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LIGHTCURVES OF EIGHTEEN ASTEROIDS

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We present lightcurves and synodic rotation periods for eighteen asteroids including the family parent asteroid (2732) Witt.

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 et al., 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, matched with their corresponding time, 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. Whenever 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 data presented here, other than by estimating G .

Lightcurve Results

Eighteen asteroids were observed from New Mexico Skies observatory at 2210 meters elevation in southern New Mexico (before November 7) or from Howling Coyote Remote Observatories at 2295 meters elevation in western New Mexico (after November 7). 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 fitted with a Schott GG495 light yellow filter and cooled to -15°C (before November 7) or -20°C (after November 7).

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 120 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, digital artifacts caused by changing CMOS read mode, 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.

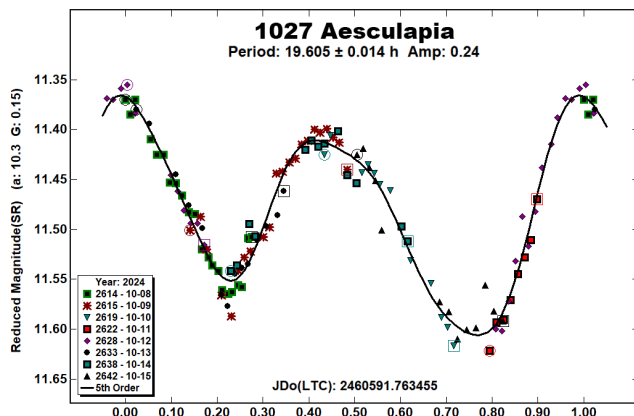
Transforms required by the GG495 light-yellow filter used here are modest in size and essentially linear (first-order), and they yield magnitudes in the standard Sloan r' (SR) passband. In our hands, using this filter (rather than a clear filter or no filter) improves transform linearity and night-to-night magnitude reproducibility to a degree outweighing the minor loss of signal-to-noise ratio caused by ~15% loss of measured flux.

Our workflow employs as comp stars all ATLAS refcat2 entries having: 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 having 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.

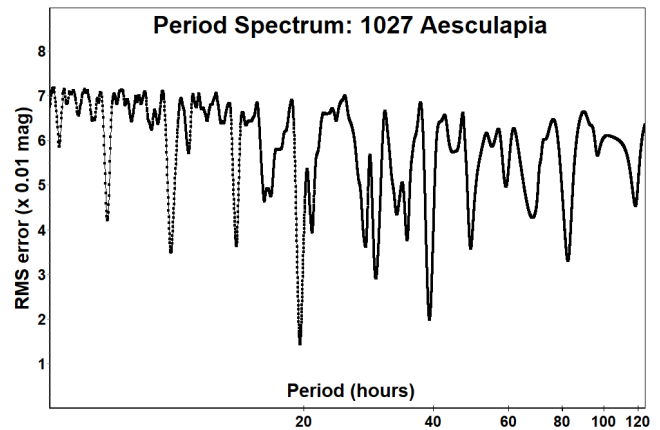
In this report, "period" denotes an asteroid's synodic rotation period, and "mmag" denotes millimagnitudes (0.001 magnitude). In the lightcurves below, *MPO Canopus* v10 shows "SR" for both Pan-STARRS and Sloan r' values.

1027 Aesculapia. This Themis-family asteroid was found to have a synodic rotation period of 19.605 ± 0.014 h, in reasonable agreement with one survey result (19.506 h, Waszczak et al., 2015) and one other result with lightcurve (19.90 h, Polakis, 2020), as well as being consistent with one constraint result (> 15 h, Behrend, 2024web), but in disagreement with other published results (6.83 h, Maleszewski and Clark, 2004; 14.4 h, Behrend, 2004web; 9.791 h, Ehlert and Kingery, 2015; 13.529 h, Hess et al., 2017).

Our observations over 8 consecutive nights yield a bimodal lightcurve with Fourier fit RMS error of 14 mmag. The narrow range of our phase angles does not allow for estimating optimum G value (H - G model), so we apply the MPC default value of 0.15.

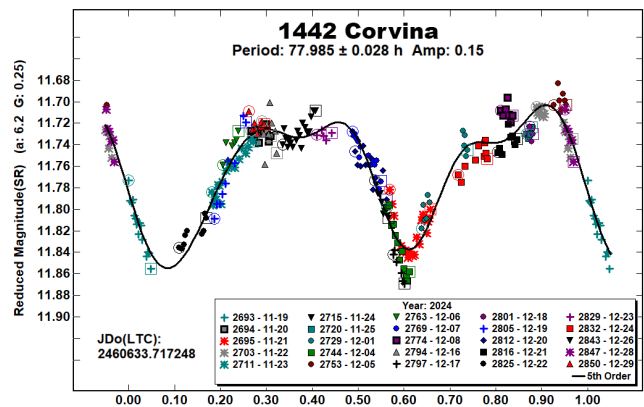


Our period spectrum's dominant signals appear at our period estimate and at twice that duration. Minor signals appear near the reported period estimates of Maleszewski and Clark, Ehlert and Kingery, and Hess et al.

