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MODERN MINOR PLANET OCCULTATION OBSERVATIONS AND ANALYSIS *

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This document sets out how the International Occultation Timing Association handles a range of issues associated with the observations of occultations by minor planets. Sometimes people not involved with occultation observing suggest that an ‘interesting’ or ‘unusual’ occultation result was not the result of an occultation by an asteroid; rather it is suggested that a terrestrial cause is involved – such as a bird, airplane, balloon or artificial satellite. The implausibility of these suggested causes is discussed in detail.

Introduction

For those not familiar with what is being achieved with minor planet occultations observed by people affiliated with one or more of the International Occultation Timing Association (IOTA), Trans-Tasman Occultation Alliance, IOTA/East Asia, and IOTA/European Section, the sections below provide a brief historical context to minor planet occultation observations, an overview of what happens with the observations, and a very short selection of relevant papers.

An overview of minor planet occultations

The first true asteroidal occultation was by (2) Pallas on 1961 Oct 2 – a 25 second occultation photoelectrically recorded at Uttar Pradesh State Observatory in India (Sinvhal et al., 1962). Organized efforts to make observations of occultations by asteroids didn’t begin in earnest until the mid-1970s. The main interest was to measure the diameter of asteroids, which at that time were no more than estimates based on their absolute magnitude. Prediction accuracy was poor due to low accuracy star positions and asteroid orbits, with efforts being made to improve the prediction by measuring the positions of the asteroid and star on the same photographic plate taken within a few days before an event. The first multi-chord success was an occultation by (433) Eros on 1975 Jan 24 where 18 observers with mobile telescopes observed 9 positive chords. Subsequently there were some major efforts – such as an occultation by (2) Pallas on 1983 May 29, with 268 separate observing sites, and 130 positive occultation events observed (Dunham et al., 1990). By 1990 there were almost 100 successfully recorded occultation events, with about 70 allowing for some level of diameter determination. The great effort that went into planning and observing these events created much excitement amongst participants. Most observations were visual, typically requiring an observer to watch a specific star continuously for several minutes; it was inevitable that some reported occultations were subsequently determined to be false.

Several claims to the detection of a minor planet satellite were made in that period. Perhaps the most notable were two that had photoelectric recordings. The first was of (532) Herculina on 1978 Jun 7, which was widely reported as the ‘first confirmed discovery’ of a satellite on the basis that two observers had independently detected it (IAUC 3241). The claim was based on the matching of observations from two sites separated by around 600 km; one was made visually with a 10-cm telescope, the other with the 42-inch telescope at Lowell Observatory with the star at an altitude of 2.5°. The second is that of (18) Melpomene on 1978 Dec 11 where the occultation was recorded photoelectrically from three locations (IAUC 3315). In 1999 an effort was made with the Hubble Space Telescope to find satellites for six asteroids said to have satellites, including these two (Storrs et al., 1999). No satellites were detected – which undoubtedly created a long-standing belief by many that

* *Editor’s Note:* The content of this article has previously appeared in a posting to the website of the Central Bureau for Astronomical Telegrams, as an appendix to CBET 5679. Reprinted here with permission.

any claim to the discovery of satellite by way of an occultation observation inherently lacked credibility. In hindsight, a review of the Herculina observation shows those observations were heavily affected by noise with there being no real evidence of an occultation by a satellite; the claimed Melpomene satellite observation was inconsistent with other photoelectric observations.

The techniques and tools used by the occultation community have advanced hugely since those early days. In particular:

- i. Almost all observations are made instrumentally – either with composite video cameras, or fast CMOS cameras – such that there is a recording that can be analyzed, not just of the target star, but at least one comparison star. In recent years the measured light curves (typically the ‘raw’ light curve) are being archived at Vizier. The typical imaging frequency of the cameras is generally set by the observer for each event; it is typically around 30 images per second but may be as many as 100 images per second, or as few as 1 per second – depending on telescope aperture, star magnitude, and seeing conditions. Visual observations are only used when they are consistent with instrumental observations of an event, and then only with a very low weighting.
- ii. Three independent tools have been developed for measuring the video files: *LIMOVIE*, *TANGRA*, and *PYMOVIE*. All include features to statistically examine the sequence of observed frames and deal with noise.
- iii. A Fresnel diffraction tool, to model the effects of Fresnel diffraction, particularly relevant for small asteroids and satellites, has recently been developed (Anderson, 2026) and is functionally accessed by *OCCULT4*.
- iv. Prediction accuracy has hugely improved. This came about firstly with the UCAC series of catalogues (the first extensive star catalogue based on Tycho2 for reference star positions), followed by the various Gaia releases. The star positions from Gaia are fully reliable except for those with a large Renormalised Unit Weight Error (RUWE). At the same time asteroid orbits have improved as the result of astrometry being reported against the reference frames of Hipparcos and Gaia. More recently, the Gaia astrometry of asteroids in the Gaia FPR release was ingested into the JPL Horizons system, resulting in a further significant improvement of asteroid orbits.

The situation now is that for the great majority of predicted occultation events, the uncertainty in the time of the event is a small number of seconds (often as small as ± 1 second) and the uncertainty in the path location is usually between a small number of km to several tens of km.

Commensurate with the increasing accuracy of predictions, the uncertainty in the positions of asteroids has reduced to a level where the number of positive observations has increased exponentially as shown in Fig.1, and observers consider small asteroids in the 3-10 km and the less than 3 km diameters to be viable observing targets, as shown in Fig.2.

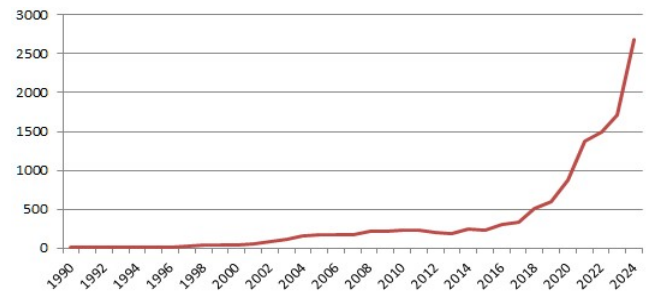


Fig. 1: Number of world-wide positive asteroid occultations reported.

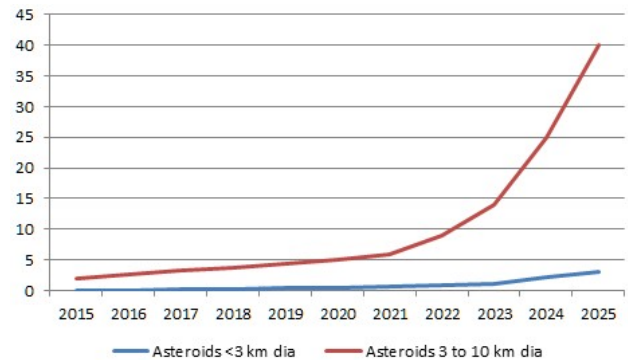


Fig. 2: Percentage of world-wide positive asteroid occultations reported in the less than 3km and the 3-10km range.

For many years observers have been submitting light curves as part of the reporting process. At the start of 2024, IOTA mandated a light curve must be included with every report where an occultation event is claimed to have occurred. As at July 2026 there are over 12,500 light curves associated with minor planet occultation observations (as well as over 7600 for lunar occultations).

With observations involving smaller solar-system bodies, including satellites of minor planets, it is not unusual for the apparent diameter of the star to be large enough (typically, greater than a few tenths of a mas) for the disappearance and reappearance events to be non-instantaneous. When the apparent diameter of the star is greater than that of the asteroid, annular occultations are observed. Additionally, the effects of Fresnel diffraction can be significant (indeed, can dominate the light curve), with the Fresnel length for a main-belt asteroid being several hundred meters for its shadow on the ground.

The situation at the start of 2026 is that the occultation database of IOTA has over 15,000 occultation events derived from over 39,000 individual observations. The annual rate of successfully observed events at the end of 2025 was over 2,500 per year - more than 7 events per day.

Short-duration events

A particular issue relates to occultation-like events that last for only one or two exposures. There are many issues that could lead to such short light-curve drops, with signal noise being the main issue. In the normal processing for astrometry, such events are treated with considerable skepticism. For a short-duration event, a discovery (whether of a double star, satellite, or anything else) is unlikely to be asserted unless

- a. There is a second observation with independent instrumentation that is confirmatory; or
- b. The light drop entails at least 3 points generally near the bottom of the light curve, and the drop is unambiguously different from the noise signals in the light curve.

Minor planet satellites

The first confirmed occultation discovery of a minor planet satellite was that of (4337) Arecibo, in 2021 (Gault et al., 2022). A full orbit solution for this system has been derived based on several subsequent occultation detections, and the system's photometric displacements as measured in the Gaia astrometry for the asteroid (Liu et al., 2024). As at July 2026 there have been 31 satellite discoveries from occultation observations announced in CBETs. The majority involve asteroids smaller than 10 km diameter. Their detection is clearly associated with observers choosing to make observations of small asteroids because of the greatly improved predictions.

Are the results of minor planet occultations real?

Sometimes people ask the question: "how can you exclude terrestrial objects such as birds, balloons, planes or orbiting satellites from being the cause of the occultation event?" This is a relevant question, with a search on the internet showing a (albeit small) number of photographs of planes and birds in front of the moon.

This criticism has some substance in the historical context of visual observations reliant on very poor predictions. However, as discussed above, modern predictions are of high accuracy, which leads to the practical question:

If an occultation of a specified star is predicted to occur at or near a geographic location with an uncertainty of (for example) ± 5 seconds, and an occultation is observed within that ± 5 seconds, to what extent is it reasonable to assert the occultation was caused by anything other than the asteroid that was predicted to occult the star?

The angular area of the visible sky is a little over 20,000 square degrees, or about 80,000 full moons. If at any one instant of time an observer could see 80 planes (or birds, balloons or satellites) visible in the sky, the probability of one of them being in front of the moon at a given time would be about 1 in a thousand. As discussed below, the angular size of birds, planes, etc., is generally considerably smaller than the moon, and the number of planes, etc., in the sky as seen from any one location at any one time is generally much fewer than 80 – indeed, unless located near an airport the number may well be less than 5. When this is allowed for, the probability of a bird, etc., being co-located is reduced by several orders of magnitude or more. Therefore, on a purely statistical basis, while the probability of a terrestrial object being co-located with a particular star and asteroid within the few seconds of when an occultation is predicted is not zero, it is very small. Given the

(as at 2026) 39000 individual occultation observations that have been made by observers in the International Occultation Timing Association and affiliates, perhaps two or three individual observations might be expected to have had that coincidence – whether or not an occultation was reported as a result.

The following will go through the issues specific to various possible objects. Firstly, in the context of minor planet occultations in general, and secondly in the context of minor planet satellite detections.

Birds. Birds have a large range of sizes. There are small birds like swallows, thrushes, finches, etc., where the body size is small compared to the aperture of the typical telescope used to observe occultations – and are therefore incapable of producing a complete or substantial light drop.

To have a meaningful drop of light with the size of telescope typically used for occultation observations, the bird would need to have a wingspan greater than around 20 cm. Most birds fly below 200 m. Two issues arise:

- a. At these distances, there is the question of whether the image of the bird would be in-focus. An out-of-focus image will not produce the sharp drop and rise in the occultation light curve that is characteristic of an occultation. While the degree of focus for an object within 200 m of the telescope will depend on the optics involved, the out-of-focus image of a low-flying bird cannot replicate the sharpness of an occultation event.
- b. A 20 cm object at a distance of 200 meters subtends angle of around 3 arc minutes. If one was observing an occultation (typically with a field of between 5 and 20 arc minutes), that bird flying across the field would not occult just the target star. It will occult all stars in a band 3 or more arc minutes wide (the larger the bird, the wider the band). Small birds typically fly with a cruising speed of 30 to 50 km/h. Assuming a wing width (as distinct from the wingspan) of 10 cm or less, any occultation by the wings would last for around 0.01 seconds.

Migratory birds can fly much higher (4 to 6 km) but generally have a large wingspan in the order of 0.5 to 4 meters – with an apparent wingspan of around 0.3 arc mins. This is a much narrower band than for birds flying at low altitudes, but it is still a band potentially covering multiple stars. Migratory birds typically fly 30 to 80 km/h (and possibly up to around 110 km/h) which is around 8 to 30 meters per second. Migratory birds generally have wings with a high aspect ratio, meaning they are significantly narrower in proportion to the wingspan than for more sedentary birds. Perhaps a ratio of around 10:1. A bird with a wingspan of 1 meter would be expected to have a maximum wing width of perhaps 0.1 meters, and at a speed of 10 meters/second, an occultation by the wing of the bird would last for around 0.01 seconds.

When measuring a recording, it is usual and expected for at least one comparison star to be included. If a bird crosses the target star it will also occult other stars in the field - such that comparison stars will also be occulted.

This leads to two outcomes. Firstly, with most observations being made with exposures longer than 0.017 s, together with (as noted under 'Short-duration events' above) the need for the occultation to extend over 3 or more exposures, the expected duration of 0.01 seconds is generally too short for reliable detection by the type of equipment used by IOTA observers. Secondly, if the light curve for

a comparison star includes a drop similar to a purported occultation event of the target star, that purported occultation event will be treated as noise, not an occultation.

Airplanes. Airplanes have often been suggested as a potential cause of an occultation. Unless the observation is being made in a war zone (where military aircraft fly with all lights off), by international agreements all aircraft flying at night must have lights on their wing tips and elsewhere, so that they are optically visible to other planes. This is very evident at night-time, where the wing lights of aircraft flying overhead are quite visible to the naked eye, and will inevitably appear in any recording.

The expected duration of an occultation by an airplane can be assessed using (as an example) an Airbus A320. In flight it travels at around 870 - 980 km/h, or about 240 - 270 m/second. The width of the wings varies along their length by between 5 and 2 meters. Using the average of both wing width and speed, the airplane will move the width of the wings in 0.014 seconds. That is, the expected duration of an occultation by the wings will be in the order of 0.01 to 0.02 seconds. With most observations being made with exposures longer than 0.017 s, and (as noted under 'Short-duration events' above) the need for the occultation to extend over 3 or more exposures, the expected duration is generally too short for reliable detection by the type of equipment used by IOTA observers. Additionally, if the light curve for a comparison star includes a drop similar to a purported occultation event of the target star, that purported occultation event will be treated as noise, not an occultation.

There are two known instances of an airplane being recorded while monitoring a target star for an occultation.

The first instance was recorded in USA on 2026 March 8 when monitoring for an occultation by (61381) 2000 PL29, with an expected maximum duration of 0.22 seconds and light drop of 100%. The event was recorded by two independent systems, using 8-cm and 25-cm telescopes separated by a short distance. They show an airplane crossing the field just seconds before the predicted occultation.

The two images Fig.3, taken with the 8-cm telescope, show the target star (marked with a red square) being occulted by a wing. The comparison stars are marked with yellow squares, and that in front of the airplane is clearly going to be occulted by the other wing. The images were taken at an interval of 0.05 seconds, with the interval between these two images being 0.10 seconds.

The top light curve is of the target star and indicates the time when the airplane passed over the target star. The bottom light curve is of the comparison star ahead of the airplane; it covers the same time interval, including the time when the wing passed over the comparison star. *Neither light curve shows evidence of an occultation event caused by the airplane.*

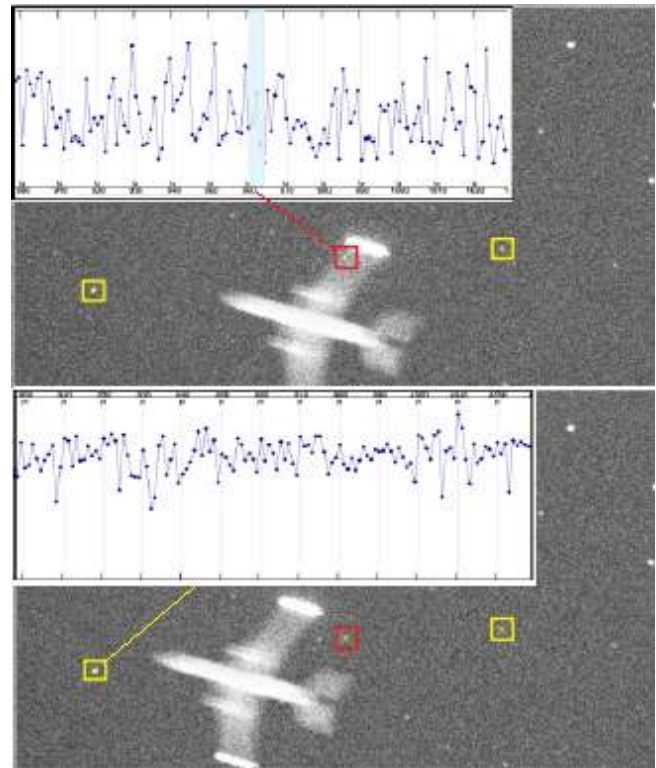


Fig. 3: Occultation image of an airplane crossing the field-of-view, observed using an 8 cm telescope.

The image in Fig.4 was taken with the 25cm telescope located a short distance from the 8-cm telescope, with the interval between exposures being 0.05 seconds. Again, the target star is marked in red, and two comparison stars in yellow.

This light curve is of the target star, and indicates when the wing passed over the star. The light curve shows no evidence of an occultation event caused by the airplane. Similarly, the light curve of the comparison star that the airplane also passed over shows no evidence of an occultation event caused by the airplane.

The reason for the light curves showing no indication of the occultations by the wings of the airplane is the expected short duration of occultations by the wings is too short to have a noticeable effect in the images given the exposure durations. Additionally, the images show:

- the lights on the end of the wings;
- the entire body of the airplane, which is illuminated by light pollution; and
- the large apparent size of the airplane, occulting multiple stars as it crosses the field.

The second instance was recorded in Japan on 2025 July 27 when monitoring for an occultation by 3I/ATLAS, with an expected maximum duration of 0.2 seconds. Exposure durations were 0.062 seconds, the field size is approximately $5' \times 10'$, and the star altitude was 20 degrees. An image of the relevant star field is shown in Fig. 5.

These clearly shows the occultation of multiple stars as the presumed airplane passed through the field from top right to bottom left. The durations of the various drops are about 25 times longer than the expected maximum duration and occurred well before the predicted times – making it clear they were not the predicted occultation event. Interestingly, the wing lights are not apparent in the recording – indicating it may have been a military aircraft.

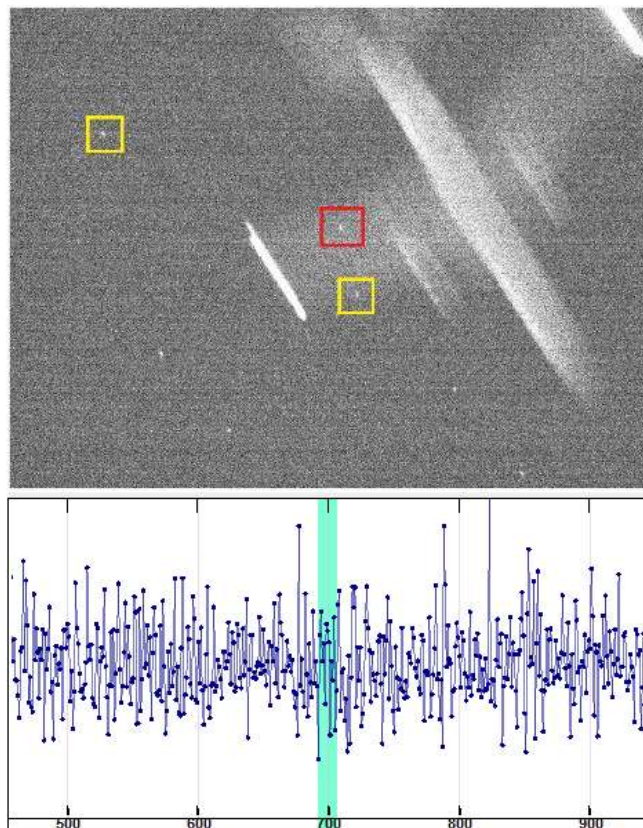


Fig. 4: Occultation image of the same airplane as Fig.3 but observed using a 25-cm telescope.

In summary, the issues generally associated with an airplane passing through the field of view of a camera monitoring a target star are:

- the wing lights will be strongly visible in the recording - unless military planes are involved (as was believed to be the case with the Japanese example).
- as shown in the first instance above, an airplane flying at night over inhabited areas will likely be 'visible', being illuminated by light pollution.
- the airplane will occult other stars as it passes through the field.
- for a main belt asteroid, the Fresnel length associated with the occultation shadow is in the order of 300 meters. The effects of Fresnel diffraction are regularly observed, particularly when the asteroid is small. The Fresnel length for the occultation shadow of an airplane is a fraction of

a meter, such that Fresnel diffraction effects from an occultation by an airplane will never be detected with the type of equipment used by IOTA observers.

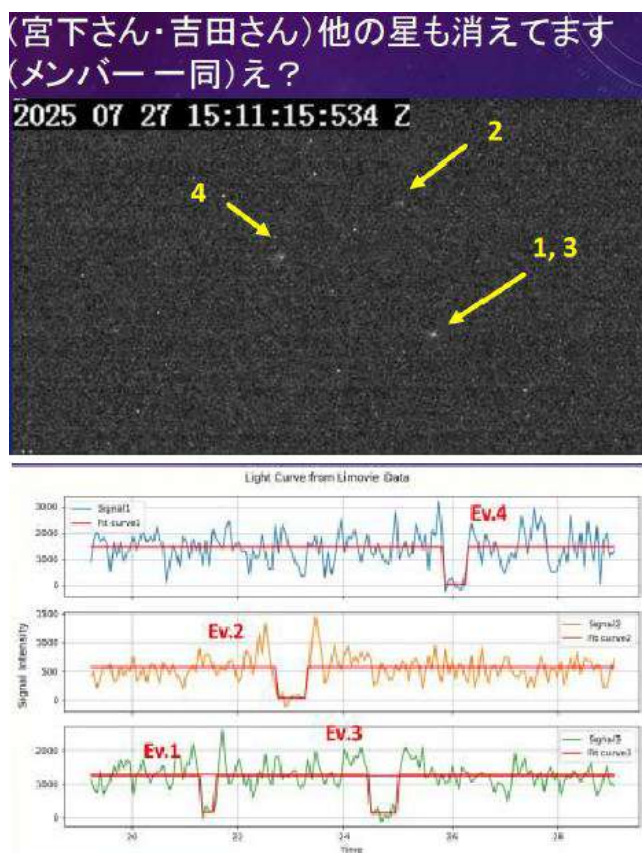


Figure 5: Occultation image and light-curves of the passage of an unilluminated airplane through the field-of-view. The arrow marked '4' refers to the target star. The light curves for the three stars, with the top light curve being the target star,

The existence of the above two instances of an airplane crossing the field of view at a frequency consistent with the statistics previously mentioned, demonstrates that such events are being detected when they occur.

Weather balloons. Large weather balloons can expand to a diameter in the order of 15 meters, or about $\frac{1}{4}$ the span of the wings on a large airplane. There are up to about 1300 weather balloons launched globally each day. That is, one balloon per minute, with the launch location being anywhere on the Earth – such that their presence in the sky as seen from an observing site is extremely low compared to planes. The likelihood of a weather balloon being co-located with a particular star and asteroid within the few seconds of when an occultation is predicted is miniscule. Additionally, and like planes, expected Fresnel diffraction effects would not occur.

Geocentric satellites. The satellites with the slowest apparent motion are geostationary satellites. The apparent motion of such a satellite is 360 degrees in one diurnal day, or 15 arcsecs every second. The size of the body of the satellite is generally less than 10 m. At the geostationary height of 36,000 km above the Earth's surface, the body would subtend an angle of 0.06 arcsec. The time taken for its apparent position to move by the diameter of the satellite (that is, the maximum duration of any occultation of a star) is then around 0.004 seconds - far too short to be detectable with the type of equipment used by IOTA observers. Should the solar

panels be aligned with the apparent direction of motion (such that an occultation was by the full length of the solar panels), their apparent length would be in the order of 30 meters and subtend an angle of $0.17''$, leading to a maximum occultation duration of around 0.011 seconds – again, too short to be reliably detectable with the type of equipment used by IOTA observers.

Large satellites in low orbits will appear larger than geostationary satellites but will have a much faster apparent motion. The duration of any occultation will be far too short to be detectable with the type of equipment used by IOTA observers. Smaller satellites (such as Starlink) will have even shorter occultation durations.

The absence of occultations of comparison stars. The probability of an unpredicted occultation by a terrestrial object is the same for all stars – including the star which is otherwise predicted to be occulted by an asteroid. The measurement of a recording to extract an occultation light curve will almost always include *at least* one comparison star, with each comparison star having the same probability as the target star for being occulted by a terrestrial object. As it is common to measure more than one comparison star, an occultation by a terrestrial object is more likely to be of a comparison star than the target star.

The Japanese example above is the only reported instance of an occultation of comparison stars. When such a situation occurs, most IOTA observers would (as in that example) be very curious and keenly excited, with questions like: ‘this is not what I was expecting - what is the explanation?’; ‘is this the discovery of something new?’ The absence of reports of occultations of comparison stars is confirmation that occultations by terrestrial bodies are exceedingly rare.

Clouds. For completeness, an occultation of a star by a solid body involves a very steep drop in light level, a period of low light, and then a sudden rise. The exceptions to this are occultations of stars with a significant angular diameter (the diameter is generally known by *inter alia* the Gaia FLAME estimation of a star’s diameter, and it is included in any modeling of a light curve); Fresnel diffraction around small bodies (again, which is modeled); and major bodies which have an atmosphere such as the major planets and Pluto (which are known). Somewhat obviously, clouds do not have a solid edge that produces the expected sudden drop and rise in the light level. Furthermore, a cloud will extend across the field of view affecting multiple stars and will be illuminated by light pollution - such that the presence of cloud is obvious.

Considerations relevant to minor planet satellites

Occasionally an observed occultation has two drops in the light curve. There are several potential causes for this situation. The approach of IOTA is that to conclude such a light curve discloses a previously unknown satellite, all other plausible explanations need to be excluded.

Double stars. The foremost consideration is whether the light curve might be explained as the detection of a double star. In this regard, it may be noted that the number of double stars discovered in minor planet occultation observations up to 2026 is in the order of 300, more than 10 times the number of minor planet satellite discoveries.

If the star is a single star, both light drops will be of the same depth (apart from Fresnel diffraction issues). If the star is a double star, the star’s total brightness will be split between the two occultation drops, which may or may not be equal.

- a. If the two components of a double star are of equal magnitude, the light drops will represent 50% of the total light of the star – which equates to a magnitude drop of 0.75 magnitudes.
- b. Unequal drops are a *prima facie* indication that the star is a double star.
- c. To assess whether a double star is involved, the magnitude drops cannot be assessed by the measured flux drop in an uncalibrated light curve. Rather there must be one or more comparison stars of substantially the same colour temperature as the occulted star, that are at least 1.0 magnitudes fainter than the occulted star. The requirement of 1.0 magnitudes is to ensure any claim to a satellite is based on a clear distinction from a double star explanation.
- d. If the satellite is small (less than 3 km), or the occultation passes near the limb of the body (a grazing occultation), the effects of Fresnel diffraction may lessen the depth of the light drop, making the two drops unequal. The presence of Fresnel diffraction is not assumed in the first instance. Rather, the combined light drops (expressed in magnitudes) must be significantly greater than the light drop treating the star as a single star. Only then is Fresnel diffraction brought into the assessment of the event.

The requirement for the light drops to be measured in magnitudes based on comparison stars, rather than the flux drop on an otherwise uncalibrated light curve, is treated as an essential step in assessing whether a double-star explanation can be excluded. For example, an occultation by (10999) Braga-Ribas on 2025 Aug 15 showed a very clear double drop to almost zero light level. However, there were no comparison stars of any brightness in the recording. This meant the magnitude of the drops could not be assessed, and therefore the double-star explanation could not be positively excluded.

The magnitude drop also depends on the brightness of the asteroid. Small asteroids are generally several to many magnitudes fainter than the target star and have no material effect of the magnitude drops. However, this may not be the case for larger asteroids, with occultations sometimes being recorded when the asteroid is brighter than the star, with a consequential light drop of less than 50%. When the predicted depth of the occultation is less than ~80%, the generally unknown contributions from the asteroid’s colour magnitudes and rotational light curve variations become relevant. For a satellite detection to be considered, the depth of the two magnitude drops must be assessed after the asteroid’s magnitude has been removed, noting that the asteroid’s magnitude may be brighter than its predicted magnitude by reason of these issues.

Grazing occultations by irregular shaped asteroids. One possibility for a light curve with two drops is where an occultation occurs at two different locations along the limb of an asteroid. The situation is well illustrated by the examples shown in Fig. 6, where distinct occultations can occur at different locations along the length of these extended irregular asteroids.

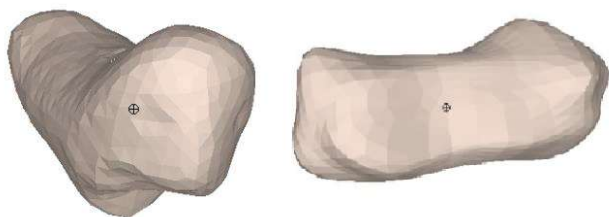


Fig. 6: (433) Eros (left) and (216) Kleopatra (right)

Factors that come into consideration are:

- The separation between the two occultation drops - is it sufficiently large to exclude a plausible elongation of the minor planet. Matters considered include:
 - the location and nature of any other observed chords for the event.
 - any light curves held in the Asteroid Lightcurve Data Exchange Format (ALCDEF) database.
 - deviations over time of the Gaia magnitude measurement of the asteroid from the magnitude predictions from JPL Horizons.
 - any oblateness estimates given in Combined spin orientation and phase function of asteroids (Carry et al., 2024).
 - DAMIT shape models – recognizing that many are of low quality (Durech et al., 2010).
- Is there any other evidence to indicate whether or not the asteroid might be highly elongate. Resources considered include:
 - past occultation observations of the asteroid.
 - whether there are features in the light curve where Fresnel diffraction modeling would support or exclude an elongate asteroid.

An example of grazing occultation considerations is the light curve in Fig 7 of a recent occultation by (255) Oppavia observed by P. Maley.

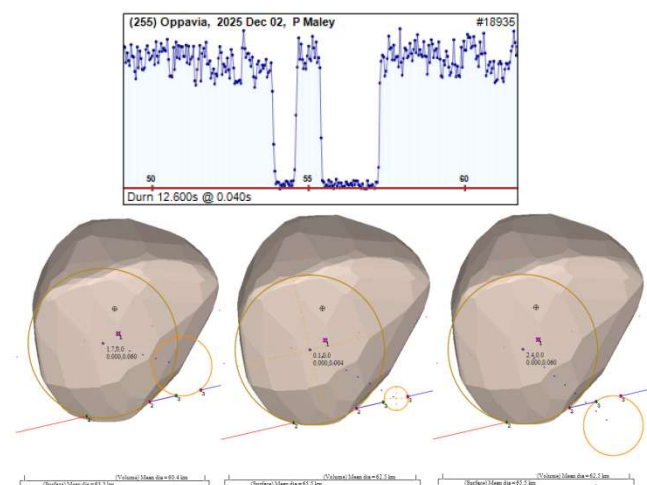


Fig. 7: Occultation light-curve with possible sky-plane plots

One could argue that this involves the detection of a satellite which is in line-of-sight with the limb of the main body. However, when the typical irregularity of asteroid limbs is considered, plausible asteroid shapes like (433) Eros and (216) Kleopatra, (Fig.6), the poor reliability of a large number of available shape models (especially models that have been derived without the benefit of a dedicated rotational light curve measurement, as is the case for this shape model), the primary explanation for this event is irregularities along an extended limb of the asteroid, with the shape model likely being ‘wrong’. That is, while a satellite is a ‘possible’ explanation, other plausible explanations cannot be excluded, and no claim for the definite detection of a satellite arises.

Can a double-drop light curve be explained by a bird,
airplane, balloon or geocentric satellite?

Once the explanations of a double star or grazing occultation are excluded, the occultation necessarily involves just one star. Therefore, any explanation based on birds, planes, balloons and satellites needs to establish how a double drop occultation event can be created by that object.

Birds. Double drop occultations typically occur with a gap of less than about 3 seconds. One bird flying exactly behind another bird spaced apart at 10 or 20 meters, could produce such a double drop. However, it is unusual for birds to fly in this manner. Rather most birds tend to fly in a V formation.

Airplanes. While an occultation could be caused by two planes flying with one closely behind the other – the required separation would be contrary to general aviation requirements. A single airplane could result in a double occultation event – an occultation by both the main wing and a tail wing. However, the extent of a tail wing is considerably less than the main wing, which results in a reduced probability of occurrence.

Weather balloons. Weather balloons do not have an inherent double structure to result in a double occultation. Weather balloons do not fly in any co-located fashion. Prima facie, they are incapable of generating a double occultation event.

Geocentric Satellites. Satellites do not have an inherent double structure to result in a double occultation. Further they do not fly closely together in a coordinated fashion. Prima facie, they are incapable of generating a double occultation event.

Asteroid + Bird/Airplane/Weather balloon/Geocentric satellite. In principle, a double occultation could be the coincidence of a minor planet occultation and an occultation by one of these other objects. The issues are the same as those discussed above under ‘Are the results of minor planet occultations real?’

Summary

Occultations of stars by terrestrial objects such as birds, planes, balloons and orbiting satellites, necessarily occur. However, an occultation of a specific star within the typical uncertainty of a predicted occultation is statistically a very rare occurrence. Should one occur, its characteristics will usually distinguish it from a minor planet occultation by issues such as event duration, occultations of other stars in the field, and Fresnel diffraction (particularly for small bodies). This, together with the almost non-existent record of terrestrial occultations of comparison stars near a target star, demonstrates that with appropriate observing and analysis, terrestrial occultations are an implausible explanation for an observed occultation of a predicted event.

Observations; a brief selection of papers

The results of occultation observations are reported in the following manner:

- Astrometry is regularly reported to the Minor Planet Center (MPC) – observatory code 275. The ADES standard for reporting astrometry was updated (Feb. 2022 and Oct. 2023) to cater for certain aspects unique to the capabilities of asteroid occultations.
- Double star observations (almost all being discovery observations) are published on an occasional basis in the *Journal of Double Star Observations*.
- The entire dataset of occultation observations and analysis is archived on a semi-regular basis a NASA's Planetary Data System – Small Bodies Node. This archive includes files specific to derived astrometry, double-star parameters, minor-planet diameters derived from fitting to shape models, and satellite observations (known satellites, discovered satellites, and events where a satellite is suspected but the observation is insufficient to establish its existence). Archive versions subsequent to version 4.0 will include a file that lists all occultation observations (including discovery observations) of known minor-planet satellites, as well as observations where a minor-planet satellite is a possible explanation.
- Light curves for minor-planet occultations are archived at Vizier.
- Minor planet satellite discoveries are announced via a CBET.
- Groups that generate asteroid shape models access the IOTA dataset of observations to incorporate occultation timings in their ADAM modelling (Viikinkoski et al., 2021).

A paper setting out in more detail a summary of what the IOTA groups are undertaking and achieving as at 2020 is set out in “Precise astrometry and diameters of asteroids from occultations – a data set of observations and their interpretation” (Herald et al., 2020). It includes a list of double-star discoveries, with separations typically in the tens of milliarcseconds. It illustrates observations of known satellites of asteroids, and it derives a diameter for Romulus [one of the satellites of (87) Sylvia]. It compares the diameters of asteroids derived from occultations with the diameters from IRAS, Akari AcuA, and NEOWISE. And it compares results with shape models.

A more recent paper that illustrates the power and reliability of occultation observations is “Direct detection of an asteroid's heliocentric deflection: The Didymos system after DART (Makadia et al., 2026). This paper uses the astrometry derived from 22 stellar occultation measurements of the 760-meter diameter Didymos between October 2022 and March 2025 to measure the change of motion of the entire Didymos system as a result of the DART impact. The occultation durations were mostly shorter than 0.5 s. As stated in the acknowledgement:

The results shown here were directly enabled by these not-so-amateur astronomers' efforts to go out into the middle of nowhere and observe the necessary stellar occultations.

The Gaia astrometry has been analyzed to identify asteroids that may have a satellite: “Binary asteroid candidates in Gaia DR3 astrometry” (Liberato et al., 2024). This led to the GAIAMOONS project which ‘exploits networks of observers of stellar occultations, very useful to validate the discoveries of binary asteroids. GaiaMoons actively supports the collaboration with a large community of amateur astronomers by exploiting the ACROSS collaboration.

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CALL FOR OBSERVATIONS OF 1256 NORMANNIA: PHASE CURVE MEASUREMENT FOR A POSSIBLE SPACECRAFT FLYBY

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Asteroid 1256 Normannia resides near the Hilda region of the outer asteroid belt. It reaches a nearly 0-degree phase angle on 2026 November 27 UT. Phase curve measurements are of particular interest for this asteroid as it has been identified as a reachable flyby target by the NASA Lucy spacecraft late in the next decade. Phase curve opposition data would provide useful input if such an encounter were to be formally considered.

NASA's Lucy spacecraft mission is on track to explore the Trojan asteroids through a series of flybys in the L4 and L5 Trojan clouds occurring over 2027 thru 2033. An ongoing trajectory analysis shows the possibility for the spacecraft to encounter 1256 Normannia in the late 2030s. Normannia is a D-type asteroid residing in the outer asteroid belt near the region of Hilda asteroids, making it an additional dynamically interesting target.

The 2026 November 27 UT opposition of Normannia provides a rare opportunity for ground-based reconnaissance, as the asteroid will reach a minimum phase angle of less than 0.2 degrees. The low phase angle allows measurement of the surface scattering properties, an important parameter for planning spacecraft imaging sequences. Thus, world-wide astronomers have an opportunity to provide useful input to support a possible spacecraft investigation; noting that no formal proposal for this flyby investigation or decision is pending at this time.

Some physical properties of Normannia are well-established, having an estimated diameter of 64 km and a well-determined rotation period of 489.80 +/- 0.05 h, with an amplitude ranging from 0.2 to 0.6 magnitude (Stefano Mottola; personal communication). The lightcurve period is impractically long for any single observer to obtain complete coverage. Fortunately, useful science measurements require only repeated measurements near the lightcurve rotational phase that will occur at the minimum phase angle at opposition. The table below indicates the epochs of the relevant lightcurve phase, with useful measurements being those over +/- 2 hours from each epoch, carefully calibrated to the R band.

The Minor Planet Bulletin will welcome publication of these measurements. The author will facilitate archival of the measurements for use in possible mission planning.

Date	UT	V mag
2026 09 06	23:31	16.3
2026 09 27	04:42	16.1
2026 10 17	11:52	15.8
2026 11 06	21:13	15.5
2026 11 27	08:03	15.1
2026 12 17	18:52	15.5
2027 01 07	04:10	15.9
2027 01 27	11:11	16.2
2027 02 16	15:43	16.4

ROTATION PERIODS OF NINETEEN HUNGARIA-FAMILY ASTEROIDS FROM TESS FULL-FRAME IMAGES

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Photometry from TESS full-frame images yields rotation periods for nineteen Hungaria-family asteroids ($H = 14.8 - 16.0$, estimated diameters 1.4 - 2.5 km), fourteen of them first determinations. Ten periods, from 2.29 to 56.54 h, are secured by detection in two or more sectors; nine more are single-sector candidates. Fifteen lightcurves exceed 0.4 mag amplitude and are fitted with double-peaked solutions, independently confirmed for four objects with recent survey periods. No object shows evidence of non-principal-axis rotation.

The Hungaria family occupies the high-inclination inner edge of the main belt and is dominated by small, predominantly E-type asteroids. Rotation periods are catalogued for only a minority of its members (Warner et al., 2009; 2023 October public release, verified against the online LCDB query system on 2026 July 10), and the slow-rotator regime ($P_{\text{rot}} \gtrsim 30$ h) is especially incomplete because it demands long, continuous time coverage that is costly from the ground. The Transiting Exoplanet Survey Satellite (TESS; Ricker et al., 2015) records nearly the full sky in ~ 27 -day sectors, and its full-frame images have already yielded rotation periods for roughly ten thousand asteroids, predominantly brighter main-belt and Trojan objects (Pál et al., 2020). The faint end of the FFIs, however, remains largely unexploited: at $V \approx 16 - 18$, where most km-scale Hungarias fall, reliable photometry requires point-response-function (PRF) fitting along the moving track with careful background control. Here we report rotation periods for nineteen km-scale Hungarias, fourteen of them first determinations, exploiting the regime in which TESS's uninterrupted coverage is decisive.

Observations and Reduction

Lightcurves were extracted from calibrated TESS FFIs using the open-source *tess-asteroids* package (Tuson et al., 2026; MovingTPF), which builds a moving target-pixel file along each asteroid's apparent track and performs PRF photometry with local background estimation. The observations span Sectors 3 - 105 (2018 - 2026); the FFI cadence is 1800 s in Sectors 1 - 26, 600 s in Sectors 27 - 55, and 200 s from Sector 56 onward. We targeted LCDB-unmeasured Hungarias whose median in-sector TESS magnitude falls in the range $\sim 16.5 - 17.5$, in which we find the extraction to be reliable; we note that the frequently tabulated near-opposition brightness is typically ~ 0.5 mag brighter than the median in-sector brightness and is therefore a poor selection metric. Observing circumstances, one line per detecting sector, are given in Table I.

Two systematic effects dominate faint moving-target photometry and were treated explicitly. First, high-signal background-star crossings survive a nominal error cut; these were removed with a bright-side robust rejection (median $-4 \times \text{MAD}$). Second, imperfect background subtraction leaves correlated ("red") noise that produces broad, spurious power at long periods; we suppress it with a cubic polynomial fit to each sector before period analysis. The

cubic baseline varies slowly compared with even the longest adopted period ($56.54 \text{ h} \approx 2.4 \text{ d}$, or ~ 9 cycles per sector), and identical periods are recovered in sectors with and without strong background ramps; periods approaching the sector length would, however, be absorbed by this step, so the survey is insensitive to $P_{\text{rot}} \gtrsim 100 \text{ h}$.

Period Analysis

Periods were measured with the Lomb-Scargle periodogram (VanderPlas, 2018) on the detrended series and refined by a dense local search; all periods are synodic. The periodogram identifies the dominant photometric period P_{phot} .

An elongated body produces two maxima and two minima per rotation, so for shape-dominated variation the rotation period is twice the strongest photometric period. We adopt $P_{\text{rot}} = 2 P_{\text{phot}}$ in two cases:

- (i) when the lightcurve folded at $2 P_{\text{phot}}$ shows alternating extrema that are unequal at high significance, verifying the doubling directly, the four confirmed slow rotators, labelled "D" in Table II;
- (ii) when the amplitude exceeds 0.4 mag, which cannot plausibly be produced by albedo variegation (Harris et al., 2014), even where the two halves of the doubled fold are statistically indistinguishable, eleven objects, labelled "D*".

