Journal for Occultation Astronomy

Volume 16 · No. 4 2026-04



GPS Data - Is It Always a Reliable Source for Timing Occultations?

Dear reader,

You are currently reading the final issue of Volume 16 of the *Journal for Occultation Astronomy*.

Juan L. Rizos, Álvaro Álvarez-Candal, and José Luis Ortiz take us on an expedition to observe a stellar occultation by Kallichore, one of Jupiter's satellites. The successful measurement of the occultation aids the navigation of the ESA's JUICE spacecraft during a flyby of this tiny moon in 2031. In their article, Joachim Siegert and Andreas Schweizer investigate whether our time measurements and position determinations using GPS satellites can be distorted by signal interference – not by natural phenomena, but by human activity. In our 'Beyond Jupiter' series, Joachim Siegert introduces us to the Centaur (83982) Crantor, an object near the orbit of Uranus. In the News section, we provide an overview of the latest discoveries of asteroid moons published in CBETs and draw attention to an article by Dave Herald *et al.*, which fundamentally supports the method of discovering asteroid moons via stellar occultations. Gregory Lyzenga provides an overview of interesting lectures from the IOTA Annual Meeting 2026. Sadly, we must bid farewell to Jean Bourgeois, a successful occultation observer and mountaineer from Belgium.

The JOA team wishes you, dear readers, an inspiring read and thanks all the authors of Volume 16 for their contributions.

Clear skies,

Oliver Klös

IOTA/ES

JOA Volume 16 · No. 4· 2026 -4 $ 5.00 · $ 6.25 OTHER (ISSN 0737-6766)

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COVER



Data from GPS satellites has been an integral part of measuring stellar occultations for many years. But can we always blindly trust this data? In addition to interference caused by natural phenomena, deliberate interference resulting from human activity is on the rise. Joachim Siegert and Andreas Schweizer examine this in more detail in their article. The cover shows an artist's impression of an attempt to hack GPS data. (Photo: O. Klös)

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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

Targeting Kallichore: An Astronomical Odyssey to Support ESA's JUICE Mission

Juan L. Rizos · IAA-CSIC[1] · Granada · Spain · jlrizos@iaa.es
Álvaro Álvarez-Candal · IAA-CSIC[1] · Granada · Spain · alvaro@iaa.es
José Luis Ortiz · IAA-CSIC[1] · Granada · Spain · ortiz@iaa.es
(1) Instituto de Astrofísica de Andalucía-CSIC

ABSTRACT: On 2025 December 15, at 03:07:37.3 UTC, the small Jovian irregular moon Kallichore occulted the Gaia DR3 star 673238292608047232 as seen from northern Italy. Its shadow swept across our planet from Turkey to the western United States, crossing Europe from side to side. An international team, led by the Instituto de Astrofísica de Andalucía (IAA-CSIC), took part in the observational campaign to support a possible flyby of Kallichore by ESA's JUICE spacecraft. In this article, we tell the story behind this amazing adventure, full of highs and lows, but with a happy ending.

What Is Kallichore?

Kallichore (also known as Jupiter XLIV or S/2003 J 11) is a small irregular moon of Jupiter that orbits the giant planet at an average distance of about 24 million kilometres. It belongs to a group (family) of objects with similar orbits: the Carme group, thought to be a fragment of a larger parent body that was shattered in a catastrophic collision. Carme is about 46 km in diameter; it is the largest moon in the group, and the one it is named after. The origin of these irregular moons, which are divided into several families—and now number more than a hundred—remains uncertain. However, many share spectral properties typical of Jupiter Trojans, Centaurs and trans-Neptunian objects (TNOs). One plausible hypothesis is that they originated in the outer Solar System and were captured by Jupiter during the early stages of planetary migration described by the Nice model.

A Problem to Solve

The story began on a cold morning in February 2025 in Granada, during a scientific meeting of the team behind JANUS, the camera aboard the *JUICE* spacecraft. There, Yves Langevin —the great-grandson of the celebrated physicist Paul Langevin and also of the renowned couple Pierre and Marie Curie—set out the challenge.

There is a possibility that *JUICE* will fly past this small moon in October 2031 on its journey to the Jovian system. Of the more than one hundred irregular moons identified so far, Kallichore is the only one that could potentially be reached by the spacecraft.

To put this in context, *JUICE* is a state-of-the-art mission carrying ten highly-advanced scientific instruments, including a laser altimeter, high-resolution spectrographs covering the ultra-violet, visible, near-infrared and submillimetre ranges, and a radar. Its primary objective is to study the ocean worlds Ganymede, Europa and Callisto in depth.

A visit by *JUICE* would also make it possible to map Kallichore's surface using multispectral images with a spatial resolution of just a few metres per pixel. This would be unprecedented for an object that likely originated beyond Neptune. The closest precedent is Phoebe, Saturn's moon observed by *Cassini* in 2004. Unlike Phoebe, however, which is more than 200 km across, Kallichore is a tiny fragment that might even have come from an inner layer of its parent body. In other words, it is a relic of the early Solar System, and for the first time we would have the opportunity to analyse it *in situ* in extraordinary detail.

Langevin, however, explained the difficulty: the flyby would only be feasible if the positional uncertainty of Kallichore at closest approach were reduced to about 30 km, which from Earth corresponds to just a few milliarcseconds (mas). Due to its apparent proximity to Jupiter and its faintness (V magnitude ≈ 24), Kallichore is extremely difficult to observe from Earth. Indeed, only about fifty astrometric measurements had been obtained since its discovery in 2003. This resulted in a positional uncertainty of more than 1,500 km—two orders of magnitude larger than ESA's requirement. How could it be reduced so dramatically in just a few years?

As readers of this journal will know, *Gaia* provides positions for the stars in its catalogue with sub-milliarcsecond precision. If Kallichore passes in front of one of these stars and we can observe the occultation, the moon's position can be determined with similar degree of precision. The obvious question was: why not try to observe a stellar occultation by Kallichore?

The Odyssey

We searched for future occultations of *Gaia* stars by Kallichore, predicting dozens of events for 2025, but none appeared feasible: either the stars were very faint, with magnitudes fainter than 19, or the shadow crossed the Pacific or the North Pole. Then, we predicted an occultation for the early hours of 2025 December 15 in Europe, with a shadow path crossing the south of the Iberian Peninsula directly over the IAA headquarters. There was little to debate: we decided to put all our eggs in that basket.

The uncertainty, however, remained huge: more than 1,000 km at the date of the occultation. Where should we place the telescopes? In Granada, Casablanca or Bordeaux? Reducing the uncertainty was essential. We applied for observing time on the 10.4 m *Gran Telescopio Canarias* (GTC), which was granted to observe Kallichore during the darkest nights of the second half of 2025, particularly right before the event, to minimise the uncertainty and organise the campaign effectively.

However, just a few days before the first GTC observation in October 2025, we learned that the telescope had suffered a technical problem with its secondary mirror. Repairs would take several weeks, so our plan went up in smoke. We had to turn to Plan B: an urgent request for Director's Discretionary Time (DDT) to as many telescopes as possible.

After several days of intense work, the first piece of good news arrived: we had been awarded time on the *Large Binocular Telescope* (LBT) in November. What a relief! Everything was ready. But another setback awaited us. The day after the scheduled observation, we received an e-mail explaining that it had been one of the rainiest nights local residents could remember—at an observatory located between the Sonoran and Chihuahuan deserts! Our mission seemed cursed.

We immediately submitted a second DDT proposal, this time to Gemini. After several days of waiting, the review panel rejected it: "this project is better suited for a European facility, with closer connections with the *JUICE* mission" (sic!).

Despite that rather short-sighted response, we did not give up and submitted a third DDT request, this time to the *Hubble Space Telescope*. The reader may be familiar with the saying "Third time lucky": our proposal was accepted. It does not rain in space, so we were finally able to observe for two complete orbits, on November 30 and December 5, just a few days before the occultation.

The Moment of Truth

The final *Hubble* observations arrived only nine days before the occultation, so we carried out the astrometric analysis in record time (Figure 1), achieving an uncertainty of just 3 mas, equivalent to 24 km in the predicted shadow path.

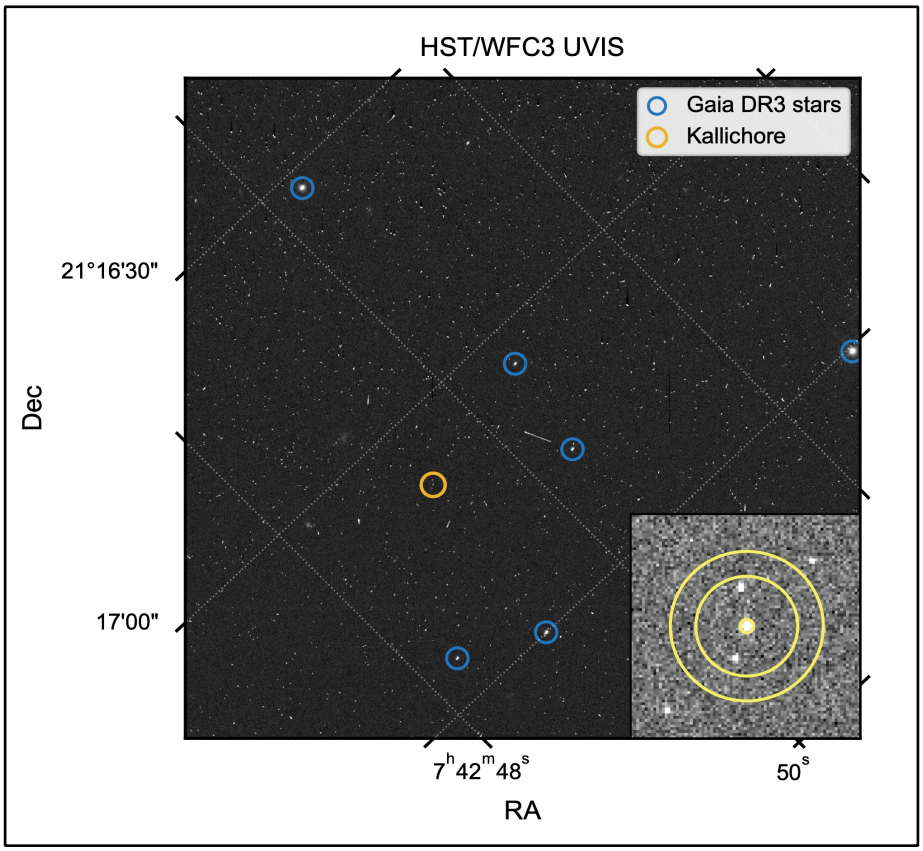


Figure 1. HST/WFC3-UVIS F606W image (ID ifry02l1q-flc) obtained on 2025 December 5 with an exposure time of 97 s. Blue circles indicate the Gaia DR3 reference stars used for the astrometric solution, while the orange circle marks Kallichore. In each panel, the lower-right inset shows a magnified view of Kallichore with the photometric apertures and sky annuli overlaid. Dotted lines represent the J2000 equatorial coordinate grid.