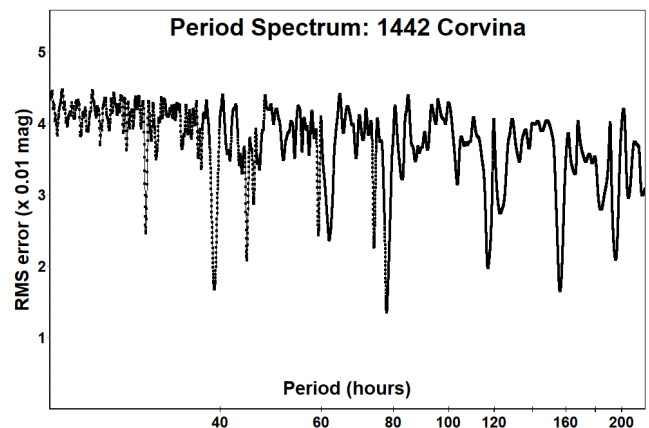


1442 Corvina. Observations during 25 nights have yielded our period estimate of 77.985 ± 0.028 h for this Koronis-family asteroid, agreeing with one published result (77.92 h, Slivan, 2021) but differing from another (31.36 h, Polakis, 2021). Our RMS error is 14 mmag, with our optimum G value being near 0.25.

The lightcurve is bimodal and shapes of the 2 brightness maxima are complex; in our hands, Fourier fits were often unreasonably poor when applying a lower fit order or when adopting the MPC default G value of 0.15.

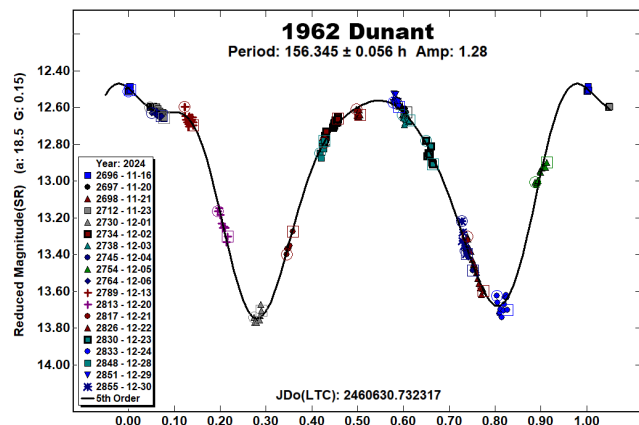


In our period spectrum, dominant signals appear at 0.5, 1.0, and 2.0 times our period estimate. Little or no signal appears near 31.36 h.

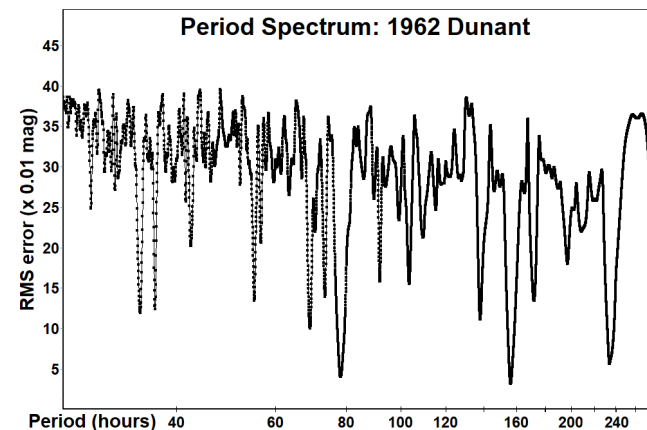


1962 Dunant. By observing this outer main-belt asteroid for 19 nights during 2024's unusually favorable opposition, we find a rotation period of 156.345 ± 0.056 h. We know of no previously

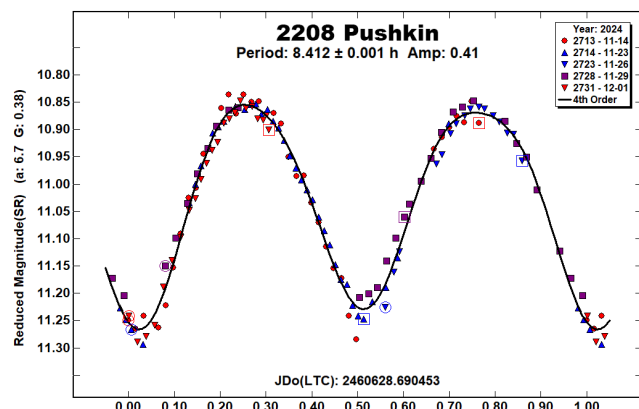
published period or lightcurve. A bimodal interpretation is supported by the lightcurve's large amplitude and by the differing shapes of alternating brightness maxima. RMS error is 32 mmag, and optimum G value is near 0.15.



