

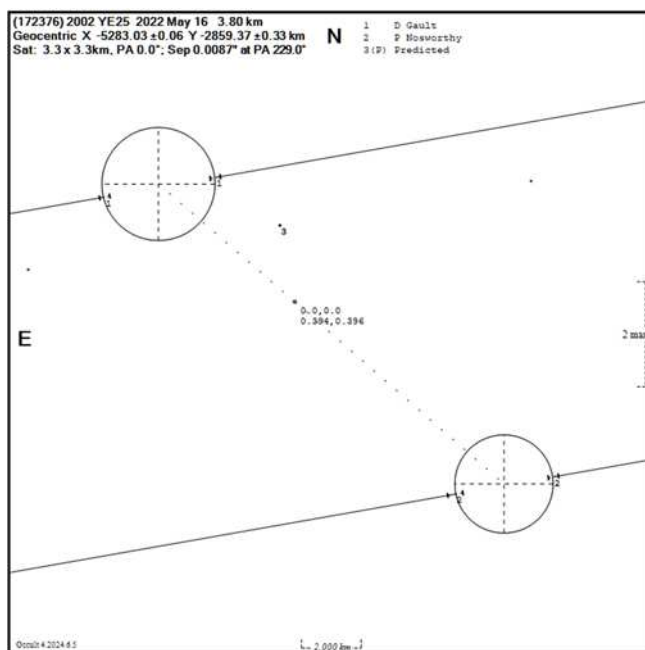


Figure 2. Reduction sky-plane plots of the 2022 May 16 occultation events for 2022 YE25.

However, if the two occultation chords were caused by spherical bodies 10 percent larger than the respective chords, the combined cross-sectional area of those bodies would be 24 sq km, fully consistent with that expected from the NEOWISE diameter. Accordingly, the observation is fully consistent with 2022 YE25 being a binary system.

Using a circular fit, we determined the chords for the two bodies:

Main body	3.8 ± 0.6 km
Satellite	3.3 ± 1.5 km

These diameters were then used to derive a separation of 8.7 ± 1.0 mas between the two with the satellite at position angle 229 ± 1 deg relative to the primary.

We are not aware of any lightcurve measurements of this asteroid. The observations of 2022 May 16 were the subject of *CBET* 5151.

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LIGHTCURVE ANALYSIS FOR FOUR NEAR-EARTH ASTEROIDS OBSERVED JULY-SEPTEMBER 2024

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(Received: 2024 October 13 Revised: 2024 October 31)

Lightcurves and amplitudes for four near-Earth asteroids observed from Great Shefford Observatory during close approaches between July and September 2024 are reported. All are small objects with rotation periods shorter than 5 minutes and one is identified as having tumbling rotation.

Photometric observations of near-Earth asteroids during close approaches to Earth between July - September 2024 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 arc seconds/pixel. All the images were calibrated with dark and flat frames and *Astrometrica* (Raab, 2024) was used to measure photometry using APASS Johnson V band data from the UCAC4 catalogue (Zacharias et al., 2013) and G band data from the Gaia DR 2 catalogue (Brown et al., 2018). *MPO Canopus* (Warner, 2023), incorporating the Fourier algorithm developed by Harris (Harris et al., 1989) was used for lightcurve analysis.

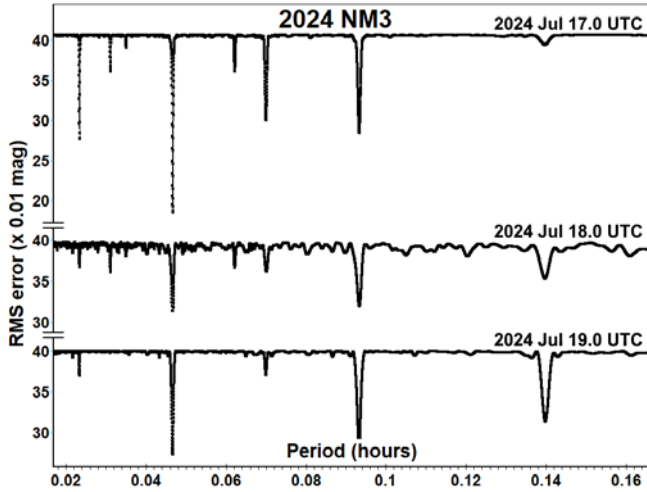
No previously reported results have been found in the Asteroid Lightcurve Database (LCDB) (Warner et al., 2009), from searches via the Astrophysics Data System (ADS, 2024) or from wider searches unless otherwise noted. All size estimates are calculated using H values from the Small-Body Database Lookup (JPL, 2024b), using an assumed albedo for NEAs of 0.2 (LCDB readme.pdf file) and are therefore uncertain and offered for relative comparison only.

