

LIGHTCURVES OF EIGHT ASTEROIDS

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We present lightcurves and synodic rotation periods for eight asteroids including the family parent asteroid (1128) Astrid.

We present asteroid lightcurves obtained via the workflow process described by Dose (2020) and later improved (Dose, 2021). This workflow applies to each image an ensemble of typically 25-80 nearby comparison (“comp”) stars selected from the ATLAS refcat2 catalog (Tonry, 2018). This abundance of comp stars and our custom diagnostic plots allow for rapid identification and removal of outlier, variable, and poorly measured comp stars.

The product of this custom workflow is one night’s time series of absolute Sloan r' (SR) magnitudes for one target asteroid. These absolute magnitudes are corrected for instrument transforms, sky extinction, and image-to-image (“cirrus”) fluctuations, and thus they represent absolute magnitudes at the top of earth’s atmosphere. These magnitudes are imported directly into *MPO Canopus* software (Warner, 2021) where they are adjusted for distance and phase-angle dependence, then fit by Fourier analysis including identifying any aliases, and plotted.

Phase-angle corrections are made by applying a $H-G$ model and finding the G value that minimizes best-fit RMS error across all nights’ data for that apparition. When we cannot estimate G , usually due to a narrow range of phase angles, we apply the Minor Planet Center’s default value of 0.15. No nightly zero-point adjustments (Delta Comps in *MPO Canopus*) were made to any session, other than by estimating G .

Lightcurve Results

Eight asteroids were observed from New Mexico Skies observatory at 2210 meters elevation in southern New Mexico. Images were acquired with: a 0.50-m PlaneWave OTA on a PlaneWave L-500 mount and equatorial wedge, and a SBIG AC4040M CMOS camera cooled to -15°C and fitted with a Schott GG495 light yellow filter.

This equipment was operated remotely via *ACP* software (DC-3 Dreams), running one-night plan files generated by python scripts (Dose, 2020). Exposure times targeted 2-5 millimagnitudes uncertainty in asteroid instrumental magnitude, subject to a minimum exposure of 90 seconds to ensure suitable comp-star photometry, and to a maximum of 480 seconds.

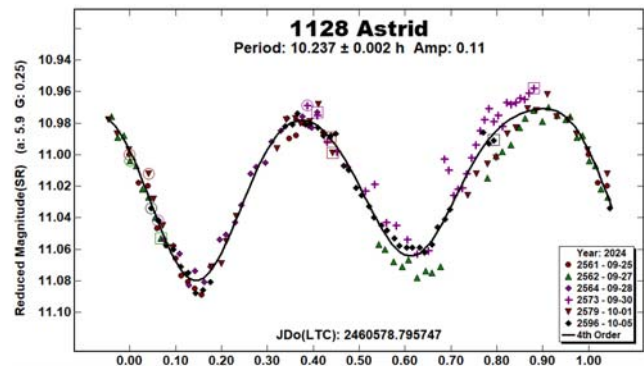
FITS images were calibrated using temperature-matched, exposure-matched, median-averaged dark images and recent flat images of a flux-adjustable light panel. Calibrated images were plate-solved by *TheSkyX* (Software Bisque), and target asteroids were identified in *Astrometrica* (Herbert Raab). All photometric images were visually inspected; the author excluded images with inadequate tracking or seeing quality, excessive interference by cloud or moon, or having stars, satellite tracks, cosmic ray artifacts, residual image artifacts, or other apparent light sources within 12 arcseconds of the target asteroid’s signal centroid. Images passing these screens were submitted to the workflow.

The GG495 light-yellow filter used here requires only modest first-order transforms to yield magnitudes in the standard Sloan r' (SR) passband. In our hands, using this filter (rather than a clear filter or no filter) improves transform linearity and night-to-night magnitude reproducibility to a degree outweighing the minor loss of signal-to-noise ratio caused by $\sim 15\%$ loss of measured flux.

