686	5.0	94+	N	13 5.4	106	50	42 Librae NSV 20363		
13	Jun 20	ZC 2366	184415 O	1.1	97+	N	9 51.3	130	42	Antares alpha Scorpii	1.2	5.5
14	Jun 23	ZC 2910	188722 K	4.7	95 -	N	21 11.0	73	36	Terebellum omega Sagittarii	5.6	5.6
15	Jul 24			1.0	84 -	N	20 10.4	73	20	Saturn		
16	Jul 29	ZC 545	76172	4.1	31 -	N	20 27.4	109	20	Merope 23 Tauri		
17	Jul 29	ZC 552	76199 K	2.9	30 -	N	21 8.7	109	20	Alcyone eta Tauri	3.0	4.6

(Continued on next page)

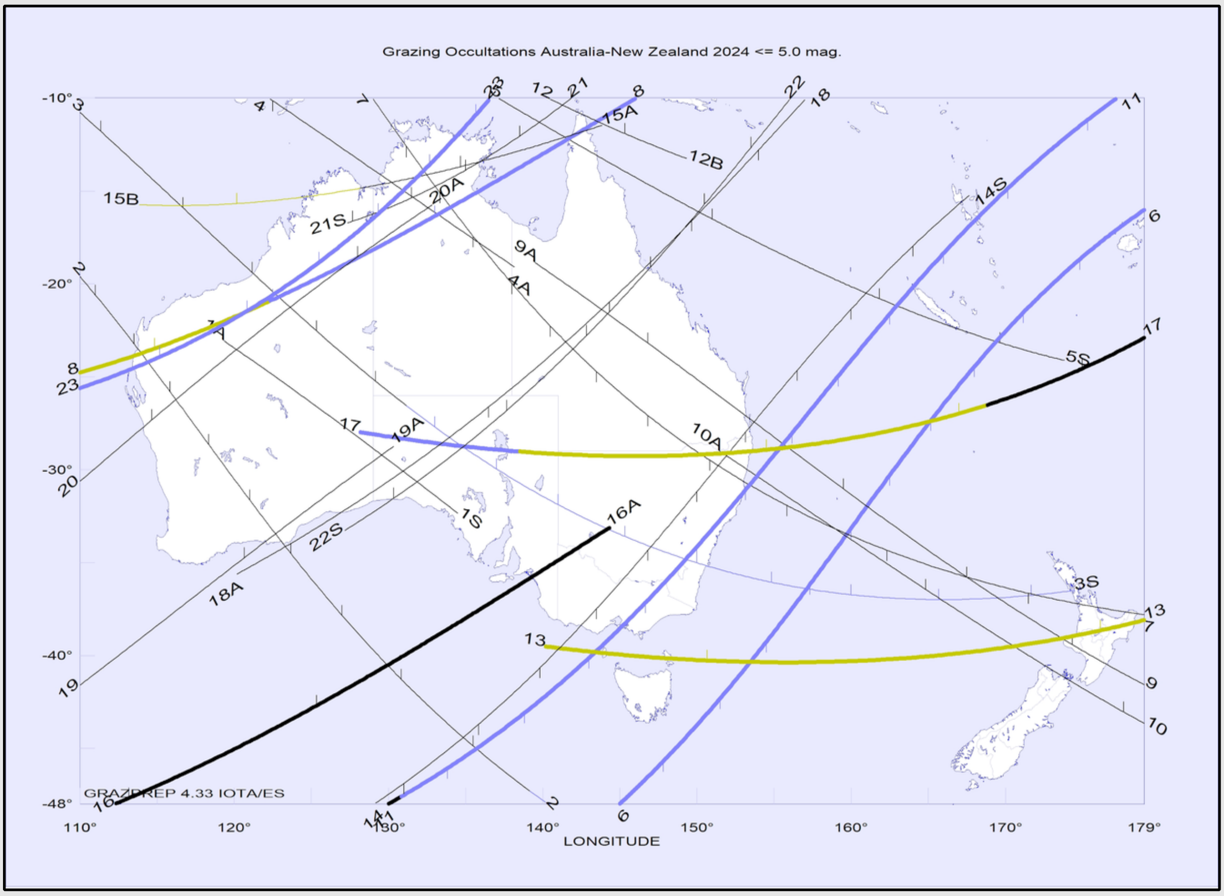

Grazing Occultations Far East 2024 <= 5.0 mag.
LONGITUDE
GRAZPREP 4.33 IOTA/ES

2024	Grazing Occultations Far East 2024 <= 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
18	Jul 29	ZC 560	76228 U	3.6	30 -	N	21 28.3	84	20	Atlas 27 Tauri	4.1	5.6
19	Aug 10	ZC 1925	157923 Z	1.0	30+	N	10 31.6	111	54	Spica alpha Virginis	1.3	4.5
20	Aug 11	ZC 2029	158401	4.9	40+	N	11 37.1	106	27	ET Virginis	4.9	5.0
21	Aug 17	ZC 2910	188722 K	4.7	94+	N	14 37.8	73	27	Terebellum omega Sagittarii	5.6	5.6
22	Aug 29	ZC 1149	79533 w	4.1	15 -	N	23 53.0	73	27	upsilon Geminorum NSV 03652		
23	Sep 30	ZC 1644	118804	4.0	3 -	N	22 17.0	95	38	Shang Tseang sigma Leonis		
24	Oct 09	ZC 2609	186237 V	4.7	38+	S	13 13.4	89	20	W Sagittarii	5.1	5.1
25	Oct 14			1.0	90+	N	19 31.1	73	39	Saturn		
26	Oct 19	ZC 537	76131 U	3.7	92 -	N	19 22.5	73	35	Electra 17 Tauri	3.9	7.0
27	Oct 19	ZC 539	76140 V	4.3	91 -	N	19 49.2	81	20	Taygeta 19 Tauri	4.6	6.1
28	Oct 19	ZC 541	76155 V	3.9	91 -	N	19 53.0	73	26	Maia 20 Tauri	4.4	5.4
29	Oct 19	ZC 552	76199 K	2.9	91 -	S	20 34.4	80	20	Alcyone eta Tauri	3.0	4.6
30	Oct 19	ZC 552	76199 K	2.9	91 -	N	20 52.7	73	53	Alcyone eta Tauri	3.0	4.6
31	Oct 19	ZC 545	76172	4.1	91 -	S	21 5.3	109	29	Merope 23 Tauri		
32	Oct 19	ZC 560	76228 U	3.6	91 -	S	22 9.1	93	33	Atlas 27 Tauri	4.1	5.6
33	Oct 27	ZC 1609	118648 C	4.6	18 -	S	20 4.8	95	51	chi Leonis	4.7	11.0
34	Oct 28	ZC 1712	119076 C	3.6	11 -	S	21 38.0	88	21	Zavijava beta Virginis	3.8	8.8
35	Oct 28	ZC 1712	119076 C	3.6	11 -	N	21 47.0	85	53	Zavijava beta Virginis	3.8	8.8
36	Dec 08			1.3	47+	N	8 45.9	119	20	Saturn		
37	Dec 13	ZC 545	76172	4.1	96+	S	17 17.7	73	22	Merope 23 Tauri		
38	Dec 13	ZC 552	76199 K	2.9	97+	S	18 5.8	73	20	Alcyone eta Tauri	3.0	4.6
39	Dec 13	ZC 560	76228 U	3.6	97+	S	19 8.4	73	30	Atlas 27 Tauri	4.1	5.6
40	Dec 24	ZC 1925	157923 Z	1.0	32 -	N	18 39.2	115	51	Spica alpha Virginis	1.3	4.5
41	Dec 27	ZC 2268	183896 H	4.5	9 -	S	22 5.4	102	31	2 Scorpii	5.6	5.6

Australia & New Zealand

2024	Grazing Occultations Australia-New Zealand 2024 <= 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 09	ZC 2554	185755 V	4.5	4 -	S	20 1.6	119	-23	X Sagittarii	5.2	5.2
2	Jan 30	ZC 1772	138721 Q	3.9	79 -	S	18 6.2	110	-20	Zaniah eta Virginis	4.6	5.9
3	Feb 04	ZC 2349	184336 L	2.9	31 -	S	20 7.9	110	-11	Al Niyat sigma Scorpii	3.3	5.3
4	Feb 18	ZC 810	77168 Y	1.6	71+	N	15 20.8	122	-10	El Nath beta Tauri	2.6	2.6
5	Mar 06	ZC 2914	188778 V	4.8	18 -	S	17 54.2	137	-10	Terebellum 60 Sagittarii	5.8	5.8

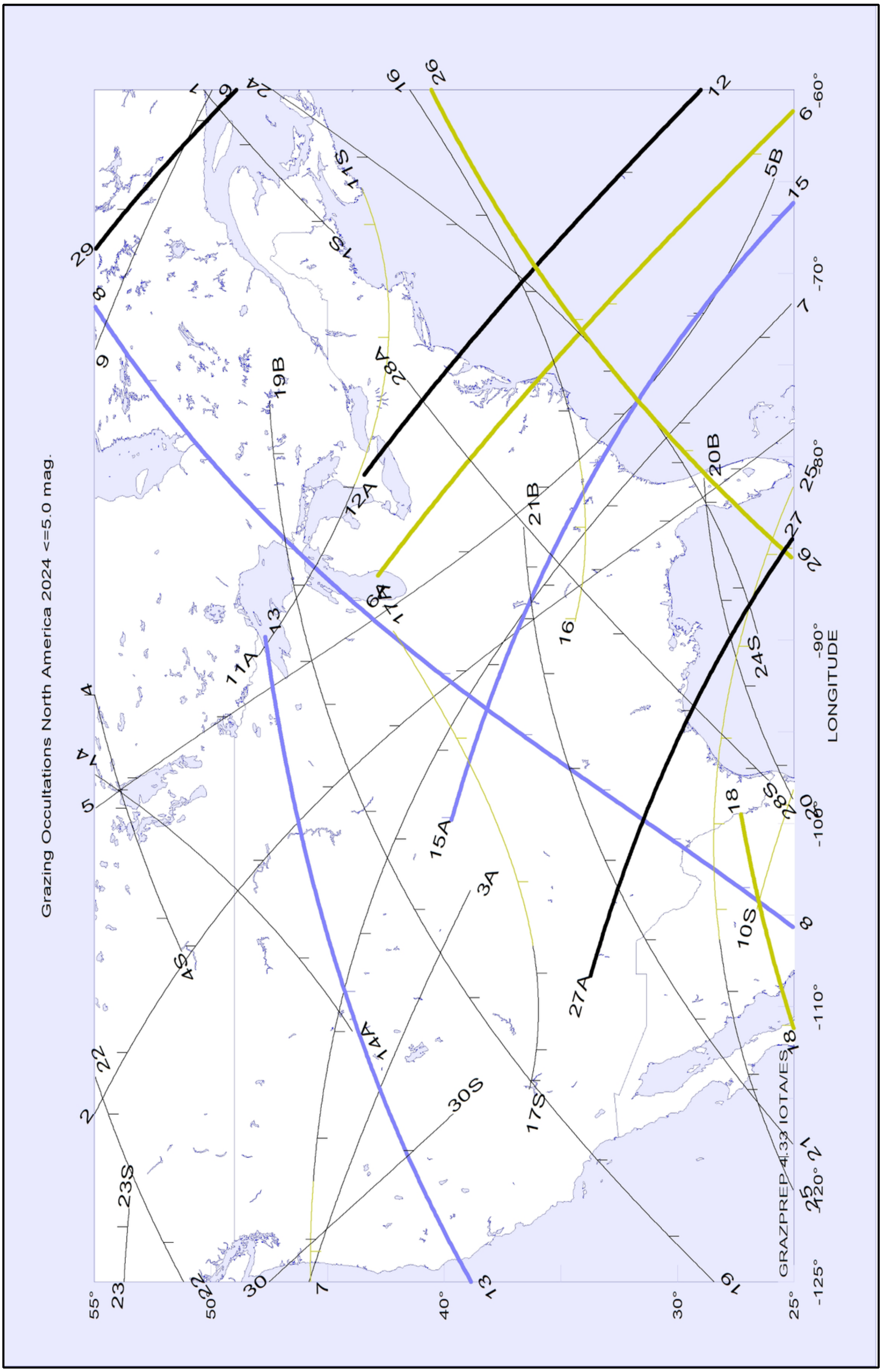
(Continued on next page)



2024			Grazing Occultations Australia-New Zealand 2024 <= 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
6	Mar 11			-1.3	1+	N	2 43.1	145	-48	Mercury		
7	Apr 21	ZC 1772	138721 Q	3.9	95+	N	13 20.6	129	-10	Zaniah eta Virginis	4.6	5.9
8	Apr 26	ZC 2366	184415 O	1.1	91 -	S	21 52.5	110	-25	Antares alpha Scorpii	1.2	5.5
9	Apr 28	ZC 2617	186328 K	4.5	80 -	S	11 57.6	139	-19		5.1	5.9
10	Apr 29	ZC 2784	187683 V	3.3	71 -	S	11 35.5	151	-29	tau Sagittarii	4.2	4.2
11	May 03			1.3	22 -	N	22 23.6	130	-48	Saturn		
12	May 27	ZC 2914	188778 V	4.8	82 -	S	13 54.8	140	-10	Terebellum 60 Sagittarii	5.8	5.8
13	Jun 27			1.2	65 -	S	13 19.7	140	-40	Saturn		
14	Jul 24	ZC 3412	146585	4.2	85 -	N	17 36.9	129	-48	phi Aquarii NSV 26044		
15	Aug 11	ZC 2029	158401	4.9	40+	S	12 52.8	114	-16	ET Virginis	4.9	5.0
16	Sep 10	ZC 2366	184415 O	1.1	44+	S	14 19.4	112	-48	Antares alpha Scorpii	1.2	5.5
17	Sep 17			0.8	99+	S	8 33.6	128	-28	Saturn		
18	Sep 21	ZC 440	75673 M	4.7	82 -	N	14 21.0	120	-36	epsilon Arietis	5.2	5.6
19	Oct 09	ZC 2617	186328 K	4.5	38+	S	14 50.9	110	-42		5.1	5.9
20	Oct 10	ZC 2784	187683 V	3.3	49+	S	15 4.1	110	-31	tau Sagittarii	4.2	4.2
21	Oct 11	ZC 2910	188722 K	4.7	57+	S	9 29.3	127	-17	Terebellum omega Sagittarii	5.6	5.6
22	Nov 13	ZC 146	109627 K	4.3	92+	S	10 6.9	127	-33	epsilon Piscium	5.2	5.2
23	Dec 08			1.3	47+	S	7 22.7	110	-26	Saturn		