In the intermediate range $0.25 \leq \Delta m < 0.4$ mag either interpretation remains possible; for the three such objects (86420, 74511, 10667, labelled "S*") we tabulate the single-peaked P_{phot} and caution that the true rotation period may be twice the tabulated value. The one object below 0.25 mag (76865) is tabulated single-peaked. For 24687 the doubled solution is also supported by rotational stability: the single-peaked alternative (2.05 h at $\Delta m = 0.43$) would sit at the cohesionless spin barrier, as would 23452's (1.886 h).

A period is regarded as confirmed only when it recurs, with significant power and allowing for harmonics, in two or more independent sectors (upper blocks of Tables I-II); objects detected in a single sector are candidates (lower blocks). For confirmed objects the tabulated period is the mean of the per-sector values, and the uncertainty is the larger of the formal least-squares error (Montgomery and O'Donoghue, 1999) and the sector-to-sector scatter (the standard deviation of the per-sector periods, or half their difference when only two sectors are available). For single-sector candidates only the formal error can be quoted; it is a lower bound that excludes the systematic contribution which dominates the multi-sector error budget.

Every object was also screened for non-principal-axis (tumbling) rotation, which would appear as a second, incommensurate frequency (Pravec et al., 2005). Candidates were tested by removing the primary period and searching the residuals for a coherent second tone, and with a phase-coherence check: a genuine frequency maintains phase across the full sector, whereas red noise, strong in short segments, does not. None of the nineteen objects shows a second frequency down to a residual spectral power of ~ 0.10 , corresponding to a second-component amplitude of roughly 0.1 mag at the typical noise level. Lower-amplitude tumbling cannot be excluded: a relevant caveat, since damping timescales for km-scale rotators at $P_{\text{rot}} > 30 \text{ h}$ can exceed the age of the solar system (Pravec et al., 2005).

Number	Name	yyyy mm/dd	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E.	Amp	A.E.	Sec	Grp
10667	van Marxveldt	2019 10/28-10/30	4.3, 3.4	37	5	20.3	0.6	0.36	0.03	17	H
		2026 01/22-02/01	25.6, 23.0	160	-27					99	
		2026 02/03-02/28	22.6, 17.1	162	-27					100	
23452	Drew	2021 09/02-09/12	*5.7, 7.2	347	-7	3.77198	0.00035	0.41	0.02	42	H
24687	1990 HW	2018 09/24-10/14	*18.2, 18.9	8	-30	4.0981	0.0004	0.43	0.03	3	H
		2020 03/23-04/15	22.6, 19.6	201	29					23	
		2023 06/05-06/19	*6.3, 9.8	266	-7					66	
39866	1998 DB24	2023 04/06-04/18	19.4, 17.8	213	-25	44.77	0.28	0.89	0.02	64	H
		2026 06/14-06/20	16.6, 14.2	278	-18					105	
43357	2000 UM19	2023 03/16-04/02	*11.7, 12.9	181	-16	34.050	0.013	0.48	0.02	63	H
45825	2000 QW123	2026 01/22-02/01	22.6, 19.5	142	-26	33.713	0.021	0.63	0.03	99	H
53422	1999 RN30	2023 09/20-10/05	*1.1, 5.9	5	1	26.602	0.013	0.60	0.03	70	H
55720	Daandehoop	2020 10/22-11/09	*18.5, 19.4	44	-25	10.4668	0.0010	0.74	0.03	31	H
56351	2000 AN93	2025 07/26-08/19	*7.7, 12.1	319	-10	33.888	0.009	0.67	0.03	95	H
58098	Quirrenbach	2024 01/30-02/15	21.9, 20.6	144	33	56.54	0.33	0.64	0.04	75	H
		2025 08/20-09/02	*22.0, 22.2	333	-33					96	
66195	1999 AN25	2022 10/05-10/28	*19.2, 20.6	29	25	52.400	0.010	0.67	0.01	57	H
71737	2000 PV6	2021 02/07-02/08	13.7, 13.7	140	-19	4.292	0.011	0.58	0.07	34	H
74511	1999 FH8	2021 08/23-09/13	*4.0, 10.8	345	-7	16.899	0.008	0.34	0.02	42	H
		2023 04/10-05/01	10.8, 17.2	203	-17					64	
76865	2000 XW38	2019 10/30-11/01	15.3, 15.1	39	25	2.294	0.005	0.24	0.03	17	H
		2021 04/29-05/19	*17.5, 19.6	233	-25					38	
		2022 12/15-12/22	*8.5, 9.3	87	14					59	
86420	2000 BT2	2022 02/15-02/24	8.2, 9.3	146	13	8.211	0.009	0.34	0.03	48	H
		2023 09/20-10/03	2.0, 11.0	355	2					70	
		2025 03/19-04/07	*4.6, 7.7	189	-7					90	
92227	2000 AU95	2021 12/31-01/27 [†]	*7.5, 13.9	108	10	46.587	0.027	0.97	0.03	47	H
		2025 02/26-03/11	*10.9, 12.7	164	-15					89	
97779	2000 KA67	2020 12/13-12/16	13.7, 13.6	82	-22	7.011	0.008	0.94	0.09	32	H
147449	2003 YQ154	2020 01/21-01/30	*8.2, 9.0	124	11	33.555	0.008	0.73	0.02	21	H
		2023 04/06-05/03	*18.3, 21.4	205	-27					64	
200474	2000 XD46	2020 02/20-03/17	*6.2, 12.3	160	8	7.1426	0.0007	0.55	0.03	22	H
		2024 11/01-11/20	*18.8, 19.9	54	25					85	

Table I. Observing circumstances and results, one line per TESS sector in which the period is detected. The phase angle is given for the first and last date of each sector span; an asterisk indicates that it reached an extremum within the span. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude and latitude at mid-date range (see Harris et al., 1984). The adopted period and amplitude are given on each object's first line. Sec is the TESS sector; Grp: H = Hungaria (Warner et al., 2009). Objects are listed in numerical order. [†] Observation ending in 2022.

Results

Table II lists the nineteen adopted periods together with absolute magnitudes (H , from the JPL Small-Body Database) and diameters estimated assuming $p_v = 0.35$, typical of E-type Hungarias. Seventeen of the periods are absent from the LCDB (2023 October release; online query verified 2026 July 10), and fourteen are to our knowledge first determinations; the five objects with prior or concurrent determinations (76865, 56351, 24687, 53422, 97779) are discussed under Individual objects. Figure 1 shows the folded lightcurves of the ten confirmed objects and Figure 2 those of the nine candidates. The confirmed periods span 2.29 - 56.54 h; the four confirmed slow rotators ($P_{\text{rot}} > 30$ h) all display directly verified double-peaked lightcurves with amplitudes 0.64 - 0.97 mag, implying elongations up to $a/b \approx 2.4$ at the observed phase angles. Amplitudes are as observed at the phase angles of Table I, without correction to zero phase angle (Zappalà et al., 1990), and may be slightly diluted by background flux in TESS's 21-arcsec pixels. Among the candidates, the amplitude criterion places four more objects (45825, 56351, 43357, 66195) beyond 30 h; several of the doubled folds in Figures 1-2 show mildly unequal alternating extrema, consistent with the adopted solutions. The high proportion of slow rotators (8 of 19) reflects TESS's uninterrupted 27-day coverage and this survey's faint-limit selection (long-period, high-amplitude variations are the easiest to detect at low signal-to-noise) and should not be read as the underlying Hungaria spin distribution.

Individual Objects

10667 van Marxveldt has a larger period uncertainty because its densest sectors are noisy and the fold is shallow.

(24687) 1990 HW and (53422) 1999 RN30 appear in the untargeted TESS Cycle 1 rotation survey of McNeill et al. (2023), which reports 4.0992 h and 26.6107 h, matching our adopted 4.0981 ± 0.0004 h and 26.602 ± 0.013 h to 0.03%. For (53422) the Cycle 1 detection comes from an earlier apparition than our Sector 70 lightcurve and thus provides an effective second epoch; we raise its proposed quality code to $U = 2$. We note that all four externally matched periods (24687, 53422, 56351, 97779) equal twice our dominant photometric period, empirically supporting the amplitude-criterion doubling adopted in this paper.

(56351) 2000 AN93 has an LCDB entry: a sidereal period of 33.856 h ($U = 2$) from sparse-photometry lightcurve inversion (Durech et al., 2020). Our dense single-sector lightcurve gives a synodic $P_{\text{rot}} = 33.888 \pm 0.009$ h, adopted via the amplitude criterion, in agreement to 0.1%. The independent concordance both secures the period and validates the amplitude-based doubling; we accordingly raise its proposed quality code to $U = 2$.

58098 Quirrenbach, (92227) 2000 AU95, (39866) 1998 DB24, and (147449) 2003 YQ154 are further verified double-peaked slow rotators with well-defined, high-amplitude curves; the two sectors of (147449) agree in P_{phot} to 0.04%.

(76865) 2000 XW38 has an LCDB entry: an ambiguity-flagged ($U = 1$) period of 5.14 h from sparse wide-field photometry, twice the 2.57 h reported by Chang et al. (2016) from Palomar Transient Factory data. Our three independent TESS sectors give 2.294 ± 0.005 h; the sparse 2.57 h solution is consistent with a diurnal alias of this period, an artifact of ground-based sampling that continuous TESS coverage excludes.

(97779) 2000 KA67 shows the largest amplitude of the sample ($\Delta m = 0.94$): $P_{\text{phot}} = 3.505$ h, adopted $P_{\text{rot}} = 7.011$ h. Its two other extracted apparitions are > 1 mag fainter and below the detection threshold, so it cannot yet meet the two-sector criterion, but the single-sector detection itself is unambiguous (spectral power 0.61, formal false-alarm probability $< 10^{-50}$). Moreover, a convex-inversion model from Gaia DR3 photometry independently gives a sidereal period of 7.0057 h (Durech and Hanuš, 2023), matching our adopted period and supporting the doubled solution; we raise its proposed quality code to $U = 2$.

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Number	H	D (km)	P_{phot} (h)	LC	N	U
10667	15.25	2.0	20.293	S*	3	2
23452	15.33	1.9	1.8860	D [†]	1	2-
24687	15.06	2.2	2.0491	D [†]	3	2+
39866	14.76	2.5	22.387	D	2	3-
43357	15.64	1.7	17.025	D [†]	1	2-
45825	15.21	2.0	16.857	D [†]	1	2-
53422	15.92	1.5	13.301	D [†]	1	2
55720	15.76	1.6	5.2334	D [†]	1	2-
56351	15.35	1.9	16.944	D [†]	1	2
58098	15.20	2.0	28.272	D	2	3-
66195	15.24	2.0	26.200	D [†]	1	2-
71737	15.35	1.9	2.1460	D [†]	1	2-
74511	15.74	1.6	16.899	S*	2	2
76865	15.07	2.2	2.2942	S	3	2+
86420	15.54	1.8	8.2110	S*	3	2
92227	16.00	1.4	23.293	D	2	3-
97779	15.46	1.8	3.5054	D [†]	1	2
147449	15.35	1.9	16.777	D	2	3-
200474	16.00	1.4	3.5713	D [†]	2	2+

Table II. Physical parameters and lightcurve classification. H is from the JPL Small-Body Database; the diameter D assumes $p_v = 0.35$. P_{phot} is the dominant photometric period; the adopted rotation periods and amplitudes are in Table I. LC: D = double-peaked, doubling verified by significantly unequal alternating extrema; D[†] = doubled on the amplitude criterion ($\Delta m > 0.4$ mag); S = single-peaked; S* = single-peaked tabulated, but the true period may be twice the tabulated value. N = number of sectors with an independent detection; U = proposed LCDB quality code. Objects are listed in numerical order; single-sector candidates are those detected in one sector.

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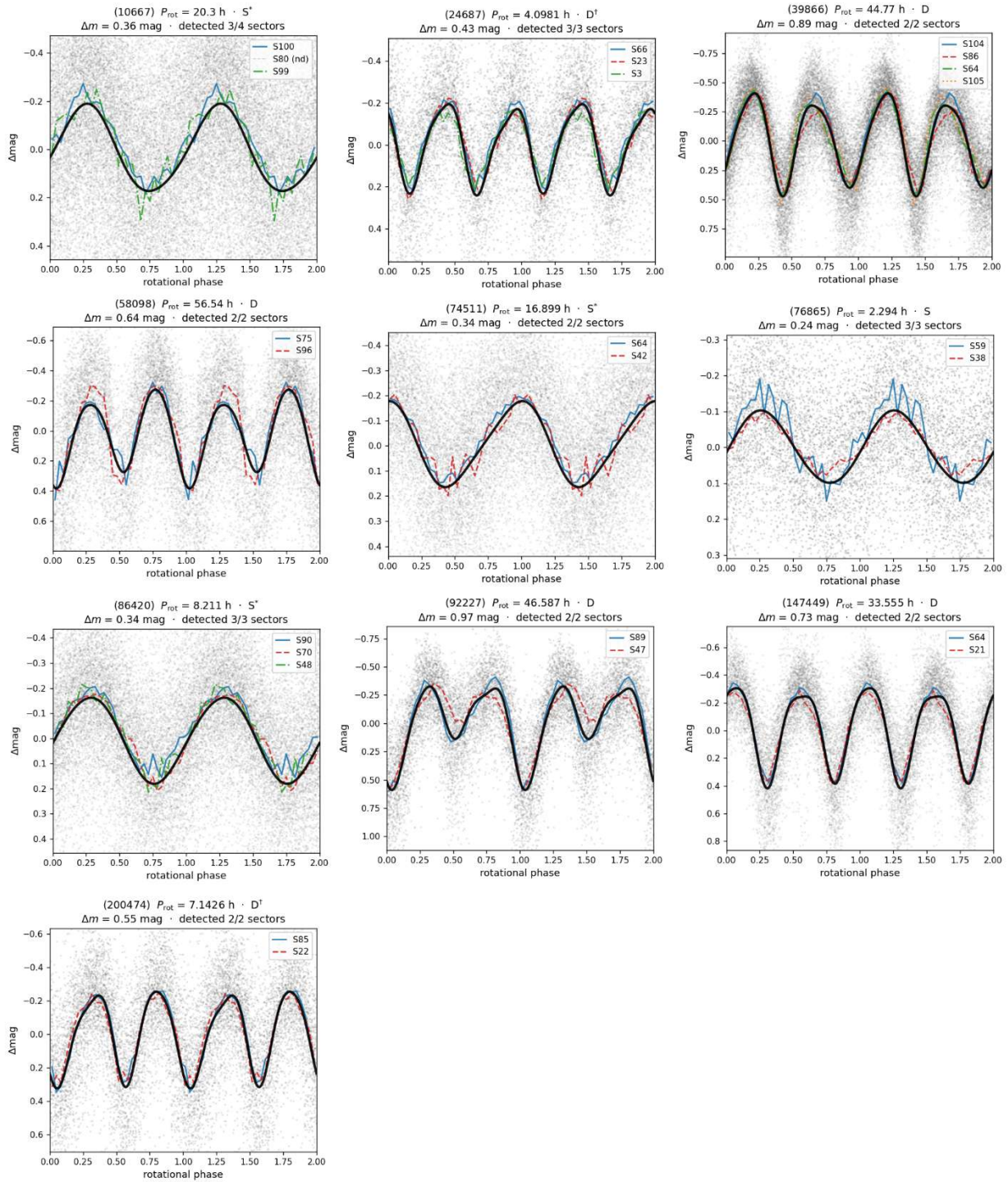


Figure 1. Folded lightcurves of the ten confirmed objects, in numerical order. Each panel folds all extracted sectors at the adopted P_{rot} of Table II, with per-sector phase zero-points aligned (multi-year sectors cannot be absolutely phase-connected). Gray points show the pooled photometry; thin curves are the per-sector binned medians, with line styles distinguishing sectors and "nd" marking sectors without an independent detection; the heavy curve is a Fourier model of the detecting sectors. Sectors with too few points to bin are omitted from the display but included in the header counts.

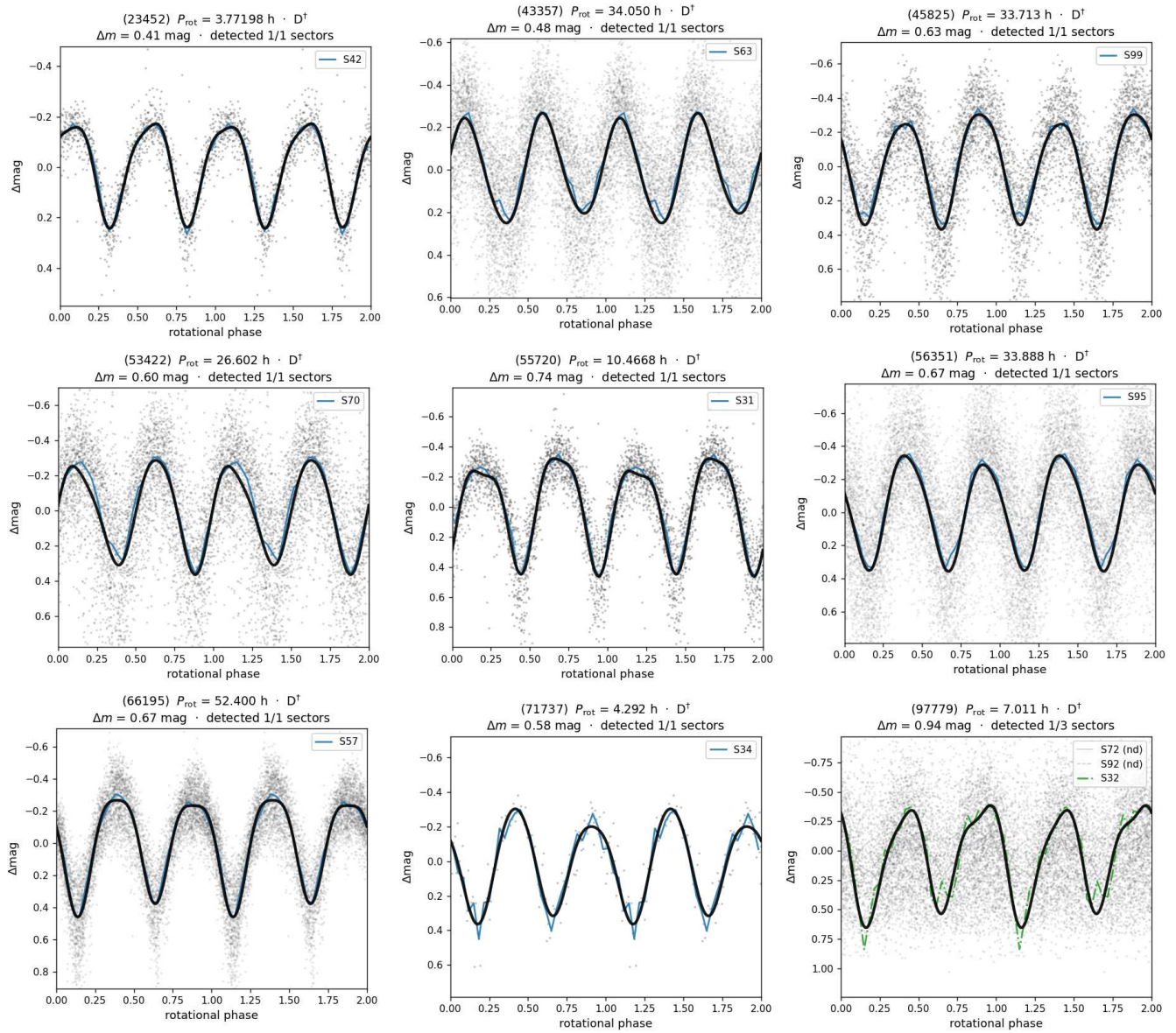


Figure 2. Folded lightcurves of the nine single-sector candidates, in numerical order. Symbols as in Figure 1.

LIGHTCURVE ANALYSIS FOR TEN NEAR-EARTH ASTEROIDS OBSERVED IN 2011 AND FROM APRIL TO JUNE 2026

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Lightcurves and amplitudes for ten near-Earth asteroids observed from Great Shefford Observatory during close approaches in 2011 and from April to June 2026 are reported. All are small objects and nine have rotation periods significantly shorter than the spin barrier at ~ 2.2 h. Four are identified as having tumbling rotation.

Photometric observations of near-Earth asteroids during close approaches to Earth in 2011 and from April to June 2026 were made at Great Shefford Observatory using a 0.40-m Schmidt-Cassegrain and Apogee Alta U47+ CCD camera. All observations were made unfiltered and with the telescope operating with a focal reducer at $f/6$. The $1K \times 1K$, 13-micron CCD was binned 2×2 resulting in an image scale of 2.16 arcsec/pix. All the images were calibrated with dark and flat frames and *Astrometrica* (Raab, 2025) was used to measure photometry using G band data from the Gaia DR3 catalogue. *MPO Canopus* (Warner, 2023), incorporating the Fourier algorithm developed by Harris (Harris et al., 1989) was used for lightcurve analysis.

No previously reported results have been found in the Asteroid Lightcurve Database (LCDB) (Warner et al., 2009), from searches via the Astrophysics Data System (ADS, 2026) or from wider searches unless otherwise noted. All size estimates are calculated using H values from the Small-Body Database Lookup (JPL, 2026a) unless otherwise noted, using an assumed albedo for NEAs of 0.2 (LCDB readme.pdf file) and are therefore uncertain and offered for relative comparison only.

2011 EU20. This is a small Apollo ($H = 27.3$, $D \sim 10$ m) discovered by the Mt. Lemmon Survey on 2011 Mar 8.3 UTC and which subsequently passed Earth at a geocentric distance of 1.6 Lunar Distances (LD) on 2011 Mar 11.43 UTC (Urakawa et al., 2011). It is listed by the Sentry impact monitoring service (JPL, 2026b) and Clomon-2 (NEODyS, 2026) as a virtual impactor with just a few extremely low probability chances ($\leq 1.0 \times 10^{-8}$) of potential impacts.

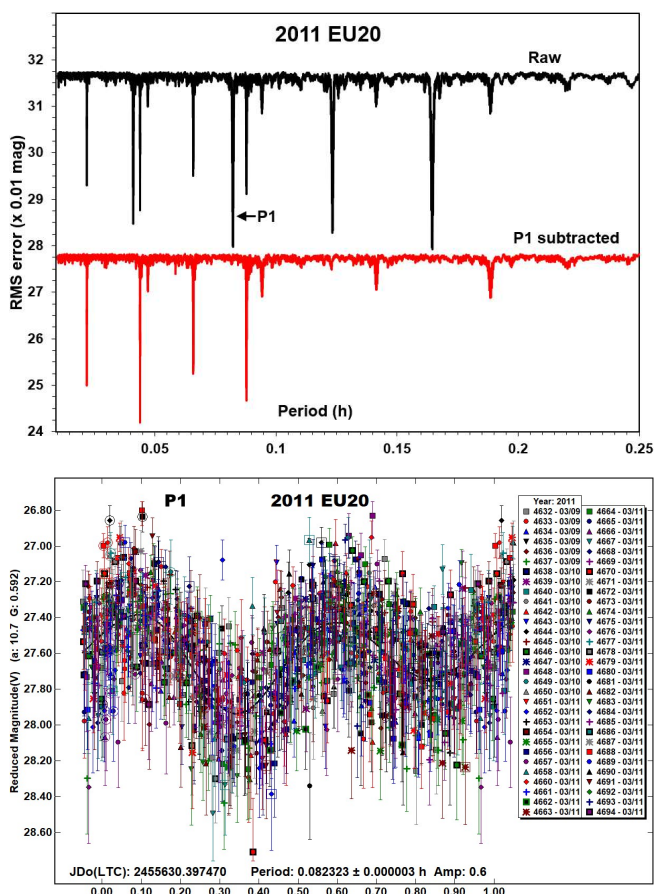
It was observed for 1.3 h starting on 2011 Mar 9.90 UTC when the phase angle was 10° and again for 6.2 h starting on 2011 Mar 10.94 UTC, when the phase angle increased from 21° to 36° , the minimum phase angle for this opposition of 5° was reached between these sessions on 2011 Mar 10.4 UTC. Independent period spectra for the two dates produces similar results and the linearly scaled figure here is from the combination of both dates. The best-fit rotation period is at ~ 0.0823 h, marked as “P1” in the period spectrum line labelled “Raw” and the 4th order reduction also gives weaker but related minima at $\times 1/2$, $\times 3/2$ and $\times 2$ this value, equating to monomodal,

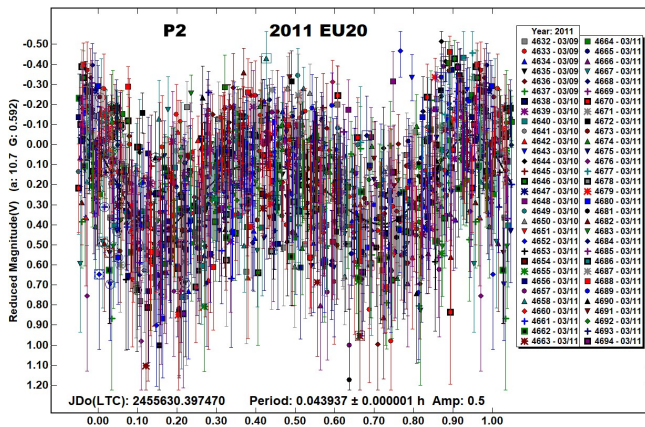
trimodal and quadrimodal lightcurves. However, there are other significant minima in the Raw spectrum suggesting that the object has non-principal axis (NPAR), or tumbling rotation. The *MPO Canopus* Dual Period Search function was used to subtract the effect of the dominant period to produce the period spectrum labelled “P1 subtracted”, with two different sets of equally spaced minima remaining, the strongest solution being at ~ 0.0439 h and a much weaker one at ~ 0.0944 h. The best-fit NPAR solution is found to be:

$P1 = 0.082323 \pm 0.000003$ h (~ 4.9 min), amplitude 0.6

$P2 = 0.043937 \pm 0.000001$ h (~ 2.6 min), amplitude 0.5

Lightcurves for this solution are labelled P1 and P2. A weaker NPAR solution, consisting of the same dominant P1 period but with a secondary period P3 of 0.0944 h appears to be related to the best-fit solution, as P3 is just a linear combination of the frequencies of P1 and P2, where $1/P2 - 1/P1 \sim 1/P3$ suggesting that P2 or P3 is just an alias of the real secondary period. On the scale defined in Pravec et al., (2005) this equates to a code of $PAR = -3$ (NPA rotation reliably detected with the two periods resolved), even when there are ambiguities like this, as long as the resulting spectrum of frequencies with significant signal is the same for the different solutions. The full amplitude suggested by the P1-P2 NPAR solution on the first date, when the phase angle was smallest and amplitude expected to be lowest is ~ 0.9 magnitudes. On the first and second dates, 2011 EU20 completed 15 and 75 rotations of the P1 period respectively and 29 and 141 rotations of the P2 period.

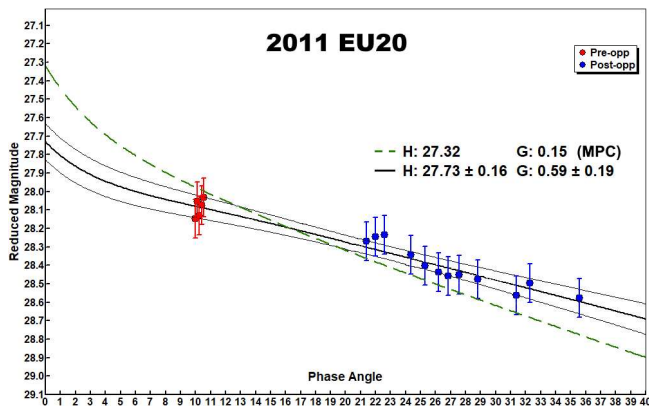




It is noted that between the first and second dates, 2011 EU20 brightened by ~ 0.23 mags more than predicted using a value of $G = 0.15$ in the H-G system. During this time the phase angle ranged from 9.9° - 35.9° . The Minor Planet Center lists 2011 EU20 with a value of $H = 27.32$ and a presumably assumed value of $G = 0.15$ (MPC, 2026a). An estimate of the potential H-G parameters required to satisfy the observed magnitudes was made by reducing all the magnitudes to unit distance from Earth and Sun, converting the unfiltered, G-band measured photometry to V using $V - G = 0.28$ (MPC, 2026b) and then forming 17 points, 5 from the 1st night and 12 from the 2nd night. Each point is the mean of 40-100 reduced measurements obtained over intervals of 12-29 minutes. As these intervals span 2.4-5.8 rotation periods of P1, each point provides an approximation of the mean magnitude of the rotational lightcurve. The points were added into the *MPO Canopus* H/G Calculator with an assumed error of 0.1 mags and the best-fit solution was found to be:

$$H = 27.73 \pm 0.16, G = 0.59 \pm 0.19$$

The magnitude-phase figure includes this solution together with a dashed curve representing the MPC's H-G parameters. The large value of G determined here may be consistent with 2011 EU20 having a high albedo, similar to asteroids with an E-type taxonomy.



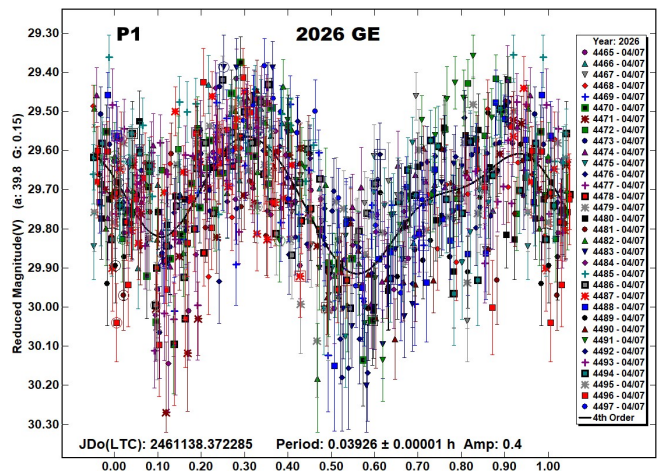
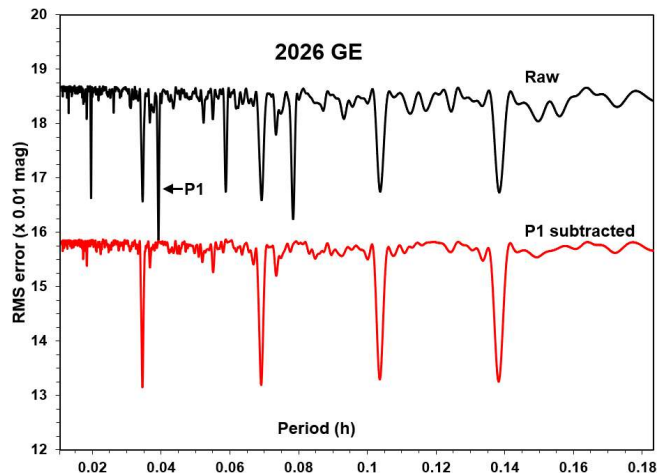
2026 GE. This small Apollo ($H = 28.4$, $D \sim 6$ m) was discovered at the Piskésető Mountain Station of the Konkoly Observatory on 2026 Apr 6.8 UTC and it passed Earth at 0.46 LD on 2026 Apr 8.04 UTC (Bacci et al., 2026). Photometry was collected for 86 minutes starting at 2026 Apr 7.87 UTC when it was at a distance of 0.6 LD

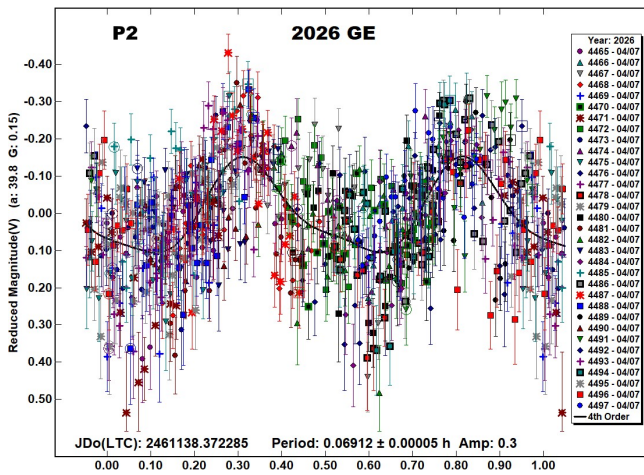
and due to the rapid and increasing apparent speed exposures were gradually reduced from 1.7 s to 1.3 s. Initial lightcurve analysis indicated the best-fit rotation period was ~ 0.0393 h (~ 2.4 min), labelled "P1" in the period spectrum figure, but the resulting period spectrum labelled "Raw" revealed indications that the object is tumbling. The *MPO Canopus* Dual Period Search function was used to subtract the effect of the dominant period to produce the period spectrum labelled "P1 subtracted", helping to isolate a well-defined set of minima at integer multiples of 0.0346 h, with the best-fit NPAR solution being:

$$P1 = 0.03926 \pm 0.00001 \text{ h } (\sim 2.4 \text{ min}), \text{ amplitude } 0.4$$

$$P2 = 0.06912 \pm 0.00005 \text{ h } (\sim 4.1 \text{ min}), \text{ amplitude } 0.2$$

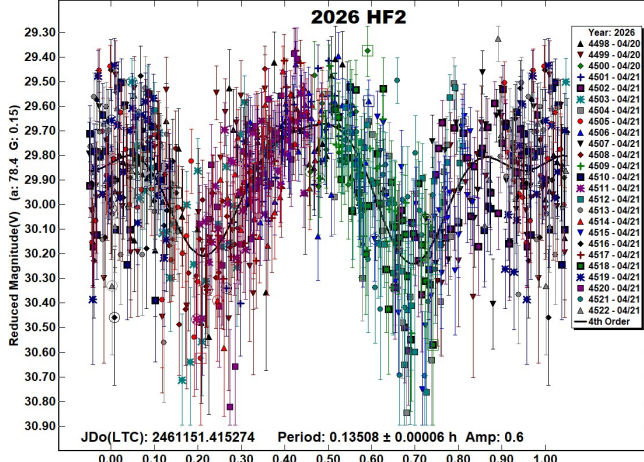
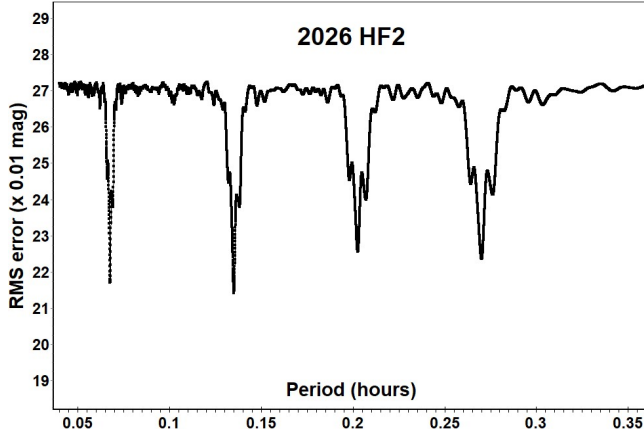
Another much weaker set of minima at integer multiples of 0.0184 h can be seen in the "PAR subtracted" period spectrum, with the period at $P3 = 0.03674$ h (~ 2.2 min) giving a bimodal solution, but this just appears to be an alias of P1 and P2, where $1/P1 + 2/P2 \sim 2/P3$. It is therefore expected that 2026 GE may be rated on the scale defined in Pravec et al., (2005) as $PAR = -3$ (NPA rotation reliably detected with the two periods resolved). The full amplitude suggested by the NPAR solution is ~ 0.6 magnitudes and during the 1.4 h of observation, 2026 GE completed 36 rotations of the P1 period and 20 of the P2 period.





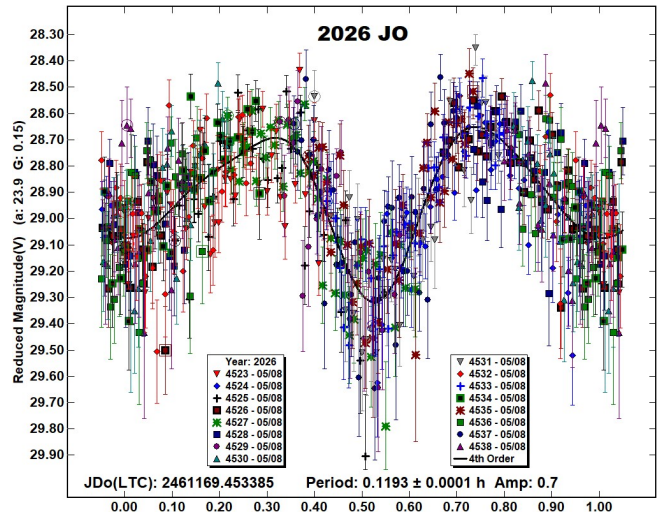
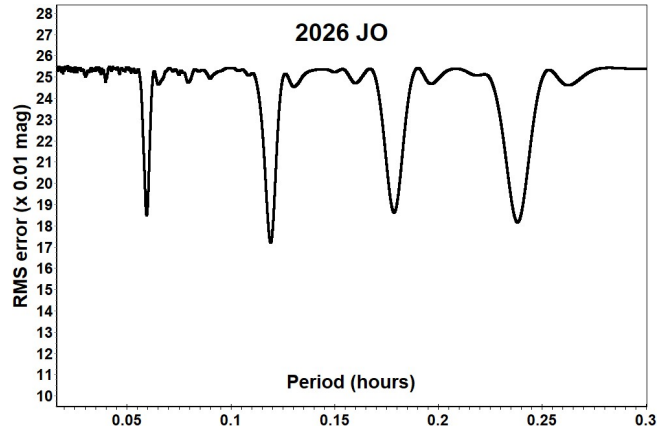
2026 HF2. This small Apollo ($H = 27.6$, $D \sim 9$ m) discovered by the Mt. Lemmon Survey on 2026 Apr 20.4 UTC passed Earth at a geocentric distance of 0.3 LD 20 hours later on 2026 Apr 21.2 UTC (Luongo et al., 2026). It is listed as a virtual impactor by impact monitoring services Sentry (JPL, 2026b), Clomon-2 (NEODyS, 2026) and Aegis (ESA, 2026), each indicating the first of a number of potential impacts is on 2098 Apr 21, with Sentry predicting a 1 in ~ 1800 chance of impact.

It was observed initially for 12 minutes starting at 2026 April 20.92 UTC and then again for 63 minutes 2 hours later and exposures were reduced from 3 s, down to 1.7 s as its distance decreased from 1.2 to 0.7 LD. Lightcurve analysis indicates a period of 0.13508 h (~ 8.1 min) and 0.6 mag amplitude. During the 75 minutes it was being observed it completed 9 rotations.



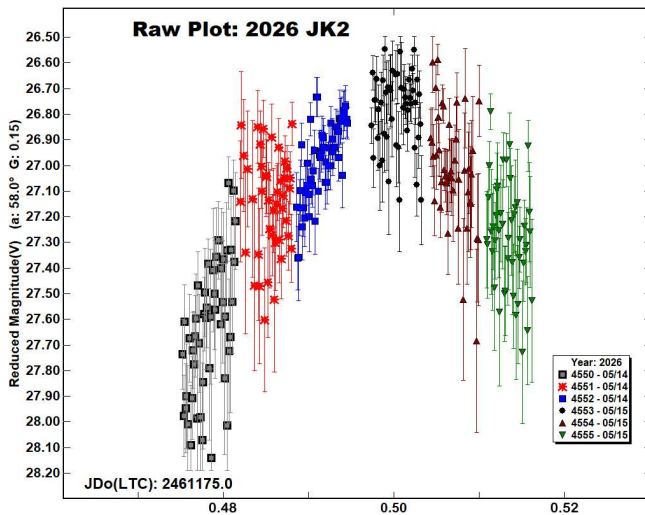
2026 JO. This Apollo ($H = 28.0$, $D \sim 7$ m) was discovered by the MAPS team from San Pedro de Atacama on 2026 May 8.2 UTC and it passed Earth at 0.35 LD 24 hours later (Ivanov et al., 2026).

Photometry was collected for 58 minutes starting at 2026 May 8.95 UTC and with the object at 0.8 LD, exposures were limited to 3 s or shorter to keep the length of trails within the *Astrometrica* measurement annulus. The rotation period of 0.1193 ± 0.0001 h (~ 7.2 min) indicates that 2026 JO completed 8 rotations during observation.



2026 JK2. This Apollo ($H = 25.6$, $D \sim 22$ m) is another flagged as virtual impactor and was discovered by the Mt. Lemmon Survey on 2026 May 11.4 UTC (Pittichova et al., 2026). The three impact monitoring systems, Sentry, Clomon and Aegis all agree in listing 2095 May 16 as the date of the first possible impact, with probabilities of at most $\sim 1.2 \times 10^{-6}$.

Photometry was collected for 58 minutes starting on 2026 May 14.98 UTC before conditions deteriorated, precluding further observation. Assuming 2026 JK2 has a bimodal lightcurve, the resulting partial lightcurve shown in the raw plot indicates the amplitude is likely to be ≥ 1 mag at a phase angle of 58° and the period likely to be > 4 h.