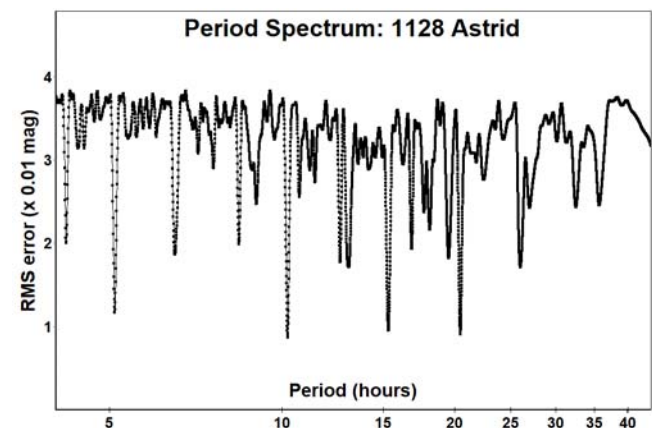
Our workflow employs as comp stars all ATLAS refcat2 entries with: distance of at least 15 arcseconds from image boundaries and from other catalogued flux sources, no catalog VARIABLE flag, SR magnitude within $[-2, +1]$ of the target asteroid’s SR magnitude on that night (except that very faint asteroids used comp stars with magnitudes in the range 14 to 16), Sloan $r'-i'$ color value within $[0.10, 0.34]$, and absence of variability as seen in session plots of each comp star’s instrumental magnitude vs time.

In this report, “period” denotes an asteroid’s synodic rotation period, and “mmag” denotes millimagnitudes (0.001 magnitude). In the lightcurves below, *MPO Canopus* v10 shows “SR” for both Pan-STARRS and Sloan r' values.

1128 Astrid. This parent asteroid of the Astrid family was found to have a synodic rotation period of 10.237 ± 0.002 h, in agreement with most (10.228 h, Behrend, 2005web; 10.2 h, Behrend, 2010web; 10.229 h, Waszczak et al., 2015; 10.2340 h, Āurech et al., 2020; 10.25 h, Polakis, 2021) but not all (14.552 h, Dittion et al., 2018) previous reports. We find a bimodal lightcurve shape. Our Fourier fit RMS error is 9 mmag, and a H-G model G value of 0.25 gave a markedly improved fit vs the MPC default value of 0.15.



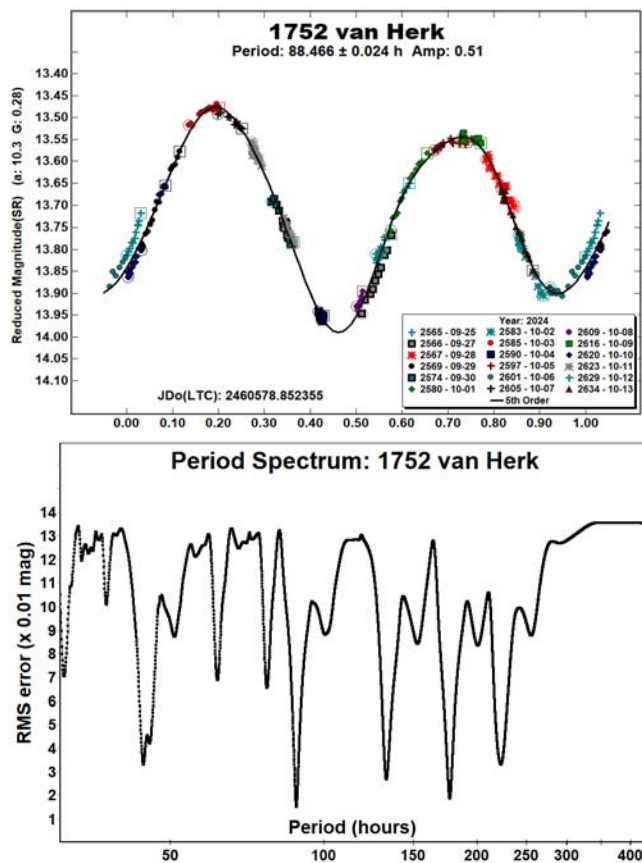
The period spectrum displays aliases at multiples of one-half the bimodal period, but the 10.237 h period estimate on a bimodal basis appears secure.