North America

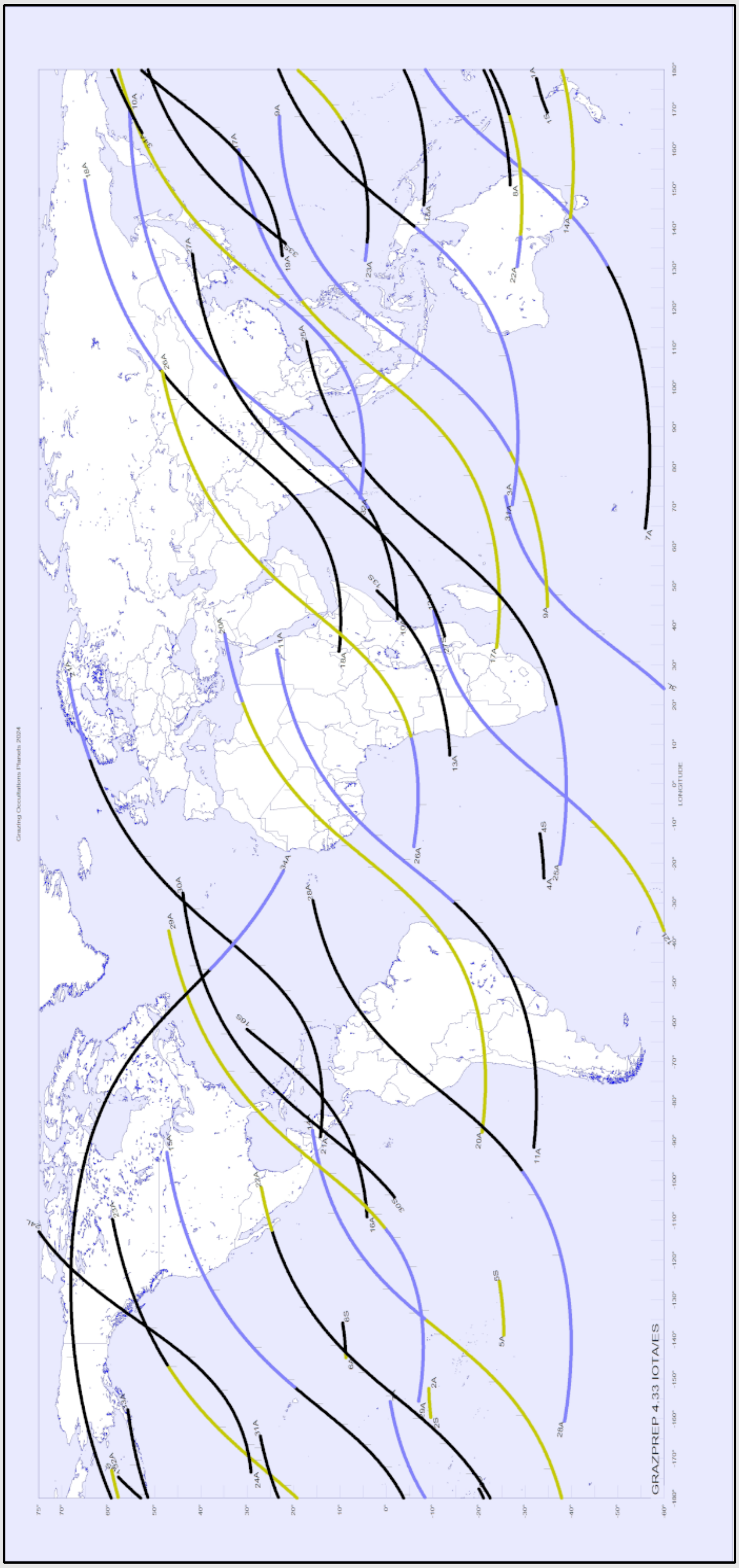
2024			Grazing Occultations North America 2024 <=5.0 mag.								GRAZPREP 4.33, IOTA/ES	
No.	M D	USNO	SAOPPM D	MAG	%SNL	L.	W.UT	LONG	LAT	STAR NAME	MAG1	MAG2
1	Jan 19	ZC 465	93328	4.3	68+	S	21 18.4	-68	45	Botein delta Arietis		
2	Jan 29	ZC 1644	118804	4.0	89 -	S	8 55.3	-116	55	Shang Tseang sigma Leonis		
3	Feb 16	ZC 472	75810 K	4.9	46+	N	7 12.7	-125	46	zeta Arietis	5.8	5.8
4	Feb 19	ZC 890	77675 V	4.6	73+	S	0 27.0	-107	51	136 Tauri NSV 02696	4.8	6.3
5	Feb 26	ZC 1712	119076 C	3.6	97 -	S	9 15.6	-99	55	Zavijava beta Virginis	3.8	8.8
6	Mar 03	ZC 2366	184415 O	1.1	54 -	N	7 34.8	-86	43	Antares alpha Scorpii	1.2	5.5
7	Mar 19	ZC 1149	79533 w	4.1	69+	N	2 37.5	-125	46	upsilon Geminorum NSV 03652		
8	Apr 07			-3.3	2 -	N	16 2.3	-105	25	Venus		
9	Apr 11	ZC 472	75810 K	4.9	7+	N	1 12.2	-74	55	zeta Arietis	5.8	5.8
10	Apr 11	ZC 472	75810 K	4.9	7+	S	1 24.6	-104	27	zeta Arietis	5.8	5.8
11	Apr 30	ZC 2912	188742	4.5	63 -	S	8 14.6	-90	48	Terebellum 59 Sagittarii		
12	May 24	ZC 2366	184415 O	1.1	100 -	N	1 53.3	-81	43	Antares alpha Scorpii	1.2	5.5
13	Jun 27			1.2	65 -	N	16 22.1	-125	39	Saturn		
14	Jul 29	ZC 472	75810 K	4.9	37 -	N	7 8.3	-111	44	zeta Arietis	5.8	5.8
15	Sep 06	ZC 1925	157923 Z	1.0	11+	S	15 50.1	-100	40	Spica alpha Virginis	1.3	4.5
16	Sep 09	ZC 2287	183987W	2.9	37+	S	23 31.7	-106	44	pi Scorpii	3.4	4.6
17	Sep 10	ZC 2298	184068	5.0	38+	N	1 54.3	-114	36			
18	Sep 17			0.8	99+	S	11 40.1	-111	25	Saturn		
19	Sep 22	ZC 537	76131 U	3.7	76 -	N	9 14.4	-125	28	Electra 17 Tauri	3.9	7.0
20	Sep 22	ZC 539	76140 V	4.3	76 -	N	10 26.0	-98	25	Taygeta 19 Tauri	4.6	6.1
21	Sep 22	ZC 541	76155 V	3.9	76 -	N	10 2.6	-117	25	Maia 20 Tauri	4.4	5.4
22	Sep 22	ZC 552	76199 K	2.9	75 -	N	10 56.7	-125	51	Alcyone eta Tauri	3.0	4.6
23	Sep 30	ZC 1609	118648 C	4.6	4 -	S	14 8.4	-125	54	chi Leonis	4.7	11.0
24	Oct 14	ZC 3421	146612 c	4.9	91+	S	23 27.4	-89	27	chi Aquarii	4.9	5.1
25	Oct 21	ZC 810	77168 Y	1.6	80 -	N	10 5.9	-120	25	El Nath beta Tauri	2.6	2.6
26	Nov 11			1.2	69+	N	2 38.9	-85	25	Saturn		
27	Nov 27	ZC 1925	157923 Z	1.0	13 -	S	10 53.5	-108	34	Spica alpha Virginis	1.3	4.5
28	Dec 04	ZC 2914	188778 V	4.8	13+	S	23 39.0	-97	26	Terebellum 60 Sagittarii	5.8	5.8
29	Dec 18			-0.9	90 -	S	9 36.0	-68	55	Mars		
30	Dec 18	ZC 1308	80378 V	4.7	88 -	S	14 45.1	-125	48	Asellus Borealis Gamma Cancri	5.5	5.5



Grazing Occultations North America 2024 <=5.0 mag.
LONGITUDE
GRAZPREP 4.33 IOTA/ES

Planets Worldwide

2024	Grazing Occultations Planets 2024							GRAZPREP 4.33, IOTA/ES
No.	M D	MAG	%SNL	L.	W.UT	LONG	LAT	STAR NAME
1	Feb 12	8.0	9+	S	7 56.3	169	-35	Neptune
2	Mar 11	-1.3	1+	N	4 50.2	-159	-10	Mercury
3	Apr 06	1.3	8 -	N	10 4.0	24	-60	Saturn
4	Apr 07	8.0	3 -	N	6 54.3	-24	-34	Neptune
5	Apr 07	-3.3	2 -	S	14 33.0	-139	-25	Venus
6	Apr 07	-3.3	2 -	N	14 55.1	-144	9	Venus
7	May 03	1.3	22 -	N	21 42.1	64	-56	Saturn
8	May 04	8.0	15 -	N	17 30.8	150	-27	Neptune
9	May 05	1.1	12 -	S	0 32.6	44	-35	Mars
10	May 05	1.1	12 -	N	0 43.2	41	-2	Mars
11	May 31	1.3	43 -	N	6 45.3	-91	-32	Saturn
12	May 31	1.3	43 -	S	7 26.0	-37	-60	Saturn
13	Jun 01	8.0	34 -	N	1 19.2	7	-14	Neptune
14	Jun 27	1.2	65 -	S	13 19.6	142	-40	Saturn
15	Jun 27	1.2	65 -	N	13 21.4	146	-8	Saturn
16	Jun 28	8.0	57 -	N	7 18.9	-109	4	Neptune
17	Jul 24	1.0	84 -	S	18 51.3	34	-24	Saturn
18	Jul 24	1.0	84 -	N	19 10.3	33	10	Saturn
19	Jul 25	7.9	78 -	N	13 25.7	133	22	Neptune
20	Aug 21	0.9	97 -	S	1 6.9	-88	-21	Saturn
21	Aug 21	0.9	97 -	N	1 29.3	-89	14	Saturn
22	Sep 17	0.8	99+	S	8 33.5	130	-28	Saturn
23	Sep 17	0.8	99+	N	8 46.2	132	5	Saturn
24	Sep 18	7.8	100 -	N	6 15.4	-173	29	Neptune
25	Oct 14	1.0	90+	S	16 33.4	-20	-38	Saturn
26	Oct 14	1.0	90+	N	16 36.0	-16	-6	Saturn
27	Oct 15	7.8	96+	S	15 40.0	37	-13	Neptune
28	Nov 11	1.2	69+	S	0 2.5	-160	-38	Saturn
29	Nov 11	1.2	69+	N	0 3.8	-155	-7	Saturn
30	Nov 12	7.9	80+	S	0 59.1	-104	-2	Neptune
31	Dec 08	1.3	47+	S	7 1.3	70	-27	Saturn
32	Dec 08	1.3	47+	N	7 15.0	72	6	Saturn
33	Dec 09	8.0	59+	S	8 26.8	136	22	Neptune
34	Dec 18	-0.9	90 -	S	7 56.5	164	53	Mars


Grazing Occultations Planets 2024
GRAZPREP 4.33 IOTA/ES
LONGITUDE

Signal-to-Noise Improvements for Observations of 2023 Betelgeuse's Occultation

Costantino Sigismondi · ICRA Rome/ICRANet-Pescara · ITIS G.Ferraris · Roma · Italy ·sigismondi@icra.it
Claudio Costa · Specola Vaticana · IOTA/ES · Roma · Italy · carocicosta@gmail.com
Alfonso Noschese · AstroCampania · IOTA/ES · Pontecagnano · Italy · a.noschese@astrocampania.it
Konrad Guhl · IOTA/ES · Berlin · Germany · kguhl@astw.de
Mariangela Bisconte · Saracena Library · Saracena · Italy · mariangelabisconte@gmail.com

ABSTRACT: The occultation of Betelgeuse by the asteroid (319) Leona was known for decades, and it has been prepared carefully. The local organisers of AstroCampania association were ready to react in real-time to the meteo conditions and move and accommodate many observers from the Thyrrenian to the Ionian coast of Calabria, near the predicted centre line. An IOTA/ES meeting was held at lunch time on 2023 Dec 12th in Cassano all'Ionio. The uncertainty in the astrometry and in the diameter of Betelgeuse suggested to stay near the centre line, to obtain the maximum from the data. The battle against the scintillation was finally won by realising multi-hole masks for large field-telescopes. The preliminary results have been presented at the IAU meeting on 2023 Dec 16th in memory of J. M. Pasachoff (1943-2022) who also planned special observations of this event.

Introduction

Among stellar occultations the one of Betelgeuse presented the opportunity to see a red supergiant, with the largest angular diameter, partially covered by an asteroid recently carefully monitored by a Spanish team [1]. A vaste zone of stellar penumbra was expected by the occultation of a 80 × 54 mas asteroid over a 48 mas star, and a centre line width of 17 km was ±10 km uncertain because of the astrometry of Betelgeuse [2], too bright for *Gaia* instruments.

Moreover, Betelgeuse is the brightest variable star, classified as SR-C type, which underwent a major dimming in 2019 - 2020, of more than a magnitude, down to visual mag 1.8 [3, 4].

The centre line's uncertainty, and the possible stellar activity, being Betelgeuse's luminosity at maximum phase (visual mag. 0.2), suggested to locate the best instruments on the predicted centre line.

Constraints from Meteo and Geography

The field trips of this type of observations imply to set up an observing station in a short time, where the centre line is predicted and the weather is favourable. The Ionian coast of Calabria was considered better than the other, because of the clouds lying on the Thyrrenian basin and near the coast. The blocking made by the Pollino massif to the clouds coming from the north guaranteed good observations on that night, except for some lenticular and thick clouds (Figures 1-4).

