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LIGHTCURVE ANALYSIS OF SIX ASTEROIDS

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Photometric observations of six asteroids were made from 2015 March to May. We report the results of our lightcurve analysis for 425 Cornelia, 625 Xenia, 664 Judith, 785 Bredichina, 910 Anneliese, and 1831 Nicholson.

This paper contains the photometric results of six asteroids obtained from 2015 March to April. These asteroids were selected from the Collaborative Asteroid Lightcurve Link (CALL): 425 Cornelia, 625 Xenia, 664 Judith, 785 Bredichina, 910 Anneliese, and 1831 Nicholson.

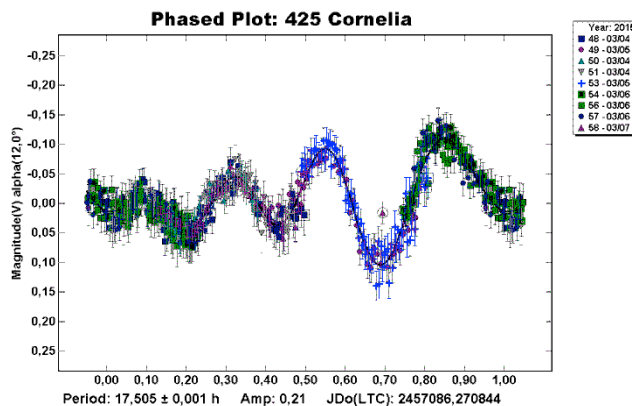
Five observers, Alfonso Carreño, Amadeo Aznar, Enrique Arce, Pedro brines, and Juan Lozano all contributed lightcurves with clear filters (see Table I for equipment details). All images were dark and flat field corrected.

Differential photometry measurements were made in *MPO Canopus* (Warner, 2012). The Asteroid Lightcurve Database (LCDB; Warner *et al.*, 2009) contains previously reported results for 425 Cornelia, 625 Xenia, 664 Judith, and 785 Bredichina, but those results are from few years ago, so the results we offer in this paper could be an update for LCDB database.

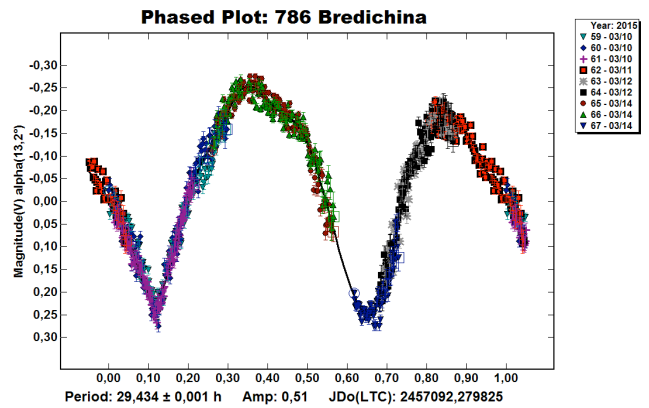
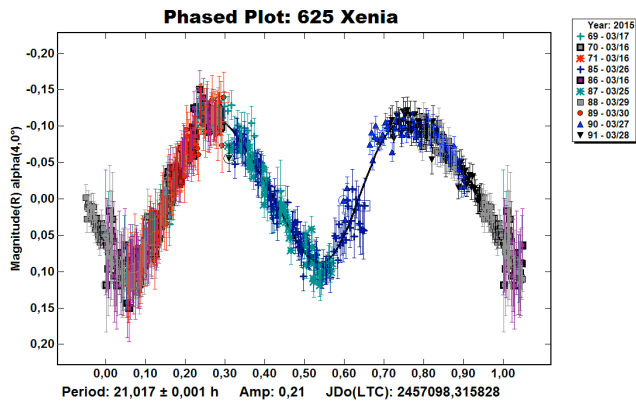
Telescope	Observatory	CCD
Refractor 10cm	Zonalunar	Atik 383L+
Cassegrain 35cm	Isaac Aznar	SBIG STL1001E
Cassegrain 25cm	Vallbona	SBIG ST7-XME
R-Chretien 20cm	TRZ	QHY8
D-Kirkham 25cm	Elche	SBIG ST8-XME

Table 1: List of instruments used for the observations.

425 Cornelia is a main-belt asteroid of 64 km discovered by Auguste Charlois in 1896. A total of 546 data points were obtained over 4 nights during 2015 March 4-7. The solar phase angle was $+12.0^\circ$ and $+13^\circ$ at the start and end of the period. Its magnitude was $V \sim 13.9$. The lightcurve shows a period of 17.505 ± 0.001 h and amplitude of 0.21 mag. The LCDB shows a period of 17.56 h and amplitude of 0.19 mag calculated by Behrend (2004).

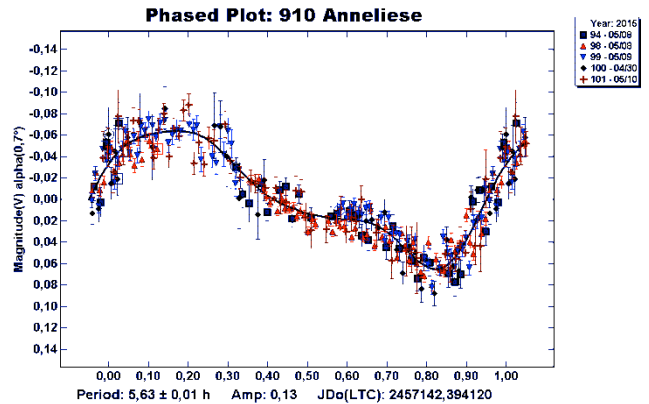
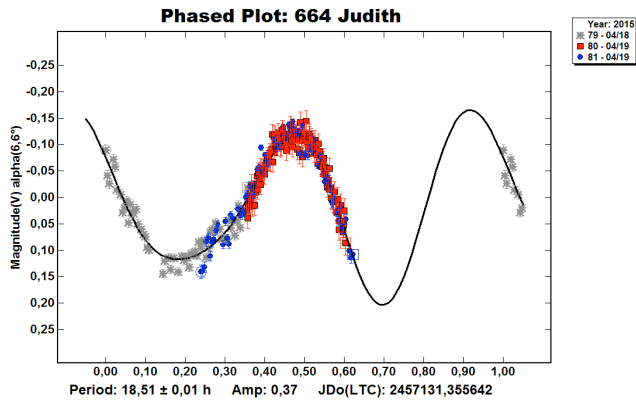


625 Xenia is a main-belt asteroid of 28.37 km discovered by August Kopff in 1907. 655 points were obtained over 8 nights from 2015 March 14-31. The solar phase angle was $+4^\circ$ and $+8^\circ$ at the start and end of the period. The asteroid's magnitude was about 14.5. The lightcurve shows a period of 21.017 ± 0.001 h and amplitude of 0.21 mag. The LCDB shows a period of 21.101 h calculated by (Worman *et al.*, 2003) and 33.46 h calculated by (Behrend, 2003). We have not been able to test the 33.46 h period because the asteroid is already positioned at very low altitude and it is recommended to continue the analysis in the next opposition. The curve obtained with a period of 21.017 h is consistent with an RMS of 1.706 and a total of 10 sessions from different observatories that corroborate that period.



664 Judith is a main-belt asteroid of 72.68 km, discovered by August Kopff in 1908. A total of 264 points were obtained over 2 nights, 2015 April 18-19. The solar phase angle was $+3^\circ$. The asteroid was $V \sim 14.0$.

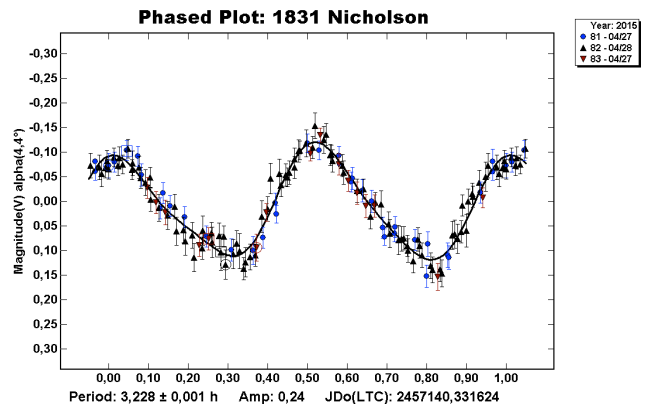
910 Anneliese is a main-belt asteroid discovered by Karl W. Reinmuth in 1919. There was no information about this body in the LCDB. A total of 269 points were obtained over 4 nights from 2015 April 30 to May 10. The solar phase angle was $+3^\circ$ at the start and $+1^\circ$ at the end of the period. The asteroid was $V \sim 13.7$. The lightcurve shows a period of 5.63 ± 0.01 h and amplitude of 0.13 mag.



The lightcurve shows a period of 18.51 ± 0.01 h and amplitude of 0.37 mag. The LCDB shows a period of 10.9829 h calculated by (Hosek, 2011) and 13.364 h calculated by (Behrend, 2010). The curve obtained with period of 18.51 h is not consistent with 3 sessions and it is recommended to continue the analysis in the next opposition because the asteroid is already positioned at very low altitude. Finally, we have adopted a bi-modal solution, very similar to that obtained by Behrend, as the RMS obtained is 1.66, much lower than periods of fewer hours.

1831 Nicholson is a main-belt asteroid discovered by P. Wild in 1968. There was no information in the LCDB. A total of 144 points were obtained over on 2015 April 27-28. The solar phase angle was $+4^\circ$. The asteroid was about $V = 14.4$ at the time. The lightcurve shows a period of 3.228 ± 0.001 h and amplitude of 0.24 mag.

786 Bredichina is a main-belt asteroid of 91.6 km, discovered by Franz Kaiser in 1914. More than 920 points were obtained over 4 nights from 2015 March 10-14. The solar phase angle was $+13^\circ$ and $+14^\circ$ at the start and end of the period. The asteroid was $V \sim 13.6$ at the time. The lightcurve shows a period of 29.434 ± 0.001 h and amplitude of 0.51 mag. The LCDB shows a period of 18.61 h and amplitude of 0.60 mag (Gil- Hutton *et al.*, 2003).



Acknowledgments

We would like to thank Brian Warner for all of his work with the program *MPO Canopus* and for his efforts in maintaining the

“CALL” website and also for reply all answer we don resolving me many doubts.

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FINDING THE LIGHTCURVE AND ROTATION PERIOD OF MINOR PLANET 13003 DICKBEASLEY

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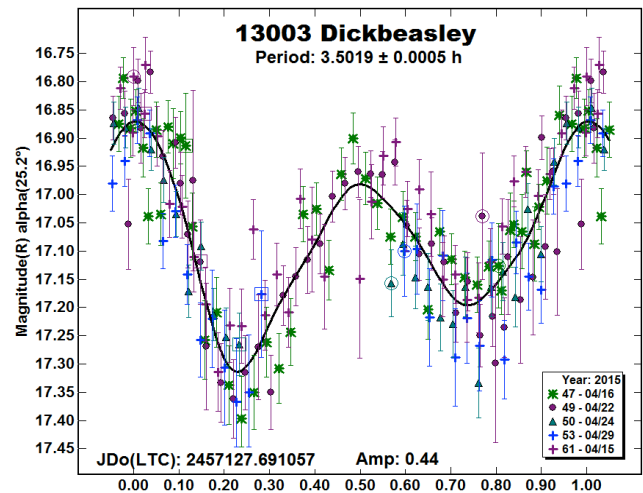
The lightcurve of 13003 Dickbeasley was determined using five nights of data from 2015 April and May, from which we found its rotation period to be 3.502 ± 0.0005 hrs. Images were taken at the Phillips Academy Observatory.

The purpose of this research was to obtain the lightcurve of 13003 Dickbeasley in order to determine its rotation period. The target was chosen for its magnitude range and high declination, as well as its appealing name. A search of the asteroid lightcurve database (LCDB; Warner *et al.*, 2009) and other sources did not reveal previously reported lightcurve results for the asteroid. Images were measured using *MPO Canopus* (Warner, 2013) using a differential photometry technique.

All observations were made with a 0.40-m *f*/8 Ritchey-Chrétien by DFM Engineering. Images of the asteroid were taken using an Andor Tech iKon DW436 with a 2048x2048 array of 13.5-micron pixels. The resulting image scale was 0.86 arcseconds per pixel. All images were dark and flat-field corrected and guided.

MPO Canopus was used to make photometric measurements of the asteroid as well as to generate the final lightcurve. Comparison stars were chosen to have near solar color using the Comp Star Selector tool in *MPO Canopus*. In addition, brighter comparison stars were favored. Data merging and period analysis were also done with *MPO Canopus* using an implementation of the Fourier analysis algorithm of Harris (FALC; Harris *et al.*, 1989). The combined data set was analyzed by Dear, Jenkins, Nasser, and Nix, who are students in an astronomy research class taught by Odden at Phillips Academy.

The amplitude was found to be 0.44 mag. The period spectrum favored a period of 3.502 ± 0.0005 hrs.



Acknowledgements

Research at the Phillips Academy Observatory is supported by the Israel Family Foundation. Funding for the Andor Tech camera was generously provided by the Abbot Academy Association.

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PHOTOMETRIC OBSERVATIONS OF 2020 UKKO

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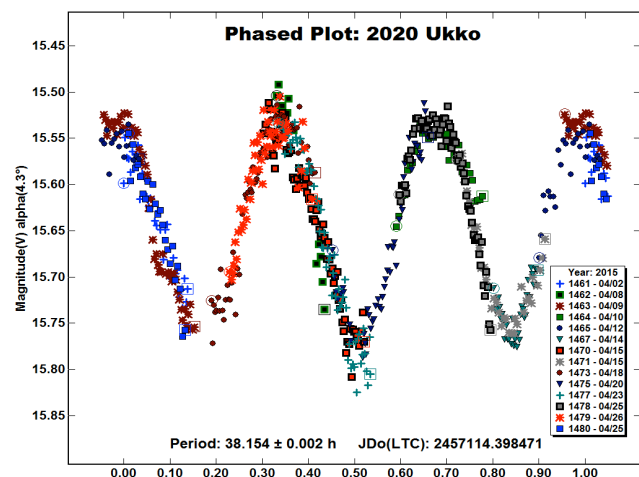
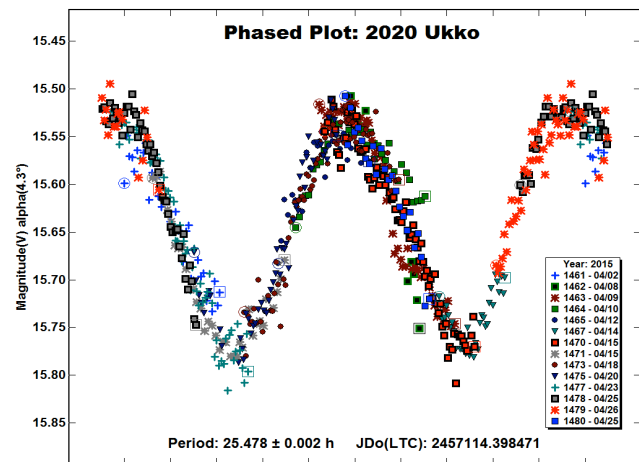
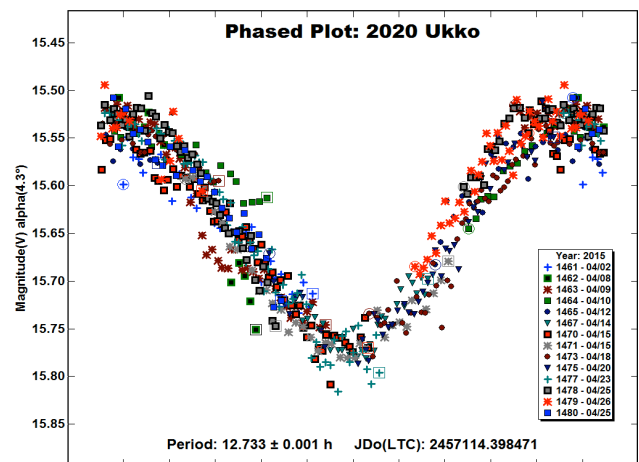
These are the first photometric observations ever reported for 2020 Ukko. We find a rotational amplitude of 0.24 ± 0.02 magnitudes and prefer a period of 25.478 ± 0.002 hours with a symmetric bimodal lightcurve. However, periods of 12.733 ± 0.001 hours with a monomodal lightcurve and 38.154 ± 0.002 hours with a trimodal lightcurve fit the data almost as well.

Minor planet 2020 Ukko was a very faint target whose rotation period early in the investigation appeared to be nearly commensurate with an Earth day. For this reason, the authors agreed to collaborate to obtain full phase coverage. Benishek used a 0.35-m Meade LX-200 GPS Schmidt-Cassegrain and SBIG ST-8 XME CCD camera. Pilcher also used a 0.35-m Meade LX-200 GPS Schmidt-Cassegrain and SBIG STL-1001E CCD. For maximum light on a faint target, both observers used a clear filter and measured magnitudes in the V band.

We obtained 14 sessions in the interval 2015 April 2 - 26 at small phase angles between 4.3 and 8.8 degrees. The data have comparably good fits to periods of 12.733 ± 0.001 hours, 25.478 ± 0.002 hours, and 38.154 ± 0.002 hours, with one, two, and three maxima and minima per cycle, respectively, and amplitude 0.24 ± 0.02 magnitudes.