2024 NM3. The ATLAS facility at Rio Hurtado, Chile discovered this Aten ($H = 25.2$, $D \sim 28$ m) on 2024 Jul 14.3 UTC. It passed Earth at 2.0 Lunar Distances (L.D.) on 2024 Jul 17.6 UTC (Dupouy et al., 2024) and was observed on three consecutive nights, 2024 Jul 17.0, 18.0 and 19.0 UTC. Average apparent magnitude and speed (arcsec/min) over the three nights were 16.7, 16.7, 17.6 and 100, 113, 53 respectively, resulting in the least scatter being achieved in the first night's measurements. Independent period spectra from the three nights produced very similar results, combined here in one diagram separated vertically. It can be seen that all the significant minima in the last two dates correspond with minima in the plot for Jul 17.0 UTC. The best fit in all three dates is for a rotation period of 0.047 h and all the other significant minima are integer multiples of $1/4$, $1/3$ or $1/2$ of that period. *MPO Canopus* was configured to plot phased lightcurve diagrams for the three dates with the lightcurve maximum positioned at phase = 0.00 (= phase 1.00). The best-defined period, from Jul 17.0, of 0.046654 ± 0.000003 h (~ 2.8 min) was then used to propagate likely errors forwards to the other two dates to estimate whether the maximum in the first date matched the maxima in the following two dates and therefore whether the lightcurve shapes were directly comparable. The likely

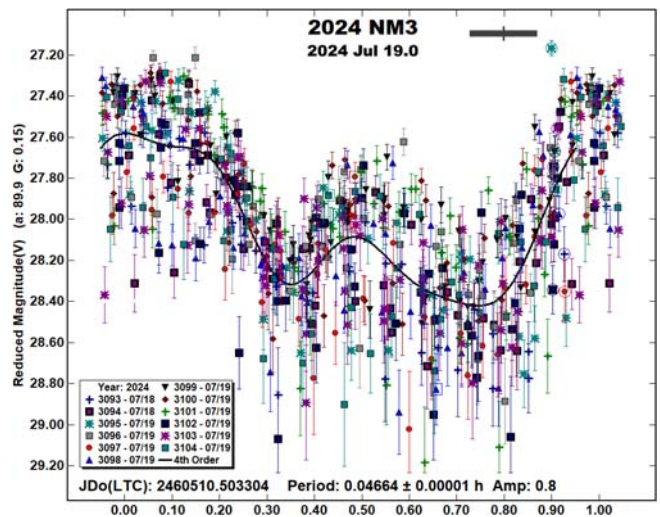
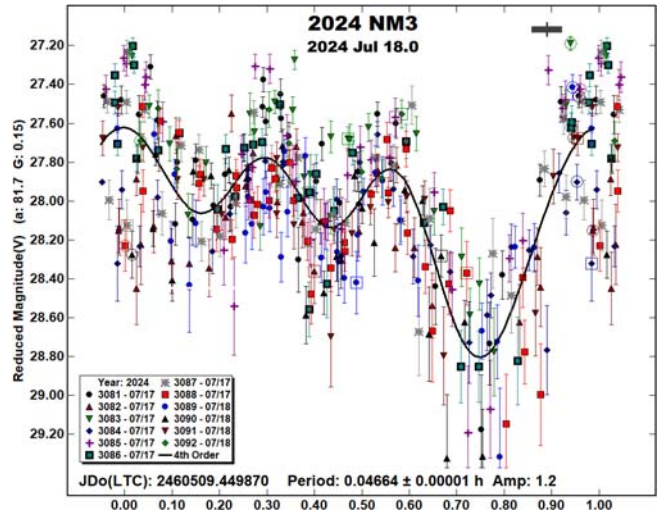
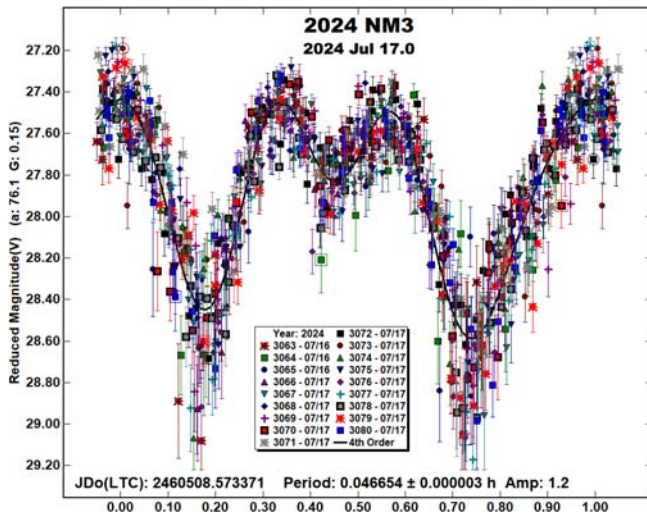
error in number of rotations ΔN between two dates was derived from eq. (3) in Kwiatkowski et al. (2010):