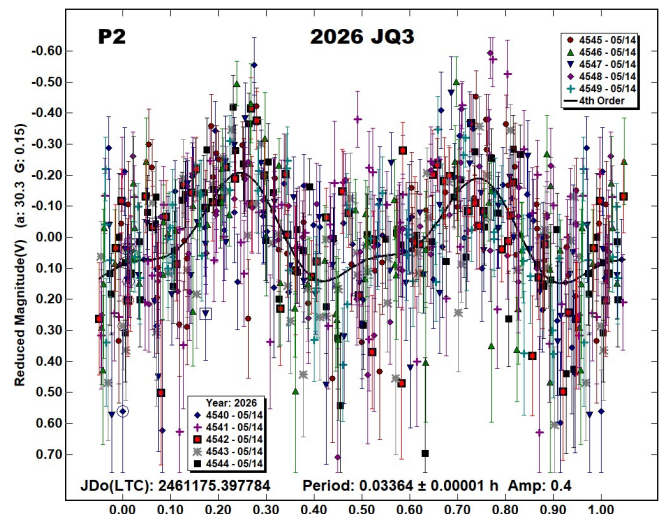
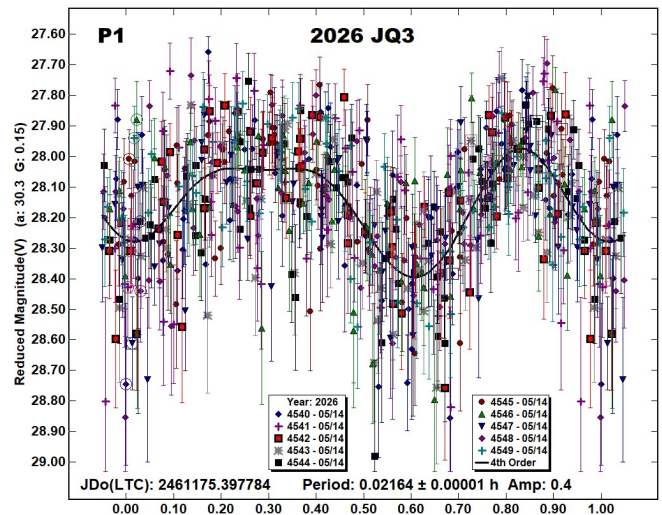
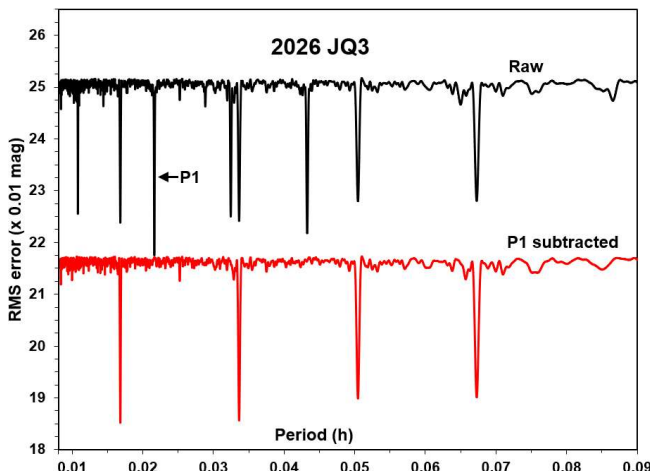


2026 JQ3. Another small Apollo ($H = 27.1$, $D \sim 11$ m) discovered by the Catalina Sky Survey on 2026 May 14.4 UTC, 28 hours before it passed Earth at 2 LD (Smith et al., 2026). It was observed for 100 minutes starting at 2026 May 14.90 UTC and a period spectrum from the initial lightcurve analysis is labelled “Raw” and shows a number of well-defined potential solutions. The best is at ~ 0.0216 h (~ 1.3 min) and is labelled “P1”. All the significant minima are integer multiples of either 0.0108 h or 0.0165 h and indicate tumbling rotation is likely to be present. The *MPO Canopus* Dual Period Search function was again used to subtract the effect of the dominant P1 period to produce the period spectrum labelled “P1 subtracted” and this shows the minima for the first and the second harmonics, at 0.0165 h and 0.0336 h are essentially of equal depth, with the longer period being selected here as the most likely second period of the NPAR solution, having a bimodal rather than monomodal lightcurve:

P1 = 0.02164 ± 0.00001 h (~ 1.3 min), amplitude 0.4

P2 = 0.03364 ± 0.00001 h (~ 2.0 min), amplitude 0.4

Again, with NPA rotation reliably detected with the two periods resolved, on the scale defined in Pravec et al., (2005), 2026 JQ3 may be rated as PAR = -3. The full amplitude suggested by the NPAR solution is ~ 0.8 magnitudes. 2026 JQ3 completed 77 rotations of the P1 period and 50 of the P2 period while under observation.



2026 KF. The MAPS team at San Pedro de Atacama discovered this Apollo ($H = 26.0$, $D \sim 19$ m) on 2026 May 16.17 UTC, almost 6 days ahead of an approach to within 1.7 LD of Earth on 2026 May 22.05 UTC (Ikari et al., 2026). It was observed for 2.4 h over a 3.5 h span starting on 2026 May 21.95 UTC. A period spectrum from the initial lightcurve analysis is labelled “Raw” and shows the best fit solution is at ~ 0.0114 h with the next best fit at double that value, but there are also a significant number of lesser minima present, again suggesting that tumbling may be present. The *MPO Canopus* Dual Period Search function was used to subtract the effect of the dominant P1 period to produce the period spectrum labelled “P1 subtracted” and this makes more obvious some other periodicities, the strongest being at ~ 0.0895 h. The best-fit NPAR solution is found to be:

P1 = 0.11389 ± 0.00006 h (~ 6.8 min), amplitude 0.9

P2 = 0.08955 ± 0.00003 h (~ 5.4 min), amplitude 0.7

But there are a number of weaker possible NPAR solutions, each combining the dominant P1 period with possible secondary period values of P3 = 0.0642 h, P4 = 0.0737 h or P5 = 0.0557 h. However, the frequencies of all these appear to be linear combinations of the frequencies of P1 and P2, i.e.

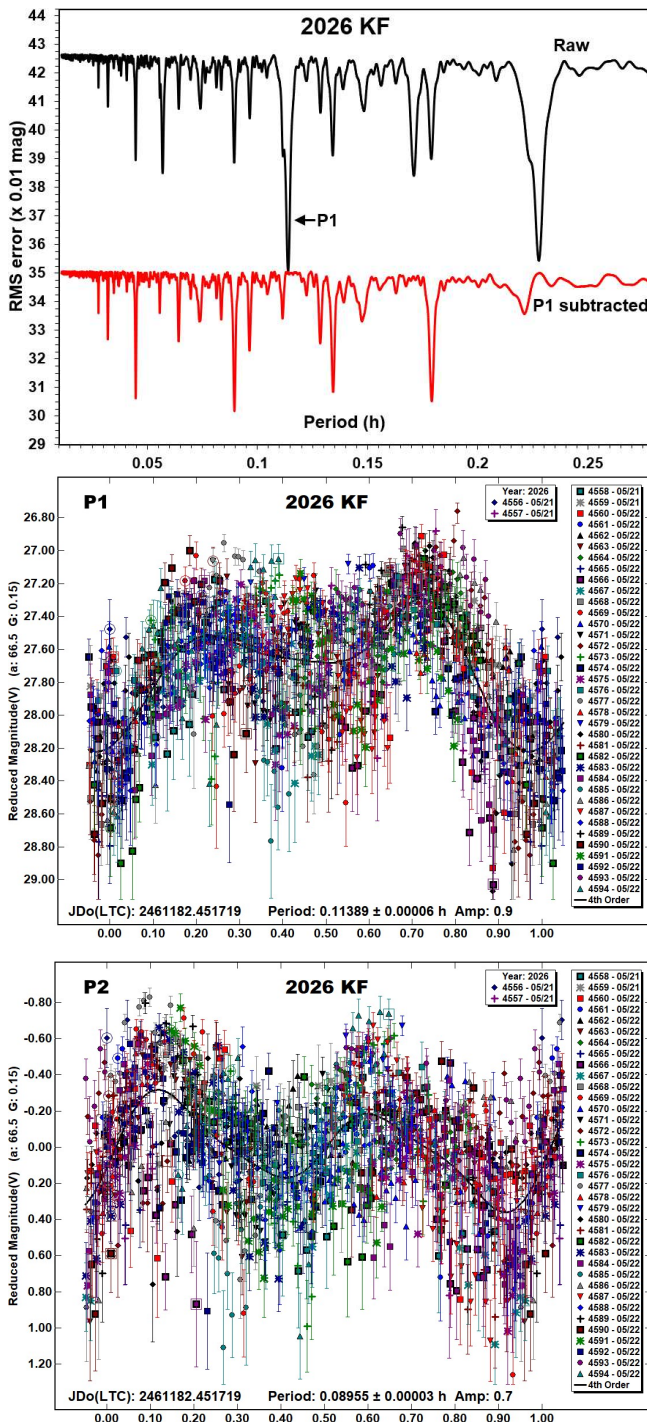
$$1/P_1 + 2/P_2 = 2/P_3$$

$$2/P_2 - 1/P_1 = 1/P_4$$

$$4/P_2 - 1/P_1 = 2/P_5$$

and are likely to be just aliases of the P1-P2 solution. So, even with those apparent ambiguities, it may be rated on the scale defined in Pravec et al. (2005) as another $\text{PAR} = -3$ result (NPA rotation reliably detected with the two periods resolved).

The full amplitude suggested by the NPAR solution is ~ 1.6 magnitudes. 2026 KF completed 20 rotations of the P1 period and 26 of the P2 period while under active observation.

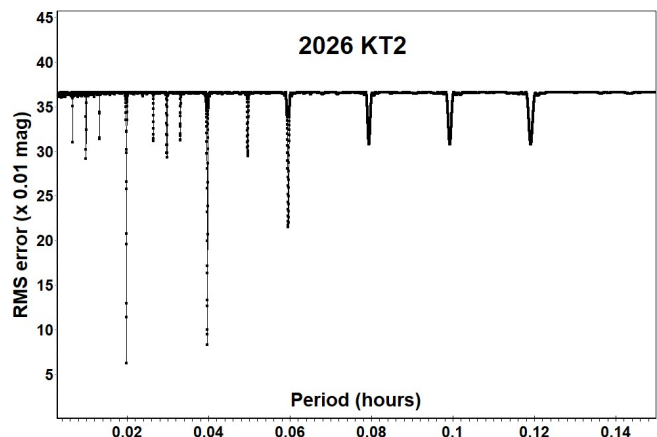


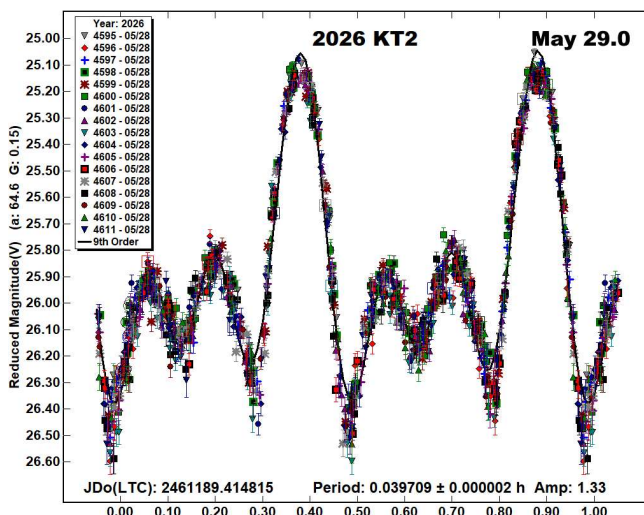
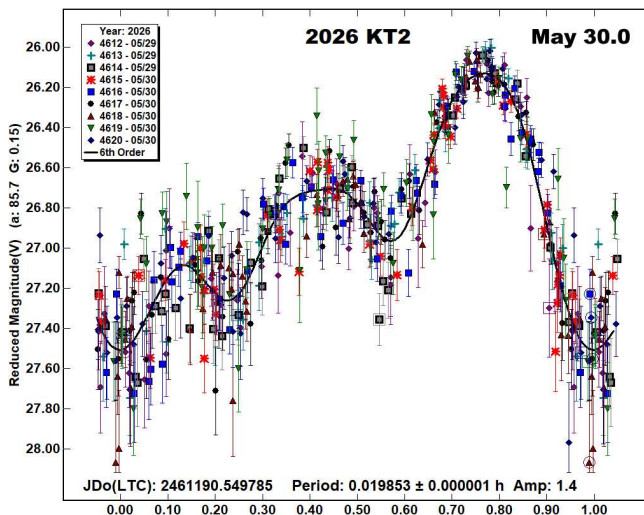
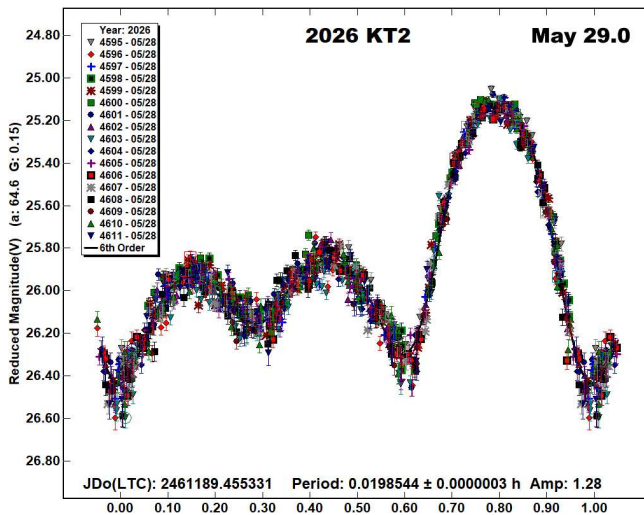
2026 KT2. Yet another discovery by the MAPS team, this Apollo ($H = 23.7$, $D \sim 55$ m) was found on 2026 May 24.99 UTC and passed Earth at 2.0 LD on 2026 May 28.53 UTC (Drummond et al., 2026). It was observed for 2 h starting on 2026 May 28.91 UTC when it was 14th mag and again for 3 h starting on 2026 May 29.96 UTC by which time it had faded by more than 2 magnitudes. Analysis of each night gives a similar best-fit rotation period, with the first night giving 0.0198544 ± 0.0000003 h (71.476 ± 0.001 s) but this produces an unusual tri-modal lightcurve for both dates, see the figures labelled May 29.0 and May 30.0, both aligned so that the minimum of each curve is at phase = 0 to aid comparison. For both nights, adopting a period twice as long produces a poorer fit. On the higher quality first night, for example, the RMS increases from 0.062 mag for the 71.5 s period to 0.083 mag when the period is doubled, an increase of approximately 33%. A phased lightcurve for the double length period is also given for that first date, using a 9th order fit, the curve requiring a remarkable symmetry between the two opposing hemispheres presented toward the observer.

Although unusual, it is not impossible for a tri-modal solution to be found at a phase angle of 65° (Butkiewicz-Bąk et al., 2017) and, together with the superior RMS, the shorter period is adopted here.

A consequence of that choice is that on the second night, when exposures were 16 s, the integration time (Δt) would be a relatively large fraction of the period P , i.e. $\Delta t / P = 16 / 71.5 = 0.224$. The optimum integration time required to detect the second (and normally strongest) harmonic in a lightcurve is developed in Pravec et al. (2000) and found to be $0.185 P$ which in this case would be 13 s. However, for 2026 KT2, where the third harmonic has significant strength, the equivalent optimum integration time for the third harmonic is shorter, at $0.124 P$, or 9 s. The 16 s exposures likely reduced the apparent amplitude significantly, which may explain why the measured amplitude increased by only 0.1 magnitudes (from 1.3 to 1.4) despite the phase angle increasing from 65° to 86° over the two nights. Fortunately, on the first night the 4.8 s exposures were short enough for lightcurve smoothing to be negligible.

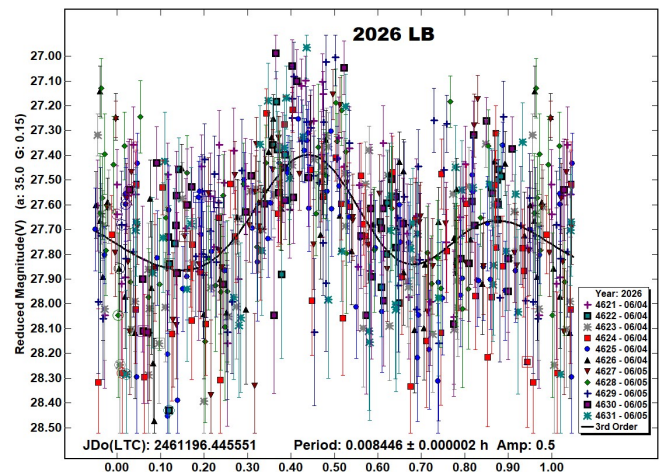
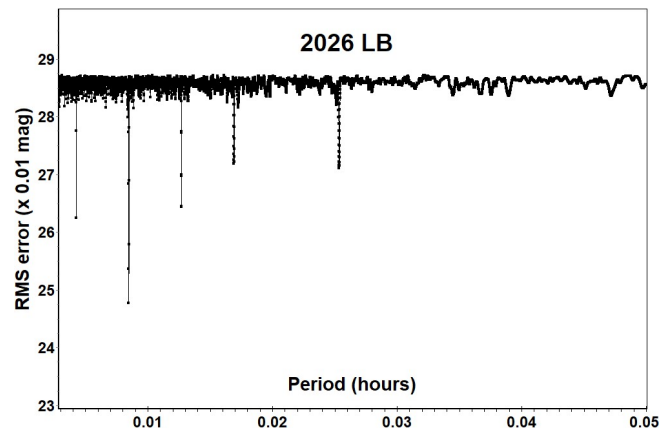
Similar results have been reported for 2026 KT2 by several other observers in a thread on the Minor Planet Mailing List (MPML, 2026a; 2026b). A. Diepvens reported the longer period of 0.001654 ± 0.000004 d = 142.9 ± 0.4 s, from observations started on 2026 May 28.88 UTC using a 0.20-m f/6.75 refractor (Diepvens, 2026). Å Fornas reported the shorter period of 1.1926 ± 0.0006 min = 71.53 ± 0.04 s from observations started on 2026 May 27.89 UTC using a 0.61-m reflector, noting that the period could also be double that given (Fornas, 2026).



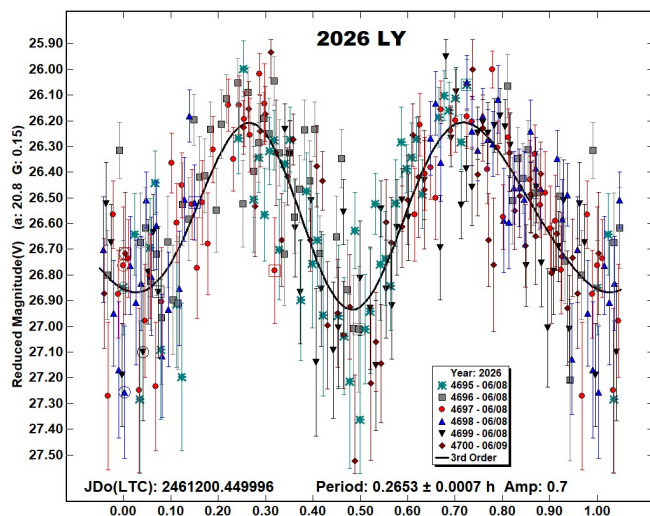
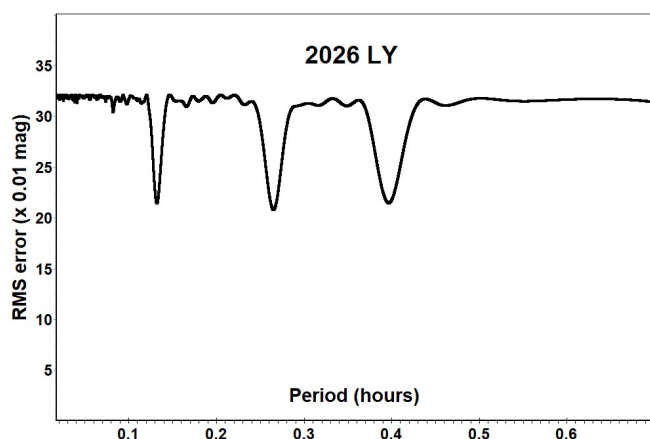


2026 LB. This Amor ($H = 26.6$, $D \sim 14$ m) was discovered by the Catalina Sky Survey on 2026 June 3.33 UTC and made an approach to within 3.7 LD of Earth on 2026 June 5.7 UTC (Pettarin et al., 2026). It was observed for 2.3 h starting on 2026 June 4.95 UTC when it was at 3.8 LD and moving at 50 arcsec/min, but at 18th mag was relatively faint for the equipment. Despite that, the resulting period spectrum reveals a clear solution with a period of 0.008446 ± 0.000002 h (~ 30.4 s), even though overall scatter in the solution is ~ 0.25 mag. It is noted that 52% of the exposures used were 8 s long and this integration time (Δt) is a relatively large fraction of the period P , i.e. $\Delta t / P = 8 / 30.4 = 0.263$ and is likely to have caused some lightcurve smoothing (Pravec et al., 2000). With the second harmonic dominating in this case, the apparent amplitude may be only $\sim 60\%$ of the true amplitude, implying that the true amplitude may have been ~ 0.8 mag.

During the period of observation, 2026 LB completed 278 rotations, averaging ~ 2 photometry points per rotation.



2026 LY. Discovered at the Palomar Mountain--ZTF facility on 2026 June 8.3 UTC, this Aten ($H = 25.6$, $D \sim 22$ m) had already passed Earth at 5 LD on 2026 June 7.97 UTC (Dupouy et al., 2026). It was observed for 80 minutes starting at 2026 June 8.95 UTC when it was at 6 LD and about 9 hours before opposition, with the phase angle at 20° and decreasing. 2026 LY completed 5 rotations while under observation.



Number	Name	Integration times	Max intg/Pd	Min a/b	Pts	Flds
2011	EU20	2-6	0.038 ²	1.9 ⁵	1218	62
2026	GE	1.3-1.7	0.006 ²	1.3 ¹	775	33
2026	HF2	1.7-3.0	0.006	1.2 ¹	823	25
2026	JO	2.2-2.8	0.007	1.4	596	16
2026	JK2	7.9-8.6	<0.001	>1.4 ¹	278	6
2026	JQ3	6.1-6.3	0.081 ²	1.5	604	10
2026	KF	1.5-2.2	0.007 ²	1.6 ¹	1254	39
2026	KT2	4-4.8	0.067	1.5 ¹	915 ³	17
2026	KT2	15.8-16	0.224	1.4 ¹	438 ⁴	9
2026	LB	6-8	0.263	1.2	538	11
2026	LY	8.9-9.2	0.010	1.5	280	6

Table I. Ancillary information, listing the integration times used (seconds), the fraction of the period represented by the longest integration time (Pravec et al., 2000), the calculated minimum elongation of the asteroid (Zappala et al., 1990), the number of data points used in the analysis and the number of times the telescope was repositioned to different fields. Note: 1 = Value uncertain, based on phase angle > 40°, 2 = Calculated using the shorter of the NPAR periods, 3 = Data for 2026 May 29.0, 4 = Data for 2026 May 30.0, 5 = Calculated for 2011 Mar 9.9 when phase angle was 10°.

Acknowledgements

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

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Number	Name	yyyy mm/dd	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E.	Amp	A.E	PAR	H
	2011 EU20	2011 03/09-03/11	*10.6, 35.9	176	2	0.082323	0.000003	0.6	0.3	-3	27.2
						0.043937	0.000001	0.5	0.3		
	2026 GE	2026 04/07-04/07	39.2, 40.2	179	-5	0.03926	0.00001	0.4	0.2	-3	28.4
						0.06912	0.00005	0.3	0.2		
	2026 HF2	2026 04/20-04/21	78.5, 87.0	205	41	0.13508	0.00006	0.6	0.3		27.6
	2026 JO	2026 05/08-05/08	23.7, 26.8	238	8	0.1193	0.0001	0.7	0.2		28.0
	2026 JK2	2026 05/14-05/15	57.9, 59.0	239	29	>4		≥1			25.6
	2026 JQ3	2026 05/14-05/14	30.1, 29.5	220	5	0.02164	0.00001	0.4	0.3	-3	27.1
	2026 KF	2026 05/21-05/22	66.7, 81.6	273	20	0.03364	0.00001	0.4	0.3	-3	26.0
						0.11389	0.00006	0.9	0.4		
	2026 KT2	2026 05/21-05/22	66.7, 81.6	273	20	0.08955	0.00003	0.7	0.4	-3	26.0
						0.0198544	0.0000003	1.28	0.09		
		2026 05/28-05/28	64.5, 67.1	237	32	0.0198544	0.0000003	1.28	0.09		23.7
		2026 05/29-05/30	85.7, 86.8	258	43	0.019853	0.000001	1.4	0.2		
	2026 LB	2026 06/04-06/05	34.9, 34.1	257	17	0.008446	0.000002	0.5	0.3		26.6
	2026 LY	2026 06/08-06/09	20.7, 20.1	252	9	0.2653	0.0007	0.7	0.3		25.6

Table II. Observing circumstances and results. The phase angle is given for the first and last date. If preceded by an asterisk, the phase angle reached an extrema during the period. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude/latitude at mid-date range (see Harris et al., 1984). Amplitude error (A.E.) is calculated as $\sqrt{2} \times$ (lightcurve RMS residual). PAR is the expected Principal Axis Rotation quality detection code (Pravec et al., 2005) and H is the absolute magnitude at 1 au from Sun and Earth taken from the Small-Body Database Lookup (JPL, 2026a).

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COLLABORATIVE ASTEROID PHOTOMETRY FROM UAI: 2026 APRIL-JUNE

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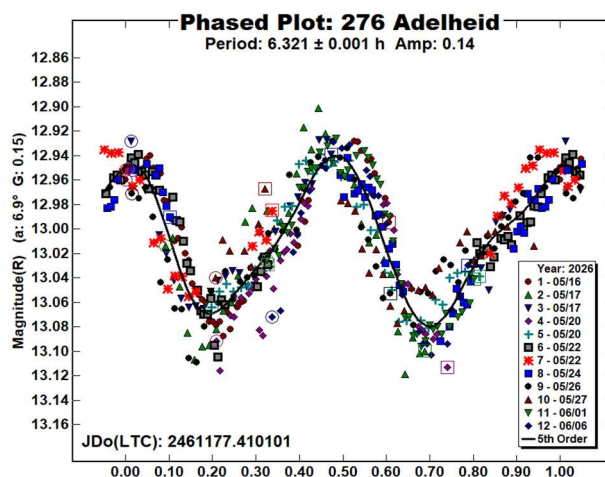
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(Received: 2026 July 14)

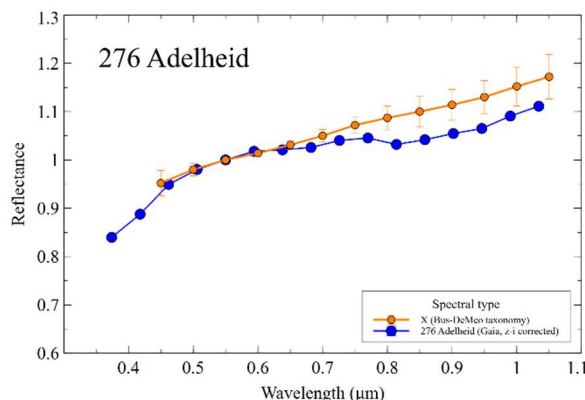
Photometric observations of six asteroids were collected to contribute to their physical characterization. Lightcurves were acquired for 276 Adelheid, 660 Crescentia, 1629 Pecker, 1684 Iguassu, 3909 Gladys, and (152637) 1997 NC1.

Collaborative asteroid photometry was conducted within the Italian Amateur Astronomers Union (UAI, 2026) to support their physical characterization. Table I shows the observing circumstances and results. The CCD/CMOS observations were made in 2026 April-June using the instrumentation described in Table II. Lightcurve analysis was done by M. Iozzi, A. Valvasori belonging to the UAI group (2026) with *MPO Canopus* (Warner, 2023). All the images were calibrated with dark and flat frames and converted to standard magnitudes using solar colored field stars from CMC15 and ATLAS catalogues, distributed with *MPO Canopus*.

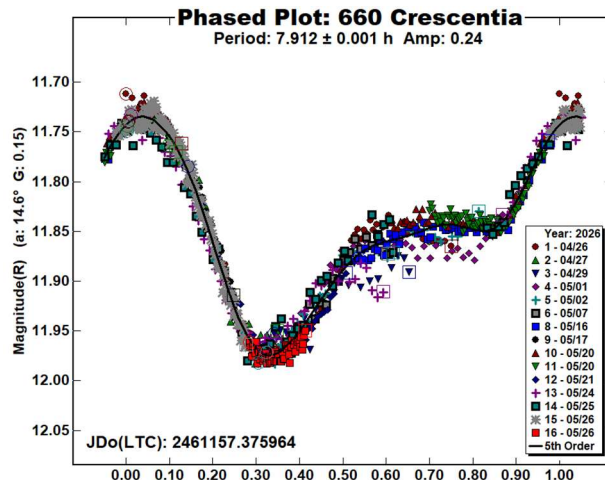
276 Adelheid is a low albedo outer main-belt asteroid classified as a X-Type in the Tholen taxonomy (Tholen, 1984). Collaborative observations were made over twelve nights. We found a bimodal solution with a synodic period of $P = 6.321 \pm 0.001$ h and an amplitude $A = 0.14 \pm 0.05$ mag. The period is close to the previously published results in the lightcurve database (Warner et al., 2009).



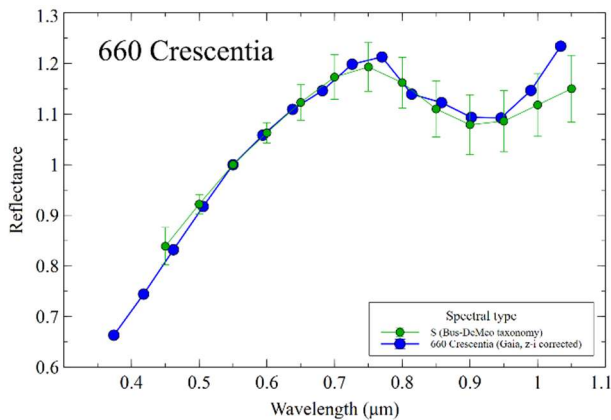
The reflectance spectrum for 276 Adelheid, retrieved from the Gaia ESA Archive (2025) and corrected for the z-i parameter (Franco, 2025), is consistent with an X-type classification within the Bus-DeMeo taxonomy (DeMeo et al., 2009) and agrees with the taxonomic attribution by Franco (2025).



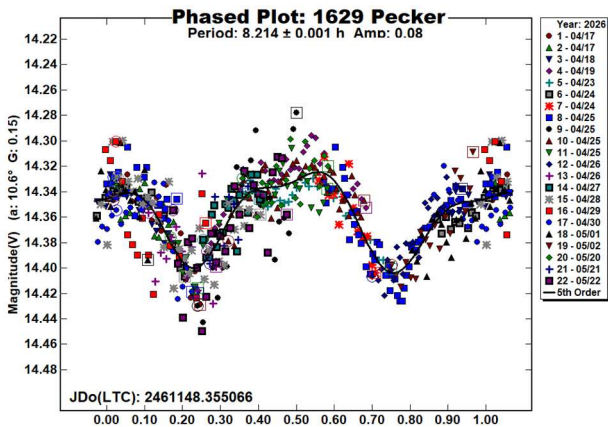
660 Crescentia is a medium albedo middle main-belt asteroid classified as a S-Type in the Tholen taxonomy (Tholen, 1984). Collaborative observations were made over sixteen nights. We found a bimodal solution with a synodic period of $P = 7.912 \pm 0.001$ h and an amplitude $A = 0.24 \pm 0.06$ mag. The period is close to the previously published results in the lightcurve database (Warner et al., 2009).



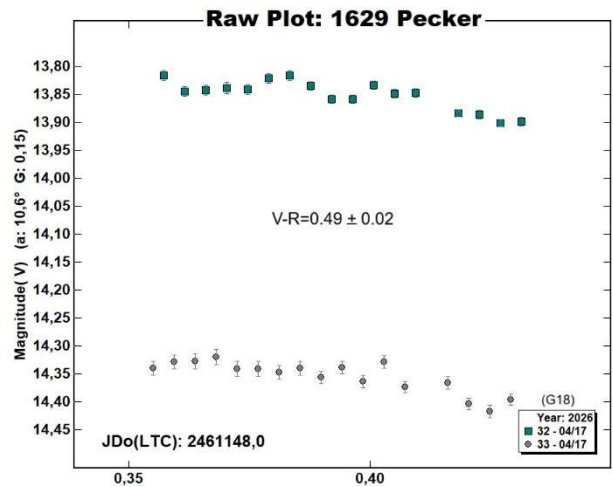
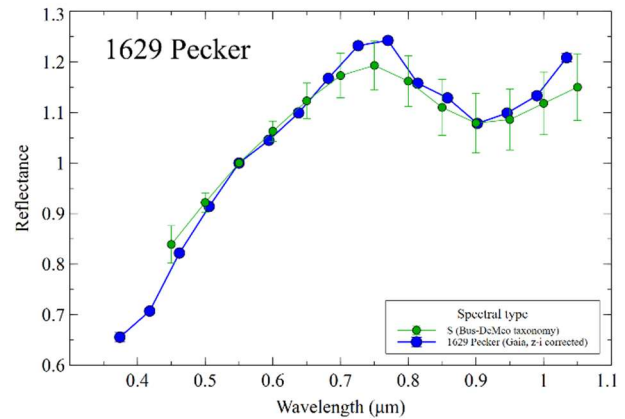
The reflectance spectrum for 660 Crescentia, retrieved from the Gaia ESA Archive (2025) and corrected for the z - i parameter (Franco, 2025), is consistent with an S-type classification within the Bus-DeMeo taxonomy (DeMeo et al., 2009) and agrees with the taxonomic attribution by Franco (2025).



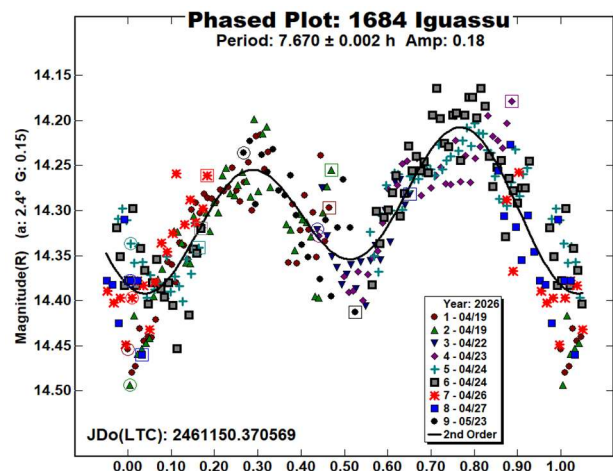
1629 Pecker is a medium albedo inner main-belt asteroid classified as a S-Type in the SMASS II taxonomy (Bus and Binzel, 2002). Collaborative observations were made over twenty-three nights. We found a bimodal solution with a synodic period of $P = 8.214 \pm 0.001$ h and an amplitude $A = 0.08 \pm 0.03$ mag. The period is close to the previously published results in the lightcurve database (Warner et al., 2009).



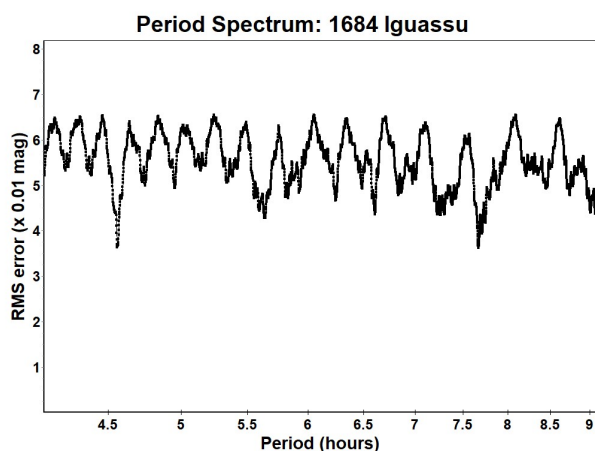
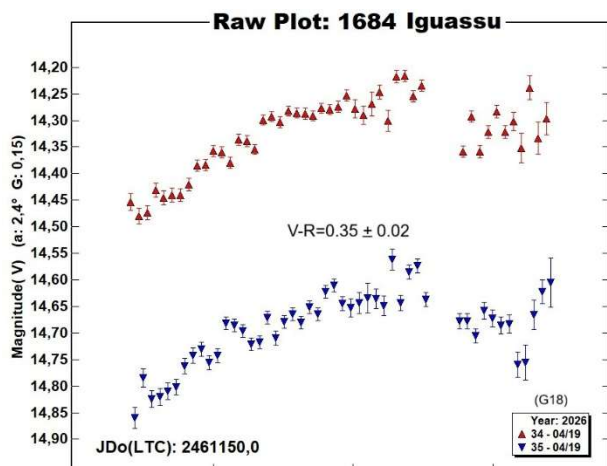
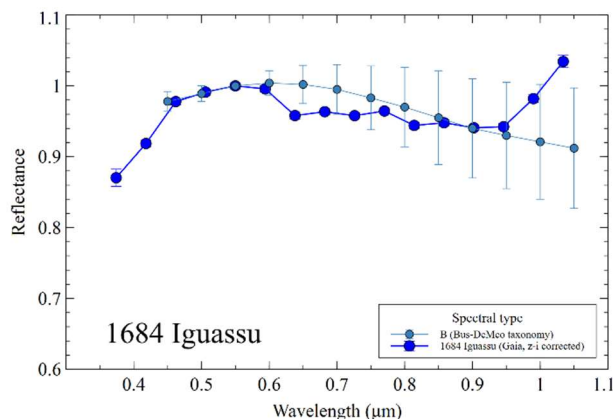
The reflectance spectrum for 1629 Pecker, retrieved from the Gaia ESA Archive (2025) and corrected for the z - i parameter (Franco, 2025), is consistent with an S-type classification within the Bus-DeMeo taxonomy (DeMeo et al., 2009) and agrees with the taxonomic attribution by Franco (2025). Multiband photometry was acquired by A. Valvasori (G18) and M. Iozzi (L63) from which we found a mean color index $V-R = 0.49 \pm 0.02$, consistent with an S-type asteroid (Shevchenko and Lupishko, 1998; 0.49 ± 0.05).



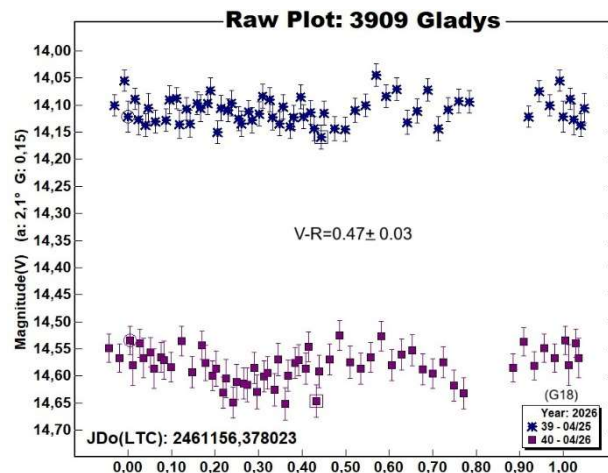
1684 Iguassu is low albedo inner main-belt asteroid. Collaborative observations were made over nine nights. The period spectrum shows minimum with a bimodal solution of $P = 7.670 \pm 0.002$ h and an amplitude $A = 0.18 \pm 0.04$ mag. This solution differs from the previously published results in the lightcurve database (Warner et al., 2009).



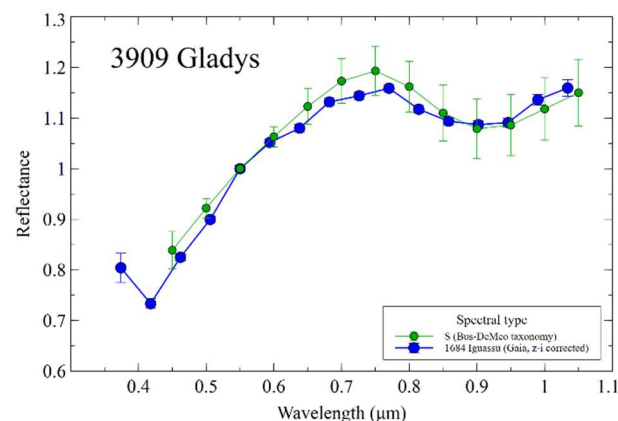
The reflectance spectrum for 1684 Iguassu, retrieved from the Gaia ESA Archive (2025) and corrected for the z-i parameter (Franco, 2025), is consistent with a B-type classification within the Bus-DeMeo taxonomy (DeMeo et al., 2009) and agrees with the taxonomic attribution by Franco (2025). Multiband photometry was acquired by A. Valvasori (G18) from which we found a mean color index $V-R = 0.35 \pm 0.02$, consistent with a C-type asteroid (Shevchenko and Lupishko, 1998; 0.38 ± 0.05).



3909 Gladys is a medium albedo middle main-belt asteroid. Collaborative observations were made over six nights. The reflectance spectrum for 3909 Gladys, retrieved from the Gaia ESA Archive (2025) and corrected for the z-i parameter (Franco, 2025), is consistent with an S-type classification within the Bus-DeMeo taxonomy (DeMeo et al., 2009) and agrees with the taxonomic attribution by Franco (2025).



Multiband photometry was acquired by A. Valvasori (G18) on 2026 April 25 and May 12 from which we found a mean color index $V-R = 0.47 \pm 0.03$, consistent with an S-type asteroid (Shevchenko and Lupishko, 1998; 0.49 ± 0.05).



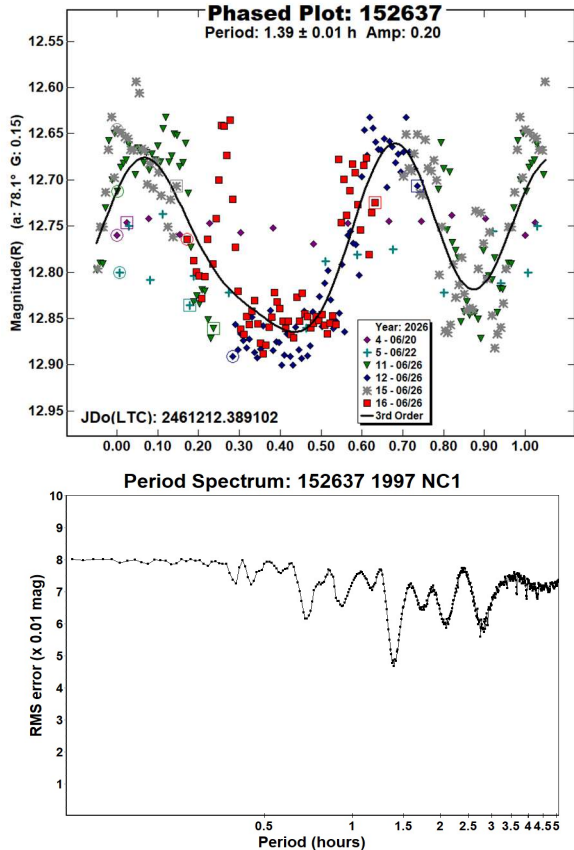
(152637) 1997 NC1 is an Aten Near-Earth asteroid and a Potentially Hazardous Asteroid (PHA), discovered by the NEAT survey at Haleakalā, Hawaii, on 1997 July 5, with $H = 17.87$ and a Minimum Orbit Intersection Distance (MOID) from Earth of 0.01671 au. Collaborative observations obtained over six nights during the asteroid's approach to its close encounter with Earth on 2026 June 27 (nominal geocentric distance 0.01715 au) yielded a bimodal lightcurve solution with a synodic rotation period of $P = 1.39 \pm 0.01$ h and a lightcurve amplitude of $A = 0.20 \pm 0.05$ mag. Under the assumption of a triaxial ellipsoid shape we derived a lower limit for the axis ratio of $(a/b) = 10^{(0.4A)} = 1.20$.