We present all three lightcurves so that the reader may make his own independent analysis. The 38.154 hour lightcurve might seem favored because of a slight asymmetry. However Harris *et al.* (2014) show that, based on geometric considerations alone, a triangular shape cannot provide an amplitude greater than 0.156 magnitudes. Our amplitude of 0.24 magnitudes is much larger, and this would seem to rule out the 38.154 hour period with trimodal lightcurve. The apparent asymmetry could be removed with a slight adjustment of instrumental magnitudes of some sessions with only a very small increase in RMS residual. The bimodal 25.478 hour lightcurve looks highly symmetric, and this requires either that the real period is only half as great or that the shape model is highly symmetric over a 180° rotation, an unlikely occurrence. However the 12.733 hour monomodal lightcurve has a somewhat greater scatter of data. Large amplitude monomodal lightcurves are often found at large phase angles, caused by shadowing effects of major surface irregularities. However our data are at phase angles of $\leq 8.8^\circ$, at which a 0.24 mag amplitude for a monomodal lightcurve seems very large.

We prefer the 25.478 ± 0.002 hour period with 0.24 ± 0.02 magnitude amplitude. We also recommend that 2020 Ukko be studied again at a different position in the sky, when it may be possible to increase the confidence in the period or rule it out in favor of a simple fraction or multiple.



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ROTATION PERIOD DETERMINATIONS FOR 318 MAGDALENA AND 335 ROBERTA

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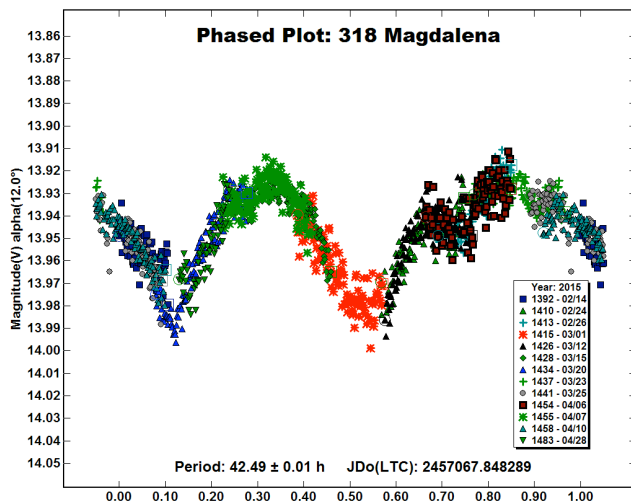
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Synodic rotation periods and amplitudes are found for 318 Magdalena (42.49 ± 0.001 hours, 0.06 ± 0.01 magnitudes) and 335 Roberta (12.028 ± 0.001 hours, 0.14 ± 0.01 magnitudes).

We agreed to collaborate to obtain photometric data on minor planets 318 Magdalena and 335 Roberta in order to determine their synodic rotation periods. Observations by Pilcher were made at the Organ Mesa Observatory with a Meade 35-cm LX200 GPS Schmidt-Cassegrain, SBIG STL-1001E CCD. Exposures were unguided. Martinez, at Lenomiya Observatory, used a Celestron CPC 1100 28-cm Schmidt-Cassegrain, SBIG STT1603ME CCD, and clear filter.

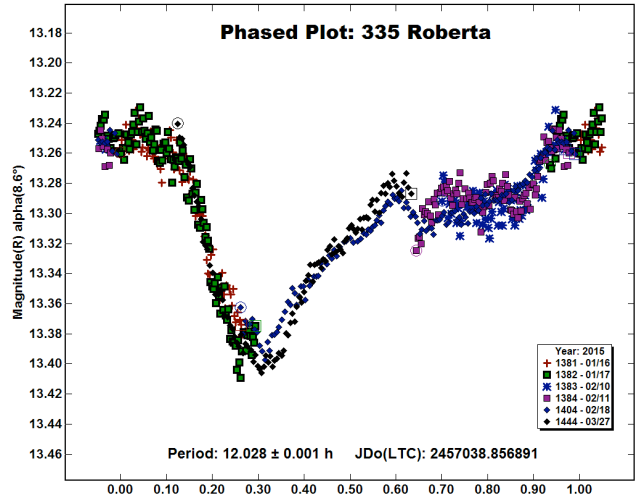
MPO Canopus software was used by both observers to measure the images, share data, adjust instrumental magnitudes up or down to produce the best fit, and prepare the lightcurve. Due to the large number of data points acquired, the lightcurves have been binned in sets of three data points with a maximum of five minutes between points.

318 Magdalena. The only previous period determination is 59.5 hours by Behrend (2004). New observations on 13 nights from 2015 Feb 14 - Apr 28 provide a good fit to a lightcurve with period 42.49 ± 0.01 hours, amplitude 0.06 ± 0.01 magnitudes. A period near 59.5 hours is now ruled out.



335 Roberta. Several previous efforts produced periods near 12.03 hours: Behrend (2004; 12.02 h), Behrend (2007; 12.02 h), Behrend (2011; >12 h), Harris *et al.* (1992; 12.035 h), and Warner *et al.* (2007; 12.054 h). Two other considerably different periods

were published by Binzel (1987; 8.03 h) and by Riccioli *et al.* (2001; 4.349 h). Our new observations on 6 nights from 2015 Jan 16 - Mar 27 provide a good fit to a lightcurve phased to a period of 12.028 ± 0.001 hours with amplitude 0.14 ± 0.01 magnitudes. This is in good agreement with several previous investigations, and the shape of our new lightcurve is similar to some of these. Periods near 8.03 hours and 4.349 hours can now be definitively ruled out.



335 Roberta is on the target list of the OSIRIS-REX Target Asteroids Citizen Science Program. Observations of these targets complement professional observations, provide greater geographic distribution, and create larger data sets through more frequent observing.

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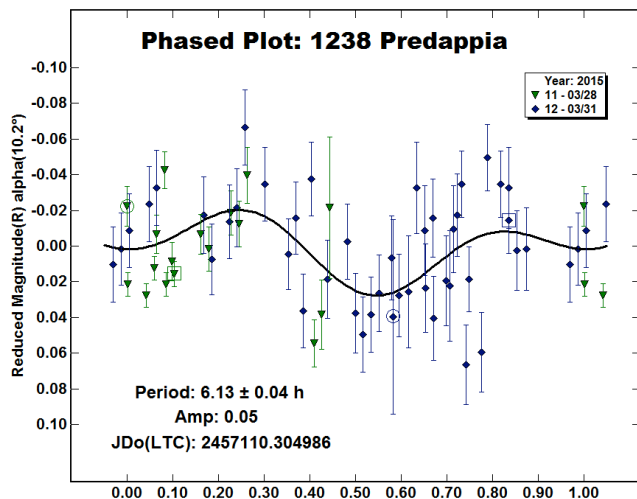
LIGHTCURVE ANALYSIS FOR 1238 PREDAPPIA

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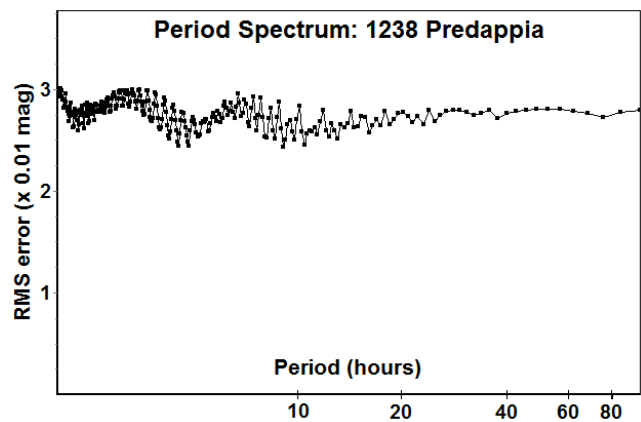
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Lightcurve analysis using *MPO Canopus* from two nights of observation of 1238 Predappia found a possible rotation period of 6.13 ± 0.04 h and lightcurve amplitude of 0.05 mag. Low lightcurve amplitude and period spectrum analysis did not provide enough evidence to confirm this rotation period. There are three possible conclusions to gather from these data: Predappia may have a nearly spherical shape, long rotation period, or pole-on orientation during the observation period.

Remote CCD observations of the main-belt asteroid 1238 Predappia were made on 2015 Mar 28 and Mar 31 using the T7 Planewave 0.43-m CDK telescope located in the AstroCamp Observatory in Nerpio, Spain, using exposure times of 300 s with the luminance filter and a binning of 1x1. The telescope uses an SBIG STL-11000M CCD with pixel size $9 \times 9 \mu\text{m}$, and a resolution of 0.63 arcsec/pixel (iTelescope). A total of 73 images were gathered: 17 from Mar 28 and 44 from Mar 31. After reviewing the calibrated images, a total of 12 images were discarded due to tracking errors, saturation, or too much noise from moonlight. Aperture and differential photometry were applied to the data using *MPO Canopus* software and a Fourier analysis was performed on the data in order to determine a rotation period and uncertainty (Warner, 2013).



The period spectrum from a Fourier analysis with 2 orders has no distinct minimum, which indicates that there is no clear best-fit rotation period for the data. As a result, there is not enough evidence to claim a definitive rotation period of 6.13 ± 0.04 h. Further, the low amplitude of the lightcurve and relatively large reported diameter of 19.96 km (JPL, 2015) may indicate that 1238 Predappia is a nearly spherical object.



Another possibility is that 1238 Predappia may have an unusually long rotation period, and future observers will need multiple nights of observation to confirm if this is the case. A search of the Asteroid Lightcurve Database (LCDB; Warner *et al.*, 2009) found a reported rotation period of 8.94 h (Warner, 2006). Our data do not support this rotation period, however, since no clear pattern emerged when we phased the lightcurve to that period. Warner does report his result may be wrong by 30 percent, which is in agreement with our result. Further, Warner's raw data plot has a similar amplitude, providing credibility to our results. Pravec and Harris (1999) also report that asteroids with a diameter of about 20 km generally have rotation periods from 4 to 8 h.

The third possibility is that the asteroid was observed pole-on, similar to looking at the Earth from above the North Pole. From this point of view, the projected shape of the asteroid does not appear to change significantly over time, meaning that it is reflecting approximately the same amount of light over one rotation. This would explain why there is such a small change in magnitude in the lightcurve. This would give the false impression that 1238 Predappia is not undergoing significant fluctuations in magnitude when, in reality, only one part of it is being analyzed.

Acknowledgements

This research was funded by the Astronomy Department at the University of Maryland, College Park. The observations were made with Internet telescopes provided by iTelescope at the AstroCamp Observatory in Nerpio, Spain. This work was guided by Dr. Melissa Hayes-Gehrke, who works in the Astronomy Department at the University of Maryland, College Park.

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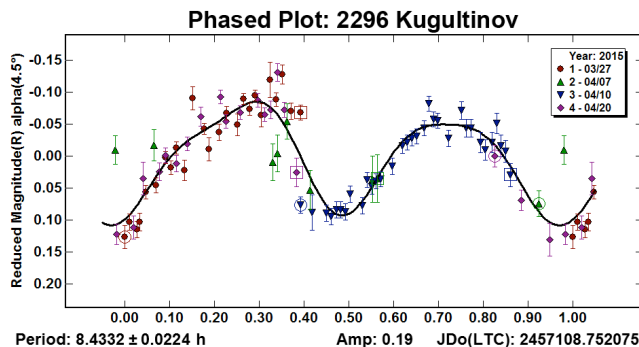
ROTATION PERIOD DETERMINATION FOR 2296 KUGULTINOV

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Photometric observations of main-belt asteroid 2296 Kugultinov were made over a period of five nights spanning 2015 March 27 to April 20. The measured rotation period is 8.4332 ± 0.0224 h.

The 0.43-m Planewave CDK telescopes used for our photometric observations of 2296 Kugultinov were provided through iTelescope (2015). The system at Mayhill, New Mexico, used an FLI PL-6303E CCD camera while the one at Nerpio, Spain, used an SBIG STL-11000M. All the images had an exposure of 300 s through a luminance filter. The images from the four nights (2015 March 27th, April 7th, April 10th, and April 20th) were analyzed using *MPO Canopus*. Images from the first three nights were collected from Mayhill, New Mexico. Images from the final night, April 20th, were collected from Nerpio, Spain. The combined data from all four nights were processed using Fourier analysis to determine a synodic period of 8.4332 ± 0.0224 hours.



A previous period determination was made by Crippa and Manzini (Behrend, 2014) with a provisional lightcurve and was entered into the Asteroid Lightcurve Database (LCDB; Warner *et al.*, 2009) with a period of 10 hours. That period determination has a large gap in the plotted lightcurve; our new observation data fill in this gap, providing a seemingly more precise and accurate period since it was collected over several rotations.

Acknowledgements

We would like to thank University of Maryland's Astronomy Department for their funding of this project and iTelescope for use of their telescopes.

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<http://www.MinorPlanet.info/lightcurvedatabase.html>

ROTATION PERIOD DETERMINATION FOR 6518 VERNON

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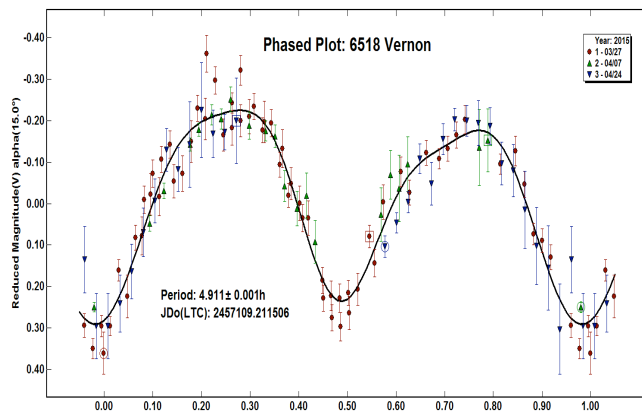
(Received: 2015 May 12)

Photometric data were collected over the course of three nights in 2015 March and April for asteroid 6518 Vernon. A rotation period of 4.911 ± 0.001 hours was determined with an amplitude of 0.52 magnitudes.

6518 Vernon is a main-belt asteroid discovered at the Palomar Observatory on 1990 March 23 by Eleanor F. Helin. The asteroid was selected from the "Lightcurve/Photometry Opportunities" table in the *Minor Planet Bulletin* (Warner *et al.*, 2015).

Observations were made on 2015 March 27 and April 7 using a remote iTelescope location at Mayhill, New Mexico. The instrumentation consisted of a Planewave CDK 431-mm telescope on a Planewave Ascension 200HR mount and FLI PL-6303E CCD camera. This combination gave a scale of 0.96 arcsec/pixel (iTelescope, 2015). Exposures were 300 s using a luminance filter. A total of 64 images were taken on March 27, while 24 images were taken on April 7. Lorenzo Franco observed the asteroid from Rome, Italy, on 2015 April 24, taking 30 images with a 0.2-m Meade LX-200 Schmidt-Cassegrain telescope coupled to an SBIG ST7-XME CCD camera.

The images were measured in *MPO Canopus* (Warner, 2013) using aperture and differential photometry techniques that compared the brightness of the asteroid against five comparison stars. A Fourier transform method was then applied to find the rotation period as well as the error. A search of the LCDB (Warner *et al.*, 2009) showed that Behrend (2015) determined an unpublished period of 4.88249 ± 0.00007 h. This is in good agreement with our result.



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TARGET ASTEROIDS! OBSERVING CAMPAIGNS FOR 2015 OCTOBER THROUGH DECEMBER

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Asteroid campaigns to be conducted by the *Target Asteroids!* program during the 2015 October-December quarter are described. In addition to asteroids on the original *Target Asteroids!* list of easily accessible spacecraft targets, an effort has been made to identify other asteroids that are 1) brighter and easier to observe for small telescope users and 2) analogous to 101955 Benu and (162173) 1999 JU3, targets of the OSIRIS-REx and Hayabusa-2 sample return missions.

Introduction

The *Target Asteroids!* program strives to engage telescope users of all skill levels and telescope apertures to observe asteroids that are viable targets for robotic sample return. The program also focuses on the study of asteroids that are analogous to 101955 Benu and (162173) 1999 JU3, the target asteroids of the NASA OSIRIS-REx and JAXA Hayabusa-2 sample return missions respectively. Most target asteroids are near-Earth asteroids (NEA) though

observations of relevant main-belt asteroids (MBA) are also requested.

Even though many of the observable objects in this program are faint, acquiring a large number of low S/N observations allows many important parameters to be determined. For example, an asteroid's phase function can be measured by obtaining photometry taken over a wide range of phase angles. The albedo can be constrained from the phase angle observations, as there is a direct correlation between phase function and albedo (Belskaya and Shevchenko, 2000). The absolute magnitude can be estimated by extrapolating the phase function to a phase angle of 0°. By combining the albedo and absolute magnitude, the size of the object can be estimated.

An overview of the *Target Asteroids!* program can be found at Hergenrother and Hill (2013).

Current Campaigns

Target Asteroids! continues to conduct a number of dedicated campaigns on select NEAs and analog carbonaceous MBAs during the quarter. These campaigns have a primary goal of conducting photometric measurements over a large range of phase angles.

Target Asteroids! objects brighter than $V = 17.0$ are presented in detail. A short summary of our knowledge of each asteroid and 10-day (shorter intervals for objects that warrant it) ephemerides are presented. The ephemerides include approximate RA and Dec positions, distance from the Sun in AU (r), distance from Earth in AU (Δ), V magnitude, phase angle in degrees (PH), and elongation from the Sun in degrees (Elong).

We ask observers with access to large telescopes to attempt observations of spacecraft accessible asteroids that are between V magnitude ~ 17.0 and ~ 20.0 during the quarter (contained in the table below).

Asteroid Number	Name	Peak V Mag	Time of Peak Brightness
(7350)	1993 VA	18.2	early Oct
(10302)	1989 ML	18.7	late Dec
(25143)	Itokawa	19.7	late Nov
(52381)	1993 HA	18.2	early Dec
(68278)	2001 FC7	18.5	early Oct
(163000)	2001 SW169	16.6	early Oct
(350713)	2001 XP88	18.9	early Oct
	2006 KV89	19.9	late Nov
	2012 XD112	19.7	late Nov

The campaign targets are split into two sections: 1) carbonaceous MBAs that are analogous to Benu and 1999 JU3 and 2) NEAs analogous to the Benu and 1999 JU3 or that provide an opportunity to fill some of the gaps in our knowledge of these spacecraft targets (examples include very low and high phase angle observations, phase functions in different filters and color changes with phase angle).