$$\Delta N \approx \Delta t \Delta P / P^2$$

where Δt is the time interval separating two lightcurves, P is the period from one of the individual solutions and ΔP is the maximum period uncertainty, with Δt , ΔP and P expressed in the same units.

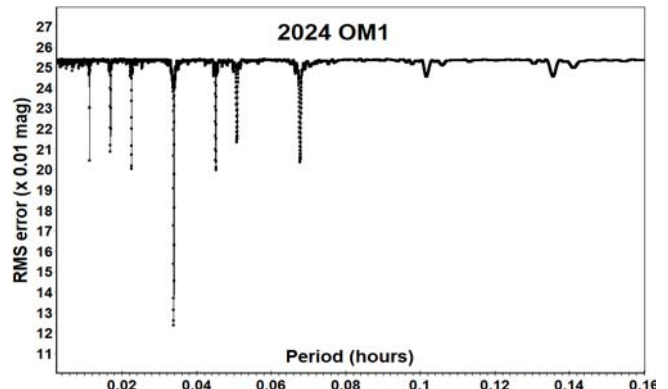


Propagating the period and its likely error from Jul 17.0 to Jul 18.0 predicts that maximum would occur at phase 0.89 ± 0.03 on the Jul 18.0 plot after 450 rotations had completed. Similarly propagating from Jul 17.0 to Jul 19.0 predicts that maximum would occur at phase 0.80 ± 0.07 on the Jul 19.0 plot after 992 rotations had completed. These predicted ranges of maxima are shown on the last two lightcurves as horizontal grey bars towards the top right and indicate that corresponding features in each are indeed likely to be comparable at similar phase values but also suggest the real error in the period used for Jul 17.0 is probably several times larger than stated. Matching features can be identified in each plot, including the deepest minima occurring at phase ~ 0.75 . The trimodal lightcurve apparent in Jul 17.0 and Jul 18.0 becomes less defined by Jul 19.0. Being at close range throughout and traversing 76° of sky, it is likely the aspect angle of 2024 NM3 (Earth $\rightarrow$ asteroid $\rightarrow$ asteroid spin axis) changed dramatically over the three nights, causing rapid changes to the surface features presented to Earth and probably accounting for the reducing amplitude with increasing phase angle and the observed changes in lightcurve shape.

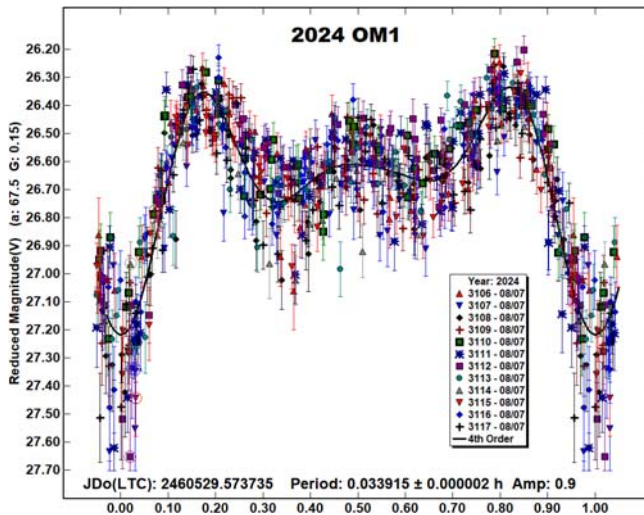


While under observation on Jul 17.0, 18.0 and 19.0, 2024 NM3 completed 60, 46 and 63 rotations respectively.

