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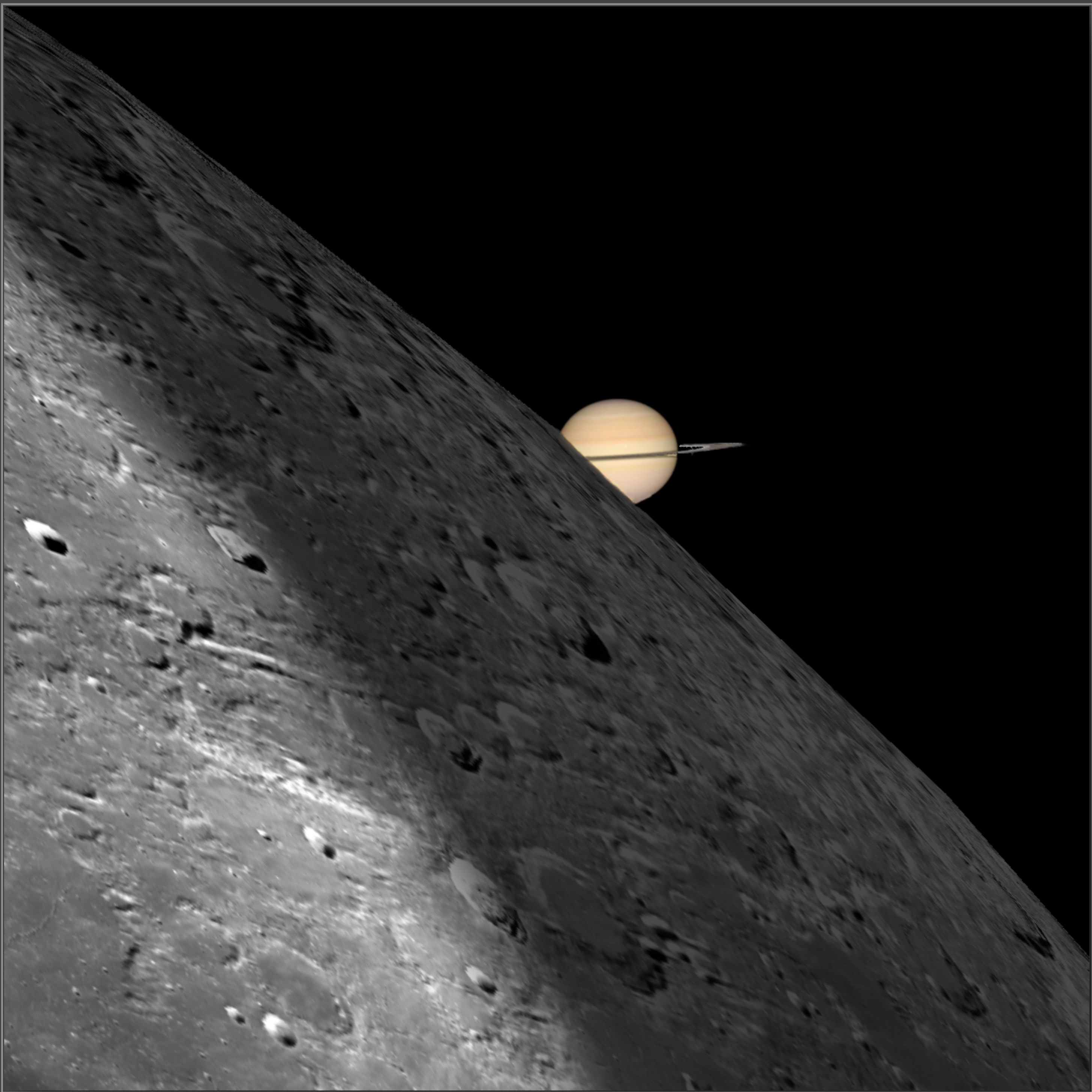

Lunar Occultation of Saturn

Dear reader,

Occultation astronomy is a field of astronomy where the cooperation between many observers and observing stations is essential. Technical advances in computers, digital cameras and other electronic components have made a significant contribution to closing the gap between professional and amateur work.

Very often, results can only be achieved when professional and amateur observers work together in joint observations. It has taken a long time for the work of amateurs to be recognised by the community of professional astronomers.

For about a decade now, the term "PRO-AM" has become increasingly common in the literature and at conferences. The networks of amateurs and professionals have achieved extremely valuable scientific results. Recently, a colloquium in Paris in honour of Prof. Bruno Sicardy demonstrated the full significance of Pro-Am work. It was a presentation of Bruno's scientific work (he is also a IOTA/ES member). Occultations by Triton, Pluto, Charon, Chariklo and many other objects demonstrated the power of joint observational networks. He is since about 40 years one of the main scientists in this field and engaged in many professional-amateur collaborations. For his long and important scientific work he was awarded a few months ago the significant Jules Janssen prize of the Société Astronomique de France.

IOTA members are co-authors on many peer reviewed publications and are further encouraged to increase their observation activities.

Wolfgang Beisker
IOTA/ES Research & Development

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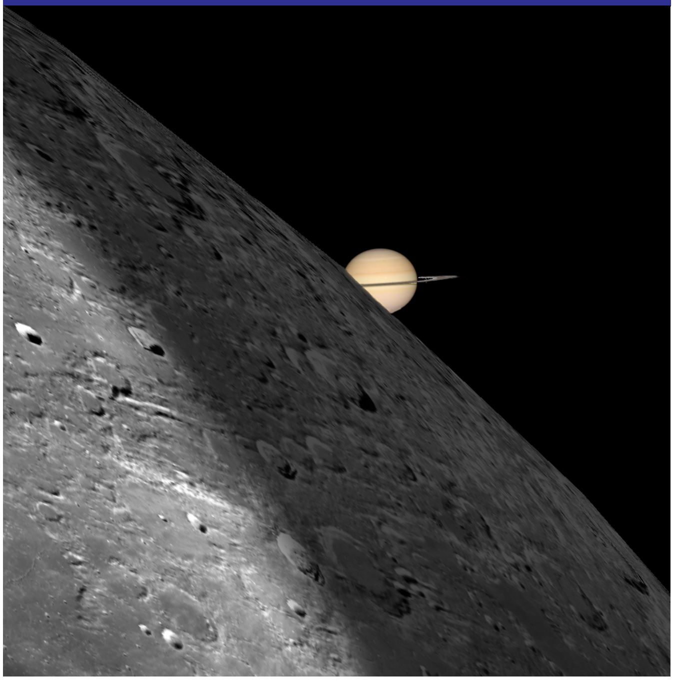


Simulation of the grazing lunar occultation of Saturn on 2024 July 24 at 20:30 UT in Jhansi, India. The Moon will be about 51 degrees above the south-eastern horizon. The two prominent craters are Schwabe G on the left edge of the image and Schwabe F close to the terminator. Image was compiled with a graphic from Project Pluto's *GUIDE 9.1* based on Clementine data for the Moon and an image of Saturn from *Cartes du Ciel* by Patrick Chevalley. North is at the top. (Graphic: O. Klös)

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

CALL FOR OBSERVATIONS:

Occultations by Jupiter Trojan (17365) Thymbraeus in 2024

Oliver Klös · IOTA/ES · Eppstein-Bremthal · Germany · oliverkloes@nexgo.de

ABSTRACT: Jupiter Trojan (17365) Thymbraeus is a possible elongated dumbbell-shaped asteroid at the trailing Lagrangian point L_5. With its low density which is less than that of water, it is close to the point of separating. Its interesting shape was predicted from light curves and could be confirmed with measurements of stellar occultations. This call for observations presents six upcoming observable occultations by (17365) Thymbraeus until the end of 2024.

Introduction

Measuring shadow profiles of asteroids with stellar occultations is one of the most accurate ways to determine the shape of an asteroid with ground-based observations. Especially uniquely shaped objects like the dog-bone shaped asteroid (216) Kleopatra are highly interesting targets for such observations [1]. The *Occult* database lists no occultation observations by this object [2]. The Jupiter Trojan (17365) Thymbraeus should be on the list of high-priority targets.

The Trojan

The asteroid was discovered on 1982 November 7 by Eleanor Helin and Schelte Bus at *Palomar Observatory*, USA, and was given the designation 1978 VF11 [3]. In September 2023, the Trojan was officially named after Thymbraeus, one of the two sons of Laocoön who was killed by sea serpents sent to punish the father for attempting to warn the Trojans about the danger of the wooden horse left by the Greeks [4].

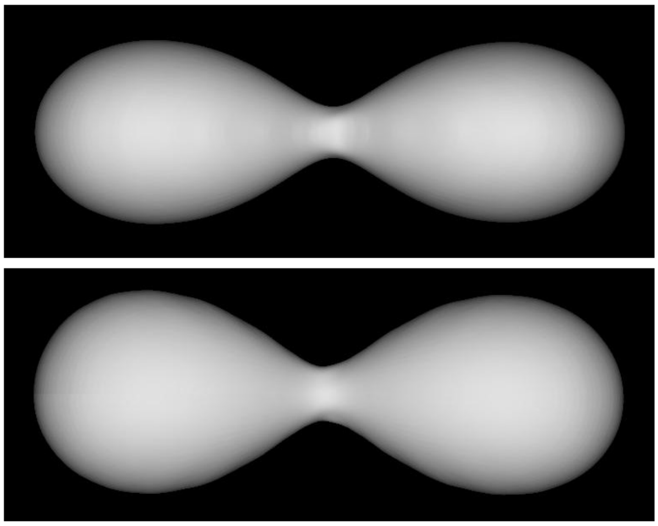


Figure 1. Shape model of (17365) Thymbraeus, seen from the equator (top) and the spin axis (bottom). (Source [7])

In 2007, Mann et al. predicted (17365) Thymbraeus as a binary system by analysing light curves [5]. The Johnston's Archive lists diameters of 34.33 ± 0.41 km for the primary and 28.94 ± 2.33 km for the secondary component [6]. The density of the Trojan is 830 ± 50 kg m^{-3} and therefore lower than that of water [7]. Its sidereal rotation was determined to 12.672 h with two symmetric poles corresponding to the direct and prograde rotation at J2000 equatorial coordinates (α0, δ0) of (92°, −77°) and (268°, +77°), ±2° respectively [7].

B. Carry, et al. analysed light curves from 2015 and 2021 as well as observations from 2005, 2006, and 2013. They analysed the light curves with a formalism of dumbbell equilibrium figures and obtained a good match. In September 2023, they came to the conclusion that the Trojan is not a binary system but has a bilobated shape with an angular velocity close to fission (Figure 1). At an even higher rotation velocity the asteroid would disintegrate into two bodies of equal size like Jupiter Trojan (617) Patroclus [7]. Without a formalism of dumbbell equilibrium figures the Database of Asteroid Models from Inversion Techniques (DAMIT) describes in model no. 8332 the Trojan as a fist-wedge shaped object [8].

Upcoming Occultations

The predictions of the ERC Lucky star project show several occultations by the Jupiter Trojan until the end of year 2024 [9]. The author of this paper has selected six events with stars brighter than Mv 15 and good observing conditions from land sites. The predictions were recalculated in June 2024 with D. Herald's software *Occult* [2] with data from Gaia EDR3 [10] and ephemeris from JPL Horizons [11]. The predictions are based on an average diameter for the asteroid of 45 ± 4 km from the *Occult* database. The apparent magnitude of the Trojan will be between 17.6 to 17.8 for the upcoming events.

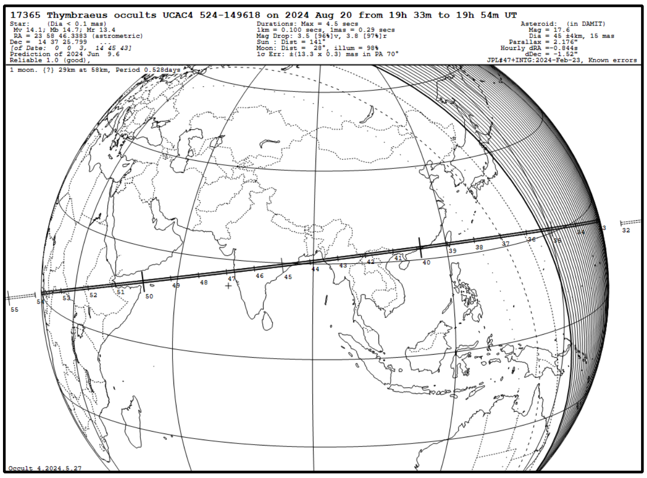


Figure 2. Occultation of UCAC4 524-149618 on 2024 Aug 20, calculated on 2024 Jun 9 with Occult V4.2024.5.27

2024 August 20

The first event in the series will take place on 2024 August 20 across South and East Asia. UCAC4 524-149618 (Mv 14.1) will be occulted with a maximum duration of 4.5 seconds (Figure 2).

The September Occultations

The faint star UCAC4 520-146034 (Mv 14.8) will be occulted on 2024 September 12 for a maximum duration of 3.0 seconds at 23:42 UT. Dawn has already begun when the shadow reaches remote areas in Finland and northern Sweden. The path crosses a narrow part of northern Norway before crossing the sea north of the British Isles (Figure 3).

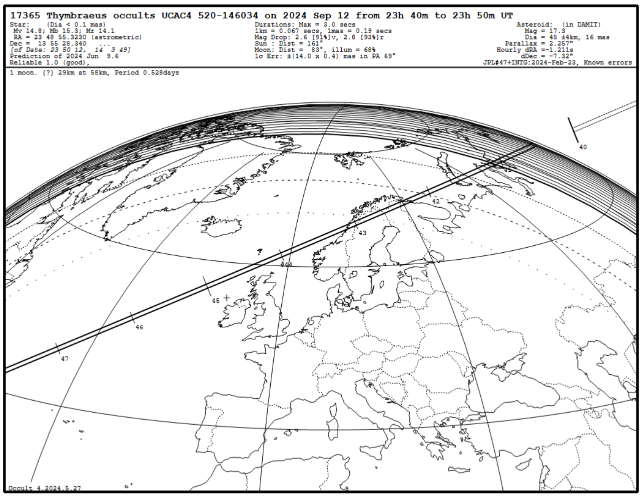


Figure 3. Occultation of UCAC4 520-146034 on 2024 Sep 12, calculated on 2024 Jun 9 with Occult V4.2024.5.27

In the early morning of September 16, (17365) Thymbraeus will occult UCAC4 519-144141 (Mv 13.8) for a maximum duration of 2.9 seconds in a trans-Atlantic event. The Sun will be only 10 degrees below the horizon in the south of Poland at 03:14 UT.