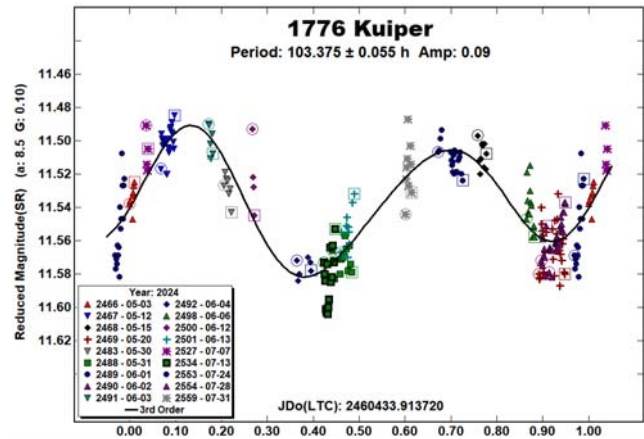
Number	Name	yyyy mm/dd	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
1128	Astrid	2024 09/25-10/05	6.1, 1.8	16	-1	10.237	0.002	0.11	0.02	AST
1752	van Herk	2024 09/25-10/13	*10.6, 2.9	17	4	88.466	0.024	0.51	0.04	FLO
1776	Kuiper	2024 05/03-07/31	*8.6, 17.8	244	11	103.375	0.055	0.09	0.03	MB-O
1808	Bellerophon	2024 10/04-10/07	15.4, 14.2	41	1	4.147	0.002	0.16	0.02	MB-O
2984	Fedynskij	2024 05/28-07/12	*2.3, 15.7	247	6	8.140	0.001	0.42	0.04	MB-O
3831	Pettengill	2024 09/26-10/08	26.0, 28.8	326	-1	5.431	0.001	0.77	0.05	FLO
4339	Almamater	2024 10/02-10/14	10.2, 3.3	23	3	109.074	0.084	0.30	0.03	MB-I
6453	1991 NY	2024 09/28-09/30	10.6, 9.4	22	0	2.872	0.002	0.21	0.03	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).

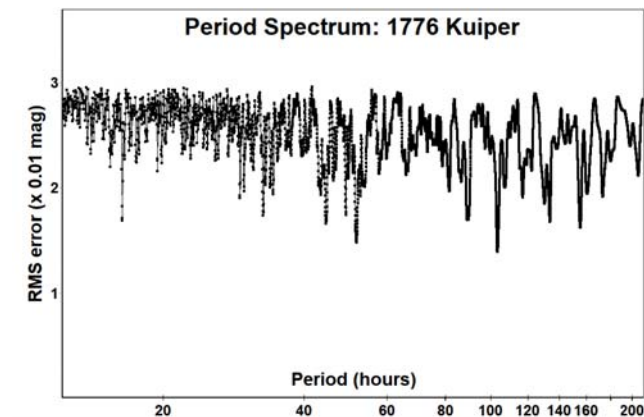
1752 van Herk. From 18 nights' observations of this Flora-family asteroid, we estimate the rotation period to be 88.466 ± 0.024 h, in agreement with one known survey report (88.45 h, Āurech et al., 2020). Using a G value of 0.28 rather than the MPC default of 0.15 markedly decreased the Fourier fit RMS error, which is 15 mmag.



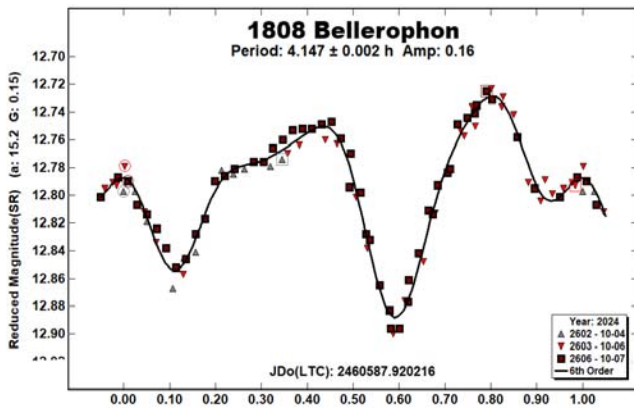
1776 Kuiper. For this bright outer main-belt asteroid, we estimate a period of 103.375 ± 0.055 h from 18 nights of data taken over a span of 20 periods. We found no previous reports of period or lightcurve for this asteroid. The amplitude is modest, and the lightcurve shows significant within-night magnitude trending, consistent with precession (“tumbling”). Our RMS error of 14 mmag includes effects of precession, and a G-value of 0.10 improved the fit.