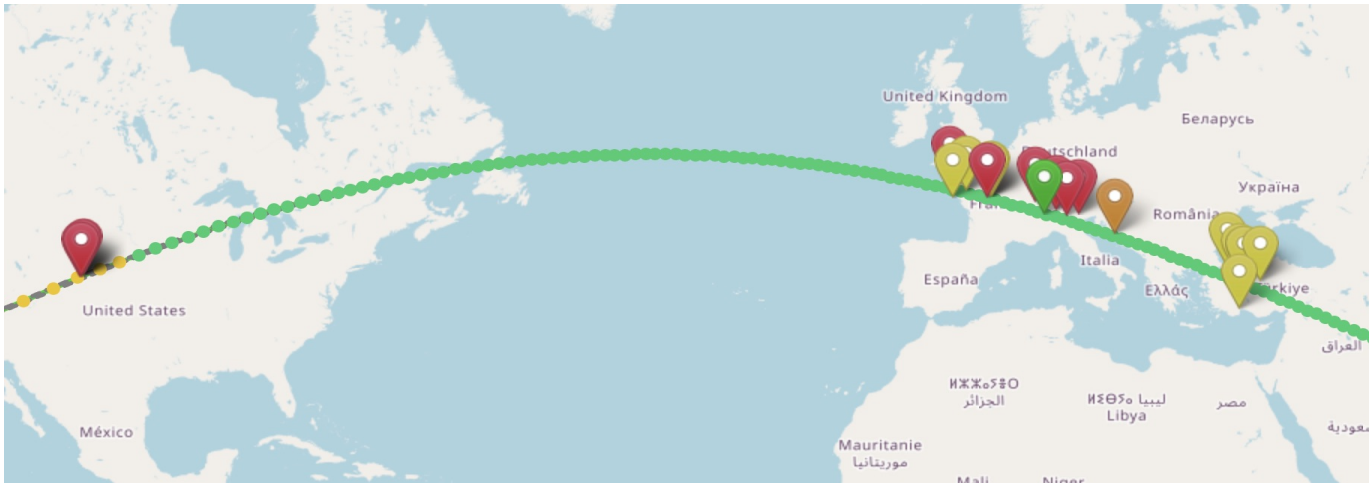


Figure 2. Predicted occultation by Kallichore on 2025 December 15. The markers identify the participating stations: red denotes negative results; yellow, cloud cover; orange, technical problems; and green, positive detections.
An interactive map is available at https://opop.obspm.fr/public/chords/2644.

At last, it was feasible to organise a campaign to catch Kallichore in the act. But another surprise awaited us: the shadow path no longer crossed the south of the Iberian Peninsula, but northern Italy and France instead (Figure 2).

It was impossible to organise an expedition from Andalusia at such short notice, so we could not participate directly. Instead, we issued an international call through several channels, asking observers from Turkey to the western United States for support. Dozens of people responded, and everything seemed to be on track. Then another obstacle arose: once again, the atmosphere was not willing to cooperate. Almost all of Europe was under a cloud deck on December 15. Our hopes shifted to the United States, where the weather was more favourable, but unfortunately only four stations were ultimately deployed in Denver, Colorado.

The night of December 15 was disheartening. The forecast was dreadful, and most European observers told us that they had not even been able to open their domes or go out and observe.

The following morning, just as we were preparing to thank the participants and write off the campaign, an e-mail arrived from collaborators in northern Italy. They were observers at the *Astronomical Observatory of the Autonomous Region of the Aosta Valley*. They told us that the clouds had parted just enough at the predicted instant for them to open their three telescopes (with a maximum separation of ~12 m along track and ~13 m across track) and record Kallichore occulting the star. The signal left no room for doubt: three positive detections. For the first time, an irregular moon of a giant planet—only a few kilometres across and roughly four astronomical units away—had been characterised from Earth. A resounding success!

What Have We Learnt about Kallichore?

Among other results, our analysis transformed Kallichore from a faint point of light into a body about 3.8 km in diameter, with a very low albedo of just 3.7%, consistent with the 3.5% measured for Carme, the moon after which the group is named. We also discovered that Kallichore is noticeably elongated: if we assume it is a triaxial ellipsoid, its a/b axis ratio is at least 1.5. Such a shape is consistent with the pronounced asymmetry expected of a fragment produced by a collision.

From an astrometric perspective, we reduced the uncertainty predicted for the date of the possible flyby from about 1,500 km to roughly 260 km—an improvement of more than 80%. Although we are still a bit far from the ideal ~30-km target, most importantly, we have shown that the goal is achievable and now have a clear roadmap to get there.

Readers interested in the scientific details of the analysis can consult the paper published in Nature Astronomy:

Rizos, J. L., Gómez-Limón, J. M., Kilic, Y. et al. Kilometre-scale Jovian moon characterized for a potential JUICE flyby. *Nat Astron* (2026). https://doi.org/10.1038/s41550-026-02929-z

An open-access version is also available on arXiv:
https://arxiv.org/abs/2607.28357

What Happens Next?

By the end of 2026, ESA will decide whether to proceed with the flyby scheduled for October 2031. If the decision is favourable, there will still be work to do: we have not yet reached the final uncertainty target. We will organise new observing campaigns using both space- and ground-based telescopes, and we will need your help. If you would like to join this adventure, please register on our Occultation Portal (https://occultationportal.org) Whenever an event is favourable from your location, we will contact you. We hope the next campaigns will be a little easier; after all, it would be hard for things to get any tougher.

A Special Acknowledgement

In late 2025, almost in step with each of the setbacks described above, several sightings of a white Iberian lynx were reported in the south of the Iberian Peninsula, very close to Granada. The animal attracted considerable attention because no such specimen had ever been photographed before (Figure 3). Social media quickly filled with superstitious and/or tongue-in-cheek messages. Some claimed that an Iberian god had appeared to offer a message of hope to Spain's long-suffering citizens. We are well aware that correlation does not imply causation and that the appearance of this almost mythical animal after every obstacle was surely just a coincidence... or was it? In any case, we would like to pay a small tribute to this inspiring companion, nicknamed "el Caudillito", by dedicating these words to him.



Figure 3. Our inspiring white Iberian lynx sighted in Andalusia in 2025. Photograph: Ángel Hidalgo (EFE).

Journal for Occultation Astronomy

GPS-Time Based (Occultation) Astronomy in Times of Hybrid Warfare

Joachim Siegert · IOTA/ES · Amberg · Germany · joachim.siegert@protonmail.com
Andreas Schweizer · SOTAS · IOTA/ES · Wettswil · Switzerland · aschweiz@mac.com

ABSTRACT: Astronomy in general and occultation astronomy in particular use GPS data to determine location and/or time. During the last few years a growing number of successful manipulation incidents show that GPS may not always be fully reliable and accurate. The system owners and interested third parties are both able to influence satellite data. The following information is intended to give a short overview on that topic and a possible way for (amateur) astronomers to mitigate it, at least at the moment.

Background

On 2025 April 3 the observation of the occultation of the star UCAC4 632-042172 by asteroid (52669) 1998 DO_2 using a mobile station, raised concerns about possible third party interference with our observations. After following routine procedures – report to SODIS [1], waiting for review – a surprise was waiting. The reviewer's e-mail asked for checking the coordinates given in the report because they show an observation site located in the middle of a forest.

What had happened? During the observation the coordinates were calculated by the GPS[1] receiver using data from six satellites. Normally, this is sufficient to receive reasonably accurate coordinate values for the report to SODIS. A look at a map showed a distance error of several hundred metres between the real site and the location derived from the GPS signal. There was a discrepancy in both coordinates, longitude and latitude. The observer's error was to trust the GPS and to use these numbers for the report without cross-checking with a map. At the time the cause remained unclear, but a workaround was available – ignore GPS coordinates and obtain them from maps only. Since then the observer stopped looking at the GPS numbers.

In the following months several reports broadcasted by radio stations about wrong altitudes displayed by airplane GPS [2] attracted the attention of the observer to the fact that there exist methods to influence GPS data. These were not only planned errors by the owner of the satellites but also caused by unknown parties directly influencing a GPS signal in certain areas. As the author lives in an area between two large training areas of the US Army, the idea of a GPS manipulation during the April, 3rd observation materialised and another question arose. If there is a possibility to influence geographical data what about manipulating a time signal?

[1] GPS is the US American variant of a global navigation satellite system (GNSS). Nevertheless, the shortcut GPS is used here as a synonym for all GNSS. Instead of satellite system, also the terms satellite network or satellite constellation are used.

Today, most occultation observations are based on GPS signals for geography and time measurements. While geographical errors can be excluded by cross-checking with a map, time errors are, at least at first glance, more difficult to handle. Therefore, the decision was made to contact the developers of the DVTI+CAM to get some information about this possible time problem, an estimate of its size and possible ways to control it.

Before continuing with the answer from Switzerland, first a few facts to remember how GPS works, what are the positive effects and where are the weaknesses, including potential manipulation possibilities.

Simplified Overview on How GPS Works

Every satellite transmits data packages in a periodic way, which contain among other things the following important information:

- the orbital elements of the satellite which are necessary to calculate the position of a receiver, and
- a highly-accurate time signal of the transmission time (taken from the atomic clocks on board the satellite).

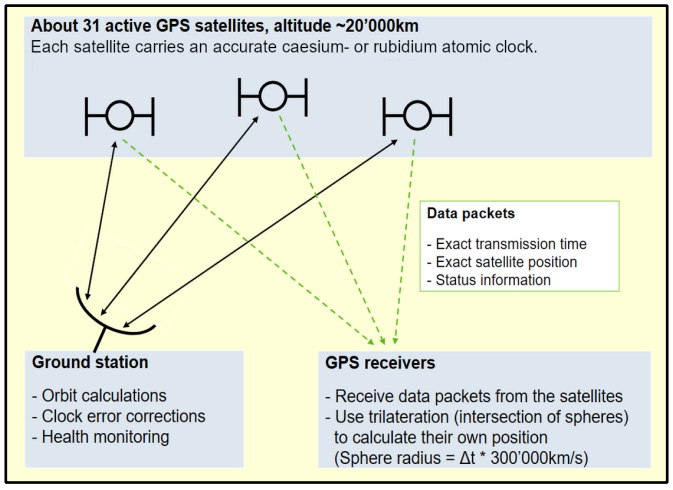


Figure 1. Data transmittance to and from the GPS satellites. (Graphic by Andreas Schweizer)

The position of the receiver can then be obtained by (3-dimensional) trilateration. Contrary to the better-known triangulation, which uses angles to calculate positions, trilateration uses distances, here the radii of spheres around the satellites. The radii are calculated using the time difference between transmission and reception of the signal, multiplied by the speed of light. Ideally, without measurement errors, the position of the receiver is at the intersection of three spheres, normally two points, one of them can be excluded by plausibility considerations. The problem that in most cases the receiving time is not measured by an atomic clock is discussed in the stated literature [3], [4].

Using a fourth satellite not only improves the exactness of geographical coordinates but also allows to calculate the UTC-time at the location of the receiver. An overview is given in [3], section 'Timekeeping'. Thus, to be able to calculate the time of an event, at least four satellites are necessary. In a more mathematical sense: to calculate one variable you need one equation, to calculate the three spatial coordinates/variables you need three equations and the time is a fourth variable, therefore you need four equations and every satellite contributes to one equation. From four satellites onward data from every additional satellite minimises both, errors in geographical coordinates as well as in time. Therefore the rule: the more satellites, the better (more exact) the values.

Natural Effects Influencing GPS Reliability

Possible sources of natural influences to GPS are numerous [5], here two examples only:

- atmospheric effects
- space weather

Most of the natural influences are dealt with by using physical/mathematical models to correct the GPS data. But models are "only" approximations, implying more or less errors. Therefore, today, natural effects are probably more often the reason for a reduction of the coordinates' accuracy and time errors than manipulations. But incidents of proven manipulation efforts are documented and this cannot be excluded in case of wrong data.

Artificially Influencing GPS

For this paragraph sources [3], [6], [7], [8], [9] have been used for information. Satellite network owners can communicate with all satellites and therefore they have all possibilities to manipulate the data transmitted by a satellite within the system. Until 2000 a "Selective Availability", a deliberate error, introduced into the US American GPS data that military receivers could correct for, is an example of such a manipulation [10]. Growing civilian GPS usage increased the pressure to remove this error and technical advances in methods to perform local GPS jamming (see below) led to the political insight that the global degradation of the system was no longer necessary.