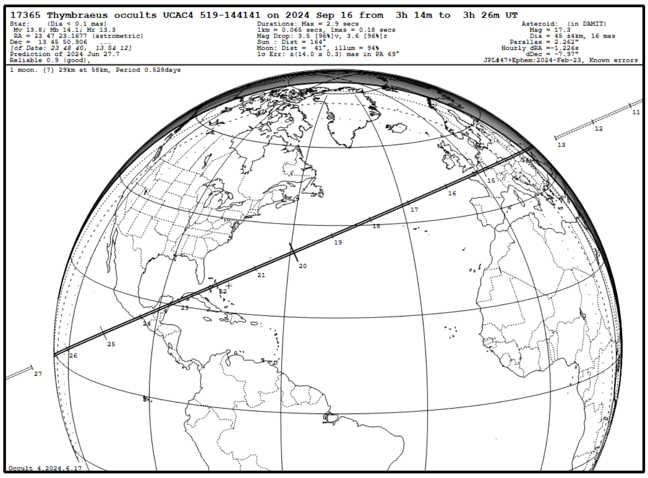


Figure 4. Occultation of UCAC4 519-144141 on 2024 Sep 16, calculated on 2024 Jun 27 with Occult V4.2024.6.17

The path will cross Czechia, central Germany, Luxembourg, southern Belgium, and northern France. The shadow reaches the Bahamas and Cuba at 03:22 UT and southern Mexico at 03:23_UT (Figure 4).

The shadow of (17365) Thymbraeus will cross Europe again on the evening of 2024 September 20. The star UCAC4 518-147064 (Mv 13.3) will be occulted for 2.9 seconds. The path will cross Russia at 21:04 UT and reach the southern parts of the Baltic states Latvia and Lithuania at 21:06 UT. The shadow path will continue over Poland, Czechia, south-east Germany with Munich inside the path, western Austria, Liechtenstein, Switzerland, the south of France and Spain. The Canary Islands lie outside of the shadow path (Figure 5). Observers south-east of Prague, Czechia, have the opportunity to observe the occultations on September 16 and 20 without having to travel to distant observing sites.

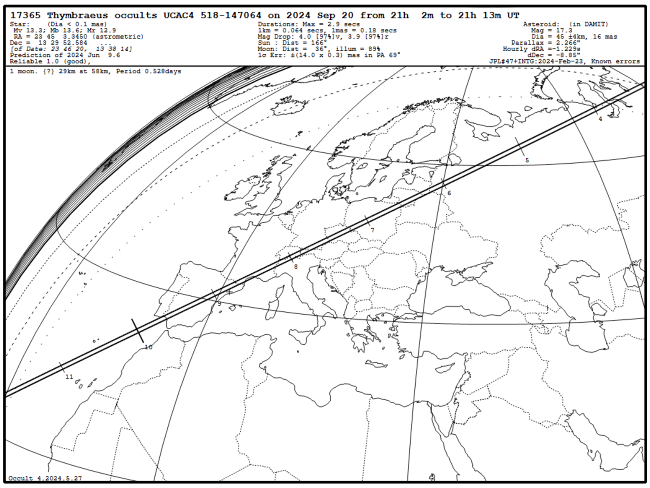


Figure 5. Occultation of UCAC4 518-147064 on 2024 Sep 20, calculated on 2024 Jun 9 with Occult V4.2024.5.27

UCAC4 517-142144 (Mv 13.3) will be occulted by the Jupiter Trojan on 2024 September 22. The shadow reaches the Earth at 20:05 UT in China. It moves on across Pakistan, Afghanistan, and

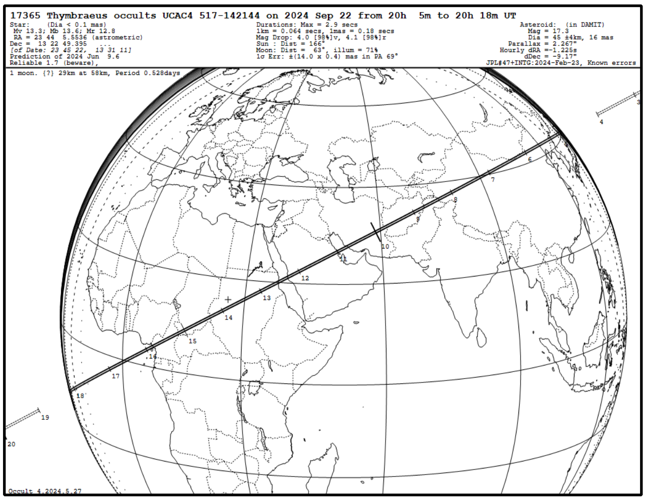


Figure 6. Occultation of UCAC4 517-142144 on 2024 Sep 22, calculated on 2024 Jun 9 with Occult V4.2024.5.27

Iran. The Arabian Peninsula will be crossed in Saudi Arabia and the countries of Sudan, Chad and Cameroon will be covered by the path in Africa (Figure 6).

The Final Event for 2024

The last occultation for 2024 is the longest in duration. On 2024 November 18, the faint star UCAC4 499-145489 (Mv 14.5) will be occulted for 7.2 seconds. The shadow will pass over north-east Asia on remote sites in Russia. China and North Korea will be crossed. The path will reach southern Japan on the island of Kyûshû at 10:25 UT. After crossing Western New Guinea in Indonesia at 10:36 UT, the shadow will move on to Australia, with Melbourne and Tasmania inside the path (Figure 7).

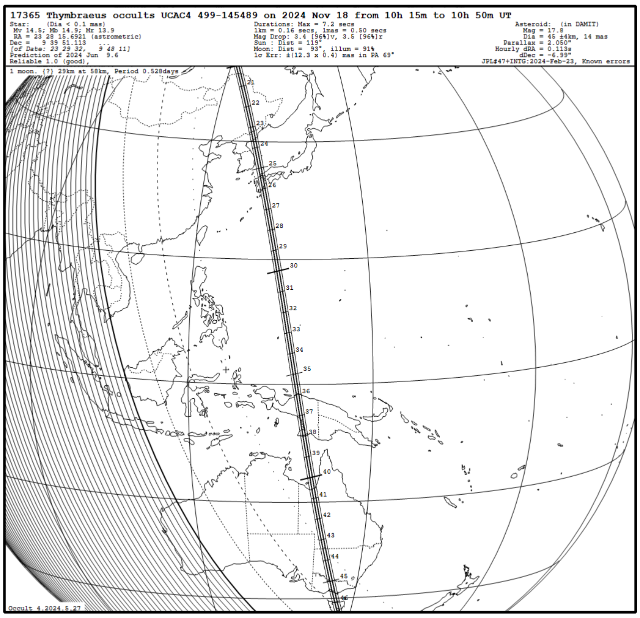


Figure 7. Occultation of UCAC4 499-145489 on 2024 Nov 18, calculated on 2024 Jun 9 with Occult V4.2024.5.27

With these occultations it is possible to measure the shadow profile from different rotation angles. Calculations carried out with model no. 8332 from DAMIT in *Occult* show the different phase angles at the time of events (Table 1).

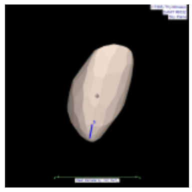
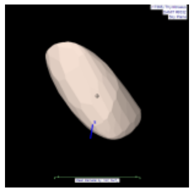
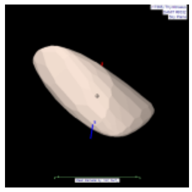
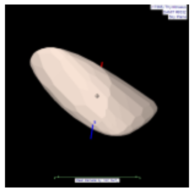
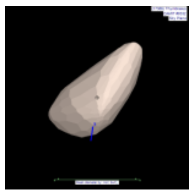
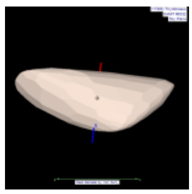
Date 2024	Time UT	Phase Angle	DAMIT Model No. 8332
Aug 20	19:45	7.0°	
Sep 12	23:43	320.2°	
Sep 16	03:14	305.9°	
Sep 20	21:08	301.5°	
Sep 22	20:12	198.5°	
Nov 18	10:26	262.6°	

Table 1. Phase angles at the times of the occultations and the corresponding orientation of DAMIT model no. 8332. (Source: Occult V4.2024.6.17.)

Uncertainties

Light curves of (17365) Thymbraeus show an amplitude of up to one magnitude [6]. This leads to uncertainties regarding the duration of the occultations, the path widths and the drops in magnitude. The observing stations should coordinate their efforts to cover the entire path and the error limits. Stations near to the actual path limits should be prepared to observe two events during the occultation. Observers located near to the actual centre line of the paths should watch for a faint increase in the combined magnitude due to a very brief partial occultation by the small centre of the dumbbell. Therefore, high frame rates and a good signal-to noise ratio of the recordings are essential.

Conclusion

The upcoming occultations by (17365) Thymbraeus offer a good opportunity to confirm the elongated dumbbell shape or the binarity of the Jupiter Trojan. In particular, the two occultations in Europe on 2024 September 16 and 20 could be covered by several observing stations. The rotation phase at the second event will be shifted by ~14° compared to the first occultation on 2024 September 16. This is a good opportunity to demonstrate again the value of stellar occultation observations for the study of Jupiter Trojans.

Acknowledgements

These predictions have made use of data from JPL Horizons provided by the Solar System Dynamics Group of the Jet Propulsion Laboratory and of data from the European Space Agency (ESA) mission Gaia (https://www.cosmos.esa.int/gaia), processed by the Gaia Data Processing and Analysis Consortium (DPAC, https://www.cosmos.esa.int/web/gaia/dpac/consortium). Funding for the DPAC has been provided by national institutions, in particular the institutions participating in the Gaia Multilateral Agreement.

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30 Years Ago – Asteroidal Occultation Predictions for Sale!

From *Occultation Newsletter* Vol. 6 No. 4:

ASTEROID PRO

David W. Dunham

"Asteroid Occultations Made Easy" proclaims the headline for an add for Asteroid PRO, sold for $169.95 by Pickering Anomalies, on p. 79 of the 1994 October issue of **Sky and Telescope**. "Accurately locates over 400 world wide occultations per month, compared to the one or two for North America found in popular publications". Interesting, but how accurate? The larger number of events is found by considering all numbered minor planets (over 5500), most of them much smaller than the 50-km limit considered by even Edwin Goffin in the searches that he performs for IOTA. Like Goffin, Asteroid PRO uses the PPM and ACRS catalogs totaling about 340,000 stars, so there is nothing new there. Asteroid PRO uses an exclusive perturbation scheme that claims to represent the asteroid paths to the highest accuracy, but this accuracy is no better than the 1″ accuracy of most observations used to determine the orbits. At the current epoch, the PPM and ACRS positions are accurate to 0.″2 or a little worse, so the overall accuracy of most asteroid occultation predictions will be just over the ephemeris accuracy of about 1″. Since most of the asteroids have angular diameters of less than 0.″01, you will have less than one chance in 100 of seeing the large majority of events predicted by Asteroid Pro. Even if you're lucky enough to be in one of these narrow paths, you better not blink, since most events will last less than 1 second, making it pretty hard to make a timing good to 5% of the diameter. You're better off sticking with the larger objects predicted by IOTA, without the distracting clutter of a large number of unproductive small objects. As experienced observers know, it's hard enough to catch the big asteroid shadows. If you want to get a lot more practice finding star fields, or if you have a large telescope and just want to find many asteroids, Asteroid PRO can help you, but it will not make asteroid occultations any easier.

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

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Timing Accuracy Using GPS Flash Timing

Michael Camilleri · Trans Tasman Occultation Alliance (TTOA) ·
Auckland · New Zealand· michaelcamilleri@actrix.co.nz

ABSTRACT: The timing accuracy of short exposure video recordings that have been time stamped using GPS 1 PPS flashes has been measured. Under ideal controlled conditions using an analogue video camera with GPS timestamps as a reference, a timing accuracy of less than 4% (95% CI) of the exposure duration was achieved for exposures ranging from 40 to 1,280 ms, with a maximum error of ±3 ms (95% CI). Under typical real conditions the accuracy was at worst 6% (95% CI) of the exposure time. For typical exposures of 40 to 320 ms the maximum error was ±5 ms (95% CI). When using a digital camera, additional sources of error may occur from PC clock drift and from target drift with a rolling shutter camera. These can be corrected or minimised by measuring the time delays before and after the event and interpolating. Best practice guidelines are provided to help achieve the best accuracy possible. When done properly this method of GPS flash timing is accurate enough for most asteroid occultations and is well suited for large scale campaigns or new observers with its low cost and versatility.

Introduction

Stellar occultations are used to make extremely accurate measurements of the position and size of solar systems bodies with accuracies that exceed those possible with large ground based or space telescopes. Highly accurate Coordinated Universal Time (UTC) time stamping and the observer's precise position are required to achieve this accuracy which is readily achieved by cameras with built-in Global Positioning System (GPS) receivers (e.g. the QHY174M-GPS [1]) capable of better than millisecond precision or GPS Video Time Inserters (VTI) such as the IOTA-VTI [2] which place GPS time stamps on analogue video streams with millisecond accuracy.

The analogue video cameras which were the main types in use for occultations have been largely replaced in the consumer market by modern digital cameras and are now only available from a very small number of manufacturers for specialist uses. Acquiring and maintaining an analogue video system for occultations has become increasingly difficult, for example the International Occultation Timing Association (IOTA)-supplied cameras and VTI were unavailable temporarily for a period of 1-2 years due to the Covid-19 pandemic and the popular WATEC-910HX cameras have reached end of life with no like-for-like replacement available [3].

Being able to use commonly available and cheap digital cameras for occultations would ensure the ongoing viability of occultation observations and make it easier and cheaper for new or casual observers to participate. However, the timestamps provided by a personal computer (PC) or other common recording systems have unknown accuracy as the processing from camera through to recording software and saved image files is essentially a 'black box'. The challenge is to find a low cost, simple and reliable method of time stamping these recordings with a sufficiently accurate time that can be used with a wide range of acquisition systems and cameras.

For occultations, the absolute UTC start and end time of each frame exposure needs to be known accurately, ideally with millisecond (ms) accuracy or better. Established timing methods used for occultations are:

- GPS time stamp inserted into an analogue video stream (e.g. IOTA-VTI)
- GPS time stamp by the camera or recording system (e.g. QHY174M-GPS camera)
- GPS flashes recorded by the camera with times derived by analysis - examples:

  Arduino micro-controller based GPS flasher/logger (i.e. Aart's timers) [4] with analysis in *PyMovie/PyOTE*

  IOTA-EA / JOIN method using VK172 USB GPS receiver and *LiMovie* [5, 6]

  GPS flash times analysed using the method of Le Cam [7]

  Phone Apps such as *AstroFlashTimer* and *Occult Flash Tag*
- Timestamps for PC time disciplined using GPS receiver time or Network Time Protocol (NTP) (e.g. Shelyak TimeBox [8])
- Other less accurate methods including radio time signal audio recording (e.g. WWV in the USA and DCF77 in Europe).