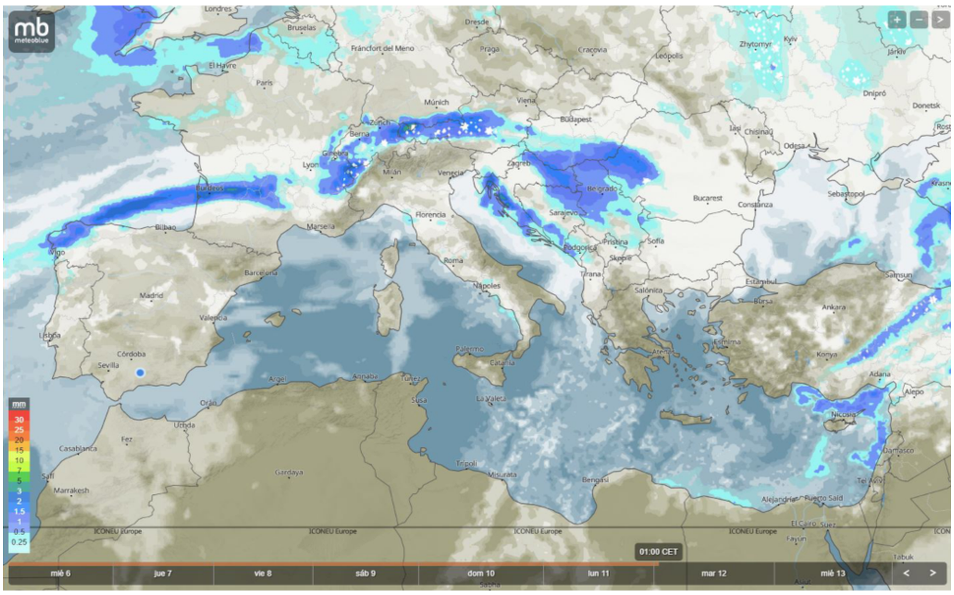


Figure 1. Weather forecast for Europe for the night of 2023 December 11 -12, generated six days before the occultation event. (Meteoblue elaboration).

Figure 2. Real meteo conditions (satellite) in Calabria and Puglia at sunset of 2023 December 11. The blue dot is Sibari. (Meteoblue)

Figure 3. Lenticular clouds with the atmospheric circulation in Calabria, as on 30 november 2023 from Saracena. (M. Bisconte)

Figure 4. Lenticular clouds at sunrise of 2023 December 13 from Sibari (Betelgeuse's centre line). (C. Sigismondi)

Stellar Scintillation with Small Telescopes

It is well known that stellar scintillation is due to the continuous high-frequency modifications of the unperturbed wavefronts and to the Poissonian noise, when the photon counts are low. For Betelgeuse the high luminosity saturates almost all astronomical sensors, even with small telescopes. The first approach was to use small aperture telescopes (50-60 mm).

But the scintillation signal was much stronger than the expected signal from the occultation, which was going to be partial, around ¼ of the total luminosity of the star, for most of the centre line.

It was clear that a small telescope would have lost the light modulation's details from the progressive stellar covering. The idea of using multihole masks[1] came out as the solution and we made trial videos to show the bounty of that choice. The result was immediately spread worldwide to allow all the observers to get better data from this unique opportunity [5].

[1] Also known as *Hartmann masks* for focusing, but it was not the case here.

Figure 5. Noschese's "Leviathan" 50 cm Dobsonian telescope with mask. (A. Noschese)

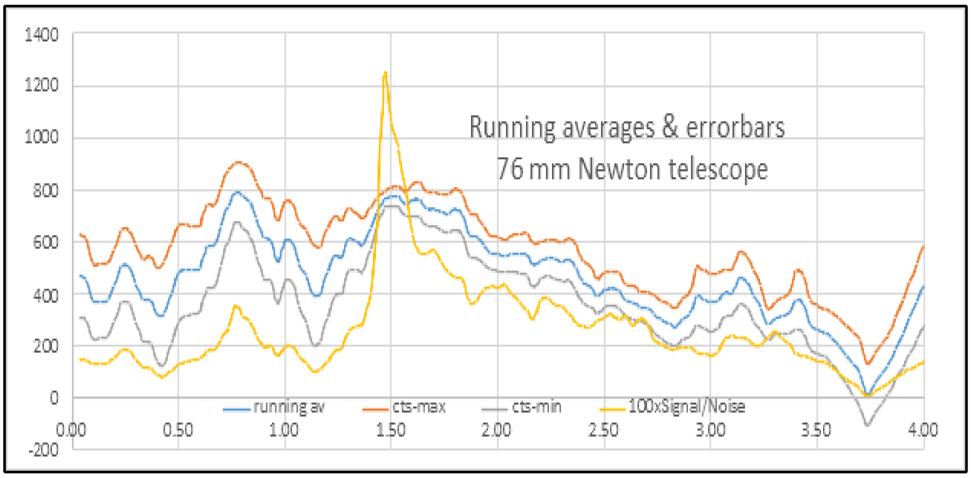


Figure 6. The signal to noise ratio during the occultation of Betelgeuse by a cloud at 1:08:30 UT on 2023 Dec 12 (Sigismondi's observing station, Sibari, 6 km north of the predicted centre line). The max value of S/N is 12, while the masked Leviathan allowed us to reach 30 consistently.

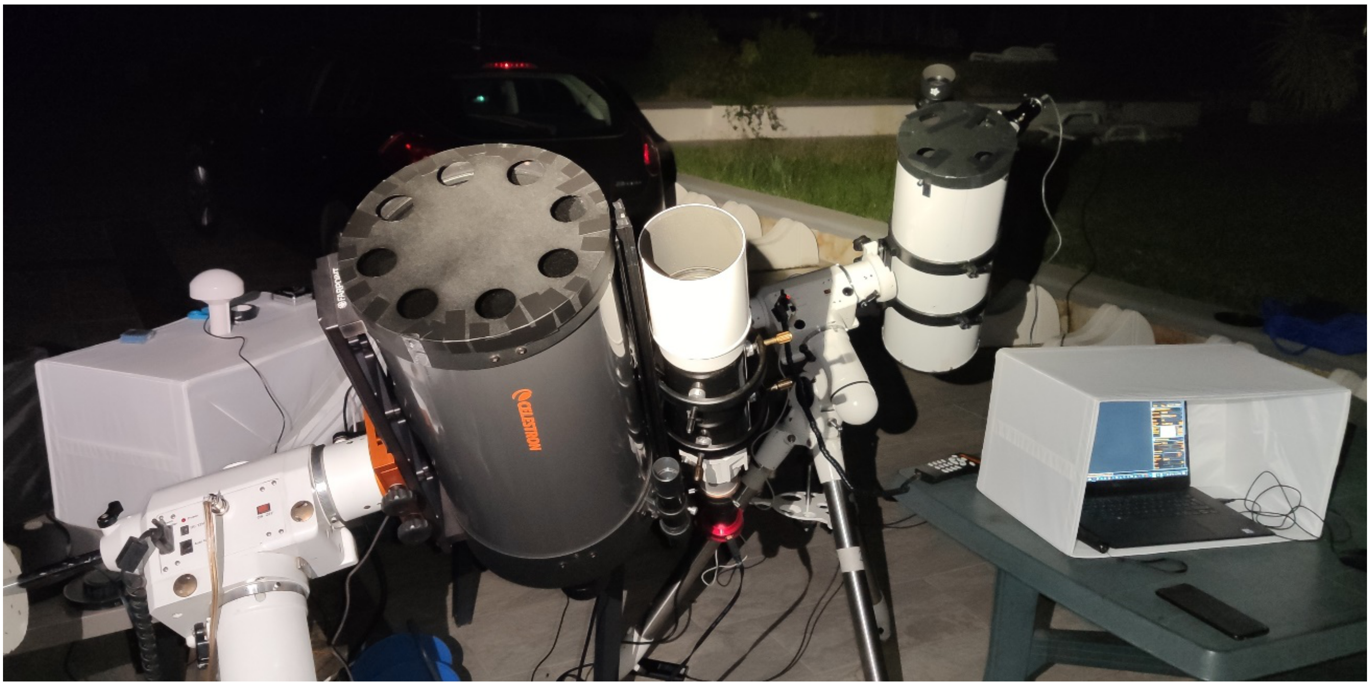


Figure 7. The telescopes' setup at Noschese's observing place: C9 and 10 cm refractor. (A. Noschese)

Light Curves

The preliminary analysis is still ongoing in the weeks after the occultation, but this paper wants to show the Signal-to-Noise of the masked Leviathan (Figure 10) compared with the 3″ Newtonian (Figure 6), even if clouded out at the climax moment.

The starting of the occultation is the first bending of the curves (Figures 8, 9 and 10), and the total occultation lasted about 12 s. The angular velocity of the asteroid was 8.22 mas/s [6]. The duration of the occultation in B band (10 cm telescope) (Figures 7, 8), and V band (28 cm) (Figure 9) is also clearly visibile, and this allowed us to do the first estimates of the stellar diameter[2].

The start-to-end time of the occultation to the present analysis is transformed into an angular chord of the asteroid+star as H-α 100±0.7 mas (Figure 10); V-Band 103 mas and 98.6 mas in B-band. A smaller H-α size than the V-band is intriguing, but completely preliminary.

Also, asymmetries in the light curve have to be confirmed by independent observations, because a cloud veil could have caused them very easily.

[2] D. Herald on Planoccult mailing list, 2023 Dec 16: The Star is 58 mas in H-α, 59 in V-band and 59 in B-band, the LDF parameter u=0.98.

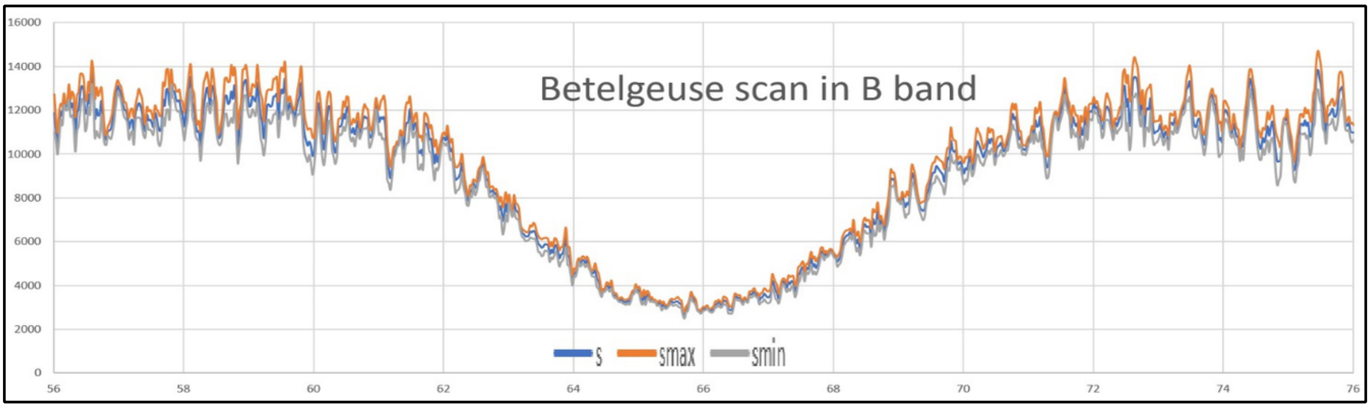


Figure 8. Occultation at Noschese's station in B-band starts at 1:12:00 UTC, 2023 Dec 12. Refractor 10 cm f/5, no mask, 25 ms exposure.

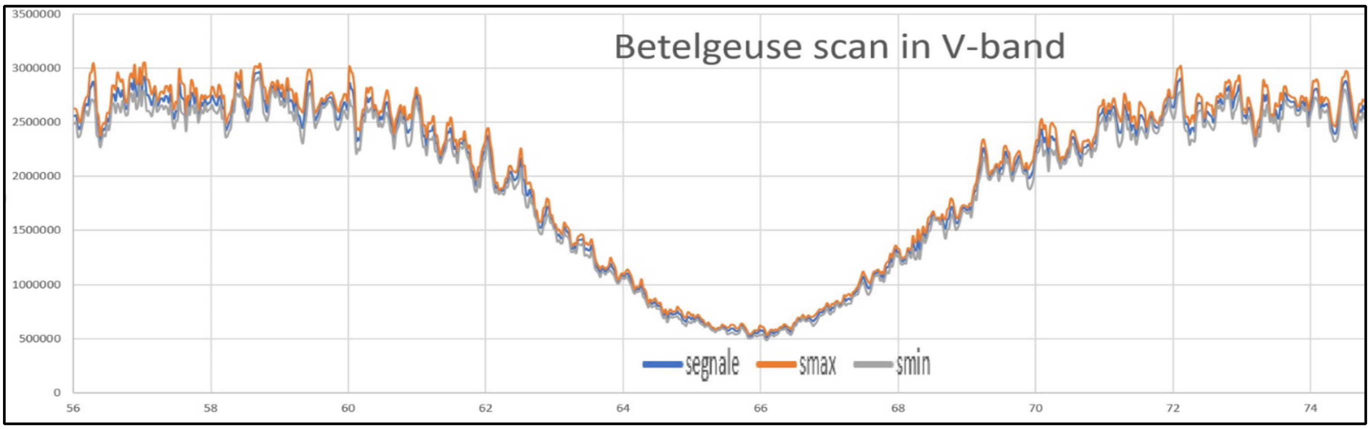


Figure 9. Betelgeuse scan in V-band (Noschese's station, telescope C 9, 23.5 cm f/10), V filter Johnson Cousins, 8 holes x 40 mm mask, exposure: 25 ms. Time from 1:12:00 UTC, 2023 Dec 12.