The ephemerides listed below are just for planning purposes. In order to produce ephemerides for your observing location, date and time, please use the Minor Planet Center's Minor Planet and Comet Ephemeris Service:

<http://www.minorplanetcenter.net/iau/MPEph/MPEph.html>

or the *Target Asteroids!* specific site created by Tomas Vorobjov and Sergio Foglia of the International Astronomical Search Collaboration (IASC) at

<http://iasc.scibuff.com/osiris-rex.php>

Analog Carbonaceous Main Belt Asteroid Campaigns

1257 Mora ($a = 2.49$ AU, $e = 0.08$, $i = 3.9^\circ$, $H = 12.0$)

The target asteroids of the OSIRIS-REx and Hayabusa-2 missions originated in the inner part of the Main Belt (between 2.0 and 2.55 AU) on low inclination orbits. Over the past few quarters *Target Asteroids!* has conducted many campaigns on objects in this region of the Belt. This quarter we will focus on inner main-belt carbonaceous asteroid 1257 Mora, a carbonaceous (C-type) object that is not an obvious member of any known collisional family.

This quarter Mora covers a range of phase angles from 19° to an extremely low 0.3° at opposition on November 4. It is also at its brightest that day at $V = 15.4$. Lightcurve photometry found a period of 5.3 h and amplitude of 0.23-0.43 magnitudes. Filter photometry is especially requested to detect color changes at different phase angles.

DATE	RA	DEC	Δ	r	V	PH	Elong
10/01	03 05	+17 20	1.85	2.68	16.3	14	139
10/11	02 59	+16 44	1.77	2.68	16.1	11	150
10/21	02 52	+15 58	1.72	2.69	15.8	7	162
10/31	02 43	+15 03	1.70	2.69	15.6	2	174
11/10	02 34	+14 04	1.70	2.69	15.6	2	174
11/20	02 25	+13 09	1.74	2.69	15.9	7	161
11/30	02 18	+12 23	1.80	2.69	16.1	11	149
12/10	02 13	+11 49	1.88	2.69	16.3	14	138
12/20	02 11	+11 31	1.99	2.69	16.5	17	127
12/30	02 11	+11 28	2.10	2.69	16.7	19	117

Near-Earth Asteroid Campaign Targets

(33342) 1998 WT24 ($a = 0.72$ AU, $e = 0.42$, $i = 7.3^\circ$, $H = 17.9$)

One of the better characterized NEAs, 1998 WT24 is a Xe-type with high albedo (0.34 ± 0.20) and an equivalent diameter of 0.415 ± 0.040 kilometers (Busch *et al.*, 2008). It will be brighter than magnitude $V = 18.0$ between 2015 Oct 24 and 2016 Jan 9. During that time, phase function photometry is possible over a phase angle range of 21° to 115° . Peak brightness occurs on Dec 10 at $V = 11.3$.

DATE	RA	DEC	Δ	r	V	PH	Elong
10/01	09 45	-06 34	0.28	0.80	20.1	126	40
10/11	09 26	-06 16	0.25	0.87	19.0	112	53
10/21	09 14	-06 02	0.22	0.92	18.2	101	65
10/31	09 07	-05 59	0.19	0.96	17.5	92	76
11/10	08 59	-06 06	0.15	0.99	16.7	83	87
11/20	08 45	-06 12	0.10	1.01	15.7	73	100
11/30	08 04	-05 36	0.06	1.02	14.0	57	119
12/10	04 55	+00 53	0.03	1.01	11.3	21	158
12/20	00 13	+09 14	0.05	0.99	14.1	78	99
12/30	23 05	+09 41	0.09	0.96	16.3	100	74

(294739) 2008 CM ($a = 0.83$ AU, $e = 0.21$, $i = 8.5^\circ$, $H = 16.9$)

Another bright NEA visible this quarter is (294739) 2008 CM, which will become brighter than magnitude $V = 18.0$ on Nov 27, $V = 15.0$ on Dec 22, and peak at $V = 12.6$ on Dec 30. During that time, its phase angle will decrease from $\sim 90^\circ$ to 31° . Past observations have determined a rotation period of 3.05 h and amplitude of ~ 0.48 magnitudes (Warner, 2014). Little else is known about 2008 CM, so new photometry will shed light on its color, taxonomy, and phase function.

DATE	RA	DEC	Δ	r	V	PH	Elong
11/30	16 38	+49 43	0.34	0.94	17.8	89	71
12/10	16 08	+52 14	0.23	0.96	17.1	90	76
12/20	14 34	+55 10	0.12	0.99	15.6	84	89
12/30	09 06	+15 08	0.06	1.03	12.6	35	143

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ROTATION PERIOD DETERMINATION FOR ASTEROID (16813) 1997 UT6

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Photometric observations of main-belt asteroid (16813) 1997 UT6 were made over two nights during 2015 March and April. Observations were obtained remotely at iTelescope Observatory H06 in Mayhill, New Mexico. Analysis of the CCD data found several possible periods. The most likely period is 8.2934 ± 0.0035 h with an alternate period of 7.88 ± 0.003 h.

CCD photometric observations were made of main-belt asteroid (16813) 1997 UT6 at iTelescope Observatory H06 in 2015 (iTelescope, 2015). These observations were made in response to the asteroid being listed as a potential photometry opportunity in *The Minor Planet Bulletin* (Warner *et al.*, 2015). No previous lightcurves for (16813) 1997 UT6 have been reported in the LCDB (Warner *et al.*, 2009). All images were taken with a 0.43-m, *f*/6.8 Planewave CDK with *f*/4.5 focal reducer and a FLI PL-6303E CCD camera with 3072x2048 pixels. Images were taken with a 300-s exposure using a clear filter. The camera was operated at 1x1 binning mode, which produced an image scale of 0.64 arcsec/pixel.

Photometric analysis was carried out with *MPO Canopus* (Warner, 2013). All images were calibrated internally by *MPO Canopus* during the photometric analysis. Differential magnitudes were calculated using reference stars of similar color to the Sun.

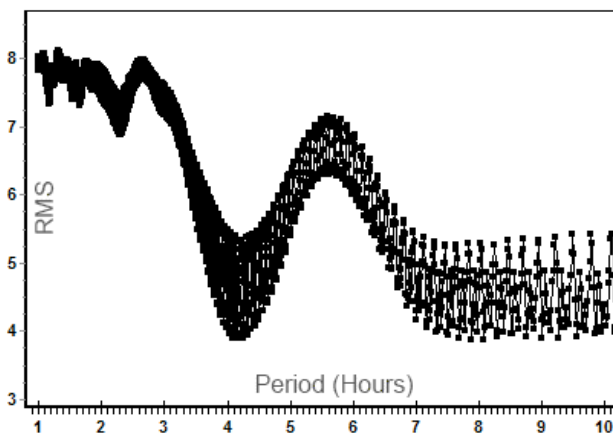
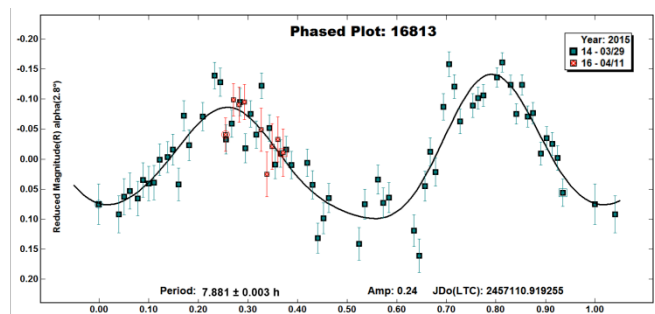
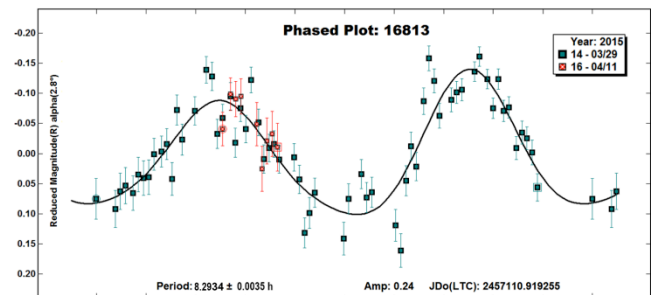


Figure 1. The period spectrum from 1 to 10 hours for (16813) 1997 UT6, showing two clusters of similar RMS values, with no distinct solutions.

Figure 1 was produced using a Fourier analysis of the raw data, resulting in an RMS graph with no pronounced minimum but rather two clusters of similar values, centered at four hours and eight hours. After analyzing the periods of the left-most cluster of RMS values, it was determined that these values show characteristics consistent with a half period of the rotation of an asteroid, due to their monomodal shapes. The characteristics of the

right-most RMS cluster were consistent with that of a full period, having bimodal shapes. The smallest RMS value of the half-period cluster was found at $P = 4.145$ h. In order to find a potential full-period this was doubled, producing 8.29 h. This value was almost identical to one of the lowest RMS values of the right-most RMS cluster found at $P = 8.2934$ h. Because of this relation, $P = 8.2934$ h was chosen as the primary period.

There are several almost equally likely solutions that need to be considered as well due to the rather flat nature of the RMS data derived. A single alternate period of $P = 7.881$ h was chosen from these since this period had the absolute minimum RMS value found, being smaller than the RMS value at $P = 8.2934$ h by the smallest of margins. There are many other potential periods within a similar range which are also plausible. Further observations will be needed in order to determine the rotation period with more certainty.



Acknowledgments

Funding for observations was provided by the Astronomy Department at the University of Maryland. We would also like to thank *itelescope.net* for the use of their facilities to study this asteroid.

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LIGHTCURVE ANALYSIS OF 5181 SURF

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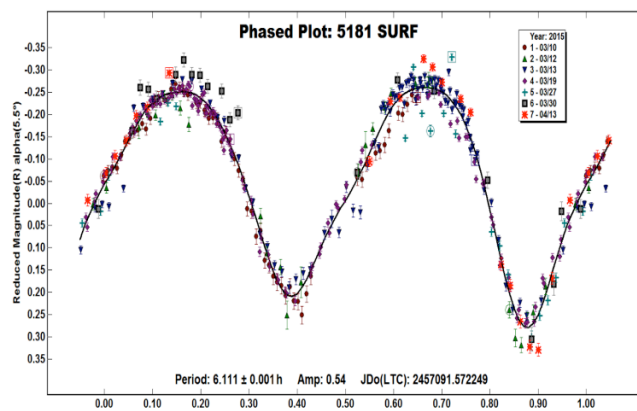
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(Received: 2015 May 12)

A lightcurve was determined for the main-belt asteroid 5181 SURF. The asteroid was observed for seven nights over the course of two months during 2015 March-April. The rotation period was found to be 6.111 ± 0.001 h.

CCD photometric data from a total of seven nights were analyzed with differential photometry to ascertain a rotation period for 5181 SURF. Sixteen student astronomers observed over three nights, combined with four nights of data taken by Don Pray at Sugarloaf Mountain Observatory. The students observed remotely from the T7 telescope in Nerpio, Spain, using the iTelescope observing service. The T7 was a 431-mm $f/6.8$ Planewave CDK telescope, and the imager was a SBIG STL-11000M CCD. Images were exposed for 300 s through a luminance filter. Data from Pray were obtained using a 0.5-m $f/4$ reflector and an SBIG ST-10XME CCD. Differential photometry and period analysis were all accomplished using *MPO Canopus* (Warner, 2013).



Acknowledgements

The authors of this paper would like to thank Donald Pray for willingness to collaborate and share his data. We also thank iTelescope.net for enabling us to use the T7 telescope located in Nerpio, Spain, remotely. This research was made possible by the Astronomy Department at the University of Maryland, College Park. Operations at Sugarloaf Mountain Observatory were supported by a Gene Shoemaker NEO grant from The Planetary Society.

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LIGHTCURVE OF MINOR PLANET 1492 OPPOLZER

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Lightcurve measurements of 1492 Oppolzer were performed in 2015 May. Data analysis produced a lightcurve with a synodic period of 3.7689 ± 0.00048 h and amplitude about 0.12 mag.

Our lightcurve for 1492 Oppolzer is the first attempt of photometry observations from Osservatorio Astronomico di San Polo a Mosciano, Scandicci (MPC: 632). The target was selected from the list of asteroid photometry opportunities published by Warner *et al.* (2015).

The observations were made on three nights between 2015 May 10-18 using a 0.4-m $f/4.5$ Newtonian. The CCD camera was an SBIG ST7 XME binned 2x2 with AO8 adaptive optic system, and yellow filter Wratten n°12. Exposure times were 120 s. Raw images were processed in *Astroart 5* using flats and dark frames. Analysis of the combined data sets was done using *MPO Canopus* software 7.6 version (Warner, 2004). The derived synodic rotation period was 3.7689 ± 0.00048 hrs. These results are in good agreement with those reported by Pravec *et al.* (2015) of $P = 3.7697 \pm 0.0007$ h, $A = 0.11$ mag.

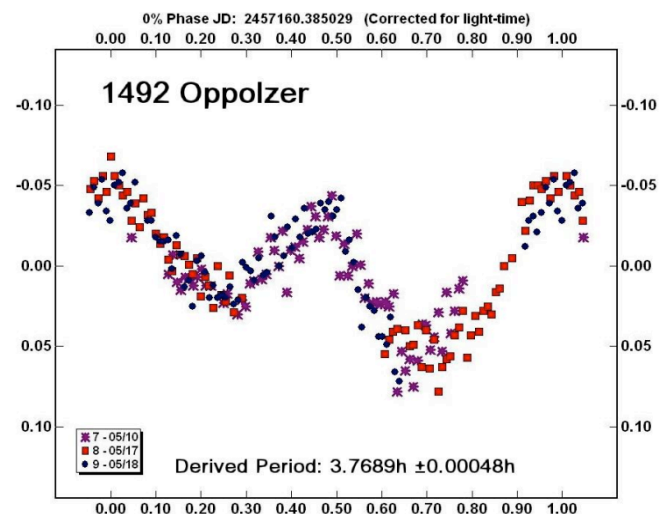


Figure 1. Composite lightcurve of asteroid 1492 Oppolzer derived from 3 nights of observations and 3.7689 ± 0.00048 hours rotation period.

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PHOTOMETRY OF THREE ASTEROIDS WITH THE ZA-320M TELESCOPE OF PULKOVO OBSERVATORY

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Results of photometric observations of 702 Alauda (color-indices), 3737 Beckman (fragment of raw lightcurve), and (251346) 2007 SJ (phased lightcurve) are presented.

Photometric asteroid observations were made at the Laboratory of Observational Astrometry of Pulkovo Observatory with a ZA-320M (Cassegrain reflector, $D = 320$ mm, $F = 3200$ mm). It is situated in Pulkovo Observatory at the edge of the city of Saint Petersburg, Russia. The telescope is equipped with an SBIG STX-16803 CCD camera (4096×4096 pixels of 9×9 μm) and *BVRI* filters. We used 3×3 binning. The field-of-view was 39'×39'.

The CCD frames were processed with the *APEX-II* program package developed in Pulkovo Observatory (Devyatkin, 2010). Usually, we send results of astrometric processing of our asteroid observations to MPC. Some photometric results are shown in the present paper.

Star magnitudes on CCD frames are determined using aperture or PSF photometry methods. We use 2MASS as the reference star catalog in accordance with the paper of Warner (2007). We made transformation of observed colour-indices from instrumental colour system to the standard one using coefficients determined previously by observations of Landolt's areas (Landolt, 1992).

702 Alauda is a binary asteroid (Johnston, 2015). It has rotational period of 8.3531 ± 0.0004 h and low amplitude of 0.10 ± 0.01 mag (Alkema, 2014).

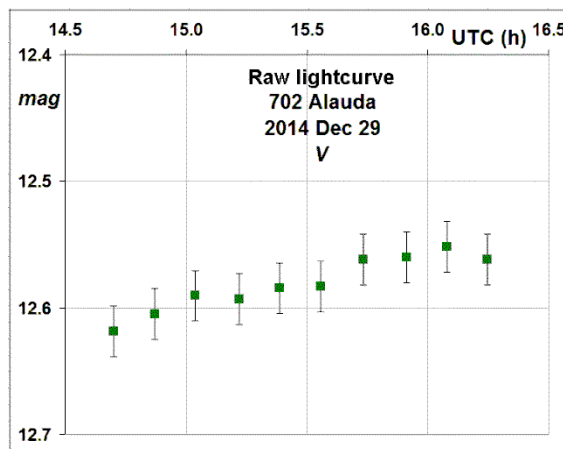
Our observations were made in five nights with the ZA-320M telescope in order to determine color-indices of Alauda. We changed each pair of filters several times. For example, on 2014 Dec 29, we used all four filters in the following order: *VIVIV- VBVBVB-VRVRVRV*. Thus, a number of the color-index values were observed for each pair of filters in a night. The values were averaged. The results for each night and overall average value of the color-indices are presented in Table I. It contains dates of the observations, phase angles of the asteroid at the time of the observations, average values of the color-indices with their RMS for each night when the indices were observed, and number of averaged values (in parenthesis). Overall averages are in the last line of the table.