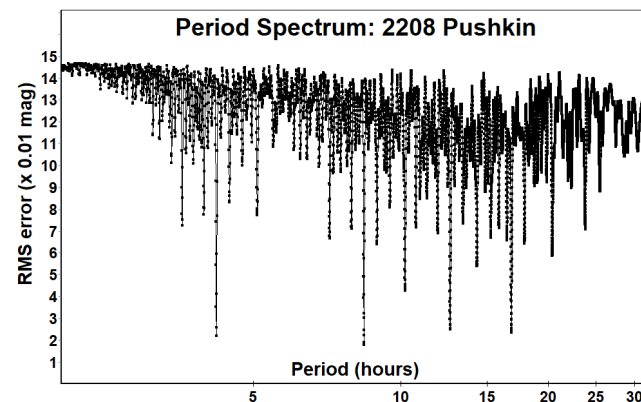
Our period spectrum is dominated by signals at 1, 2, and 3 times our proposed rotation period. Relative weakness of the signal near 0.5 times our proposed period further supports a bimodal shape.



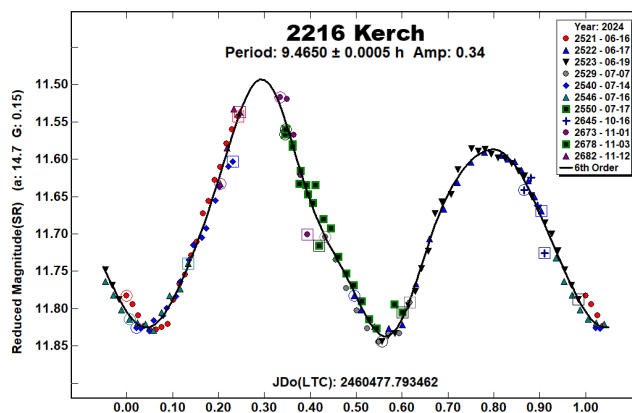
2208 Pushkin. For this outer main-belt asteroid, we report a rotation period of 8.412 ± 0.001 h, in agreement with one published survey estimate (8.405 h, Waszczak et al., 2015). The amplitude of 0.41 mag persuades us to adopt a bimodal lightcurve interpretation, though the folded lightcurve's two halves are similar. Our Fourier fit RMS error is 18 mmag, and our best G estimate was the MPC default of 0.15.



The period spectrum's major signals appear at 0.5, 1, 1.5, and 2 times our period estimate, consistent with a bimodal lightcurve whose halves are very similar in shape. The secondary signal near 10.2 h is an alias of our estimate by 1/2 rotation per day.

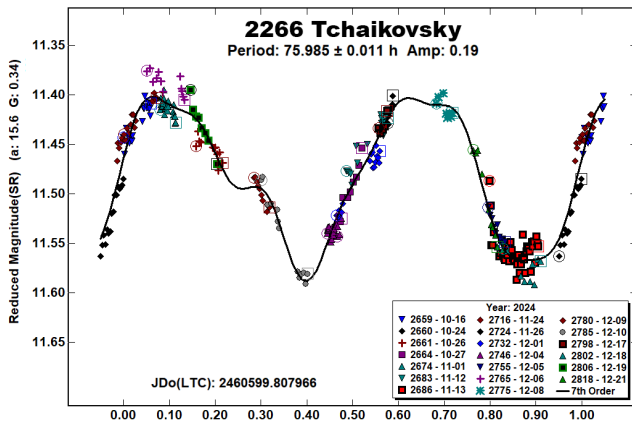


2216 Kerch. Our new period estimate of 9.4650 ± 0.0005 h for this Eos-family asteroid matches all three previously published estimates (9.462 h, Krotz et al., 2010; 9.47 h, Yeh et al., 2020; 9.46607 h, Āurech et al., 2020). The lightcurve is clearly bimodal in shape, and it remained remarkably consistent though our 16 weeks of observations and through a very wide range of phase angles. Our RMS error is 14 mmag and was optimized with a G value of 0.15.

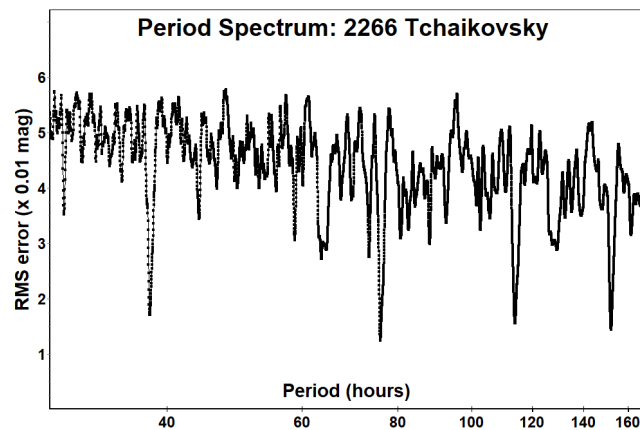


2266 Tchaikovsky. We observed this outer main-belt asteroid for 20 nights during its favorable 2024 opposition, and we propose a rotation period of 75.985 ± 0.011 h, in agreement with one survey estimate (76.1605 h, Pál et al., 2020) but differing from two other published estimates (4.883 h, Warner, 2006; 37.7 h, Warner, 2011), this last having been presented on a monomodal basis and being in fact close to half our new estimate.