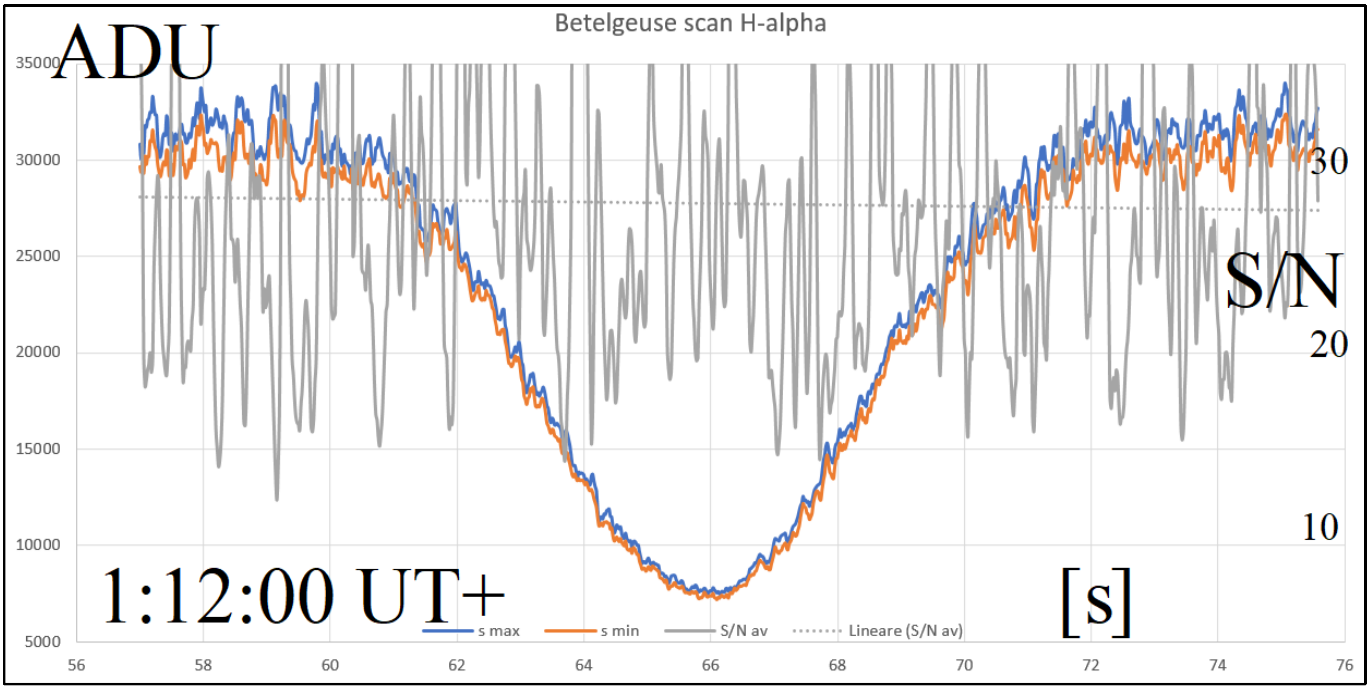


Figure 10. The H-α curve of the occultation of Betelgeuse (50 cm Dobsonian, the "masked Leviathan"). In red the minimum signal and in blue the maximum. Exposure time 20 ms, moving averages over 0.1 s intervals, along with the standard deviations from the same value. The Signal-to-noise ratio is always at level 30. Time from 1:12:00 UTC, 2023 Dec 12.

Naked Eye Spectroscopy in Saracena and Kepler's Planetary Occultation

At 11.7 km north of Preston's predicted centre line [6] another team was observing the phenomenon with the naked eye.

Mariangela Bisconte reported: *It was not an ON/OFF phenomenon, but rather a dimming. It is like a dark veil was passing on Betelgeuse which darkened the colours from red-orange it become opaque and grey. Immediately after this passage the star turned bright and sparkling red again.*

The timing of this phenomenon was 2:13:00 local time, as in the ephemerides, and the perceived duration was slightly larger than 1 second. The time to pronounce "Angelo–di" rapidly.

The change in colour was perceived, and this can be explained as originated by asteroid (319) Leona covering the centre of Betelgeuse and leaving visible the limb darkened peripheral zones. The account was original and not changed according to previous astrophysical technical knowledge.

To find a similar account about colours, we have to go back to the year 1590 when Johannes Kepler observed with his master Michael Maestlin in Heidelberg, Germany, the occultation of Mars by Venus [7]. Kepler accounted of the white colour of Venus merging with the red one of Mars. In that phenomenon, during 36 minutes, the two planets were separated by less than 20 arcseconds, the limit for naked-eye angular resolution.

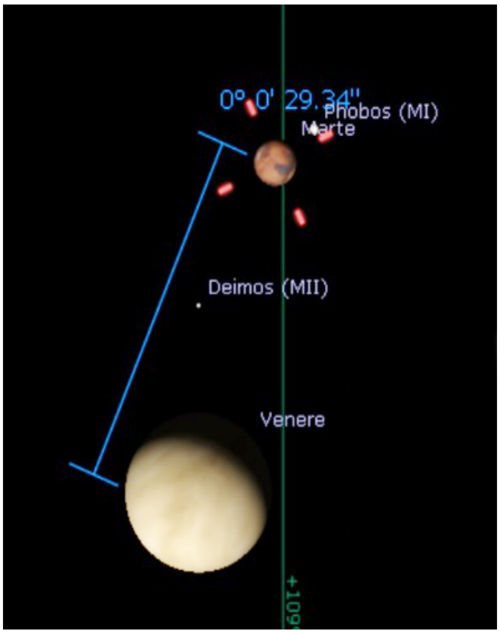


Figure 11. Simulation of the Venus-Mars occultation on 1590 Oct 13 at 4-5 AM, observed by Kepler and Maestlin in Heidelberg. (Stellarium 0.20.2)

Conclusion

The decision to adopt many-hole masks matured in the discussions before the occultation and it allowed us to achieve a Signal-to-noise ratio of 30 in each frame of the video, necessary to obtain clear light curves of this unique occultation [9].

The first occultation curves fit a diameter for Betelgeuse larger than predicted (60 vs 48 mas) with differences in H-α, V and B-bands [8]. A strong limb darkening (u>0.5) is also evident, from fits and from naked eye observations.

The change in colour of Betelgeuse during the occultation was also visible to the unaided eye, without previous specific advice. This was possibly the first naked-eye observation of limb darkening evidence of another star, beyond the Sun.

Acknowledgements

Massimo Corbisiero of AstroCampania association, who chaired the local organising committee. Maria Dal Pian, Paolo Ochner and Federico Manzini who discussed the preliminary data. Cesare Barbieri and the AQUEYE/IQUEYE team, already active in Occultation projects at *Asiago Observatory* and Vincenzo Leonardo Manuli.

References

[1] Ortiz, J. L. et al., The stellar occultation by (319) Leona on 13 September 2023 in preparation for the occultation of Betelgeuse, Monthly Notices of the Royal Astronomical Society: Letters, Volume 528, Issue 1, February 2024, Pages L139–L145, https://doi.org/10.1093/mnrasl/slad179

[2] Sigismondi, C., Detecting the penumbra of Betelegeuse with a diffuse telescope during the Leona occultation, Gerbertus 19, 361 (2023), http://www.icra.it/gerbertus/2023/Gerb-19-2023-Sigismondi-Beteleguse-361-366.pdf

[3] I.C.R.A. Network - Betelgeuse dimming, 2020 Jan 17 meeting https://www.icranet.org/index.php?option=com_content&task=view&id=1281

[4] Fall and Rise of Betelgeuse, 16th Marcel Grossmann Meeting, virtual meeting (icra.it), http://www.icra.it/mg/mg16.html

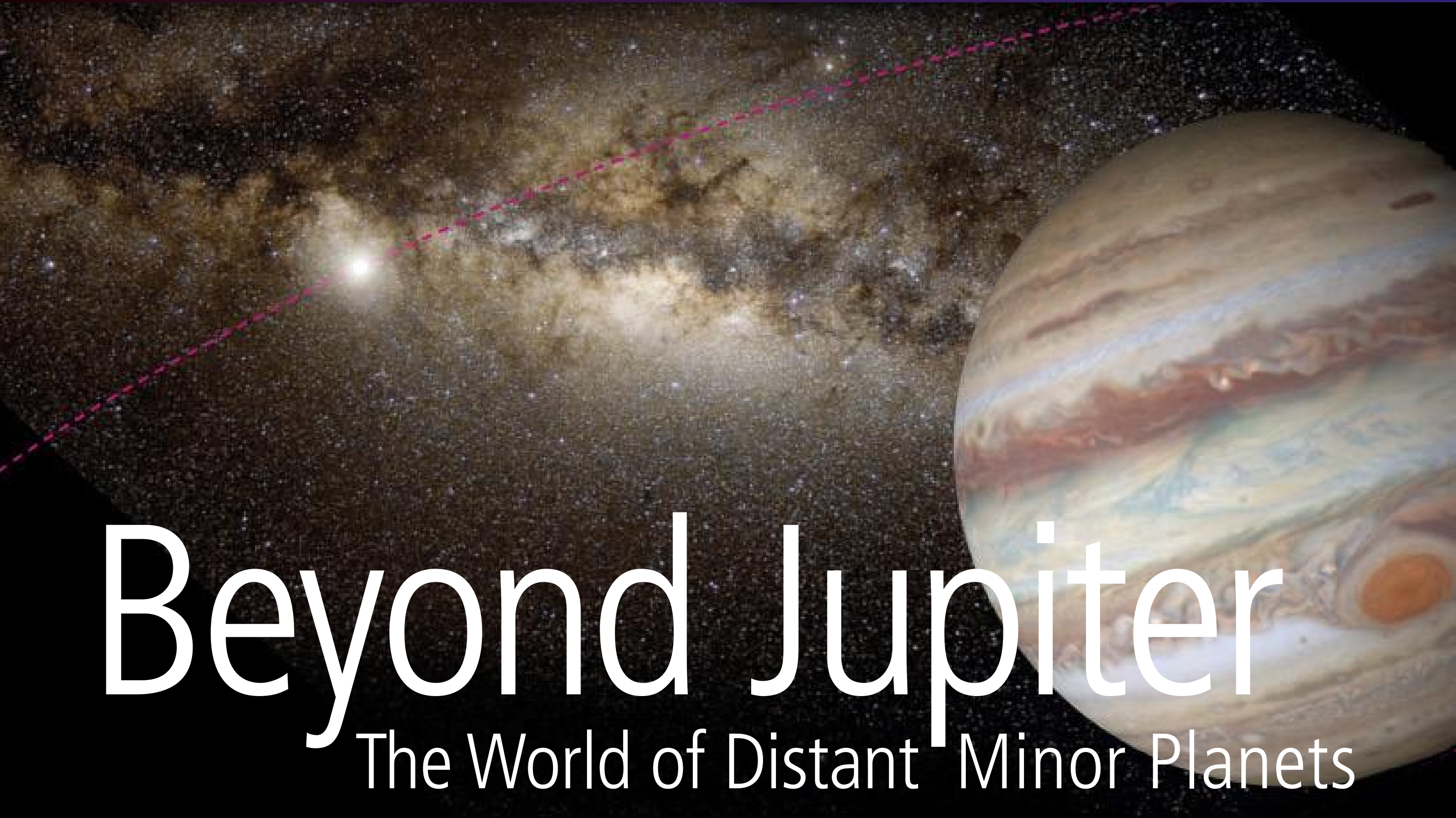
[5] Sigismondi, C., Costa, C., Noschese, A., The occultation of Betelgeuse by Leona: recovering the stellar surface brightness of a red supergiant, with a diffuse telescope, on Dec 12 1:12 UT, The Astronomer's Telegram, #16374, https://www.astronomerstelegram.org/?read=16374

[6] Preston, S., Prediction for occultation of Betelgeuse by (319) Leona on 2023 Dec 12, Occult Watcher Cloud, https://cloud.occultwatcher.net/event/1075-319-83995-648466-H27989/1246616

[7] Planetary transits and occultations, Wikipedia, https://en.wikipedia.org/wiki/Planetary_transits_and_occultations#cite_note-sat57-3

[8] Starblink Occultation Simulator, realized by University of Granada, Astrogranada-Sociedad Astronomica Granadina and Instituto de Astrofisica de Andalucia, https://www.starblink.org/occult_simulator

[9] Betelgeuse occulted and unveiled, https://www.icranet.org/index.php?option=com_content&task=view&id=1512=



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 2023 December 29, the *Minor Planet Center* listed 1570 Centaurs and 3210 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:

(7066) Nessus

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

ABSTRACT: Since 2016, JOA regularly publishes portraits of objects beyond the orbit of Jupiter since such objects are prime targets for future occultation studies.
This short communication on the Centaur (7066) Nessus tells the story of its discovery, the meaning behind its name and the nature of its orbit. Its size and physical properties are also discussed, these being taken from data published up to 2020.

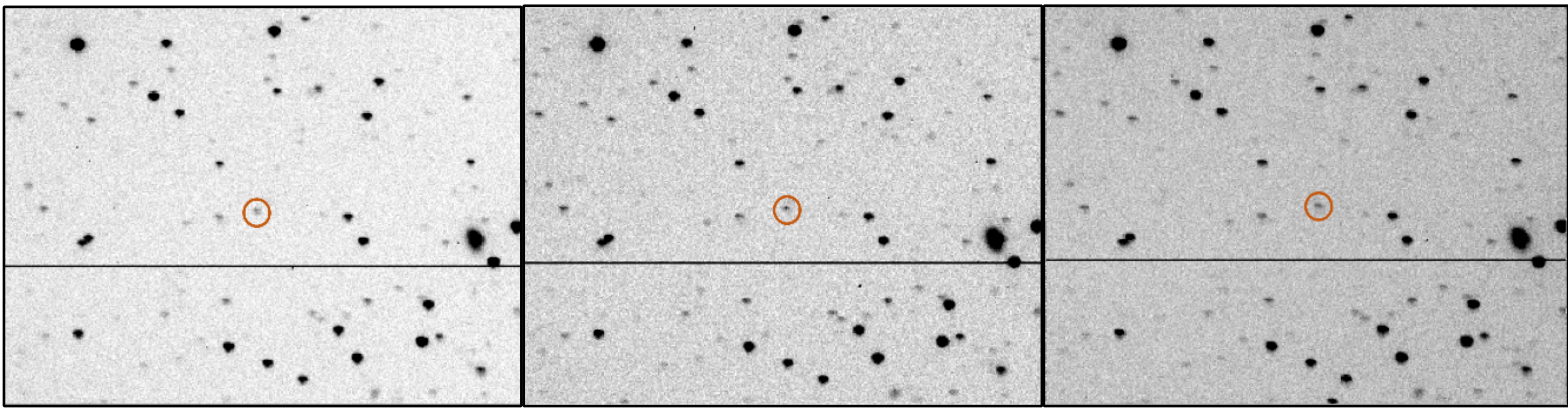
No.	Name	Author	Link to Issue
944	Hidalgo	Oliver Klös	JOA 1 2019
2060	Chiron	Mike Kretlow	JOA 2 2020
5145	Pholus	Konrad Guhl	JOA 2 2016
5335	Damocles	Oliver Klös	JOA 2 2023
8405	Asbolus	Oliver Klös	JOA 3 2016
10370	Hylonome	Konrad Guhl	JOA 3 2021
10199	Chariklo	Mike Kretlow	JOA 1 2017
15760	Albion	Nikolai 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
32532	Thereus	Konrad Guhl	JOA 1 2023
38628	Huya	Christian Weber	JOA 2-2021
47171	Lempo	Oliver Klös	JOA 4 2020
50000	Quaoar	Mike Kretlow	JOA 1 2020
54598	Bienor	Konrad Guhl	JOA 3 2018

No.	Name	Author	Link to Issue
55576	Amycus	Konrad Guhl	JOA 1 2021
58534	Logos & Zoe	Konrad Guhl	JOA 4 2023
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
486958	Arrokoth	Julia Perła	JOA 3 2023
-	2004 XR_{190}	Carles Schnabel	JOA 1 2022

The Discovery

The object was discovered on 1993 April 26 by the Spacewatch Project at *Kitt Peak National Observatory* (Figures 1a-c). The Spacewatch Project was initiated by Tom Gehrels and Robert S. McMillan in 1980–82. These days it is called SPACEWATCH® and utilises 0.9-m, 1.8-m and 2.3-m telescopes on the 2,095 m high Kitt Peak in Arizona (USA).