Number	Name	2026 mm/dd	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
276	Adelheid	05/16-06/06	*6.8- 6.8	247	16	6.321	0.001	0.14	0.05	MB-O
660	Crescentia	04/26-05/26	*14.6-12.0	237	20	7.912	0.001	0.24	0.06	MB-M
1629	Pecker	04/16-05/22	10.3-24.1	202	14	8.214	0.001	0.08	0.02	MB-I
1684	Iguassu	04/19-05/23	2.3-12.3	213	4	7.670	0.002	0.18	0.04	MB-O
3909	Gladys	04/17-05/16	2.1	219	0					MB-M
152637	1997 NC1	06/15-06/26	90.5-41.0	287	38	1.39	0.01	0.20	0.05	NEA

Table I. Observing circumstances and results. The first line gives the results for the primary of a binary system. The second line gives the orbital period of the satellite and the maximum attenuation. The phase angle is given for the first and last date. If preceded by an asterisk, the phase angle reached an extrema during the period. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude/latitude at mid-date range (see Harris et al., 1984). Grp is the asteroid family/group (Warner et al., 2009).

Observatory (MPC code)	Telescope	CCD/CMOS	Filters	Observed Asteroids (#Sessions)
Castelmartini (160)	0.25-m SCT f/6.3	ZWO ASI2600MM PRO	C	276 (6), 660 (8), 1629 (11), 1684 (4), 152637 (4)
Astronomical Observatory, University of Siena (K54)	0.30-m MCT f/5.6	SBIG STL-6303e (bin 2x2)	Rc	660 (3), 1629 (2), 3909 (2)
ALMO Observatory (G18)	0.30-m NRT f/4.0	ZWO ASI533MM PRO (bin 2x2)	V, Rc	1629 (2), 1684 (2), 3909 (2)
Iota Scorpii (K78)	0.40-m RCT f/6.1	CMOS QHY 268 (bin 4x4)	Rc	276 (4), 1629 (1)
GiaGa Observatory (203)	0.36-m SCT f/5.8	Moravian G2-3200	C	660 (2), 152637 (1)
Osservatorio Astronomico Nastro Verde (C82)	0.35-m SCT f/6.3	SBIG ST10XME (bin 2x2)	C	276 (2), 1629 (1)
Osservatorio Aldebaran (D31)	0.36-m SCT f/6.8	QHY268M	Rc	1629 (1), 1684 (2)
Zen Observatory (M26)	0.30-m RCT f/7.4	ATIK 383L+ (bin 2x2)	C	1629 (1), 152637 (1)
HOB Astronomical Observatory (L63)	0.20-m SCT f/6.0	ATIK 383L+ (bin 2x2)	V, Rc	1629 (1)

Table II. Observing Instrumentations. MCT: Maksutov-Cassegrain, NRT: Newtonian Reflector, RCT: Ritchey-Chretien, SCT: Schmidt-Cassegrain.



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LIGHTCURVES AND ROTATION PERIODS OF FOUR MAIN-BELT ASTEROIDS AND ONE NEAR-EARTH ASTEROID

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CCD photometric observations of four main-belt asteroids (2711 Aleksandrov, 4493 Naitomitsu, 5552 Studnička, and (19261) 1995 MB) and the near-Earth asteroid (424482) 2008 DG5 were obtained during their 2024-2025 apparitions. Synodic rotation periods and light curve amplitudes were derived from differential photometry and Fourier analysis. The results confirm previously published rotational solutions for four targets, while the 48.343 ± 0.008 h period obtained for 2711 Aleksandrov appears to be the first published determination of its rotation period.

For all asteroid targets discussed herein, exposures were obtained using a clear filter and subsequently transformed to the Sloan r' photometric system through application of the corresponding instrumental zero-point. Standard image calibration procedures were applied, including master dark subtraction to correct for thermal signal and master flat-field correction to account for pixel-to-pixel sensitivity variations and optical illumination gradients. Photometric measurements were performed using reference magnitudes from the Asteroid Terrestrial-impact Last Alert System (ATLAS) catalogue, following the calibration framework described by Tonry et al. (2018).

Observational control was conducted either remotely via internet-based interfaces or locally at the respective facilities, depending on site-specific infrastructure. Image acquisition at all Maltese observatories was performed using *Sequence Generator Pro* (Binary Star Software), ensuring standardized sequencing, autofocus routines, and automated calibration frame integration.

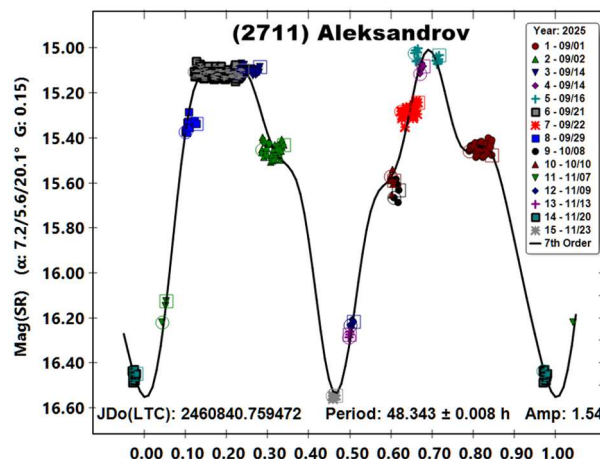
The Slovakian and Canadian observatories employed *NINA* (*Nighttime Imaging 'N' Astronomy*; Berg, 2023) for telescope control, image acquisition, and full observatory automation, including plate solving and meridian management.

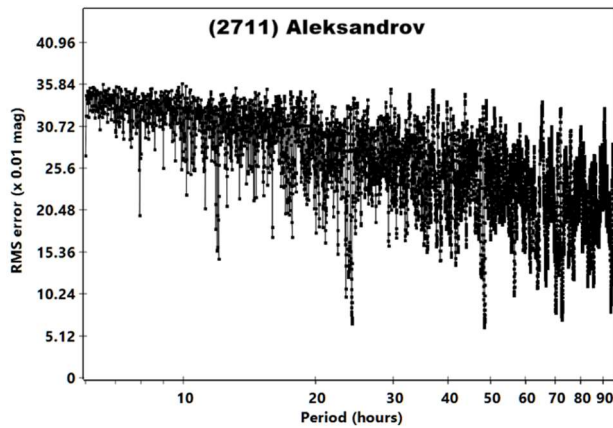
Post-acquisition data reduction and photometric analysis were conducted using *MPO Canopus* (Warner, 2016). Differential aperture photometry was applied to extract instrumental magnitudes, and composite light curves were constructed from calibrated time-series data. The software's Comparison Star Selector (CSS) module was used to identify reference stars with near-solar colour indices, thereby minimizing systematic errors arising from colour-dependent atmospheric extinction and detector response mismatches.

Observatory	Tel. and Type	Camera	Asteroid	Runs
A la belle étoile Obs. CANADA	0.2-m MK	Moravian G2-1600	4493	1
MCD Obs. (MPC: X04) CANADA	0.35-m SCT	ASI183 PRO	2711	2
Flarestar Obs. (MPC: 171) MALTA	0.25-m SCT	Moravian G2-1600	2711 4493 19261 424482	13 2 4 8
Luckystar Obs. (MPC: M55) SLOVAKIA	0.25-m SCT	Atik 460EX	4493 5552	4 7
Manikata Obs. MALTA	0.20-m SCT	ZWO ASI 2600 MM	4493	2

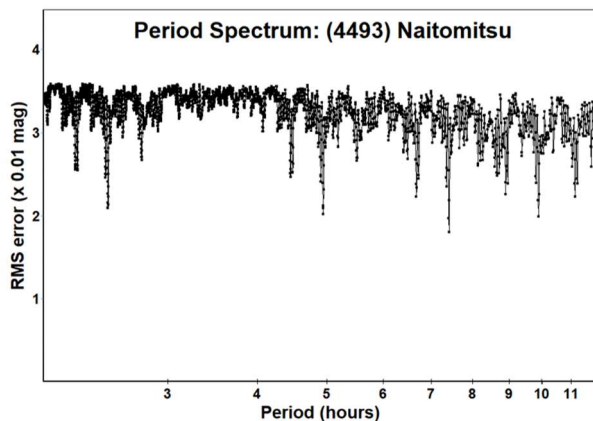
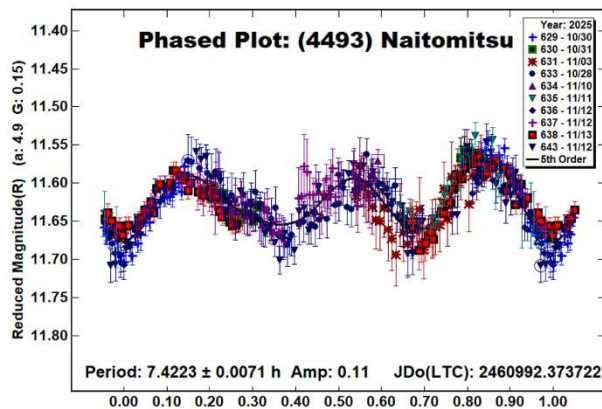
Table 1. Instrumentation and Observation Runs. SCT: Schmidt-Cassegrain; MK: Maksutov-Cassegrain.

2711 Aleksandrov is a main-belt asteroid discovered in 1978 August 31 by N. Chernykh at Nauchnyj. It is named in honour of Anatolij Petrovich Aleksandrov, an outstanding physicist and president of the Academy of Sciences. (USSR). The diameter of this asteroid is 13.547 ± 0.489 km with absolute magnitude $H = 12.00$ mag based on the information provided JPL small-body database (JPL, 2026). 2711 Aleksandrov has been observed during its 2025 favorable apparition between 2025 September 1 and November 23 from Flarestar Observatory and MCD Observatory. Fifteen observation sessions were conducted for light curve construction. Fourier data analysis derived its synodic rotation period as 48.343 ± 0.008 h with an amplitude of 1.54 ± 0.04 mag. No published synodic period was found in the LCDB database.

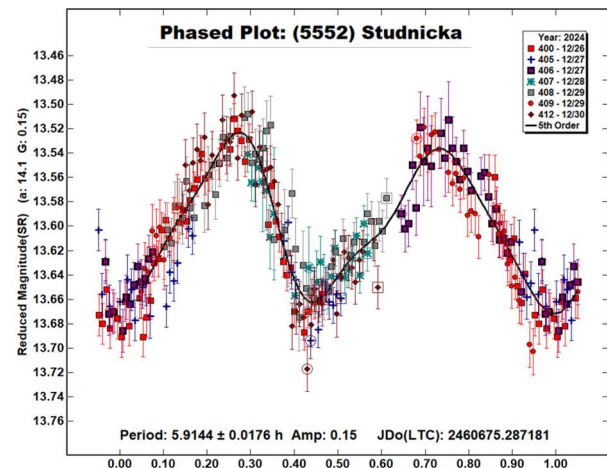




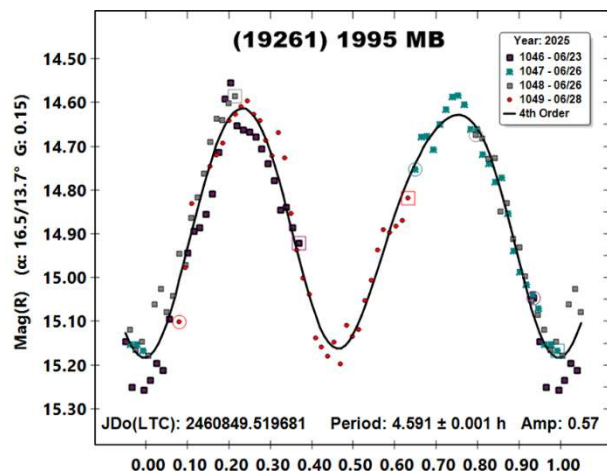
4493 Naitomitsu is a main-belt asteroid. It was discovered on 1988 Oct. 14 by T. Kojima at Chiyoda and is named after Mitsu Naito, the mother of the first female Japanese astronaut. This asteroid was observed during its favorable 2025 apparition. The diameter of 4493 Naitomitsu is 16.809 ± 0.592 km with absolute magnitude $H = 11.45$ mag based on the information provided JPL small-body database (JPL, 2026). This asteroid was reobserved from four observatories to confirm the published period by Zeigler (2021) of 7.423 ± 0.010 h based on partial coverage. We have observed the asteroid over 10 nights starting from October 30, 2025 to November 12, 2025. We estimate the synodic rotation period of 4493 Naitomitsu to be 7.4223 ± 0.0071 hours, with an amplitude of 0.11 ± 0.03 magnitudes. This period is in line with the previously published value by Zeigler (2021).



5552 Studnička was discovered in 1982 Sept. 16 by A. Mrkos at Klet. The asteroid is named in memory of František Josef Studnička (1836-1903), a professor of mathematics at Charles University in Prague. According to the JPL small-body database, the diameter of 5552 Studnička is 7.331 ± 0.106 km with absolute magnitude $H = 12.94$ mag (JPL, 2026). Two independent studies of this target were published in issue of *Minor Planet Bulletin* (Vol. 52, No. 2). Marchini and Papini (2025) derived a rotation period of $P = 5.912 \pm 0.001$ h with a light curve amplitude of 0.12 ± 0.02 mag. Similarly, Wiles (2025) reported its period as 5.915 ± 0.003 and amplitude of 0.119 ± 0.018 mag. Based on the observations by Luckystar Observatory; our analysis yields the rotation of 5552 Studnička as having a period of $P = 5.9144 \pm 0.0176$ h with a peak-to-peak amplitude of 0.15 ± 0.03 mag. The derived period is fully consistent, within uncertainties, with both published determinations, thereby corroborating the reported rotational solution.



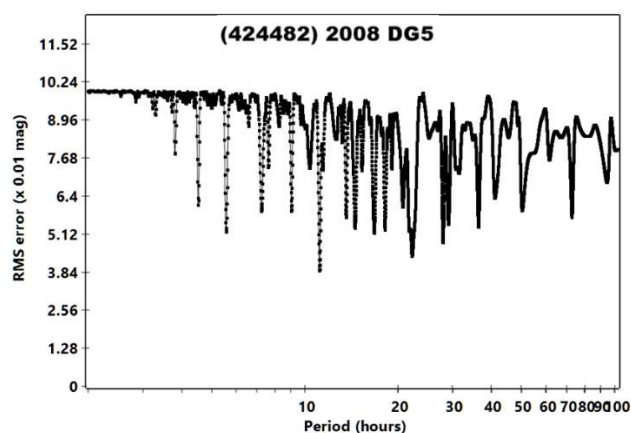
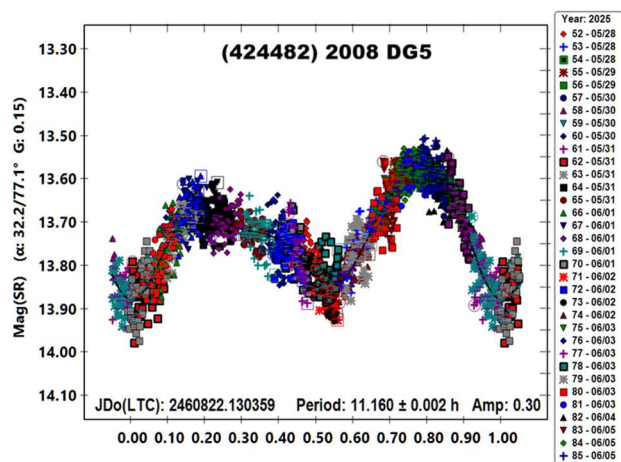
(19261) 1995 MB was discovered in 1995 June 21 by McNaught at Sliding Spring observatory. According to the JPL small-body database, the diameter of 19261 is 7.299 ± 0.142 km with absolute magnitude $H = 12.85$ mag (JPL, 2026). An independent study of this target was published in issue of *Minor Planet Bulletin* (Vol. 53, No. 1) by Papini et al. (2026) that derived a rotation period of $P = 4.591 \pm 0.001$ with a light curve amplitude of 0.66 ± 0.02 mag. Based on the observations by Flarestar Observatory over 4 nights, our analysis yields the rotation of (19261) 1995 MB as having a period of $P = 4.591 \pm 0.001$ h with a peak-to-peak amplitude of 0.57 ± 0.04 mag. The derived period is fully consistent with Papini et al. (2026) thereby corroborating the reported rotational solution.



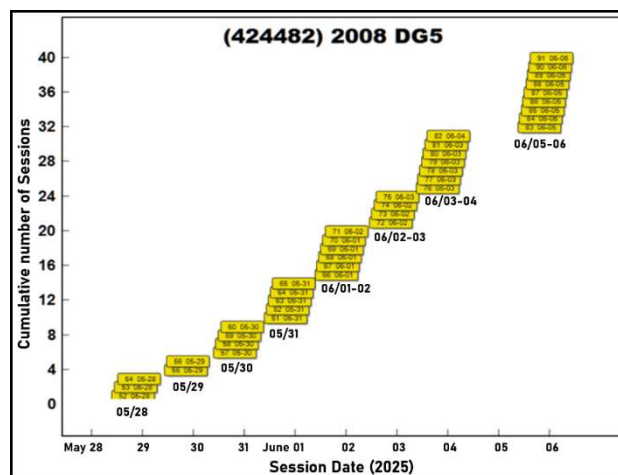
(424482) 2008 DG5 is a Near-Earth Asteroid and is classified as a Potentially Hazardous Asteroid (PHA). During its 2025 approach, photometric data were gathered to confirm its synodic rotation period and to constrain its light curve amplitude through a different phase angle than previously observed. Photometric data were acquired from Flarestar Observatory over the period of 2025 May 28 to June 5. Because the asteroid was positioned along the inbound branch of its trajectory during these sessions, the observing aspect remained largely stable, providing a consistent light curve morphology for analysis.

This Near-Earth Asteroid (NEA) exhibited a relatively fast apparent motion, starting at $8.7''/\text{min}$ during the first run and increasing to $22.41''/\text{min}$ by the final run. Because the telescope's field of view was constrained to a narrow $25' \times 17'$, the target quickly drifted out of frame. To maximize imaging time, the telescope had to be periodically recentered before the asteroid was lost, dividing the continuous observation runs into multiple shorter sessions. Consequently, this methodology required gathering 40 separate sessions across 8 nights.

While preliminary estimates indicated a rotation period of 11.26 h, further refinement to correct systematic calibration offsets yielded a definitive synodic period of $P = 11.160 \pm 0.002$ h with an amplitude of 0.30 ± 0.05 mag. These results demonstrate excellent agreement with independent data obtained by Pravec et al. (2025) using the 1.54-m telescope at La Silla in March and April 2025 (personal communication), which established a period of 11.162 ± 0.003 h. While the general solutions are in agreement, slight morphological variations in the light curve between the March-April and May-June lunations were attributed to the differing observing aspects of the asteroid.



The figure below illustrates the progression of the observational campaign for the near-Earth asteroid (424482) 2008 DG5. The dates of individual observing sessions are shown within the yellow blocks, while the vertical axis represents the cumulative number of sessions acquired. A total of 40 observing sessions were obtained between 2025 May 28 and June 6, providing extensive temporal coverage over ten consecutive nights. The relatively large number of sessions was necessitated by the asteroid's increasing apparent motion across the sky as it approached Earth, requiring frequent recentering of the target within the telescope's field of view and consequently the initiation of new observing sessions with new comparison stars. The stepwise increase in the cumulative count highlights the distribution of observations from night to night and demonstrates the sustained observational effort undertaken to achieve adequate rotational phase coverage for reliable lightcurve analysis and period determination.



Number	Name	yyyy mm/dd	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E.	Amp.	A.E.	Grp
2711	Aleksandrov	2025 09/01-11/23	7.3, 20.0	355	-4.9	48.343	0.008	1.54	0.04	9104
4493	Naitomitsu	2025 10/03-11/12	13.9, 3.8	46	7.7	7.4223	0.0071	0.11	0.03	606
5552	Studnička	2024 12/26-12/30	14.0, 15.6	74	-11.4	5.9144	0.0176	0.15	0.03	9106
19261	1995 MB	2025 06/23-06/28	16.1, 14.2	295	5.7	4.591	0.001	0.57	0.04	9104
424482	2008 DG5	2025 05/28-06/05	32.1, 75.1	229	12.9	11.160	0.002	0.30	0.05	9101

Table I. Observing circumstances and results. The phase angle is given for the first and last date. L_{PAB} and B_{PAB} are the approximate phase.

Acknowledgements

The author expresses sincere gratitude to Dr. Petr Pravec (Astronomical Institute of the Czech Academy of Sciences) for his invaluable assistance in the analysis of the photometric data and for providing comparative results from the Ondrejov Asteroid Photometry Project. His technical expertise and collaborative support were instrumental in establishing the rotation period presented in this work. We would like to thank Brian Warner for his work in the development of *MPO Canopus* and for his efforts in maintaining the CALL website (Warner, 2017; Warner et al., 2009; Warner, 2016). This research has made use of the JPL's Small-Body Database (JPL, 2026).

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ASTEROID PHOTOMETRY FOR THIRTEEN MAIN-BELT ASTEROIDS AND ONE APOLLO OBJECT

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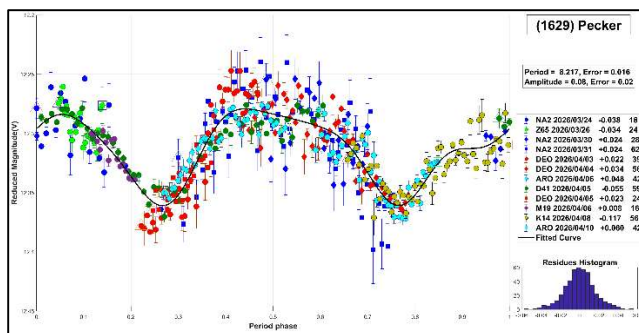
(Received: 2026 July 15)

Synodic rotation periods and amplitudes are reported for:
1629 Pecker, 1678 Hveen, 1684 Iguassu, 1733 Silke,
2149 Schwambraniya, 2307 Garuda, 2832 Lada, 3668
Ilfpetrov, 3840 Mimistrobell, 4408 Zlata, 5557
Chimikeppuko, 6152 Empédocles, 9191 Hokuto, 52340
1992 SY.

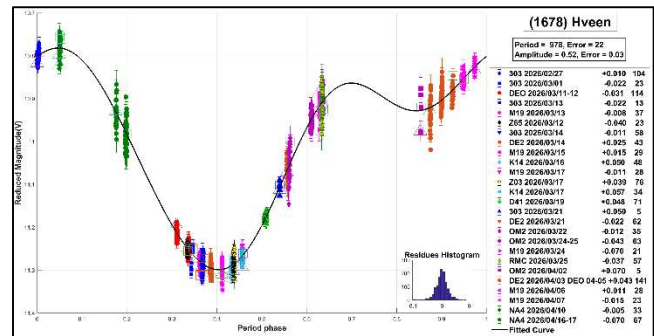
The periods and amplitudes of asteroid lightcurves presented in this paper are the product of collaborative work by the GORA (Grupo de Observadores de Rotaciones de Asteroides) group. In all the studies, we have applied relative photometry assigning V magnitudes to the calibration stars. The image acquisition was performed without filters and with exposure times of a few minutes. All images used were corrected using dark frames and, in some cases, bias and flat-field corrections were also used. Photometry measurements were performed using *FotoDif* software and for the analysis, we employed *Periodos* software (Mazzone, 2012).

Below, we present the results for each asteroid studied. The lightcurve figures contain the following information: the estimated period and period error and the estimated amplitude and amplitude error. In the reference boxes, the columns represent, respectively, the marker, observatory MPC code, or - failing that - the GORA internal code, session date, session offset, and several data points. Targets were selected based on the following criteria: 1) those asteroids with magnitudes accessible to the equipment of all participants, 2) those with favorable observation conditions from Argentina, Venezuela, Spain, Italy, or Croatia, i.e. with negative or positive declinations δ , and 3) objects with few periods reported in the literature and/or with Lightcurve Database (LCDB) (Warner et al., 2009) quality codes (U) of less than 3.

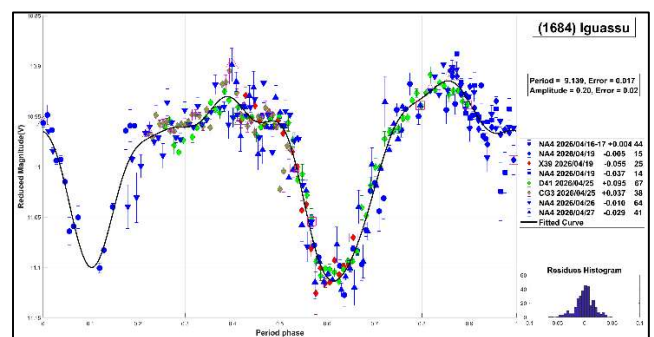
1629 Pecker is a main-belt asteroid discovered in 1952 by L. Boyer, with an estimated diameter of 8.536 km. A previously reported rotational period for this asteroid is $P = 8.2166$ h (Pravec et al., 2006web). We measured a period of $P = 8.217 \pm 0.016$ h, with an amplitude of $\Delta m = 0.08 \pm 0.02$ mag.



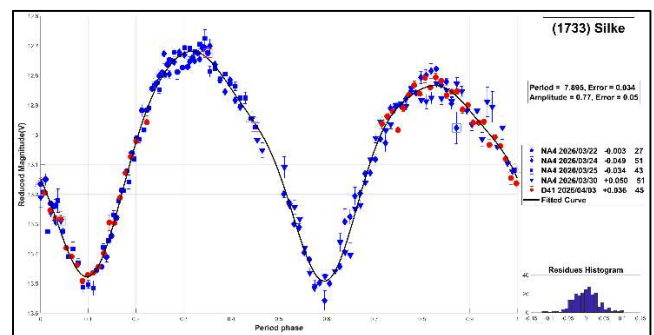
1678 Hveen is a main-belt asteroid discovered in 1678 by Y. Vaisala. It has an estimated diameter of 42.665 km. The reported rotational period for this asteroid is $P = 5.987$ h (Carbognani, 2014). Our observations suggest a long period, yielding a value of $P = 978 \pm 22$ h with $\Delta m = 0.52 \pm 0.03$ mag.



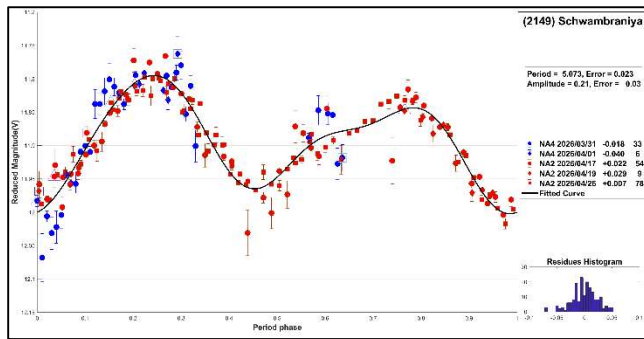
1684 Iguassu is a main-belt asteroid with an estimated diameter of 30.21 km, discovered in 1951 by M. Itzigsohn. The reported rotational period for this asteroid is $P = 6.4156$ h (Skiff, 2018web). Our observations suggest a longer period, yielding a value of $P = 9.139 \pm 0.017$ h with $\Delta m = 0.77 \pm 0.05$ mag.



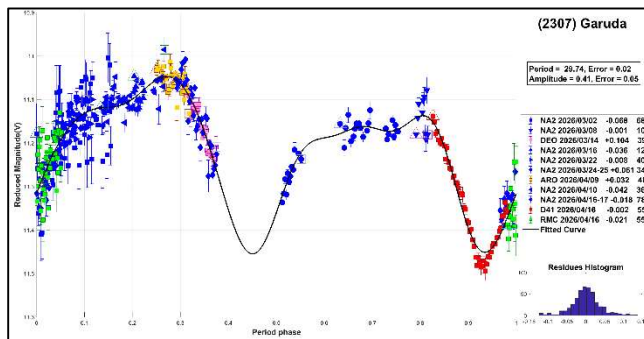
1733 Silke. This main-belt asteroid was discovered in 1938 by A. Bohrmann and has an estimated diameter of 6.715 km. A rotational period of $P = 7.89393$ h was previously reported for this asteroid (Pál et al., 2020). Our results are consistent with this rotation period, giving a value of $P = 7.895 \pm 0.034$ h and an amplitude of $\Delta m = 0.77 \pm 0.05$ mag.



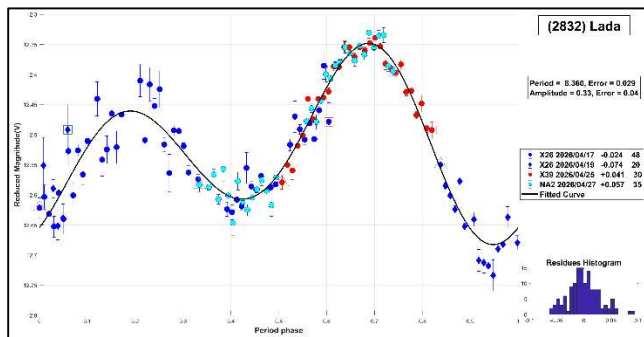
2149 Schwambraniya is a main-belt asteroid discovered in 1977 by N.S. Chernykh, with a diameter of 11.180 km. The reported rotational period for this asteroid is $P = 5.676$ h (Brincat et al., 2023). In this work, we propose a period of $P = 5.073 \pm 0.023$ h with $\Delta m = 0.21 \pm 0.03$ mag.



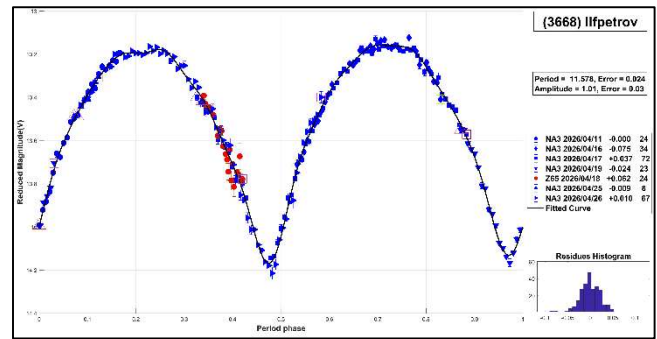
2307 Garuda is a main-belt asteroid with an estimated diameter of 40.139 km, discovered in 1957. The more recent period published in the literature corresponds to $P = 29.76$ h (Behrend, 2020web). Our period $P = 29.74 \pm 0.02$ h with $\Delta m = 0.41 \pm 0.05$ mag agrees with the one measured by Behrend.



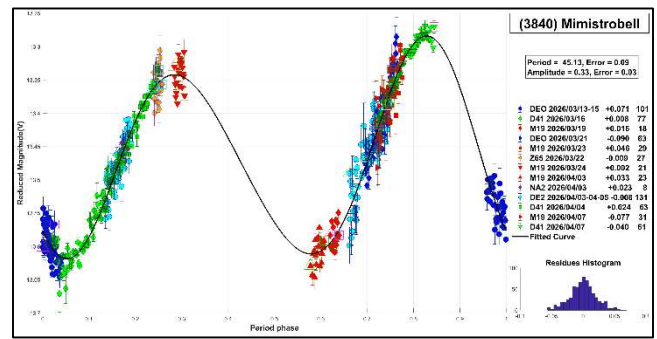
2832 Lada is a main-belt asteroid discovered in 1975 by N. Chernykh, with a diameter of 6.090 km. A previously reported rotational period for this asteroid is $P = 8.357$ h (Durech et al., 2020). In this work, we measured a period of $P = 8.360 \pm 0.029$ h and an amplitude of $\Delta m = 0.33 \pm 0.04$ mag.



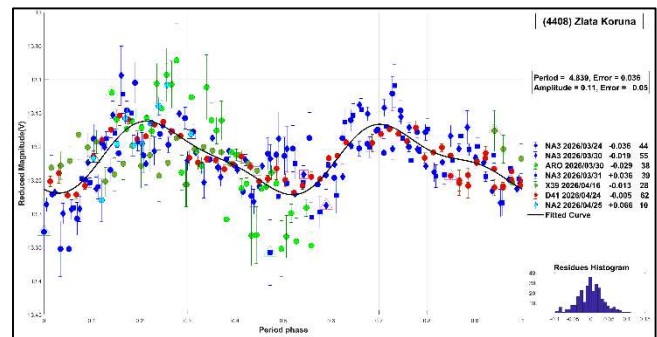
3668 Il'fpetrov is a main-belt asteroid with an estimated diameter of 6.496 km, discovered in 1982 by L.G. Karachkina. The reported rotational period for this asteroid is $P = 15.268$ h (Waszczak et al., 2015). In this work, we propose a shorter period of $P = 11.578 \pm 0.024$ h with $\Delta m = 1.01 \pm 0.03$ mag.



3840 Mimistobell is a main-belt asteroid with an estimated diameter of 5.174 km, discovered in 1980 by C. Shoemaker. No published rotational periods for this asteroid were found in the literature. In this work, we propose a period of $P = 45.13 \pm 0.09$ h with $\Delta m = 0.33 \pm 0.03$ mag.



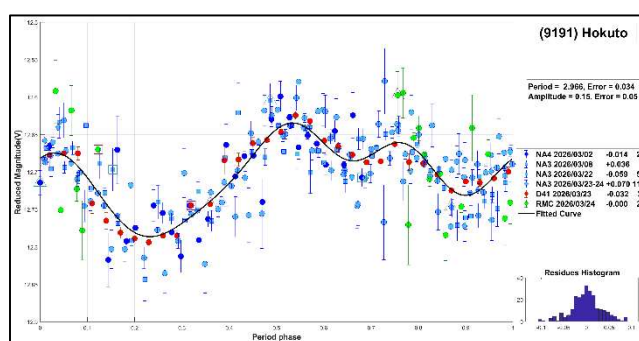
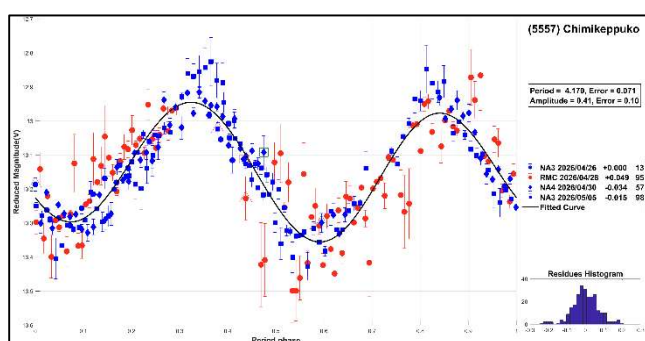
4408 Zlata Koruna is a main-belt asteroid discovered in 1988 by A. Mrkos. The more recent period published in the literature corresponds to $P = 4.392$ h (Olguín et al., 2020). Our period $P = 4.839 \pm 0.036$ h with $\Delta m = 0.11 \pm 0.05$ mag agrees with the one measured by Olguín and collaborators.



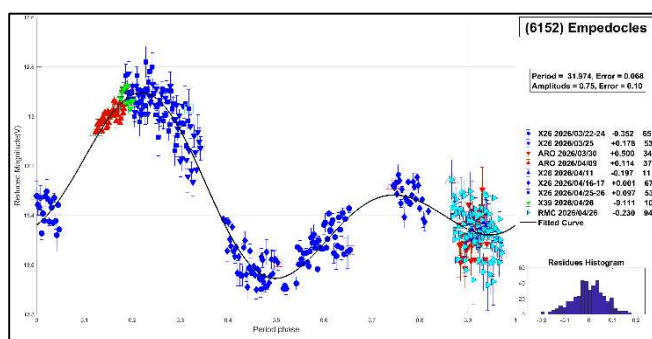
5557 Chimikeppuko is a main-belt asteroid discovered in 1989 by Endate and Watanabe, with a diameter of 7.1 km. The reported rotational period for this asteroid is $P = 4.168$ h (Waszczak et al., 2015). In this work, we measure a period of $P = 4.170 \pm 0.071$ h with $\Delta m = 0.41 \pm 0.10$ mag.

Number	Name	yy/ mm/dd- yy/ mm/dd	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
1629	Pecker	26/03/24-26/04/10	*12.8, 09.2	199	13	8.217	0.016	0.08	0.02	MB-I
1678	Hveen	26/02/27-26/04/17	*05.3, 12.7	171	-1	978	22	0.52	0.03	MB-O
1684	Iguassu	26/04/16-26/04/27	*03.6, 02.6	213	4	9.139	0.017	0.20	0.02	Them
1733	Silke	26/03/22-26/04/04	*07.0, 02.2	193	3	7.895	0.034	0.77	0.05	Flora
2149	Schwambraniya	26/03/31-26/04/26	13.4, 02.8	219	5	5.073	0.023	0.21	0.03	MB-I
2307	Garuda	26/03/02-26/04/17	*08.5, 10.3	181	-9	29.74	0.02	0.41	0.05	MB-O
2832	Lada	26/04/17-26/04/27	*05.5, 02.5	216	5	8.360	0.029	0.33	0.04	MB-I
3668	Ilfpetrov	26/04/11-26/04/26	*02.5, 06.9	205	1	11.578	0.024	1.01	0.03	MB-I
3840	Mimistrobell	26/03/13-26/04/08	03.5, 16.4	169	4	45.13	0.09	0.33	0.03	MB-I
4408	Zlata Koruna	26/03/24-26/04/25	*12.9, 03.6	208	-2	4.839	0.036	0.11	0.05	MB-I
5557	Chimikeppuko	26/04/26-26/05/05	09.7, 05.6	231	-5	4.170	0.071	0.41	0.10	MB-I
6152	Empédocles	26/03/22-26/04/27	*08.8, 10.1	198	-2	31.974	0.068	0.75	0.10	MB-I
9191	Hokuto	26/03/02-26/03/25	*08.9, 10.4	171	-15	2.966	0.034	0.15	0.05	Euno
52340	1992 SY	26/03/11-26/03/16	31.3, 25.8	158	9	2.900	0.036	0.07	0.05	NEA

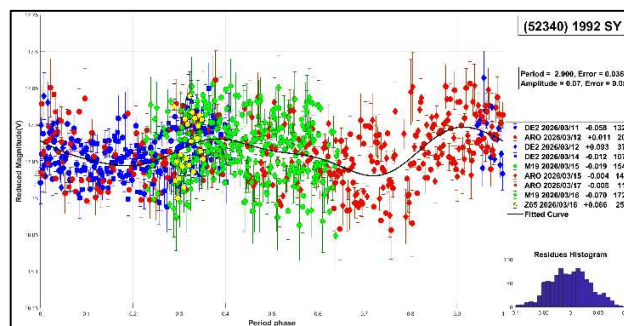
Table I. Observing circumstances and results. The phase angle is given for the first and last date. If preceded by an asterisk, the phase angle reached an extremum during the period. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude/latitude at mid-date range (see Harris et al., 1984). Grp is the asteroid family/group (Warner et al., 2009). MB-I: main-belt inner; MB-O: main-belt outer; Them: 24 Themis; Flora: 8 Flora; Euno: 15 Eunomia; NEA: NEA.



6152 *Empédocles* is a main-belt asteroid with a diameter of 6.889 km, discovered in 1989 by E.W. Elst. For this asteroid, we couldn't find published periods in the literature either. Based on our observations and thorough analysis, we propose a period of $P = 31.974 \pm 0.068$ h and $\Delta m = 0.75 \pm 0.10$ mag.



(52340) 1992 SY is a near-Earth object discovered in 1992 by Spacewatch. We couldn't find a reported period for this object in the literature. We propose a period of 2.900 ± 0.036 h with $\Delta m = 0.07 \pm 0.05$ mag.



Acknowledgements

We want to thank Julio Castellano as we used his *FotoDif* program for preliminary analyses, Fernando Mazzone for his *Periods* program, which was used in final analyses. We also used *Seqplot* (<https://www.aavso.org/seqplot>), which proved very effective for checking the magnitudes of the calibration stars. This research has made use of the Small Bodies Data Ferret (<https://sbnapps.psi.edu/ferret/>), supported by the NASA Planetary System. This research has made use of data and/or services provided by the International Astronomical Union's Minor Planet Center.

9191 *Hokuto* is a main-belt asteroid discovered in 1991 by S. Otomo. For this asteroid, we could not find any published rotational periods in the literature. In this work, we propose a short period of $P = 2.966 \pm 0.034$ h with $\Delta m = 0.15 \pm 0.05$ mag.

Observatory	Telescope	Camera
303 Obs. Astr. Nacional Llano del Hato	Newtonian (D=1000mm; f=5.5)	CCD FLI PL4240
D41 Osservatorio Astronomico di Orciatico	SCT (D=355mm; f=7.4)	CCD SBIG ST10XME
K14 Obs. Astronómico de Sencelles	Newtonian (D=250mm; f=4.0)	CCD SBIG ST-7XME
M19 Osservatorio Explorer	RCT (D=304 mm; f=6,5)	CMOS Player One-Poseidon
X26 Obs. Astronómico Naos	Newtonian (D=250mm; f=4.0)	CMOS QHY 163M
X39 Obs. Astronómico Antares	Newtonian (D=250mm; f=4.72)	CCD QHY9 Mono
Z03 Obs. Astr.RioCofio	SCT (D=254mm; f=6.3)	CCD SBIG ST-8XME
Z65 Obs. Astronómico Corgas	Newtonian (D=310mm; f=4.8)	CMOS ZWO ASI 294 MM
ARO Obs. Astronómico de Albatàrrec	Refractor (D=160mm; f=5.6)	CMOS Player O-P M Pro
DEO Dark Energy Observatory	Refractor (D=115mm; f=7.0)	CMOS QHY 294M pro
DE2 Dark Energy Observatory 2	RCT (D=200mm; f=5.4)	CMOS Player One Ares-M
GC3 Specola Giuseppe Pustorino 2	RCT (D=400mm; f=8.0)	CCD Atik 383L+Mono
NA2 Obs. Astronómico Naos 2	Newtonian (D=200mm; f=5.0)	CMOS ZWO ASI 174
NA3 Obs. Astronómico Naos 3	SCT (D=279; f=10)	CMOS ZWO 183
NA4 Obs. Astronómico Naos 4	Newtonian (D=200mm; f=5.0)	CMOS ZWO ASI 17
OM2 Obs. Astr.Vuelta por el Universo 2	Newtonian (D=200mm; f=5.0)	CMOS POA Neptune-M
RMC Obs. Astr.de Raúl Melia Carlos Paz	Newtonian (D=254mm; f=4.7)	CMOS QHY 174M

Table II. List of observatories and equipment.