VTI and analogue cameras accuracy have been tested and shown to have accuracy at the ms level provided the correct camera and VTI corrections are applied [9]. These corrections are specific to each camera and VTI device and may be caused by internal processing delays and are available to observers in the IOTA reporting forms. The QHY174M-GPS has accuracy claimed by the manufacturer down to the microsecond level provided the internal calibration process is used. Tests using the SEXTA time analysis system [10] showed that the QHY174M-GPS was accurate to better than 2 ms when calibrated [11]. GPS flash timing is a newer method that is less commonly used and its accuracy is not as well understood. Claims of accuracy of 'within a few ms' are in the *PyMovie/PyOTE* manual [12] and the IOTA-EA/JOIN method described as '... corrected in milliseconds' [5], however, neither source includes supporting measurements. An accuracy of ± 2 ms (97% CI) was measured for the camera acquisition delay for bench tests using a local NTP GPS server but not for actual observations [7]. *AstroFlashTimer* was bench tested and measured timing errors of up to 7 ms for iPhone 6+ and found up to 15 ms for iPhone 5, although the performance will be different for different devices and network conditions [13]. NTP timing can achieve accuracy of ±15 ms if set up, calibrated and managed carefully [14].

The various GPS flash timing methods each have their pros and cons, however, a detailed discussion is beyond the scope of this paper. The method of Le Cam [7] is not widely known, however it is cheap and flexible as it can use almost any GPS flash source and almost any light curve reduction software. This method is tested to determine its timing accuracy under ideal and real conditions. A complete description of the author's implementation of the method with practical instructions for observers and calculation workbook is available for download from the IOTA Group files section [15] or from the author's cloud storage [16].

Material and Methods

GPS Flash Unit

The Hiletgo VK172 USB GPS receiver [17] has been used extensively by the IOTA-EA/JOIN group in Japan for occultations and the 1 PPS rising pulse is known to be accurate with a duration of 100 ms [5]. Manufacturer's specification for low-cost civilian GPS receivers typically show an accuracy of the PPS start time of between 10 to 100 µs.

The pulse timing and duration of the VK172 was tested by comparing video recordings of the VK172 GPS flashes at 1 ms exposure to the LED flashes from the KIWI-OSD VTI, which are known to be precise and accurate. The VK172 light pulse started in the same frame as the KIWI-OSD so is accurate to less than 1 ms. The duration was 100 frames at 1 ms exposure. The full exposure light intensity was stable. So, the VK172 produces GPS flash

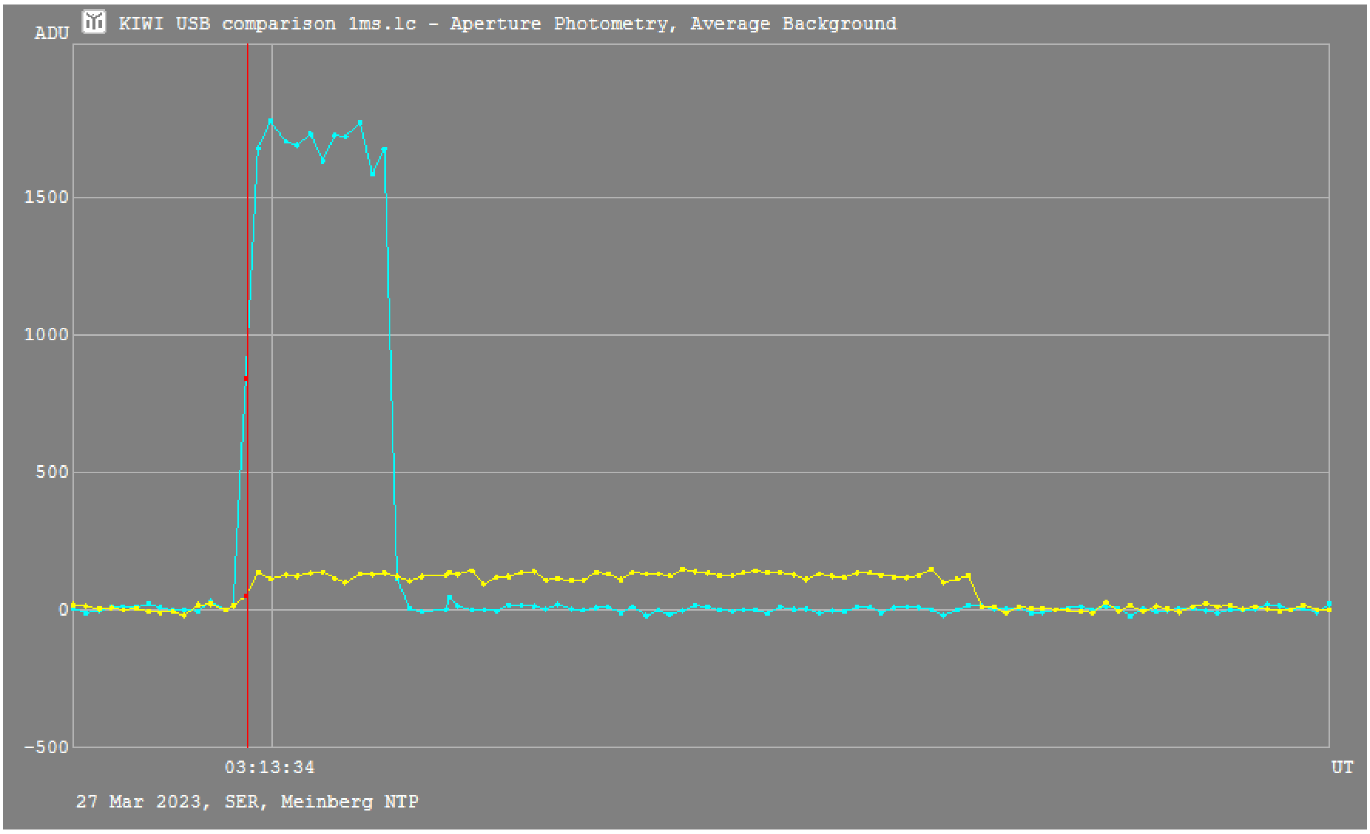

Figure 1. Light curve of the VK172 (yellow) and KIWI-OSD (blue) LED flashes with 1 ms exposure.

rising pulses that are accurate to <1 ms of UTC with a nominal duration of 100 ms ± 0.5 ms. Tests were also done on two other GPS units that use U-BLOX NEO 6M or NEO 7M GPS chips and they also had 100 ms pulse widths. It would be advisable to test the pulse width and light output profile of any GPS device used for flash timing. U-BLOX makes a range of GPS chips for GPS devices in various configurations [18].

Delay Calculation Method

Le Cam [7] developed a method for measuring the acquisition delay of a camera using GPS 1 PPS flashes, shown schematically in Figure 2. This represents four consecutive 40 ms duration frames where a 100 ms long GPS flash has been recorded with the measured flux represented by the blue rectangle. The end times of the frames as recorded by the acquisition software are T1, T2, T3 and T4 with corresponding light fluxes Flux 1, Flux 2 etc. The start time of the GPS PPS pulse is Tpps and is assumed to be exactly on the UTC second. Le Cam [7] derived the acquisition delay as follows:

Total Flux = Flux 1 + Flux 2 + Flux 3 + Flux 4

Unit Flux (per ms) = Total Flux / 100 ms (flash duration)

The duration of the flash in Frame 1 in ms is calculated as:

PPS1 Duration = Flux 1/ Unit Flux

The actual UTC end time of Frame 1 is:

T-end = Tpps + PPS1 Duration

The end time of Frame 1 as measured by the acquisition software is T1 so:

Acquisition Delay = T1 - T-end

So for example if T1 is at time 00:00:00.100 as measured by the acquisition software then the nearest actual UTC is 00:00:00.000 which is Tpps. Therefore T-end is Tpps + 15 ms = 00:00:00.015 so the Acquisition Delay = 00:00:00.100 - 00:00:00.015 = +85 ms.

This calculation can be done using an *Excel* spreadsheet as supplied by Le Cam [19], or a modified version by the author (same method but with additional features and instructions) or by automated processing using a *Python* program written by the author that calculates time delays for all the flash pulses in a light curve CSV file or directly from ADV video or FITS image sequences.

The estimated error in the measured delays by Le Cam [7] were ±2 ms at 3 SD (99.7% CI) for exposure times ranging from 25 to 50 ms with a global shutter ASI174MMC camera and rolling shutter ASI224MC camera. The global shutter camera had slightly lower measurement error than the rolling shutter camera.

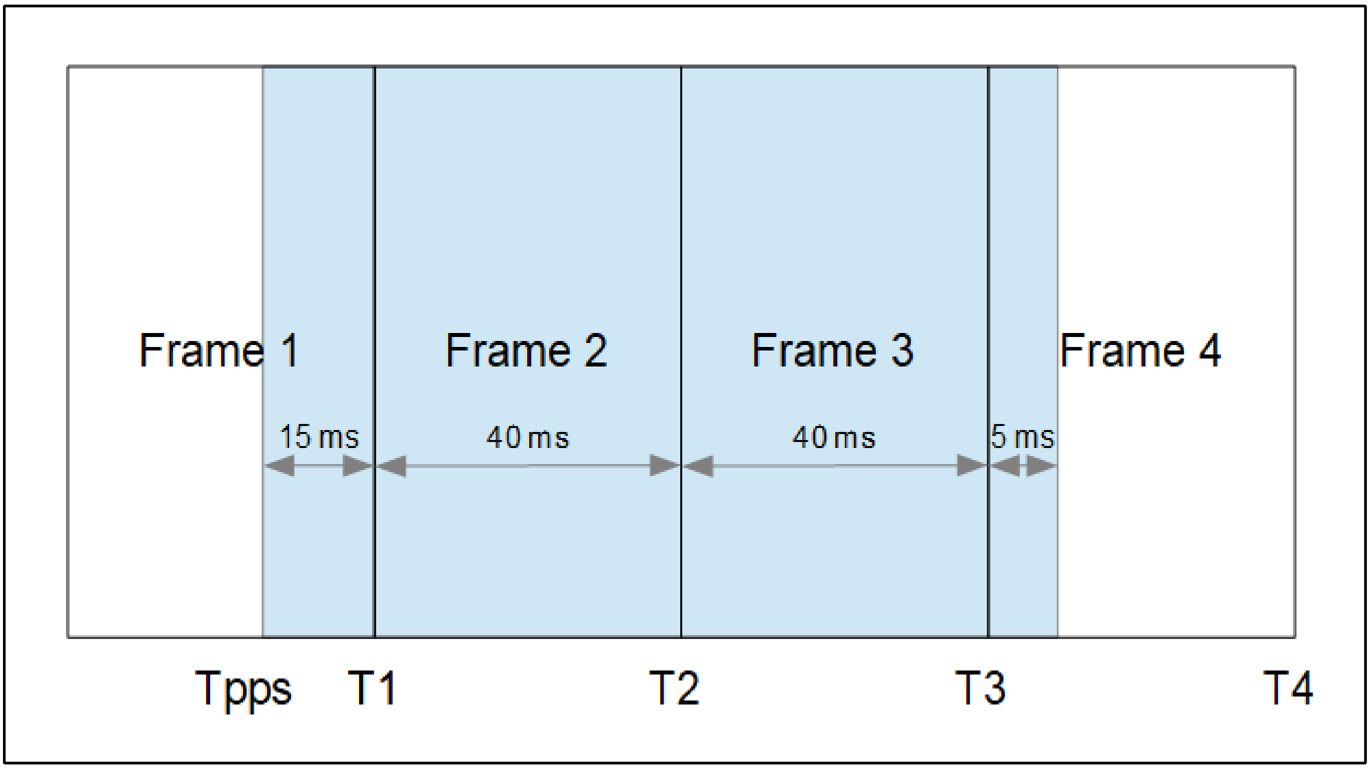

Figure 2. Schematic representation of the timing calculation of Le Cam [20].

For this method the maximum exposure duration that could be used was claimed to be 50 ms as it requires the PPS light signal to be spread out over at least 3 consecutive frames [7]. However, it does work for longer exposures as long as the start time of each frame does not always occur on or very close to the start of the PPS flash or such that the 100 ms flash is only in a single frame. In practice, if exposures are not integer multiples of the flash duration (e.g. 100 ms, 200 ms, 300 ms) then the frame times relative to the flash pulse will shift for each exposure and there will always be some flash events that occur across two frames. Likewise, integer divisors of 100 ms (e.g. 50 ms) should be avoided as the flash times will always be the same number of ms offset from the flash pulse and if this is very short duration accurate measurement of the flux may be compromised. A series of flashes should be used (e.g. 5-10) to ensure there is at least one flash spread over 2 or more consecutive frames.

There are other practical limitations of the method. To get accurate times the nearest UTC second must be correctly identified. If the exposure time is > 500 ms (or exposure + delay > 500 ms) then the correct UTC may be 1 second earlier. This can be corrected but requires careful analysis, may defeat automated analysis and risks a 1 s error in timing. If the exposure time is > 1,000 ms then a single frame will have light from 2 or more overlapping flashes. This can be managed by very careful (and somewhat mind-bending) selection of frames or using only a single flash or multiple flashes separated by several seconds.

Measurements

A series of 1-2-minute video recordings were done using the Watec 910HX camera with GPS timestamps inserted by the KIWI-OSD VTI. A long sequence of GPS flashes from the VK172 were recorded. Exposure on the Watec camera was at field integrations of 2×, 4×, 8×, 16×, 32× and 64× which corresponds to 40 ms, 80 ms, 160 ms, 320 ms, 640 ms and 1,280 ms exposure times for the PAL video system. Occultation observations would typically be done in the 2×-16× range, corresponding to 40 ms to 320 ms exposure.

The video recordings were analysed using *Tangra* [21] to generate light curves. The 2×/40 ms exposure recording is at the PAL frame rate of 25 fps, however, for higher integrations (4× and higher) the video capture is at a higher frame rate than the camera, so the light curves were binned so that each camera integrated frame corresponded to a single binned frame. The timing delays were analysed using the method as described in the previous section.