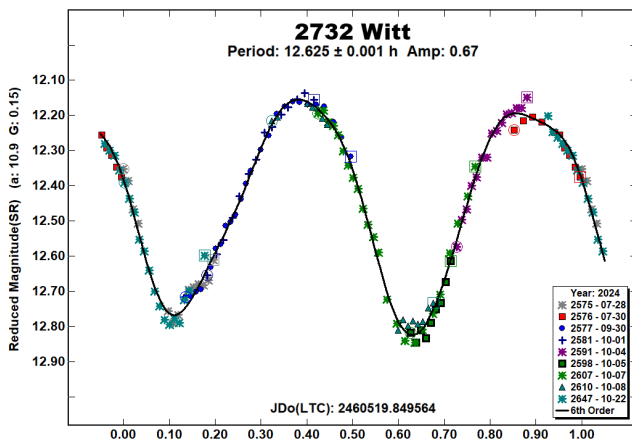
Despite our lightcurve's modest amplitude, we favor a bimodal interpretation because of differing shapes of the dimming phase segments as well as differing shapes of the brightness minima. Our Fourier fit RMS error is 12 mmag, and applying a G value of 0.34 resulted in RMS error about 40% of the error obtained when the MPC default of 0.15 was applied.



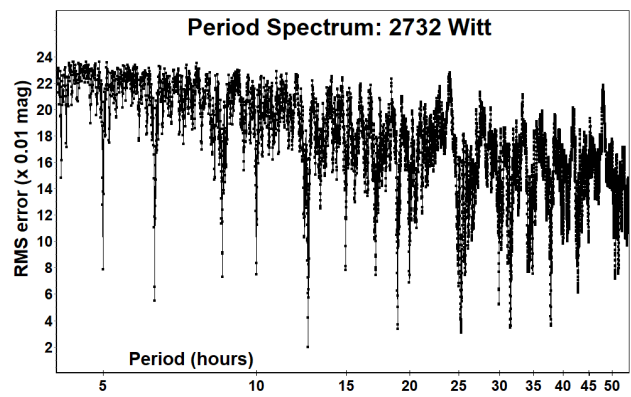
Our period spectrum has major signals only at 0.5, 1, 1.5, and 2 times our period estimate.



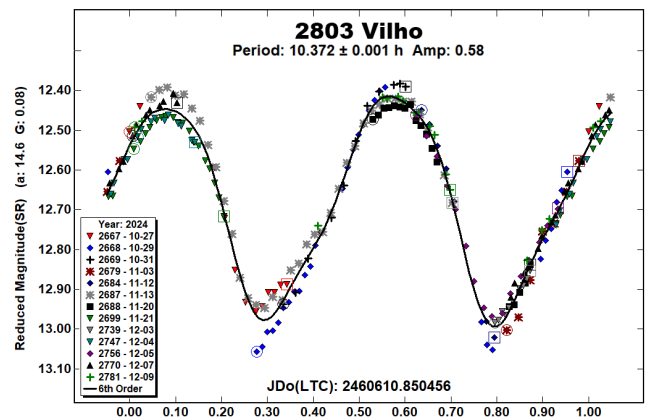
2732 Witt. For this parent asteroid of the Witt family, we confirm previous period constraints and estimates (> 0.88 h, Erasmus et al., 2018 and Erasmus et al., 2019; 12.662 h, Behrend, 2018web; 12.6244 h, Pilcher, 2025) with our new estimate of 12.625 ± 0.001 h. The lightcurve's amplitude is large, and its shape is clearly bimodal. Our RMS error is 20 mmag, and optimum G value is the MPC default of 0.15, which we applied.



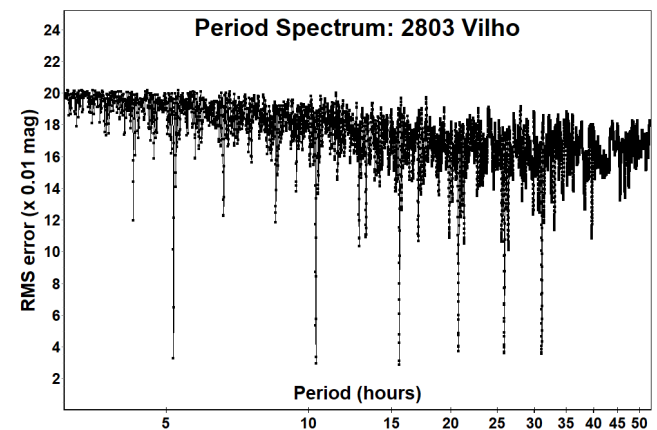
In the period spectrum, major signals appear only at multiples of $\frac{1}{2}$ our period estimate, as common for bimodal lightcurves whose halves are similar.