This was the second Centaur object found by Spacewatch having been discovered by David L. Rabinowitz using the 0.91-m Newtonian telescope (Figure 2) and it received the provisional designation, 1993 HA_2 [1]. The number designation 7066 was assigned on 1996 July 1 [2], whilst its official name was given on 1997 April 22 for the mythological centaur, Nessus [3].



Figures 1a-c. Discovery images of 1993HA_2. Image orientation: East (increasing Right Ascension) to the left, and north (increasing Declination) towards the top.
Credit: University of Arizona, The Lunar and Planetary Laboratory, SPACEWATCH®, Roger E. Carpenter, MD.

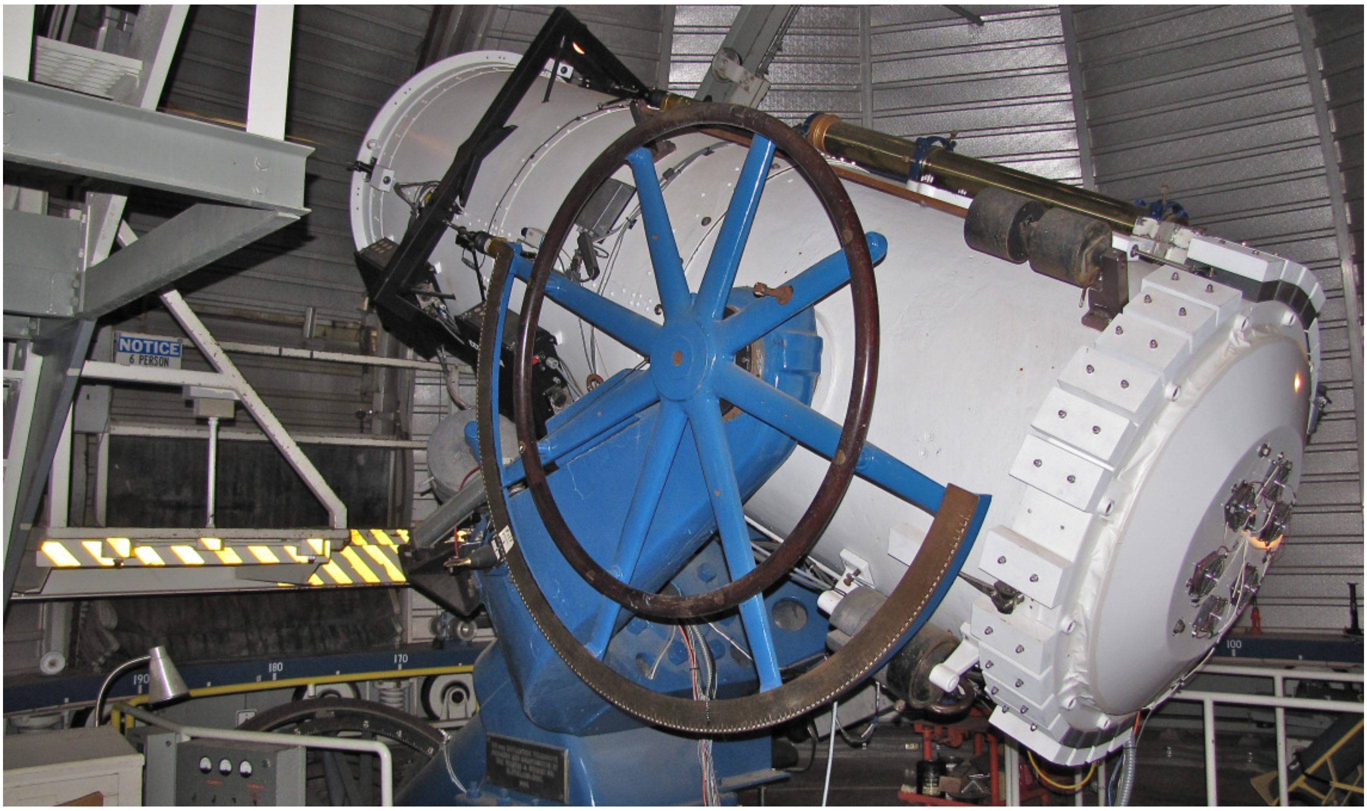


Figure 2. The 0.91-m telescope of the Spacewatch program at Kitt Peak.
Credit: University of Arizona, The Lunar and Planetary Laboratory, SPACEWATCH®, Roger E. Carpenter, MD.

The Name

Nessus is the Latinised form of the ancient Greek Νέσσος (Néssos). This centaur of Greek mythology once ferried the bride of Hercules, Deïaneira, across a flooded river. In the process, Nessus tried to kidnap Deïaneira and gallop off with her. Hercules saved her by shooting Nessus with a poisoned arrow. Dying, Nessus advised Deïaneira to "catch a little of my blood and keep it. If you fear losing the love of Hercules, soak his robe with it and he will never look at another woman but you." But his blood was poisoned by the arrow of death. Years later, when Hercules turned to another woman, Deïaneira carried out Nessus' revenge. The proverbial Nessus Shirt poisoned Hercules by burning his flesh. Thus, as once prophesied, Hercules was killed by a dead man. Figure 3 shows an artist's impression of Hercules firing the arrow at Nessus.

Figure 3. Hercules - Nessus - Deïaneira. Engraving by Johann Wilhelm Bauer (1600-1640) for Ovid's Metamorphoses Book IX, 99-133. Public-domain, copyright expired due to date of death of author (artist).

The Orbit

The orbit is eccentric (e = 0.52) and is inclined to the ecliptic by 15.6°. With a semi-major axis of 24.59 AU, the distance from the Sun varies between 11.8 au and 37.34 au. In this respect, the orbit lies completely outside that of Saturn. The orbital period is approximately 122 years. Like all objects having a perihelion between the orbits of Jupiter and Neptune, it belongs to the group known as Centaurs. After (2060) Chiron and (5145) Pholus (also discovered by Spacewatch), (7066) Nessus was the third Centaur to be discovered. Due to perturbations by the giant planets the orbit of this centaur (like all Centaurs) is unstable in the long-term.

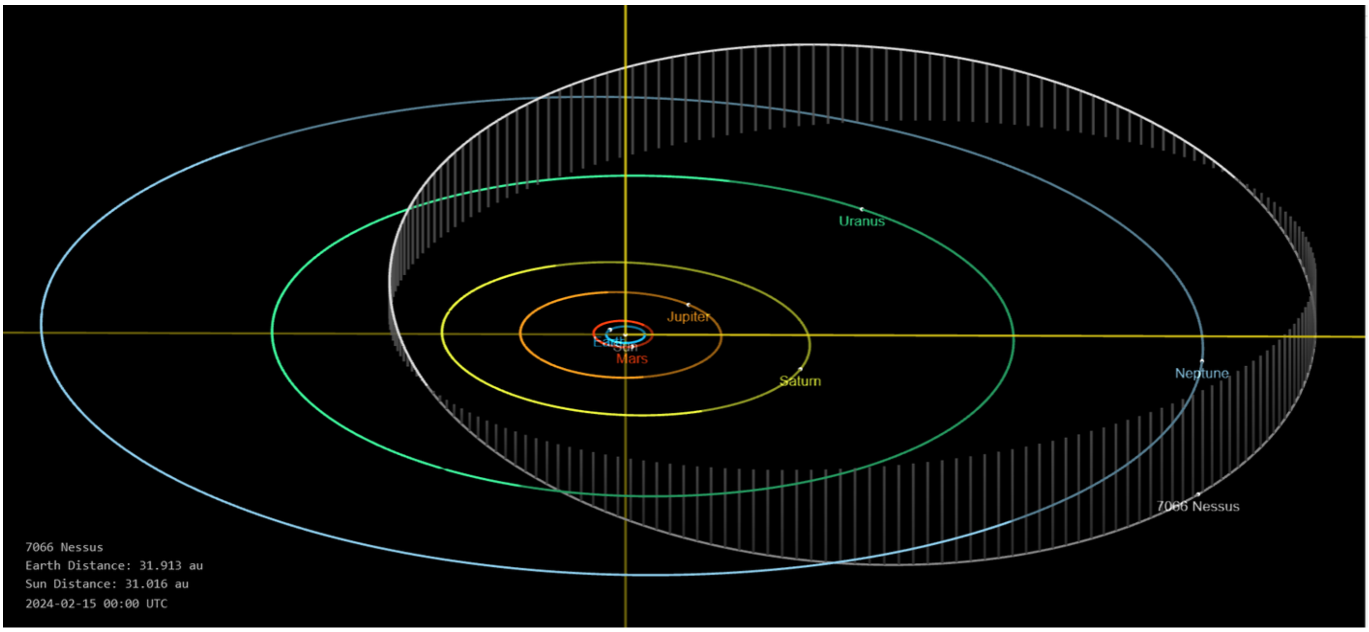


Figure 4. Orbit diagram and position of (7066) Nessus on 2024 February 15.
(Source: NASA/JPL Small-body database lookup, https://ssd.jpl.nasa.gov/tools/sbdb_lookup.html#/?sstr=7066)

Physical Characteristics

(7066) Nessus has been observed with the *Spitzer Infrared Space Telescope* to determine its diameter from thermal models [4]. The diameter found by this approach is 59.7 +15.9/−15.1 km. In Ref. [5] the data were re-analysed and the published diameter was 57 +17/−14 km. Its absolute magnitude (H) is reported in [4] and [5] as 9.7 mag and 9.51 +/- 0.22 mag. Spectral observations show the object as being very red. In Ref. [6] Nessus is classified in the BVRIJ taxonomy as particularly "red" or RR. In this source the albedo is reported to be 0.086 +0.08/-0.03. Currently, no measurable rotational light curve has been measured, nor any moons detected.

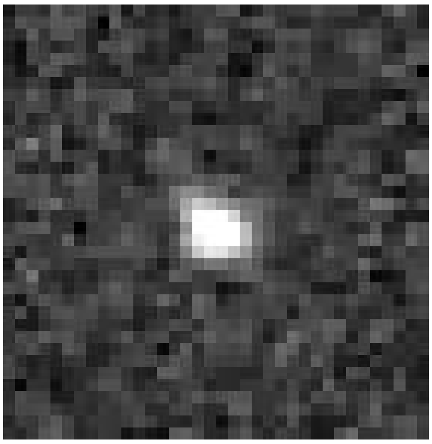


Figure 5. Hubble Space Telescope image of the Centaur (7066) Nessus, taken on 2009 September 28.
Hubble Space Telescope/Michael E. Brown

Occultations by (7066) Nessus

When discovered, (7066) Nessus was 20th magnitude and had passed through perihelion a year or so earlier, and since that time it has been receding from the Sun such that the last astrometry reported dates from 2004. Up to now, no occultations by (7066) Nessus have been observed, which is indicative of the fact that its orbit is now too imprecise for accurate predictions to be possible. Certainly, no stellar occultations by (7066) Nessus are predicted by specialists such as the *Lucky Star* team. To have a chance of including (7066) Nessus in future occultation predictions, it will need to be recovered using a large instrument as it currently is approaching 25th magnitude. Hopefully it will be detected by the *Vera C. Rubin Observatory*, once it becomes operational in a few years' time, when it is expected to discover moving objects down to 27th magnitude.

References

[1] MPC22169
https://www.minorplanetcenter.net/iau/ECS/MPCArchive/1993/MPC_19930604.pdf
[2] MPC27439
https://www.minorplanetcenter.net/iau/ECS/MPCArchive/1996/MPC_19960701.pdf
[3] MPC29671
https://www.minorplanetcenter.net/iau/ECS/MPCArchive/1997/MPC_19970422.pdf
[4] Stansberry, J. et al.: "Physical Properties of Kuiper Belt and Centaur Objects: Constraints from Spitzer Space Telescope", To Appear in: The Solar System beyond Neptune (M.A. Barucci et al., Eds.) U. Arizona Press, 2007, https://arxiv.org/abs/astro-ph/0702538
[5] Duffard, R. et al.: ""TNOs are Cool": A survey of the trans-Neptunian region. XI.", Astronomy & Astrophysics manuscript no. paper-centaurs 13, ESO 2018, https://doi.org/10.1051/0004-6361/201322377
[6] Belskaya, Irina N. et al: "Updated taxonomy of trans-Neptunian objects and centaurs: Influence of albedo", Icarus 250 (2015) 482–491 https://doi.org/10.1016/j.icarus.2014.12.004

Useful Links

About objects like TNOs and Centaurs:
NASA/JPL Small-Body Database Lookup
https://ssd.jpl.nasa.gov/tools/sbdb_lookup.html#/
Spacewatch, Lunar and Planetary Laboratory, University of Arizona
https://spacewatch.lpl.arizona.edu
Minor Planet Center
https://minorplanetcenter.net

Figure 1. Group photo in front of Armagh Planetarium (O. Klös)

ESOP XLII - Report of the 42nd European Symposium on Occultation Projects

Alex Pratt · IOTA/ES · BAA · Leeds · England · alex.pratt@bcs.org.uk
Oliver Klös · IOTA/ES · Eppstein-Bremthal · Germany · pr@iota-es.de

ABSTRACT: The 42nd European Symposium on Occultation Projects (ESOP) took place at Armagh Observatory and Planetarium (AOP), Northern Ireland, during the weekend of September 16 – 17 and it was a hybrid event held simultaneously as an in-person meeting and an online video conference. A total of 26 delegates attended the meeting, accompanied by 10 family members, and 55 persons participated online via Zoom, altogether representing Algeria, Australia, Belgium, Brazil, Czechia, Denmark, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, Poland, Spain, Türkiye, the United Kingdom and the USA. The science meeting was followed by social excursions on the Monday and Tuesday.