Measurements were done either using the *Python* code or manually using the *Excel* spreadsheet. The measured delays for 32× and higher were calculated manually using the *Excel* spreadsheet and not the *Python* code as the longer exposure time causes the pattern of frames to sometimes not have a gap between flashes (which are 1 s apart). This can occur when the exposure time is 500 ms or more and the frames need to be selected carefully to ensure the delay calculation is correct.

A series of timing tests were performed:

- Test 1: Comparison of GPS flash timing delays to GPS video time inserter under controlled indoor conditions.
- Test 2: Comparison of GPS flash timing delays to GPS video time inserter during an occultation observation (uncontrolled conditions).
- Test 3: Comparison of GPS flash timing delays for a digital camera with Rolling Shutter with respect to NTP timing with poor stability (uncontrolled conditions).
- Test 4: Comparison of GPS flash timing delays for a digital camera with Rolling Shutter with respect to NTP timing with good stability (uncontrolled conditions).

Test 1 is designed to measure the timestamp delay of the analogue camera with Video Time Inserter as accurately as possible. These delays are precisely known and by comparing the GPS flash time delay an estimate of the measurement error can be made. This is done under controlled indoor conditions with the GPS flash unit fixed in place in front of the camera lens and the lens blacked out.

Test 2 is designed to see how the accuracy is affected when recording in uncontrolled conditions with exposure dictated by the occultation observation parameters, with ambient light, sky background noise, potentially higher sensor noise and varying position and intensity of the GPS flash.

Test 3 calculates the GPS flash timing delay between a digital camera and the NTP timing on the recording laptop which will have an offset from UTC (estimated by the NTP software) and is known to drift. The stability of the GPS timing delay will give an indication of how much the stability of the NTP time affects the accuracy. The test was done using a 10-year-old HP Elitebook 840 laptop under *Windows 10* which has relatively poor clock stability and drifts under recording load.

Test 4 is the same as test 3 but using a recent model ASUS gaming laptop under *Windows 10* with powerful processor and gaming graphics card. This laptop shows much more stable NTP time and appears to be unaffected by the processing load of video recording.

Watec Frame Integration	Exposure/ Delay (ms)	Test 1 delay (ms) Ideal	Test 1 % error	Test 2 delay (ms) Real	Test 2 % error
2×	40	40.0 ± 0.2	0.5%	40.1 ± 0.5	1.3%
4×	80	80.1 ± 1.3	1.6%	80.8 ± 2.4	3.0%
8×	160	160.6 ± 1.4	0.9%	160.9 ± 2.5	1.6%
16×	320	319.5 ± 0.9	0.3%	319.3 ± 1.1	0.3%
32×	640	638.4 ± 1.0	0.2%	639.8 ± 2.7	0.4%
64×	1,280	1,278.6 ± 0.6	0.1%	1,282 ± 5	0.4%

Table 1. Measured delays of the Watec camera with 1 SD errors. The delay of the Watec camera with KIWI-OSD VTI is taken from the IOTA/TTOA occultation reporting form and is equal to the exposure time for this particular camera and VTI combination.

Results

The measured delays are in Table 1 with the mean and standard deviation in ms of the series of flashes timed. The % error is the standard deviation in ms divided by the exposure time in ms.

For Test 1 (ideal conditions) the measured delays are the same as the actual delays to within the error limits. For 16× and longer integrations there were systematic differences of ~5 ms in the initial measurements. This was found to be caused by rounding of the binned frame times by *Tangra*. *Tangra* appears to round the times to the lowest 10 ms for the exported CSV light curve for longer exposures and this affects the 16×/320 ms and longer measurements. The effect of rounding down by 5 ms is to reduce the measured delay by 5 ms. The actual field timestamps have been inspected and the ms digit of the frame first video field start has been used to alter the timestamps to correct for this rounding in the reanalysis. Note that this would not occur under normal use where frames would not be binned for the time delay measurement.

For Test 2 (real observation conditions) the measured delays show in general larger differences from the actual delay and a larger standard deviation. They are still the same as the actual delays to within the error limits. The largest percentage error was at 4× integration, 80 ms exposure. Overall the percentage error ranges from 0.3% to 3.0%, typically much less than 3%.

For Test 2 the gain settings are much higher than the controlled conditions test and consequently there is more sensor noise and there is also sky background noise. The GPS flash unit was handheld in front of the telescope so the light level for each flash varies much more than the ideal test. The higher background noise varies much more than the ideal test. The higher background noise and varying handheld flash levels were anticipated to result in more noise in the light curve and to increase the timing error. It is essential that the GPS flash does not saturate the sensor as this will make accurate measurement impossible and can actually disrupt and delay the data transfer from a digital camera. Brighter flash pulses tended to have slightly better accuracy as did flash events where the first frame had a longer flash duration - this suggests that the SNR of the flash affects the measured timing accuracy. Note that the recording was done from an 8 bit analogue video stream - a digital camera at 12 bit or higher recording should have lower noise.

These tests show that GPS flash timing can be used to derive frame times accurate to <2% (1 SD) of the exposure time under ideal controlled conditions and to within <3% (1 SD) under real conditions. This is consistent with the measurement error reported by Le Cam [7] of 2 ms (3 SD) which is ~0.6 ms (1 SD) for a relative percentage error of ~1.2%.

However, there are other potential sources of timing error for a digital camera that need to be considered. Digital cameras have a delay in acquisition and processing before the frame is timestamped using the system time, which is not exactly at UTC so the timestamp delay is from camera acquisition and processing delay + PC clock offset. The *Windows* PC clock is set by default by the *Windows* Time Service (which uses NTP) but can be better controlled using dedicated NTP software such as Meinberg NTP.

When using GPS flash timing with PC NTP time as a timing reference the GPS flash provides a correction for that point in time. However since the GPS flashes are done before and/or after the occultation event itself the time correction could drift, caused by PC time drift, drift in the NTP server time or drift in the recording software. Further tests were done to measure the stability of the overall timing correction over the duration of the recording to get an understanding of how large these effects can be for an old laptop and modern fast laptop.

Exposure Time	Test 3 Old Laptop (ms)	Test 4 Fast Laptop (ms)
40 ms	± 2.2	± 0.5
80 ms	± 3.7	± 0.7
160 ms	± 5.2	± 0.6

Table 2. Measured standard deviation in delays for Test 3 and 4 using a digital camera and NTP time.

The measured delays for these tests are different from the Watec results as the delay is not fixed but is the combination of the NTP time offset and the camera acquisition and recording delay. What is of interest here is not the measured delay itself (not reported) but the variation of the delay as measured by the standard deviation. The standard deviation is higher than for Test 1 and Test 2 for the Test 3 Old Laptop but not for the Test 4 Fast

Laptop. This indicates that there are additional sources of variation of a few ms when using the Old Laptop, most likely caused by drift in the PC time. *Windows* operating systems before *Windows 10* can have larger time errors and drift [8] and have not been tested here.

Discussion

PC Clock Timing

For this timing method to work the PC clock needs to be accurate to much less than 1 second accuracy so that the nearest UTC second can be identified reliably. Unlike the methods which log the exact UTC times of the GPS flashes, the time of each flash is assumed to be that of the nearest UTC second. This has the advantage that a simpler method and equipment can be used without logging flash times, but the PC clock MUST be accurate to much less than 1 s and the recording software acquisition delay much less than 1 s (or at least known) so that the correct UTC second can be identified.

To achieve this timing accuracy, Network Time Protocol (NTP) can be used. Programs such as *Meinberg NTP* [22] discipline the PC clock and adjust it to the time derived from internet based NTP servers. This can give times accurate to a few ms or tens of ms, however, the performance of each system and its network connection will differ. With poor internet connection or only mobile network hot-spot the performance might not be good enough.

Meinberg NTP (and perhaps other NTP software) can use the VK172 USB GPS or other USB GPS devices directly as a time source. This uses the GPS signal so will work anywhere a GPS signal is available even if no internet connection is available. This is particularly useful for remote observations.

The program *NMEATime2* by VisualGPS.net [23] uses a USB GPS receiver to discipline the PC clock, and disciplines much more aggressively and faster than *Meinberg NTP* so should result in less timing drift and better stability. The author has tested it with the VK172 and it works. However, it can suffer from interference when a digital camera is running on the same laptop or nearby and cause a loss of GPS lock so a GPS unit with a separate antenna is preferable.

Note that the USB GPS time will have a delay due to the USB interface, likely of 50-100 ms. This can be calibrated out however as long as the overall time error is much less than 1 s it is good enough for this method of GPS flash timing.

Global vs Rolling Shutter Cameras

Digital cameras have various types of electronic shutters depending on the intended use and technology, the most common being Rolling Shutter and Global Shutter. A Global Shutter exposes and reads all pixels in the sensor at the same time with minimal dead time between frames. A Rolling Shutter camera reads each line of the frame in sequence, one line at a time, so each line and each pixel has a slightly different start and end time. Rolling Shutter digital cameras are more common, and are in general cheaper and more sensitive overall than Global Shutter cameras.

The line delays for Rolling Shutter astronomy cameras are small but are large enough to affect occultation timing so need to be accounted for. Le Cam [7] reported a ~22 ms delay from top to bottom for an ASI224MMC camera. For the ASI462MM camera at 640×512 resolution (binned 2×) the measured delay was about 7 ms from the top to bottom of the frame. So drift of the target star in the frame could cause drift of a few ms and should be corrected in the analysis.

Global Shutter cameras have the same start and end time for every pixel in the frame so are ideal for high accuracy timing and the flash delays can be measured at any pixel. The Rolling Shutter cameras have a small delay (unrelated to the exposure time) for each line and a much smaller delay across each pixel in the line. To derive the most accurate times for occultations the timing delay for the line where the occulted star is should be measured. This can be done by setting a fixed measurement aperture at the same line as the occulted star at the event time. Alternatively, the tracked occulted star measurement aperture can be used. However, if the star drifts up or down in the image frame then the timing will drift by a small amount. This can be accounted for by making measurements before and after the event time to derive an average or interpolated time delay which will give the correct time if the drift is linear in the Y direction but will have a small error if the drift is non-linear (e.g. an Alt Az mount or EQ mount with the declination axis not aligned to the sensor Y direction).

Best Practice Recommendations

To ensure the most reliable and accurate GPS flash timing:

- Ensure the PC clock is stable before recording - suggest at least 15 minutes start up time.
- Allow at least 15 minutes for the GPS to start up and acquire the leap-second correction. Once the 1 PPS flashes are stable it should have an accurate time. If they start and stop the times may be inaccurate until the GPS lock has been stabilised.
- Ensure a good SNR for the GPS flash pulses by checking the recording histogram and aim for the peak to be at 30-50% of maximum.
- Do not saturate the sensor with overly bright flashes. This will ruin the timing and may cause large readout delays in a digital camera.

- Avoid exposure times that are multiples or divisors of the flash duration of 100 ms, otherwise the duration of flash in the first frame may be too low for an accurate measurement. So avoid 50, 100, 200 ms etc, use 40, 80, 160, 290 ms etc.

- Select flashes to analyse which have a good level and avoid flashes where the flash intensity/time in the first frame is low compared to other frames.

- Use a fixed measurement aperture at the same Y position as the target star at the event time(s).

- Using the tracked target star measurement aperture is acceptable if the mount has linear drift in Y (e.g. EQ mount aligned to Y-axis or pre-point mount) or accurately guided.

- Make two sets of flashes, one before and one after the event, and interpolate to the event time (this is done by the author's analysis spreadsheet). This will minimise or eliminate the effect of PC clock drift and target drift.

- Take great care when applying the measured offsets as it is easy to make errors in manual data entry.

Summary

GPS flash timing using the method of Le Cam [7] is accurate enough for asteroid occultation observations with timing accuracy under actual observation conditions of better than ±5 ms (95% CI). To achieve this accuracy good practice and procedures need to be followed to ensure suitable GPS-driven optical flashes illuminating the camera sensor are recorded for accurate analysis and to properly deal with additional potential sources of error such as PC clock drift and target drift for Rolling Shutter cameras. In most cases these additional sources of error can be corrected or minimised by measuring the timing delay before and after the event and interpolating the measured delays to the event time. Calculation spreadsheets are available to perform the delay calculations and apply these corrections.

This method of GPS flash timing is simple and cheap and can be used with almost any camera and recording and analysis software. Wider adoption of this method would make occultation observations more accessible to new observers and enable adhoc participation with a wide range of camera and recording configurations.

A complete description of the author’s implementation of this GPS flash timing method with practical instructions for observers and calculation workbook is available for download from the IOTA Group files section [15] or from the author’s cloud storage [16]. *Python* software for automated processing is available on request.

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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 2024 July 1, the *Minor Planet Center* listed 1654 Centaurs and 3409 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:

(471143) Dziewanna

Wojciech Burzyński · IOTA/ES · President SOPiZ PTMA[1)] · Białystok · Poland · wburzynski@poczta.onet.pl

ABSTRACT: (471143) Dziewanna, discovered in 2010, is a body from the group of 2:7-resonant trans-Neptunian objects and it is still very poorly known with only a few individual occultation observations. The relatively large size of the object makes it an interesting target for future studies. This is the story of its discovery, the meaning behind its name and the nature of its orbit.

[1)] Occultation Section of the Polish Amateur Astronomer's Society

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
7066	Nessus	Konrad Guhl	JOA 1 2024
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
53311	Deucalion	Konrad Guhl	JOA 2 2024

No.	Name	Author	Link to Issue
54598	Bienor	Konrad Guhl	JOA 3 2018
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

In 2010, astronomers from the *Astronomical Observatory of the University of Warsaw*, under the direction of Andrzej Udalski, used the 1.3-metre *Warsaw Telescope* (Figures 1, 2) at the *Las Campañas Observatory* in Chile to observe large areas of the southern sky. Their goal was to search for massive objects on the edges of the Solar System. They conducted the project as part of one of the world's biggest large-scale sky surveys - the Optical Gravitational Lensing Experiment (OGLE) [1], [Appendix].