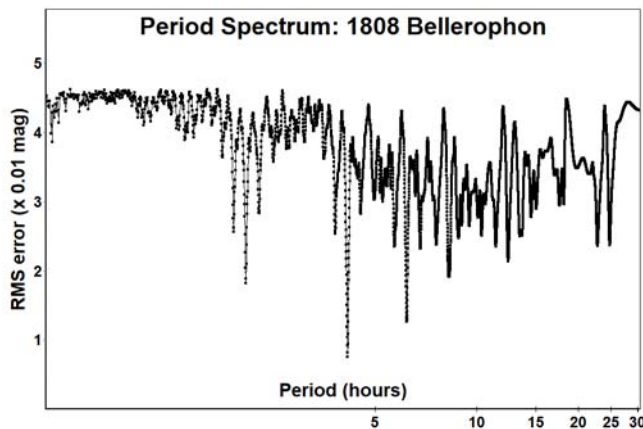
In the period spectrum, precession effects increase the RMS error of the main signals, but the major signals do lie at 0.5, 1, and 1.5 times our proposed period.



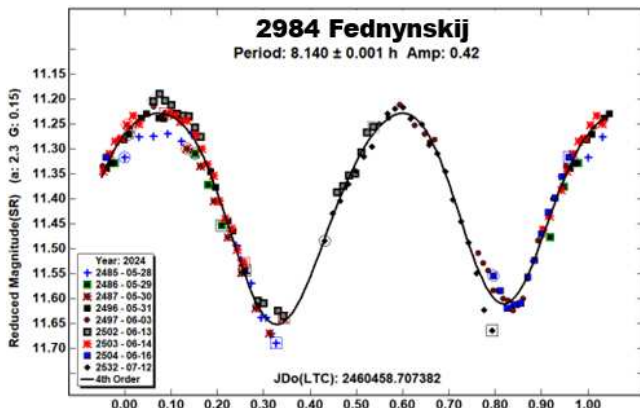
1808 Bellerophon. For this outer main-belt asteroid, we find a period of 4.147 ± 0.002 h, consistent with an early estimate (4 ± 1 h, Harris, 1983) but differing from one known survey result (3.820 h, Waszczak et al., 2015). As the small phase-angle range of our observations precludes G-value estimation, we have applied the MPC default value of 0.15. Our Fourier fit RMS error is 7 mmag.



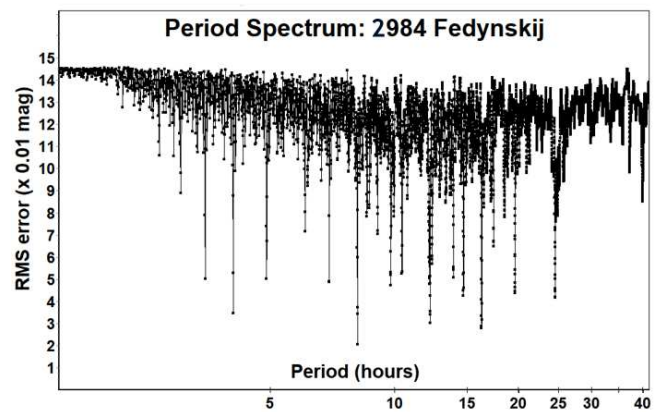
The period spectrum supports our new estimate. No clear signals appear at previous estimates of 3.82 h and 4 h. The 3.82 h estimate is an alias of our result by 1 rotation per day.