For interested parties outside an owner's system there are today in general two publicly known methods to artificially influence GPS – GPS Jamming and GPS Spoofing. Both are based on the universal problem of spacecraft: the energy consumption has to be minimised as much as possible. Transmitting radio signals is energy consuming and therefore satellite signals are relatively weak when being transmitted from the satellite and even weaker when received on the Earth's surface. Depending on the satellite network the transmit power was 20-50 Watts for the first satellite generation and 120-300 Watts for those launched around 2020.

This is the key to impinge on GPS signals either by overwhelming GPS receivers with powerful radio signals that drown out the signals from the satellite constellations (= jamming, it renders the receiver unable to calculate its position or time accurately) or by generating counterfeit signals (= spoofing), which are difficult to distinguish from legitimate ones and cause receivers to incorrectly calculate position and time information. This also is the reason why every global navigation satellite system can be affected.

Possible Results of GPS Manipulations for Astronomical Applications

The answer from the developers of the DVTI+CAM confirmed that manipulations are possible but it also shows a way to get rid of the problem. In a GPS system location and time are closely connected to each other. A location error of 300 m (distance observer – satellite) is equivalent to a time error of about 1 microsecond and vice versa. At the moment, occultation observers are working mainly in the millisecond range. Hence, to be of some importance for our measurements it is possible to identify time errors by looking at the longitude and latitude values of the GPS. A manipulated time signal with an error of 1 millisecond would result in a distance error (observer – satellite) of 300 km. Conversion of this distance to distances on the surface of the Earth also leads to errors of several hundred kilometres. Thus, the above-mentioned error of a few hundred metres can be neglected for the time measurement, but may be of some interest for the astrometry of the asteroid. This result describes the situation if only the time information of the satellite signal is manipulated. As mentioned above, this signal also contains the satellite's position data which can be manipulated, too. A compensation of at least a part of the distance error to mask the time manipulation seems possible, but this is beond the scope of this article.

Practical Recommendations for Observers as Possible Countermeasures

In the text above the easiest way to check for wrong GPS data was already mentioned. Cross-check with a map. But there are more.

The different satellite constellations transmit their information using different radio frequencies. The necessary effort to influence all frequencies is high and while one constellation (e.g. GPS) may

be affected, others (e.g. GLONASS, Galileo) may still provide accurate data. Comparing data from different constellations can help to identify manipulations. A multi-constellation receiver is necessary[2]. Inconsistencies in log files of satellite count and metrics[3] can give an indication of a manipulation and last but not least, for very important events a redundant time source such as GPS flashers or NTP-based solutions should be considered.

Conclusions

The final conclusions of all the gathered information (not all are mentioned above):

- GPS signals can be manipulated, from satellite system owners as well as from external interested parties.
- Until a few years ago manipulation efforts were rare but close to military training areas, combat areas or during military training seasons outside training areas the probability seemed to be higher. Today, live GPS spoofing and jamming maps (of unknown reliability to the authors) are available on the internet (e.g. https://gpswise.aero or https://gpsjam.org)
- Because of the connection of time and location in GPS data, a not negligible error in time always leads to a large difference (hundred kilometre range) between the indicated GPS coordinates and the true position. Therefore, it is easily detectable, if only the time information is manipulated. Adding manipulated satellite position data may compensate, at least, a part of the large difference.
- Possible countermeasures:
  - Always cross-check GPS coordinates against a map.
  - Use multi-constellation receivers if possible.
  - Log satellite count and metrics, if possible.
  - Consider alternative, redundant time sources for very high value events.
- Nevertheless, manipulation techniques are developing and this last statement may be wrong sometime in the future. According to media and literature [11], [12], hard- and software improvements to uncover and to prevent manipulations are on the way. Unfortunately, there are no indications when they will be available for a low or medium budget.

[2] A camera containing a multi-constellation receiver and, by default, listens to GPS and GLONASS satellites, is the DVTI+CAM. Galileo and Baidou are available via the software.

[3] The DVTI+CAM software also supports logging this information in a CSV file during a recording.

References

[1] SODIS (Stellar Occultation Data Input System) is the data collection programme of IOTA/ES for observations of stellar occultations by asteroids, comets, planets and their moons in our solar system, The suspicious occultation can be found at SODIS ID 8195. https://sodis.iota-es.de

[2] Example of one of the radio broadcasts (German only): GPS-Spoofing: Sabotage im Flugzeugcockpit, https://www.ardsounds.de/episode/urn:ard:episode:e6e9e895e7cfdee3/

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[12] European Space Agency (ESA), Navigating through interference at Jammertest, published 2025 October 6, retrieved 2026 September 13, https://www.esa.int/Applications/Satellite_navigation/Navigating_through_interference_at_Jammertest



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 2026 October 6 , the *Minor Planet Center* listed 2230 Centaurs and 4105 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:

(83982) Crantor

Joachim Siegert · IOTA/ES · Amberg · Germany · joachim.siegert@protonmail.com

ABSTRACT: Since 2016, the JOA regularly publishes portraits of objects beyond Jupiter's orbit. This short article on the Centaur object (83982) Crantor gives some background information concerning its discovery, the meaning behind its name and its orbit. Due to the gravitational influence of the Sun, Uranus and Saturn the long-term stability of the orbit is questionable. Known physical properties are mentioned and favourable occultations through till 2035 are detailed.

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
31824	Elatus	Konrad Guhl	JOA 2 2025
32532	Thereus	Konrad Guhl	JOA 1 2023
38628	Huya	Christian Weber	JOA 2 2021
47171	Lempo	Oliver Klös	JOA 4 2020
49036	Pelion	Joachim Siegert	JOA 4 2025
50000	Cyllarus	Michael O'Connell	JOA 3 2026
52975	Quaoar	Mike Kretlow	JOA 1 2020
53311	Deucalion	Konrad Guhl	JOA 2 2024
54598	Bienor	Konrad Guhl	JOA 3 2018
55576	Amycus	Konrad Guhl	JOA 1 2021

No.	Name	Author	Link to Issue
58534	Logos & Zoe	Konrad Guhl	JOA 4 2023
60558	Echeclus	Oliver Klös	JOA 4 2017
65489	Ceto and Phorcys	Konrad Guhl	JOA 1 2025
90377	Sedna	Mike Kretlow	JOA 3 2020
90482	Orcus	Konrad Guhl	JOA 3 2017
120347	Salacia	Andrea Guhl	JOA 4 2016
121725	Aphidas	Konrad Guhl	JOA 1 2026
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_8	Sven Andersson	JOA 3 2022
225088	Gonggong	Mike Kretlow	JOA 2 2026
229762	G!kún‖'hòmdímà	Konrad Guhl	JOA 3 2025
341520	Mors-Somnus	Konrad Guhl	JOA 4 2022
471143	Dziewanna	Wojciech Burzyński	JOA 3 2024
486958	Arrokoth	Julia Perła	JOA 3 2023
–	2004 XR_{190}	Carles Schnabel	JOA 1 2022
541132	Leleākūhonua	Konrad Guhl	JOA 4 2024

The Discovery

The asteroid was officially discovered on 2002 April 12 at *Palomar Observatory*, California, USA by astronomers of the *Near-Earth Asteroid Tracking (NEAT)* team. Its provisional name was registered as 2002 GO_9 and assigned the number and name (83982) Crantor in 2005 December (MPC 55724). It was named for Crantor from Greek mythology [1].

Closer examination of exposures taken by the *Sloan Digital Sky Survey* from *Apache Point Observatory* on 2001 March 19 revealed that the minor planet was first observed more than a year prior to its official discovery observation by *NEAT*. Further observations beginning one night later at the *Air Force Maui Optical Station (AMOS)* on Haleakala, Hawaii, also helped to extend the observational arc.

The Name

This minor planet was named after Crantor, a Lapith from Greek mythology. He was killed in the battle between the Lapiths[1] and the Centaurs[2] at a wedding feast. The centaur Demoleon tore off Crantor's chest and left shoulder with a tree trunk that he had thrown at Theseus, king of Athens, who ducked out of the way [1].

[1] Tribe, who in Greek mythology lived in Thessaly in the valley of the River Pineios and on Mount Pelion (Figure 1).
[2] Creatures from Greek mythology with the upper body of a human and the lower body and legs of a horse that were said to live in the mountains of Thessaly (Figure 2).

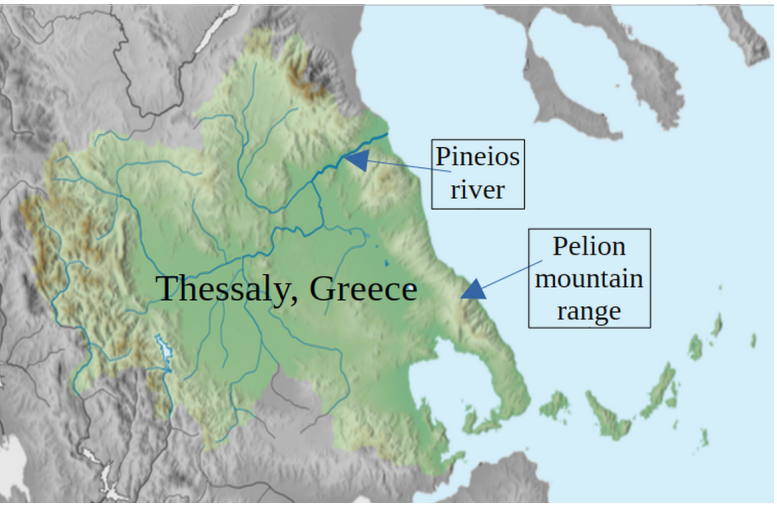


Figure 1. Map of Pineios river and the peninsula formed by the Pelion mountain range, Greece. Map: https://commons.wikimedia.org/wiki/File:Greece_(ancient)_Thessaly_(relief-cropped).png, Wikimedia Commons. 17 Aug. 2024, 11:25 UTC. 2 Jun. 2025, 13:48, release as public domain. Text: inserted from the author of this article.

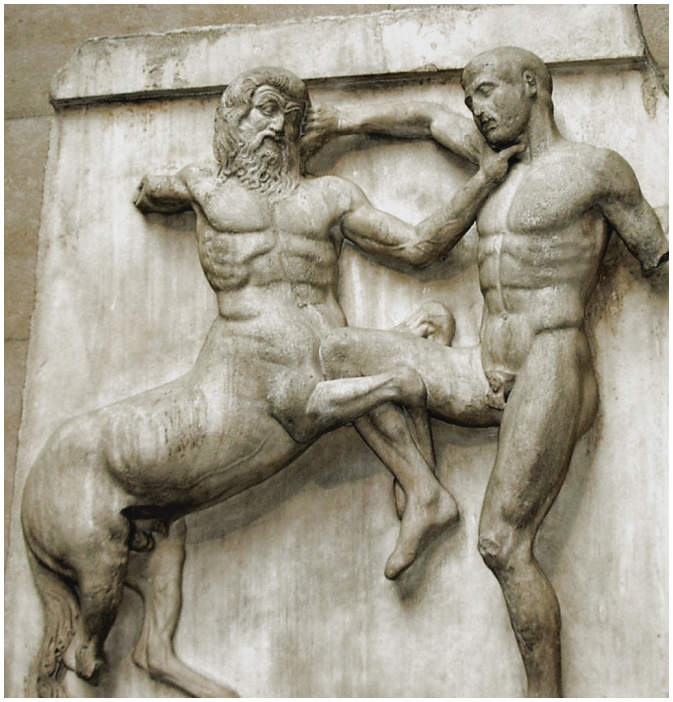


Figure 2. Lapith fighting a Centaur. This image was originally posted to Flickr by Following Hadrian at https://www.flickr.com/photos/41523983@N08/14063376069. It was reviewed on 19 January 2015 by FlickreviewR and was confirmed to be licensed under the terms of the cc-by-sa-2.0 (Creative Commons Attribution-Share Alike 2.0 Generic license).