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LIGHTCURVE ANALYSIS FOR TWENTY-FOUR MAIN-BELT ASTEROIDS

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From photometric observations for twenty-four main-belt asteroids, we derived the following rotational synodic periods: 151 Abundantia, 10.156 ± 0.019 h; 218 Bianca, 6.3369 ± 0.0002 h; 250 Bettina, 5.0545 ± 0.0001 h; 351 Yrsa, 13.2994 ± 0.0002 h; 420 Bertholda, 10.9871 ± 0.0007 h; 513 Centesima, 4.815 ± 0.012 h; 572 Rebekka, 5.650 ± 0.004 h; 611 Valeria, 6.961 ± 0.003 h; 787 Moskva, 6.0560 h; 1102 Pepita, 5.104 ± 0.001 h; 1307 Cimberia, 2.82071 ± 0.00001 h; 1584 Fuji, 14.884 ± 0.002 h; 1600 Vyssotsky, 3.2012 ± 0.0006 h; 1884 Skip, 2.8936 ± 0.0002 h; 2476 Andersen, 8.253 ± 0.012 h; 3259 Brownlee, 9.2499 ± 0.0008 h; 3478 Fanale, 3.245 ± 0.007 h; 3918 Brel, 3.0965 ± 0.0004 h; 4001 Ptolemaeus, 5.021 ± 0.002 h; 4613 Mamoru, 5.3873 ± 0.0004 h; 6690 Messick, 3.239 ± 0.004 h; (19261) 1995 MB, 4.5901 ± 0.0006 h; (20520) 1999 RC38, 3.202 ± 0.078 h; 24101 Cassini, 4.076 ± 0.009 h.

We report photometric observations for twenty-four main-belt asteroids. The data were obtained during 2025 - 2026. Lightcurves were analyzed to derive synodic rotation periods and amplitudes. Several complete and well-defined lightcurves allowed accurate period determinations.

Observatory	Telescope	CCD
Y76	SC - 9.25"	ASI 2600 MM Pro

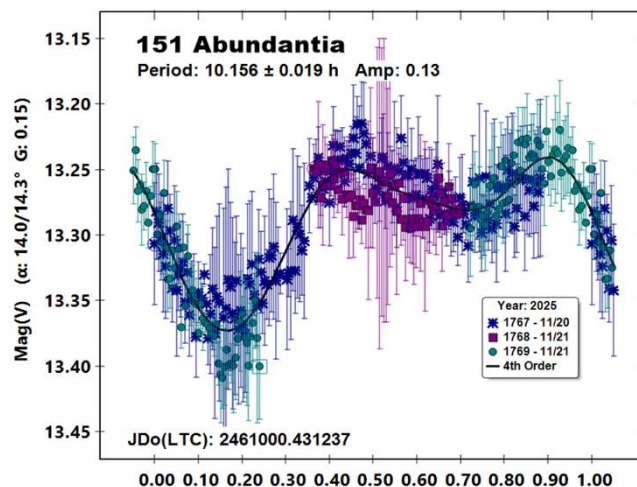
Table I. List of instruments used for the observations.

The targets were selected from the Collaborative Asteroid Lightcurve Link (CALL) website (<http://www.minorplanet.info/call.html>), and the Minor Planet Center (<http://www.minorplanet.net>). The Asteroid Lightcurve Database (LCDB; Warner et al., 2009) was consulted to locate previously published results.

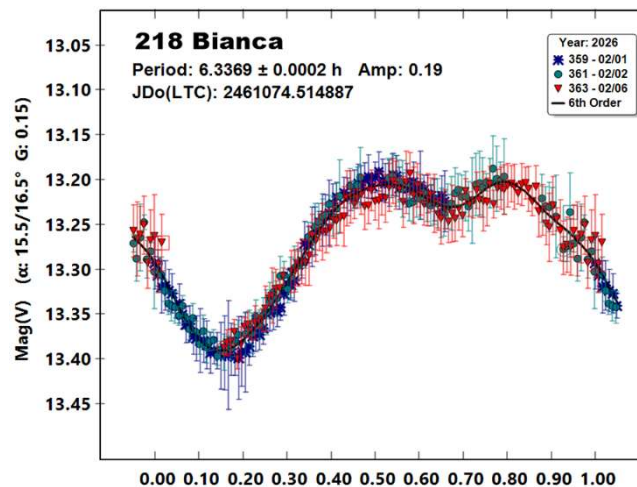
Images were measured using *MPO Canopus* (Bdw. Publishing) with a differential photometry technique. The comparison stars were restricted to near solar color to minimize color dependencies, especially at larger air masses. The lightcurves show the synodic rotation period. The amplitude (peak-to-peak) that is shown is that for the Fourier model curve and not necessarily the true amplitude.

151 Abundantia. This main-belt asteroid was discovered on 1875 Nov 1 by Johann Palisa at the Pola Observatory. We obtained photometric observations on 2025 Nov 20 to 21. From our data, we derive a synodic rotation period of 10.156 ± 0.019 h and a lightcurve amplitude of 0.13 mag. Behrend (2006web) reported a period of

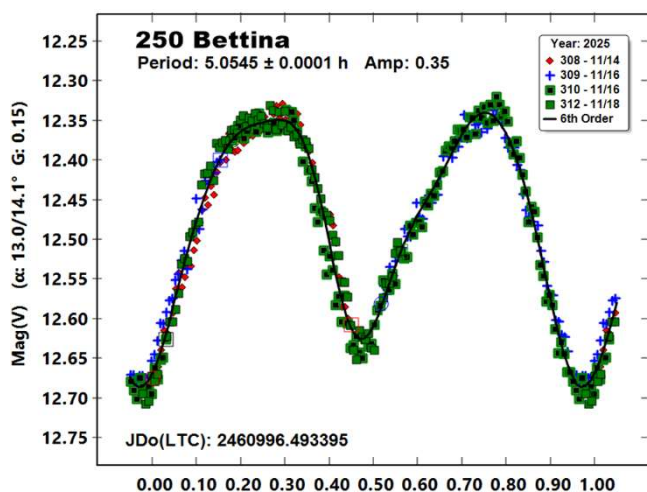
9.8640 h. Warner (2011b) found 9.861 h, and Durech et al. (2020) reported 9.86432 h. Robinson (2011web) determined a period of 19.8 h. Our result differs significantly from most previously published determinations and should be considered preliminary pending additional observations.



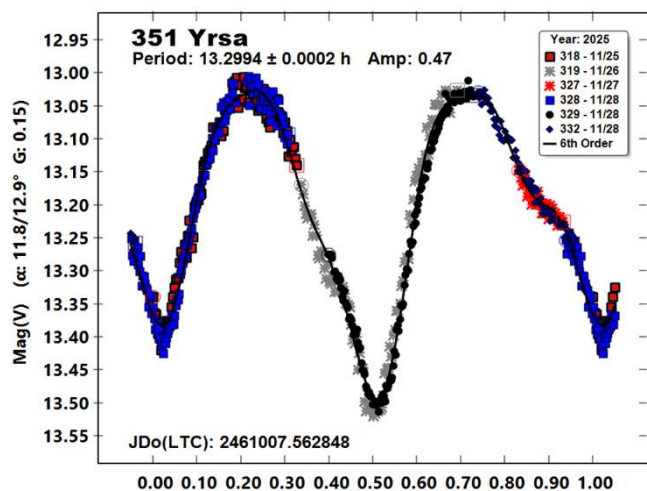
218 Bianca. This main-belt asteroid was discovered on 1880 Sep 4 by Johann Palisa at the Pola Observatory. We obtained photometric observations on 2026 Feb 1 to 6. From our data, we derive a synodic rotation period of 6.3369 ± 0.0002 h and a lightcurve amplitude of 0.19 mag. Harris and Young (1989) reported a period of 6.337 h, Kryszczyńska et al. (1996) found 6.337 h, Behrend (2006web, 2010web, 2020web and 2023web) found 6.3371, 6.3390 h, 6.339 h and 6.330 h. Durech et al. (2007) reported 6.33717 h, Shevchenko et al. (2016) reported 6.3355 h, Fauerbach and Bennett (2005) found 6.337 h, Alton (2019) reported 6.339 h, Garcerán (2014web) reported 6.338 h, and Fornas et al. (2023) reported 6.3380 h.



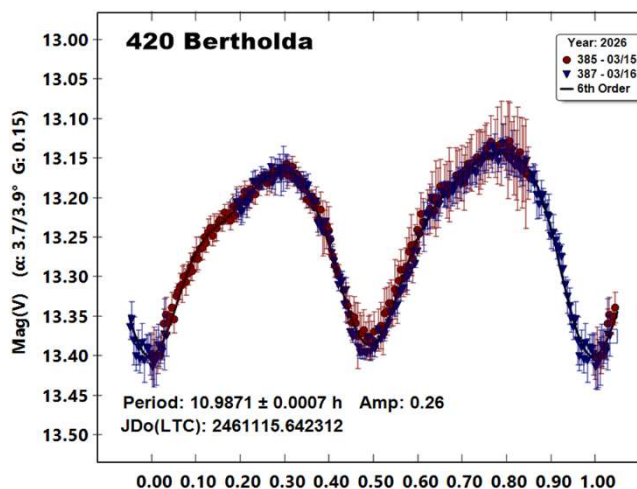
250 Bettina. This main-belt asteroid was discovered on 1885 Sep 3 by Johann Palisa at the Vienna Observatory. We obtained photometric observations on 2025 Nov 14 to 18. From our data, we derive a synodic rotation period of 5.0545 ± 0.0001 h and a lightcurve amplitude of 0.35 mag. This result is consistent with previous determinations in LCDB, which includes observations from several authors.



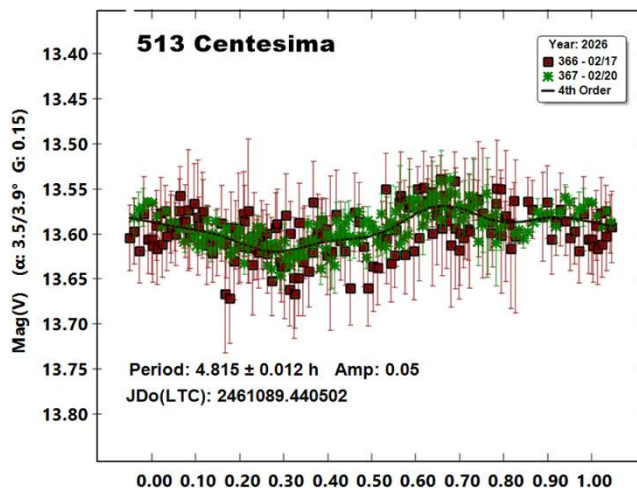
351 Yrsa. This main-belt asteroid was discovered on 1892 Jul 16 by Max Wolf at the Heidelberg Observatory. We obtained photometric observations on 2025 Nov. 11 to 28. From our data, we derive a synodic rotation period of 13.2994 ± 0.0002 h and a lightcurve amplitude of 0.47 mag. Denchev (1999) and Denchev (2000) reported a period of 13.29 h. Hanus et al. (2013) found 13.312 h and Behrend (2018web) reported 13.308 h.



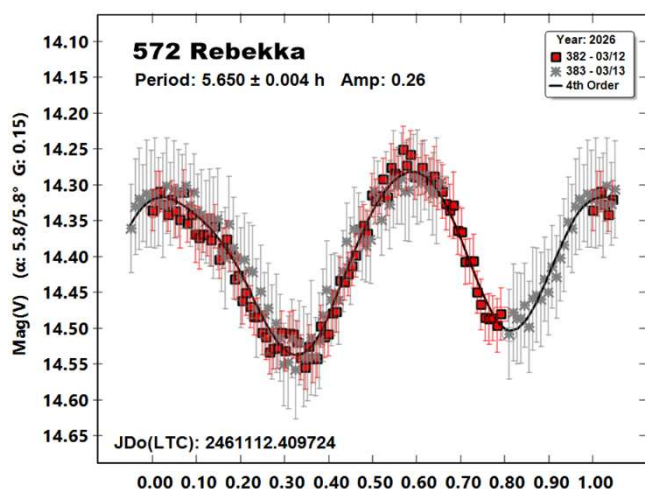
420 Bertholda. This main-belt asteroid was discovered on 1896 Sep 7 by Max Wolf at the Heidelberg Observatory. We obtained photometric observations on 2026 Mar 15 to 16. From our data, we derive a synodic rotation period of 10.9871 ± 0.0007 h and a lightcurve amplitude of 0.26 mag. There are several previous calculations in LCDB. Among them, the most significant are Durech et al. (2020) who found a sidereal period of 10.98717 h, Pál et al. (2020) found 10.987 h and Pilcher (2021) with 10.987 h.



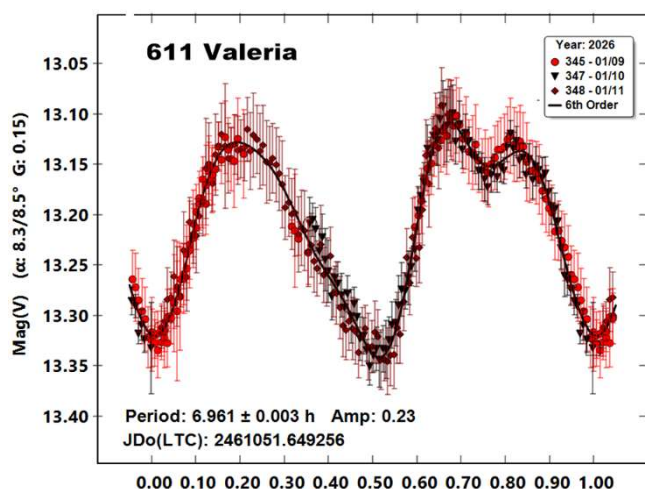
513 Centesima. This main-belt asteroid was discovered on 1903 Aug 24 by Max Wolf at the Heidelberg Observatory. We obtained photometric observations on 2026 Feb 17 to 20. From our data, we derive a synodic rotation period of 4.815 ± 0.012 h and a lightcurve amplitude of 0.05 mag. In LCDB there are calculations with different periods: Durech et al. (2016) calculated a sidereal period of 5.32399; Behrend (2021web) reported 4.794 h and Polakis (2022) calculated 4.79 h.



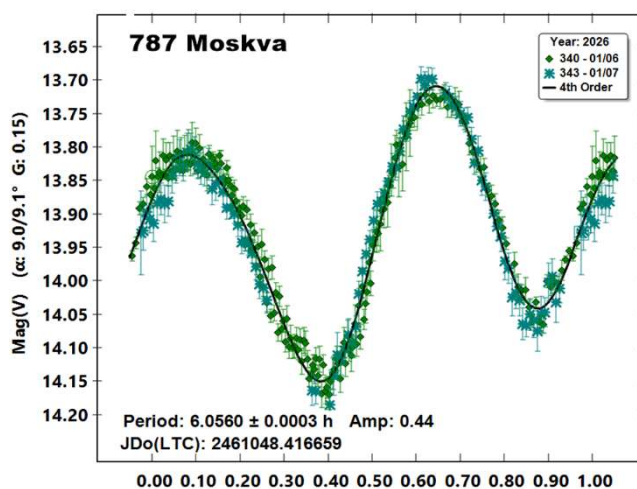
572 Rebekka. This main-belt asteroid was discovered on 1905 Sep 19 by Max Wolf at the Heidelberg Observatory. We obtained photometric observations on 2026 Mar 12 to 13. From our data, we derive a synodic rotation period of 5.650 ± 0.004 h and a lightcurve amplitude of 0.26 mag. Warner and Higgins (2008) calculated a period of 5.656 h. Behrend (2009web) reported 5.6497 h. Hanus et al. (2013) calculated a sidereal period of 5.65009 h. Stephens and Warner (2021) found 5.653 h.



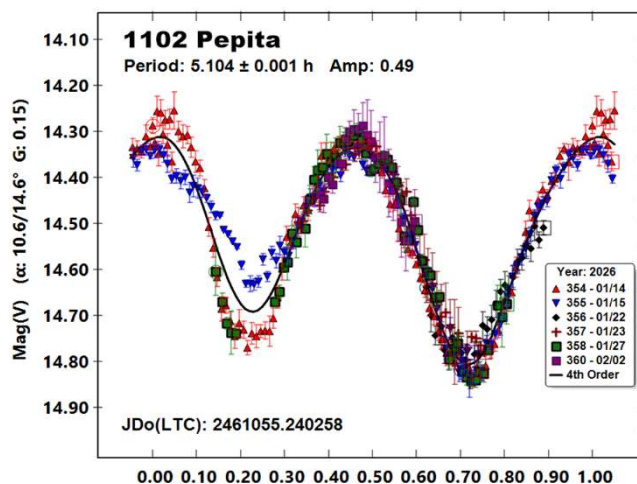
611 Valeria. This main-belt asteroid was discovered on 1906 Sep 24 by Max Wolf at the Heidelberg Observatory. We obtained photometric observations on 2026 Jan 9 to 11. From our data, we derive a synodic rotation period of 6.961 ± 0.003 h and a lightcurve amplitude of 0.23 mag. Behrend (2002web, 2003web, 2005web and 2018web) found a period of 6.9819 h, 6.98 h, 6.98 h and 6.9821 h. Pilcher (2012) found 6.977 h. Klinglesmith III (2017) calculated 6.977 h. Durech et al. (2020) reported a sidereal period of 6.97893 h. Wilawer et al. (2022) calculated 6.9788 h.



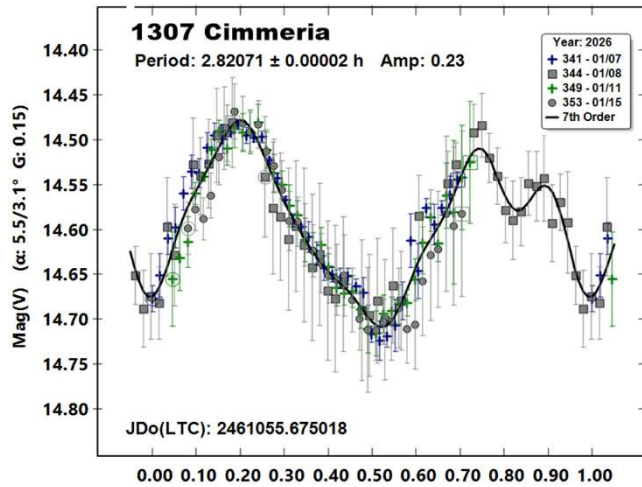
787 Moskva. This main-belt asteroid was discovered on 1914 Apr 20 by Grigory Neujmin at the Simeiz Observatory. We obtained photometric observations on 2026 Jan 6 to 7. From our data, we derive a synodic rotation period of 6.0560 ± 0.0003 h and a lightcurve amplitude of 0.44 mag. Behrend (2003web, 2004web, 201web and 2020web) reported a period of 6.0558 h, 6.056 h, 6.0553h and 6.0579 h. Svoren et al. (2009) calculated 6.0559 h. Warner (2011a) calculated 6.056 h. Hanus et al. (2013) calculated a sidereal period of 6.05581 h. All are consistent with our result.



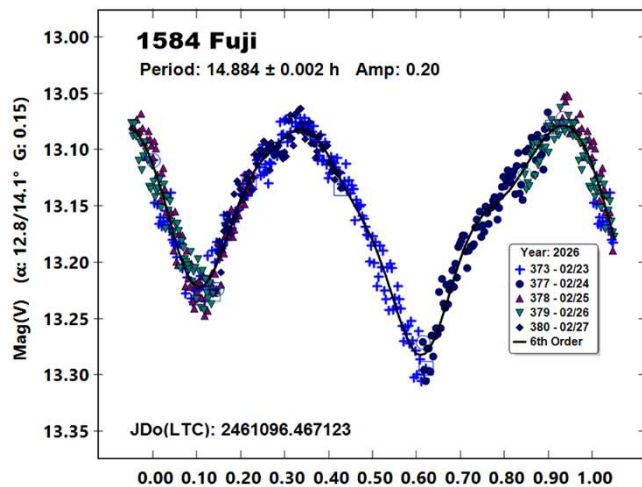
1102 Pepita. This main-belt asteroid was discovered on 1928 Aug 20 by Karl Reinmuth at the Heidelberg Observatory. We obtained photometric observations on 2026 Jan 14 to Feb 2. From our data, we derive a synodic rotation period of 5.104 ± 0.001 h and a lightcurve amplitude of 0.49 mag. Behrend (2007web, 2019web) reported a period of 5.104 h and 5.106 h. Stephens and Sada (2007) found a period of 5.1014 h. Hanus et al. (2011) calculated a sidereal period of 5.10532 h.



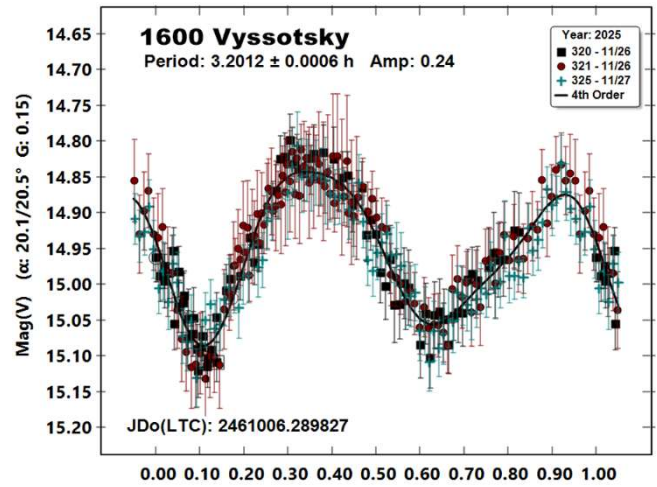
1307 Cimmeria. This main-belt asteroid was discovered on 1930 Feb 13 by Grigory Neujmin at the Simeiz Observatory. We obtained photometric observations on 2026 Jan 7 to 15. From our data, we derive a synodic rotation period of 2.82071 ± 0.00002 h and a lightcurve amplitude of 0.23 mag. Warner (2005) found a period of 2.82 h. Klinglesmith III (2013web) found 2.821 h and Hanus et al. (2013) calculated 2.820723 h.



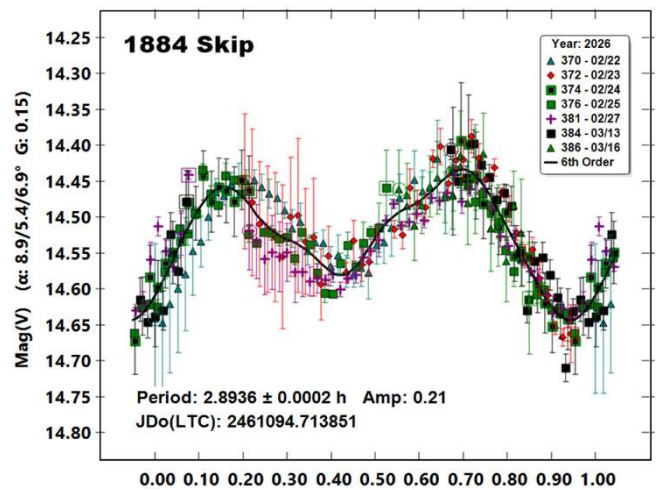
1584 Fuji. This main-belt asteroid was discovered on 1927 Feb 22 by Okuro Oikawa at the Tokyo Observatory. We obtained photometric observations on 2026 Feb 23 to 27. From our data, we derive a synodic rotation period of 14.884 ± 0.002 h and a lightcurve amplitude of 0.20 mag. Behrend (2006web) reported a period of 14.876 h. Durech et al. (2020) found a sidereal period of 14.8865 h derived from lightcurve inversion models.



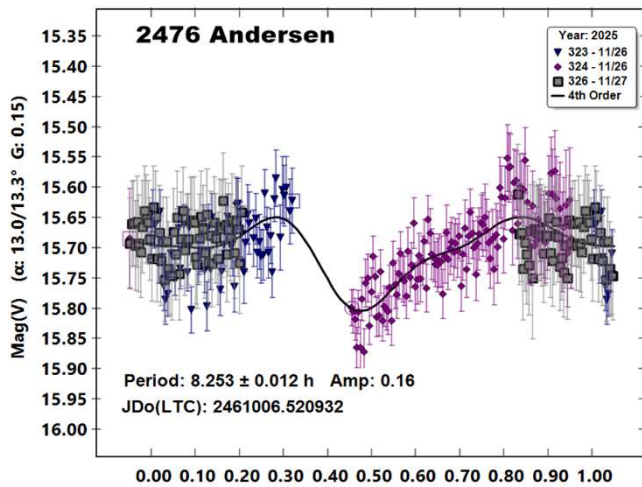
1600 Vyssotsky. This main-belt asteroid was discovered on 1947 Oct 22 by Grigory Neujmin at the Simeiz Observatory. We obtained photometric observations on 2025 Nov 26 to 27. From our data, we derive a synodic rotation period of 3.2012 ± 0.0006 h and a lightcurve amplitude of 0.24 mag. There are several entries in LCDB. I highlight the results of Warner et al. (2008) with a calculation of a sidereal period of 3.201264 h. Behrend (2010web) reported 3.20124 h. Benishek et al. (2019) found 3.20145 h and Wang and Xu (2021) found 3.201264 h.



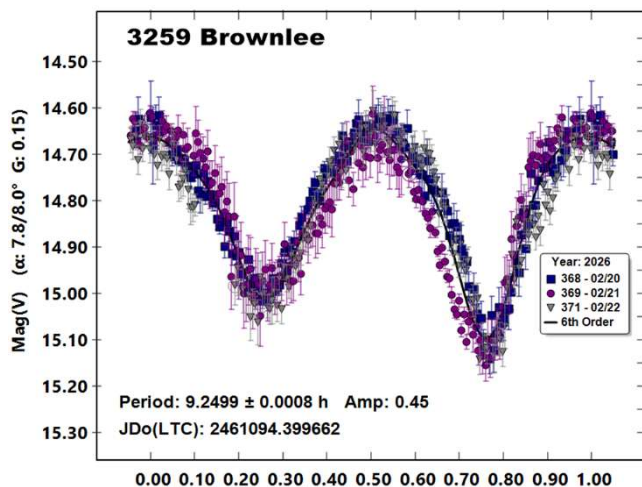
1884 Skip. This main-belt asteroid was discovered on 1971 Aug 26 by Carlos Torres at the El Leoncito Observatory. We obtained photometric observations on 2026 Feb 22 to Mar 26. From our data, we derive a synodic rotation period of 2.8936 ± 0.0002 h and a lightcurve amplitude of 0.21 mag. Behrend (2017web) got a period of 2.9151 h. Benishek and Rowe (2018) calculated 2.89484 h. Skiff et al. (2019) found a period of 2.8887 h. Durech et al. (2020) calculated a sidereal period of 2.89442 h. Benishek (2022) found 2.894 h.



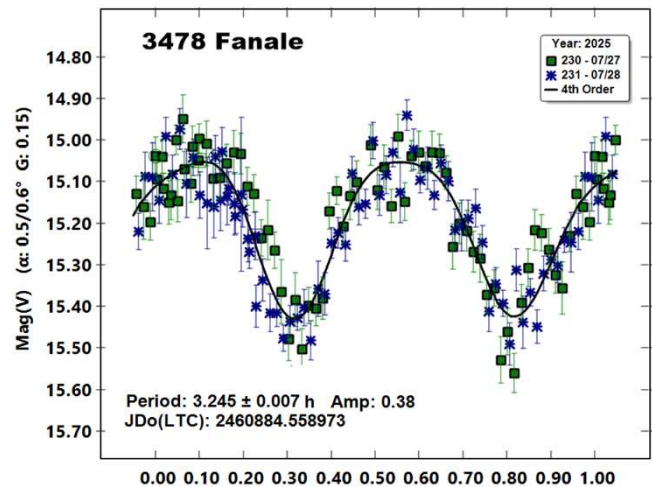
2476 Andersen. This main-belt asteroid was discovered on 1977 Aug 12 by Nikolai Chernykh at the Crimean Astrophysical Observatory. We obtained photometric observations on 2025 Nov. 26 to 27. From our data, we derive a synodic rotation period of 8.253 ± 0.012 h and a lightcurve amplitude of 0.16 mag. Hills (2016) found a period of 8.241 h.



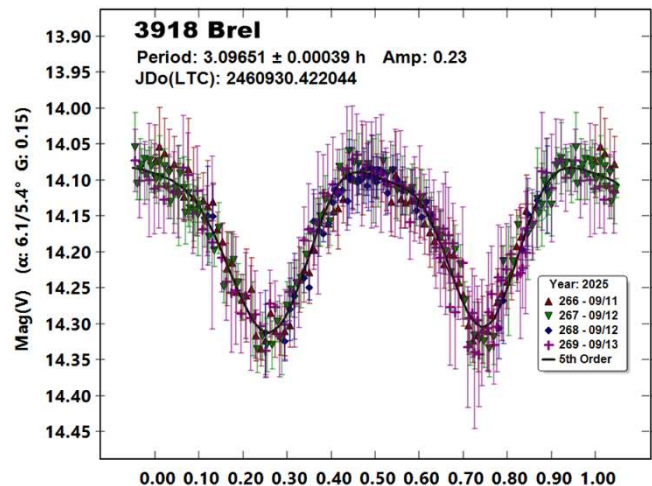
3259 Brownlee. This main-belt asteroid was discovered on 1981 Feb 11 by Norman G. Thomas at the Lowell Observatory. We obtained photometric observations on 2026 Feb 20 to 22. From our data, we derive a synodic rotation period of 9.2499 ± 0.0008 h and a lightcurve amplitude of 0.45 mag. De Sanctis et al. (1994) found a period of 9.24 h. Carbo et al. (2009) found 9.25 h and Durech et al. (2019) found a sidereal period of 9.25483 h.



3478 Fanale. This inner main-belt asteroid was discovered on 1979 Dec at Anderson Mesa by Edward Bowell. We obtained photometric observations on 2025 Jul 27 to 28. From our data, we derive a synodic rotation period of 3.245 ± 0.007 h and a lightcurve amplitude of 0.38 mag. Our result is in excellent agreement with previous determinations; Owings (2013) found 3.245 h. Stephens (2013) found 3.245 h. Mieczkowska et al. (2021) reported 3.25 h. Hanus et al. (2016) found a sidereal period of 3.244883 h, close to our synodic period.



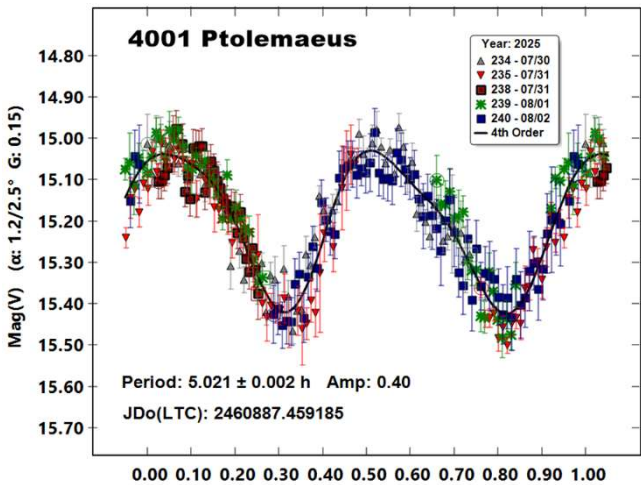
3918 Brel. This main-belt asteroid was discovered on 1988 Jan 24 by Eric Walter at the La Silla Observatory. We obtained photometric observations on 2025 Sep. 11 to 13. From our data, we derive a synodic rotation period of 3.0965 ± 0.0004 h and a lightcurve amplitude of 0.23 mag. Pravec (2005web, 2007web) reported periods of 3.0966 and 3.098 h. Dykhuis et al. (2016) found a sidereal period of 3.09686 h. Hanus et al. (2016) reported a sidereal period of 3.09679 h, close to our synodic period.



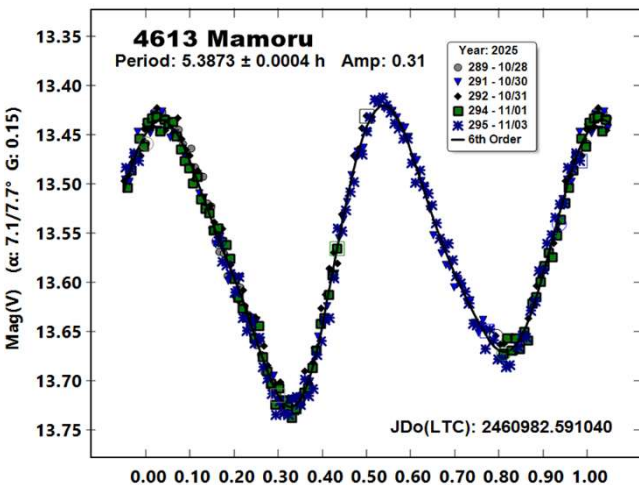
4001 Ptolemaeus. This main-belt asteroid was discovered on 1949 Sep 8 by Reinmuth at the Heidelberg observatory. We obtained photometric observations on 2025 Jul 30 to Aug. 2. From our data, we derive a synodic rotation period of 5.021 ± 0.002 h and a lightcurve amplitude of 0.40 mag. There is no previous information in LCDB about this asteroid.

Number	Name	yyyy mm/dd	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
151	Abundantia	2025/11/20-21	13.7, 14.0	24.9	-0.95	10.156	0.019	0.13	0.1	MB-M
218	Bianca	2026/02/01-06	15.3, 16.4	92.6	-17.0	6.3369	0.0002	0.19	0.03	MB-M
250	Bettina	2025/11/14-18	12.8, 13.9	15.9	-0.3	5.0545	0.0001	0.35	0.03	MB-M
351	Yrsa	2025/11/25-28	11.6, 12.6	37.1	-9.6	13.2994	0.0002	0.47	0.03	MB-M
420	Bertholda	2026/03/15-16	3.1, 3.7	167.4	-7.8	10.9871	0.0007	0.26	0.03	MB-M
513	Centesima	2026/02/17-20	3.1, 3.9	144.4	-7.7	4.815	0.012	0.05	0.02	MB-O
572	Rebekka	2026/03/12-13	5.5, 5.8	161.4	-7.1	5.650	0.004	0.26	0.02	MB-M
611	Valeria	2026/01/09-11	8.2, 8.5	102.3	-17.3	6.961	0.003	0.23	0.02	MB-M
787	Moskva	2026/01/06-07	8.8, 9.0	94.6	18.6	6.0560	0.0003	0.44	0.02	MB-M
1102	Pepita	2026/01/14-02/02	10.4, 14.5	87.0	-15.5	5.104	0.001	0.49	0.02	MB-M
1307	Cimmeria	2026/01/07-15	5.6, 3.1	114.2	-4.9	2.82071	0.00002	0.23	0.03	MB-M
1584	Fuji	2026/02/23-27	12.5, 14.1	146.5	-17.5	14.884	0.002	0.20	0.02	MB-M
1600	Vysotsky	2025/11/26-27	19.7, 20.2	36.3	-8.4	3.2012	0.0006	0.24	0.03	MB-M
1884	Skip	2026/02/22-03/26	9.0, 12.2	164.9	4.4	2.8936	0.0002	0.21	0.03	MB-I
2476	Andersen	2025/11/26-27	12.7, 13.0	32.1	-9.2	8.253	0.012	0.16	0.04	MB-M
3259	Brownlee	2026/02/20-22	7.7, 7.9	147.5	-19.2	9.2499	0.0008	0.45	0.02	MB-I
3478	Fanale	2025/07/27-28	0.2, 0.5	304.0	0.2	3.245	0.007	0.38	0.04	MB-I
3918	Brel	2025/09/11-13	6.6, 5.5	356.4	-2.8	3.0965	0.0004	0.23	0.03	MB-M
4001	Ptolemaeus	2025/07/30-08/02	0.7, 2.4	306.2	0.6	5.021	0.002	0.40	0.03	MB-M
4613	Mamoru	2025/10/28-11/03	7.1, 7.6	37.9	-9.9	5.3873	0.0004	0.31	0.02	MB-M
6690	Messick	2025/08/13-15	0.5, 1.8	319.5	0.1	3.239	0.004	0.25	0.03	MB-I
19261	1995 MB	2025/07/04-07	11.4, 10.3	295.5	8.7	4.5901	0.0006	0.56	0.02	MB-I
20520	1999 RC38	2025/11/29	7.7	68.0	-15.2	3.202	0.078	0.26	0.04	MB-I
24101	Cassini	2025/12/29-30	21.6	72.0	-22.7	4.076	0.009	0.14	0.03	MB-M

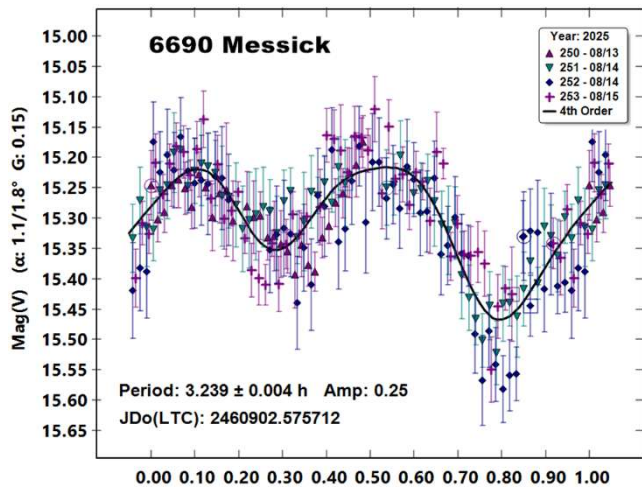
Table I. Observing circumstances and results. The phase angle is given for the first and last date. If preceded by an asterisk, the phase angle reached an extrema during the period. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude/latitude at mid-date range (see Harris et al., 1984). Grp is the asteroid family/group (Warner et al., 2009).



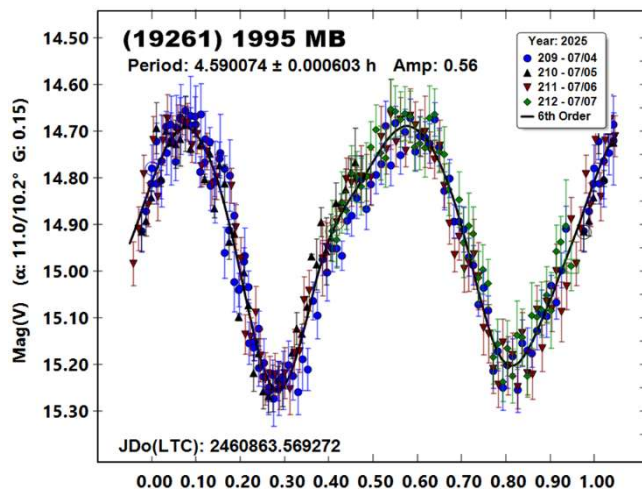
4613 Mamoru. This main-belt asteroid was discovered on 1987 Feb 22 by Tsutomu Seki at the Geisei Observatory. We obtained photometric observations on 2025 Oct 28 to Nov 3. From our data, we derive a synodic rotation period of 5.3873 ± 0.0004 h and a lightcurve amplitude of 0.31 mag. Casalnuovo (2013) found a period of 5.388 h. Durech and Hanus (2018) found a sidereal period of 5.38872 h and Durech et al. (2019) found 5.388653 h.



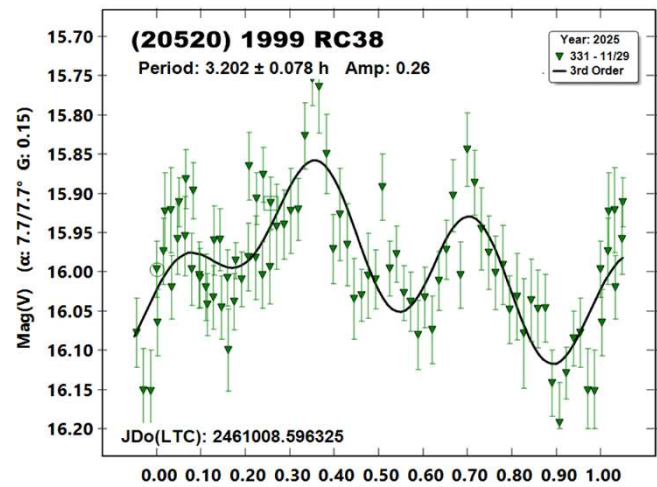
6690 Messick. This main-belt asteroid was discovered on 1987 Sep 25 by Edward Bowell at the Anderson Mesa Station. We obtained photometric observations on 2025 Aug 13 to 15. From our data, we derive a synodic rotation period of 3.239 ± 0.004 h and a lightcurve amplitude of 0.25 mag. There is no previous information in LCDB about this asteroid.



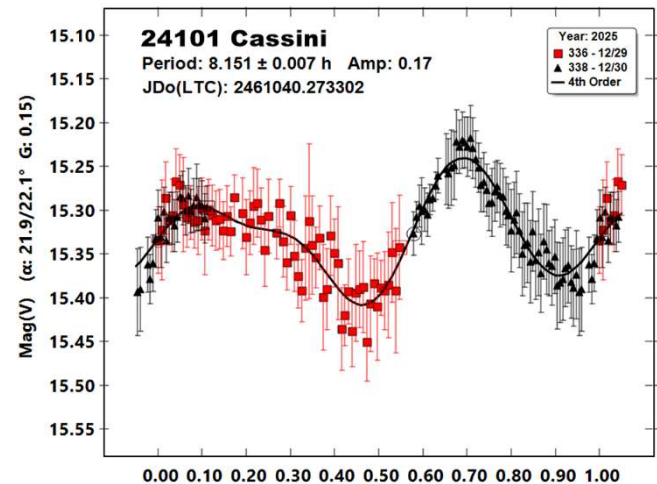
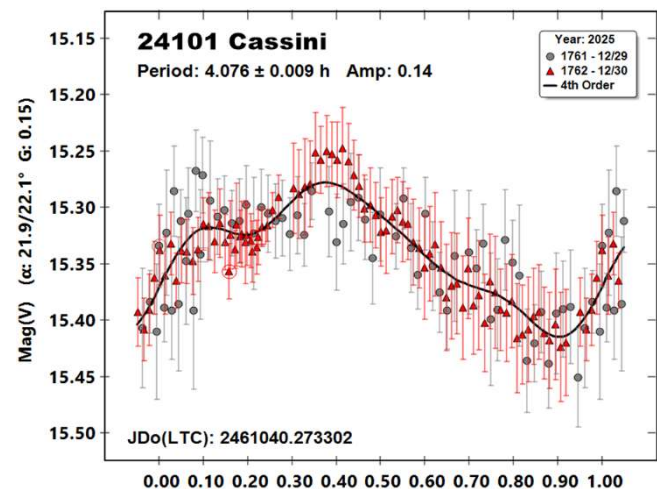
(19261) 1995 MB. This main-belt asteroid was discovered on 1995 Jun 24 by R.H. McNaught at Siding Spring. We obtained photometric observations on 2025 Jul 4 to 7. From our data, we derive a synodic rotation period of 4.5901 ± 0.0006 h and a lightcurve amplitude of 0.56 mag. Carbognani (2011) calculated a period of 4.586 h. Owings (2011) found 4.5911 h and Behrend (2021web) found 4.565 h.