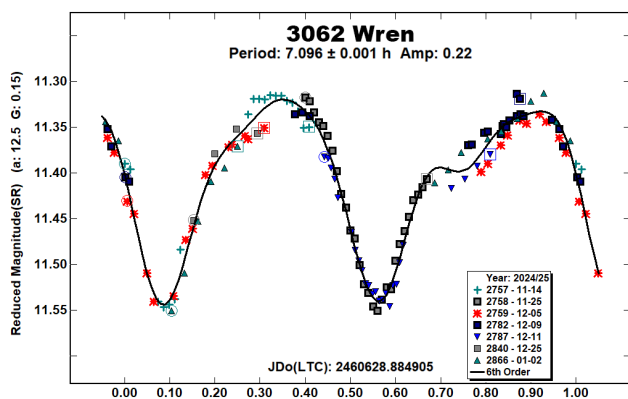
2803 Vilho. Our period estimate of 10.372 ± 0.001 h for this Themis-family asteroid agrees with one published survey estimate (10.37278 h, Āurech et al., 2019) but differs from another report (12.5 h, Behrend, 2015web). Our Fourier fit RMS error is 27 mmag, as minimized by our G estimate of 0.08.



The period spectrum appears as expected for a bimodal lightcurve of high signal-to-noise ratio and similar halves.

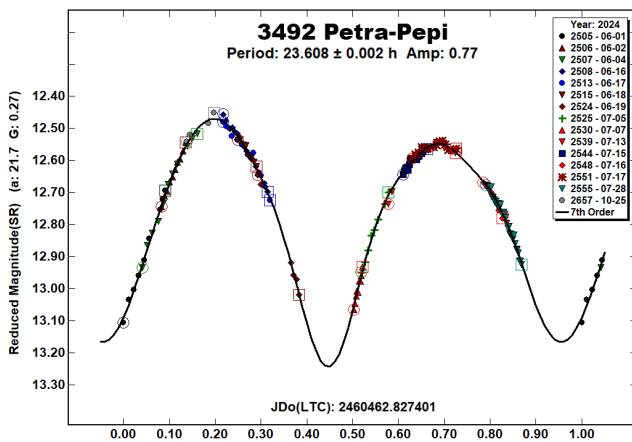


3062 Wren. We estimate the rotation period for this Eos-family asteroid to be 7.096 ± 0.001 h, agreeing with most (6.967 h, Behrend, 2006web; 7.097 h, Carbo et al., 2009; 7.097 h, Vinson et al., 2014) but not all (5.50 h, Behrend, 2020web) published reports. The lightcurve appears to be bimodal in shape, though our data do not strictly rule out a monomodal solution. Our RMS error is 12 mmag, and the MPC default G value of 0.15 was close to optimum.

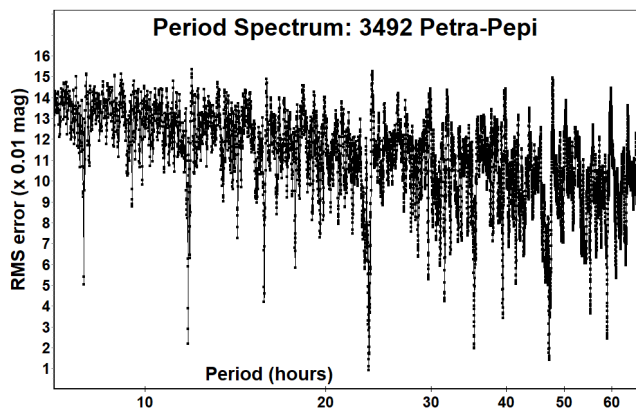


Our lightcurve is missing data at both brightness minima, and this is due to two unfortunate (for observers) properties of this period: (1) the nearness to 24 h means that one's observations advance in phase very little from night to night, so that full phase coverage requires a campaign of at least 60 days; and more subtly, (2) the period's exact difference from 24 h causes loss of observing nights near full moons to repeat in phase every two lunar cycles. This latter means that, for any single opposition of this asteroid, two spans of phases, separated by about 0.5, will always be missing from a phased lightcurve, no matter how many weeks long the observing campaign or how many hours long the nightly observing sessions.

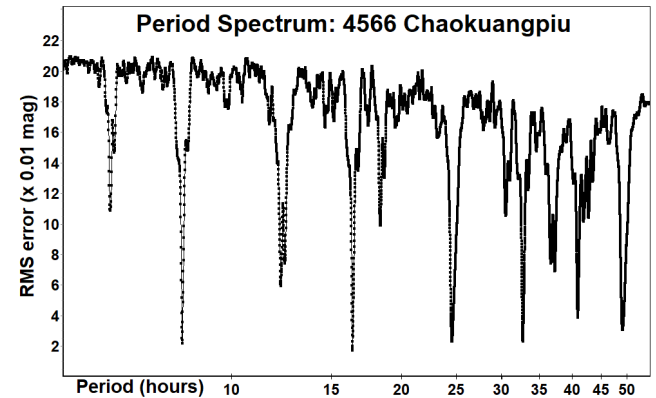
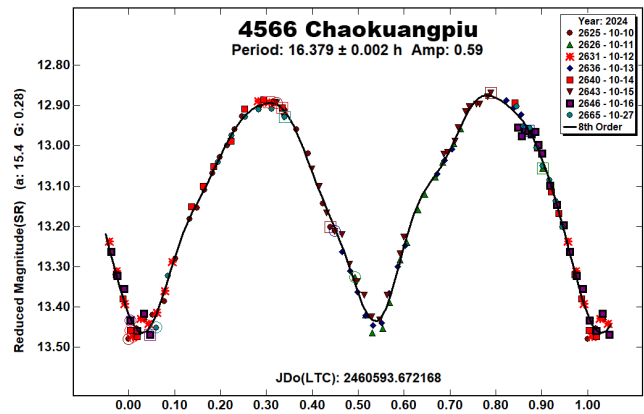
As this effect is lunar rather than sidereal, resulting phase coverage gaps cannot be remedied by cooperative observing from multiple longitudes. That is: single-opposition lightcurves of (3492) Petra-Pepi built from terrestrial observations will probably always contain phase-coverage gaps very much like those we display below. These gaps would be minimized by observing closer to the moon near full moons; the lightcurve's high amplitude might help make that possible.