2024 OM1. Discovered from the Moonbase South Observatory in Namibia on 2024 Jul 29.0 UTC this Apollo ($H = 24.3$, $D \sim 41$ m) passed Earth at 3.6 L.D. on 2024 Aug 6.9 UTC (Herman et al., 2024). It was observed over a period of 2.3 h starting at 2024 Aug 7.03 UTC and, with an apparent speed of 105 arcsec/min exposures were kept to 5.6 seconds to keep trailing within the measurement annulus of *Astrometrica*. 691 measurements were obtained for the photometric analysis.

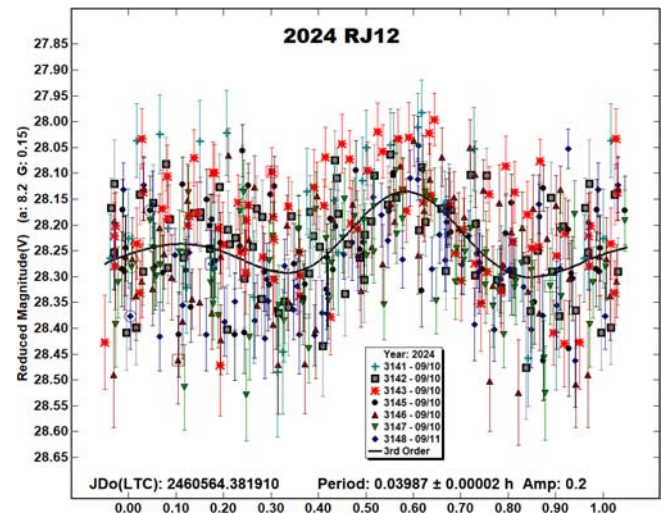
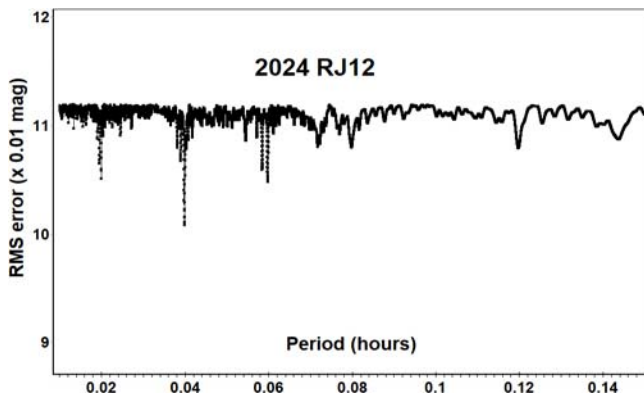


A period spectrum shows the best fit period to be 0.0339 h (~2.0 min) and the resulting lightcurve is apparently tri-modal, with an amplitude of 0.9. The next eight strongest minima in the period spectrum give significantly worse fits and are all integer multiples of half or a third of the best-fit period. During the period under observation 2024 OM1 completed 68 revolutions.

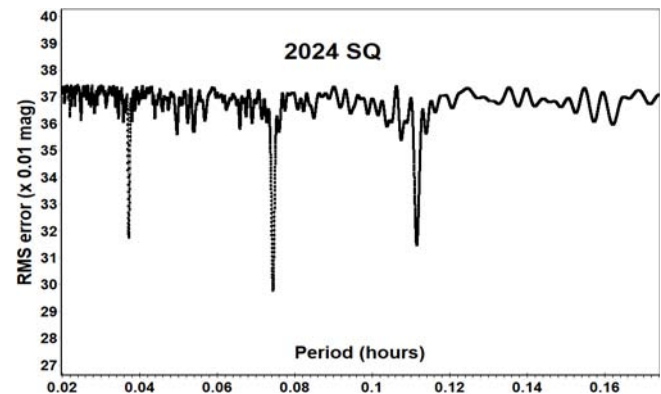


2024 RJ12. This Apollo ($H = 27.7$, $D \sim 8$ m) was a ZTF team discovery from Mt. Palomar on 2024 Sep 10.2 UTC, passing closest to Earth at 1.7 Lunar Distances (LD) about 90 min later (Bacci et al., 2024). It was actively observed for 67 min over a period of 3.7 h starting at 2024 Sep 10.88 UTC and with an apparent speed of 80 arcsec/min exposures were kept to shorter than 8 s to limit image trailing. The phase angle reduced to 3.9° by the end of the period of observation, with 2024 RJ12 reaching opposition 2 h later.