Date yyymmdd	Phase (deg)	<i>B-V</i>	<i>V-R</i>	<i>V-I</i>
141225	12.1	0.610 ± 0.015 (5)	0.410 (1)	
141226	12.6		0.411 ± 0.021 (5)	
141229	13.2	0.580 ± 0.014 (5)	0.411 ± 0.012 (5)	0.686 ± 0.005 (5)
150304	17.2			0.519 ± 0.016 (7)
150312	16.6			0.500 ± 0.015 (4)
Avg.	14.3	0.60 ± 0.02	0.41 ± 0.01	0.57 ± 0.10

Table I. Color index results for 702 Alauda.

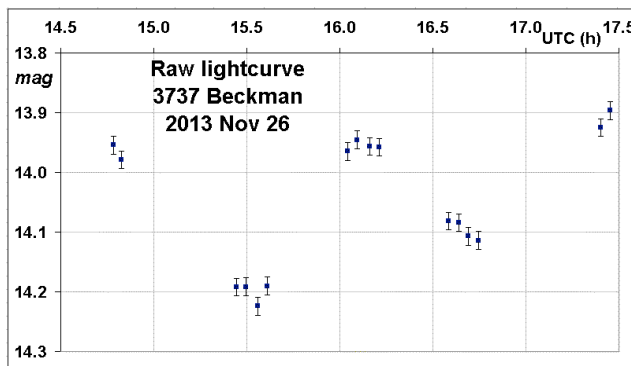
Our value of *B-V* is somewhat less than value of $B-V = 0.665 \pm 0.022$ published on the JPL small-body database (JPL, 2015). The values of *V-R* have good agreement for the 3 nights of observations. However, one value of *V-I* (Dec 29) has a large difference from the other two, although intrinsic accuracy of the night is good and other color-indices of the night have satisfactory agreement with other nights. Thus, the overall RMS of *V-I* is too large.

Along with color-indices, a fragment of the lightcurve for Alauda in *V* band was constructed from the observations on 2014 Dec 29. It has average accuracy about 0.02 mag and duration of about 1.5 hours (near 0.2 of the whole rotational period).



3737 Beckman was observed on 2013 Nov 26 along with (251346) 2007 SJ. Beckman is a Mars-crossing asteroid (JPL, 2015). Its rotational period is 3.130 ± 0.002 h and amplitude is 0.27 ± 0.10 mag (Klinglesmith *et al.*, 2014).

We made the observations of 3737 Beckman using the ZA-320M telescope without filters. The magnitudes from 16 CCD frames depict a fragment of the asteroid lightcurve with an average accuracy of about 0.015 mag and duration of about 2.7 h, or about 0.85 of the published rotational period. The lightcurve fragment shows peak-to-peak amplitude of about 0.27 mag.

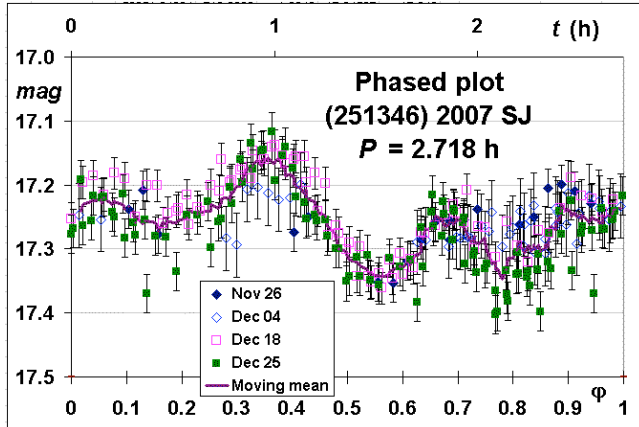


(251346) 2007 SJ is a potentially hazardous asteroid (JPL, 2015). Our photometric observations were made near its encounter to the Earth in 2014 Jan. We observed fragments of the asteroid's lightcurve during four nights, 2013 Nov 26 and Dec 4, 18, 25, with the ZA-320M telescope without filters. The fragments have duration of 3.5–6.5 h and accuracy of 0.025–0.050 mag.

The observed lightcurve fragments were corrected for heliocentric and topocentric distances. Despite large phase angles ranging from

42°–79°, we constructed the asteroid phase curve using average values of the lightcurve fragments and then corrected the data for phase angle. As result, all our fragments are in good agreement on magnitude level.

The rotational period of the asteroid was determined by Warner (2014; 2.718 ± 0.002 h). Our lightcurve fragments have time span of 29 days and they fit the period value very accurately. Therefore our observations confirm the period value.



The phased lightcurve of the asteroid 251346 seems to have three maxima: one high and two lower and equal to each other. Peak-to-peak amplitude of the lightcurve is about 0.18 mag (Warner, 2014) published the amplitude value of 0.14 ± 0.02 mag.

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ROTATION PERIOD OF 2019 VAN ALBADA

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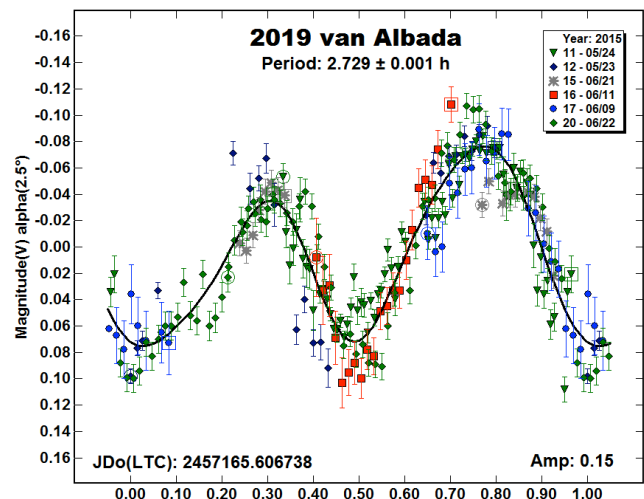
(Received: 2015 June 23)

Analysis of photometric observations for asteroid 2019 van Albada shows a synodic rotation period of $P = 2.729 \pm 0.001$ h with an amplitude $A = 0.15$ mag.

Main-belt asteroid 2019 van Albada was discovered at Johannesburg on 1935 Sep 28 by H. van Gent. Its orbit has a semi-major axis of 2.241 AU, eccentricity of 0.1650, and orbital period of 3.68 years (JPL, 2015). Behrend (2012; 2013) reported lightcurves of this asteroid, both times with a period of about 2.72 h.

The most recent observations of 2019 van Albada were made at Lvye Observatory (IAU P34) and iTelescope Observatory (IAU Q62) between the nights of 2015 May 23 and Jun 22. The instruments of Lvye Observatory are a Skywatcher 0.25-m $f/4.4$ reflector telescope, QHY9 CCD camera at -20°C , binned 2×2 , unfiltered, and have an image scale of 1.99 arc seconds per pixel. The exposure time was 60 s on 2015 May 23–24 and 120 s on 2015 Jun 9 and 11. Observations obtained at iTelescope Observatory were by a RCOS 0.32-m Ritchey–Chrétien and SBIG ST-8 XME CCD camera; the exposure time was 120 s. All images were dark, bias, and flat corrected by *MaxIm DL v5.23*.

Differential photometry and period analysis were made with *MPO Canopus*. The lightcurve shows a period $P = 2.729\text{h} \pm 0.001$ h with an amplitude $A = 0.15$ mag. This is in good agreement with the earlier works.



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THE LIGHTCURVE FOR ASTEROID 107 CAMILLA

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Photometric observations of the main-belt asteroid 107 Camilla were made from 2015 May to June. Our analysis found a synodic period of 4.845 ± 0.005 h and lightcurve amplitude of 0.33 mag.

Observations of main-belt asteroid 107 Camilla were made from 2015 May 29 through June 6. We started observations with an ST9 CCD camera in Sanda Shouinkan Senior High School and a remote Internet telescope via iTelescope.net (T17). The details of the telescopes and cameras are shown in Table I and the observation details are given in Table II.

Name	D (m)	f1 (mm)	Camera	Location
Shouinkan	0.3	1500	ST9	Japan
T17	0.43	2912	FLI PLI4710	Siding Spring (AU)

Table I. observation equipment list

UT Date	Time	Telescope	Ph	Points	Filter
May 29	12:00-14:59	Shouinkan	5.4°	305	R
Jun 03	09:58-10:57	T17	6.6°	32	R
Jun 06	08:37-13:53	T17	7.3°	109	R

Table II. Observations List

The combined data set consists of 446 data points. All images were unbinned with Johnson-Cousins R-band filter. Measurements were made using *MPO Canopus* (Warner, 2011), which employs differential aperture photometry to produce the raw data. Period analysis was done using *MPO Canopus*, which incorporates the Fourier analysis algorithm (FALC) developed by Harris (Harris *et al.*, 1989). We found that the period is 4.845 ± 0.005 h and the amplitude is 0.33 mag.

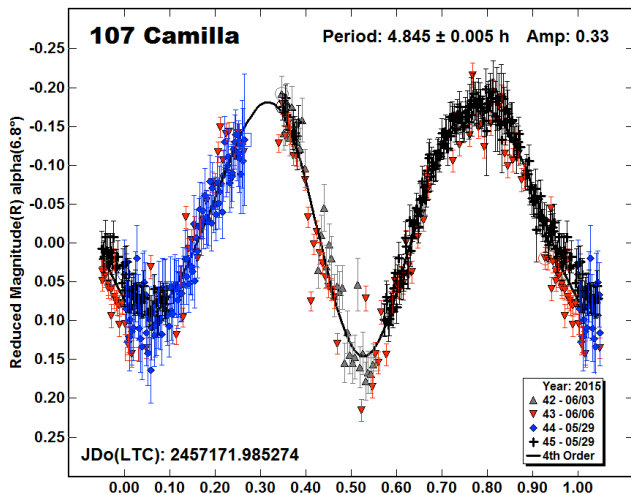


Figure 1. Observations of 107 Camilla phased to a rotational period of 4.845 ± 0.005 h.

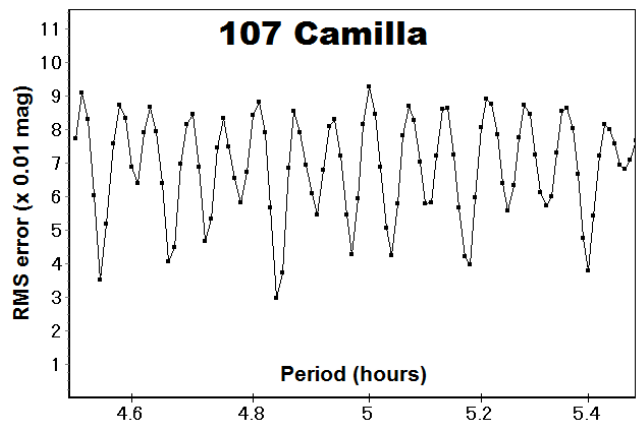


Figure 2. The period spectrum for 107 Camilla based on our observations.

Jan Svoren and Ulrika Babiakova (2002) determined a period of 4.844 h for Camilla and an amplitude of 0.39 mag. Torppa *et al.* (2003) found a period of 4.84393 h while Polishook (2009) determined a period of 4.844 ± 0.003 and amplitude 0.45 ± 0.03 . Hanus *et al.* (2013) determined the period of 4.843928 h. These previous results are similar to with ours. It is concluded that the rotation period of the main belt asteroid 107 Camilla is static, or at least any changes are undetectable over a period of only a few years.

Acknowledgement

We thank the staff of itelescope.com for their continuous support.

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3841 DICICCO: A BINARY ASTEROID

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Initial observations of 3841 Diccico indicated a period of 3.6 hours with three nights being anomalously low over part of the period. Further analysis showed that 3841 is a binary asteroid with a primary period of 3.5950 ± 0.0001 h with an amplitude of 0.19 mag and a secondary period of 21.641 ± 0.002 h with an amplitude of 0.19 mag. Both the primary eclipse and secondary eclipses were visible. We also estimate the H and G parameters to be $H = 13.63 \pm 0.04$, $G = 0.15 \pm 0.05$.

The S-type asteroid (Bus and Binzel, 2002) 3841 Diccico was observed on 18 nights from 2014 Nov 21 through 2015 Jan 11. Starting from the first sessions, we noticed some anomalous attenuations in the lightcurves that made us suspect they were due to eclipse and/or occultation events (Figure 1, 2). Five observatories were in the campaign to confirm the initial observations. Table I lists the observers and equipment they used.

Observers	Telescope	CCD
Franco (A81)	0.2-m $f/5.5$ SCT	SBIG ST-7XME
Klinglesmith (719)	0.35-m $f/10$ SCT	SBIG STL-1001E SBIG ST-10XME
Marchini (K54)	0.30-m $f/5.6$ MCT	SBIG STL-6303E (bin 2x2)
Odden (I12)	0.4-m $f/8$ R-C	Apogee CCD
Scardella, Tomassini (D06)	0.35-m $f/10$ SCT	SBIG ST-8XE

Table I. Observers and Equipment. SCT: Schmidt-Cassegrain. R-C: Ritchey-Chretien. MCT: Maksutov-Cassegrain.

All images were calibrated with dark and flat-field frames and processed with *MPO Canopus* version 10.4.7.6 (Warner, 2015). Clear and R filter magnitudes were calibrated to the standard

system using the method described by Dymock and Miles (2009) and CMC-15 stars with near-solar color indexes selected by using VizieR (2014).

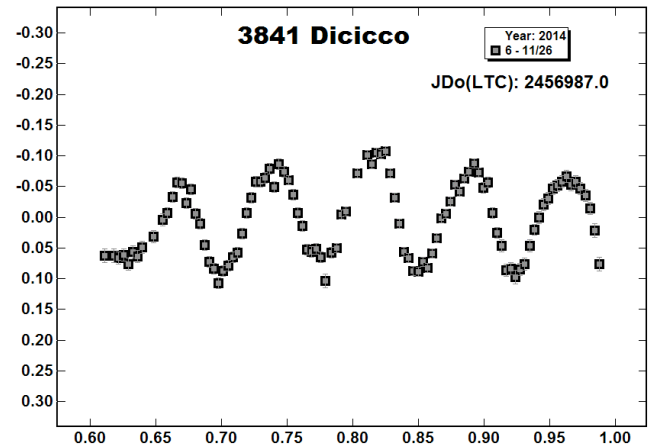


Figure 1. Raw data from 2014 Nov 26. The data cover nine hours, which is more than two complete cycles of the lightcurve. No obvious anomalies are present.

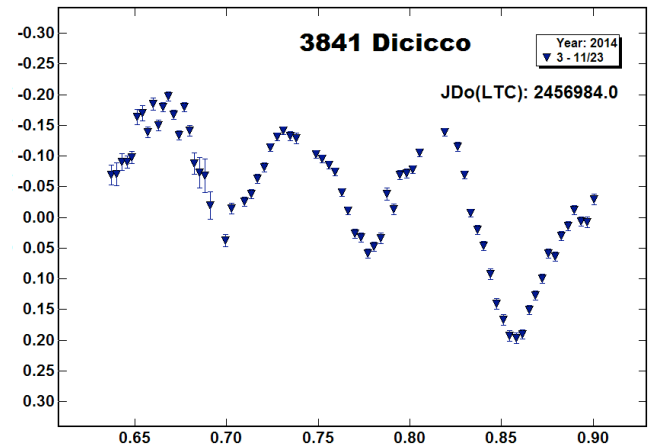


Figure 2. Raw data from 2014 Nov 23. The data more than six hours, which is almost two complete cycles of the lightcurve. An eclipse or occultation is present at the end of the night.

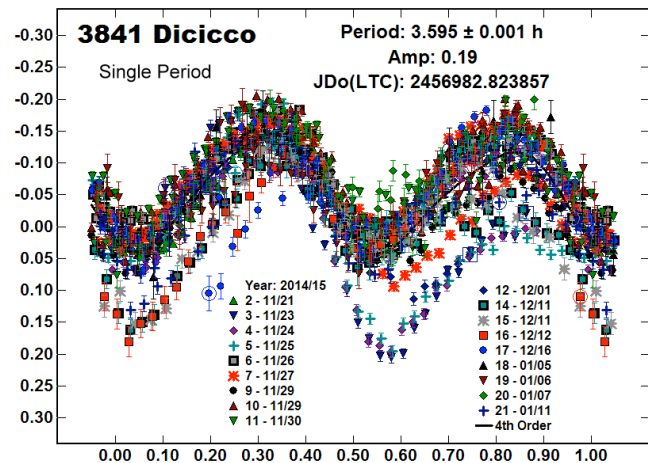


Figure 3. Sixteen nights of data fit to a single period. Note that 3 nights show an obvious lowering of the lightcurve.

Using the single period solution from *MPO Canopus* we obtained a period of 3.595 ± 0.001 h and an amplitude of 0.19 mag (Figure 3). However it was obvious that the data from at least three nights did not fit well. Using the iterative dual period solution from *MPO Canopus* we obtained a primary period of 3.5950 ± 0.0001 h with an amplitude of 0.19 mag (Figure 4) and a secondary period (Figure 5) of 21.641 ± 0.002 h. The mutual eclipse/occultation events have amplitudes of 0.08 to 0.15 magnitudes. The first value gives a lower limit on the secondary-to-primary effective diameter ratio of $D_s/D_p \geq 0.28$.

The data were sent then to Pravec who confirmed that it was a binary system. Authors DK, LF, and PP announced the discovery through the *CBET* 4033, published on 2014 Dec 8.

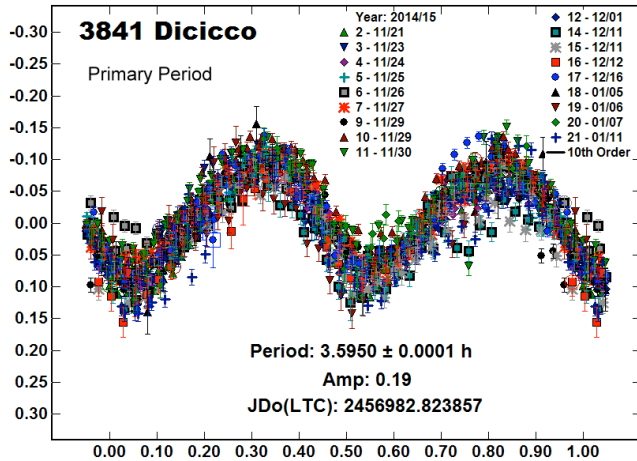


Figure 4: Using the 2-period search within *MPO Canopus* we obtain the primary period after subtracting out the secondary period.