The Orbit

(83982) Crantor belongs to the Centaur class of solar system bodies. These are objects with an orbit lying between Jupiter and Neptune. Occasional passes close to the giant planets generally make their orbits unstable on longer time scales which is especially true for (83982) Crantor. Today it orbits the Sun every 85.22 yr, coming as close as 14.02 au to the Sun and reaching as far as 24.71 au away [1]. This places the midpoint of its orbit at a similar distance from the Sun as Uranus (perihelion 18.29 au, aphelion 20.10 au) whilst approaching within the planet's orbit at perihelion and travelling further away at aphelion [4]. (83982) Crantor's orbit shows an eccentricity of 0.276 and an inclination to the ecliptic of 12.79° [1].

Calculations revealed that (83982) Crantor is moving in a 1:1 mean motion resonance with Uranus [5]. It currently moves inside Uranus' co-orbital region on a complex (non-regular) horseshoe orbit with a period of around 8500 years[3]. Non-regular means that compound horseshoe-quasi-satellite loops are possible. The motion is primarily driven by the influence of the Sun and Uranus, although Saturn plays a significant role in destabilising its orbit. The precession of the nodes of (83982) Crantor, which is accelerated by Saturn, controls its evolution and short-term stability.

[3] for a simple explanation see:
https://en.wikipedia.org/wiki/Co-orbital_configuration

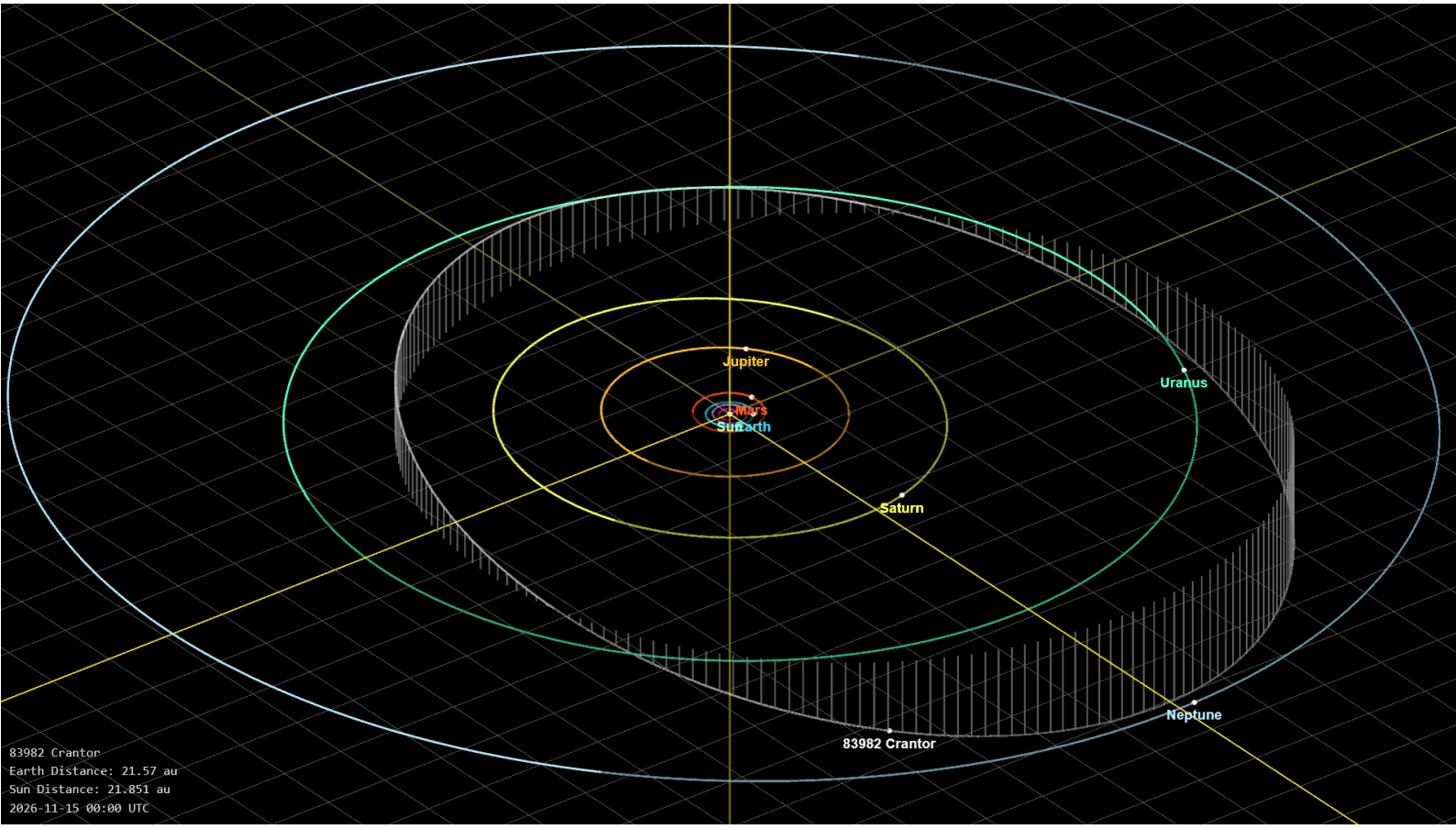


Figure 3. Orbit diagram and position of (83982) Crantor on 2026 November 15. (Source: https://ssd.jpl.nasa.gov/tools/sbdb_lookup.html#/?sstr=83982&view=VOP)

The nature of the orbit of this object constrains the degree of predictability of its dynamical evolution on timescales longer than a few 10 kyr. This strongly suggests that its dynamical age is much shorter than that of the solar system. Regarding the question of stability, (83982) Crantor's orbital inclination is close to the edge of one of the stability islands in inclination for Uranus Trojans [6]. Perhaps this may lead to a future, more stable orbit as a Trojan.

Although having a U parameter [4] of 1 and a long observational arc (329 observations between 2001 and 2025), the asteroid is included in the category of "Observable Critical-List Minor Planets" that can be found on the MPC website [7]. The list tabulates objects for which existing measurements of the orbit and position are especially in need of improvement [8]. The probable reason (83982) Crantor is on the list is its unclear dynamic evolution over longer timescales. Stellar occultations are an excellent means for improving our knowledge of its orbit in future.

[4] As a measure of uncertainty of the orbit, the MPC uses the parameter U (an integer in the range 0 to 9, where 9 is the highest uncertainty). For (83982) Crantor U = 1 [1], i.e. the difference between the observed mean anomaly and the calculated one lying in the range of 1.0 - 4.4 arcsec after 10 years [9].

Some Physical Properties and Chemical Surface Characteristics

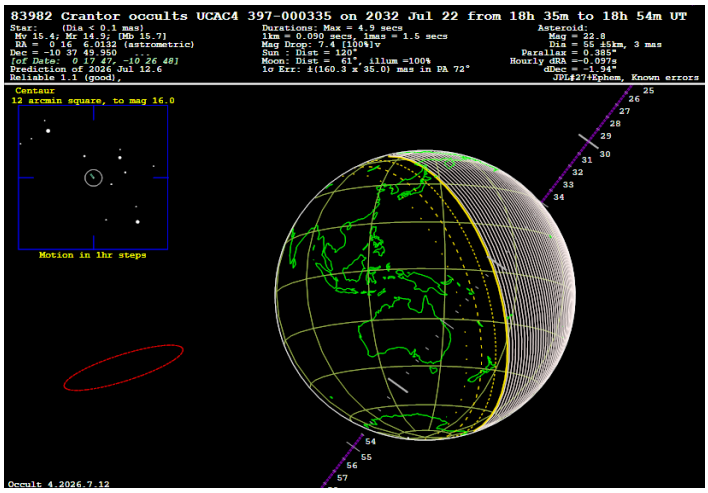
(83982) Crantor's visual magnitude during opposition is in the range of m = 20 to 22 mag [1]. The absolute magnitude is H = 8.91 mag [10], its diameter from infrared measurements is often given to be around 59 ± 13 km [11] and the geometric albedo 0.11 ± 0.07 [11, 11b]. A rotation period from fragmentary light curves was first determined in [12] to be either 9.67 or 6.97 hours. In the "Asteroid Light Curve Database (*ALCD*)" it was changed in 2023 to 13.94 hours [13] with reference to [12], but the quality rating of *ALCD* itself being "Result based on fragmentary lightcurve(s), may be completely wrong".

Concerning the surface colour, (83982) Crantor belongs to the red Centaur class, where the surface material absorbs a larger part of the blue light causing a redder appearance [14]. In fact, it is one of the reddest in the solar system. Following the results of chemical laboratory experiments on Earth, simulating surface conditions on planets, moons and asteroids, it is supposed that the red colour is due to the occurrence of 'tholins'. These are

disordered polymer-like materials made of repeating chains of linked subunits and complex combinations of functional groups produced by ultraviolet and cosmic rays impacting on simpler carbon-bearing and other molecules such as carbon dioxide (CO_2), methane (CH_4) and ethane (C_2H_6), often in combination with nitrogen (N_2) or water (H_2O) in the gas or solid phase [15]. At least water has been detected on Crantor [16].

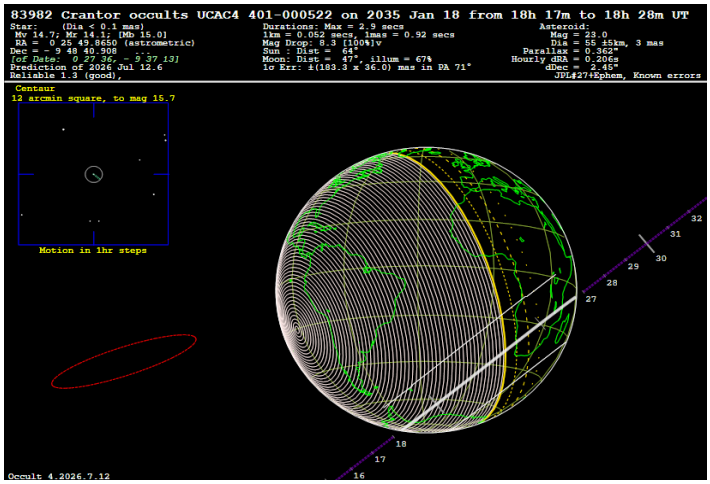
Future Occultations

Predictions from *Occult* [17] until 2035 list a total of eight occultations, but only four of them are favourable passing over continental mainland during night time. Here are the details of these more favourable observing opportunities:



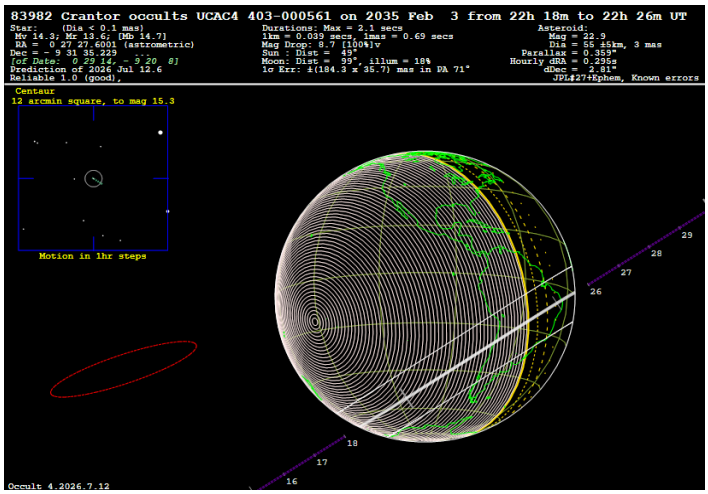
2032 July 22
Star magnitude (visual) 15.4 mag
maximum duration 4.9 s
magnitude drop 7.4 mag