(20520) 1999 RC38. This main-belt asteroid was discovered on 1999 Jan 13 by the LINEAR Project. We obtained photometric observations on 2025 Nov 29. From our data, we derive a preliminary synodic rotation period of 3.202 ± 0.078 h and a lightcurve amplitude of 0.26 mag. We need more data to calculate the period with accuracy. There is no previous information in LCDB about this asteroid.



24101 Cassini. This main-belt asteroid was discovered on 1999 Feb 9 by the LINEAR Project. We obtained photometric observations on 2025 Dec 29 to 30. From our data, we derive a synodic rotation period of 4.076 ± 0.009 h and a lightcurve amplitude of 0.14 mag. The result seems monomodal. However, the lightcurve may be bimodal, in which case the true rotation period would be 8.151 ± 0.007 h and an amplitude of 0.17 mag. Additional observations are required to confirm the preferred solution. The results can be seen in the accompanying figures.



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STUDY, ANALYSIS AND REVIEW OF NINE MAIN-BELT ASTEROIDS

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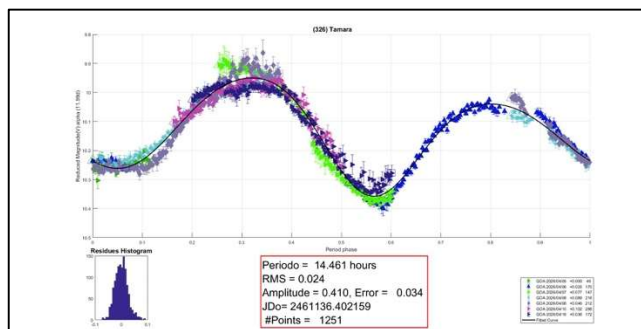
(Received: 2026 June 21)

We present here rotation period study results carried out by our team (GOAS) for nine main-belt asteroids: 326 Tamara (14.461 h), 735 Marghanna (20.629 h), 1301 Yvonne (7.323 h), 1901 Moravia (19.450 h), 2538 Vanderlinden (27.791 h), 3495 Colchagua (5.483 h), 3793 Leonteus (5.618 h), 4159 Freeman (4.403 h) and 8271 Imai (3.217 h).

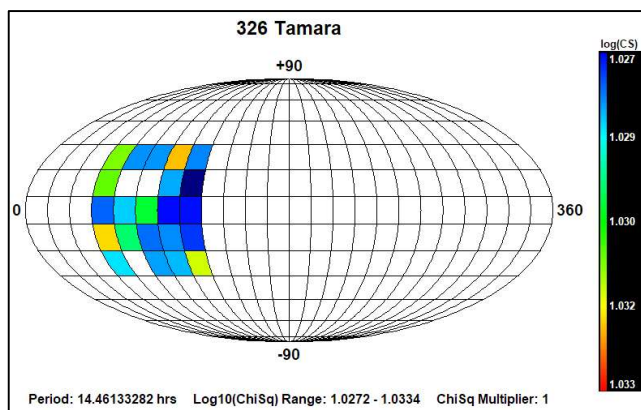
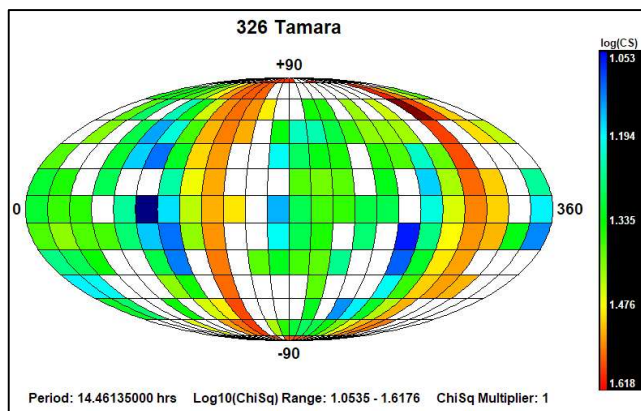
We offer a continuing report on our study of minor planet rotations. As on other occasions, the images we obtained were calibrated in the conventional mode, without photometric filter, and with the application of darks, bias and flats. Data analysis and processing were performed using *FotoDif* (2021), *Tycho Tracker* (2023) and *Periodos* (2020) software. Besides, all data were light-time corrected. The results are summarized below. Individual lightcurve plots along additional comments as required are also presented.

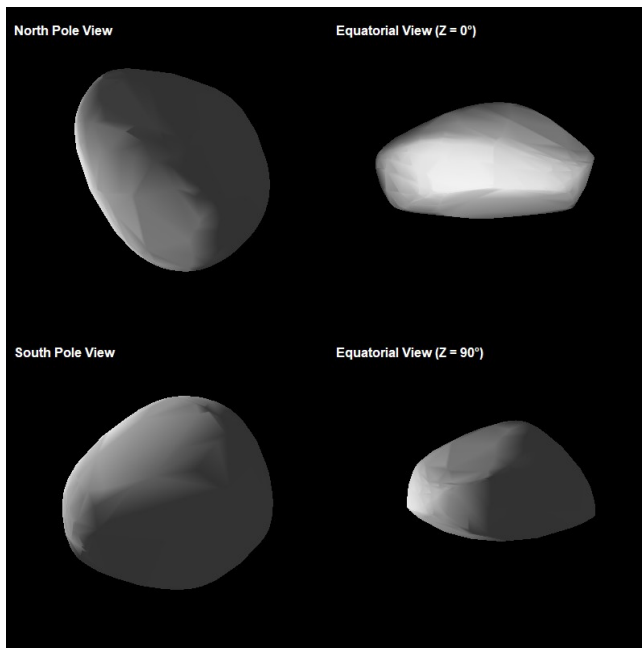
326 Tamara. Classified as a carbonaceous C-type asteroid, Tamara was discovered in 1982 March from the Vienna Observatory. Its rotation period, as recorded in the literature, is almost 14.5 hours; it also has an irregular shape and a very low albedo, typical of C-type asteroids.

During the first fortnight of 2026 April, our team spent several nights observing the object. Using the data collected, we plotted its lightcurve and were able to deduce a rotation period $P = 14.461 \pm 0.024$ h and $A = 0.41 \pm 0.03$ mag, which is very much in line with previously published figures for this parameter. (Behrend, 2012web).

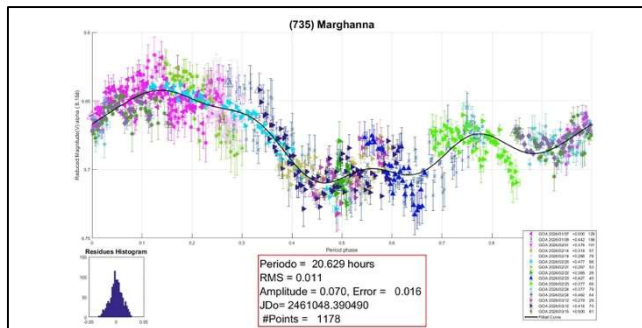


Using our observations, together with those recorded in other sources (ALCEDF, ATLAS, CATALINA, PALOMAR, USNO) we were able to develop a 3D model, for which we obtained the values of spin axis of $\Lambda = 78.109$, $B = 1.954$ and $P = 14.46133282$. To do this, we apply the applying the lightcurve inversion method implemented in the *MPO* package *LCInvert*.

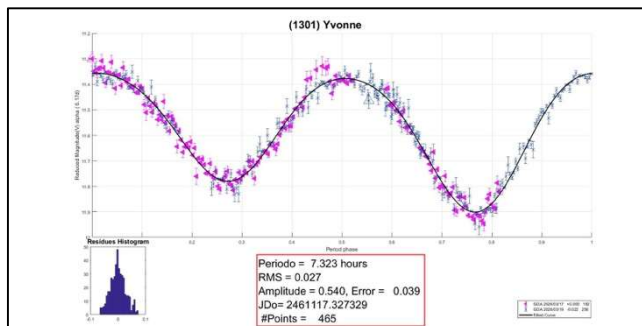




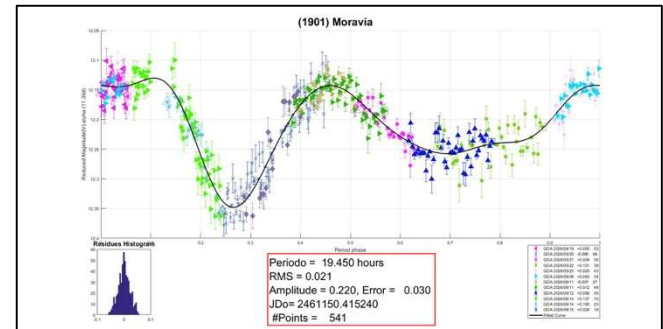
735 Marghanna. Discovered in Germany towards the end of 1912, it has a published rotation period of almost 21 hours. Our studies, carried out between 2026 January and March, yielded a value very similar to that recorded (Skiff et al., 2019). Our data: $P = 20.629 \pm 0.011$ hours, and $A = 0.07 \pm 0.01$.



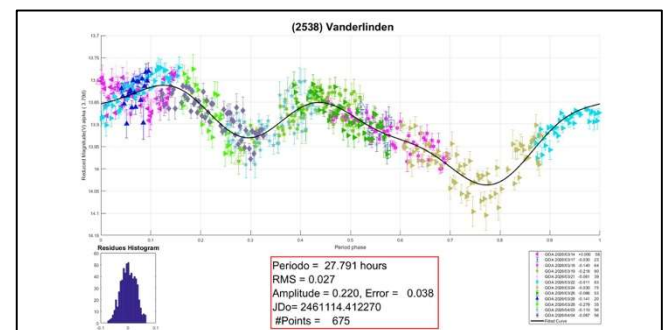
1301 Yvonne. With a notably inclined orbit and an estimated diameter of just over 21 km, it has a published rotation period of just over 7 hours (Behrend, 2017web). Between 17 and 20 March 2026, our team tracked this asteroid, obtaining its lightcurve and rotation period. $P = 7.323 \pm 0.027$ hours, and $A = 0.54 \pm 0.04$.



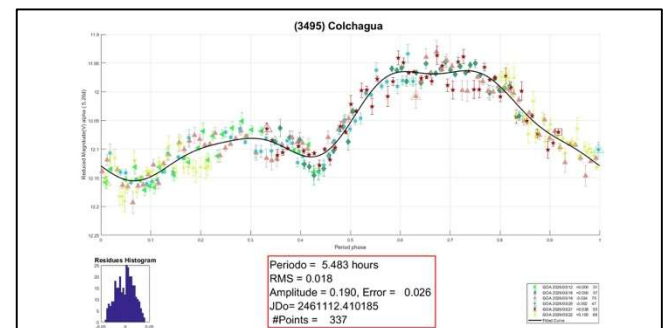
1901 Moravia. We have found no data in the literature regarding the rotation period or lightcurve of this asteroid, which was discovered in Germany in January 1972. Interestingly, there is a model proposed in DAMIT. The observations carried out by our GOAS group took place between 2026 January and March. As a result, we were able to deduce a rotation period $P = 19.450 \pm 0.021$ hours, and $A = 0.22 \pm 0.03$ that is consistent with the model appearing in DAMIT.



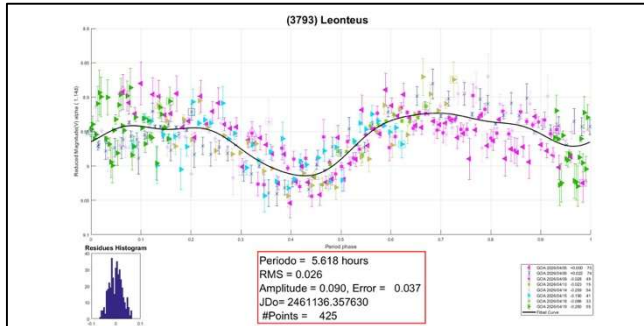
2538 Vanderlinden. With a diameter of less than 6 km, this asteroid, discovered in Belgium in 1954 October, has no published rotation period or lightcurve in the literature we have consulted. During 2026 March and April, we at GOAS monitored it over several nights. We were able to deduce a rotation period $P = 27.791 \pm 0.027$ hours, and $A = 0.22 \pm 0.04$.



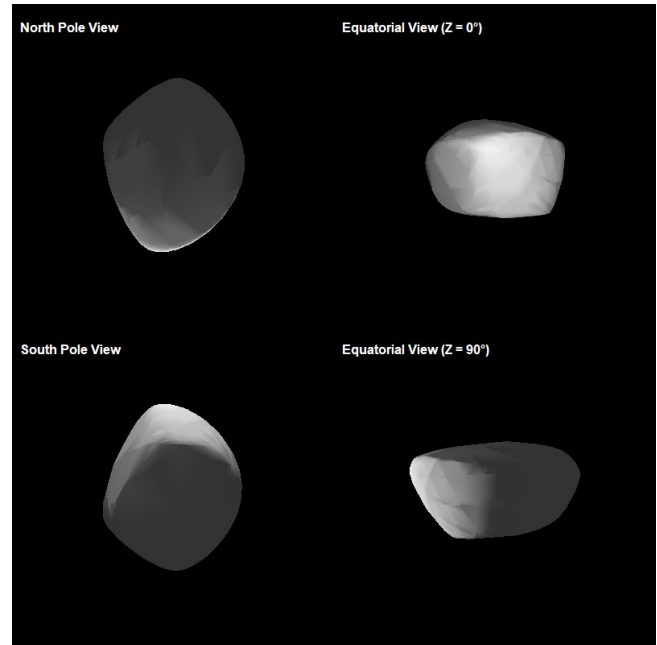
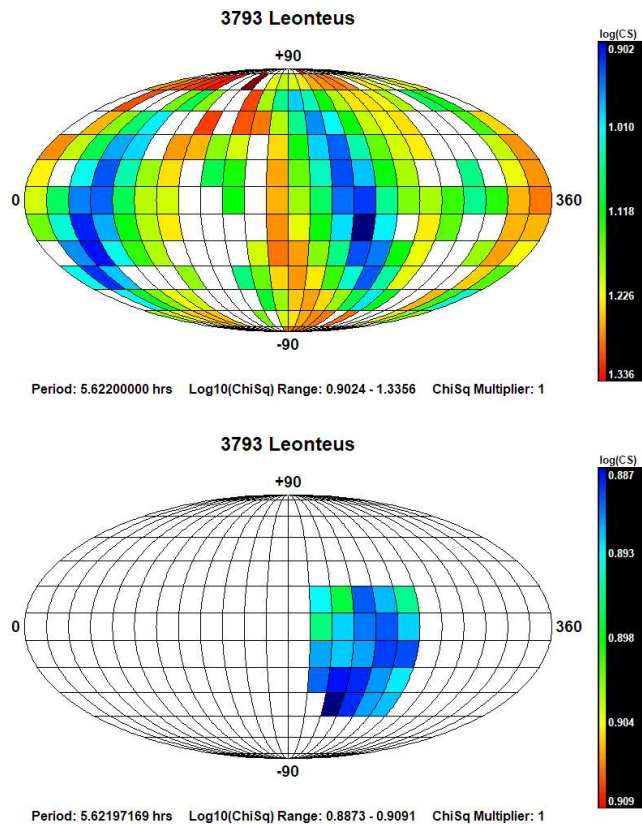
3495 Colchagua. We have not found any information published in ALCDEF or JPL regarding the rotation period or lightcurves of this asteroid, which was discovered in Chile in July 1981. During March 2026, we undertook to track and observe it. We were able to deduce its period $P = 5.483 \pm 0.018$ hours, and $A = 0.19 \pm 0.02$.



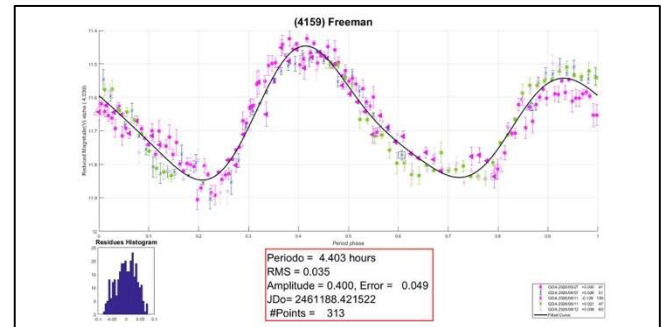
3793 Leonteus. The most recent published references we have found on this asteroid date from 2021 (Stephens and Warner, 2019). It is, however, a widely studied asteroid. Our contribution to these studies was carried out during 2026 March and April, and we obtained results that were very much in line with those found in the literature: $P = 5.618 \pm 0.026$ hours, and $A = 0.09 \pm 0.04$.



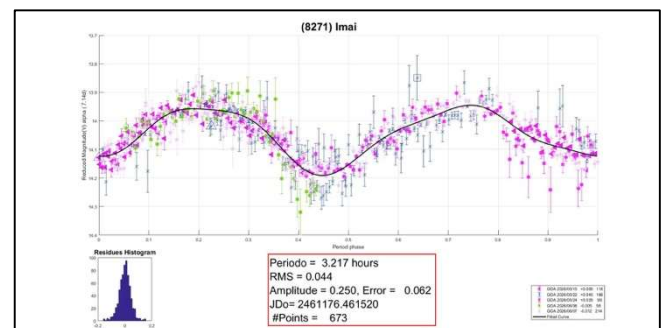
As there is no 3D model available in DAMIT, we proposed a geometric model based on our own data and some data retrieved from the literature (ALCEDF, ATLAS, CATALINA, PALOMAR, USNO). The model was computed using the LC-invert software package. We obtain a spin axis of $\lambda = 224.219$, $\beta = -10.964$, and $P = 5.62197169$ h that is in good agreement with the lightcurve obtained.



4159 Freeman. One of the most recent references we have found in the literature on this asteroid dates from 2022 (Behrend, 2022web). During 2026 May and early June, GOAS observed it on several nights. Using our data and its lightcurve, we were able to deduce a rotation period that is very much in line with the most recent published value: $P = 4.403 \pm 0.035$ hours, and $A = 0.40 \pm 0.05$.



8271 Imai. We have not found any data in the standard literature regarding the rotation period of this faint asteroid, which is only about 6 km in diameter, nor regarding its lightcurve. The data collected on nights during the second half of 2026 May and early June allowed us to determine its rotation period $P = 3.217 \pm 0.044$ hours, and $A = 0.25 \pm 0.06$.



Observer	Telescope	Camera
Botana Alba, Carlos (Y85)	Newton 8"	ZWO ASI183M Pro
De Elias Cantalapiedra, Javer (L46)	CDK 12.5"	QHY268m
Fernández Andújar, Jose M ^a (Z77)	SC 8"	Atik460Ex
García de la Cuesta, Faustino (J38)	RCX 10"	SBIG ST8XE
González Farfán, Rafael (Z55)	SC 11"	Atik414ex m
Limón Martínez, Fernando (Z50)	SC 8"	ZWO ASI533MM Pro
Reina Lorent, Esteban (Z32)	SC 10"	ZWO 294MM
Ruiz Fernández, Javier (J96)	RC 16"	ST8XME
Polancos Ruiz, Javier	Vixen ED103S	Atik314L+

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<http://alcdef.org>

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https://ssd.jpl.nasa.gov/tools/sbdb_lookup.html#/?sstr=52768

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<https://minplanobs.org/bdwpub/php/mpocanopus.php>

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<https://www.tycho-tracker.com>

Number	Asteroid	20yy mm/dd	Phase	Period(h)	P.E.	Amp	A.E.
326	Tamara	26/04/05-26/04/16	12.0-15.8	14.461	0.024	0.41	0.03
735	Marghanna	26/03/17-26/03/16	8.2-19.3	20.629	0.011	0.07	0.01
1301	Yvonne	26/03/17-26/03/19	6.2- 6.9	7.323	0.027	0.54	0.04
1901	Moravia	26/04/19-26/06/15	17.0-13.7	19.450	0.021	0.22	0.03
2538	Vanderlinden	26/03/14-26/04/04	3.8-13.0	27.791	0.027	0.22	0.04
3495	Colchagua	26/03/12-26/03/18	5.3- 3.0	5.483	0.018	0.19	0.02
3793	Leonteus	26/04/05-26/04/19	1.1- 3.9	5.618	0.026	0.09	0.04
4159	Freeman	26/05/27-26/06/12	4.0- 8.2	4.403	0.035	0.40	0.05
8271	Imai	26/05/15-26/06/07	7.2-12.3	3.217	0.044	0.25	0.06

Table I. Observing circumstances and results. Phase is the solar phase angle given at the start and end of the date range. If preceded by an asterisk, the phase angle reached an extrema during the period.

ROTATION PERIODS OF 78 DIANA, 717 WISIBADA, 1397 UMTATA, AND 4460 BIHORO: A CASE STUDY OF LONG-PERIOD ASTEROID MEASUREMENT LIMITATIONS

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Rotation period measurements are presented for four main-belt asteroids using archival data from the ALCDEF database. These include the first rotation period measurement for 4460 Bihoro, and report non-detections for two long-period targets whose LCDB quality codes are updated accordingly. We apply the Fourier Analysis of Light Curves (FALC) method of Harris et al. (1989), which simultaneously fits session zero-point offsets and a Fourier series model, avoiding signal loss from per-session normalization. We obtain reliable periods for 78 Diana (7.2936 $\pm$ 0.0021 h) and 4460 Bihoro (9.83 $\pm$ 0.15 h), while 717 Wisibada and 1397 Umtata yield no reliable period due to insufficient per-session phase coverage. Simulations show that per-session coverage below $\sim$ 25% produces broad chi-squared minima and ambiguous period solutions.

Introduction

The rotation period of an asteroid is a fundamental physical property that provides insight into its internal structure, collisional history, and dynamical evolution. While thousands of asteroid rotation periods have been measured (Warner et al., 2009), long-period asteroids ($P > 24$ h) remain underrepresented in the literature due to observational challenges.

Ground-based photometry typically acquires data in discrete nightly sessions of 2-4 hours. For asteroids with rotation periods much longer than a single session, the brightness variation within each night is approximately linear, and the unknown zero-point offset between sessions (arising from different reference stars, filters, and atmospheric conditions) can mask the true periodic signal. Traditional per-session normalization (subtracting each night's median) removes these offsets but also suppresses the long-period signal itself. The Fourier Analysis of Light Curves (FALC) method (Harris et al., 1989) addresses this by simultaneously fitting a Fourier series model and session zero-point offsets in a single least-squares system. In this work, the FALC method is applied to ALCDEF data for four main-belt asteroids: 78 Diana, 717 Wisibada, 1397 Umtata, and 4460 Bihoro. Our goals are to measure the rotation period of 4460 Bihoro, to validate the FALC implementation using the well-characterized 78 Diana, and to investigate the limitations of period determination for long-period targets.

Observations and Data Reduction

All data were obtained from the Asteroid Lightcurve Data Exchange Format (ALCDEF) database (2024). Table I summarizes the observing circumstances. Observations were made by multiple contributors using various telescope apertures (0.35-0.50 m) and CCD detectors; details are available in the ALCDEF metadata for each session.

Data processing included: (1) iterative 3-sigma outlier rejection within each session (2 iterations, convergence at <0.01 mag change), (2) removal of sessions with fewer than 4 data points. We applied the standard FALC procedure (Harris et al., 1989) without additional preprocessing. Period uncertainties were estimated from the delta chi-squared = 1 confidence interval of the FALC period scan. The Lomb-Scargle periodogram (Lomb, 1976; Scargle, 1982) was used for initial period screening. The Bayesian Information Criterion (Schwarz, 1978) was used to select the Fourier order. For both 4460 Bihoro (BIC: 69.5 for $n=2$ vs 82.1 for $n=3$) and 78 Diana (BIC: 167.2 for $n=2$ vs 183.8 for $n=3$), $n=2$ was the most parsimonious choice.

Results were validated using odd-even session splitting and per-session linear trend testing. Coverage simulations using a synthetic double-peaked lightcurve (0.12 mag amplitude, 0.02 mag Gaussian noise) show that per-session phase coverage below $\sim$ 25% produces broad chi-squared minima that cannot reliably constrain the period.

Results

78 Diana. Observed by F. Pilcher and V. Benishek across 15 sessions from 2007 to 2024 (4234 data points). The FALC chi-squared scan (Figure 1(a)-(b)) shows a global minimum at 7.2936 h. This value differs from the LCDB adopted value of 7.2991 h by 0.0055 h (0.075%). The difference exceeds the formal $\pm 1\sigma$ uncertainty ($\Delta\chi^2 = 1$) by a factor of ~ 2.7 , which likely reflects systematic effects from heterogeneous observing conditions across multiple apparitions rather than a genuine period disagreement. Amplitude 0.147 mag.

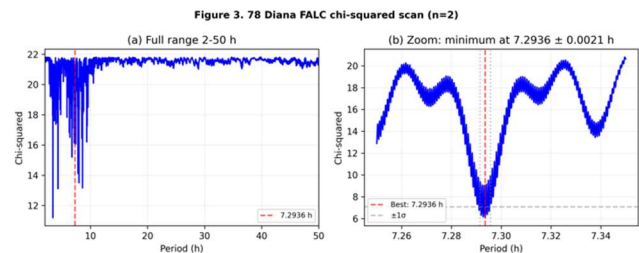


Figure 1. 78 Diana FALC chi-squared scan ($n=2$). (a) Full range 2-50 h showing global minimum at 7.2936 h. (b) Zoom with $\pm 1\sigma$ ($\Delta\chi^2 = 1$) confidence interval.

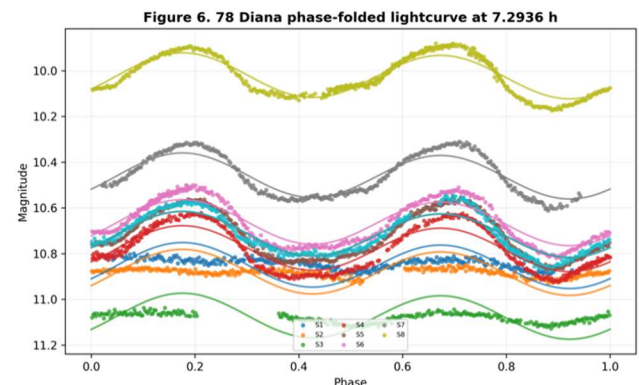


Figure 2. 78 Diana phase-folded lightcurve at 7.2936 h. Solid curve: Fourier $n=2$ fit.

717 Wisibada. Despite 8170 observations across 35 sessions from 2012 to 2024, no reliable period could be determined. The LS periodogram shows no significant peak, and the FALC chi-squared scan shows no clear minimum. The LCDB currently lists two provisional periods for this object: 609 h ($U=2$; Dose, 2024) and 1250 h ($U=2$; Colazo, 2024). However, Pilcher (2024), who contributed the majority of these observations, reported that no rotation period could be found from over 200 hours of photometry. Our analysis is consistent with this result. We scanned periods up to 3000 h, covering both provisional LCDB values, and found no significant chi-squared minimum.

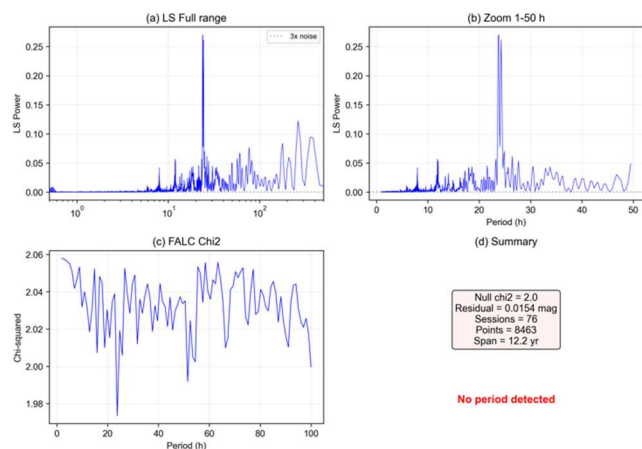


Figure 3. 717 Wisibada analysis. (a) LS full range. (b) LS zoom 1-50 h. (c) FALC chi-squared scan. (d) Summary statistics. No period detected.

1397 Umtata. With 543 observations across 17 sessions spanning 24 days, Figure 5 shows the analysis. No significant LS peak appears near the LCDB provisional value of 30 h ($U=1$; Warner et al., 2009). Each session covers $\sim 16\%$ of a rotation; the FALC chi-squared scan confirms no sharp minimum. The ALCDEF data cannot yield a reliable period. Fitting the data to the 30-h period from the literature does not produce a coherent phased lightcurve, consistent with this non-detection result.

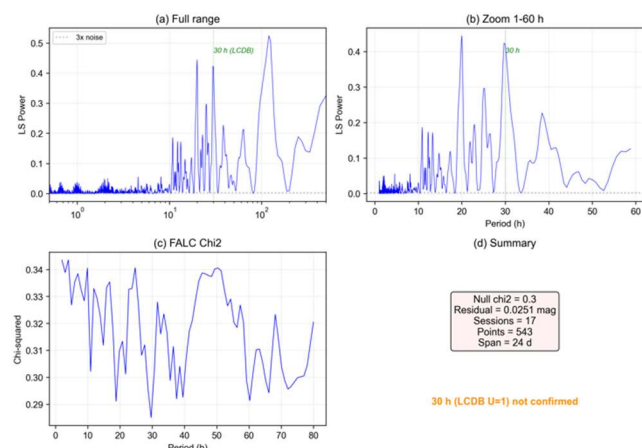


Figure 4. 1397 Umtata analysis. (a) LS full range. (b) LS zoom 1-60 h. (c) FALC chi-squared scan. (d) Summary. LCDB 30 h not confirmed

4460 Bihoro. Observed by M. Wiles on 7 nights from 2023 Dec 8 to 2024 Jan 3 (542 data points, 7 sessions). The LS periodogram (Figure 5(a)) shows a dominant peak at 4.9125 h, corresponding to the half-period of a double-peaked lightcurve. The full rotation period of 9.83 ± 0.15 h was adopted based on the phase-folded lightcurve (Figure 7), which shows two distinct maxima per cycle. The FALC analysis gives amplitude 0.064 mag. BIC selects $n=2$. The odd-even split (Figure 8) and linear trend test (Figure 9) confirm the stability of the result.

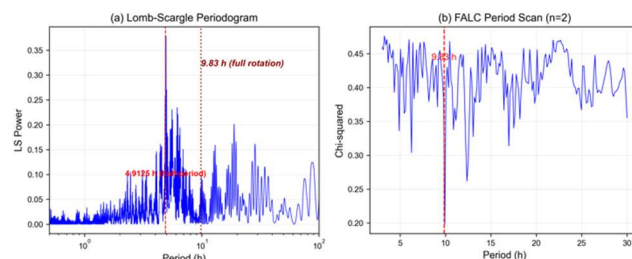


Figure 5. 4460 Bihoro. (a) Lomb-Scargle periodogram with half-period (4.9125 h) and full period (9.83 h) marked. (b) FALC chi-squared scan ($n=2$).

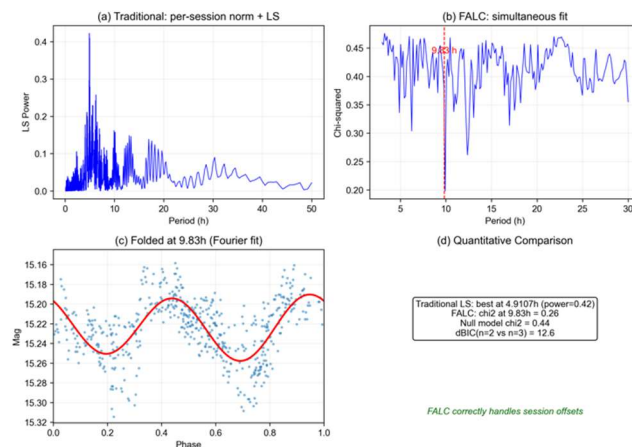


Figure 6. Traditional per-session normalization vs FALC for 4460 Bihoro. (a) Traditional LS. (b) FALC chi-squared scan. (c) Folded at 9.83 h. (d) Quantitative comparison.

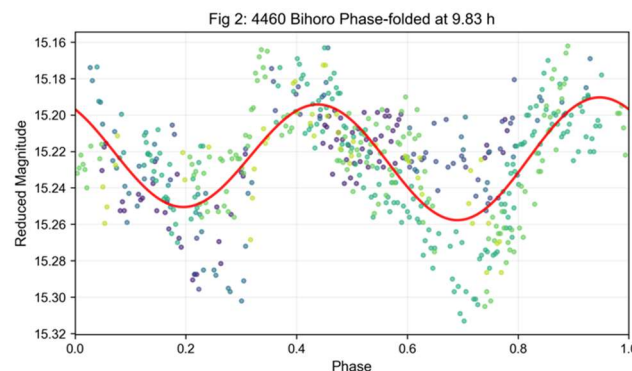


Figure 7. 4460 Bihoro phase-folded lightcurve at 9.83 h. Symbols correspond to individual observing sessions. Solid curve: Fourier $n=2$ fit.

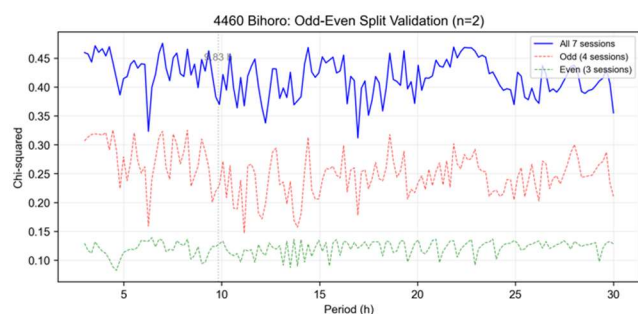


Figure 8. 4460 Bihoro odd-even split validation: all, odd, and even sessions show consistent chi-squared minima near 9.83 h.

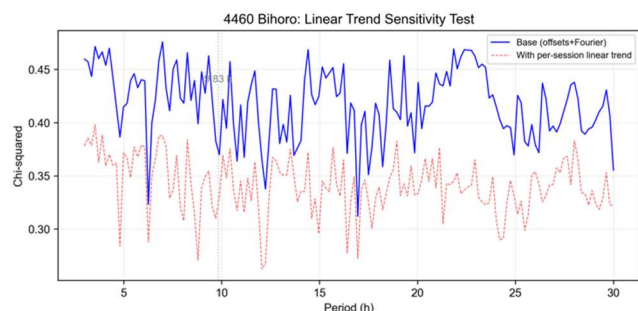


Figure 9. 4460 Bihoro linear trend sensitivity test: including per-session linear trends does not shift the chi-squared minimum.

Summary

The FALC method successfully recovered rotation periods for 78 Diana and 4460 Bihoro. For 78 Diana, the similarity of our result to the LCDB value supports the correctness of our reduction pipeline. For 4460 Bihoro, the amplitude of 0.064 mag corresponds to a peak-to-peak variation of $\sim 6\%$ in brightness, assuming the brightness variation is dominated by shape rather than albedo and a triaxial ellipsoid geometry viewed near equatorial aspect, this corresponds to a minimum projected axial ratio of approximately 1.06:1.

The primary limitation for long-period targets is per-session phase coverage. Our simulations indicate that coverage below $\sim 25\%$ produces ambiguous chi-squared minima. Both 717 Wisibada and 1397 Umtata fall below this threshold. Additionally, 717 Wisibada's 12-year span (35 sessions) suggests that even extensive multi-year data cannot compensate for insufficient per-session coverage if the period is very long (>100 h) or the amplitude is low. For targets with per-session phase coverage above $\sim 25\%$, simultaneous offset fitting preserves more long-period signal than per-session normalization. For extreme long-period cases, practical solutions include longer nightly observing runs, multi-site coordinated observations, or space-based surveys such as TESS (Pál et al., 2020) that provide continuous coverage.

Acknowledgments

This work uses data from the ALCDEF database, which is supported by NASA grant 80NSSC18K0851, and all observers who contributed data to the database. The authors thank Chan Kei Wang, Cheung Kwok Ho, and Wong Chi Nang for their valuable feedback on the manuscript.

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Number	Name	yyyy mm/dd	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
78	Diana	2007-2024	-9.70, 21.62	177.4	-5.9	7.2936	0.002	0.147	0.05	MB-M
717	Wisibada	2012-2024	0.80, 21.40	43.5	1.7	---	--	--	--	MB-O
4460	Bihoro	2023 12/08-2024 01/03	11.40, 12.78	90.0	29.5	9.83	0.15	0.064	0.05	MB-M

Table 1. Observing circumstances and results. The phase angle is given for the first and last date. If preceded by an asterisk, the phase angle reached an extrema during the period. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude/latitude at mid-date range (see Harris et al., 1984). Grp is the asteroid family/group (Warner et al., 2009).

LIGHTCURVE AND ROTATION PERIOD OF BINARY ASTEROID (1727) METTE

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(Received: 2026 July 14)

Photometric observations of the inner main-belt binary Hungaria asteroid (1727) Mette were obtained on eleven nights in March and April 2026. Analysis of R-band lightcurves yields a synodic rotation period of 2.9810 ± 0.0004 h with a peak-to-peak amplitude of 0.26 mag, implying an estimated minimum equatorial axis ratio of $a/b \gtrsim 1.27$. After removal of the primary rotational lightcurve, residuals were examined for mutual events attributable to the known satellite. No mutual-event signals were identified above the noise floor; a phase-angle-bisector longitude near 206° , roughly 90° from both prior detection epochs, indicates a more nearly pole-on aspect during the present apparition, which would suppress mutual-event signatures.

Photometry of asteroid (1727) Mette was obtained remotely at the MonitorMyPlanet Observatory (MPC code R60) in Nerpio, Spain. Observations were conducted using a 0.305-m (12-inch) Ritchey-Chrétien telescope operated at an effective focal ratio of $f/6$ using a $0.75\times$ focal reducer, mounted on a Sky-Watcher EQ8-R equatorial mount and equipped with an ASI2600 monochrome camera and a filter wheel containing Johnson-Cousins U, B, V, R, I filters. Images were binned 2×2 , providing a pixel scale of 0.848 arcsec pixel $^{-1}$. Observations were obtained on eleven nights from March 24 to April 22 (UT).

Standard bias, dark, and flat-field corrections were applied to all images prior to photometric extraction. Differential photometry was performed using ensemble comparison stars within each field. Image reduction and photometric calibration were carried out using *Tycho Tracker* software (Parrott, 2025), with reference magnitudes drawn from the ATLAS star catalog in the Sloan r band.

Time-series observations were obtained in the R band, with 180 second exposure times. Period analysis of the combined R-band dataset was performed using a fourth-order Fourier series fit. The resulting periodogram (Fig. 1) exhibits a well-defined minimum corresponding to a synodic rotation period of 2.9810 ± 0.0004 h. The composite phased lightcurve, combining eleven nights of data (Fig. 2), displays a stable, double-peaked morphology with a peak-to-peak amplitude of 0.26 mag, consistent with principal-axis rotation. The rotation period is consistent with the 2024 apparition reported by Warner (2024), however the amplitude of the rotation lightcurve is lower (Table I). Amplitude Error (A.E.) was estimated as 0.04 mag from $\sqrt{2}$ times the RMS residual of the lightcurve. Assuming a triaxial ellipsoid viewed near the equatorial plane and negligible albedo variegation, the observed amplitude implies an estimated minimum equatorial axis ratio of $a/b \gtrsim 1.27$.

Source	Period (h)	Amplitude (mag)
Warner (2024)	2.9809 ± 0.0001	0.46
This work (2026)	2.9810 ± 0.0004	0.26

Table I. Rotation period and amplitude comparison for (1727) Mette.

After subtraction of the 2.9810 h primary rotational lightcurve, the residuals were searched for mutual events associated with the known satellite. The residual data were also phased to the 21.00 h mutual orbital period reported by Warner (2024). Fig. 3 shows no clear signal was visible above the noise floor during the 2026 observations. During the present observations the phase-angle-bisector (PAB) longitude was approximately 206° , nearly 90° from both the Warner and Stephens (2013) geometry near 114° and the Warner (2024) geometry near 303° . This aspect change, together with the lower peak-to-peak lightcurve amplitude measured in 2026 relative to 2024 (0.26 vs 0.46 mag), indicates that the satellite orbit was viewed closer to pole-on. Under such geometry, mutual occultations and eclipses may be shallow or absent, making the satellite difficult to observe during this apparition.

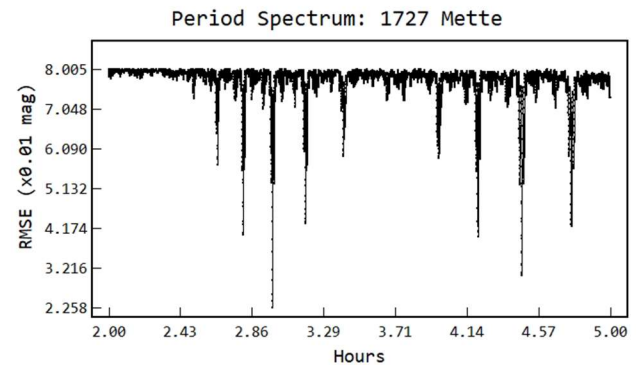


Fig. 1. Periodogram (2–5 h) computed with a 4th-order Fourier fit showing the preferred solution at 2.9810 h.

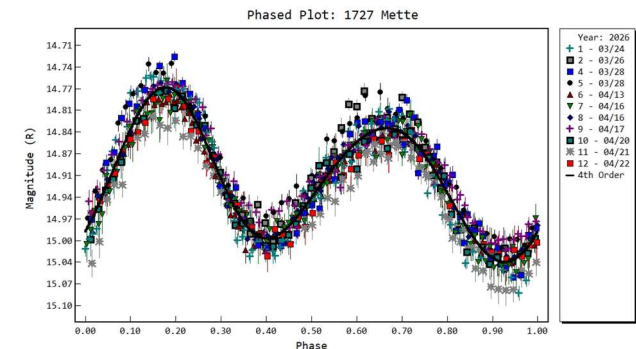


Fig. 2. Lightcurve of (1727) Mette combining eleven nights (2026 Mar–Apr) phased to a period of 2.9810 hours.

Number	Name	yyyy mm/dd	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
1727	Mette	2026 03/24–04/22	*22.6, 20.8	206.0	31.5	2.9810	0.0004	0.26	0.04	MB-I

Table II. Observing circumstances and results. The phase angle is given for the first and last date. If preceded by an asterisk, the phase angle reached an extrema during the period. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude/latitude at mid-date range (see Harris et al., 1984). Grp is the asteroid family/group (Warner et al., 2009).