Friday 15th September 2023

Registration opened from 3 pm – 5 pm in the foyer of the Planetarium and the first arrivals to the Symposium collected their conference badges and programme, and met for a chat and a coffee. It was a good opportunity to look around the informative displays about astronomy and spaceflight, and purchase items from the shop.

The informal reception took place from 7:30 pm in Spires Bar, Armagh City Hotel, where most of the delegates were staying. Lead organiser Dr Apostolos (Tolis) Christou of AOP welcomed everyone to ESOP 42 and we were treated to soft drinks, red or white wine, and a buffet spread.

Saturday 16th September 2023

The registration desk opened again at 8:30 am for delegates to collect their name badges and programmes, then proceed into the Copernicus Hall where the conference would take place. On each seat was an AOP gift bag containing a notepad and a pen, a map showing locations of interest in the city and places to eat, notes on health and safety and conference etiquette, and a nice AOP insulated flask.

Tolis welcomed everyone to ESOP 42 and Konrad Guhl (President IOTA/ES) thanked him and all the AOP staff for organising the most westerly ESOP in the history of IOTA/ES, and greeted all the delegates who had travelled to Armagh. He commented that this Symposium was also being presented online but attendance via a computer screen cannot replace the value of face-to-face interactions.

Figure 2. Apostolos Christou welcomes the delegates. (O. Klös)

Session 1 - Observation Reports
chaired by Wolfgang Beisker

Baba Aissa Djounai et al (Center of Research in Astronomy, Astrophysics and Geophysics, Algiers, Algeria) presented by Baba Aissa Djounai - The positive observation of the stellar occultation by the trans-Neptunian object 19521 Chaos at the Algiers Observatory (CRAAG)

Djounai outlined the research undertaken at Algiers observatory and its range of equipment, where he leads a team working on meteoritic studies and stellar occultations, particularly by TNOs and NEAs. He mentioned the work of Irish astronomer Kenneth Edgeworth on a reservoir of trans-Neptunian objects. He described how CRAAG used the 81 cm telescope at Algiers observatory on 2023 March 29 to successfully record a 17 s occultation by the TNO (19521) Chaos. Djounai also coordinates an national campaign to involve 150 amateur observers in occultation work. He discussed their plans for the Leona-Betelgeuse event on December 12 and their earlier attempts to monitor occultations by Leona. He concluded with a summary of their plans for 2024, including the occultation by (16) Psyche on October 8.

Figure 3. Baba Aissa Djounai talks about his campaign. (O. Klös)

Konrad Guhl (Archenhold Sternwarte, Berlin) – Baily's beads observations during the total solar eclipse of 2022 April 20

Konrad described the long-term projects of IOTA and IOTA/ES to use video recordings of Baily's beads phenomena to measure the Sun's diameter, and he mentioned the short-lived *PICARD* satellite mission. The solar eclipse of April 20 barely nudged Western Australia, and Konrad and his wife Elke coordinated with Luca Quaglia to observe from Cape Range National Park. Their 8-pack of batteries was confiscated at Berlin airport but they overcame this, and other difficulties, to record Baily's beads with a 100/1000 Maksutov telescope, 535 nm filter and a QHY174MGPS camera (12-bit). He showed their reduction process and results: a solar radius of 960.01" +/- 0.12 (Occult: 959.63"). They also participated in a photometric experiment. (See JOA 2023-4).

Figure 4. Konrad Guhl presents results from his expedition to the annular solar eclipse in 2023. (O. Klös)

Marcelo Assafin et al ((Universidade Federal do Rio de Janeiro - Observatório do Valongo) – presented by Marcelo Assafin (via Zoom) - Kilometre-precise (UII) Umbriel physical properties from the multichord stellar occultation on 2020 September 21

Marcelo summarised the nature of Uranus, one of the least explored planets in the solar system and its moons whose surfaces are composed of various ices. He led the pro-am campaign to observe this occultation of a 13th mag. star by Umbriel which produced 19 positive chords recorded across Canada and the USA. This determined the physical characteristics of Umbriel, its high-precision astrometric position in RA and Dec, upper limits on a putative atmosphere and topographical comparisons with data from *Voyager II*. Valuable information for any future space missions.

Figure 5. Marcelo Assafin (on screen) during the Q&A session after his talk. (O. Klös)

Session 2 - Observation Reports II
chaired by Michael O'Connell

Marek Zawilksi (Polish Association of Amateur Astronomers) – (via Zoom) - A short history of the Irish eclipses and occultations

Marek's presentations on historical eclipses and occultations seen from the host country are a traditional highlight of ESOP. The first event in his talk was of a solar eclipse of 512 June 26, recorded in the Annals of Ulster. The eclipse of 1652 April 8, inspired a dramatic description of the solar corona. Thomas Romney Robinson observed that the lunar limb of the 1836 May 15 eclipse displayed threads of light, also reported by Francis Baily. Marek also mentioned the Grubb Coelostat at *DIAS-Dunsink Observatory*, used at the 1919 eclipse to validate Einstein's prediction of the gravitational deflection of light.

Figure 6. Marek Zawilski presented live from Poland his lecture about historical Irish eclipses and occultations. (O. Klös)

Tim Haymes (Assistant Director: Occultations, BAA Asteroid and Remote Planets Section) - Observation highlights in the GB/IE region for 2022-2023.

The BAA's ARPS Section has about 15 active occultation observers (from UK, IE, NL and BE) and Tim is the region's lead SODIS reviewer. He described some notable events: two well-separated chords across 12 km-diameter (4471) Graculus; a probable graze of (325) Heidelberga (see below); multiple chords across (64) Angelina; a single chord across comet 29P/ Schwassmann-Wachmann (a first UK success); a step event of (1051) Merope which was a diffraction effect. Tim had success with dual home and mobile stations for (5022) Roccapalumba.

Figure 7. Tim Haymes shows the distribution of observers of BAA's ARPS section. (O. Klös)

Alex Pratt (Leeds, England) - A grazing asteroidal occultation by (325) Heidelberga on 2023 January 19

The predicted maximum duration was 6 s and Alex recorded a 0.4 s dip followed by another of 1.70 s. Different analysis methods in *Tangra* showed this pair and reductions in *PyOTE* by Christian Weber gave 0.90 s and 1.60 s. Positive chords by Konrad Guhl (DE) and Kevin Green (US), and a valuable negative report by Andrew Scheck (US) confirmed Alex's grazing result. There are no shape models of Heidelberga and more observations are requested.

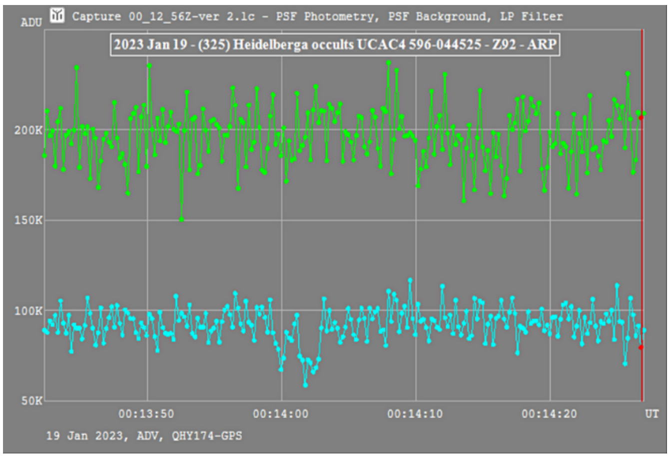


Figure 8. The light curve of the grazing occultation by asteroid (325) Heidelberga. Analysed with Tangra. (A. Pratt)

Richard Miles (Director, BAA Asteroid and Remote Planets Section) - Stellar occultations by comet nuclei: The story of Centaur-comet 29P

Richard leads the BAA's Mission 29P campaign on monitoring this comet-like object which lies in a circular orbit between Jupiter and Saturn. It frequently undergoes outbursts, brightening by 5 or 6 magnitudes and he has developed a model, where cryovolcanism explains this behaviour. He discussed the occultation of comet 28P/Neujmin on 2022 February 8 and listed the positive chords obtained across 29P in 2022 and 2023, including a single chord from the UK, giving an elliptical fit to a body about 65 km in diameter.

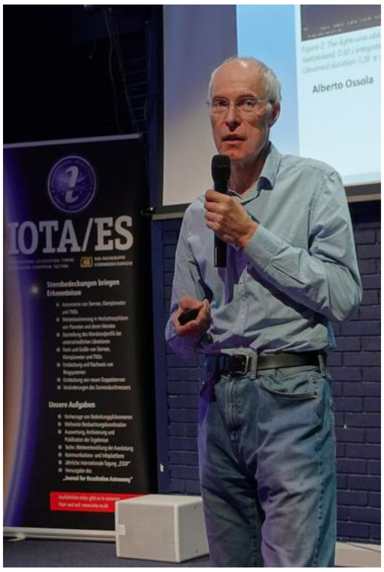


Figure 9. Richard Miles gives a talk about Centaur-comet 29P. (O. Klös)

Session 3 - Reporting Formats and Databases chaired by William Stewart

Sven Andersson (Berlin, Germany) SODIS – The portal for reporting occultations of stars by minor planets

Eric Frappa maintained the Euraster database for 25 years, assisting observers with their reports and processing them as European coordinator. This major contribution ended in December 2022 and a new system was needed. Sven explained that *Occult Watcher Cloud* couldn't be used, an Excel solution was possible (such as used in North America) but in October 2022 software developer Erik Tunsch offered to build a reporting system and a test version was available in November. After rapid development it went live in January 2023. SODIS (Stellar Occultation Data Input System) has regional reviewers supported by Sven, Christian Weber and a SODIS forum, and at the end of August had over 200 registered users reporting 495 positive and 1,212 negative observations.

Figure 10. Sven Andersson presents the new European reporting portal SODIS. (O. Klös)

Yücel Kiliç (TÜBİTAK National Observatory, Türkiye) - A statistical overview and current state of the Occultation Portal

Yücel is lead developer and manager of the Occultation Portal, a web-based platform for observations and analyses of the Lucky Star and ACROSS pro-am campaigns. He presented statistics on the Portal's numbers of events, observing reports, sites and users, plus breakdowns of the numbers of chords per event, numbers of events with at least one chord, the proportions of positive and negative observations, types of target object, their magnitudes, the spread of participating countries and the different kinds of telescopes and cameras in use.

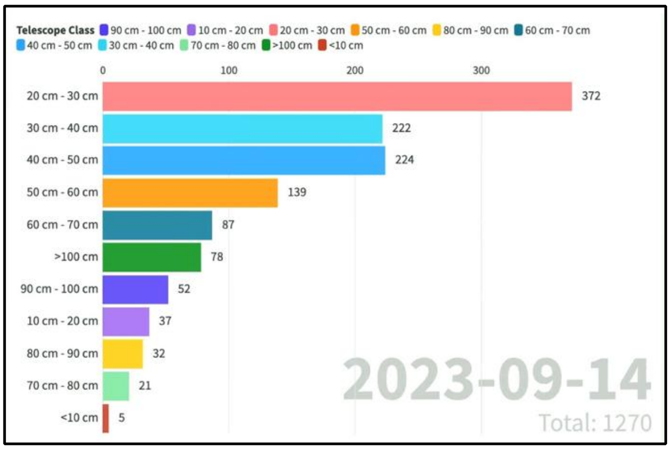


Figure 11. Reported observations to the portal according to telescope class. (Y. Kiliç)

Tim Haymes (BAA) - Submitting light curves to Dave Herald – The new Occult4 function

Tim demonstrated a new, simplified method for a user with SODIS Reviewer status to submit a light curve to Dave Herald. After a report has been Accepted, the Reviewer will see that SODIS displays an EXPORT option and clicking on this will download an .xml file. Open the Asteroid Observations Editor in *Occult*, open the .xml file, right click on the observer entry, read the .csv file and click OK. This should populate all the fields for light curve submission.

Nikolai Wünsche - Long-term storage of observation data

Astronomical photographic plates remain a valuable resource after 150 years, but Niko asked, how much of our occultation data is safely archived? Our results are in multiple databases, but what about our raw data? What should we keep for future analyses?

Niko discussed the importance of taking backup copies, he compared long-term storage on disk drives versus cloud storage, and considered the costs incurred and ease of access and retrieval. Are these tasks for individuals or should we take a coordinated approach? This led to a lively discussion.

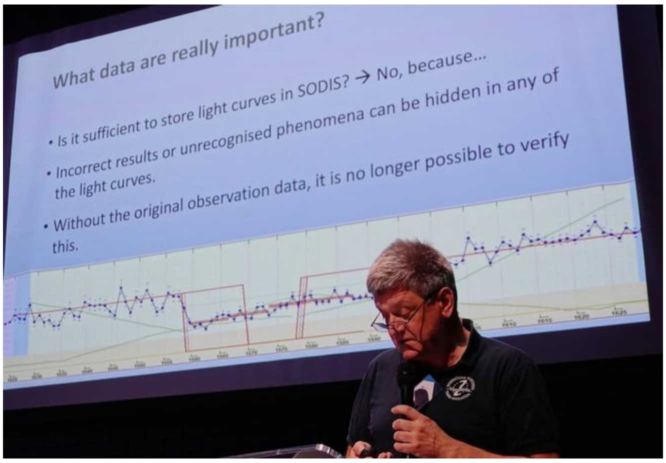


Figure 12. Nikolai Wünsche asks the participants what data of observations should be stored. (O. Klös)

Mike Kretlow (Instituto de Astrofísica de Andalucía, Granada, Spain) - CORA – Collaborative Occultation Resources and Archive. Status quo and future plans

Unfortunately, Mike could not present his talk due to illness.