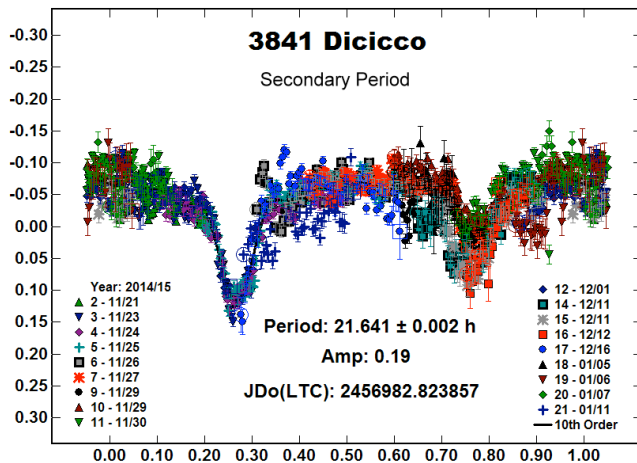


Figure 5: Using the 2-period search within *MPO Canopus* we obtain the secondary period after subtracting the primary period.

H and G Determination

For each lightcurve, the R mag was measured using half peak-to-peak amplitude with *Peranso* (Vanmunster, 2014) via a second order polynomial fit and excluding any eclipse/occultation events. The V mag was derived adding the typical color index $V-R = 0.49$ for an S-type asteroid (Shevchenko and Lupishko, 1998) to the R mag. Using the H-G Calculator function of *MPO Canopus*, we derived $H = 13.63 \pm 0.04$ mag and $G = 0.15 \pm 0.05$ (Figure 6). This H value is quite different from $H = 13.1$ published on the JPL Small-Body Database Browser (JPL, 2015).

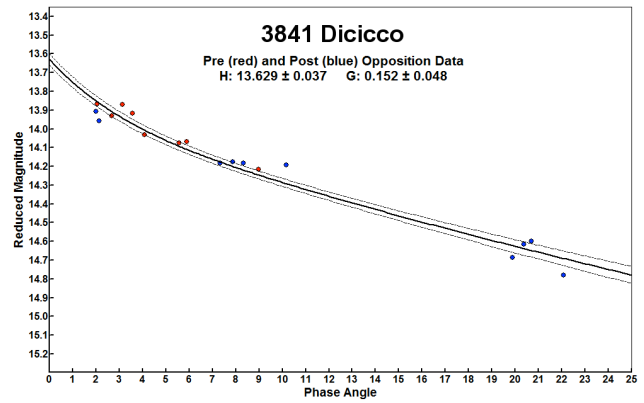


Figure 6: H and G curve for 3841 Diccio.

Acknowledgements

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ASTEROIDS OBSERVED AT ETSORN OBSERVATORY: 2015 APRIL - JUNE

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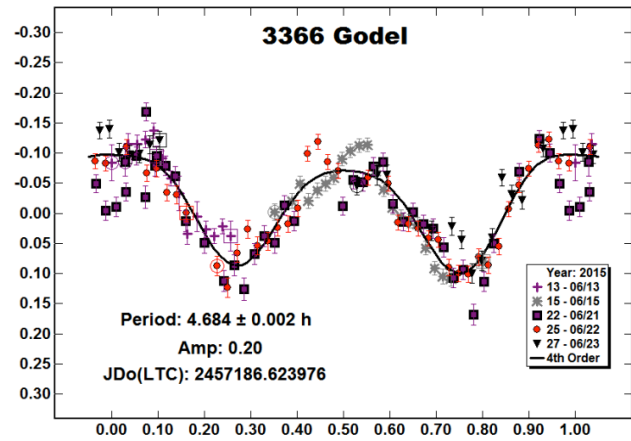
We observed four main-belt asteroids and obtained periods and amplitudes: 3366 Godel, $P = 4.684 \pm 0.002$ h, $A = 0.20$ mag; 5438 Saurez, $P = 2.941 \pm 0.001$ h, $A = 0.20$ mag; 8474 Rettig, $P = 11.514 \pm 0.024$ h, $A = 0.91$ mag; and 15224 Penttila, $P = 4.377 \pm 0.001$ h, $A = 0.51$ mag.

Observations of four asteroids were obtained at the Etsorn Campus Observatory (ECO, 2015) with our three Celestron C-14 (0.35-m) Schmidt-Cassegrain telescopes (SCT) on Software Bisque Paramount ME mounts (SB, 2015). Two of the telescopes used SBIG STL-1001E CCDs that have 1024x1024x24-micron pixels. The third C-14 used an SBIG ST-10XME with an Optec 0.5x focal reducer. The ST-10XME was binned 2x2 providing an image of 1092x736x13.6-micron pixels; the resulting scale was 1.28 arcsec/pixel, yielding a 20x16 arc minute field-of-view. The pixel scale for the STL-1001E cameras was 1.25 arcsec/pixel. This provided a 22x22 arc minute field-of-view.

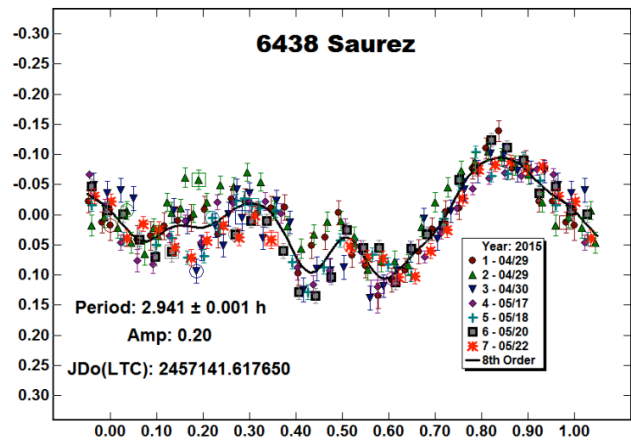
The asteroid images were obtained through a clear filter. Exposure times varied between 3 and 5 minutes depending on the brightness of the object. Each evening a series of 11 dome flats were obtained and combined into a master flat with a median filter. The telescopes were controlled with Software Bisque's TheSky6 (SB, 2015) and the CCDs were controlled with CCDsoft V5 (SB, 2015). The images were dark subtracted and flat-field corrected using image processing tools within *MPO Canopus* version 10.4.7.6 (Warner, 2015). The multi-night data sets for each asteroid were analyzed using the FALC routine (Harris *et al.*, 1989) within *MPO Canopus* to provide synodic periods.

The information about the discovery and names were obtained from the JPL Small Body Database Search Engine (JPL, 2015).

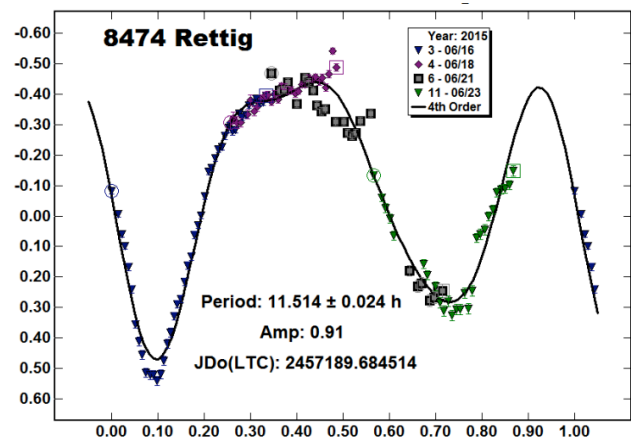
3366 Godel is a main-belt asteroid discovered by T. Schildknecht at Zimmerwald on 1985 Sep 22. It is also known as 1985 SD1, 1952 HH, 1969 QH, 1975 XE, 1978 EN3, 1978 GX1, 1978 JQ2, 1979 ND, 1980 UC1, 1983 EO, and 1983 FE. We observed the asteroid on five nights between 2015 Jun 13-23. Using four orders for the Fourier series, we obtained a period of 4.684 ± 0.002 h with an amplitude of 0.20 mag.



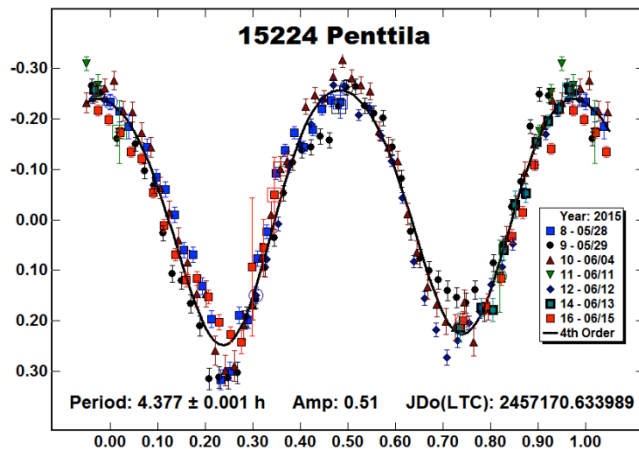
6438 Saurez is a main-belt asteroid discovered by H. Debehogne at the European Southern Observatory on 1988 Jan 18. It is also known as 1988 BS3, 1972 NH, 1975 ET5, 1978 ER, and 1989 RD5. We observed 6438 Saurez on six nights between 2015 Apr 29 and May 22. We used eight orders to fit the extra hump in the lightcurve. We obtained a period of 2.941 ± 0.001 h with an amplitude of 0.20 mag. Pravec (2015) reports in his "Photometric Survey for asynchronous Binary Asteroids" an identical period with an amplitude of 0.15 mag.



8474 Rettig is a main-belt asteroid discovered by E. Bowell at the Anderson Mesa Station, Lowell Observatory on 1985 Apr 15. It is also known as 1985 GA1 and 1992 NQ. We observed 8474 Rettig on four nights between 2015 Jun 16-23. We used four orders in the Fourier series to obtain a period of 11.514 ± 0.024 h with an amplitude of 0.91 mag.



15224 Penttila is a main-belt asteroid discovered by E. Bowell at the Anderson Mesa Station, Lowell Observatory on 1985 May 15. It is also known as 1985 JG, 1970 HB, and 2000 HR19. We observed Penttila on seven nights between 2015 May 28 and Jun 15. We used four orders in the Fourier series to obtain a period of 4.377 ± 0.001 h with an amplitude of 0.51 mag.



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ROTATION PERIOD AND H-G PARAMETERS DETERMINATION FOR 910 ANNELIESE

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Lightcurve analysis for 910 Anneliese was performed using observations during its 2015 opposition. The synodic rotation period was found to be 11.2863 ± 0.0002 h and the lightcurve amplitude was 0.16 ± 0.02 mag; the absolute magnitude was $H_R = 9.974 \pm 0.028$ mag and the slope parameter was $G = 0.107 \pm 0.030$. These lead to an estimated diameter of 46.3 ± 3.5 km.

Minor planet 910 Anneliese is a main-belt object discovered in 1919 by Karl W. Reinmuth at Heidelberg (Germany); it was named in honor of a dear friend of the German astronomer, Julius Dick. It appeared on the CALL web site as an asteroid photometry opportunity due to it reaching in 2015 a favorable apparition (*i.e.*, one of the five brightest apparitions from 1995 to 2050) and in the short list of those 3-digit asteroids still having no defined lightcurve parameters (Alvarez, 2015).

CCD photometric images were taken at Observatorio Los Algarrobos, Salto, Uruguay (OLASU, MPC Code I38) in 2015 from May 5 to July 9. The telescope was a 0.3-m Meade LX-200R reduced to $f/6.9$. The imager was a QSI 516wsg NABG (non-antiblooming gate) with a 1536x1024 array of 9-micron pixels and 23x16 arcminutes field-of-view. Clear, V, and R filters were used. The exposures increased from 90 to 150 seconds as the asteroid faded past opposition. 2x2 binning was used, yielding an image scale of 1.77 arcseconds per pixel. The camera was set to -15°C and off-axis guided by means of an SX Lodestar camera and *PHD2 Guiding* (Stark Labs) software. Image acquisition was done with *MaxIm DL5* (Diffraction Limited). The computer was synchronized with atomic clock time via Internet NTP servers at the beginning of each session.

All images were dark and flat-field corrected and then measured using *MPO Canopus* (Bdw Publishing) version 10.4.3.16 with a differential photometry technique. The data were light-time corrected. Catalog magnitudes were taken from the MPOSC3 catalog, which is based on the 2MASS catalog converted to the BVRCc system using formulae developed by Warner (2007). Night-to-night zero point calibration was accomplished by selecting up to five comparison stars with near solar colors according to recommendations by Warner (2007) and Stephens (2008). The nightly zero points have been found to be consistent to about ± 0.06 mag or better, except for the last two sessions (respectively requiring -0.09 and -0.14 mag). Period analysis was also done with *MPO Canopus*, which incorporates the Fourier analysis algorithm developed by Harris (Harris *et al.*, 1989).

A total of 23 nights were devoted to observe this asteroid exclusively over a total span of 64 days. More than 106 hours of effective observation and about 3,200 data points were required in order to solve the essentially flat lightcurve (Figure 1). Over the span of observations, the phase angle varied from 1.5° to 0.3° to 21.6° , the phase angle bisector ecliptic longitude (*i.e.*, the viewing aspect) varied from 227.0° to 232.4° , and the phase angle bisector

ecliptic latitude from $+0.7^\circ$ to -2.5° . The rotation period for 910 Anneliese was determined to be 11.2863 ± 0.0002 h with a lightcurve peak-to-peak amplitude of 0.16 ± 0.02 mag.

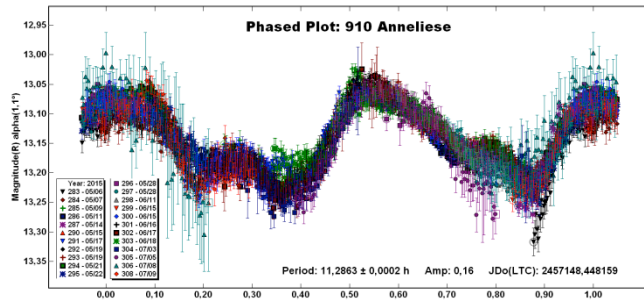


Figure 1. Composite lightcurve of 910 Anneliese.

The absolute R -band magnitude (H_R) and slope parameter (G) were found using the H-G Calculator tool of *MPO Canopus*, which is based on the FAZ algorithm developed by Alan Harris (1989). Two pre- and 21 post-opposition data were used (Figure 2), all of them representing the maximum of the curve for each observing session. The absolute R -band magnitude was determined to be 9.974 ± 0.028 mag and the slope parameter 0.107 ± 0.030 . Such a low G parameter is typical of low albedo asteroids (Lagerkvist and Magnusson, 1990).

The color index was determined to be $V-R = 0.369 \pm 0.020$ mag (mean of 28 values found from the session of May 14). Adding the mean $V-R$ color index to the H_R value gives $H = 10.343 \pm 0.050$. This H value is slightly lower than the one published at the JPL Small-Body Database ($H = 10.4$).

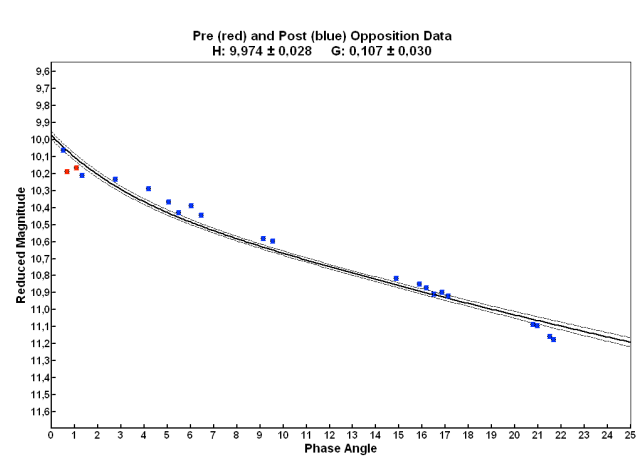


Figure 2. H-G plot in R-band for 910 Anneliese.

According to Shevchenko and Lupishko (1998), the measured $V-R$ color index (0.369 mag) is very close to the value that has been determined to correspond to *carbonaceous* asteroids (0.38 mag). For such C-type asteroids (the largest taxonomical class), the geometric albedo on the Johnson V band (p_V) is 0.06 ± 0.02 . Applying the formula by Pravec and Harris (2007) for the asteroid diameter (D) in kilometers

$$D = \frac{1329}{\sqrt{p_V}} 10^{-0.2H}$$

gives an estimated diameter of $D = 46.3 \pm 3.5$ km.

At the time of this study, 910 Anneliese was one of only 17 three-digit numbered asteroids for which no rotation parameters were found in the literature. However, not all of the already measured 983 rotation periods for the first 1000 asteroids are reliable (*i.e.*, many still have $U < 3$; see Warner *et al.*, 2009). Therefore, ongoing investigations to verify, refine, or revise their values remains an important and pending endeavor.

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LIGHTCURVE ANALYSIS OF THE NEAR-EARTH ASTEROID (6053) 1993 BW3

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CCD photometric observations of the near-Earth asteroid (6053) 1993 BW3 were made at the Center for Solar System Studies-Palmer Divide Station (CS3-PDS) in 2015 January and March. Analysis of the individual and combined data sets produced a period on the order of 2.8 hours. This differs significantly from the results of Pravec *et al.* (1997; $P = 2.573$ h) and from shape models by Durech (2002) and Kaasalainen (2002). While this discordance is not resolved, the 2.573 h value has the greatest amount of data supporting it, and for now, remains the favored period solution.