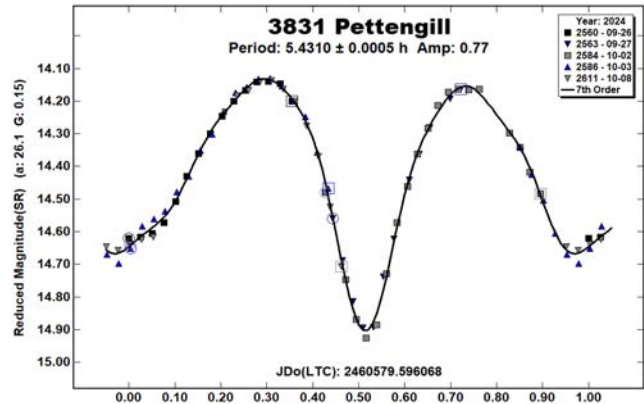
2984 Fedynskij. We find a rotation period of 8.140 ± 0.001 h for this outer main-belt asteroid, in close agreement with one previous survey result of 8.14041 h (Durech et al., 2020). The substantial amplitude of 0.42 magnitudes and a persistent difference between the shapes of the bimodal halves persuade us to interpret the lightcurve as bimodal. Our Fourier fit RMS error is 21 mmag.



The period spectrum displays numerous alias signals, but all major signals lie at multiples of $\frac{1}{2}$ our proposed period, as expected for a bimodal lightcurve with similar halves.

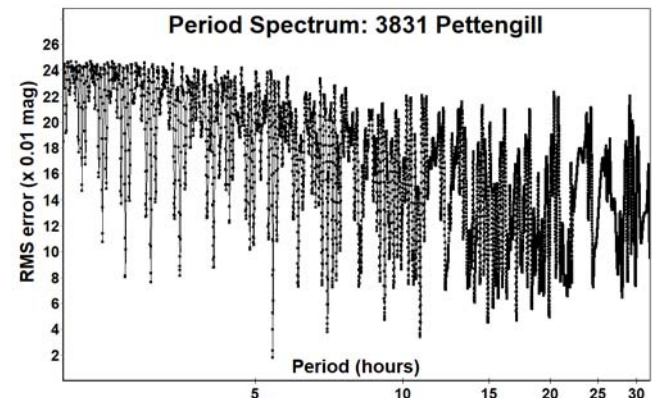


3831 Pettengill. For this Flora-family asteroid, our period estimate of 5.4310 ± 0.0005 h confirms the majority of previous period reports (5.432161 h, Durech et al., 2020; 5.431 h, Erasmus et al., 2020; 5.43141 h, Pál et al., 2020) but differs from one other (4.78 h, Behrend, 2011web). The bimodal lightcurve's halves appear as each others' reverse in time. Given the narrow range of phase angles, we adopt the MPC default G value of 0.15, and our fit RMS error is 15 mmag.

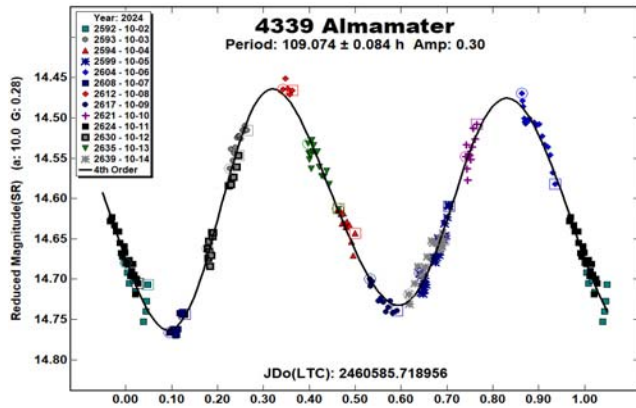


The period spectrum favors our period estimate. Very many signals appear at alias values and at multiples of $\frac{1}{2}$ our period estimate, but the observations' high signal-to-noise ratio might distract from the fact that our estimate's fit RMS error is one-half that of the next best period solution (which itself lies at twice our estimate).

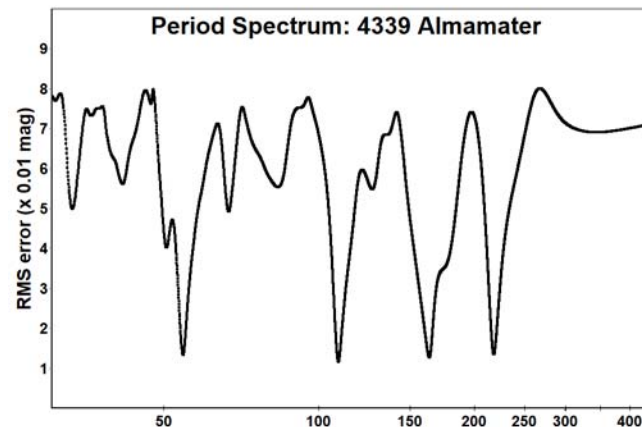
The previously reported estimate of 4.78 h does not appear as a major signal, and we cannot explain it as an alias or simple fractional multiple of the emerging consensus estimate.