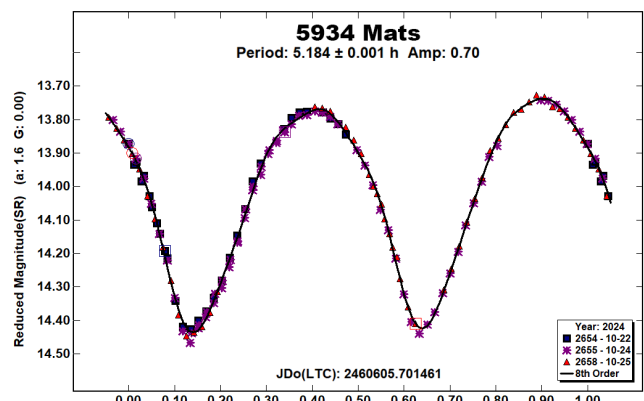
Despite gaps in phase coverage, our period spectrum is essentially unambiguous. The previously reported estimates near 47 h appear as a strong secondary signal; but corresponding lightcurves are tetramodal in shape.



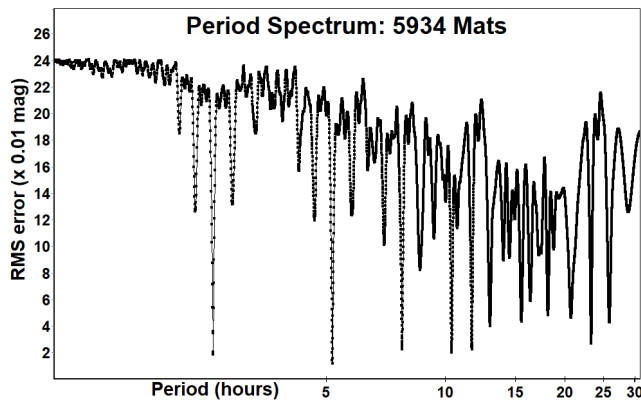
4566 Chaokuangpiu. We find a rotation period of 16.379 ± 0.002 h for this Itha-family asteroid, in agreement with one survey result (16.3825 h, Āurech et al., 2020). The lightcurve amplitude is large enough to favor bimodal interpretation, resulting in our estimate. Applying G value of 0.28 gave the best fit, yielding an RMS error of 17 mmag.



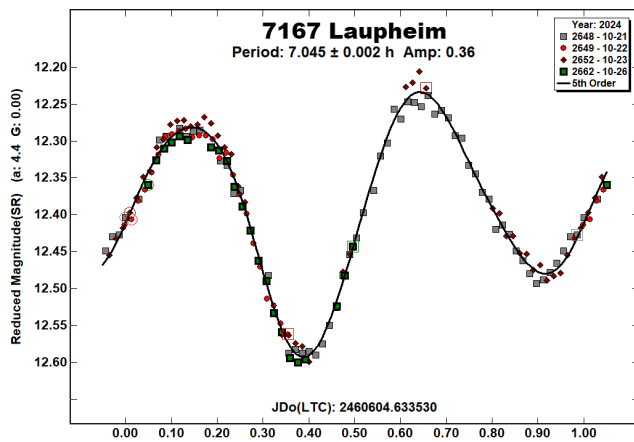
5934 Mats. For this asteroid, commonly assigned to the Nysa or Hertha family, three nights of observations sufficed to estimate its rotation period as 5.184 ± 0.001 h, in agreement with one known published report (5.184 h, Erasmus et al., 2020). The period spectrum and the lightcurve's large amplitude together support our bimodal interpretation. A G value of 0.0 modestly improved the fit relative to the MPC default G of 0.15, yielding our RMS error of 12 mmag.



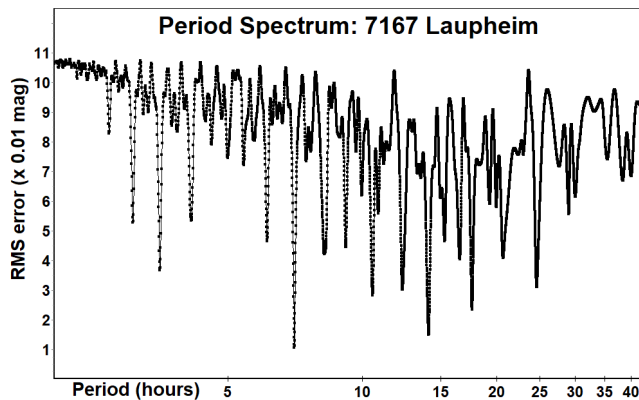
The period spectrum is dominated by signals at multiples of $\frac{1}{2}$ our period estimate, as expected from the lightcurve shape.