Figure 1. Dome of the Warsaw Telescope, Las Campañas Observatory, Chile. (Source: OGLE)

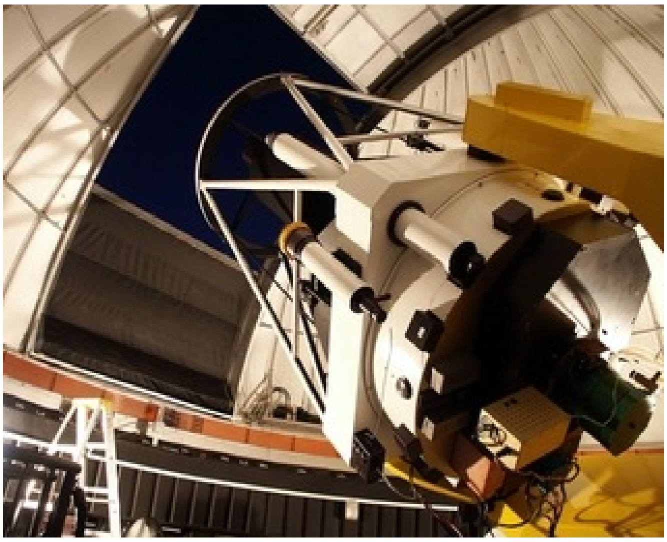
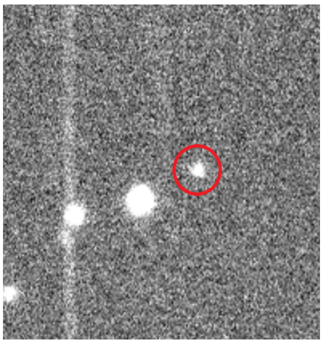


Figure 2. The 1.3-metre Warsaw Telescope, Las Campañas Observatory, Chile. (Source: OGLE)

The asteroid was discovered on 2010 March 13 as a slow-moving stellar-like object of mag 19.7 (Figure 3). The discovery team included Andrzej Udalski, Scott S. Sheppard, Marcin Kubiak and Chad A. Trujillo. It received the provisional designation, 2010 EK_{139}. In subsequent analyses, precovery images of (472243) Dziewanna were found to have been taken by the Near-Earth Asteroid Tracking (NEAT) program at *Palomar Observatory* on 2002 March 15 (Figure 4) and April 8, 2003 March 23, and 2005 May 12.



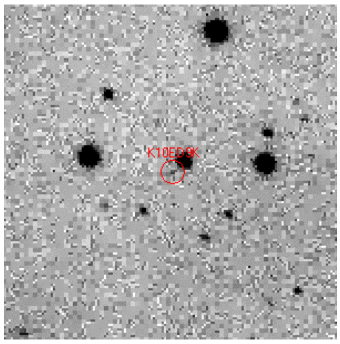


Figure 3 (left). (471143) Dziewanna's discovery image taken by the 1.3-m Warsaw Telescope in Chile. (Source: OGLE)

Figure 4 (right). Earliest precovery image of (471143) Dziewanna taken on 2002 March 15. (Source: NEAT)

The Name

For the names of distant trans-Neptunian objects, the Minor Planet Center uses a special convention - the names of deities from the mythology of various nations are chosen.

"*When at the end of 2017, our 2010 EK_{139} was added to the list of objects that can be given proper names, we decided to maintain this convention of finding a name related to Polish or, more generally, Slavic deities, in order to have an object in space that refers to our traditions,*" recalled Udalski [2].

Figure 5. Dziewanna as a goddess. Drawn by Kamila Kuc, Poland.

The choice fell on a young and beautiful goddess with golden hair by the name of Dziewanna, who appears in various Slavic mythologies, a protector of wild nature, forests and woods and the hunt, bringing spring, new life and revitalizing the Earth (Figure 5), [3]. Her symbol is that of the wild yellow mulleins flower (*Polish*: dziewanna) which after drying were used as torches during ceremonies related to the goddess. 15^{th}-century Polish historian, Jan Długosz in *Annales seu cronici incliti regni Poloniae*, associates her with the Roman goddess Diana, whose name shares a proto-Indo-European root. "*Although the name Dziewanna in other Slavic languages may be easier for foreigners to pronounce, we decided to use the Polish spelling to emphasize the Polish roots of our discovery and the OGLE project*," explains Michał Szymański, director of the Astronomical Observatory of the University of Warsaw and co-creator of the OGLE project" [2].

Thus, the Polish name Dziewanna does not only represent a Slavic goddess but is also the Polish name of a popular wildflower, the Mullein (*Verbascum*) found mainly in temperate zones of Europe and Asia with a centre of diversity in Turkey, where 230 species grow. Some species also occur in North Africa and the highlands of East Africa. There are 87 species growing in Europe. Mullein has been used as a lamp wick since ancient times. Many species of mullein are medicinal plants. Some species are cultivated as ornamental plants (Figure 6), [4].

Figure 6.
Dziewanna wildflower.
(Image: Christian Weber)

The Orbit

(471143) Dziewanna's orbit is eccentric (e = 0.528) and is inclined to the ecliptic by 29.48°. With a semi-major axis of 68.73 AU, the distance from the Sun varies between 32.47 AU and 105.00 AU [5]. In this respect, the orbit lies completely outside that of Neptune and the body orbits the Sun in the so-called 2:7 orbital resonance with this planet. The orbital period is approximately 570 years. Since its discovery, it has been observed more than 450 times, and the uncertainties of its orbit in astrometric coordinates are about 61 mas in right ascension and 43 mas in declination [6].

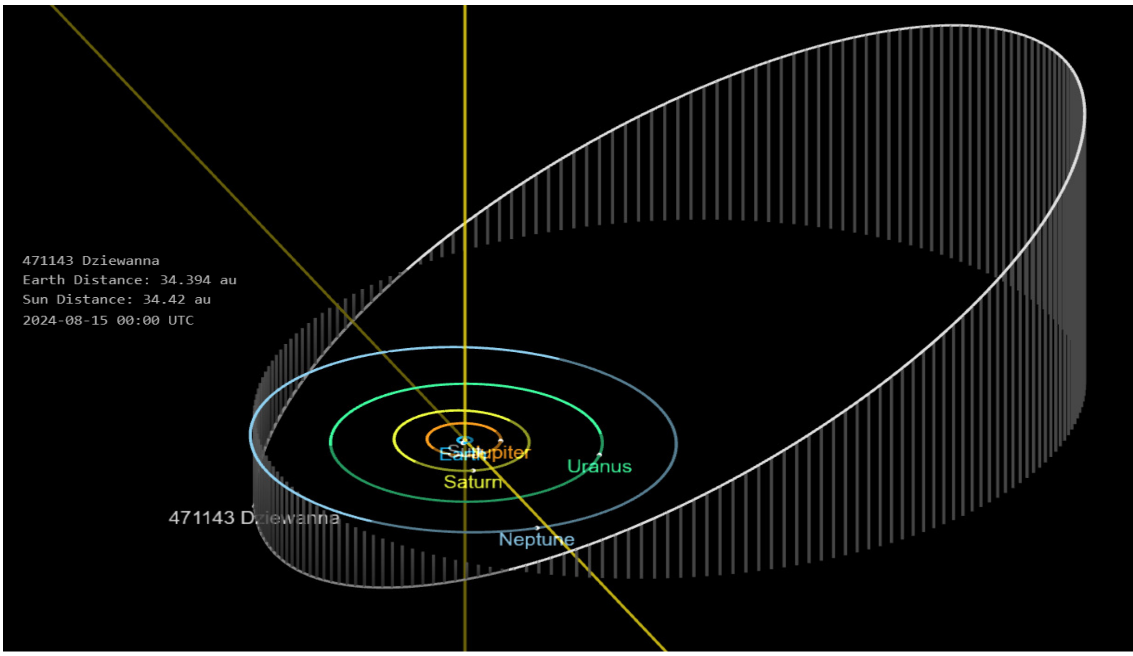


Figure 7. Orbit diagram and position of (471143) Dziewanna on 2024 August 15.
(Source: NASA/JPL Small-body database lookup, *https://ssd.jpl.nasa.gov/tools/sbdb_lookup.html#/?sstr=471143)*

Physical Characteristics

This asteroid, along with 2010 HE_{79}, 2010 EL_{139} and 2010 FX_{86}, is one of four large asteroids discovered by Polish astronomers from the OGLE team in 2010. The passing years have shown that (471143) Dziewanna is still the largest "Polish" object in the Solar System [7],[8] and [9]. Initially, its size was estimated at about 1000 km, which would place it towards the end of the first 20 largest asteroids. An image of this object captured by the *Hubble Space Telescope* is shown in Figure 8.

In 2010, the thermal radiation of (471143) Dziewanna was observed by the *Herschel Space Telescope*, which allowed astronomers to estimate its diameter at about 470 km. Most likely, the diameter lies between 400 and 700 km. This value is based on an assumed albedo of 25% and an absolute magnitude of mag 3.9. The stellar occultation by (471143) Dziewanna, observed on 2019 May 17, resulted in a single chord of 504 km (Figure 10).

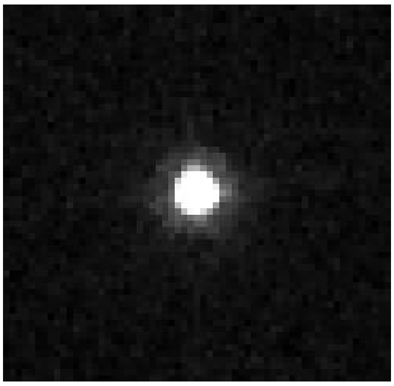


Figure 8. Dziewanna imaged by the Hubble Space Telescope in 2012.
(NASA/ESA, STScI)

This makes it still one of the 45 largest independent bodies in the Solar System (SSBs) and a potential candidate for a dwarf planet. In practice, a more precise determination of (471143) Dziewanna's size will only be possible using the occultation method.

A rotational lightcurve was obtained from photometric observations at the discovering observatory, with the 2.5-metre *Irénée du Pont Telescope*, and published in May 2013. The lightcurve shows that the rotation period is 7.07 ± 0.05 hours; the variation in brightness amounts to magnitude 0.12 [10], (Figure 9).

Observations by American astronomer Michael Brown at the *Keck Telescope* in March 2012 failed to find a satellite. There is therefore currently no means to determine (471143) Dziewanna's mass.

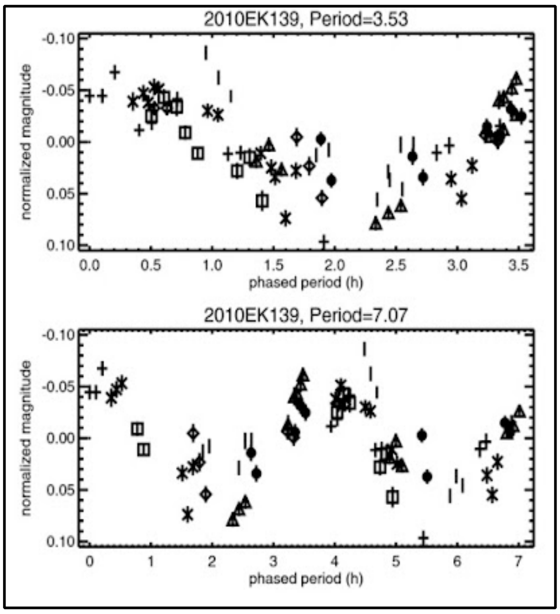


Figure 9. Light curves obtained by 2.5-m telescope at Las Campañas Observatory [10].

Occultations by (471143) Dziewanna

Unfortunately, for observers in the northern hemisphere the asteroid has remained basically inaccessible since the time of discovery in March 2010 when its declination in the sky was -29.5°. Since then, the asteroid has been rapidly moving deeper into the southern sky and its current declination is as far south as -46°. It will reach perihelion in 2039 when at its June opposition it will reach declination –52° and shine at a maximum brightness of Vmag 19.25, when it will be closest to Earth at a distance of 31.61 AU. For northerly observers it will be available in the sky in the late 2060s.

Nevertheless, observers in the southern hemisphere have a chance to observe occultations of stars by (471143) Dziewanna. On 2018 July 15, the first stellar occultation involving (471143) Dziewanna was observed by the 4.1-metre *Southern Astrophysical Research (SOAR) Telescope* in Chile (Figure 10).

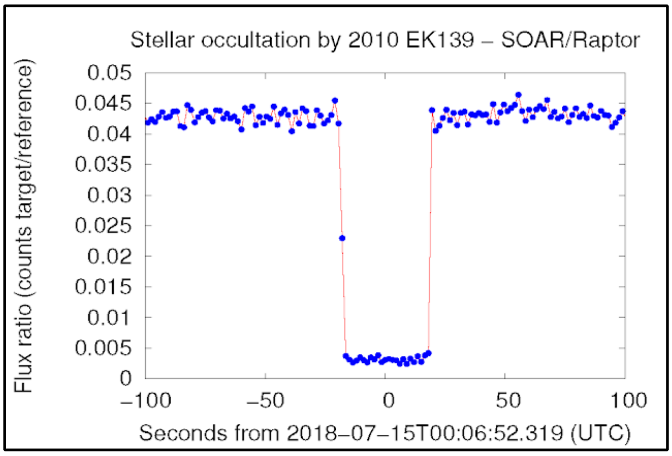


Figure 10. The first (471143) Dziewanna occultation observed by 4.1-metre SOAR telescope in Chile [11].

It also turns out that one lucky person in the recent past namely Dean Hooper, one of our occultation colleagues from Australia, obtained a chord of about 507 km from his very first successful occultation event: that of 2019 May 17 (Figure 11), whilst Australian colleague Dave Gault also measured a positive event on 2023 September 17.

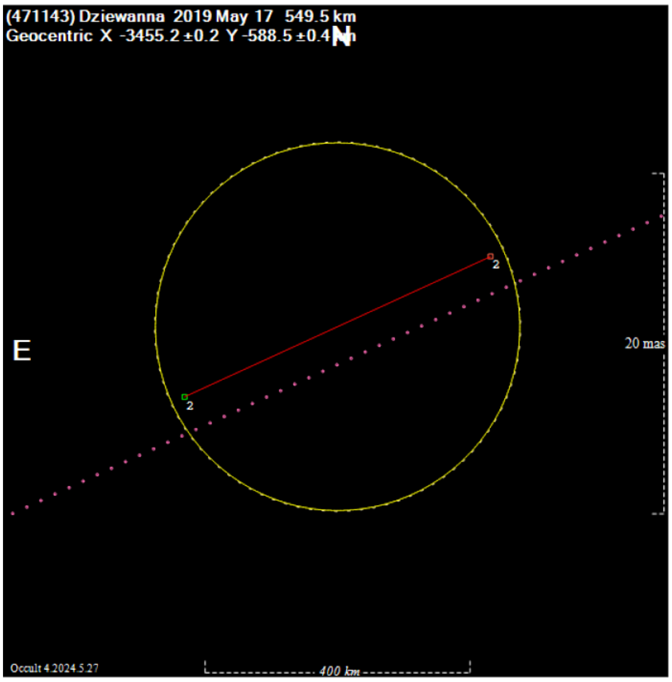


Figure 11. (471143) Dziewanna occultation observed in 2017 by Dean Hooper, Australia. (Occult V4.2024.5.27. database) [12]

When it comes to possibilities of observing future occultations by (471143) Dziewanna, unfortunately they will occur quite rarely and in areas devoid of observers. Nevertheless, the author of this paper has selected notable events. Of course, they will all apply mainly to observers in the southern hemisphere. In the case of (471143) Dziewanna and its relatively large orbital uncertainty, we must rely on the precise ephemeris of the ERC Lucky Star project, calculating events many years in advance is pointless for now.