CCD photometric observations of the near-Earth asteroid were made at the Center for Solar System Studies-Palmer Divide Station (CS3-PDS) from 2015 January and March. A 0.30-meter Schmidt-Cassegrain telescope and Finger Lakes ML-1000E camera were used. The pixel scale was approximately 1.50 arcsec/pixel. All observations were unfiltered since a clear filter can result in a 0.1-0.3 magnitude loss. The exposures were all 240 sec.

Measurements were made using *MPO Canopus*. If necessary, an elliptical aperture with the long axis parallel to the asteroid's path was used. The Comp Star Selector utility in *MPO Canopus* found up to five comparison stars of near solar-color for differential photometry. Catalog magnitudes were usually taken from the MPOSC3 catalog, which is based on the 2MASS catalog (<http://www.ipac.caltech.edu/2mass>) but with magnitudes converted from J-K to BVRI using formulae developed by Warner (2007). The nightly zero points have been found to be consistent to about ± 0.05 mag or better, but on occasion are as large as 0.1 mag. Period analysis was also done using *MPO Canopus*, which implements the FALC algorithm developed by Harris (Harris *et al.*, 1989).

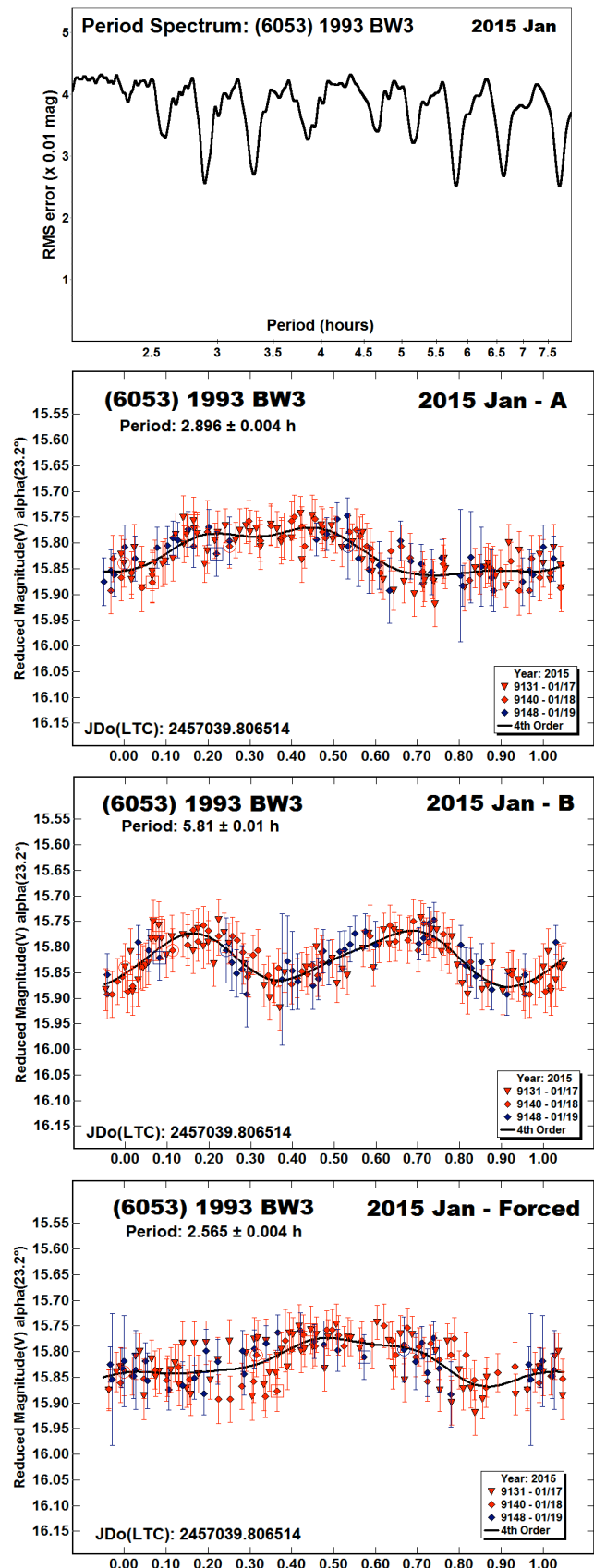
In the plots below, the "Reduced Magnitude" is Johnson V as indicated in the Y-axis title. These are values that have been converted from sky magnitudes to unity distance by applying $-5 \cdot \log(r\Delta)$ to the measured sky magnitudes with r and Δ being, respectively, the Sun-asteroid and Earth-asteroid distances in AU. The magnitudes were normalized to the given phase angle, e.g., $\alpha(6.5^\circ)$, using $G = 0.15$, unless otherwise stated. The X-axis is the rotational phase, ranging from -0.05 to 1.05.

Analysis and Discussion

Pravec *et al.* (1997) found a period of 2.573 h for this NEA. Durech (2002) and Kaasalainen *et al.* (2002) found shape and spin axis models with an averaged sidereal period of 2.5737 h. Data obtained from CS3-PDS in 2015 January and March lead to a significantly different answer.

The period spectrum based on the 2015 January 17-19 observations shows a strong minimum at about 2.9 hours and a significantly weaker minimum at the previous result of 2.57 hours.

It's important to note that the two periods differ by almost exactly one rotation over a 24-hour period.

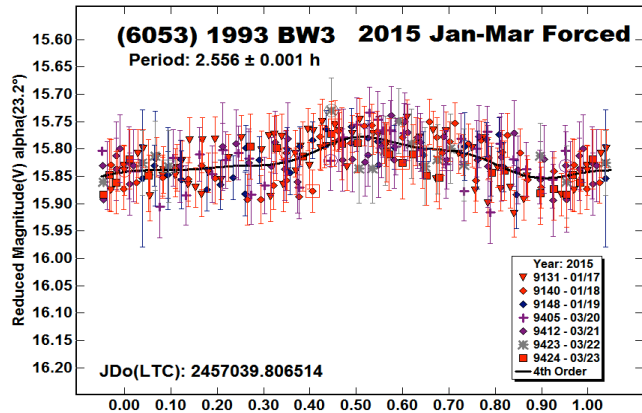
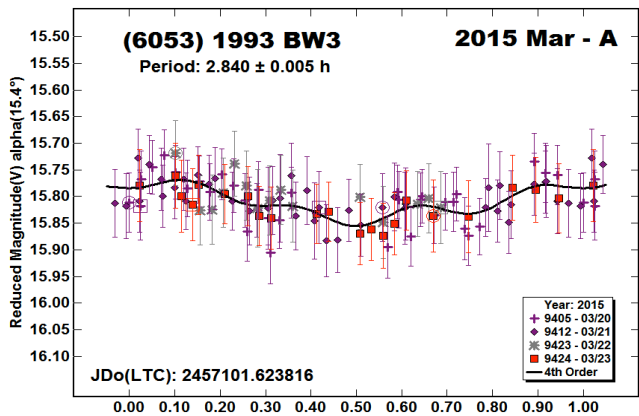
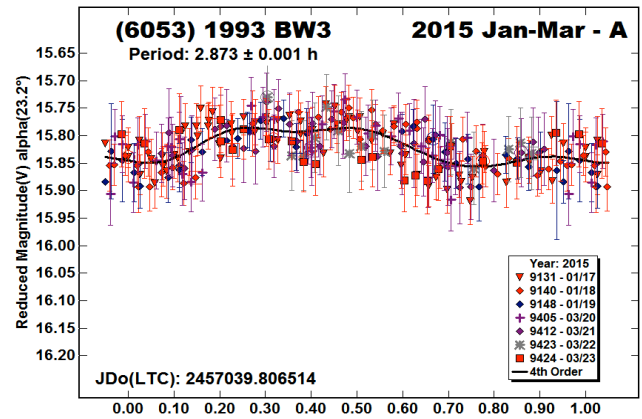
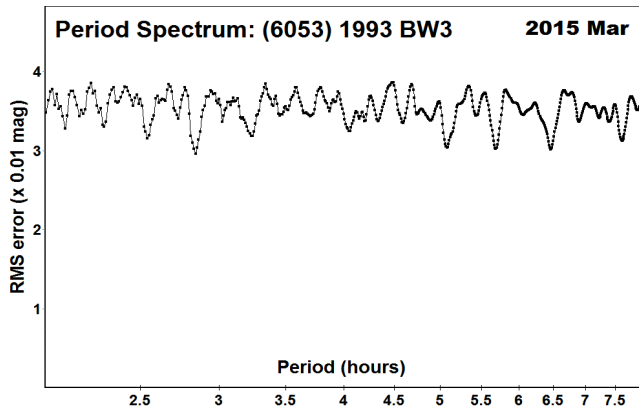
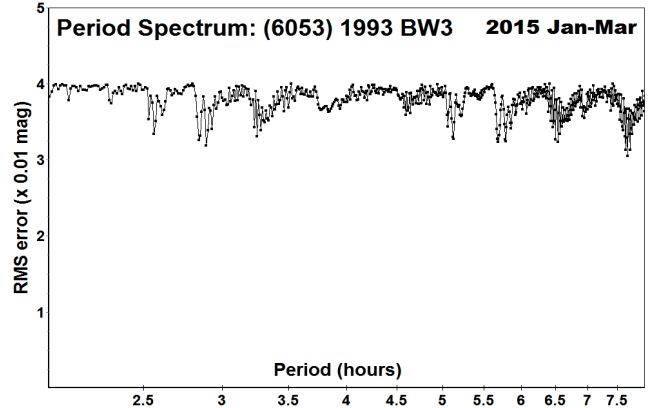


Number	Name	2015 mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period	P.E.	Amp	A.E.	Grp
6053	1993 BW3	01/17-01/18	142	23.2, 22.7	154	-2	2.896	0.004	0.09	0.01	NEA
6053	1993 BW3	03/20-03/23	114	15.4, 16.5	151	-10	2.838	0.005	0.09	0.02	NEA
6053	1993 BW3	01/16-03/23	114	23.2, 15.4, 16.5	153	-7	2.873	0.001	0.07	0.01	NEA

Table II. Observing circumstances. Pts is the number of data points used in the analysis. The phase angle (α) is given at the start and end of each date range, unless it reached a minimum, which is then the second of three values. If a single value is given, the phase angle did not change significantly and the average value is given. L_{PAB} and B_{PAB} are, respectively the average phase angle bisector longitude and latitude, unless two values are given (first/last date in range). Grp is the orbital group of the asteroid. See Warner *et al.* (LCDB; 2009).

The “A” and “B” plots above show, respectively, the monomodal and bimodal solution. Given the low amplitude, a bimodal solution cannot be assumed (Harris *et al.*, 2014). The “Forced” plot is the best fit near 2.57 h and a noticeably poorer fit.

The 2015 March data set covered four consecutive nights with each run extending for more than 4 hours, i.e., about 1.5 rotations. Usually this is more than sufficient to remove a *rotational alias*, i.e., one due to a miscount of the number of rotations over the span of the data set. The period spectrum again favors a period near 2.9 hours with the alternate solution of 2.57 hours stronger by comparison than in the January data set. The “A” plot shows the monomodal solution. A “Forced” plot using only the March data showed a noticeably poor fit to a period of 2.560 hours.



The Pravec *et al.* data set covered 1995 July through 1996 February. During that time the phase angle ranged from 75° in late 1995 September to 5° in late 1996 January. The lightcurve amplitude varied from 0.03 to 0.5 mag. In general, the longer the total time span of the observations, the greater the certainty in the derived rotation period. Based on this, the 2015 January and March PDS data sets were combined to see if the longer time span might result in a period closer to the one found by Pravec *et al.*, Durech, and Kassalain. This was not the case.

The period spectrum still favored a period near 2.9 hours. The “A” plot shows the best fit between 2.4 and 3.1 hours, 2.873 ± 0.001 h. The “Forced” plot shows the best fit near 2.57 h, i.e., 2.556 h. The two plots are almost indistinguishable at this point. The period spectrum actually favors a period of 7.68 h, which is exactly 3x the “Forced” period.

Given the far more extensive data set of Pravec *et al.*, a period of about 2.5737 h must, for now, be considered the correct answer. The additional data from 2015 combined with the earlier data set

may, or may not, change that result or at least allow improving the existing models.

Acknowledgements

Funding for PDS observations, analysis, and publication was provided by NASA grant NNX13AP56G. Work on the asteroid lightcurve database (LCDB) was also funded in part by National Science Foundation Grant AST-1210099. This research was made possible through the use of the AAVSO Photometric All-Sky Survey (APASS), funded by the Robert Martin Ayers Sciences Fund.

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NEAR-EARTH ASTEROID LIGHTCURVE ANALYSIS AT CS3-PALMER DIVIDE STATION: 2015 MARCH-JUNE

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(Received: 4 July)

Lightcurves for 35 near-Earth asteroids (NEAs) were obtained at the Center for Solar System Studies-Palmer Divide Station (CS3-PDS) from 2015 March-June.

CCD photometric observations of 35 near-Earth asteroids (NEAs) were made at the Center for Solar System Studies-Palmer Divide Station (CS3-PDS) from 2015 March-June. Table I lists the telescope/CCD camera combinations used for the observations. All the cameras use CCD chips from the KAF blue-enhanced family and so have essentially the same response. The pixel scales for the combinations range from 1.24-1.60 arcsec/pixel.

Desig	Telescope	Camera
Squirt	0.30-m f/6.3 Schmidt-Cass	ML-1001E
Borealis	0.35-m f/9.1 Schmidt-Cass	FLI-1001E
Eclipticalis	0.35-m f/9.1 Schmidt-Cass	STL-1001E
Australius	0.35-m f/9.1 Schmidt-Cass	STL-1001E
Zephyr	0.50-m f/8.1 R-C	FLI-1001E

Table I. List of CS3-PDS telescope/CCD camera combinations.

All lightcurve observations were unfiltered since a clear filter can result in a 0.1-0.3 magnitude loss. The exposure duration varied depending on the asteroid's brightness and sky motion. Guiding on a field star sometimes resulted in a trailed image for the asteroid.

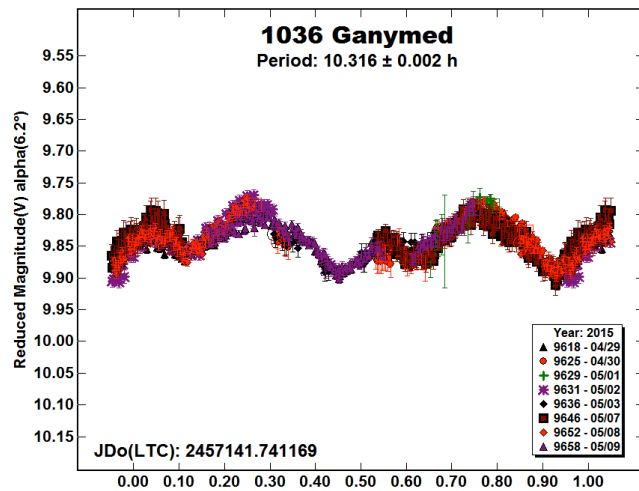
Measurements were done using *MPO Canopus*. If necessary, an elliptical aperture with the long axis parallel to the asteroid's path was used. The Comp Star Selector utility in *MPO Canopus* found up to five comparison stars of near solar-color for differential photometry. Catalog magnitudes were usually taken from the MPOSC3 catalog, which is based on the 2MASS catalog (<http://www.ipac.caltech.edu/2mass>) but with magnitudes converted from J-K to BVRI using formulae developed by Warner (2007). When possible, magnitudes are taken from the APASS catalog (Henden *et al.*, 2009) since these are derived directly from reductions based on Landolt standard fields. Using either catalog, the nightly zero points have been found to be consistent to about ± 0.05 mag or better, but on occasion are as large as 0.1 mag. This consistency is critical to analysis of long period and/or tumbling asteroids. Period analysis is also done using *MPO Canopus*, which implements the FALC algorithm developed by Harris (Harris *et al.*, 1989).

In the plots below, the "Reduced Magnitude" is Johnson V as indicated in the Y-axis title. These are values that have been converted from sky magnitudes to unity distance by applying $-5 \cdot \log(r\Delta)$ to the measured sky magnitudes with r and Δ being, respectively, the Sun-asteroid and Earth-asteroid distances in AU. The magnitudes were normalized to the given phase angle, e.g., $\alpha(6.5^\circ)$, using $G = 0.15$, unless otherwise stated. The X-axis is the rotational phase, ranging from -0.05 to 1.05 .

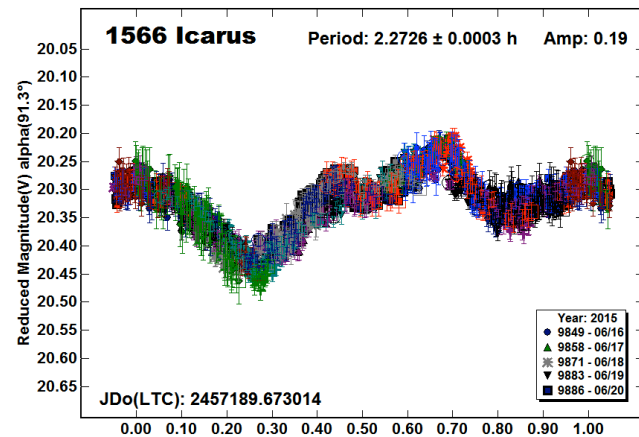
For the sake of brevity, only some of the previously reported results may be referenced in the discussions on specific asteroids. For a more complete listing, the reader is directed to the asteroid lightcurve database (LCDB; Warner *et al.*, 2009). The on-line version at <http://www.minorplanet.info/lightcurvedatabase.html> allows direct queries that can be filtered a number of ways and the results saved to a text file. A set of text files of the main LCDB tables, including the references with bibcodes, is also available for download. Readers are strongly encouraged to obtain, when possible, the original references listed in the LCDB for their work.