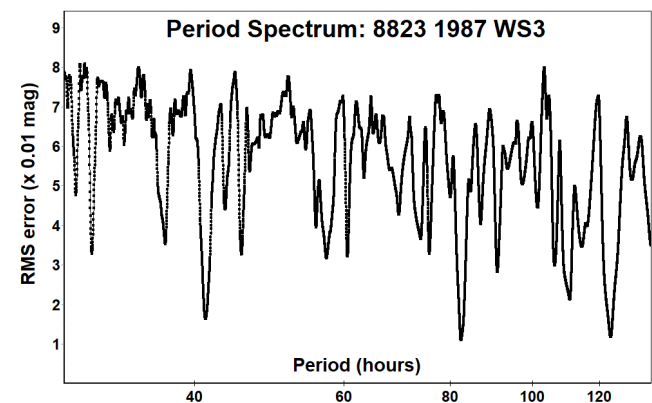
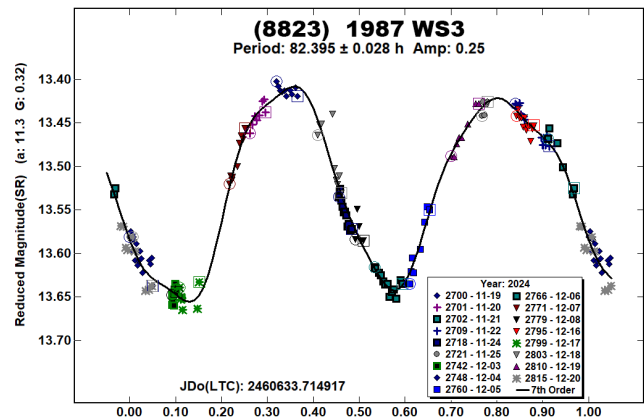
7167 Laupheim. Four nights of observations sufficed to determine the period of this outer main-belt asteroid as 7.045 ± 0.002 h, in agreement with one survey report (7.040 h, Waszczak et al., 2015). Applying G value of 0.0 modestly improved the Fourier fit relative to the MPC default G of 0.15, yielding our RMS error of 11 mmag.



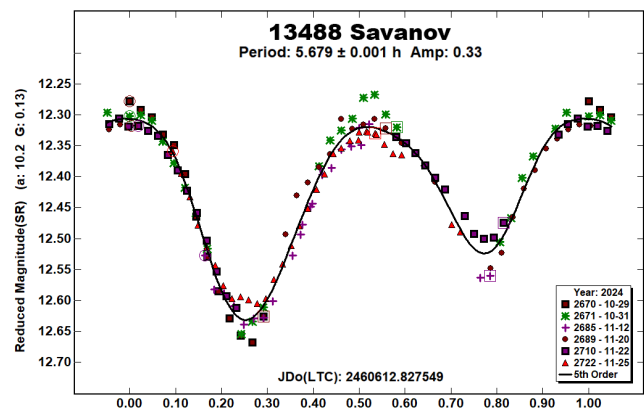
The period spectrum is dominated by a signal at our period estimate, with a strong secondary signal at twice our estimate.



(8823) 1987 WS3. Three estimates have recently been published for the rotation period of this Mitidika-family asteroid, and all three differ (110.88 h, Behrend, 2020web; 86 h, Marchini et al., 2021; 80.811 h, Noschese et al., 2021). From 17 nights of observation spanning 32 calendar nights (9 period durations), we find a period of 82.395 ± 0.028 h, remarkably disagreeing with all three previous reports. Our phase coverage is quite nearly complete, yielding a lightcurve that is clearly bimodal in shape. Adopting a G value of 0.32 strongly reduced the fit RMS error relative to the MPC default of 0.15, resulting in an RMS error of 11 mmag.

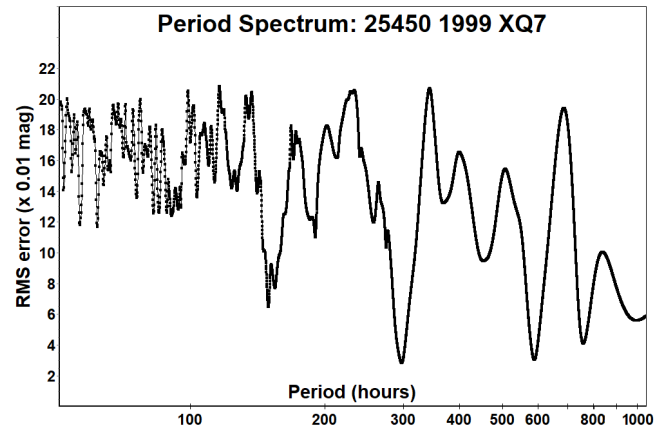
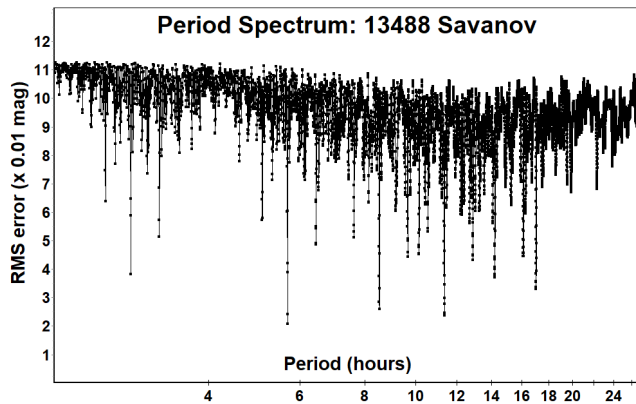