The first event will be observed in northern Australia and Indonesia on 2024 July 6. Unfortunately, the occulted star will be faint and its brightness will be about mag 17 but its expected duration of 30 s gives a chance for it to be detected (Figure 12).

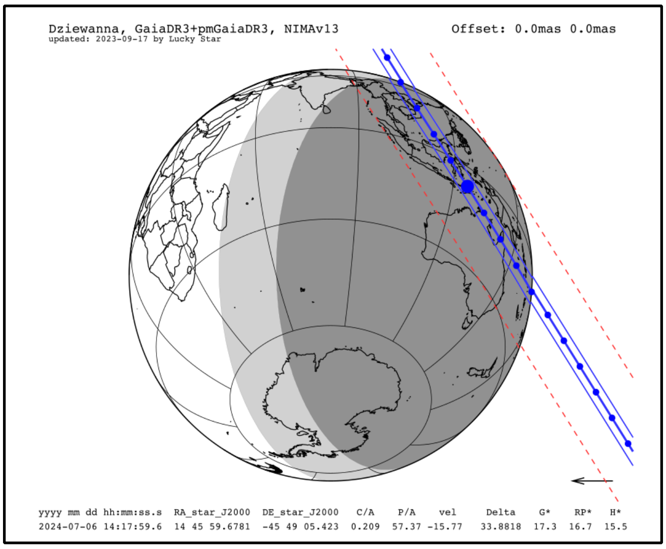


Figure 12. Stellar occultation of (471143) Dziewanna on 2024 July 6. (ERC Lucky Star project, 2023 Sep 17)

The next event is on 2025 March 27, and here there is an exceptional chance to observe the occultation from the northern hemisphere - through telescopes on the Canary Islands. The occulted star will also be 17th magnitude and the expected duration is 27 seconds (Figure 13).

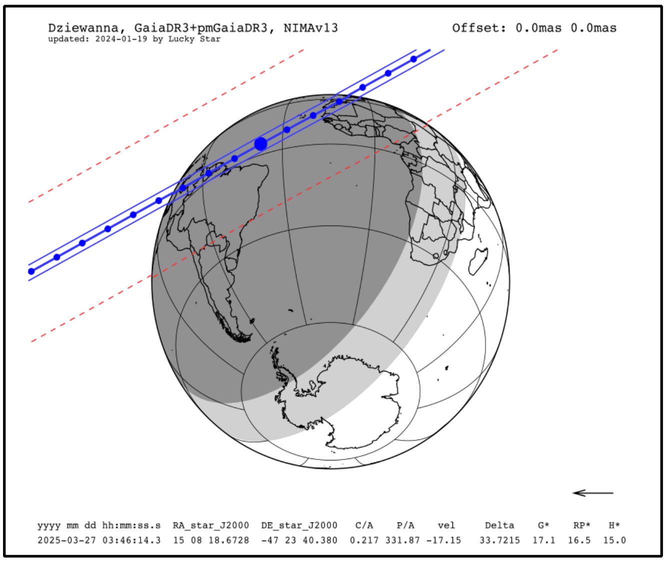


Figure 13. Stellar occultation of (471143) Dziewanna on 2025 March 27. (ERC Lucky Star project, 2024 Jan 19)

References

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[2] Polish Press Agency – Science in Poland, https://scienceinpoland.pl/en/news/news%2C31303%2Cdziewannalargest-polish-object-solar-system.html
[3] Dziewanna, the goddess, https://en.wikipedia.org/wiki/Devana
[4] Dziewanna, the wildflower: https://en.wikipedia.org/wiki/Verbascum
[5] Small-Body Database Lookup, 471143 Dziewanna (210 EK139), NASA, JPL, retrieved June 2024 https://ssd.jpl.nasa.gov/tools/sbdb_lookup.html#/?sstr=471143
[6] ERC Lucky Star Project, NIMA ephemeris for (471143) Dziewanna, https://lesia.obspm.fr/lucky-star/obj.php?p=1134
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[8] List of trans-Neptunian objects, https://en.wikipedia.org/wiki/List_of_trans-Neptunian_objects
[9] TNO/Centaur diameters, albedos, and densities https://www.johnstonsarchive.net/astro/tnodiam.html
[10] Benecchi S. D., Sheppard, S. S. - Lightcurves of 32 large Transneptunian Objects, 2013, AJ 145 124 https://iopscience.iop.org/article/10.1088/0004-6256/145/5/124/pdf
[11] Solar System Occultations at SOAR https://noirlab.edu/science/programs/ctio/telescopes/soar-telescope/news/solar-system-occultations-soar
[12] Herald, D. Occult V4 software, https://occultations.org/observing/software/occult/

Video Links

Dziewanna Occultation, deeprandomsurvey.org, https://www.youtube.com/watch?v=0JaCbOYDbPc
Dean Hooper's Dziewanna Occultation in 2019, https://www.youtube.com/watch?v=huLwmdRCqYA

Appendix

The OGLE project - the largest observational project in the history of Polish astronomy, which has been going on for 32 years. Andrzej Udalski is the manager and co-creator of this project. The OGLE is a large-scale photometric sky survey focused on studying the brightness variations of various objects. The most important successes of the OGLE project include the detection of the first gravitational microlensing phenomena and the development of this innovative field of astrophysical research.

Further breakthrough discoveries have been made in the field of searching for extrasolar planets. For the first time, two new techniques for searching for planets were successfully used: the transit method and gravitational microlensing. About 70 extrasolar planets have been discovered so far. The OGLE project also has assembled the world's largest collection of variable stars, numbering about a million objects. It contains many unique star systems and previously unknown types of stellar variability. Explosive objects are also regularly discovered, in particular unique novae, dwarf novae and supernovae.

News

Three Asteroidal Satellite Discoveries

Dave Herald reported in the occultation mailing lists the officially recognised discoveries of three asteroidal satellites by occultation measurements in just 18 days.

The first one was recorded in the US with a single chord measured by J.-F. Gout, Starkville, MS on 2024 January 14. The star UCAC4 558-046959 disappeared twice for 0.45 s and 0.26 s during an occultation by asteroid (10424) Gaillard. Diameters of 4.3 km and 2.6 km for the two bodies could be measured according to the apparent motion of the asteroid on the sky plane. The gap between the two events was 0.31 s (3.0 km). The mag drops of at least 2.5 mag during both occultations ruled out a binary nature of the star.

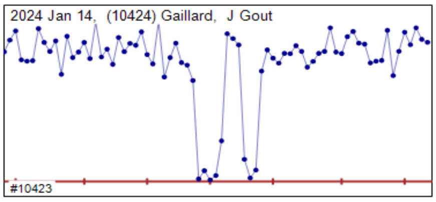


Figure 1. Several data points were recorded for both occultations by (10424) Gaillard. Source: Occult Light Curve Database

The confirmation of the satellite of (10424) Gaillard was achieved with dedicated rotational light curve observations over a period of 16 days.

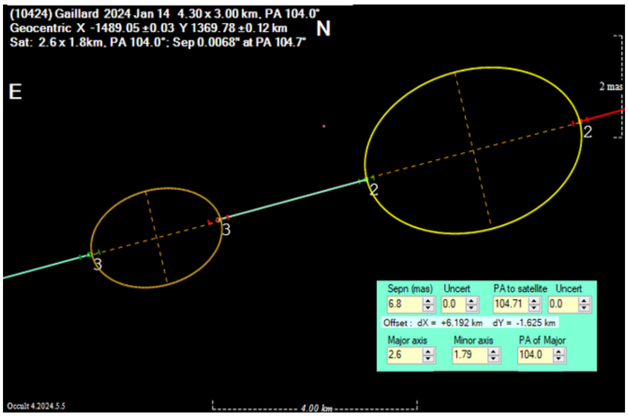


Figure 2. The single chord gives minimum diameters for both components. Source: Occult Database

Details can be found in the official announcement of the discovery in CBET No. 5370:

http://www.cbat.eps.harvard.edu/iau/cbet/005300/CBET005370.txt

The discovery of a satellite of Jupiter Trojan (100624) 1997 TR_{28} was achieved with trans-continental observations by J. Kubanek, Strasice, Czechia, and M. Ishida and Y. Ikari, Moriyama, Shiga, Japan, on 2024 January 23. J. Kubanek recorded an occultation by the main body with a duration of 0.74 s. This gives a minimum diameter of 10.9 km for this component. M. Ishida and Y. Ikari measured chord lengths for the second component of 3.2 km and 2.3 km, respectively. The displacement of the chord for the main component excludes the possibility of an elongated profile of the asteroid.

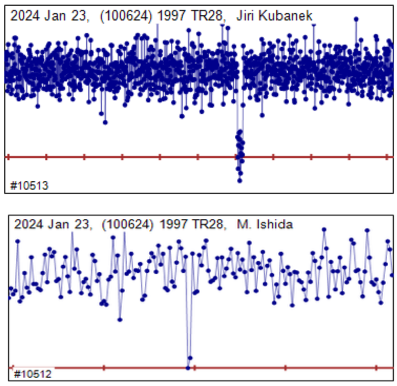


Figure 3. Light curves for the main component, recorded by J. Kubanek (top) and for the satellite by M. Ishida. Source: Occult Light Curve Database

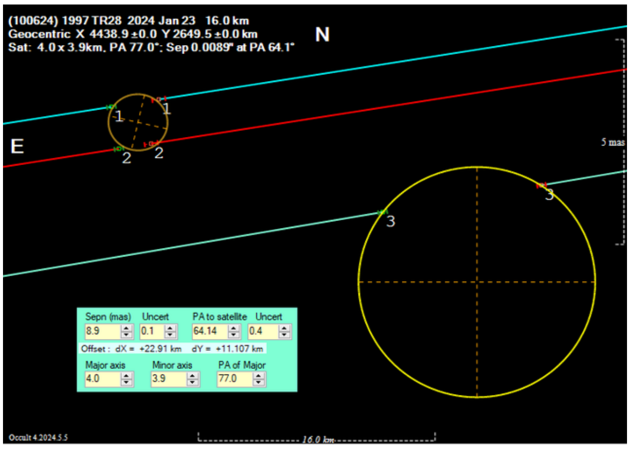


Figure 4. A trans-continental success story: Chords No. 1 & 2 were recorded in Japan, the single chord No. 3 in Czechia. Source: Occult Database

The discovery was announced in CBET No. 5388:

http://www.cbat.eps.harvard.edu/iau/cbet/005300/CBET005388.txt

News

Finally, a third discovery was made by M. Simpson, B. Yeung, and G. Schmidt, Royal Astronomical Society of Canada, Calgary, Canada, on 2024 February 1.

They observed an occultation of TYC 683-00635-1 by main-belt asteroid (5232) Jordaens and recorded three positive chords.

The observers published the result and the discussion here:

Simpson, M., (5232) Jordaens Binary System Asteroid Discovery, 2024 April 6, https://doi.org/10.17605/OSF.IO/FZM7K

The offical announcement was made in CBET No. 5382:
http://www.cbat.eps.harvard.edu/iau/cbet/005300/CBET005382.txt

Up to May 2024 there were six confirmed binary asteroids discovered by stellar occultation observations:

Asteroid	Diameter km
(4337) Arecibo	19
(5232) Jordaens	12
(5457) Queen's	21
(10424) Gaillard	6
(100624) 1997 TR_{28}	16
(172376) 2002 YE_{25}	6

The minimum diameters of these objects give a good reason to keep an eye on occultations by small asteroids.

(OK)

Archive of Asteroidal Occultation Observations at NASA's Planetary Data System - Small Bodies Node Updated

For the first time since 2019 a new archive of asteroidal occultation observations is now available at NASA's Planetary Data System - Small Bodies Node.

This data set contains more than 9,700 occultation observations through to June 2023, some observations made up to December 2023 are already included.

Dave Herald reported on the occultation mailing lists, that updates of the archive were paused for years for several reasons. One was the development of an error model for occultation observations, assisted by the team of JPL Horizons, and the setup of a new data format. The archive will be updated on an annual basis in the future.

The files will include all the data items of the data base of asteroidal occultations in *Occult*. Additionally, files with values for astrometry, diameters and double stars are given. A PDF-file presents profiles from *Occult* for 620 of the best observed asteroidal occultations.

The archive is located here:

Herald, D., Gault, D., Carlson, N., Frappa, E., Giacchini, B., Guhl, K., Hayamizu, T., Kerr, S., and Moore, J. (2024). Asteroid Occultations V4.0. urn:nasa:pds:smallbodiesoccultations::4.0. NASA Planetary Data System, https://doi.org/10.26033/ehqs-jp27

(OK)

ESA Science Newsletter Launched

The European Space Agency's Directorate of Science publishes roughly every month a newsletter for the scientific community. As they stated on their webpage the primary aim is to inform scientists in ESA member states and across the world about how to engage with the Directorate of Science.

News on developments of the science programme, research fellowship announcements, calls for membership, major mission updates, conference announcements and more will be covered in the newsletter. The first issue was published in May 2024.

You can read the latest issue or subscribe to the newsletter on this page:

https://www.cosmos.esa.int/web/scinews/newsletters

(OK)

News

Prix Jules Janssen 2023 Awarded to Bruno Sicardy

The Société Astronomique de France (French Astronomical Society – SAF) has awarded its prestigious international astronomy prize – the *Prix Jules Janssen* – to Bruno Sicardy (France) for his scientific achievements, and the co-discovery of Neptune's rings. The medal was presented to Bruno Sicardy by Sylvain Bouley, President of the Société Astronomique de France on 2024 April 10th in a ceremony which took place at the Conservatoire national des arts et métiers (CNAM) in Paris, France. A recording of the ceremony is available on YouTube (in French): https://www.youtube.com/watch?v=y-hNzoS6FMI

The famous astronomer Jules Janssen (1824-1907), who served as SAF's president between 1895 and 1897, created several awards, including the *Prix Jules Janssen* that has been awarded annually by SAF since 1897. This prize is alternatively given to a French astronomer and a foreign astronomer for outstanding scientific work as well as for their contribution to public appreciation of astronomy. Previous recipients include, among others, Percival Lowell (1904), Max Wolf (1912), Arthur Stanley Eddington (1928), Robert Esnault-Pelterie (1930), Albert Einstein (1931), Michel Mayor (1998), Thérèse Encrenaz (2007), Catherine Cesarsky (2009), Françoise Combes (2017), Hubert Reeves (2019), Ewine van Dishoeck (2020).