Figure 4. Path map of the possible occultation on 2032 July 22. Occult V4.2026.7.12



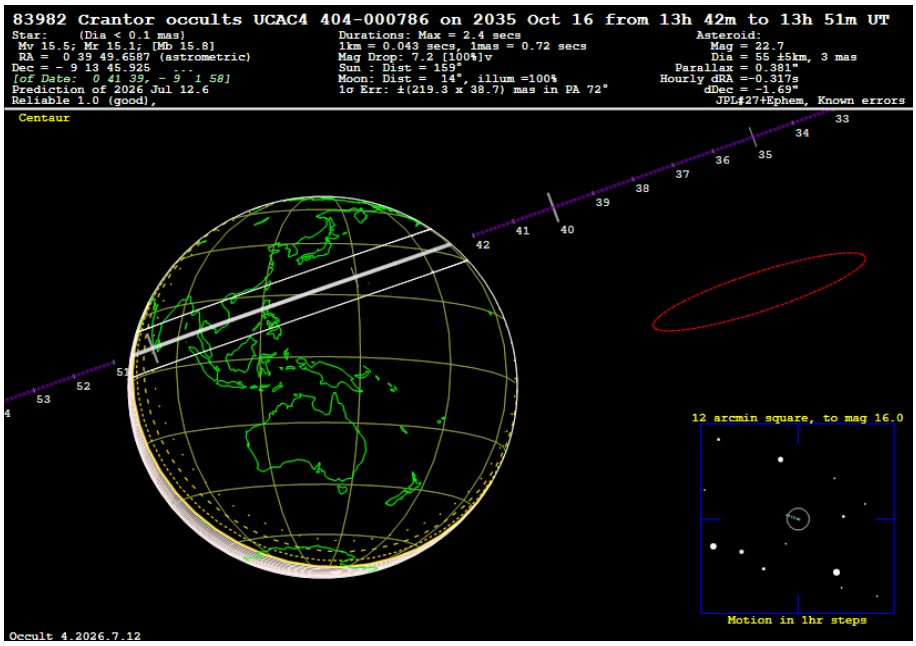
2035 January 18
Star magnitude (visual) 14.7 mag
maximum duration 2.9 s
magnitude drop 8.3 mag

Figure 5. Path map of the possible occultation on 2035 January 18. Occult V4.2026.7.12



2035 February 03
Star magnitude 14.3 mag
maximum duration 2.1 s
magnitude drop 8.7 mag

Figure 6. Path map of the possible occultation on 2035 February 03. Occult V4.2026.7.12



2035 October 16
Star magnitude 15.5 mag
maximum duration 2.4 s
magnitude drop 7.2 mag

Figure 6. Path map of the possible occultation on 2035 October 16.
Occult V4.2026.7.12

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Remark: Diameter and Albedo in [11] taken from:
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Preprint: Physical Properties of Kuiper Belt and Centaur Objects: Constraints from the Spitzer Space Telescope, 2007, DOI: 10.48550/arXiv.astro-ph/0702538

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News

Six Discoveries of Binary Asteroids by Occultation Observations

The Central Bureau for Astronomical Telegrams has announced six further discoveries of satellites of asteroids since the last issue of JOA, made following the analysis of stellar occultation observations. The discoveries are presented in the order in which they were announced.

On 2026 June 18, Simon Kidd, IOTA/ES, observed an occultation by asteroid (59195) 1999 BG_2 using a 35 cm telescope, ASI432 CMOS camera and a GPS-triggered flasher in UK. He recorded an occultation duration of 0.62 s for the main body and 0.17 s for the satellite. This timing measurements lead to chord lengths of 6.2 km and 1.7 km, and a distance of 9.7 km between the chords at the minor planet. The discovery was announced with CBET 5714.

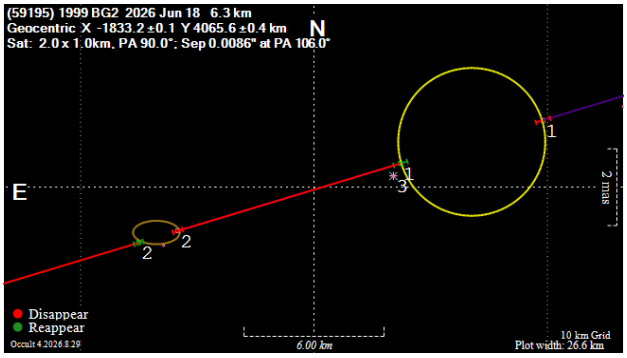


Figure 1. Profile of (59195) 1999 BG_2 and its satellite recorded by Simon Kidd. Chord 3 marks the predicted centre line.

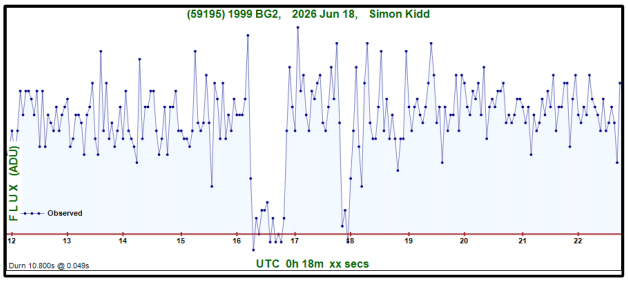


Figure 2. The lightcurve of the discovery of the satellite of (59195) 1999 BG_2.

Peter Nosworthy, and Dave Gault, Trans-Tasman Occultation Alliance (TTOA), were successful again in Australia. They observed an occultation by asteroid (39249) 2000 YR_{88} on 2026 April 10. Whilst Peter Nosworthy recorded a miss, Dave Gault measured with a 30 cm telescope, Watec WAT-910BD camera and a GPS VTI a positive chord for the main body with a duration of 1.82 s. (chord: 12.8 km), and 0.22 s (1.5 km) for the satellite. The discovery was announced with CBET 5719.

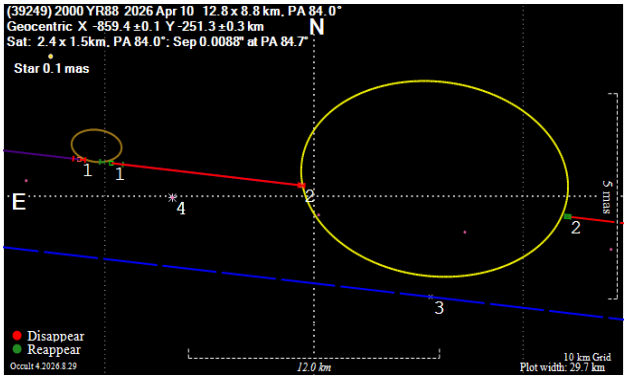


Figure 3. Profile of (39249) 2000 YR_{88} and its satellite. Chord 3 represents the negative observation.

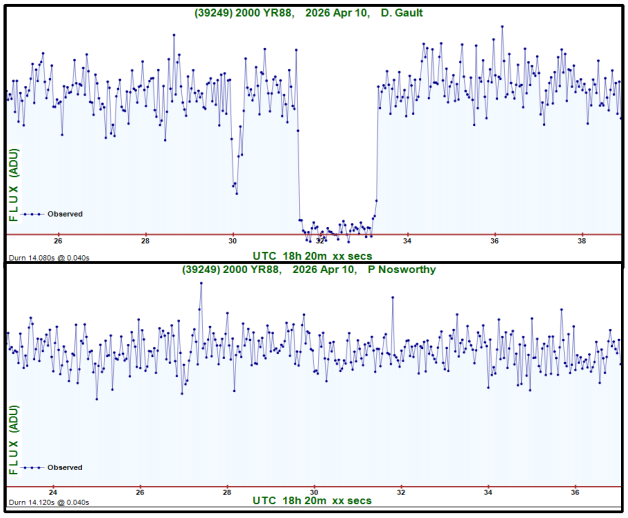


Figure 4. The lightcurve at the top represents Dave Gault's positive observation of (39249) 2000 YR_{88}. Peter Nosworthy's light curve shows no occultation, a negative measurement.

Michael O'Connell, (IE) and IOTA/ES, recorded two events during the occultation by asteroid (8007) 1988 RU_6 on 2026 July 27. The remote observation was made near Valdin, Spain with a 35 cm telescope, an Apollo-M Max Pro camera, and a personal computer synchronised by NTP. He recorded a duration of 1.32 s for the main body and 0.21 s for the satellite. These timings corresponded to chord lengths of 11.5 km and 1.8 km, respectively. The distance between the chords is 17.4 km. The discovery was announced with CBET 5730.

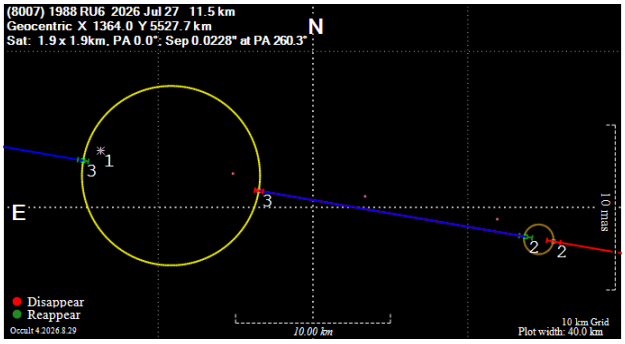


Figure 5. Profile of Michael O'Connell's measurement of the stellar occultation by asteroid (8007) 1988 RU_6 (chord 3) and its satellite (chord 2). The predicted centre line of the event is shown as chord 1.

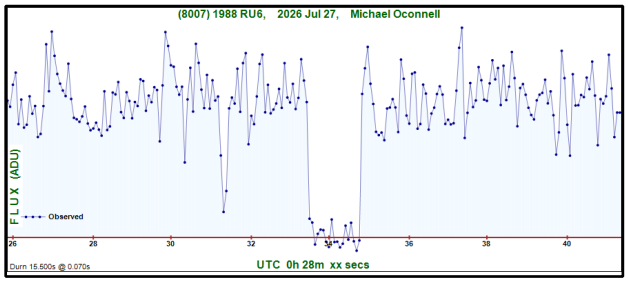


Figure 6. The lightcurve of the discovery of the satellite of (8007) 1988 RU_6. At least two data points around 31.5 s on the x-axis show the occultation by the satellite.

On 2026 August 5, Victor Bao, RASNZ, observed an occultation by asteroid (3221) Changshi in Auckland, New Zealand, with a 28 cm telescope, a ZWO ASI662MM with a GPS 1PPS sychronised PC-clock. He was able to measure two consecutive occultation events with durations of 0.15 s (0.6 km) and 2.08 s (8.3 km), respectively. The time interval between the two events was 10.81 s. The single-observation-discovery was published in CBET 5733.

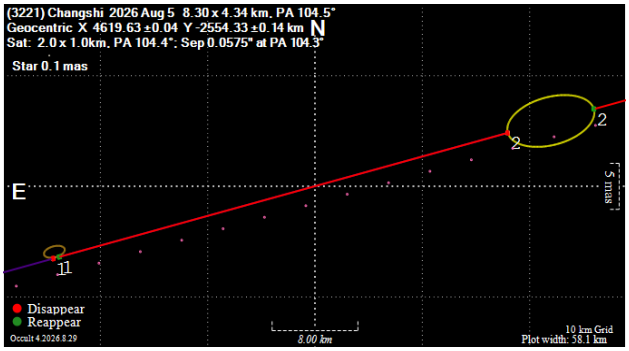


Figure 7. Profile of asteroid (3221) Changshi and its satellite measured by Victor Bao on 2026 August 5 in New Zealand.