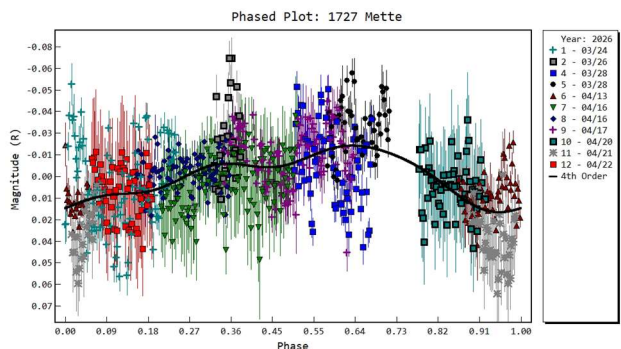


Fig. 3. Lightcurve of the primary-subtracted residuals of the known binary asteroid (1727) Mette phased to the mutual orbital period of 21.00 hours reported by Warner (2024). No clear signal visible above the noise floor during the 2026 apparition.

Acknowledgements

The author thanks Brian D. Warner and Petr Pravec for helpful suggestions on the mutual-event search and aspect analysis. The author thanks the Masason Foundation for providing funding for the telescope and AstroCamp for hosting their observatory in Nerpio, Spain.

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LIGHTCURVE ANALYSIS AND ROTATION PERIOD FOR 6917 ASSATEAGUE

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(Received: 2026 May 26)

We present the lightcurve for the main-belt asteroid 6917 Assateague. The lightcurve was calculated using 8 nights of observations and yielded a synodic rotation period of 357.2 ± 1.8 h with a lightcurve amplitude of 1.08 mag. A search of the Asteroid Lightcurve Database (Warner et al, 2009) did not find any previously reported rotation periods for 6917 Assateague.

6917 Assateague is a main-belt asteroid discovered by Satoru Otomo at Kiyosato on 1993 March 29. Its estimated diameter is 4.396 ± 0.051 km ($H = 13.74$ mag), and it orbits the Sun with a semi-major axis of 2.216 au, an eccentricity of 0.081, and a period of 3.30 yr (JPL, 2026).

Students at the University of Maryland, under the guidance of Melissa Hayes-Gehrke, in collaboration with Charles Galdies and Marek Buček, propose a long period of 357.2 ± 1.8 h for the asteroid 6917 Assateague.

Data from 2026 Apr 6, 9, 12, 15, and 18 were collected using iTelescope’s T21 telescope at the Utah Desert Remote Observatory in the Great Basin Desert, Beryl Junction, Utah, USA (iTelescope, 2024). T21 has a 0.43-m f/6.8 reflector + CCD + f/4.5 focal reducer; the CCD used was a FLI-PL6303E CCD camera, with 9µm square pixel size and a 0.96 arcsec/pixel resolution (iTelescope, 2024). Marek Buček observed 6917 Assateague on 2026 Apr 16, 17, 18, 22, 24 using a 0.27-m Rowe-Ackermann Schmidt telescope with a starlight express 674 CCD camera. Charles Galdies observed 6917 Assateague on Apr 17, 18, and 20 using a 0.20-m Schmidt-Cassegrain telescope with a Moravian G2-1600 CCD camera.

Number	Name	yyyy mm/dd	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
6917	Assateague	2026 04/06-04/24	-3.5, 8.10	201.7	3.3	357.2	1.8	1.08		MB

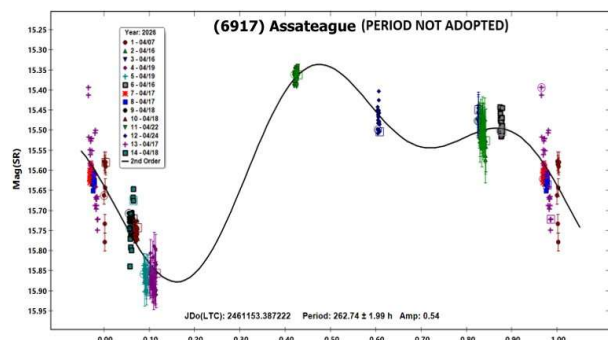
Table I. Observing circumstances and results. The phase angle is given for the first and last date. If preceded by an asterisk, the phase angle reached an extrema during the period. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude/latitude at mid-date range (see Harris et al., 1984). Grp is the asteroid family/group (Warner et al., 2009).

The data were processed by the University of Maryland authors using v12.0.7.0 of the *MPO Canopus* software (Warner, 2024), while Marek Buček and Charles Galdies used v10 of *MPO Canopus* (Warner, 2018). This software was used to determine the differential magnitude of the asteroid by utilizing comparison stars and aperture photometry.

Aperture photometry was performed using differential photometry with a minimum of 5 comparison stars. Automatic comparison star selection was initially employed but required manual refinement. Sky background subtraction was applied to mitigate interference from background stars overlapping the asteroid path. Images exhibiting tracking errors, streaking, or artifacts were excluded. Aperture alignment was monitored throughout the measurement process, with manual corrections applied where necessary.

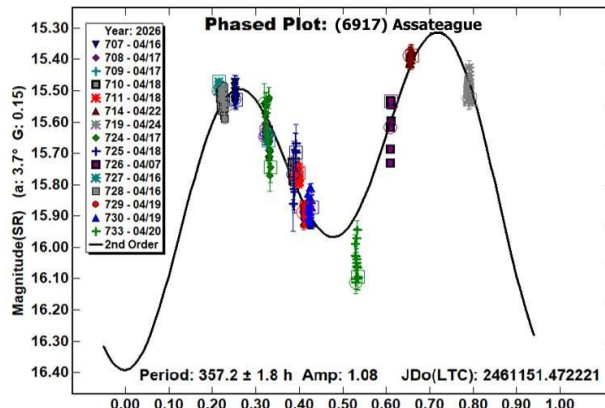
Initial lightcurves from early observing sessions (Apr. 6 and Apr. 15) showed minimal variation and did not reveal a clear periodic signal. After incorporating external observations from Buček and Galdies, the combined lightcurve exhibited a brightness variation of ~ 1 magnitude, consistent with a rotational signal rather than observational noise.

Period analysis was conducted using the Fourier analysis tools within *MPO Canopus*. A range of trial periods was tested, and two candidate periods were identified: 262.74 ± 1.99 h and 357.2 ± 1.8 h. Although the shorter period produced a slightly lower RMS residual, the longer period yielded a more physically plausible phased lightcurve with improved coherence across observing sessions since it produced a lightcurve with two distinct peaks and troughs, while the shorter period produced a lightcurve with one distinct trough and one peak with an unusual dip, which would suggest an abnormal shape for the asteroid. There was no distinct minimum in the RMS plot, so there was no significantly better-fitting rotation period due to the sparseness of the data. A number of other candidate periods with low RMS values were discarded since the points did not properly fit the line. We therefore adopted a rotation period of 357.2 ± 1.8 h. The discarded lightcurve with a period of 262.74 ± 1.99 h is shown below.



The phased lightcurve corresponding to the adopted period shows a peak-to-peak amplitude of 1.08 mag, suggesting an elongated or irregular shape. The derived rotation period (~ 14.9 days) classifies 6917 Assateague as a slow rotator, significantly longer than the typical rotation periods of main-belt asteroids, which are generally on the order of several hours. No prior rotation period determinations were found in the Asteroid Lightcurve Database (Warner et al., 2009), indicating that this result represents a new contribution.

The extended period and relatively large amplitude are consistent with a non-spherical body, though additional observations would be required to refine the period and confirm.



Acknowledgements

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Observations were possible thanks to the close guidance of our TAs and Dr. Hayes-Gehrke.

We would like to thank Marek Buček and Charles Galdies from the [APSIREASTRO.net](https://apsireastro.net) team for generously sharing their independent observations of (6917) 1993 FR2, which significantly enhanced our data set and contributed to the period determination presented in this report.

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LIGHTCURVE ANALYSIS AND ROTATION PERIOD FOR 12344 MARYLAND

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Two sets of photometric observations of the asteroid 12344 Maryland on were obtained on 2026 April 7 and 10 and using *MPO Canopus* software we plotted the lightcurve of 12344 Maryland and measured its rotation period to be about 2.0589 ± 0.0091 h.

12344 Maryland is a mid-sized main-belt asteroid that was discovered 1993 Mar 18. 12344 Maryland has an eccentricity of approximately 0.146, a semi-major axis of 2.569 AU, an inclination of 8.654° , a sidereal orbital period of 4.118 y, and a diameter of 4.621 km (JPL, 2023). A search of the Asteroid Lightcurve Database (Warner et al, 2009) showed no previously determined rotation period for 12344 Maryland. The importance of establishing a rotation period and analyzing its lightcurve contributes to the collective understanding of asteroids and builds upon the already existing research in the field.

All observations of 12344 Maryland reported here were performed at the Utah Desert Remote Observatory, Beryl Junction, Utah, using a 0.43-m f/6.8 reflector telescope with a FLI-PL6303E CCD camera with an array of 3078×2048 pixels used with a luminance filter, set to a 300-s exposure time (iTelescope Support Document, 2024). The data processing and period analysis were rendered with *MPO Canopus* software (Warner, 2026) using differential and aperture photometry to produce a rotation period of 2.0589 ± 0.0091 with an amplitude of 0.16 mag.

The data indicate the asteroid has a low amplitude of 0.16 mag, implying 12344 Maryland could be nearly spherically shaped. This low amplitude makes it difficult to see a repeating pattern in the lightcurve when conducting Fourier analysis.

The period corresponding to the lowest RMS value was selected and represented below, although the difference in RMS compared to other periods was not significant. For that reason, the results are uncertain. Due to a limited observation window, additional data will be necessary to accurately determine the rotation period of this asteroid.

Acknowledgements

Funding for iTelescope observations of 12344 Maryland described in this paper was supported by Maryland Space Grant Consortium under NASA cooperative agreement 80NSSC25M7076 and graciously directed to this project by Dr. Melissa N. Hayes-Gehrke.

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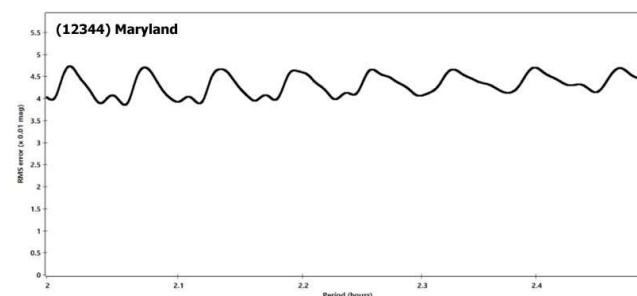
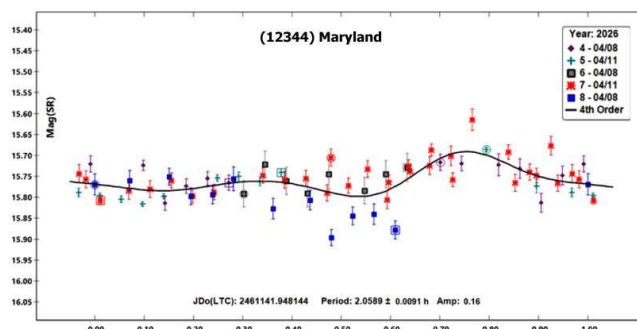
Harris, A.W.; Young, J.W.; Scaltriti, F.; Zappala, V. (1984). "Light curves and phase relations of asteroids 82 and 444 Gytis." *Icarus* **57**, 251-258.

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Number	Name	yyyy mm/dd	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
12344	Maryland	2026 04/07-04/10	5.30, 6.20	204.74	+8.3	2.0589	0.0091	0.16	0.05	MB

Table I. Observing circumstances and results. The phase angle is given for the first and last date. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude/latitude at mid-date range (see Harris et al., 1984). Grp is the asteroid family/group (Warner et al., 2009).

LIGHTCURVE ANALYSIS AND ROTATION PERIOD FOR 2278 GÖTZ

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Lightcurve analysis using *MPO Canopus* of five nights of observations of 2278 Götz produced a rotation period of 29.175 ± 0.425 h.

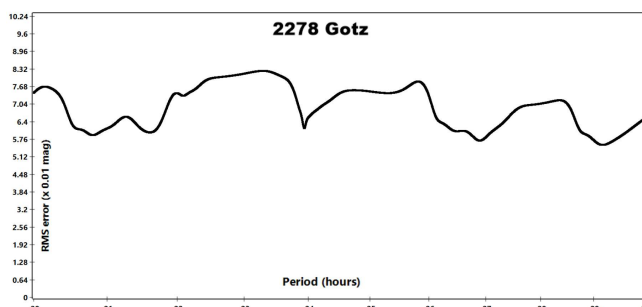
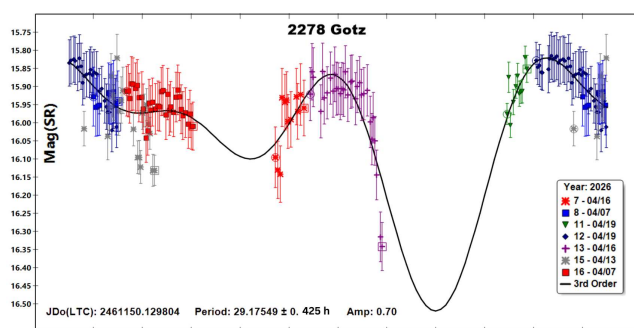
2278 Götz is a main-belt asteroid discovered in 1953 April 7 by K. Reinmuth at Heidelberg. It has a diameter of 11.769 km, a semi-major axis of 2.453 AU, an orbital period of 3.842 years, an eccentricity of 0.149, and an inclination of 4.196 deg (JPL, 2026). A search in the Asteroid Lightcurve Database (Warner et al., 2009) showed no previously determined rotation period for 2278 Götz.

2278 Götz was observed throughout April 2026 at the Siding Spring Observatory (Q62) in New South Wales, Australia. Observations were carried out with the T17 telescope remotely operated via iTelescope. T17 uses a ZWO ASI 6200MM Pro CMOS attached to a Planewave 17" CDK (iTelescope, 2026). A luminance filter was used with an exposure time of 300 seconds to capture images of the asteroid. T17 required a binning of 2.

MPO Canopus (Warner, 2026) was used to analyze the images of 2278 Götz captured with the telescopes. The software selected comparison stars as a guide for measurements of brightness, and observers selected certain stars to keep and remove from the data analysis. This was based not only on their brightness, but also on their position in the sky compared to other stars and their apertures. Some apertures overlapped each other.

The resulting lightcurve suggests a rotation period of 29.175 ± 0.425 h, which would imply a slow rotator. The relatively large amplitude of 0.7 mag, along with the elevated RMS values, indicates that this result should be interpreted with caution.

A rotation period of 29 hours classifies 2278 Götz as a slow rotator, though still in the typical range observed for objects of similar size. The lightcurve amplitude of 0.7 mag suggests that the asteroid may have an elongated shape or significant albedo variations across its surface. Such variations are associated with irregular, non-spherical bodies. Additional observations with improved coverage would better help to constrain the shape and rotational properties of 2278 Götz and determine the underlying cause of the observed variability.



Acknowledgements

This project was supported by Maryland Space Grant Consortium under NASA cooperative agreement 80NSSC25M7076.

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Number	Name	2026 mm/dd	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
2278	Götz	04/07-04/19	6.7, 1.5	208.5	2.7	29.175	0.425	0.7		MB-I

Table I. Observing circumstances and results. The phase angle is given for the first and last date. If preceded by an asterisk, the phase angle reached an extrema during the period. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude/latitude at mid-date range (see Harris et al., 1984). Grp is the asteroid family/group (Warner et al., 2009).

PHOTOMETRIC OBSERVATIONS OF ASTEROIDS 1095 TULIPA AND 1344 CAUBETA

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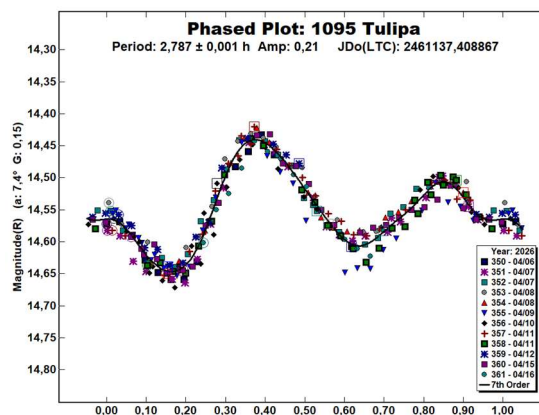
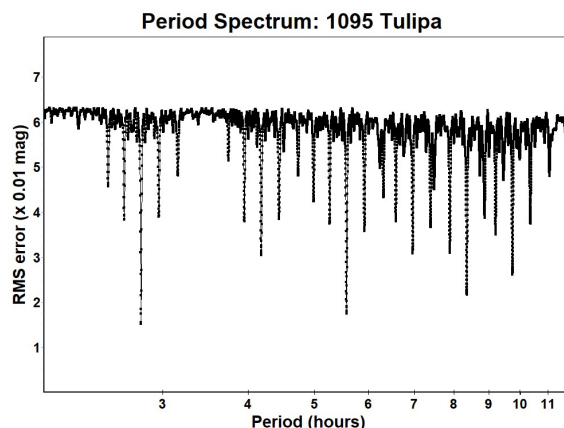
(Received: 2026 July 8)

Photometric observations of two main-belt asteroids were conducted to verify or determine their synodic rotation periods. For 1095 Tulipa, we found $P = 2.787 \pm 0.001$ h with $A = 0.21 \pm 0.02$ mag while for 1344 Caubeta, we found $P = 3.123 \pm 0.001$ h with $A = 0.13 \pm 0.02$ mag.

CCD photometric observations of two main-belt asteroids were carried out in April 2026 at the Astronomical Observatory of the University of Siena (K54). We used a 0.30-m $f/5.6$ Maksutov-Cassegrain telescope, SBIG STL-6303E NABG CCD camera; the pixel scale was 2.30 arcsec when binned at 2×2 pixels. We used a Clear filter and 300 seconds of exposure time. Data processing and analysis were done with *MPO Canopus* (Warner, 2018). All images were calibrated with dark and flat-field frames and the instrumental magnitudes converted to R magnitudes using solar-colored field stars from a version of the CMC-15 catalogue distributed with *MPO Canopus*. Table I shows the observing circumstances and results.

1095 Tulipa (1926 GS) was discovered on 1926 April 14 at Heidelberg by K. Reinmuth. It is a main-belt asteroid with a semi-major axis of 3.025 AU, eccentricity 0.016, inclination 10.011° , and an orbital period of 5.26 years. Its absolute magnitude is $H = 10.43$ (JPL, 2026). The NEOWISE satellite infrared radiometry survey (Mainzer et al., 2019) found a diameter $D = 27.875 \pm 0.362$ km using an absolute magnitude $H = 12.4$ and a geometric albedo of $p_V = 0.157$. Based on the reflectance spectra available in GAIA DR3 (Franco, 2025, 2026), Lorenzo Franco derived the taxonomic class K for 1095 Tulipa, and found a diameter $D = 30.1$ km using an absolute magnitude $H = 10.26$ and a geometric albedo of $p_V = 0.152$.

Observations were conducted over six nights and collected 289 data points. The period analysis shows a rotational period of $P = 2.787 \pm 0.001$ h with an amplitude $A = 0.21 \pm 0.02$ mag, in perfect agreement with the previously results published in the asteroid lightcurve database (LCDB; Warner et al., 2009; Binzel, 1987; Behrend, 2005web; Benishek, 2008, 2015; Waszczak et al., 2015; KlingleSmith, 2017; Āurech et al., 2018; Stephens, 2018; KlingleSmith and Hendrickx, 2018; Skiff et al., 2019; Pál et al., 2020; Martikainen et al., 2021). The lightcurve shows an anomaly in the phase range between 0.6 and 1.0; further observations are strongly recommended to verify the possible presence of a satellite.

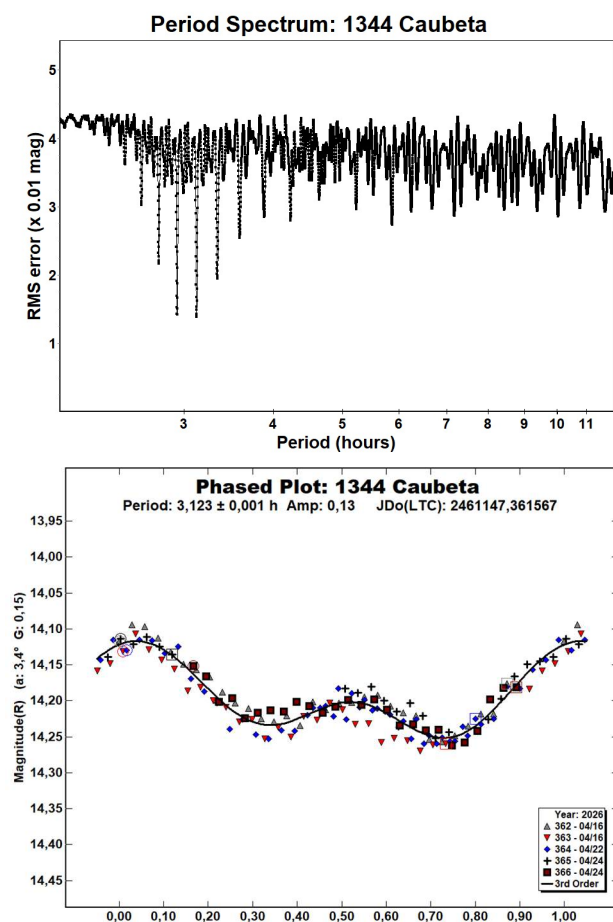


1344 Caubeta (1935 GA) was discovered on 1935 April 01 at Algiers by L. Boyer. It is an inner main-belt asteroid with a semi-major axis of 2.248 AU, eccentricity 0.119, inclination 5.653° , and an orbital period of 3.37 years. Its absolute magnitude is $H = 12.81$ (JPL, 2026). The NEOWISE satellite infrared radiometry survey (Mainzer et al., 2019) found a diameter $D = 5.844 \pm 0.118$ km using an absolute magnitude $H = 12.8$ and a geometric albedo of $p_V = 0.392$. Based on the reflectance spectra available in GAIA DR3 (Franco, 2025, 2026), Lorenzo Franco derived its taxonomic class as S, and found a diameter $D = 8.2$ km using an absolute magnitude $H = 12.59$ and a geometric albedo of $p_V = 0.241$. In February 2019, the same authors contributed to the discovery of the binary nature of 1344 Caubeta as part of the international Photometric Survey for Asynchronous Binary Asteroids collaboration, led by Petr Pravec (Pravec, 2026web), confirming the presence of a satellite with an orbital period of 42.40 ± 0.03 hours (Christmann et al., 2019).

Observations were conducted over three nights collecting 154 data points. The period analysis shows a rotational period of $P = 3.123 \pm 0.001$ h with amplitude $A = 0.13 \pm 0.02$ mag, in good agreement with those published in the LCDB (Behrend, 2009web, 2012web, 2019web; Pravec et al., 2009web, 2012web, 2019web; Chiorny et al., 2011; Waszczak et al., 2015; Christmann et al., 2019).

Number	Name	2026/mm/dd	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
1095	Tulipa	04/16-04/15	7.4, 4.5	214	7	2.787	0.001	0.21	0.02	MB
1344	Caubeta	04/16-04/24	*3.5, 4.4	209	4	3.123	0.001	0.13	0.02	MB-I

Table I. Observing circumstances and results. The phase angle is given for the first and last date. If preceded by an asterisk, the phase angle reached an extremum during the period. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude/latitude at mid-date range (see Harris et al., 1984). Grp is the asteroid family/group (Warner et al., 2009).



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LIGHTCURVE ANALYSIS AND ROTATION PERIOD
FOR 8106 CARPINO

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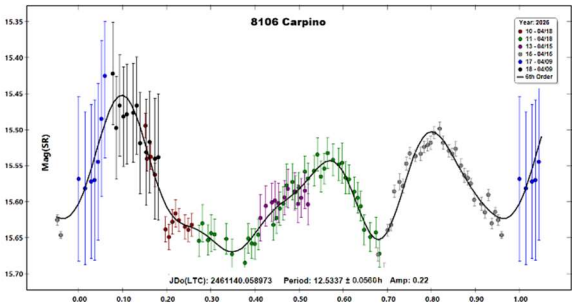
This paper provides a lightcurve and rotation period for the asteroid 8106 Carpino. The lightcurve was constructed over three nights on 2026 Apr 9, 15, and 18. From the observations, the period of the asteroid was found to be 12.5337 ± 0.0560 h with an amplitude of 0.22 mag.

8106 Carpino is an asteroid found in the main asteroid belt and is a part of the Chaldaea family (Nesvorny, 2024). It orbits the sun at 1.923 AU and has a diameter of 11.82 km (JPL, 2026). This asteroid was studied in the University of Maryland’s Astronomy in Practice course in 2026. A search of the Asteroid Lightcurve Database (Warner et al., 2009) showed no previously determined rotation period for 8106 Carpino.

Observations of 8106 Carpino occurred on 2026 Apr 9, 15, and 18. The observations were made using telescope T17 in Siding Springs Observatory, Australia. T17 is a 0.43m f/6.8 reflector. It has a CCD with a pixel array of 9576×6388 pixels and an FOV of 42.4×28.3 arcmin (iTelescope).

MPO Canopus (Warner, 2026) was used to analyze the images. Using aperture photometry, the software would focus on the desired asteroid and map out its lightcurve. Occasional manual aperture corrections were required. The software also provided a list of possible comparison stars to use, which was used to calculate the asteroid’s precise brightness. Additionally, the period was found using Fourier analysis in MPO Canopus. The results suggest a rotation period of 12.5337 ± 0.0560 h. The large error bars on 2026 Apr 9 are due to heavy cloud cover, which made the images noisier.

The proposed phased lightcurve is unusual as it has 3 maxima and minima. This would indicate the asteroid has an irregular shape. The minima could be caused by large craters within the asteroid that lower the observed magnitude. However, from this lightcurve alone, it is not possible to make conclusions about that shape, and the reason for the plot could be purely from an abnormal shape.



Acknowledgements

This project was supported by Maryland Space Grant Consortium under NASA cooperative agreement 80NSSC25M7076.

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Number	Name	yyyy mm/dd	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
8106	Carpino	2026 04/09-04/18	10.8,13.6	202.2	-14.7	12.5337	0.0560	0.22		415

Table I. Observing circumstances and results. The phase angle is given for the first and last date. If preceded by an asterisk, the phase angle reached an extrema during the period. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude/latitude at mid-date range (see Harris et al., 1984). Grp is the asteroid family/group (Warner et al., 2009).

LIGHTCURVE AND ROTATION PERIOD OF (3409) ABRAMOV

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(Received: 2026 June 29)

Photometric observations of the Koronis-family outer main-belt asteroid (3409) Abramov were obtained on four nights in September 2025. Analysis of R-band lightcurves yields a synodic rotation period of 8.505 ± 0.001 h with a peak-to-peak amplitude of 0.49 mag, implying a moderately elongated shape with a minimum equatorial axis ratio of $a/b \gtrsim 1.57$.

CCD photometry of asteroid (3409) Abramov was obtained remotely at the MonitorMyPlanet Observatory (MPC code R60) in Nerpio, Spain. Observations were conducted using a 0.305-m (12-inch) Ritchey-Chrétien telescope operated at an effective focal ratio of $f/6$ using a $0.75\times$ focal reducer, mounted on a Sky-Watcher EQ8-R equatorial mount and equipped with an ASI2600 monochrome camera and a filter wheel containing Johnson-Cousins U, B, V, R, I filters. Images were binned 2×2 , providing a pixel scale of 0.848 arcsec pixel $^{-1}$. Observations were obtained on four nights from 2025 September 15 to 18 (UT), spanning solar phase angles from approximately 4.1° to 5.4° .

Standard bias, dark, and flat-field corrections were applied to all images prior to photometric extraction. Differential photometry was performed using ensemble comparison stars within each field. Image reduction and photometric calibration were carried out using *Tycho Tracker* software (Parrott, 2025), with reference magnitudes drawn from the ATLAS star catalog in the Sloan r band.

Time-series observations were obtained in the R band, with 180 second exposure times. Period analysis of the combined R-band dataset was performed using a fourth-order Fourier series fit. The resulting periodogram (Fig. 1) exhibits a well-defined minimum corresponding to a synodic rotation period of 8.505 ± 0.001 h. The composite phased lightcurve, combining all four nights of data (Fig. 2), displays a stable, double-peaked morphology with a peak-to-peak amplitude of 0.49 mag, consistent with principal-axis rotation.

Amplitude Error (A.E.) was estimated as 0.03 mag from $\sqrt{2}$ times the RMS residual of the lightcurve. Assuming a triaxial ellipsoid viewed near the equatorial plane and negligible albedo variegation, the observed amplitude implies a minimum equatorial axis ratio of $a/b \gtrsim 1.57$.

The period found in this work differs from the value reported by Sada (2008), who obtained a period of 7.791 ± 0.002 h and an amplitude of 0.55 mag during the 2008 apparition. To test this, our 2025 R-band data were phased to 7.791 h, as shown in Fig. 3. This period does not produce a coherent composite lightcurve: the maxima and minima from different nights do not align well.

Acknowledgements

The author thanks the Masason Foundation for providing funding for the telescope and AstroCamp for hosting their observatory in Nerpio, Spain.

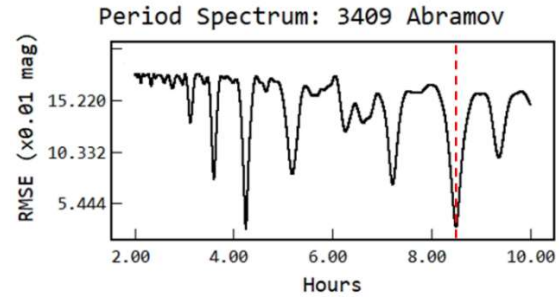


Fig. 1. Periodogram (2–10 h) computed with a 4th-order Fourier fit showing the preferred solution at 8.505 h.

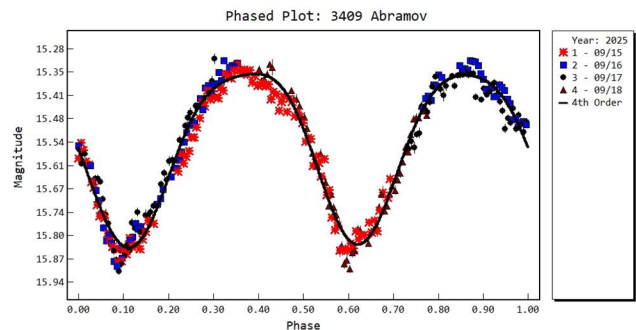


Fig. 2. Lightcurve of (3409) Abramov combining all four nights (2025 Sept 15-18) phased to a period of 8.505 hours.

Source	Period (h)	Amplitude (mag)
Sada (2008)	7.791 ± 0.002	0.55
This work (2025)	8.505 ± 0.001	0.49

Table I. Rotation period comparison for (3409) Abramov.

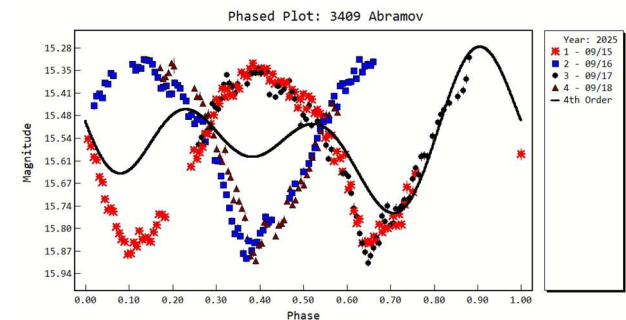


Fig. 3. Lightcurve of (3409) Abramov phased to the period reported by Sada (2008).

Number	Name	yyyy mm/dd	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
3409	Abramov	2025 09/15-09/18	4.1, 5.4	344.3	1.3	8.505	0.001	0.49	0.03	MB-O

Table II. Observing circumstances and results. The phase angle is given for the first and last date. If preceded by an asterisk, the phase angle reached an extrema during the period. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude/latitude at mid-date range (see Harris et al., 1984). Grp is the asteroid family/group (Warner et al., 2009).

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LIGHTCURVE AND ROTATION PERIOD OF
62701 DAVIDRANKIN

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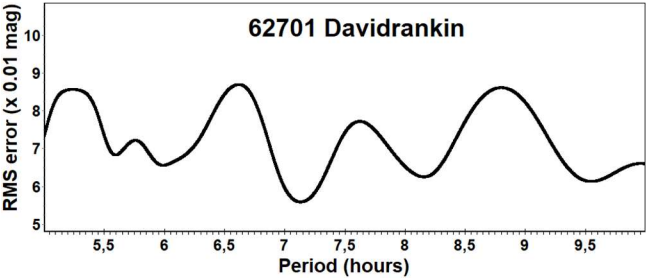
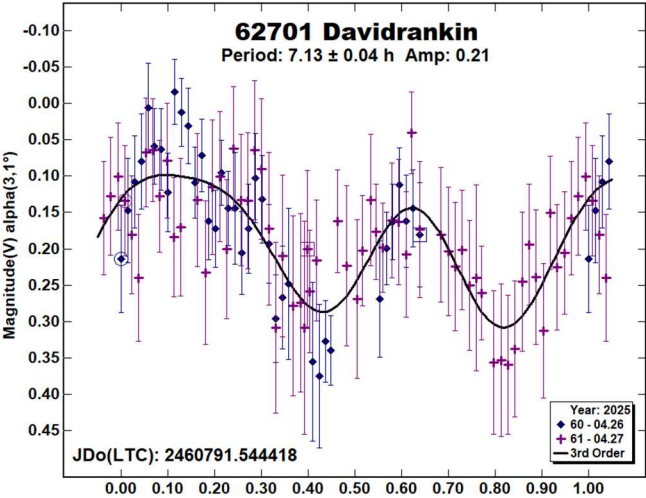
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Deep Random Survey
GERMANY

(Received: 2026 April 21)

Unfiltered CCD photometric observations of 62701 Davidrankin were obtained in Rio Hurtado, Chile during April 2025. We report a most likely synodic rotation period of 7.13 ± 0.04 h and an amplitude of 0.21 ± 0.03 mag.

62701 Davidrankin is an asteroid in the outer main belt. It was discovered by L. Ball at Emerald Lane on 7 October 2000. It last came to opposition on 3 May 2025, at a peak brightness of 19.3 mag. Based on observations made in 2010 with the WISE spacecraft (Mainzer et al., 2019), the asteroid has a moderately dark albedo of 0.068 ± 0.025 , corresponding to a diameter of 5.60 ± 0.85 km. The LCDB listed no previously reported periods for Davidrankin.

Our observations were made with a PlaneWave CDK400 at Deep Random Survey (MPC: X09) in Rio Hurtado, Chile, on the nights of 26 April and 27 April 2025 UT, with a total observing time of 12.0 hours. Based on these measurements, we find a most likely synodic rotation period of 7.13 ± 0.04 h and a lightcurve amplitude of 0.21 ± 0.03 mag. Possible period aliases occur at 8.16 ± 0.05 h and 9.55 ± 0.06 h. Each was checked visually. Both aliases provide a considerably worse fit to the data. While we cannot rule out other periods completely, none of the remaining aliases appear very likely.



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Number	Name	yyyy/mm/dd	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
62701	Davidrankin	2025/04/26-04/27	3.1,2.7	223	5	7.13	0.04	0.21	0.03	MB-outer

Table I. Observing circumstances and results. The phase angle is given for the first and last date. If preceded by an asterisk, the phase angle reached an extrema during the period. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude/latitude at mid-date range (see Harris et al., 1984). Grp is the asteroid family/group (Warner et al., 2009).

LIGHTCURVES AND SYNODIC ROTATION PERIODS FOR 20 ASTEROIDS FROM SOPOT ASTRONOMICAL OBSERVATORY: 2025 DECEMBER – 2026 JULY

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(Received: 2026 July 14)

Lightcurves and synodic rotation periods for 20 asteroids were determined from photometric data obtained at the Sopot Astronomical Observatory (SAO) in the time span 2025 December - 2026 July.

Photometric observations of 20 asteroids were conducted at Sopot Astronomical Observatory (SAO) from 2025 December through 2026 July in order to determine the asteroids' synodic rotation periods. For this purpose, two 0.35-m *f*/6.3 Meade LX200GPS Schmidt-Cassegrain telescopes were employed. The telescopes are equipped with a SBIG ST-8 XME and a SBIG ST-10 XME CCD cameras. The exposures were unfiltered and unguided for all targets. Both cameras were operated in 2×2 binning mode, which produces image scales of 1.66 arcsec/pixel and 1.25 arcsec/pixel for ST-8 XME and ST-10 XME cameras, respectively. Prior to measurements, all images were corrected using dark and flat field frames.

Photometric reduction was conducted with *Maxim DL 6.21* software (Diffraction Limited, 2020) using differential photometry with up to five comparison stars of near solar color ($0.5 \leq B-V \leq 0.9$), wherever such stars are available in the field of view. This helped to ensure a satisfactory quality level of night-to-night zero-point calibrations and correlation of the measurements within the standard magnitude framework. Field comparison stars were calibrated using standard Cousins R magnitudes derived from the Carlsberg Meridian Catalog 15 (VizieR, 2026) Sloan *r'* magnitudes using the formula: $R = r' - 0.22$, as well as G-band data from the Gaia DR3 catalog converted to Johnson-Cousins V magnitudes using a third-degree transformation polynomial from the Gaia DR3 catalog documentation available online. The polynomial includes stellar color indices $G_{bp}-G_{rp}$, i.e. the difference in magnitudes in the blue and red Gaia passbands:

$$G - V = -0.02704 + 0.01424(G_{bp} - G_{rp}) - 0.2156(G_{bp} - G_{rp})^2 + 0.01426(G_{bp} - G_{rp})^3$$

The asteroid Johnsons-Cousins V magnitudes measured using the converted comparison star magnitudes were subjected to magnitude corrections to compensate for the change in viewing geometry and solar phase angle, as described in detail in section 15.1.3 of the reference Warner (2016).

In some instances, small zero-point adjustments were necessary in order to achieve the best match between individual data sets in terms of achieving the most favorable statistical indicators of Fourier fit goodness. Lightcurve construction and period analysis was performed using *Perfindia* custom-made software developed in the R statistical programming language (R Core Team, 2026) by the author of this paper. The essence of its algorithm is reflected in finding the most favorable solution for rotational period by minimizing the *residual standard error* of the lightcurve Fourier fit. A description of the method implemented in the *Perfindia* algorithm is given in the reference Benishek (2025).

The lightcurve plots presented in this paper show so-called 2% error for rotational periods, i.e. an error that would cause the last data point in a combined data set by date order to be shifted by 2% (Warner, 2012) and represented by the following formula:

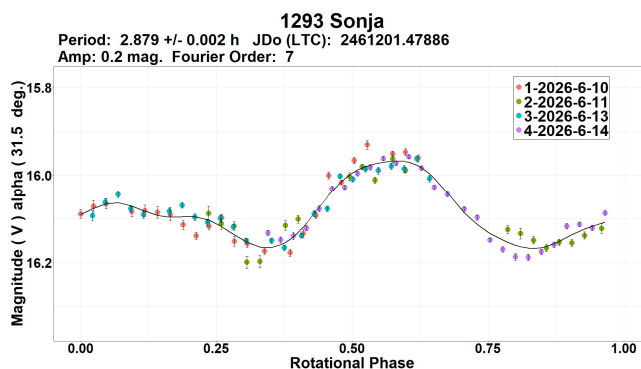
$$\Delta P = \frac{0.02 \cdot T}{P^2}$$

where *P* and *T* are the rotational period and the total time span of observations, respectively. Both of these quantities must be expressed in the same units.

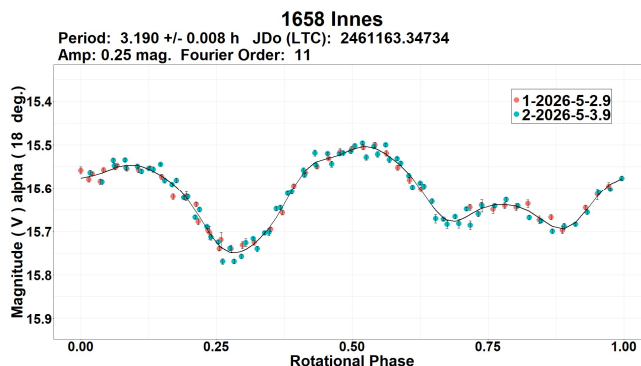
Observations and Results

Table I summarizes the observing circumstances and results. Notes for individual objects follow.

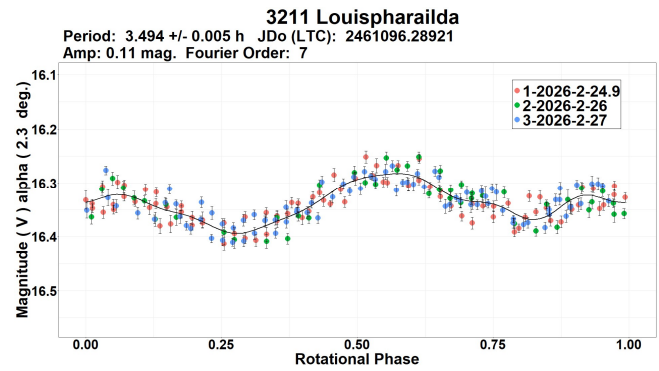
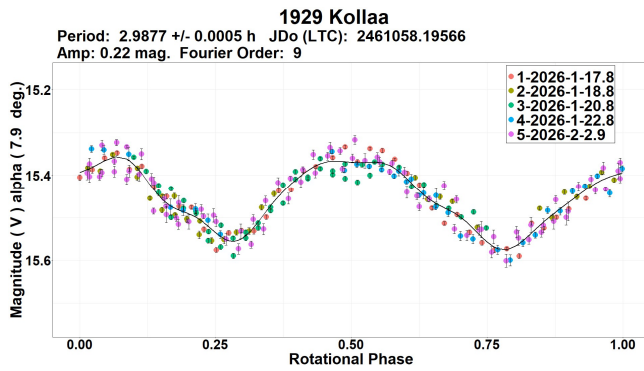
1293 Sonja. A value $P = 2.879 \pm 0.002$ h is derived from the SAO data obtained over four nights in the first half of 2026 June is in high agreement with virtually all previously determined rotation period results reported in the Asteroid Lightcurve Database records (LCDB; Warner et al., 2009), some of which are as follows: 2.878 h (Higgins and Goncalves, 2007); 2.8785 h (Behrend, 2006web); 2.879 h (Benishek, 2008); 2.8768 h (Pravec, 2016web); 2.879 h (Stephens, 2017); 2.8761 h (Skiff et al., 2019).