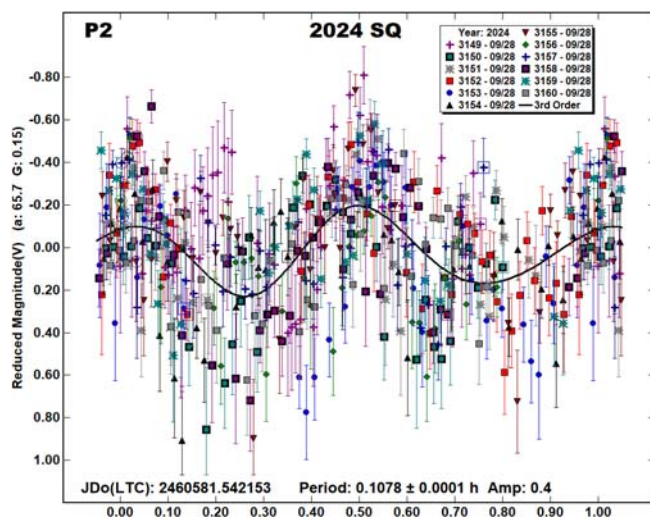
The analysis indicates that with phase effects being minimal it has a relatively low 0.2 mag amplitude and a bimodal lightcurve with period 2.4 min. During the 67 min 2024 RJ12 was being observed it completed 28 rotations.



2024 SQ. The Mt. Lemmon Survey discovered this Apollo ($H = 25.8$, $D \sim 20$ m) on 2024 Sep 24.3 UTC, 4 days before an approach to within 3 LD from Earth on 2024 Sep 28.3 UTC (Gilmore et al., 2024). It is listed by both the SENTRY (JPL, 2024a) and NEODYs (NEODYs, 2024) systems as a virtual impactor with a number of low-probability potential impacts starting in 2084. It was actively observed for 1.3 hours over a period of 2.1 hours starting on 2024 Sep 28.04 UTC when its apparent speed was 120 arcsec/min. Exposures were kept to 5.4 seconds or shorter to limit image trailing. Large magnitude variations were obvious within 1 minute and at occasional minima 2024 SQ was too faint to record. A period spectrum shows the best-fit solution to be at 0.0744 h (~4.5 min) but a lightcurve, marked PAR shows a large amount of scatter especially between phases 0.6 - 0.8 and non-principal axis rotation (NPAR) or tumbling was suspected.



Several possible secondary periods were identified using the Dual Period Search function of *MPO Canopus* with the strongest of those at 0.1078 ± 0.0001 h (~6.5 min), the resulting pair of NPAR lightcurves are labelled P1 and P2. However, it is not clear whether P2, or one of the other possible secondary solutions may be real and not just an alias of the real secondary period, for instance another apparent solution P3 at 0.0627 h is related to the P1 and P2 periods, where $1/P1 + 2/P2 = 2/P3$. Nevertheless, it is expected that 2024 SQ may be rated as PAR = -3 (NPA rotation reliably detected with the two periods resolved. An ambiguity of the periods solution may be tolerated provided the resulting spectrum of frequencies with significant signal is the same for the different solutions). (Petr Pravec, personal communication).



Number	Name	Integration times	Max intg/Pd	Min a/b	Pts	Flds
2024	NM3	5.1-12.9	0.077	1.4*	1836	42
2024	OM1	5.5,5.6	0.046	1.3*	691	12
2024	RJ12	6.5-7.6	0.053	1.1	424	7
2024	SQ	2.0-5.4	0.020	1.5*	472	12

Acknowledgements

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Number	Name	yyyy mm/dd	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E.	Amp	A.E	PAR	H
2024	NM3	2024 07/16–07/17	76.1–76.3	–28	12	0.046654	0.000003	1.2	0.3		25.2
		2024 07/17–07/18	81.8–82.6	–41	35	0.04664	0.00001	1.2	0.4		
		2024 07/18–07/19	90.0–90.6	–66	46	0.04664	0.00001	0.8	0.4		
2024	OM1	2024 08/07–08/07	67.5–71.1	–10	–3	0.033915	0.000002	0.9	0.2		24.3
2024	RJ12	2024 09/10–09/11	7.7–3.9	–11	3	0.03987	0.00002	0.2	0.1		27.7
2024	SQ	2024 09/28–09/28	65.8–70.0	39	–3	0.07438	0.00003	0.8	0.4	–3	25.8
						0.1078	0.0001	0.4	0.4		

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, 2024b).

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