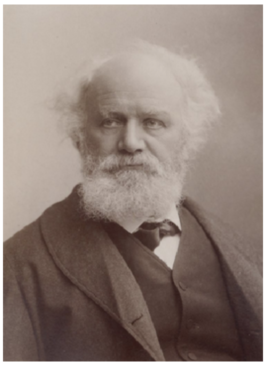


Figure 2. Jules Janssen, photographed by Nadar. (Public domain, CC0)

Figure 3. The medal of Prix Jules Janssen (Thierry Midavaine)

Figure 1. Bruno Sicardy (left) has received the medal of the Prix Jules Janssen 2023 from Sylvain Bouley. (Thierry Midavaine)

In 1984, a French team composed of André Brahic, Françoise Roques and Bruno Sicardy co-discovered the rings of Neptune during a stellar occultation observed simultaneously from the European Southern Observatory (ESO) at La Silla, and from Cerro Tololo Interamerican Observatory (CTIO) by the team of American professor William Hubbard. Sicardy then devoted most of his work to the observation and study of the dynamics of planetary rings and atmospheres, as well as the dynamics of protoplanetary disks. He defended his thesis, entitled Observational, analytical and numerical study of planetary environments: applications to the rings of Saturn and Uranus and the arcs of Neptune, at the Université Paris Diderot (Université Paris 7) in 1988 under the direction of André Brahic. He is also co-discoverer of the following rings around small bodies in the solar system: Chariklo (2013), Haumea (2017), and Quaoar (2022).

Asteroid (6280) Sicardy was named in his honour. He was awarded the *2019 Paul Doisteau-Emile Blutet prize* from the Academy of Sciences, during a ceremony held at the Institut de France, on 2019 October 15th (see JOA 2020-01, p. 35).

IOTA and the worldwide community of occultation observers congratulate Bruno Sicardy on the award of the *Prix Jules Janssen 2023*.

(OK, press release SAF)

News

Colloquium in Honour of Prof. Bruno Sicardy

Figure 1. Bruno Sicardy (left) and Stefan Renner present the paper stripe of the registration of Neptune's ring arc. Note the projection by chance on the stripe. Astronaut Dave Bowman from "2001: A Space Odyssey" calls out: "My God, it's full of rings!". (Konrad Guhl)

An honorary colloquium took place from 2024 April 22 to 26 on the occasion of the retirement of Bruno Sicardy. The venue was the historic Cassini Hall of the *Paris Observatory*. With the subtitle of the colloquium "Stellar occultations: a route to major advances in Planetary Sciences", Bruno's former students and postdocs (his scientific children) as well as his closest colleagues with whom he has been collaborating over the decades, led the auditorium through more than 40 years of scientific work. The colloquium coincided with the 40th anniversary of the discovery of Neptune's ring arcs to which the young Bruno Sicardy had contributed (Figure 1). The method of occultation observations to detect atmospheres, to discover system of rings and arcs and moons is the common thread in Bruno's scientific career. He forged the collaboration with a huge network of amateur astronomers across the globe. So he included the "unpaid astronomers" as partners in the scientific world.

Wolfgang Beisker and Konrad Guhl attended the colloqium and represented IOTA/ES. They reported about the history and presented results of citizen science in astronomy. In these contributions they pointed out that scientists have often encouraged interested laypersons to collaborate and thus promoted citizen scientists. These range from Edmond Halley to Friedrich W. Argelander and Bruno Sicardy: Over 300 years ago, Edmond Halley called on the citizens of England to observe a solar eclipse and to report the results. In 1844, Friedrich W. Argelander published an "Appeal to the Friends of Astronomy" to draw their attention to the still young field of variable star observation. The ERC Lucky Star project, launched by Bruno Sicardy in 2014, explicitly names amateur astronomers as collaborators.

(KG)

Figure 2. Julie Vermersch (IMCCE) (right) presents to the participants in Salle Cassini. (Thierry Midavaine)

News

Impressions from the colloquium:

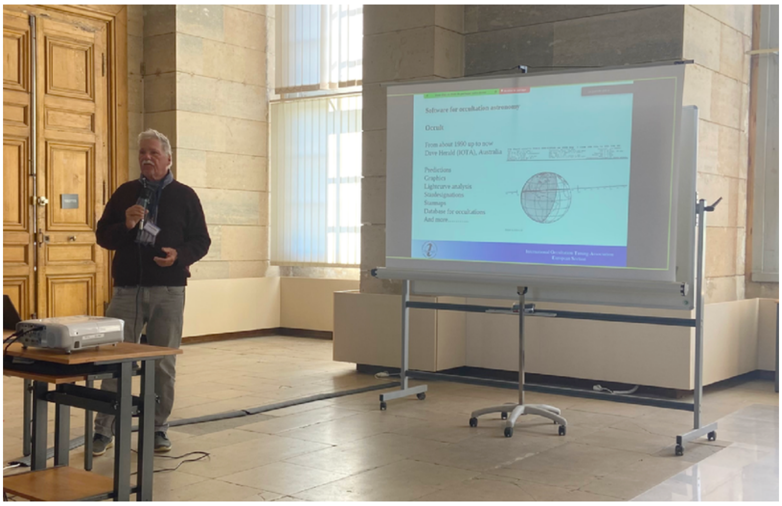


Figure 3 (top left). Wolfgang Beisker (IOTA/ES) during his presentation about citizen science in occultation work. (Konrad Guhl)

Figure 4 (top right). Always a highlight in Salle Cassini at l'Observatoire de Paris: The observation of the transit of the Sun across the meridian on the floor. (Konrad Guhl)

Figure 5 (left). Bruno Sicardy and Fabienne Casoli, Directrice de l'Observatoire de Paris (right). (Thierry Midavaine).

Figure 6 (right). Josselin Desmars (IMCCE, l'Observatoire de Paris) presents the work of the ERC Lucky Star project. (Konrad Guhl)

Webpage of the colloquium with list of participants and schedule of the program:

https://bsicardy2024.sciencesconf.org/

News

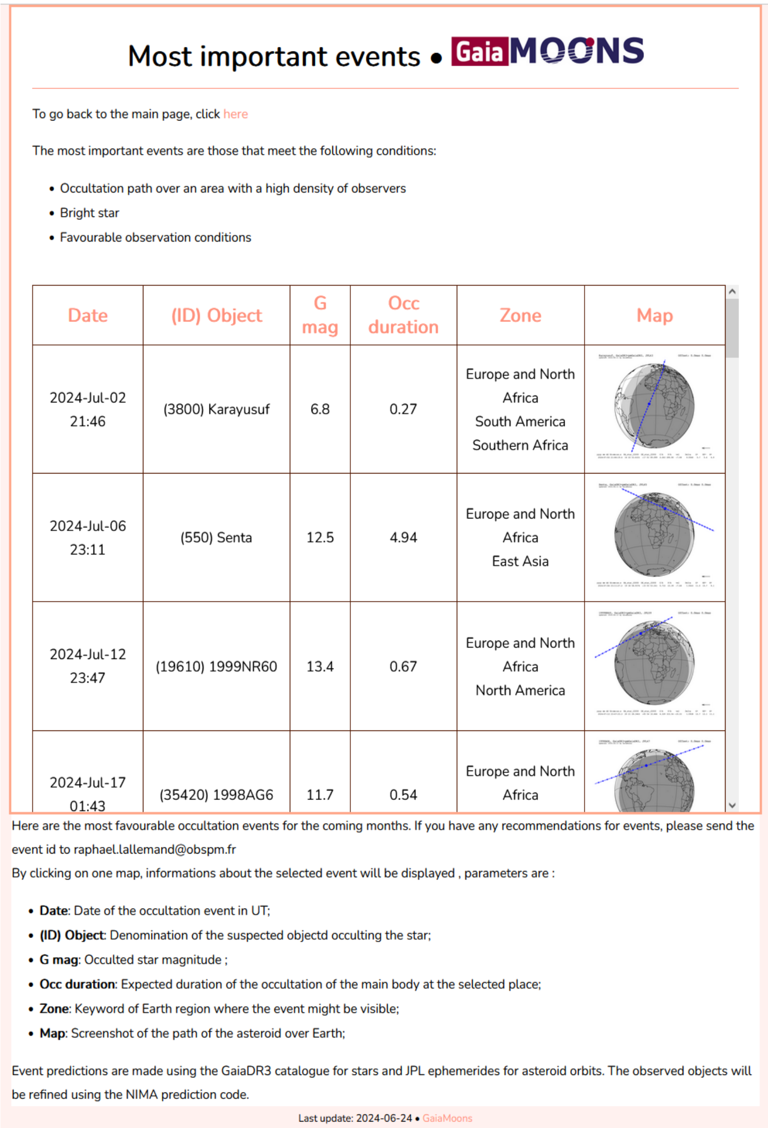
GaiaMoons - Hunting for Binary Asteroids

The new project *GaiaMoons* calls the international community of occultation observers for their participation. With the coordination by Paolo Tanga (Université Côte d'Azur, CNRS/UMR7293 Laboratoire Lagrange, Observatoire de la Côte d'Azur) and the partner coordinators Josselin Desmars (IMCCE, PSL Obs. de Paris, IPSA) and Dagmara Oszkiewicz (University of Poznan, Poland) the project's goal is to discover asteroid companions by their signature found in the asteroidal astrometry obtained from the European Space Agency's Mission *Gaia* and by ground-based observations.

The team describes the method on their webpage:

https://www.oca.eu/fr/gaiamoons

From the orbital fit, we derive from the residuals the possible signatures of the presence of a companion. This first step produces a list of candidate binary asteroids. The candidates must be analysed to check if the presence of a satellite is consistent with the supposed physical properties of the asteroid (size, density...). Candidates that are not compatibles are discarded.



Most important events • GaiaMOONS

To go back to the main page, click here

The most important events are those that meet the following conditions:

- Occultation path over an area with a high density of observers
- Bright star
- Favourable observation conditions

Date	(ID) Object	G mag	Occ duration	Zone	Map
2024-Jul-02 21:46	(3800) Karayusuf	6.8	0.27	Europe and North Africa South America Southern Africa	
2024-Jul-06 23:11	(550) Senta	12.5	4.94	Europe and North Africa East Asia	
2024-Jul-12 23:47	(19610) 1999NR60	13.4	0.67	Europe and North Africa North America	
2024-Jul-17 01:43	(35420) 1998AG6	11.7	0.54	Europe and North Africa	

Here are the most favourable occultation events for the coming months. If you have any recommendations for events, please send the event id to raphael.lallemand@obspm.fr

By clicking on one map, informations about the selected event will be displayed , parameters are :

- **Date**: Date of the occultation event in UT;
- **(ID) Object**: Denomination of the suspected objectd occulting the star;
- **G mag**: Occulted star magnitude ;
- **Occ duration**: Expected duration of the occultation of the main body at the selected place;
- **Zone**: Keyword of Earth region where the event might be visible;
- **Map**: Screenshot of the path of the asteroid over Earth;

Event predictions are made using the GaiaDR3 catalogue for stars and JPL ephemerides for asteroid orbits. The observed objects will be refined using the NIMA prediction code.

Last update: 2024-06-24 • GaiaMoons

Figure 1. Screenshot of the most-important-events webpage of GaiaMoons: https://gaiamoons.imcce.fr/mainevent

We target the candidate binaries by campaigns of photometry and stellar occultation observations from different sites. The goal is to attempt to validate the presence of the companions by other techniques, independent from the astrometric detection.

Eventually, all the properties derived by astrometry, photometry, occultations, and data available from other sources, are assembled in a coherent picture, providing the most complete possible data set of physical properties for the new binaries.

Citizen scientists from our community are wanted!

A special webpage for predictions of stellar occultations by suspected asteroids is now online:

https://gaiamoons.imcce.fr/

Filter options are similar to the already well known predictions webpage of the ERC Lucky Star project.

Further reading: Luana, L., et al., Binary asteroid candidates in Gaia DR3 astrometry, June 2024

https://arxiv.org/abs/2406.07195v2

(OK)

Workshops

3rd Meeting of the Working Group on Stellar Occultations

On 2024 May 4th, the 3rd meeting of the working group on stellar occultations took place at *Bülach Observatory* in Switzerland.

Due to the new guidelines of IOTA/ES for reporting stellar occultations to the Stellar Occultation Data Input System (SODIS) portal, the meeting was planned as a workshop. Spread over six lessons, the ten participants learned step by step the procedure for recording and reporting as well as the software required for this.

The first session was held by Jonas Schenker. He talked about how to predict and prepare an occultation observation and to create a path map.

Figure 2. Jonas Schenker (left) during his presentation.

In the following session Andreas Schweizer demonstrated the recording of a stellar occultation with the DVTI+CAM.

Figure 3. Andreas Schweizer, co-developer of the DVTI+CAM, demonstrates the software of the camera.

Figure 1. Location of the meeting: Sternwarte Bülach, canton of Zurich, Switzerland, 550 m MSL, MPC observatory code 167.

Figure 4. The low noise of the DVTI+CAM was presented during the session. A cardboard box helped to simulate a "perfect dark sky". Jonas Schenker (left), Stefano Sposetti (centre) and Marco Iten enjoy the session.

The next three sessions were held by Stefano Sposetti. He gave a lesson about how to create light curves, csv files and *AOTA* files required for reporting to SODIS. The participants had installed the required software in advance on their own notebooks and Stefano's recording of the occultation of TYC 2418-00347-1 by (14569) 1998 QB_{32} helped to follow the step-by-step process of analysing.

Figure 5. Stefano Sposetti presents the analysis process of an occultation observation with Tangra.

The last working lesson featured the reporting to SODIS including the upload to the portal. This session was held by Stefan Meister and Andreas Schweizer.

This concluded the workshop.

In the last part of the meeting Stefano Sposetti presented an occultation observation of asteroid (90) Antiope. This was followed by a discussion about the evaluation of very short occultation events with only a few data points at the flat bottom of the light curve.

Suggestions were collected for a future SODIS 2.0. This included more filter options for best events, probable discoveries of double stars and suspected satellites. A guideline for the analysis of events with possible double stars or asteroidal satellites was requested. The participants were asked to report their suggestions to the SODIS forum. A call for participation at ESOP 2024 in Stuttgart, Germany, was made by Jonas Schenker.

After the meeting the participants had the opportunity for a guided tour of *Bülach Observatory*.