This closed the sessions of the first day of ESOP42. The General Assembly of IOTA/ES followed.

It is now a tradition to hold the General Assembly during ESOP. This is intended to better involve the members and give insights into the business affairs of IOTA/ES. Members joined the General Assembly in person or via Zoom. After an introduction given by Konrad Guhl, scientific results and future projects were presented by Wolfgang Beisker. Secretary Nikolai Wünsche gave some member statistics. Oliver Klös talked about the new designed IOTA/ES - Call for Observations webpage, the news feeds on Mastodon and X (former Twitter) and the publications and webpages in different languages by IOTA/ES members. A special focus was on webpages for the upcoming occultation of Betelgeuse in December 2023. Andreas Tegtmeier presented the treasurer's report.

As every two years, the Board of IOTA/ES was to be elected. All previous members of the Board stood for re-election and were re-elected.

The day ended with a social dinner with a lively exchange at Charlemont Arms Hotel.

Sunday 17th September 2023

Session 4 - The December 2023 occultation of Betelgeuse by asteroid (319) Leona

chaired by Oliver Klös

Konrad Guhl (Archenhold Sternwarte, Berlin) - Planned observation of the occultation of Betelgeuse by (319) Leona

Betelgeuse is a bright naked-eye star and Konrad explained the plan to observe its occultation with the IOTA/ES M2 (50 cm) telescope. A beam splitter will be used to feed the star's light into two QHY174M-GPS cameras, recording at high frame rates. One camera will have an ultraviolet filter (365 nm), the other a green filter (550 nm). The large telescope is required because the U-band signal is very faint.

Figure 13. The IOTA/ES M2 telescope with a diameter of 50 cm. (K. Guhl)

Miguel Montargès (LESIA, Observatoire de Paris) - Photometry and spectroscopy of Betelgeuse (α Ori) during its occultation by 319 Leona on 12/12/2023

Miguel is leading the pro-am campaign to observe this 'once in a lifetime' event. Betelgeuse is a red supergiant and he outlined the evolutionary lifecycle of such a star, eventually leading to a supernova explosion. Betelgeuse subtends a diameter of about 55 mas and VLT/SPHERE images show light and dark areas, huge supercells in its photosphere. Asteroid (319) Leona has a diameter of about

Figure 14. Miguel Montargès joined the conference via Zoom. (Zoom screenshot)

50 mas, so the occultation would be partial / annular. Miguel showed the predicted track of the event and recommended integration times of 10 – 50 ms using R, V, B or H-alpha filters, and also requested high-resolution spectroscopy. He asked observers to register for the campaign and submit data to the Occultation Portal.

Carles Schnabel & Jose Luis Ortiz (Agrupació Astronòmica de Sabadell and Instituto de Astrofísica de Andalucía) presented by Carles Schnabel (via Zoom) – Betelgeuse occultation in Spain

Fortuitously, (319) Leona occulted a mag. 12 star on 2023 September 13, and 26 positive chords were obtained from 17 sites by observers in Spain and Portugal. A formal paper by Jose-Luis Ortiz, Mike Kretlow, Carles et al was about to be published, but Carles could give a preliminary report. Leona was larger than expected, they determined its orientation and confirmed that Leona was 'on track'. Carles showed contact details and an interactive map for anyone intending to observe Leona-Betelgeuse from Spain on Dec 12.

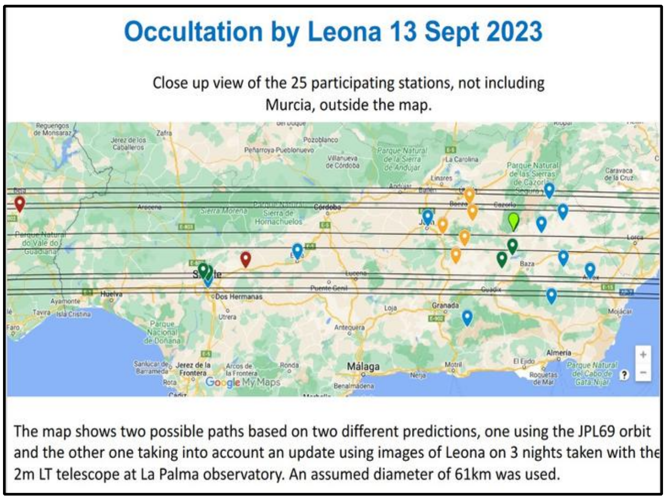


Figure 15. Distribution of the observing stations for the occultation by (319) Leona on 2023 Sep 13. (Screenshot from the presentation)

Claudio Costa and Alfonso Noschese (AstroCampania, Italy) presented by Alfonso Noschese - Betelgeuse event – Astrocampania organization to facilitate the observation of the occultation from Italy

Astrocampania, the amateur astronomical association in Campania, southwest Italy, is coordinating observations from their region, advising observers on travelling to the area, assisting them in finding accommodation and offering practical support such as the availability of tables, chairs and power supplies. Alfonso gave an overview of Astrocampania's observatories and observing projects to illustrate their experience of participating in major events.

Figure 16. Alfonso Noschese presents the observation campaign for the Betelgeuse occultation in Italy. (O. Klös)

Bernd Gährken (Bavarian Public Observatory, Germany) - Some observation ideas for the occultation of Betelgeuse

Bernd explained that during lunar occultations the red giant star Aldebaran presents different diffraction effects according to the wavelength observed, and it has a smaller diameter in blue light than in red. He proposed innovative ways to record the Betelgeuse event: a DSLR camera in video mode with a multi-image filter with R, G, B segments; an ultraviolet Venus filter on a small Newtonian telescope; a Star Analyser spectroscopic filter; old camera lenses can give the 'advantage' of soft focus; or lightly smear some skin crème over a lens!

Figure 17. During his presentation Bernd Gährken showed different instruments and lenses for the observation of the Betelgeuse occultation. (O. Klös)

Wolfgang Beisker (IOTA/ES – research and development) - Fast spectroscopy with a slitless spectrograph – Using a blazed grating with low resolution

Wolfgang described his proposal to use a low-resolution blazed grating (100 lines / mm) to record Betelgeuse spectra at a cadence of about 30 to 100 fps. This method avoids saturation and every image is a complete spectrum, depending on the spectral sensitivity of the sensor and the resolution of the setup, allowing analysis of any part of the recorded spectra. Tests on bright stars have achieved resolutions of 5 nm or better.

Session 5 - Asteroid Modelling from Occultation Data - chaired by Apostolos Christou

Dominik Černý and Josef Ďurech (Astronomical Institute of Charles University, Czech Republic) presented by Dominik Černý - Occultations as a tool for creation and validation of asteroid models

For many asteroids we only have their light curves and the inversion technique can be used to generate a convex shape model (occasionally with concave features). These models are dimensionless and they have rotational pole ambiguity (DAMIT – Database of Asteroid Models from Inversion Techniques). Dominik explained that occultation timings are used to fit chords across these models, revealing their dimensions and solving the pole ambiguity. To improve the fit, they apply ADAM (All-data Asteroid Modelling) where occultation chords and photometric data are combined to create new models.

Julia Perła and Anna Marciniak (Adam Mickiewicz University, Poland) presented by Julia Perła - Asteroid shape modelling driven by archival stellar occultation data

We have some excellent multi-chord occultation datasets across a number of asteroids for which there are no shape models. Julia's presentation gave an overview of the work towards her Master's thesis, which is a project to obtain photometry of a selected number of main belt asteroids with no shape models, avoiding slow rotators and any with poor alignment geometry, then fit them to the occultation data, and if necessary, apply the ADAM technique to reprocess the models.

Anna Marciniak, Josef Durech, Antoine Choukroun et al (Adam Mickiewicz University, Poland) presented by Anna Marciniak - Exploring asteroid shape model uncertainties in occultation fitting

Light curve inversion can produce shape models which are insensitive to vertical stretching along the axis of rotation, adding uncertainties to the size determinations. Anna described her work in inertia regularisation - investigating 10 variations of flattening or stretching of the shape model and comparing them against the occultation chords. This study constrains their vertical stretching and aims to better define asteroids' dimensions.

Frank Schaffer and Konrad Guhl (Archenhold Sternwarte, Berlin) presented by Frank Schaffer - VAMOR Validation of Asteroid Models by Occultation Results

Frank summarised a history of observations of asteroids, from measuring their positions and magnitudes in the 1900s, to modern photometry and spectroscopy, spacecraft flybys, light curve inver-

Figure 18. Apostolos Christou (left) moderates the Q&A session for Anna Marciniak (right, at the speaker's desk) in the Copernicus Hall of Armagh Planetarium. (O. Klös)

sion and DAMIT 2-D models, and now 3-D CAD modelling with VAMORCAD. He explained the process of downloading occultation timing data from *Occult* and shape models from DAMIT, and transferring the occultation data into the 3-D spatial representation in CAD software. An MP4 animation has been created. He concluded with a discussion of updating and maintaining the 3-D models and future work.

Figure 19. Frank Schaffer demonstrate the 3-D CAD modelling of asteroids with an example of (41) Daphne. (O. Klös)

Session 6 - Observation Reports III
chaired by Tim Haymes

Flavia L. Rommel et al (Federal University of Technology - Paraná (UTFPR), Brazil) presented by Flavia Rommel (via Zoom) - A summary of the stellar occultation events by the large TNO 2002 MS_4

Figure 20. Flavia L. Rommel joined ESOP live during her Q&A session. (Zoom screenshot)

Flavia is a member of the Lucky Star team and she explained that 2002 MS_4 is one of the largest TNOs and is a dwarf planet candidate. Her presentation summarised the results from nine successful occultation events and a tenth which is being analysed. This TNO was determined to have an area-equivalent diameter of 796 ± 24 km and a geometric albedo of 0.1 ± 0.025. They found some significant deviations from a fitted ellipse, evidence of crater-like features. A bulge on the limb observed in August 2020 has led to a hypothesis about it being a putative satellite of 2002 MS_4.

Session 7 - ESOP 2024
chaired by Konrad Guhl

Andreas Eberle (Sternwarte Stuttgart, Germany) – (via Zoom) - Invitation to the ESOP 43 in Stuttgart + Questions

Andreas reminded us all that Stuttgart hosted ESOP in 1999 and we are invited there again in 2024, when ESOP XLIII will be held between August 23 – 25 with excursions on August 26 – 27.

The Symposium will take place in Stuttgart Planetarium and there will be a programme for accompanying persons. Group excursions are planned for the Monday and Tuesday, not an exact repeat of those in 1999, although we hope there will be a visit again to Johannes Kepler's birthplace museum.

Figure 21. Screenshot from the Invitation by Andreas to ESOP XLIII.

Closing of ESOP 42

Tolis thanked everyone for attending ESOP in Armagh and said it had a been a very interesting meeting. He announced details of this afternoon's visit to Navan Fort and the trips on Monday and Tuesday.

Konrad Guhl expressed his grateful thanks to Tolis and the IT support team and administrators at AOP for making ESOP 42 a success, and he thanked everyone who attended, in person or online.

PDFs of the presentations of ESOP 42 can be found here:
https://www.armagh.space/meetings-conferences/esop42#deeplink-3

Excursions

Navan Fort and Visitor Centre

After a break we took a short coach trip to Navan Fort, the location of a large circular hilltop enclosure and ditch which was a royal site in pre-Christian Gaelic Ireland and is surrounded by other archaeological sites of that era. Our guide walked us around the site and we visited a reconstructed roundhouse where costumed Celtic warriors regaled us with stories of the realities of Iron Age life.

Monday 18th September 2023

We had a walking tour for the day, strolling through the city and energetically striding uphill for the Hill of Armagh Experience – a guided tour of St Patrick's Cathedral (Church of Ireland) and the Cathedral gardens, then a visit to the Robinson Library and Registry, where display cases held works such as Usher's 'The Annals of the World' and the librarian had laid out a number of historical books for us to peruse, including a 1760 copy of Newton's Principia, Institutio Astronomica (1656) by Gassendi and a copy of Johnathan Swift's 'Gulliver's Travels' (1726). This was followed by a guided tour of St Patrick's Cathedral (Roman Catholic) then a brief walk to the Mulberry Bistro for lunch.

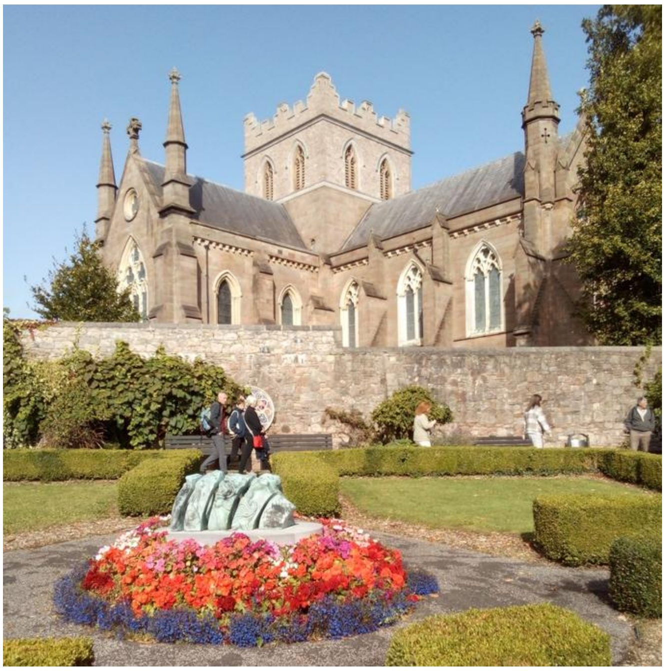


Figure 22. St Patrick's Cathedral (Church of Ireland) and the Cathedral gardens. (A. Pratt)

In the afternoon we were greeted with a welcome and introduction to the Armagh County Museum where we had free time to view the exhibits. Another walk took us back to *Armagh Observatory* where we divided into two groups for a tour of the buildings to learn about the history of the observatory, its telescopes and its notable astronomers, such as Thomas Romney Robinson, John Louis Emil Dreyer and Ernst Öpik, and its current research projects.