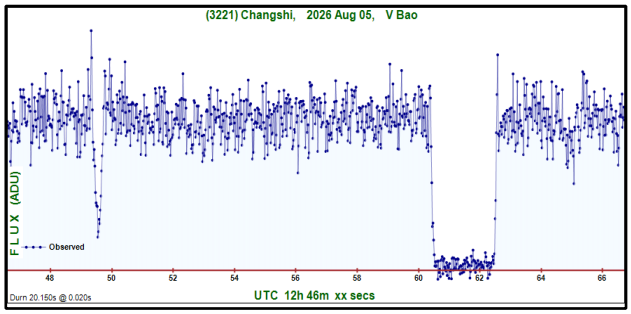


Figure 8. Light curve of the detection of (3221) Changshi's satellite. The high resolution in the frame rate helped to detect the small moon.

Richard Brown, RASNZ, recorded two occultations by asteroid (4468) Pogrebetskij on 2026 August 24 in Australia. He used a 36 cm telescope with Hyperstar lens and a QHY174M-GPS for his observation. The measurement showed two consecutive occultations of durations 0.61 s and 2.60 s, separated by 11.80 s. This leads to chord lengths of 0.97 km and 4.13 km with a midchord separation of 18.73 km. The discovery was announced with CBET 5738.

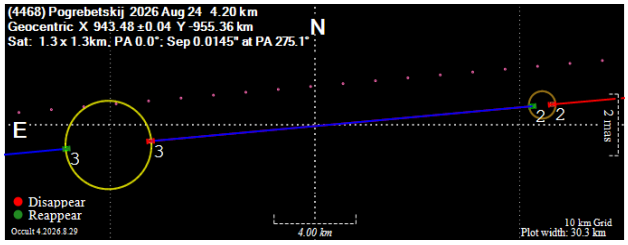


Figure 9. Profile of asteroid (4468) Pogrebetskij and its satellite recorded on 2026 August 24.

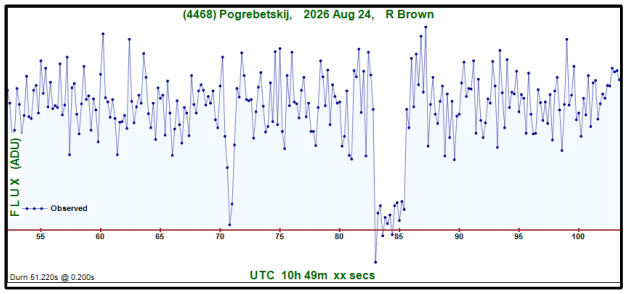


Figure 10. The lightcurve of the discovery of the satellite of asteroid (4468) Pogrebetskij by Richard Brown. Two data points show the detection of the satellite.

News

On 2026 July 7, three observers in Australia could record successfully the occultation by a satellite of asteroid (1757) Porvoo. Blair Lade observed with a 20 cm telescope and a ZWO 533MM Pro camera and recorded occultations with durations of 0.30 s (chord length: 1.71 km) and 2.73 s (15.54 km). The interval between the occultations was 3.30 s (18.83 km). Andrew Wendelborn recorded a single occultation with a duration of 1.20 s (chord: 6.83 km). He used an 11.4 cm Unistellar eVscope with an IMX224 sensor. Paul Martinaitis equipped with a 20 cm telescope and a ZWO 462MM camera measured a single occultation of 1.85 s, corresponding to a chord length of 10.53 km. The three-observation-discovery was published in CBET 5742.

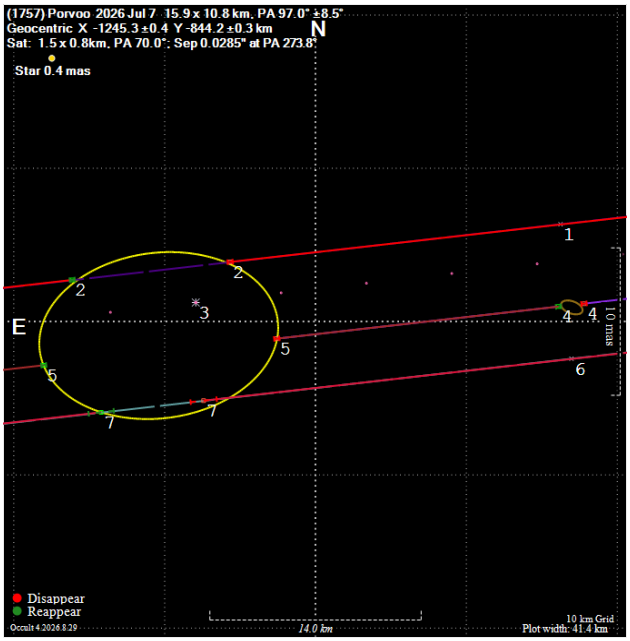


Figure 11. Profile of asteroid (1757) Porvoo and its satellite recorded by three observers in Australia on 2026 July 7.

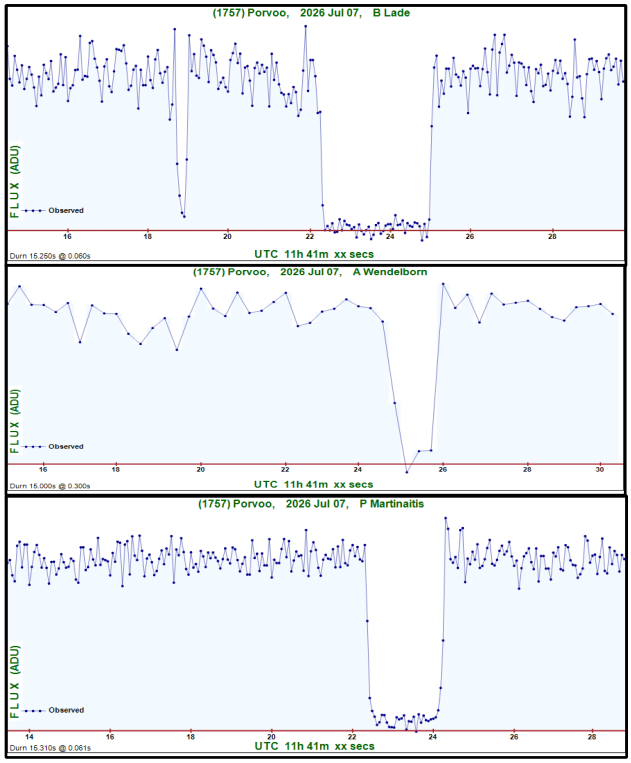


Figure 12. The lightcurves of the observation of the occultation by (1757) Povoo. Lade's lightcurve (top) shows the detection of the satellite with five data points. Lightcurves by Wendelborn (middle) and Martinaitis (bottom) could provide valuable data to determine the profile of the main body.

All plots are from *Occult V4.2026.8.29*.

Access to the 50 most recent CBETs is available here:

http://www.cbat.eps.harvard.edu/cbet/RecentCBETs.html

(O. Klös)

Up in the sky! Look! It's a Bird! It's a Plane! ... No, It's an Asteroidal Satellite!

Dave Herald, et al. wrote a document published as an appendix to CBET 5679 as a response to a request from the IAU's Central Bureau for Astronomical Telegrams which was apparently driven by a level of scepticism in satellite discoveries by stellar occultations. The authors of this paper discussing the issue of birds, planes, balloons and spacecraft as they relate to purported explanations for asteroid occultations.

A revised and expanded version of that document has now been published as the lead article in Minor Planet Bulletin Vol. 53, No. 4, A. D. 2026 October-December:

https://mpbulletin.org/issues/MPB_53-4.pdf

(O. Klös)

The International Occultation Timing Association's 44th Annual Meeting, 2026 July 18-19, in Longmont, Colorado, USA

Gregory Lyzenga · IOTA · Glendora, California · USA · lyzenga@g.hmc.edu

ABSTRACT: On 2026 July 18-19, IOTA held its 44th annual meeting at the Residence Inn in Longmont, Colorado, USA, and simultaneously via Zoom in a joint meeting with RECON (Research and Education Collaborative Occultation Network). On the following evening of 2026 July 20-21, observers from IOTA and RECON teamed up for a coordinated campaign observation of the occultation of UCAC4 424-071654 by the binary asteroid (5232) Jordaens.

Saturday 18th July 2026 - Day 1

The 44th annual meeting of the International Occultation Timing Association was held on Saturday and Sunday 2026 July 18-19 on location in Longmont, Colorado, USA, and online via Zoom.

Business Meeting

President Roger Venable welcomed everyone to the meeting following a joint welcome to both IOTA and RECON [1] attendees by Marc Buie and John Keller.

Treasurer Joan Dunham presented IOTA's financials and membership status. A full report of the business meeting is available [2].

Awards

Executive Secretary Gregory Lyzenga next presented *IOTA Lifetime Achievement*, *David E. Laird* and *Homer F. Daboll Awards*.

The *IOTA Lifetime Achievement Award* is given to recognise outstanding contributions to the science of occultations and to the work of the International Occultation and Timing Association over an extended period of the recipient's lifetime.

In 2026 this award recognises **Richard Nugent** for his decades of contributions not only to IOTA, but also to the science of occultation astronomy. As IOTA's representative for the State of Texas since 1983, he filled the Executive Secretary role from 1998 until his retirement in 2025. Richard edited and maintained "*Chasing the Shadow: The IOTA Occultation Observer's Manual*", a cornerstone guide for IOTA members. He has also recorded Baily's beads for a number of central solar eclipses and shared his novel way of analysing them in the *Occultation Newsletter*. Richard continues to contribute to astrometry and to the science of occultations through his ongoing observations and mentorship to the occultation community.



Figure 1. Richard Nugent.

The *David E. Laird Award* is given to recognise those who, more than 15 years ago, made significant contributions to occultation science and to the work of the IOTA.

This award recognises **Don Stockbauer** for guiding numerous astronomy peers in promoting occultation work across the years. A signee of IOTA's 1983 original incorporation papers, he has shared his knowledge and zeal as author of many *Occultation Newsletter* articles, managed the grazing lunar occultation reports from 1985 to 1992 and worked to strengthen lunar total and grazing occultation predictions with analyses of those times. He used discoveries of close double stars resolved by photoelectric and visual observations of lunar occultations for a comprehensive catalogue of zodiacal double stars. Don enthusiastically promoted IOTA with occultation activities throughout Texas and with local astronomy groups.

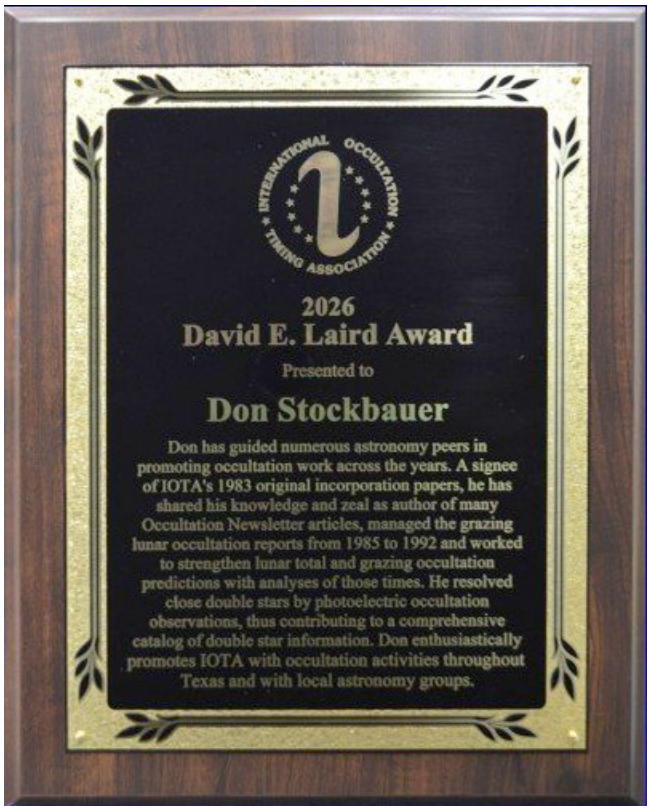


Figure 2. Certificate of the 2026 David E. Laird Award for Don Stockbauer.