13488 Savanov. For this relatively faint Eos-family asteroid, we estimate the period to be 5.679 ± 0.001 h, agreeing with both published survey results (5.678 h, Waszczak et al., 2015; 5.67941 h, Āurech et al., 2018). Our lightcurve is clearly bimodal in shape. The optimum G value is 0.13, yielding a RMS error of 19 mmag.

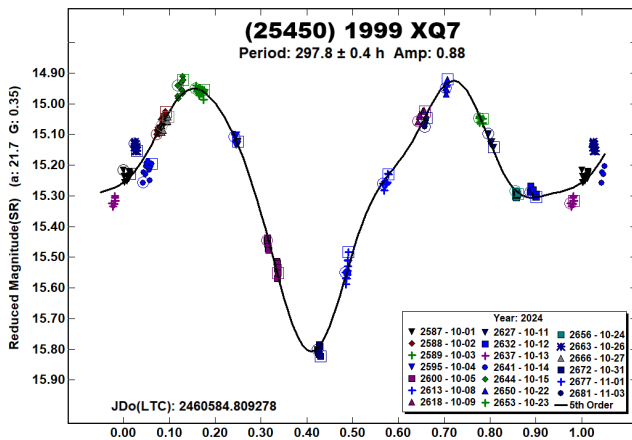


Number	Name	yyyy mm/dd	Phase	L _{PAB}	B _{PAB}	Period(h)	P.E.	Amp	A.E.	Grp
1027	Aesculapia	2024 10/08-10/15	10.4, 8.4	46	0	19.605	0.014	0.24	0.04	THM
1442	Corvina	2024 11/19-12/29	6.1, 18.1	44	0	77.985	0.028	0.15	0.03	KOR
1962	Dunant	2024 11/16-12/30	18.4, 24.0	17	0	156.345	0.056	1.28	0.08	MB-O
2208	Pushkin	2024 11/14-12/01	6.8, 1.1	72	-1	8.412	0.001	0.41	0.04	MB-O
2216	Kerch	2024 06/16-11/12	*14.8, 20.6	304	5	9.465	0.001	0.34	0.05	EOS
2266	Tchaikovsky	2024 10/16-12/21	*15.7, 9.6	66	-4	75.985	0.011	0.19	0.05	MB-O
2732	Witt	2024 07/28-10/22	*11.1, 18.9	332	-1	12.625	0.001	0.67	0.04	WIT
2803	Vilho	2024 10/27-12/09	*14.7, 3.6	69	1	10.372	0.001	0.58	0.08	THM
3062	Wren	2024-5 11/14-01/02	*12.7, 7.8	83	-7	7.096	0.001	0.22	0.04	EOS
3156	Ellington	2024-5 12/22-01/02	16.9, 13.8	120	20	9.818	0.003	0.14	0.03	MB-O
3213	Smolensk	2024 11/15-12/03	*3.1, 4.4	60	0	3.565	0.001	0.24	0.06	THM
3492	Petra-Pepi	2024 06/01-10/25	*21.8, 22.9	303	4	23.608	0.002	0.77	0.10	EUN
4566	Chaokuangpiu	2024 10/10-10/27	15.5, 8.1	46	8	16.379	0.002	0.59	0.06	ITH
5934	Mats	2024 10/22-10/25	1.6, 2.7	29	-2	5.184	0.001	0.70	0.04	NYS
7167	Laupheim	2024 10/21-10/26	4.4, 5.5	24	8	7.045	0.002	0.36	0.05	MB-O
8823	1987 WS3	2024 11/19-12/20	11.1, 23.9	43	4	82.395	0.028	0.25	0.04	MIT
13488	Savanov	2024 10/29-11/25	*10.3, 1.2	60	1	5.679	0.001	0.33	0.08	EOS
25450	1999 XQ7	2024 10/01-11/03	21.9, 4.8	43	4	297.800	0.400	0.88	0.12	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, 1984). Grp is the asteroid family/group (Warner, 2009).



(25450) 1999 XQ7. From 20 nights' observations of this inner main-belt asteroid, we estimate a rotation period of 297.8 ± 0.4 h. We know of no previous reports of period or lightcurve for this asteroid. The lightcurve shape is unusual, with similar brightness maxima but with minima differing by half a magnitude. We detect no effect of precession ("tumbling") on the lightcurve. G value of 0.35 optimized the RMS error, which is 28 mmag.



Acknowledgements

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