Figures 23, 24. Transit instruments at Armagh Observatory. (A. Pratt)

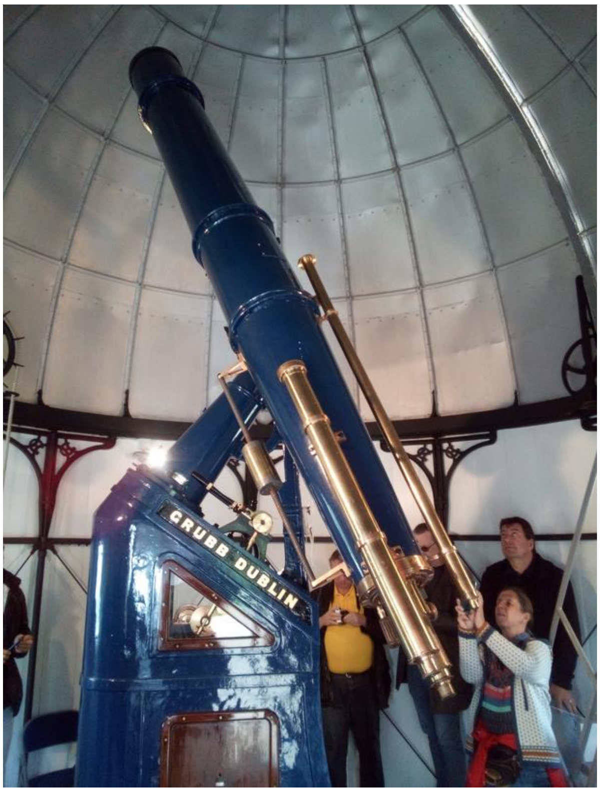


Figure 25. The 10-inch Grubb refractor at Armagh Observatory. (A. Pratt)

Figure 26. Belfast Castle (A. Pratt)

Tuesday 19th September 2023

The final day took us by coach to Belfast to visit Belfast Castle and its grounds, which gave expansive views over the city and Belfast Lough. During a drive along the Falls Road we viewed the numerous murals on the peace wall, then continued to the Titanic Quarter for a visit to the Titanic Museum shop and a walk around the waterfront. The coach took us to Belfast City Hall to explore the visitor exhibition and to take lunch in the coffee shop. In the afternoon we returned to Armagh, another opportunity to see the Planetarium displays.

Figure 27. William Stewart (left) and Michael O'Connell have a look at the displays of Armagh Planetarium. (O. Klös)

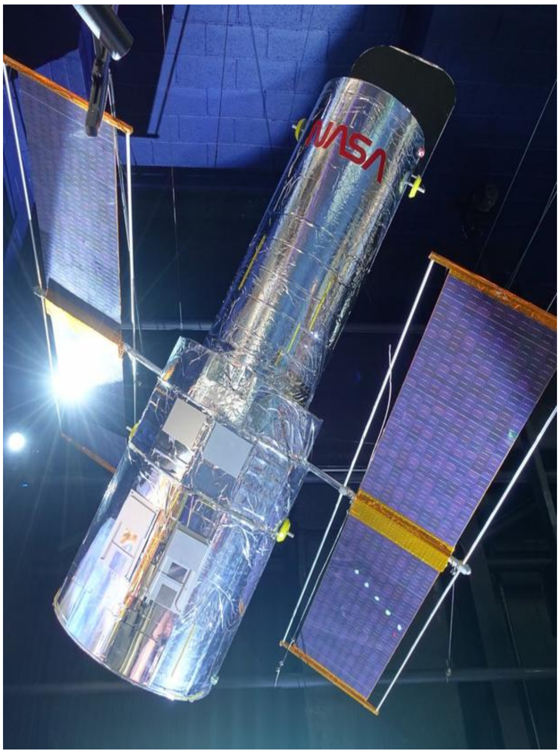
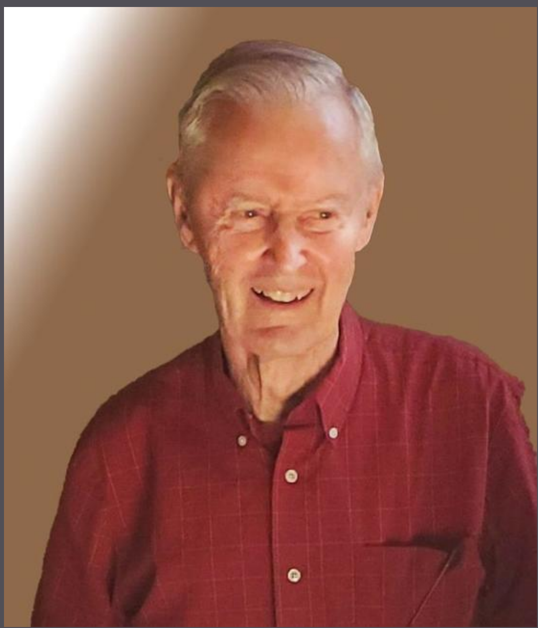
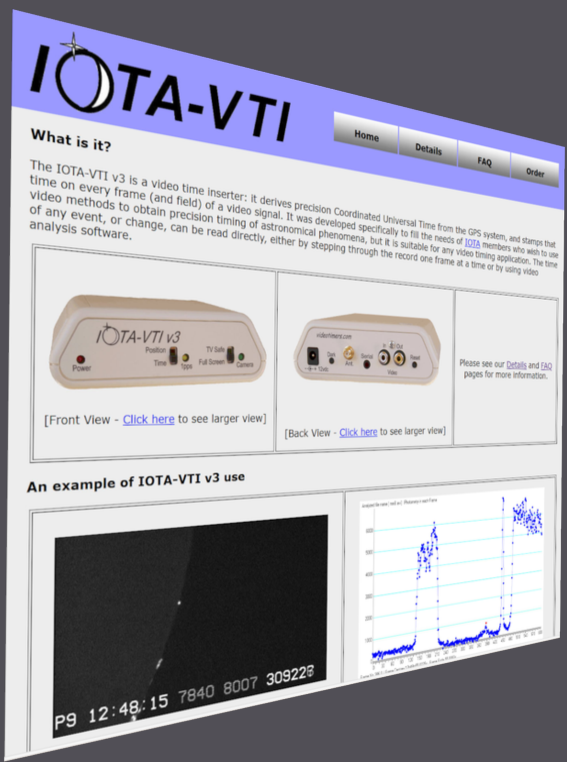


Figure 28. Model of the famous Hubble Space Telescope displayed on the ceiling in the Planetarium. (O. Klös)

Walter Morgan

1930 – 2023





Webpage of IOTA-VTI.

Walter Morgan died October 28 of pneumonia. His daughter writes "...the family had a chance to say their goodbyes, and he went peacefully, still as lucid as ever."

Walt was well known among occultation observers, for his many years of observing occultations and for his much-appreciated work bringing the IOTA Video Time Inserter to the occultation observing community. The website he prepared is still available [1].

Some of the memories shared by his daughter, **Julie Rusch**:

"When I was four we moved from rainy Seattle to Las Vegas. Dad was amazed to see clear skies most of the time and in the mid-1960s he bought a cheap telescope to show his five kids many interesting things in the night sky. He upgraded as his budget allowed until he had a good scope, mount, and clock drive. He researched related equipment, learned as much as he could about viewing, and even invested what probably seemed like a princely sum in a huge, spiral-bound Skalnate Pleso Atlas of the Heavens.

I'm not sure what drew Dad into the world of occultations. By the early 1970s he seemed to always be planning for an occultation, viewing one, or distilling the data he had collected during one. Before an event he pored over massive dot-matrix printouts with rows and columns of numbers and spent a lot of time with his sky atlas. I believe grazing occultations were his favorites.

Usually Dad would travel to view occultations. But if he was viewing from home and it wasn't too far past my bedtime, I enjoyed watching the process, and still remember the radio tuned to WWV, ticking off the seconds and reporting the time, the cassette recorder picking up the sounds of both the radio and Dad's voice -- "disappear!", "reappear!" and so on. It was all very mysterious and exciting.

When I was sixteen, Dad borrowed a second telescope and invited me to view an event using one while he manned the other. The location was about an hour drive from our home in Las Vegas which meant we were deep in the desert. I dropped Dad at his viewing station, then drove a quarter of a mile away where I set up my equipment. Finally, I was ready, nervously paying close *attention to the time as I waited for the occultation to begin. Just moments before the expected start time, I heard a helicopter directly above me. The police had spotted the car. They turned their spotlight on me before using their PA system to ask if I needed help. By the time I convinced them I was fine -- I was yelling "I'm trying to see an occultation!", which meant nothing to them -- I had missed the whole event. Later, when I picked Dad up, I found that he'd seen the helicopter and was a bit panicked, feeling guilty that he'd left his teenaged daughter alone in the desert. I got a recording of me yelling at the helicopter, but nothing more. Dad, however, did get timings, despite his worry about me -- that's how dedicated he was!*

Astronomy was always something Dad and I shared. Around the time he turned 80, his beloved KIWI-OSD time-insertion device failed. Since they were no longer readily available, he teamed up with other observers to build his own. This developed into a small business that ended up selling a few hundred IOTAVTI devices around the world. (My volunteer roles were contract reader, web-master, computer consultant, and cheerleader.) But as time passed it became harder to find cost-effective parts and his deteriorating manual dexterity also made device assembly difficult. At age 88 he decided to retire again.

After he moved to an independent living senior community ten years ago, Dad started an Astronomy Club that has grown to almost 100 members. I loved to brainstorm topics with him for the monthly meetings or assist with research for his presentations. In April of this year he gave a well-received talk to his whole Stoneridge Creek retirement community of 800+ people. Here is the video of that presentation [2].

He convinced the community management that their community needed an observatory which they built, big enough to house his 8" telescope with room for 2 observers. They also shielded or added ON/OFF switches to nearby streetlights. When he'd announce the viewing of a popular object like Saturn, there would be a line waiting outside. Eventually the community management ran internet to the observatory so Dad could share events of great interest over Zoom or piped directly to the community's 80-seat theater. He held his last meeting the day before he became ill. At his request, his observing equipment will stay with that observatory."

Others who have worked or observed with Walt also shared some memories:

Dave Gault of Kuriwa Observatory, Australia:

"Walt's efforts in the 4-member team that brought IOTA-VTI into being will always be remembered. Tony Barry the inventor of the intelligent code, Me (Dave Gault) the Quality Assurance guy, Sandy Bumgarner, the hardware guy, and Walter Morgan the manufacturer and sales manager. Although his career was not in manufacturing, he quickly understood the principles of high-quality manufacturing and reliable and trustworthy sales through the business he set up - Video Timers. All dealings with Walt were always courteous and welcome."

Although I never met him in person, I'll always remember the name Walter Morgan with fondness and friendship. Vale."

Ted Blank who currently manages sales and distribution of the VTI's:

"In addition to preparing and mailing VTI's for many years, Walt also wrote the documentation and built a webpage for VTI sales. He was a great asset and friend to IOTA and will be missed."

Ted Swift:

"I was thinking of Walt just a few days ago; how generous he was with his time in collaborating on observations, sharing his experimental results, and offering guidance and advice."

Derek Breit:

Derek expressed his sorrow at losing a friend and provided a photograph from 2008:

Derek and The Three Amigos - (left to right) Walt Morgan, Sandy Bumgarner, Derek Breit, and Art Lucas.

Joan Dunham, IOTA Treasurer:

"In 2022, Walt donated funds to IOTA, stating that these were from the profits he made operating Video Timers. He had formed the small company to make and sell the VTIs and ran it as a real business. The aggregate profit over the years he operated the company was not a large sum but he wanted it known that it had been profitable."

[1] https://videotimers.com/home.html
[2] https://www.youtube.com/watch?v=7PEny5A9QaI

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.

IOTA President: Steve Preston . . . . stevepr@acm.org
IOTA Executive Vice-President: Roger Venable . . . . rjvmd@progressivetel.com
IOTA Executive Secretary: Richard Nugent . . . . RNugent@wt.net
IOTA Secretary & Treasurer: Joan Dunham . . . . iotatreas@yahoo.com
IOTA Vice President f. Grazing Occultation Services: Dr. Mitsuru Soma . . . . Mitsuru.Soma@gmail.com
IOTA Vice President f. Lunar Occultation Services: Walt Robinson . . . . webmaster@lunar-occultations.com
IOTA Vice President f. Planetary Occultation: John Moore . . . . reports@asteroidoccultation.com

IOTA/ES President: Konrad Guhl. . . . . president@iota-es.de
IOTA/ES Research & Development: Dr. Wolfgang Beisker . . . . wbeisker@iota-es.de
IOTA/ES Treasurer: Andreas Tegtmeier . . . . treasurer@iota-es.de
IOTA/ES Public Relations: Oliver Klös . . . . PR@iota-es.de
IOTA/ES Secretary: Nikolai Wünsche . . . . secretary@iota-es.de

Trans-Tasman Occultation Alliance Director: Steve Kerr . . . . Director@occultations.org.nz
RASNZ President: John Drummond . . . . president@rasnz.org.nz
RASNZ Vice President: Nicholas Rattenbury . . . . nicholas.rattenbury@gmail.com
RASNZ Secretary: Nichola Van der Aa. . . . . secretary@rasnz.org.nz
RASNZ Treasurer: Simon Lowther. . . . . treasurer@rasnz.org.nz

Worldwide Partners

Club Eclipse (France). . . . . www.astrosurf.com/club_eclipse
IOTA/EA (East Asia) . . . . https://www.perc.it-chiba.ac.jp/iota-ea/wp/
IOTA-India . . . . https://iota-india.in
IOTA/ME (Middle East) . . . . www.iota-me.com
President: Atila Poro . . . . iotamiddleeast@yahoo.com
LIADA (Latin America) . . . . www.ocultacionesliada.wordpress.com
SOTAS (Stellar Occultation Timing Association Switzerland) . . . . www.occultations.ch

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 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 2024-2: February 15

IOTA maintains the following web sites for your information and rapid notification of events:

www.occultations.org
www.iota-es.de
www.occultations.org.nz

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, East Asia, 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.

Regulations

The Journal for Occultation Astronomy (JOA) is not covenanted to print articles it did not ask for.

The author is responsible for the contents of his article & pictures.

If necessary for any reason JOA can shorten an article but without changing its meaning or scientific contents.

JOA will always try to produce an article as soon as possible based to date & time of other articles it received – but actual announcements have the priority!

Articles can be reprinted in other Journals only if JOA has been asked for permission.