If the plot includes an amplitude, e.g., “Amp: 0.65”, this is the amplitude of the Fourier model curve and *not necessarily the adopted amplitude for the lightcurve*. The value is meant only to be a quick guide.

1036 Ganymed. This NEA has been studied extensively, most recently by Pilcher *et al.* (2012) who followed it for several months in 2011. Its period is well-established. The PDS observations in 2015 were made to help with modelling and the possible change in spin axis period due to the YORP effect, as has been seen in other NEAs (e.g., see Kaasalainen *et al.*, 2004).

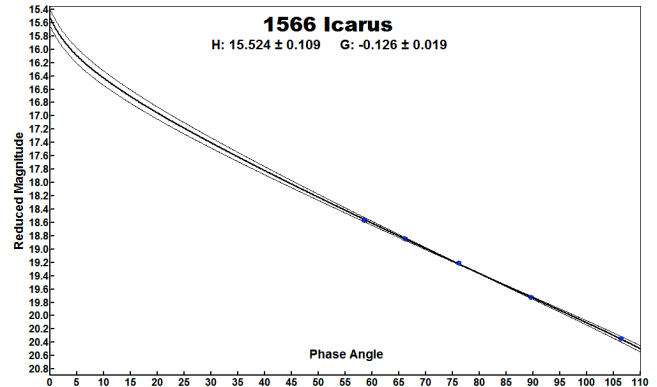


1566 Icarus. Only three previous results were found for this famous NEA, the last being in 1995. All reported a period of about 2.27 hours. The period found from the PDS data analysis found a period consistent with those earlier results.

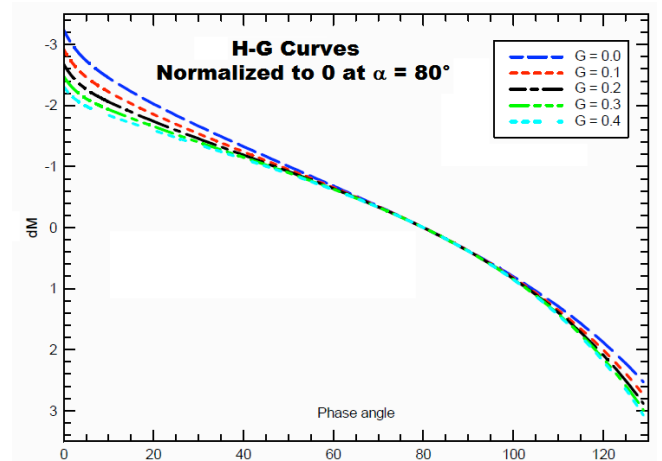


What made the 2015 apparition of particular note was the very large phase angle when observations were made, up to 107°. Since the phase angle changed significantly over the four days of

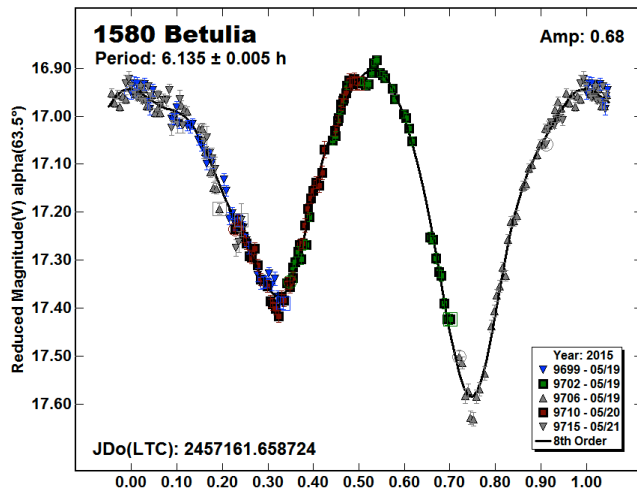
observations, it was possible to generate an H-G plot, where the average magnitude of the asteroid was plotted against the phase angle. This produced an unlikely value of $G = -0.126$ (which was used to get the phased plot above) and resulting absolute magnitude of $H = 15.52$. The latter is about 1.4 magnitudes brighter than the value listed in the MPCORB file from the Minor Planet Center.



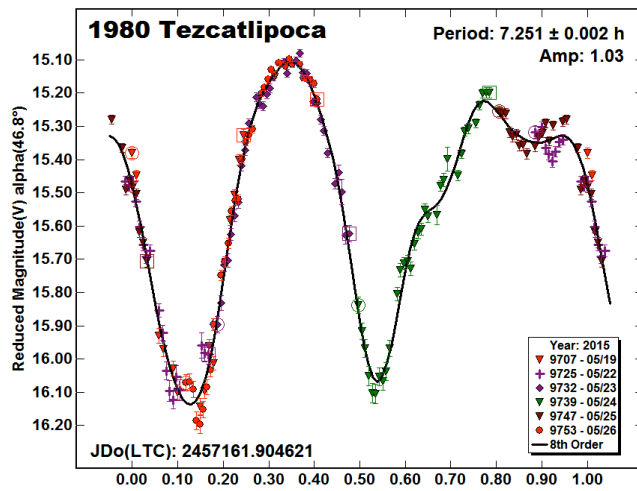
Discussions with Alan Harris (private communications), one of the co-creators of the standard H-G system, lead to his analysis shown in the H-G plot below where the curves have been normalized to zero at 80° phase angle. As is clearly shown, it is impossible to tell the difference among the curves in the phase angle range from about 60° to 100°, where most of the PDS observations were made. Even the slightest shift in values for the plot could lead to significantly different results for H . This shows why H-G determinations should be made at phase angles no larger than about 40° and, for complete accuracy, must include observations with $\alpha < 7^\circ$, preferably $\alpha < 2^\circ$



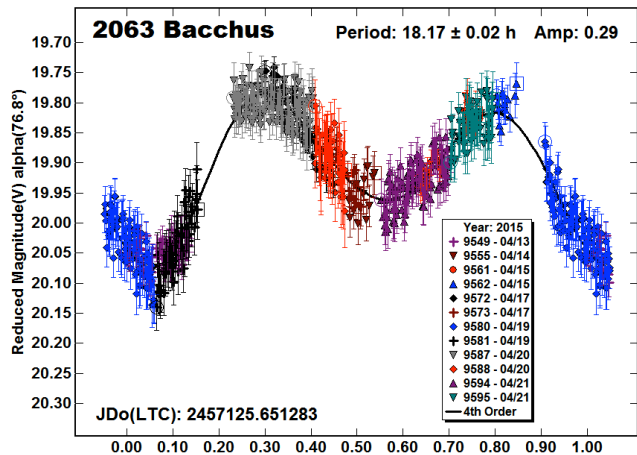
1580 Betulia. This NEA’s period is well-established at 6.1 hours (see LCDB entries) and has been modelled several times. The most recent observations in the LCDB are from about 2007. The additional data from almost a decade later could help refine the model, especially to check if the rotation rate is gradually changing due to YORP.



1980 Tezcatlipoca. The last reported lightcurve data in the LCDB for Tezcatlipoca are from 2008 (Skiff *et al.*, 2012a). The amplitude in 2015 is the largest, by almost 0.3 mag, reported to-date.

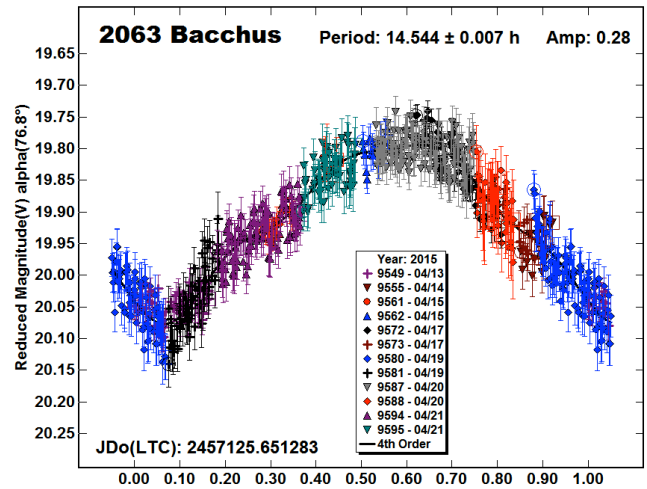


2063 Bacchus. The period spectrum for Bacchus showed two strong possibilities. The solution for 18.17 hours produced an odd-shaped lightcurve, but one entirely improbable given the high phase angle.

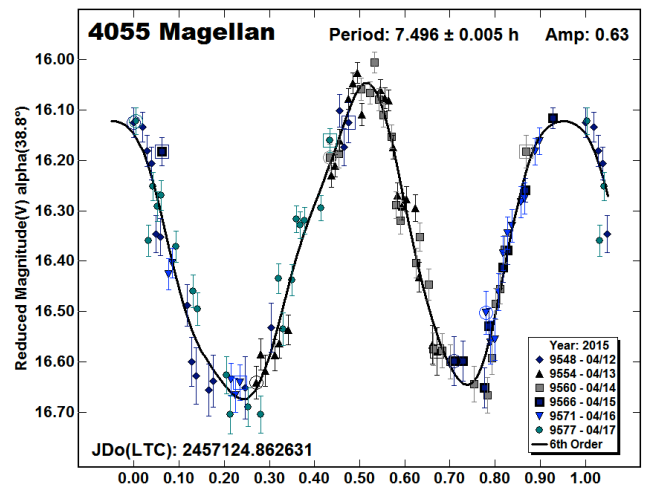


On the other hand, the solution at 14.544 hours produced a more “normal” monomodal lightcurve. Even with an amplitude of 0.28

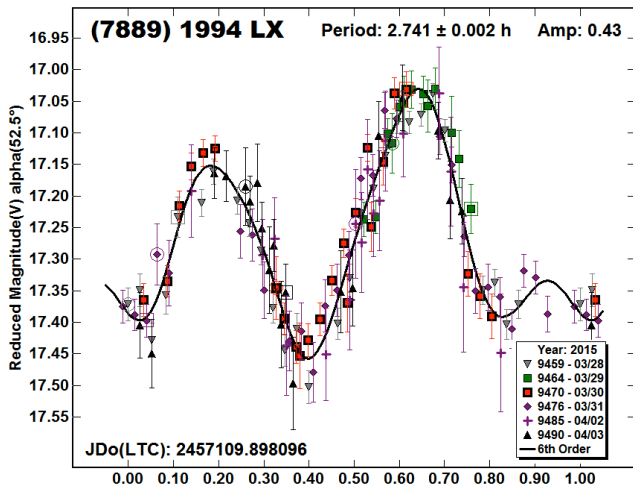
mag, this is not unexpected when, again, working at high phase angles (see Harris *et al.*, 2014). Since the shorter period is agreement with earlier results (Pravec *et al.*, 1998b; Benner *et al.*, 1999), the latter being based on radar observations, the period of 14.544 h is adopted for this paper.



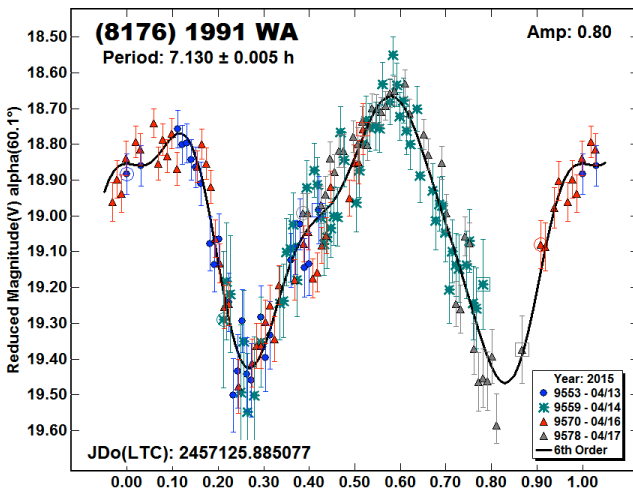
4055 Magellan. Pravec *et al.* (2000) reported a period of 7.475 h. Warner (2014) found a period of 6.384 h, but this was based on a very sparse data set. Analysis of the data from PDS in 2015 produced a period more consistent with the Pravec *et al.* result. Waszczak *et al.* (2015), using sparse data from the Palomar Transit Factory, found a period of 7.4805 h. This shows the effectiveness of sparse data surveys for period analysis, but with the caveat that there are likely strong biases that favor moderate periods and larger amplitudes (e.g., see Warner and Harris, 2011; Harris *et al.*, 2012).



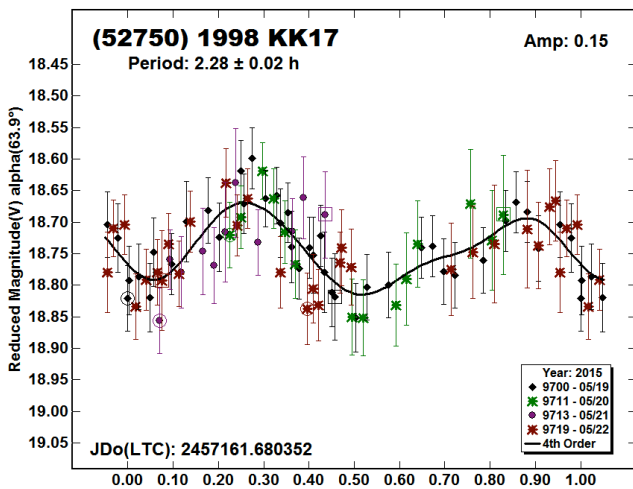
(7889) 1994 LX. Pravec *et al.* (1996, 1998) found a period of about 2.74 h. The results from the analysis of the 2015 data from PDS give the same period. The lightcurve amplitude has always been near 0.35 mag. This is not unexpected since the observations have been made within a small range of phase angle bisector (PAB; see Harris *et al.*, 1984) longitudes.



(8176) 1991 WA. The period of 7.130 found in 2015 is in good, but not perfect, agreement with the result of 7.111 h from Pravec *et al.* (1997).

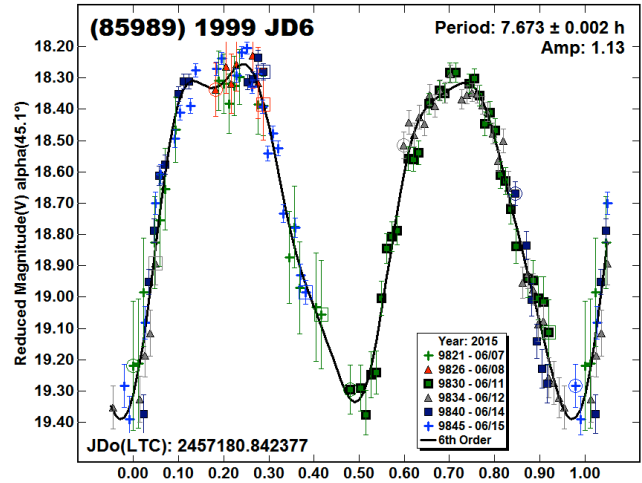


(52750) 1998 KK17. Higgins (2004) found a period of 3.124 h for this NEA. A best fit of the PDS data in the range of 3-4.5 hours was 3.99 h with a trimodal lightcurve, which also occurred when limiting the period to 3.100-3.120 hours (3.106 h).

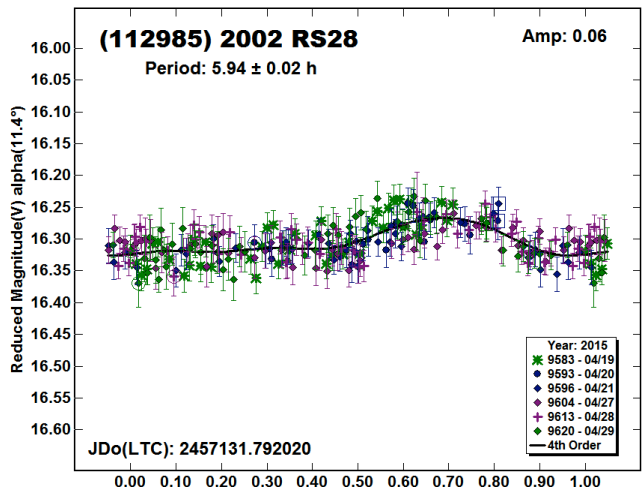


The original Higgins data were retrieved from the ALCDEF database (MPC, 2015). No solution could be found in the range of 2.0-3.0 hours. In both cases, the amplitude of the lightcurve was relatively low and the error bars were a significant fraction of the amplitude. The true period of the asteroid remains in question.