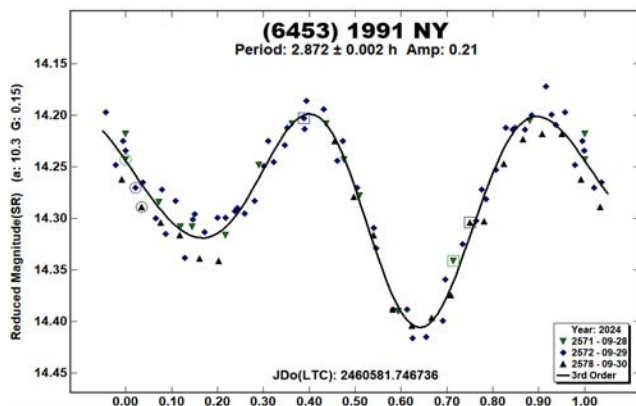
4339 Almatator. We observed this inner main-belt asteroid over 13 consecutive nights (about 3 period durations), yielding a rotation period estimate of 109.074 ± 0.084 h, which differs from the sole known report (30.84 h, Vander Haagen, 2012). The lightcurve is bimodal; the halves are similar except that they differ in minimum brightness. Fourier fit was optimized near G of 0.28, and our RMS error is 12 mmag.



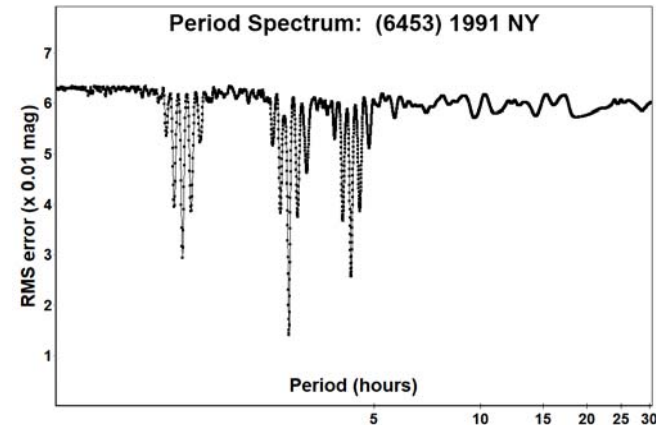
Our period spectrum is dominated by the first four multiples of $\frac{1}{2}$ period, as expected for a bimodal lightcurve with similar halves. No major signal appears near the previously reported estimate of 30.84 h.



(6453) 1991 NY. Our period estimate of 2.872 ± 0.002 h, generated from three long nights of observation, differs from the sole known period report of 15 h (Pravec et al., 2012web). The lightcurve is clearly bimodal. Our Fourier fit RMS error is 14 mmag.



Our period spectrum appears unambiguous; no signal appears at 15 h.



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ANALYSIS AND LIGHTCURVES OF ELEVEN ASTEROIDS

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The analysis, observation, and results of the lightcurves of the eleven asteroids presented here were mostly performed during the months of 2024 March to July, while the others were observed in 2021 and 2023. In some cases, we obtained rotation periods somewhat different from those previously published. For others, we could not find a period in the literature. The eleven asteroids studied and the derived rotation periods were: 236 Honoria (12.339 h), 606 Brangane (12.294 h), 737 Arequipa (14.067 h), 1509 Esclangona (3.252 h), 2383 Bradley (5.870 h), 4897 Tomhamilton (18.213 h), 5515 Naderi (5.230 h), 6012 Williammurdoch (2.891 h), 6859 Datemasamune (8.905 h), 7304 Namiki (8.873 h), and 8648 Salix (30.267 h).

We made photometric observations of a total of eleven asteroids, mostly in 2024 but some in 2021 or 2023. In all cases, the images 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. In addition, all data were light-time corrected. Individual lightcurve plots along additional comments as required are presented below.