The *Homer F. DaBoll Award* is given to recognise significant contributions to the field of occultation science and to the work of IOTA. In 2026 we have two award recipients.



Figure 3. Mark Simpson (Photo: Leah Hennel/Can Geo)

IOTA recognises **Mark Simpson** for his development and production of the Astrid camera. Astrid is a self-contained GPS-equipped astronomy imaging device with features that make it a complete, all-in-one device for recording and accurately timing occultation events. With an Astrid, a user can pre-point for an unattended automated observation or control a computerised mount to track and record the target star. The camera has made acquiring a good quality occultation observation much easier than was previously possible.

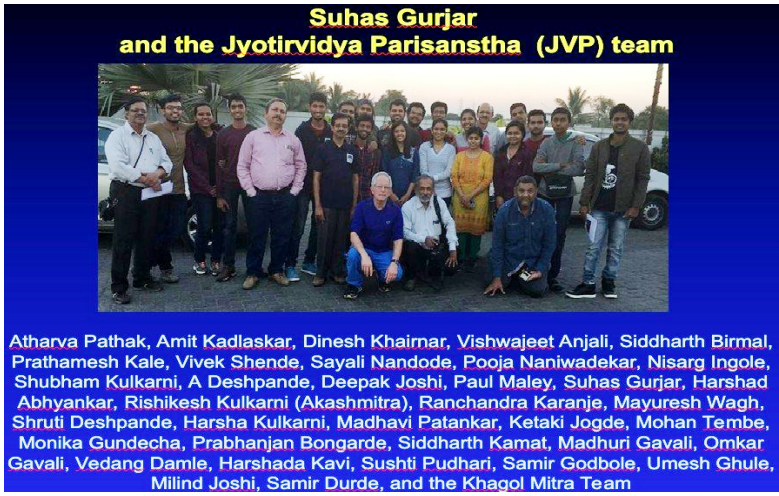


Figure 4. Suhas Gurjar (first row, centre) and the Jyotirvidya Parisanstha team.

Founded in 1944, JVP is India's oldest amateur astronomical society. As the primary organiser for the 2016 (22) Kalliope event, Suhas Gurjar led over 35 JVP members, most of whom were students, to operate 22 stations around Pune, India. With 18 positive chords and 3 defining negative chords, this spurred JVP to begin their IOTA participation. The JVP continues to contribute to occultation activities with over 24 reported asteroid occultations along with several lunar occultations.

Suhas Gurjar and the JVP are awarded the *Homer F. DaBoll Award* for their outreach in bringing forth and encouraging astronomy along with occultation science to the local community.

Technical Sessions

Mark Simpson discussed the 2024 discovery observation of the asteroidal satellite of (5232) Jordaens (Figure 5), which would be the target of the joint IOTA/RECON campaign two days later.

David Dunham gave a presentation in which he summarised the important upcoming asteroid occulations during the remainder of 2026 and 2027 [4]. The presentation included sections focusing on near Earth asteroids, main belt asteroids and Trojan asteroids, observable from the North American region. He also devoted some time to discussing the challenges of preserving and passing along the accumulated knowledge and expertise gained by IOTA mem-

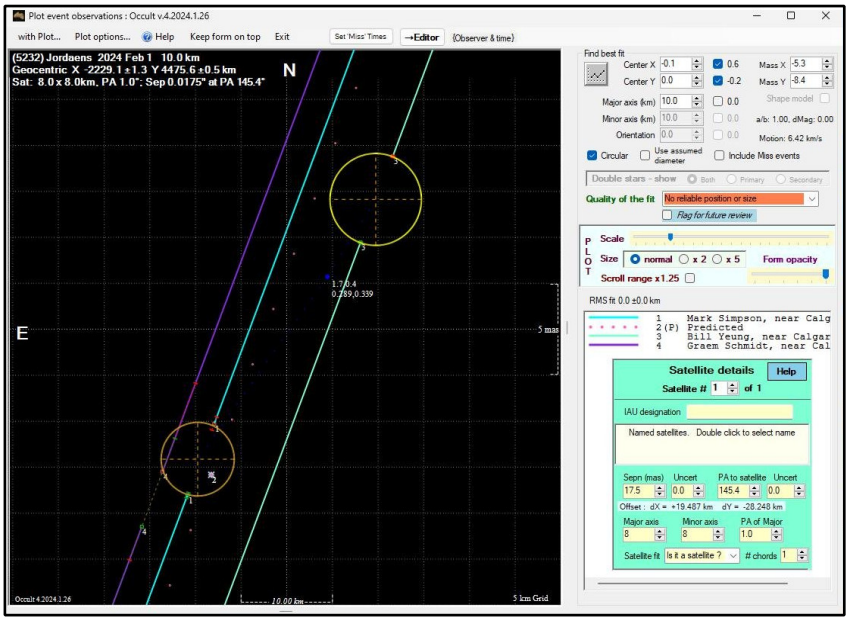


Figure 5. The profiles measured during the occultation by (5232) Jordaens on 2024 Feb 1. (Occult V4.2024.1.26)

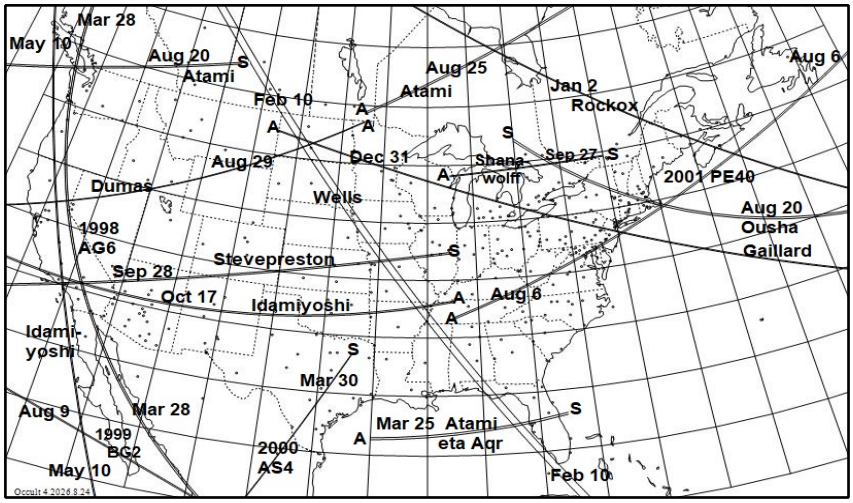


Figure 6. Map of 2027 North American occultations by the most special MB asteroids, completed after the meeting in its final form.

bers over the last several decades to the next generation of observers, willing to take on the tasks of prediction and analysis (Figure 6).

John Broughton presented a prerecorded video describing the 2021 occultation discovery of a ring orbiting the large TNO (50000) Quaoar, made by observers in Queensland, Australia (Figure 7).

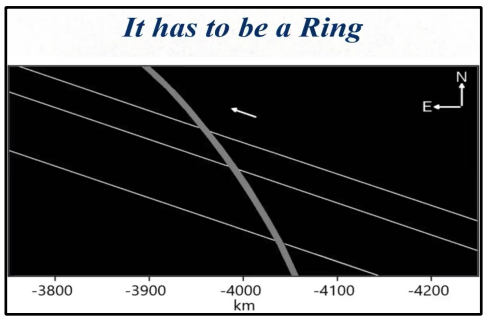


Figure 7. Three chords cover a ring around (50000) Quaoar during a stellar occultation recorded in Australia in 2021.

Vice President for Planetary Occultation Services Norm Carlson provided a wrap-up account of the best North American asteroid occultation events, and recent progress made in the review and processing of NA occultation observations.

Teddy Oakey of the University of Virginia provided thorough discussion of the history and ongoing activity of the UVA Occultation Group [3] including accounts of their observing campaigns across the United States, as well as in Africa, Asia and Australia (Figure 8).



Figure 8. The UVA Occultation Group during an observation session. (Photo: Matt Riley, UVA Communications Office)

Sunday 19th July 2026 - Day 2

Ted Blank reported on the opening and first scientific results from the *International Dark Sky Discovery Center* (IDSDC) [5] in Fountain Hills, Arizona. The centrepiece of this new facility is a 0.7 m aperture PlaneWave CDK700 telescope (Figure 9), which was used to observe the occultation of UCAC4 512-058179 by asteroid (53317) 1999 JJ_6 with results of notably high quality and signal-to-noise. The full IDSDC facility will include a planetarium, exhibit hall, theatre and classrooms for public outreach, and is planned for full opening in the first quarter of 2027 (Figure 10).

Mark Simpson gave a presentation summarising the history and ongoing development of the Astrid occultation platform [6], the hardware/software innovation that has gained widespread use by North American IOTA observers and was recognised in this year's *Homer F. DaBoll Award* (Figure 11).

Bob Anderson gave a pair of presentations on software he has written for occultation analysis. Following on his widely-acclaimed *PyMovie* and *PyOTE* packages [7], he has recently developed *GoPYOTE*, *Windows*-based software that provides a useful tool for the analysis of occultations involving significant diffraction and stellar diameter effects. In a second talk, he discussed the use of the Anthropic Claude Opus AI agent in aiding the coding of his astronomical software.

In the final technical presentation, **Michael Camilleri** discussed his development of *Occultation-Manager* [8], a *SharpCap* [9] addin that provides streamlined and automated event recording and reporting for users of CMOS cameras, including both NTP and GPS flash analysis tools for timing (Figure 12).

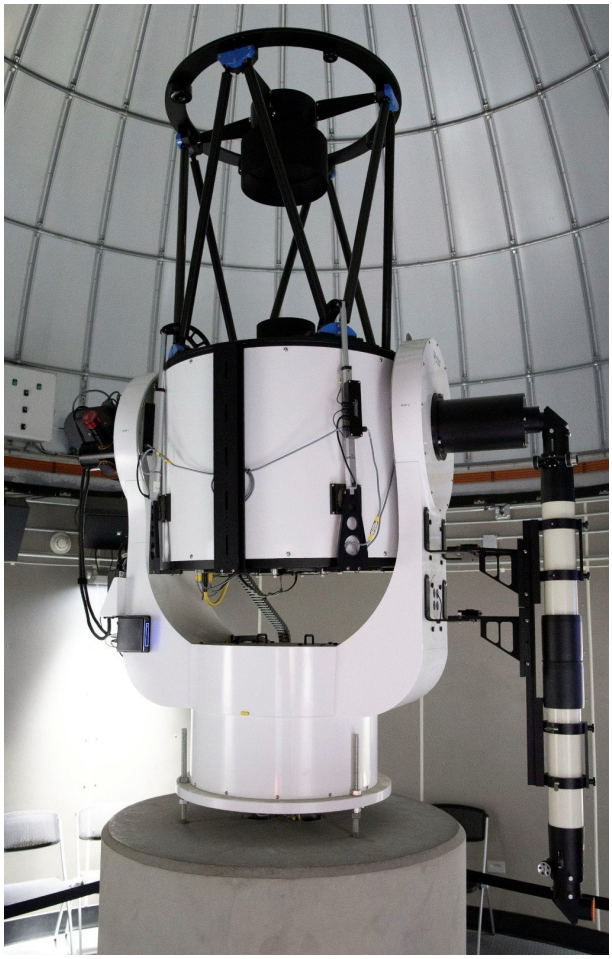


Figure 9. The 0.7 m-PlaneWave CDK700 telescope of the International Dark Sky Discovery Center. (Photo: Ted Blank)



Figure 10. Aerial view of the building of the International Dark Sky Discovery Center. (Photo: Ted Blank)



Figure 11. The Astrid Occultation System.