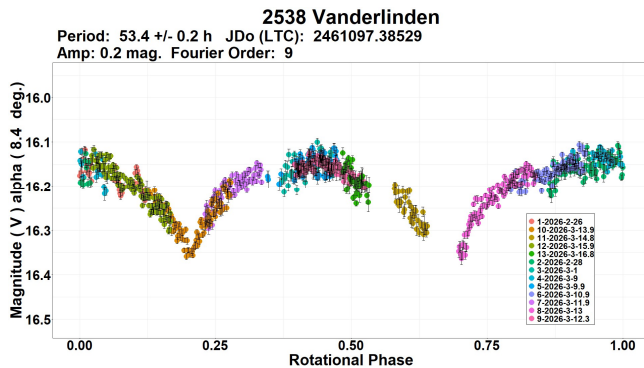
1658 Innes. The newly obtained rotation period ($P = 3.190 \pm 0.008$ h) from data obtained on two consecutive nights in 2026 May is in excellent agreement with the only two previously reported results of: 3.191 h (Franco and Papini, 2014); 3.191 h (Stephens, 2014).



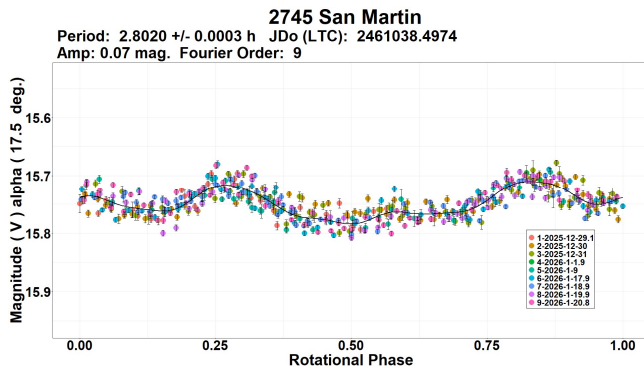
1929 Kollaa. A bimodal solution for period of $P = 2.9877 \pm 0.0005$ h was found from data collected on five nights in 2026 January - February. Several previously reported results from the LCDB are highly consistent with the new result and fall within the narrow range between 2.980 h and 2.989 h.



2538 Vanderlinden. No prior rotation period determination results were known on this asteroid. Thirteen dense photometric datasets were obtained in 2026 late February - mid March, indicating slow rotation and a bimodal lightcurve with a period of $P = 53.4 \pm 0.2$ h. The plausibility of this result should certainly be verified by future observations, given the several gaps present in the obtained lightcurve and the lack of coverage of one of the minima.

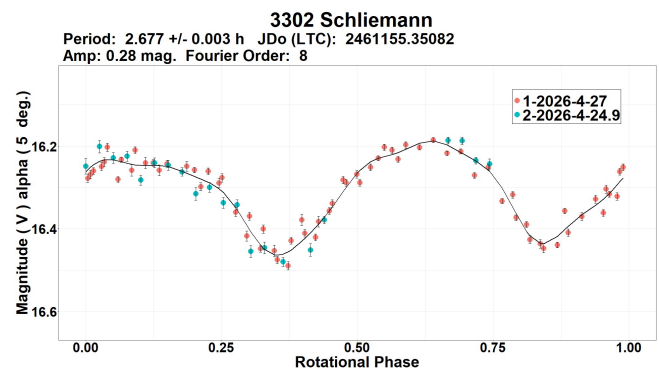


2745 San Martin. The only previously found period result found by Pál et al. (2020, 2.80289 h) is fully consistent with the newly established value of $P = 2.8020 \pm 0.0003$ h, obtained from observations conducted at SAO in 2025 December - 2026 January.

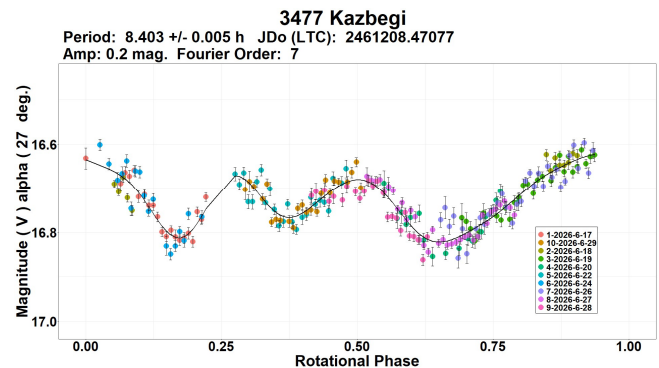


3211 Louispharailda. No records of previous rotation period determinations were found. Observations carried out on three consecutive nights in late 2026 February led to a bimodal solution for a period of $P = 3.494 \pm 0.005$ h.

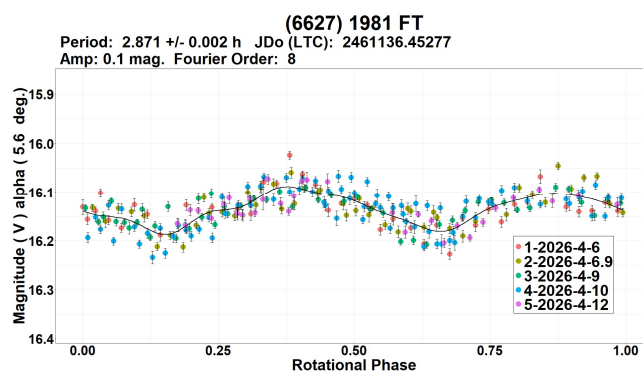
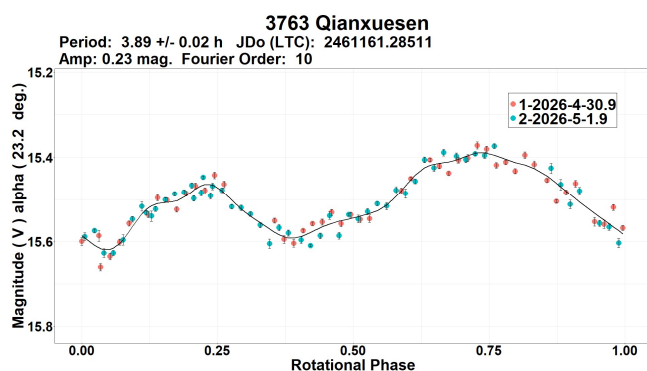
3302 Schliemann. A bimodal solution for period of $P = 2.677 \pm 0.003$ h, found from the data acquired over two nights in late 2026 April is fully consistent with the only previous result by Borczyk published on the Collaborative Asteroid Lightcurve Link (CALL) website (2018web, 2.6753 h).



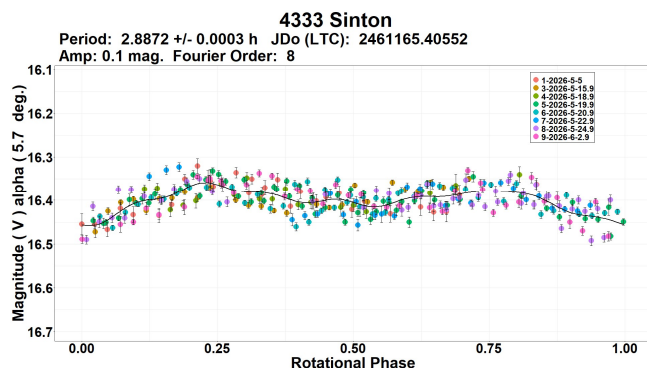
3477 Kazbegi. Period of $P = 8.403 \pm 0.005$ h, found from the 2026 June SAO data obtained on ten nights, although of somewhat lower quality, indicated a period solution statistically identical to the previous result obtained by Benishek (2022, 8.401 h).



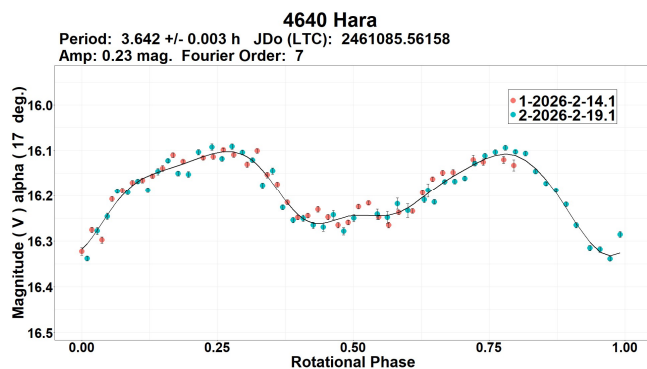
3763 Qianxuesen. Period found by Behrend (2009web, 3.884 h) is consistent with the bimodal period solution of $P = 3.89 \pm 0.02$ h, derived from the SAO data obtained over two nights in 2026 April - May.



4333 Sinton. No previous rotation period determination reports were found. Dense photometry from 2026 May - June led to the statistically most favorable period result of $P = 2.8872 \pm 0.0003$ h.

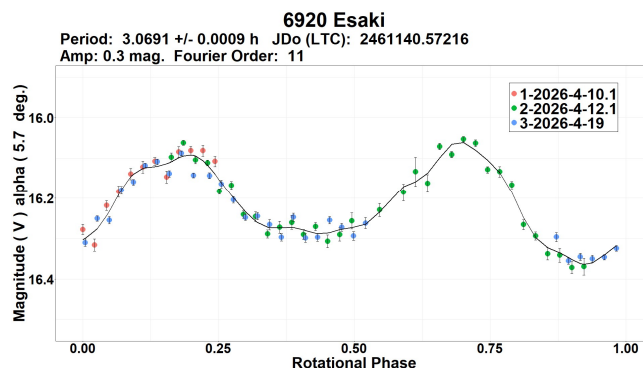


4640 Hara. A unique bimodal solution for period of $P = 3.642 \pm 0.003$ h obtained from the two-night 2026 February data differs slightly from the period reported by Black et al. (2016, 3.534 h), derived from the rather scattered data.

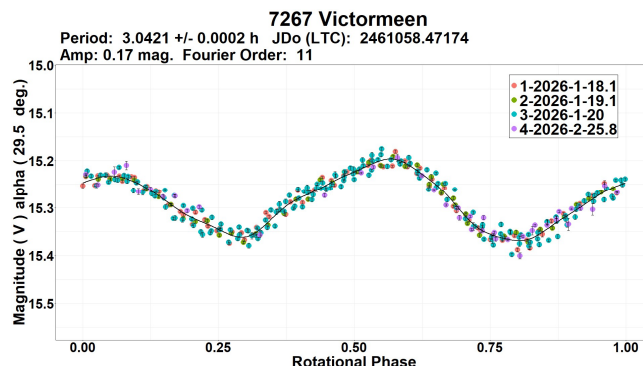


(6627) 1981 FT. A search of LCDB records indicates that the rotation period was never determined. Dense photometric data from five nights in 2026 April show a bimodal period of $P = 2.871 \pm 0.002$ h as the statistically most favorable result in the period analysis.

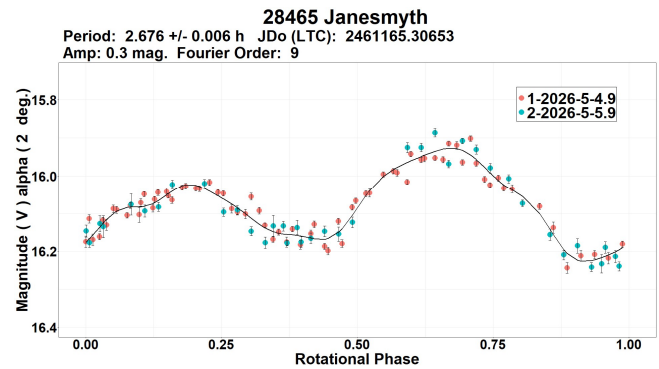
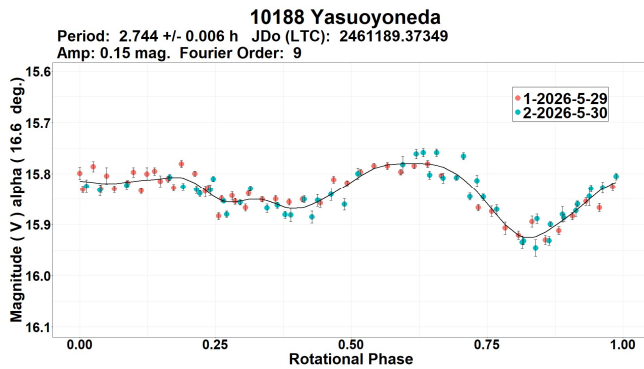
6920 Esaki. Period of $P = 3.0691 \pm 0.0009$ h is in full agreement with two previously determined values by Arminski (2022, 3.0695 h) and Benishek (2022, 3.069 h).



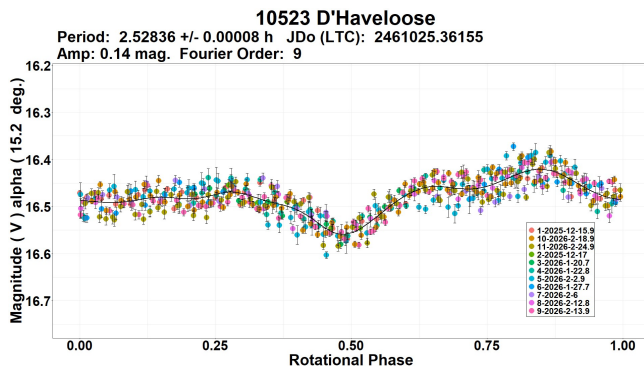
7267 Victormeen. Dense photometric data taken in 2026 January - February indicate an unambiguous bimodal solution for a period of $P = 3.0421 \pm 0.0002$ h, which is in excellent agreement with most previously reported results: Pravec (2008web, 3.0420 h), Skiff et al. (2019, 3.041 h), Pál et al. (2020, 3.04069 h).



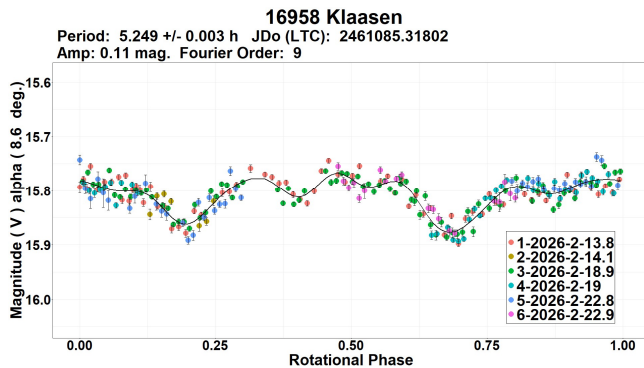
10188 Yasuoyoneda. New period result of $P = 2.744 \pm 0.006$ h is consistent with the only previous one determined by Pravec (2011web, 2.74840 h).



10523 D'Haveloose. No records on previous rotation period determinations have been found. Extensive dense photometric observations in the time span 2025 December - 2026 February yielded a bimodal lightcurve phased to a period of $P = 2.52836 \pm 0.0008$ h.

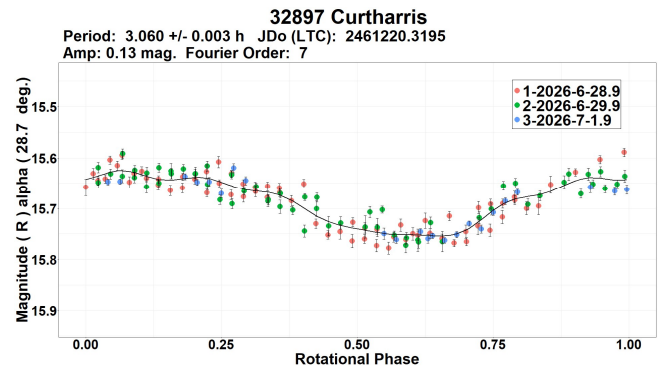
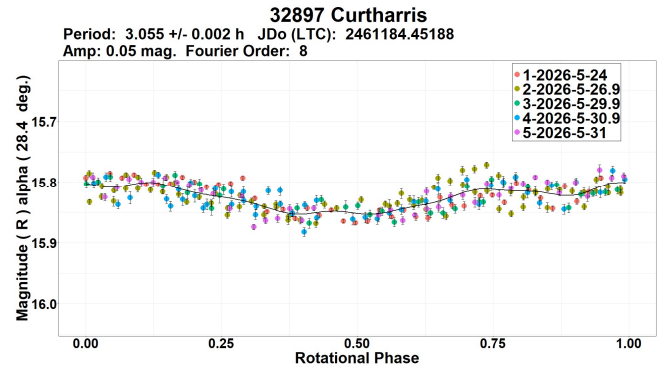


16958 Klaasen. There have been no previously reported results on this Mars-crossing asteroid. A rotation period of $P = 5.249 \pm 0.003$ h was found from data obtained over six nights in 2026 February.



28465 Janesmyth. The new bimodal period result ($P = 2.676 \pm 0.006$ h) obtained from data collected on two consecutive nights in early 2026 May is completely identical to the one found by Waszczak et al. (2015, 2.676 h).

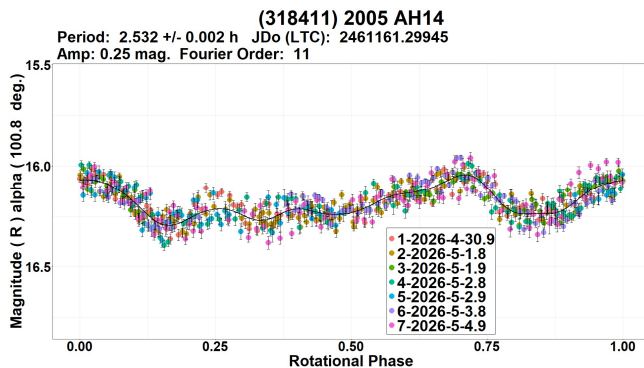
32897 Curtharris. Extensive photometric observations conducted in 2019 June-July by Benishek, Chiorny and Stephens as part of the *Photometric Survey for Asynchronous Binary Asteroids* yielded an unambiguous *bimodal* solution for a period of 3.05409 h (Pravec, 2019web). Observations conducted at SAO in both the second half of 2026 May and 2026 June - July at different viewing geometries show differences in the lightcurve shape and amplitude between two groups of data, but now indicate a *monomodal* period solution of ~ 3.05 h for both 2026 datasets ($P = 3.055 \pm 0.002$ h from 5 nights in 2026 May; $P = 3.060 \pm 0.003$ h from 3 nights in 2026 June - July). Such a monomodal solution certainly corresponds to a more polar aspect than the 2019 apparition observations.



Number	Name	20yy/mm/dd	Phase	L _{PAB}	B _{PAB}	Period (h)	P.E.	Amp	A.E.	Grp
1293	Sonja	26/06/09–26/06/14	31.5, 30.9	306	6	2.879	0.002	0.20	0.03	MC
1658	Innes	26/05/02–26/05/04	18.0, 18.3	183	11	3.190	0.008	0.25	0.02	INN
1929	Kollaa	26/01/17–26/02/03	7.9, 15.3	106	8	2.9877	0.0005	0.22	0.04	V
2538	Vanderlinden	26/02/25–26/03/16	*8.4, 4.4	171	6	53.4	0.2	0.20	0.02	MB-I
2745	San Martin	25/12/28–26/01/20	17.5, 7.1	120	-13	2.8020	0.0003	0.07	0.02	MB-I
3211	Louispharailda	26/02/24–26/02/27	2.3, 1.2	161	-1	3.494	0.005	0.11	0.03	MB-O
3302	Schliemann	26/04/24–26/04/27	5.8, 4.9	225	4	2.677	0.003	0.28	0.03	MB-I
3477	Kazbegi	26/06/16–26/06/29	27.0, 24.7	323	7	8.403	0.005	0.20	0.03	V
3763	Qianxuesen	26/04/30–26/05/01	23.2, 23.6	180	2	3.89	0.02	0.23	0.03	FLOR
4333	Sinton	26/05/04–26/06/02	*5.7, 12.1	232	6	2.8872	0.0003	0.10	0.03	MB-I
4640	Hara	26/02/14–26/02/19	*5.7, 4.2	207	7	3.642	0.003	0.23	0.03	MB-I
6627	1981 FT	26/04/05–26/04/12	5.6, 2.7	204	4	2.871	0.002	0.10	0.04	MB-I
6920	Esaki	26/04/10–26/04/19	*5.7, 4.2	207	7	3.0691	0.0009	0.30	0.02	V
7267	Victormeen	26/01/17–26/02/15	29.5, 17.2	147	25	3.0421	0.0002	0.17	0.02	MC
10188	Yasuoyoneda	26/05/28–26/05/30	16.6, 16.1	266	15	2.744	0.006	0.15	0.03	MB-I
10523	D'Haveloose	25/12/15–26/02/24	*15.2, 21.3	112	6	2.52836	0.00008	0.14	0.03	MB-I
16958	Klaasen	26/02/13–26/02/22	*8.6, 7.4	147	-7	5.249	0.0003	0.11	0.02	MC
28465	Janesmyth	26/05/04–26/05/05	2.0, 2.6	222	2	2.676	0.006	0.30	0.03	HER
32897	Curtharris	26/05/23–26/05/31	28.4, 28.1	247	36	3.055	0.002	0.05	0.02	MC
32897	Curtharris	26/06/28–26/07/01	28.7, 29.0	256	29	3.060	0.003	0.13	0.03	MC
318411	2005 AH14	26/04/30–26/05/04	100.8, 116.3	172	40	2.532	0.002	0.25	0.05	NEA

Table I. Observing circumstances and results. Phase is the solar phase angle given at the start and end of the date range. If preceded by an asterisk, the phase angle reached an extrema during the period. L_{PAB} and B_{PAB} are the average phase angle bisector longitude and latitude. Grp is the asteroid family/group (Warner et al., 2009): MB-I = main-belt inner, MB-O = main-belt outer, HER = Hertha, FLOR = Flora, V = Vesta, INN = Innes, NEA = near-Earth-asteroid, MC = mars-crosser.

(318411) 2005 AH14. The rotation period of this near-Earth asteroid has only been determined once previously by Warner and Stephens (2019, 9.65 h). Warner and Stephens note that this bimodal result was chosen as one of several closely equivalent solutions in the period spectrum, and was derived from sparse data taken at intervals of several days between different datasets. The 2026 dense photometric observations from SAO carried out on seven consecutive nights in April - May, strongly suggest another solution for a period of $P = 2.532 \pm 0.002$ h, as the statistically most favorable one.



Acknowledgements

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LIGHTCURVE ANALYSIS AND ROTATION PERIOD OF NEA 1943 ANTEROS

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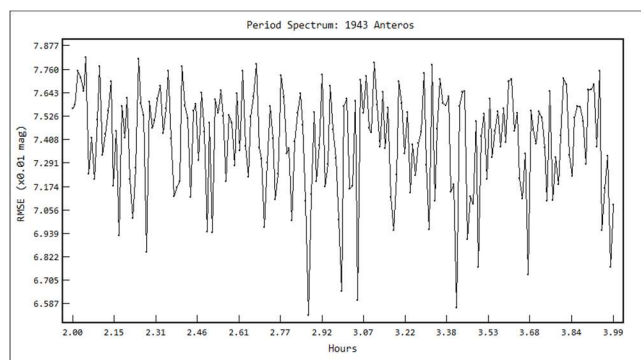
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(Received: 2026 June 19)

Analysis of lightcurve observations of the near-Earth asteroid 1943 Anteros during its approach to Earth in 2026 yields a synodic rotation period solution of 2.87 ± 0.01 h. The resulting lightcurve shows a low peak-to-peak amplitude of 0.175 ± 0.06 mag. This period is in excellent agreement with previous studies, though the low amplitude remains a characteristic of this object at various viewing geometries.

(1943) Anteros is an Amor-type near-Earth asteroid (NEA) discovered in 1973. It has been the subject of several photometric studies due to its frequent approaches and suspected complex nature. Pravec et al. (1998) first established a period of 2.8695 h. Later, the Lowell Observatory Near-Earth Asteroid Photometric Survey (NEAPS) (Koehn et al., 2014) confirmed a period of 2.9 ± 0.1 h. Most notably, Warner et al. (2017) suggested that Anteros could be a binary system, with a primary rotation period of 2.86923 h and a potential orbital period of 23.548h.

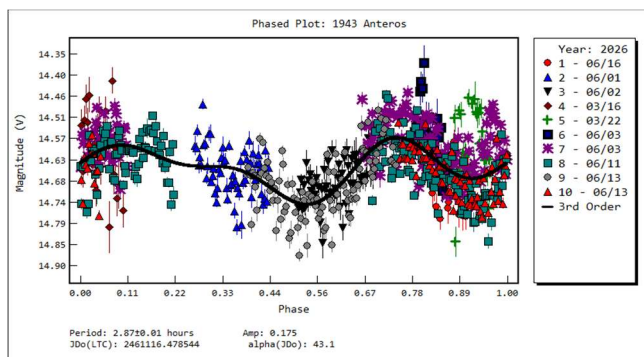
Observations were carried out between 2026 March 16 and June 16 at the OARU Observatory (X33) in Manaus, Brazil. The equipment consisted of a 0.2-m f/5 reflecting telescope and an ASI 294 MC Pro camera. All images were taken unfiltered with 2×2 binning to achieve a plate scale of 1.91 arcsec/pixel and the exposure time per frame was 30 seconds. Data reduction and period analysis were performed using *Tycho Tracker Pro* (Parrot, 2020; version 11.8.6). Differential photometry was employed using seven comparison stars selected with color indices in the range of $0.5 < B-V < 0.95$, aligning with the typical color range of asteroids. Fourier analysis of 10 combined data sets, each containing approximately 100 measurements, resulted in a dominant synodic rotation period of 2.87 ± 0.01 h. The period spectrum (periodogram) shows a clear RMSE minimum of 0.065 mag at the preferred solution, although common rotational aliases are present. This solution corresponds to the best-fit "Num 1" in the analysis list, with a formal period of 2.868687 h, reported here as 2.87 ± 0.01 h.



Number	Name	yyyy mm/dd	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
1943	Anteros	2026 03/16–2026 06/16	43.1, 58.2	219	1	2.87	0.01	0.175	0.065	NEA

Table I. Observing circumstances and results. The phase angle is given for the first and last date. If preceded by an asterisk, the phase angle reached an extrema during the period. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude/latitude at mid-date range (see Harris et al., 1984). Grp is the asteroid family/group (Warner et al., 2009).

The phased lightcurve shows a peak-to-peak amplitude of 0.175 ± 0.06 mag. This low amplitude is consistent with a nearly spherical shape or a pole-on viewing geometry, a feature also noted in previous apparitions where amplitudes ranged from 0.07 to 0.16 mag. Our observations were conducted at phase angles ranging from 43.1° to 58.2° .



While Warner et al. (2017) presented evidence for a potential satellite based on attenuations of 0.05–0.10 mag, our 2026 data set, although showing some scatter (A.E. 0.065), did not reveal conclusive photometric evidence of mutual events associated with a possible satellite. However, the preferred period is in very close agreement with values reported in previous decades, indicating long-term consistency in the rotational signal of Anteros.

The determined period of 2.87 h for 1943 Anteros reinforces its status as a fast rotator. The close agreement with historical data from Pravec et al. (1998) and Warner et al. (2017) validates the synodic period found in this study and supports the effectiveness of the employed photometric methods. Future observations at different ecliptic longitudes remain essential to further refine the asteroid's shape model and orbital characteristics.

Acknowledgments

The author thanks Andrea Nobre for her support during the observing campaign. He also thanks the *Minor Planet Bulletin* reviewers for their support.

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NEW CCD LIGHTCURVES OF 562 SALOME, 1428 MOMBASA, 1629 PECKER, AND 1684 IGUASSU

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Synodic rotation periods and amplitudes are found for 562 Salome 6.3503 ± 0.0001 h, 0.19 ± 0.02 mag, with an asymmetric lightcurve; 1428 Mombasa 25.624 ± 0.002 h, 0.22 ± 0.02 mag; and 1684 Iguassu 9.1438 ± 0.0002 h, 0.18 ± 0.02 mag. For 1629 Pecker the period found by this investigation is indeterminate; it may be either 4.108 ± 0.002 h or 8.216 ± 0.002 h, with amplitude 0.08 ± 0.01 mag.

Observations to produce the results reported in this paper were made at the Organ Mesa Observatory with a Meade 35 cm LX200 GPS Schmidt-Cassegrain, SBIG STL-1001E CCD, 60 second exposures for 562 Salome, 1629 Pecker, and 1684 Iguassu, and 120 second exposures for 1428 Mombasa, unguided, clear filter. Image measurement and lightcurve construction were with *MPO Canopus* software with calibration star magnitudes for solar colored stars from the CMC15 catalog reduced to the Cousins R band. Zero-point adjustments of a few $\times 0.01$ magnitude were made for best fit. To reduce the number of data points on the lightcurves and make them easier to read, data points have been binned in sets of 3 with maximum time difference 5 minutes.

562 Salome. The Asteroid Lightcurve Database (Warner et al., 2009, updated 2023 October) shows many previous rotation period determinations. Three with published lightcurves are mutually discordant. Bembrick and Allen (2007) published a period of 12.705 hours with an irregular but symmetric bimodal lightcurve. Their data points would have an equally good fit to an irregular lightcurve with one maximum and minimum per rotational cycle and a period of half of their published period. Alkema (2013) published an irregular lightcurve with one maximum and minimum per rotational cycle and a period of 6.351 hours. Dose (2024) published a bimodal lightcurve with period 12.699 hours and neither the irregularities nor the symmetry of the lightcurves by Bembrick and Allen (2007) and Alkema (2013).

New lightcurves were obtained on six nights 2026 Apr. 21 - June 1, covering an entire suggested rotational cycle near 12.7 hours. They show an excellent fit (Fig. 1) to a period of 6.3503 ± 0.0002 h, amplitude 0.19 ± 0.02 mag, with an asymmetric lightcurve. The split halves plot of the double period 12.7008 hours (Fig. 2) shows that the two halves are identical within the scatter of the data points. The 6.3503-hour period is secure, and a period near 12.7 hours is definitively ruled out.

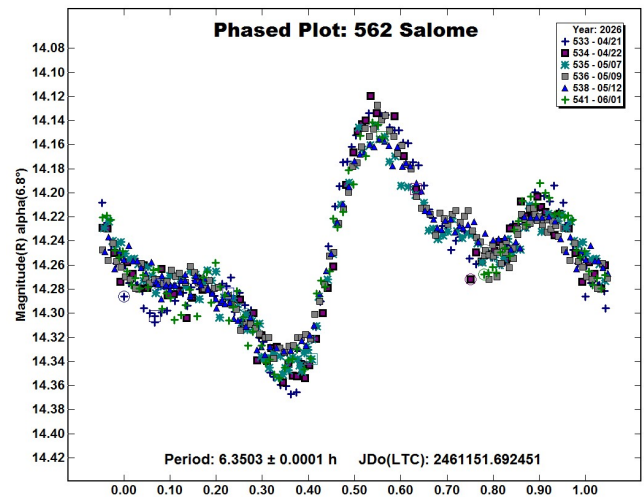


Fig. 1. The lightcurve of 562 Salome phased to a synodic period of 6.3503 hours.

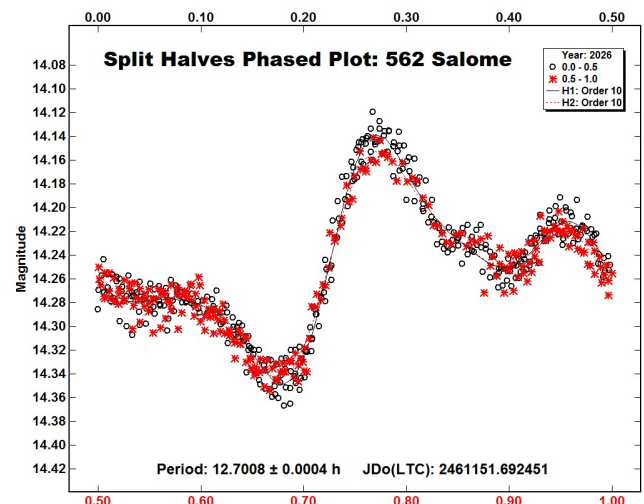


Fig. 2. The split halves lightcurve of 562 Salome phased to a period of 12.7008 hours.

1428 Mombasa. Three early publications stated periods near 17 hours: Behrend (2006web), 17.6 hours; Hawkins and Dittion (2008), 17.12 hours; Stephens (2012web), 16.67 hours. Four more recent publications all state periods near 25.6 hours: Pál et al. (2020), 25.646 hours; Dose (2021), 25.621 hours; Polakis (2024), 25.66 hours; Colazo et al. (2024), 25.604 hours. New observations obtained on seven nights 2026 May 10 - June 23 provide an excellent fit to a slightly asymmetric bimodal lightcurve (Fig. 3) with period 25.624 ± 0.002 h, amplitude 0.22 ± 0.02 magnitudes, and 95% lightcurve coverage. A period slightly greater than 25.6 hours can now be considered secure, and the early published values near 17 hours can be definitively rejected.

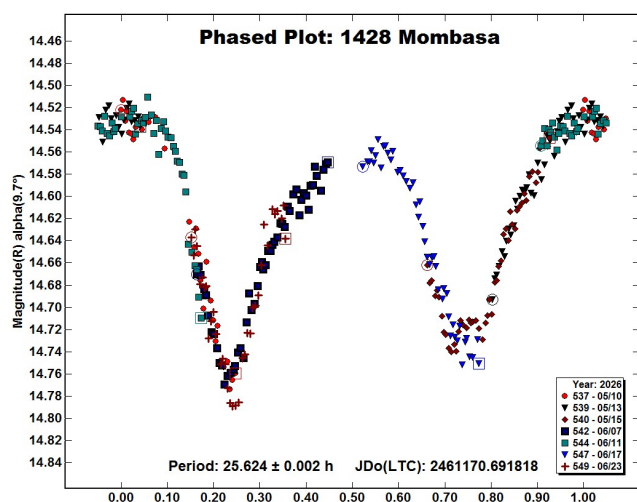


Fig. 3. The lightcurve of 1428 Mombasa phased to a synodic period of 25.624 hours.

1629 Pecker. Two previously published rotation periods are mutually discordant. Behrend (2006web), 6.156 hours; Pravec et al. (2006web), 8.2166 hours. New lightcurves were obtained on four nights 2026 Mar. 12-20. The rotation period is indeterminate, either 4.108 ± 0.002 hours with one maximum and minimum per rotational cycle (Fig. 4), or 8.216 ± 0.002 hours with two symmetric maxima and minima per rotational cycle (Fig. 5), and amplitude 0.08 ± 0.01 mag. A split halves plot of the 8.216-hour lightcurve (Fig. 6) shows that the two halves are identical within observational error. The period spectrum between 3 hours and 9 hours (Fig. 7) also shows that the rms minima of the 4.108 hour and 8.216-hour periods are equally deep and therefore equally likely. Because there may be one or two rotational cycles in a time interval of 8.216 hours, the two possible solutions, 4.108 hours and 8.216 hours, respectively, should be considered equally likely. The 6.156-hour period by Behrend (2006web) is now ruled out.

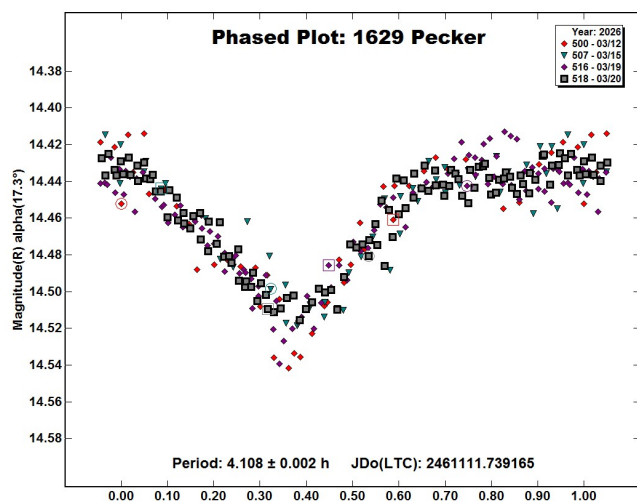


Fig. 4. The lightcurve of 1629 Pecker phased to a synodic period of 4.108 hours.

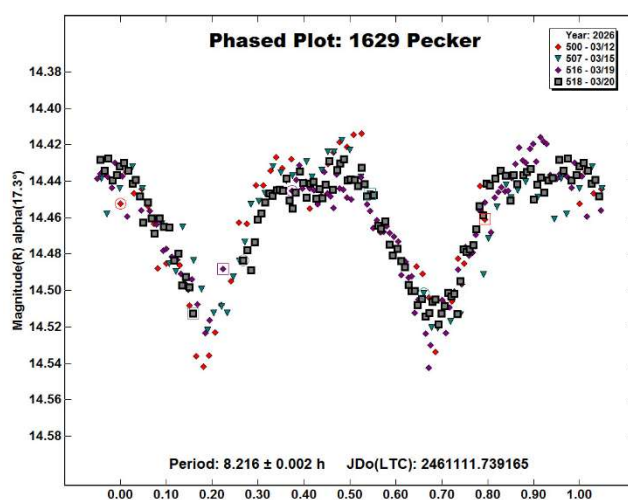


Fig. 5. The lightcurve of 1629 Pecker phased to a synodic period of 8.216 hours.

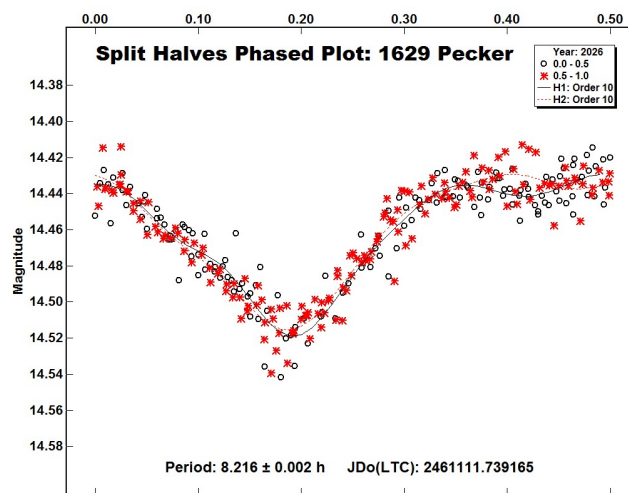


Fig. 6. The split halves lightcurve of 1629 Pecker phased to a synodic period of 8.216 hours.

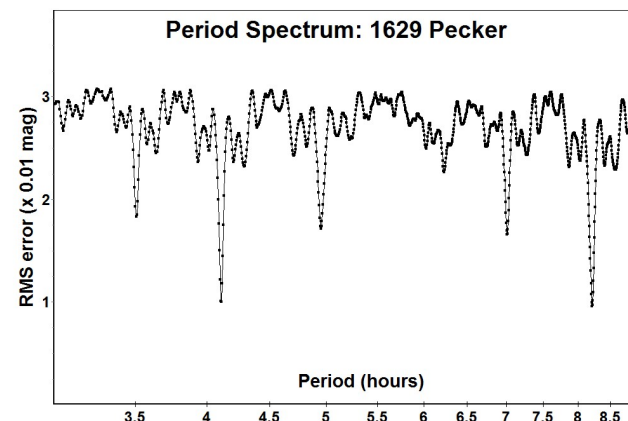


Fig. 7. The period spectrum of 1629 Pecker between 3 hours and 9 hours.

Number	Name	2026/mm/dd	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E	Amp	A.E.
562	Salome	04/21-06/01	*6.8, 8.9	228	5	6.3503	0.0001	0.19	0.02
1428	Mombasa	05/10-06/17	*9.8, 10.8	248	16	25.624	0.002	0.22	0.02
1629	Pecker	03/12-03/20	17.2, 14.2	197	12	4.108	0.002	0.08	0.01
1629	Pecker	03/12-03/20	17.2, 14.2	197	12	8.216	0.002	0.08	0.01
1684	Iguassu	03/21-04/18	12.5, 2.8	212	4	9.1438	0.0002	0.18	0.02

Table I. Observing circumstances and results. The phase angle is given for the first and last date, except that a * denotes a minimum was reached between these dates. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude and latitude at mid-date range (see Harris et al., 1984).

1684 Iguassu. Previously published rotation periods are Chang et al. (2015), 9.23 hours; Waszczak et al. (2015), 9.142 hours; and Skiff (2018web), 6.4156 hours. New observations were obtained on four nights 2026 Mar. 21-26, followed much later with observations on three more nights 2026 Apr. 16-18. They provide a good fit an irregular and slightly asymmetric bimodal lightcurve with period 9.1438 ± 0.0002 hours, amplitude 0.18 ± 0.02 magnitudes (Fig. 8). A long time interval separating two closely packed observation sets often causes rotational cycles during the long gap between observations to be incorrectly counted. The period spectrum (Fig. 9) is symmetric about a deepest minimum at 9.1438 hours, verifying that the 9.1438-hour period is the correct one. This result is consistent with Chang et al. (2015) and with Waszczak et al. (2015) and improves upon the accuracy of their results. The 6.4156-hour period by Skiff (2018) is now ruled out.

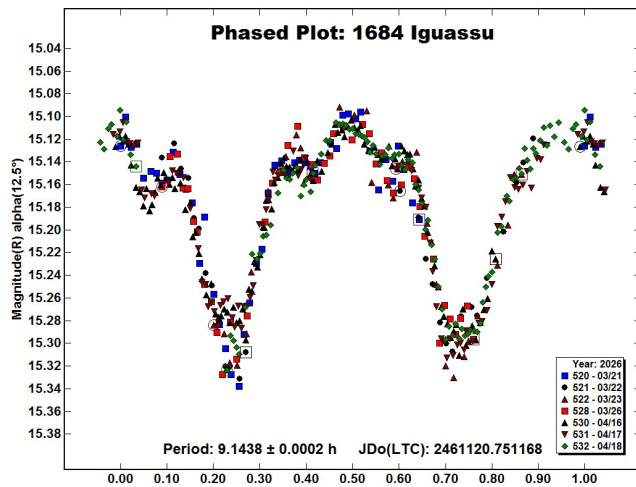


Fig. 8. The lightcurve of 1684 Iguassu phased to a synodic period of 9.1438 hours.

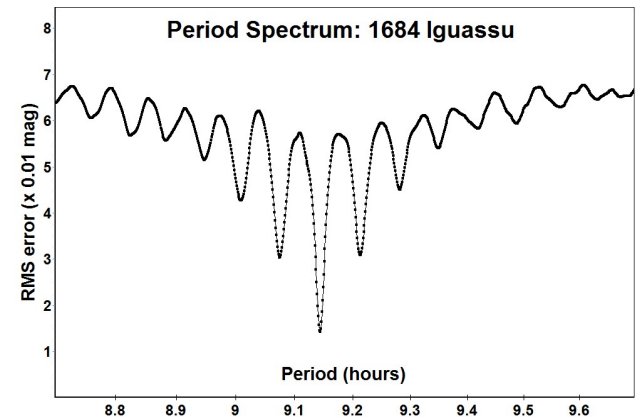


Fig. 9. The period spectrum of 1684 Iguassu between 8.7 and 9.7 hours.

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