The participants want to thank Jonas Schenker for organising the meeting, Stefan Meister, Stefano Sposetti and Andreas Schweizer for the lectures and *Bülach Observatory* for their hospitality.

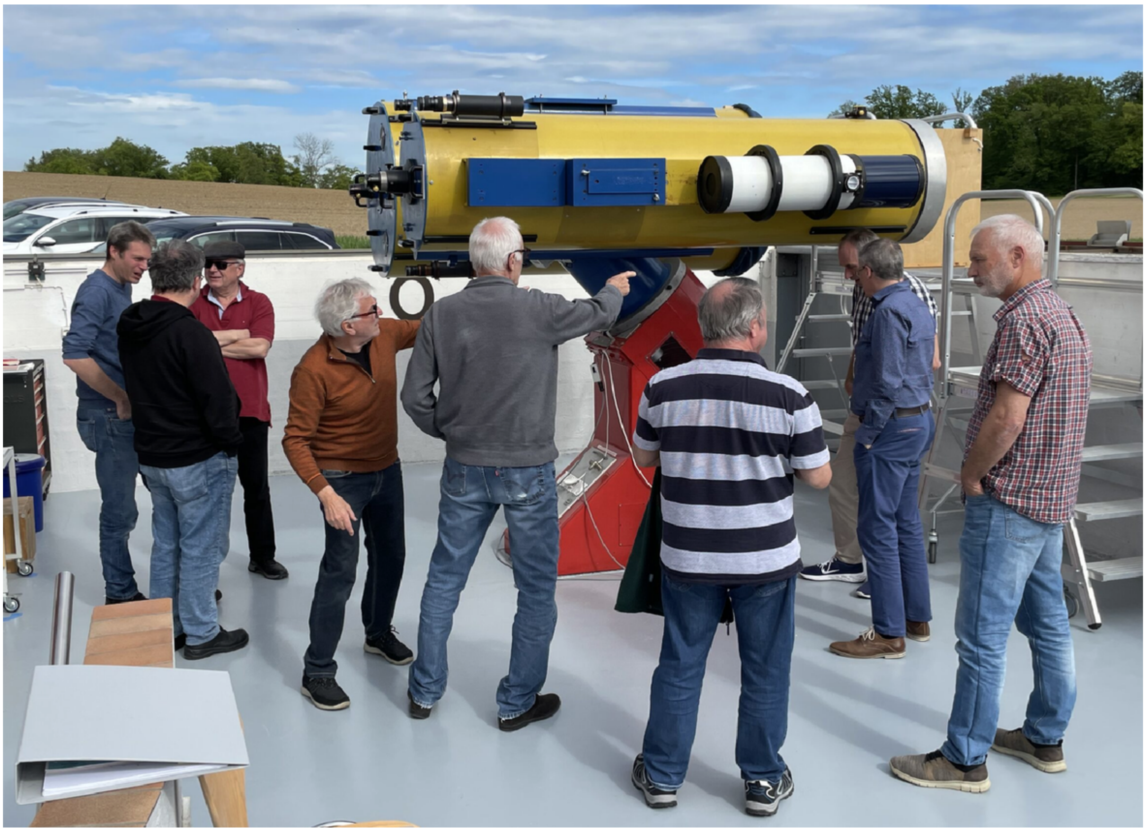


Figure 6. The participants inspect the Cassegrain telescope with a diameter of 85 cm and a focal length of 780 cm and the 50-cm-Newtonian/Cassegrain at Bülach Observatory.

Workshops

Some impressions from the meeting:

Figure 9. Marco Iten and Stefano Sposetti with the Ritchey Chrétien-Astrograph (Pro RC 360) on a GM4000QCI mount.

Figure 7 (top). Mike Kohl, Carsten Ziolek, Peter Hirt and Andreas Schweizer during the lunch break.

Figure 8 (bottom). Peter Hirt (left) discusses with Peter Stüssi during the break.

Figure 10. Mike Kohl, Marc Eichenberger, President of the Swiss Astronomical Society, Marco Iten and Stefano Sposetti (from left to right)

Images were taken by Stefan Meister and Marc Eichenberger.

Minutes of the meeting can be found here (in German):
http://occultations.ch/images/20240504_Buelach_Occultation_Meeting_Protokol_d.pdf

Report of the meeting on the webpage of the Swiss Astronomical Society (SAG-SAS):
https://sag-sas.ch/bildbericht-zum-workshop-der-fg-sternbedeckungen-in-buelach/

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Workshops

Occultation Workshop in Stuttgart

Figure 1. The participants with their notebooks during the workshop. (Andreas Eberle)

A workshop on occultation observations took place at *Sternwarte Stuttgart*, Germany, on 2024 June 15. Andreas Eberle, President of *Stuttgart Observatory*, reported:

With this year's ESOP in Stuttgart we intend to be a good host for all participants. But more than that, we want to seize the opportunity, to motivate more amateur astronomers in our region to become part of the occultation community.

To soften the entry threshold to occultation work for beginners, we already had a public lecture about the benefits of occultation observations. Now, the next step was to hold a workshop to talk about how to plan, execute, evaluate and report an occultation. Overall, 17 people, most of them complete beginners to occultation work, joined this meeting – what a great success. Special thanks to Andreas Schweizer, who helped to shape this workshop with content. We hope that this was only the first step and in the coming months the community will receive more observation reports coming from our region.

The European Symposium on Occultation Projects (ESOP) will take place at *Stuttgart Observatory* from 2024 August 23 to 27. Visit the webpage for details and registration:

https://www.sternwarte.de/esop43

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Figure 2 (top). Andreas Schweizer (SOTAS, IOTA/ES) presents the DVTI Cam Control software during the workshop at Stuttgart Observatory. (Andreas Eberle)

Figure 3 (right). Andreas Eberle shows the participants at the workshop the features of the desktop version of Occult Watcher. (Sebastian Dittmann)

Upcoming Meetings

Invitation to the IOTA/EA FY2024/25 Annual General Meeting

The International Occultation Timing Association/East Asia (IOTA/EA) will hold the FY2024/25 Annual General Meeting on 2024 August 25 from 01:00 to 07:00 UT. As with the inaugural meeting of IOTA/EA in August 2023, this year's meeting will be held remotely.

The meeting will include the agenda with voting by the full membership. In addition, there will be presentations by participants. A break of one hour is scheduled in the middle of the sessions.

Presentations may be given by non-members of IOTA/EA. The content of the presentation should focus on occultation prediction, observation, related activities and research using occultation phenomena in a broad sense. The duration of each presentation will be 15 minutes + 5 minutes for Q&A, but durations may be changed depending on the number of presentations. Oral presentations can be made in any language. It is recommended that slides be prepared in English. Please submit your presentations up to 2024 August 10.

The meeting will be held via interactive remote access via Zoom. Please register for your participation. The maximum number of participants is 80. Participation is open to all, whether members or non-members, but members will be given priority if the number of participants exceeds the limit.

Simultaneously, a streaming via YouTube will be provided. Anyone interested in occultation astronomy is invited to watch the streaming.

Schedule and Deadlines (tentative):

- 2024 August 10: Deadline for submitting presentations
- 2024 August 18: Presentations of meeting agenda and program
- 2024 August 23: Deadline for registration and proxy

Please check the webpage of IOTA/EA for details and latest news:

https://www.perc.it-chiba.ac.jp/iota-ea/wp/

(OK, IOTA/EA 1st Circular)

IOTA Meeting 2024 Scheduled

Steve Preston, President of IOTA, informed the editorial board of JOA on 2024 June 17 about the plans for the IOTA Meeting 2024.

The meeting is planned for 2024 September 28/29 remotely on Zoom.

Watch out on the mailing lists in the upcoming weeks for latest information about the meeting and check:

https://occultations.org/community/meetingsconferences/

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Jan Maarten Winkel

1961 – 2024

Jan Maarten Winkel, a quiet and hard worker, will from now on only be with us in our thoughts, but he will never be forgotten because we cherish many wonderful moments with him. With Jan Maarten, the association loses a super-active observer, both visually and digitally, a loyal and long-term treasurer, and above all, the editor of our magazine *Occultus*. Without Jan Maarten, *Occultus* would never have become the magazine it is today. But most of all, we lose a dear friend.

Jan Maarten was a special, authentic man. He was always present at the meetings of the Dutch Occultation Association, where, in his own unique way, he gave very good presentations of his observations that were often real 'discoveries'. However, he never sought the limelight. He also provided in *Occultus* the column of observational results reported by our members of occultations by the Moon and by Minor Planets.

He made and reported hundreds of observations himself, with the first observation of a (possible) occultation by a minor planet being made in 1985. He was also strict when it came to reporting observations in a timely manner. If the observer had not completed an observation report within ten days or so, he could expect an email from Jan Maarten asking when the report would come. He remained modest and honest, averse to conflict as he was; it was about the result, not about the observer himself.

He was also very active on the board of DOA from 1985 November 2 to 2022 April 22 (almost 36½ years!). He was treasurer of our association and editor of *Occultus* from issue 26 (September 1991) until issue 156 (April 2024), after which he could no longer physically cope.

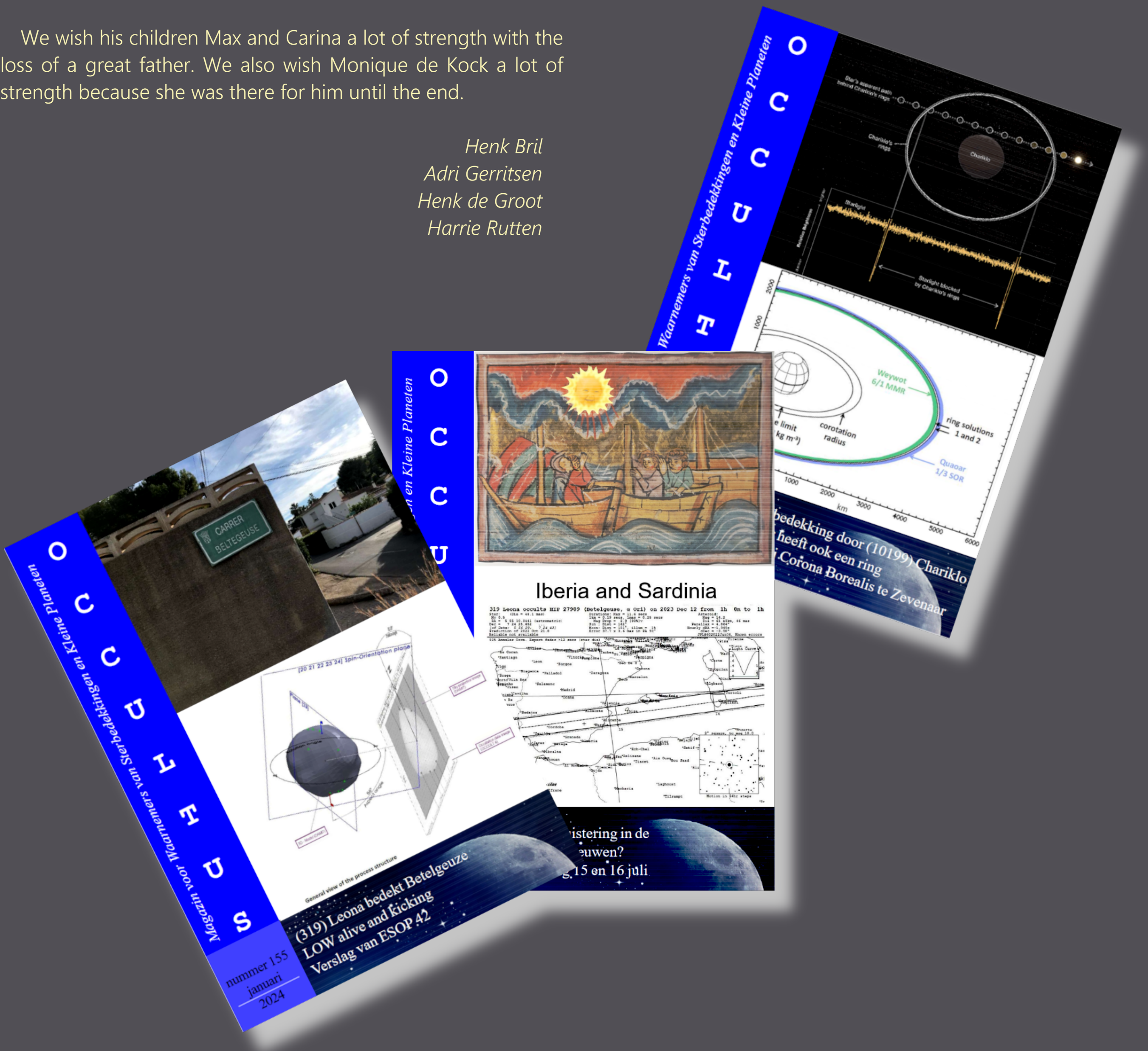
Jan Maarten was a loyal visitor to the ESOP meetings of the European occultation observers. He attended not only the ESOPs DOA organised in 1993 (Roden) and 2006 (Leiden), but also many others in Spain, Germany, Poland, Czechia, UK, Italy, France, and more. His first ESOP was in 1989 in Freiburg im Breisgau in southern Germany. He was also a passionate observer of total solar eclipses, for which he visited all continents (except Antarctica). Also very special was his presence at the Dutch Occultation Days where, in addition to his function as treasurer, he often gave a lecture in his characteristic way. It was always provided with his typical dry humour, which gave listening to it extra cachet.

We all knew Jan Maarten as a very honest administrator and treasurer for many decades. That is also the reason why he was appointed honorary member of DOA by acclamation by the members in the 2023 general meeting of members. However, the biggest honour came on 2024 January 15, when the minor planet 2002 WV$_{28}$, numbered 276389, would henceforth orbit the Sun as (276389) Winkel. With your own mortality in mind, forever in the starry sky. A tribute he deserved. He was justifiably proud of it, and so are we. Just imagine, maybe one day we will be able to observe a stellar occultation by Winkel...

In September 2021, he became seriously ill, and after long and tough resistance — he still undertook trips to Australia for the solar eclipse of 2023 April 20, and to Spain for the Betelgeuse occultation of 2023 December 12 — he finally had to give up observing in January of this year. He just couldn't manage it anymore. Jan Maarten passed away in his sleep on 2024 June 19.

We wish his children Max and Carina a lot of strength with the loss of a great father. We also wish Monique de Kock a lot of strength because she was there for him until the end.

Henk Bril
Adri Gerritsen
Henk de Groot
Harrie Rutten



Journal for
Occultation
Astronomy

INTERNATIONAL OCCULTATION TIMING ASSOCIATION

IOTA's Mission

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

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

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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.

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