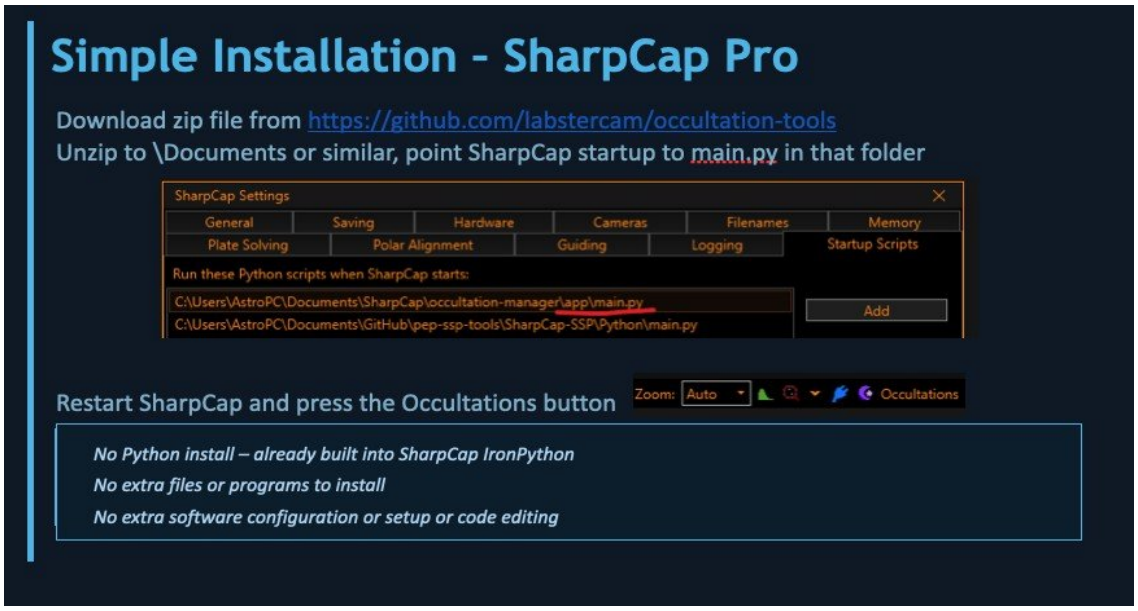


Figure 12. Screenshot of the presentation by Michael Camilleri about his tool Occultation Manager for SharpCap.

Observation Campaign for (5232) Jordaens

On the following evening of 2026 July 20-21, observers from IOTA and RECON teamed up for a coordinated campaign observation of the occultation of UCAC4 424-071654 by the binary asteroid (5232) Jordaens.

Approximately 30 telescope systems were deployed in Colorado south and east of Denver, resulting in a successful observation that will be the subject of a future report. The participants in the meetings and the campaign are grateful to Marc Buie and John Keller for their roles as hosts and organisers of the logistics and critical resources.

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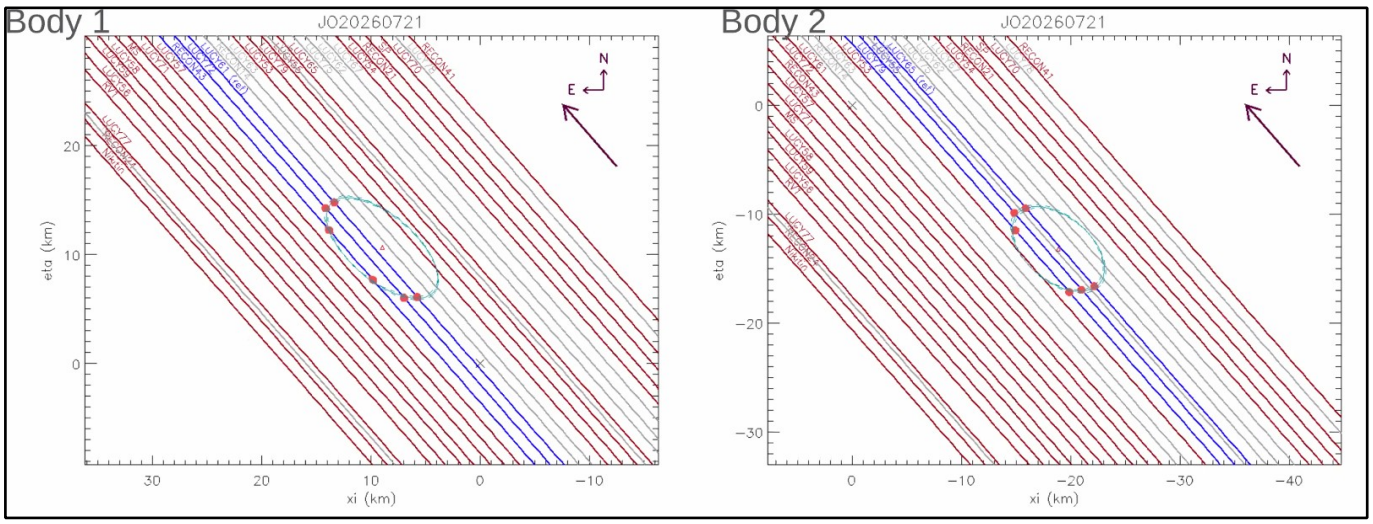
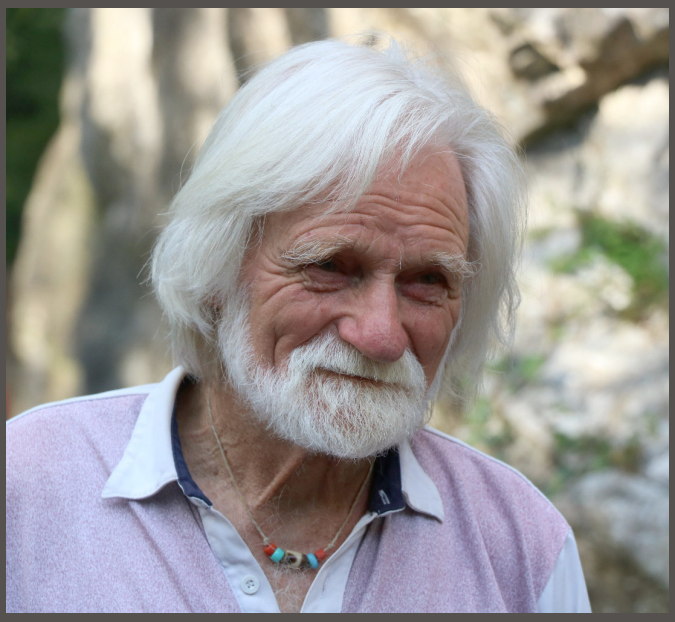


Figure 11. Preliminary analysis of the stellar occultation by double asteroid (5232) Jordaens.

Jean Bourgeois

1938 – 2026



Jean Bourgeois (2021) *(Photo: Didier Marchal)*

Jean Bourgeois was a dedicated Belgian observer, especially known for his numerous occultation observations.
He was also famous as a climber, explorer, ethnologist, lecturer and writer.

As an electronic engineer, in the early 60s, Jean built scientific instruments for the *Belgian Royal Observatory*. He then taught for two years in Africa, and back to Belgium worked for a while as a laboratory researcher. In 1968, with his wife Danielle, he followed the transhumance of nomads in Afghanistan. With many other exploration projects, Jean and Danielle began a lecturing and writing career.

However, already touched by the passion for mountaineering, Jean embarked on a series of expeditions to summits that were sometimes unclimbed. In 1966, he nearly lost his life during a climb of Nowshak between Afghanistan and Pakistan. He also was clearly reported lost then dead, during an Everest expedition at the end of 1982, but miraculously reappeared at the beginning of 1983 after a stay in a Chinese prison [1].

In astronomy, I first met Jean around 1973. At that time, he was already a lunar occultation observer, especially one among the first who timed lunar grazing occultations. These phenomena were, for the first time, predicted and observed by Jean Meeus in 1959. Clearly, Jean Meeus and Jean Bourgeois paved the way to initiate many observers looking for occultations.

In 2026, the solar eclipse of August 12 was the last observation by Jean Bourgeois. He reported his last positive asteroidal occultation on July 14, but before that, he observed more than 4,000 lunar occultations from which 780 involved double stars and more than 50 positive observations of asteroidal occultations.

Lesser known, Jean was also a dedicated solar observer for many years. Despite the weather conditions in Belgium, his perseverance did always find a little hole in the cloudy sky to perform his survey.

He succeeded to link astronomy and mountains, several times using telescopes from *Pic du Midi Observatory*. In 1989, with a video camera, he recorded the occultation of a bright star occulted by Titan. His observation, with other ones, helped to refine the properties of the atmosphere of Saturn's main satellite.

After his first wife's death, he married Pat Patfoort, anthropologist and also a climber. With Pat on the accordion, Jean played the violin in a small group of amateur musicians. He was also skilled at playing the guitar or the double bass.

Jean, I shall always remember all the time we have spent together, especially cross-country running on the slag heaps around Charleroi, annual meeting with observers from Flanders to prepare grazing occultation expeditions with Pierre Vingerhoets [2] (far away from political linguistic disputes, we formed an inseparable community). When you managed to attend our weekly reunion of local observers (beginning with a soccer game), variable stars mingled with occultations. With some enthusiasts, we have often travelled to France to observe your beloved lunar grazing occultations. I always remember the funny events that happened to us.

Bye bye, Jean.

Roland Boninsegna



Jean observing the Sun in Hα from Dourbes. (Photo: Thierry Pauwels, 2018)

One of the famous lunar grazing occultations observed by Jean: https://www.youtube.com/watch?v=3UwaucmBgXQ

[1] Jean Bourgeois (alpiniste), Wikipedia, 2026 https://fr.wikipedia.org/wiki/Jean_Bourgeois_(alpiniste)
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Jean Bourgeois, Jean Meeus and Roland Boninsegna (from left to right) (Photo: Andreas Dill, 2016)



Jean Bourgeois, the climber (Photo: Bernard Marnette)

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.

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IOTA President: Roger Venable . . . . . rjvmd@progressivetel.com
IOTA Vice President: Roxanne Kamin . . . . . rlkamin@prodigy.net
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Imprint

Publisher: International Occultation Timing Association/European Section e.V.
Am Brombeerhag 13, D-30459 Hannover, Germany
Responsible in Terms of the German Press Law (V.i.S.d.P.): Konrad Guhl
Editorial Board: Wolfgang Beisker, Oliver Klös, Alexander Pratt, Carles Schnabel, Christian Weber
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 2027-1: November 15



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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.

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Journal for Occultation Astronomy
(ISSN 0737-6766) is published quarterly in the USA by the International Occultation Timing Association, Inc. (IOTA)
PO Box 20313, Fountain Hills, AZ 85269-0313
IOTA is a tax-exempt organization under sections 501(c)(3) and 509(a)(2) of the Internal Revenue Code USA, and is incorporated in the state of Texas. Copies are distributed electronically.

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