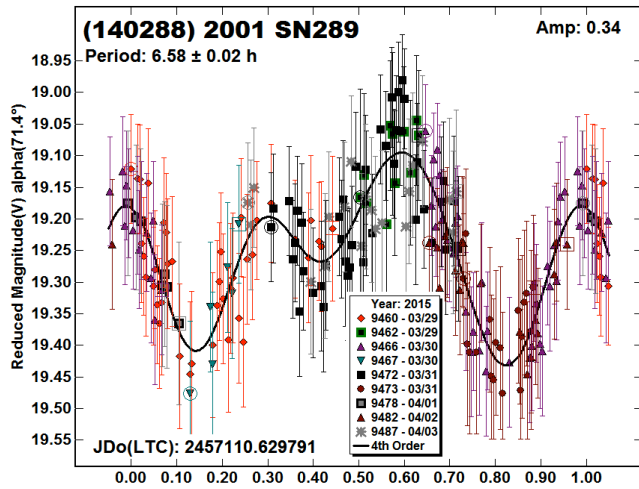
(85989) 1999 JD6. The period based on the 2015 PDS data is in good agreement with the numerous entries in the LCDB (e.g., Pravec *et al.*, 1999)



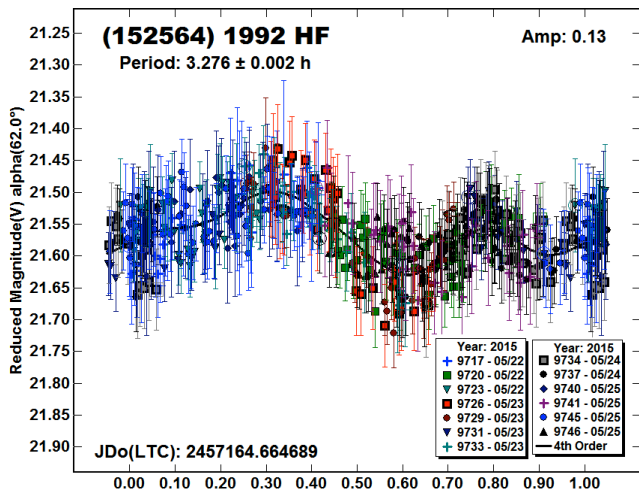
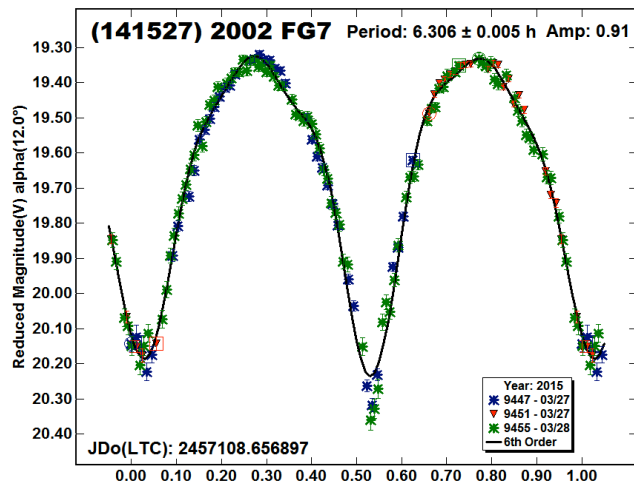
(112985) 2002 RS28. There were no previous entries in the LCDB for 2002 RS28. The adopted period is 5.94 h. There is a slightly better (lower RMS) solution at 7.92 hours. However, this may be a *fit by exclusion*, meaning the lower RMS was the result of minimizing the number overlapping data points which leaves some parts of the lightcurve with either no or very few data points.



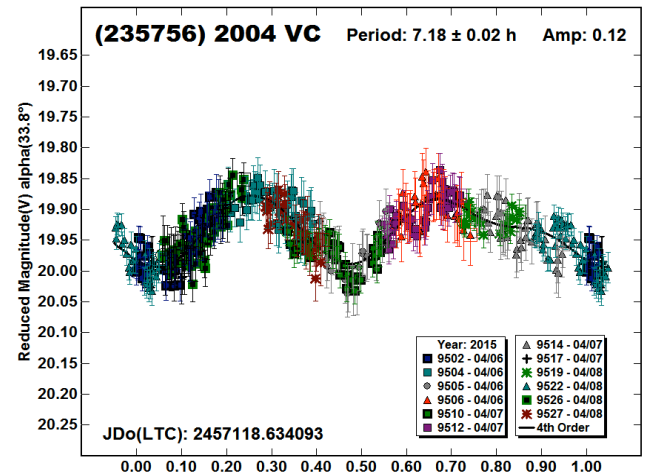
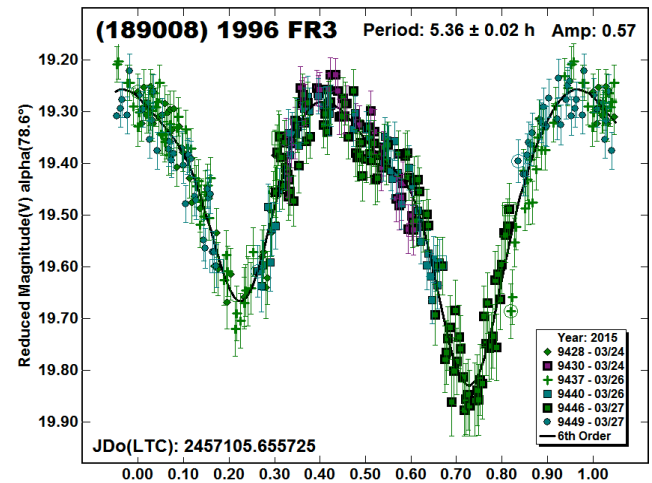
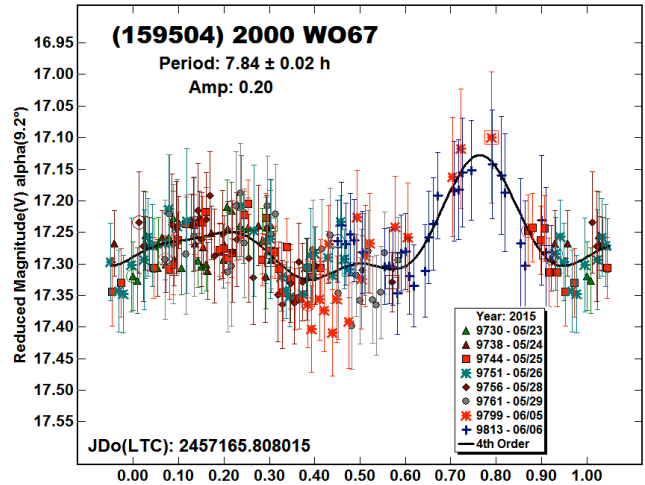
(140288) 2001 SN289. This appears to be the first lightcurve reported for this NEA. The large error bars and the unusual shape make the solution less reliable. However, the large phase angle could easily account for the shape of the lightcurve. Also working in favor of the adopted period is that the period spectrum showed only one decided minimum, the one at 6.6 hours.

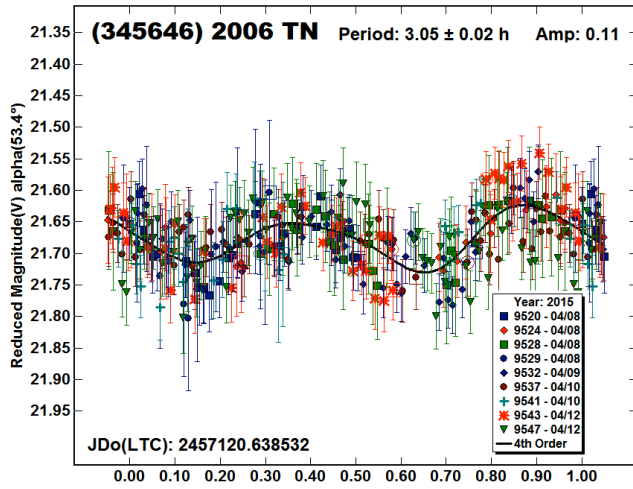


(141527) 2002 FG7 and (152564) 1992 HF. No previous entry was found in the LCDB for either asteroid. The large amplitude and low phase angle for 2002 FG7 make the solution highly secure. Despite the large error bars and low amplitude for 1992 HF, its solution is also considered secure. The period spectrum showed only two noteworthy solutions, the other being the double-period. The high phase angle probably accounts, at least in part, to the unusual shape of the lightcurve.

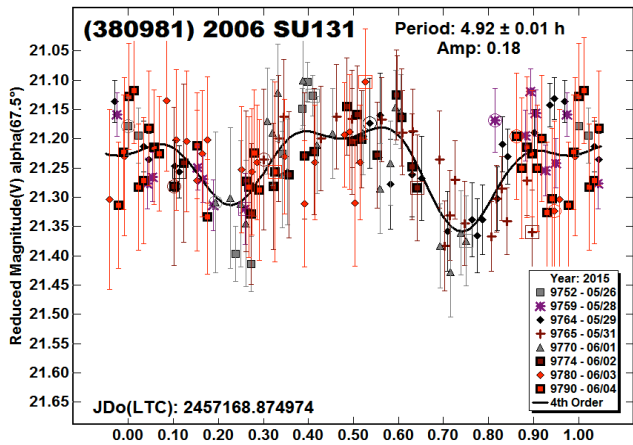


(159504) 2000 WO67, (189008) 1996 FR3, (235756) 2004 VC and (345646) 2006 TN. These appear to be the first lightcurves reported for this quartet of NEAs. For 2000 WO67, the unusual shape of the lightcurve prompted attempts to find other solutions but none could be found that were acceptable. For 2004 VC, the period spectrum also suggested a period of about 10.6 hours, which would be 1.5x the adopted solution. A look at the possible half-periods gave further support to the adopted period of 7.18 hours. The solution is considered reliable. The period and low amplitude of 2006 TN make it a good binary candidate. Unfortunately, it doesn't reach $V < 19.0$ again until 2017 May.

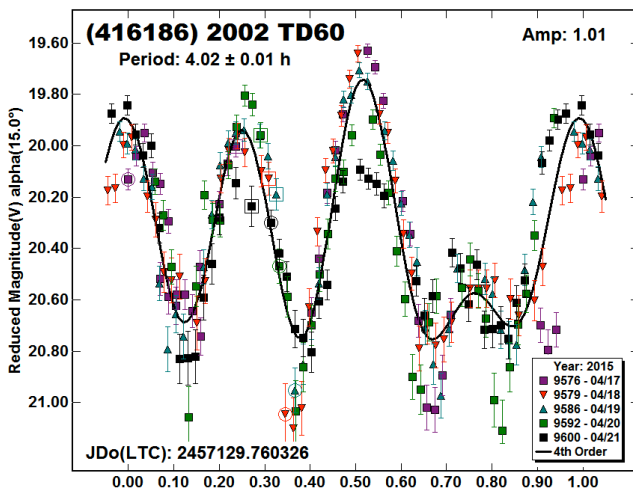




(380981) 2006 SU131. The adopted period of 4.92 h is the best guess given the quality of the data. There were numerous solutions in the period spectrum of nearly the same RMS value. The next good chance ($V < 19$) for the asteroid is 2024 August.



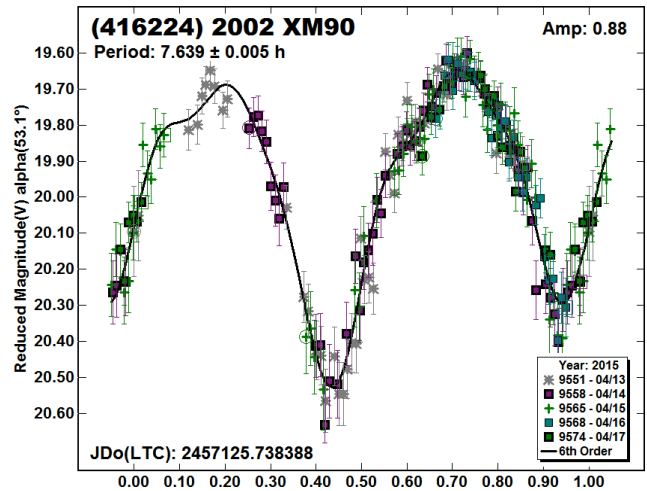
(416186) 2002 TD60. This is a known tumbler (Pravec *et al.*, 2005), an object where the asteroid is not only rotating about an axis but that axis is precessing (see Pravec *et al.*, 2014, and references therein).



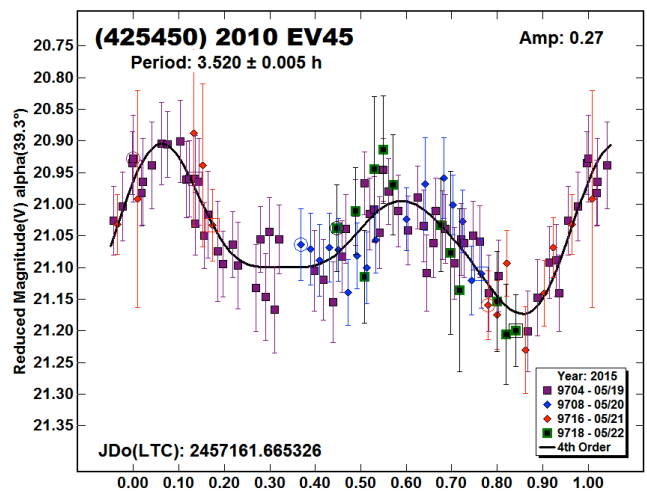
The lightcurve is a result of finding a “beat frequency” of the frequency of rotation and precession. As discussed by Harris *et al.*

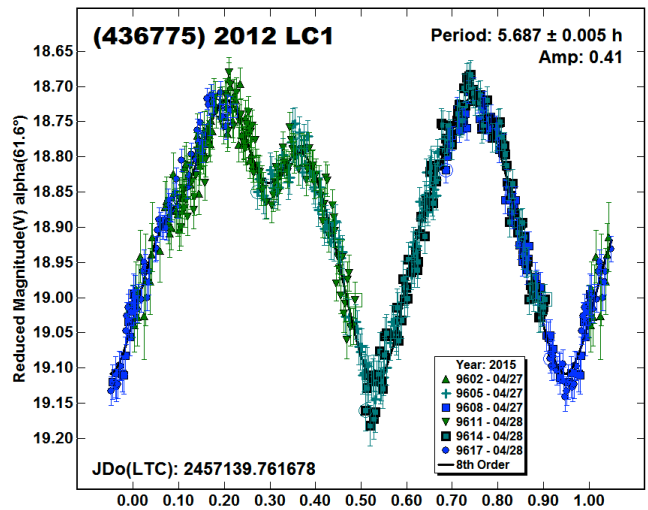
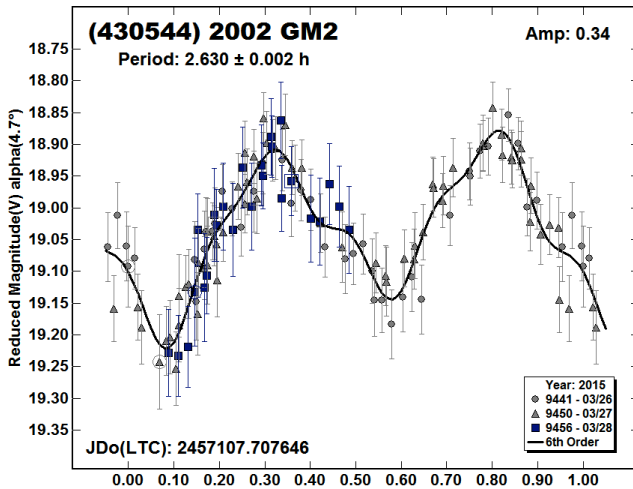
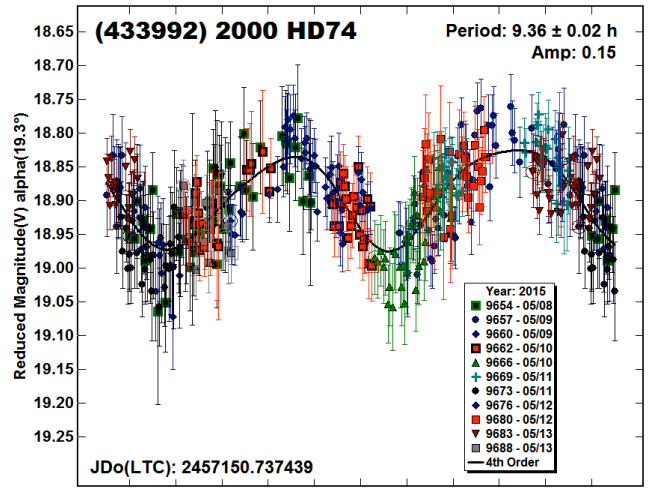
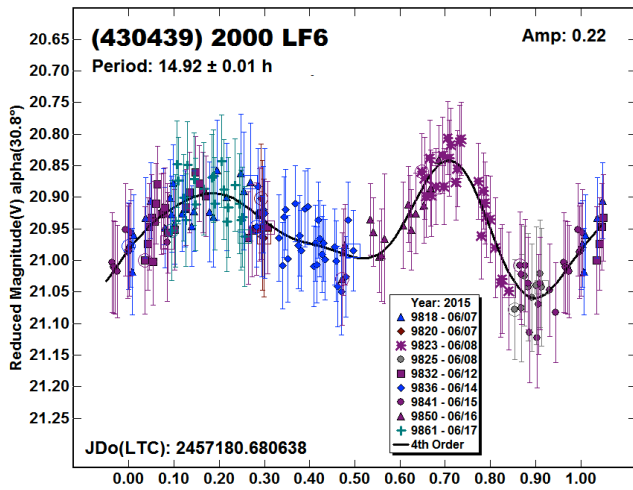
(2014), this is not a plausible single period solution since, given the amplitude and phase angle, the lightcurve would have to be bimodal. Analysis of the PDS data by Petr Pravec (private communications) found $P_1 = 2.8504$ h and $P_2 = 6.783$ h.

(416224) 2002 XM90. This is the second time the author has worked this NEA. In 2014 (Warner, 2015), a period of 7.666 h was reported. The result from observations four months later of 7.639 h is consistent given the less dense coverage during the first quarter of the phased lightcurve. It’s interesting to note that the amplitude decreased by 0.14 mag even though the phase angle increased from 27° to 52°.



(425450) 2010 EV45, (430439) 2000 LF6, and (430544) 2002 GM2. The lightcurves here appear to be the first ones to be reported for this trio of asteroids. The solutions for all three are reasonably secure, despite the unusual shapes for 2010 EV45 and 2000 LF6. In particular, 2002 GM2 is a good binary candidate given its period. Not all small binary primaries are nearly spheroidal; there are several known binary primaries with amplitudes on the order of 0.3 mag. The next time 2002 GM2 is $V < 19.0$ is not until 2028 March.



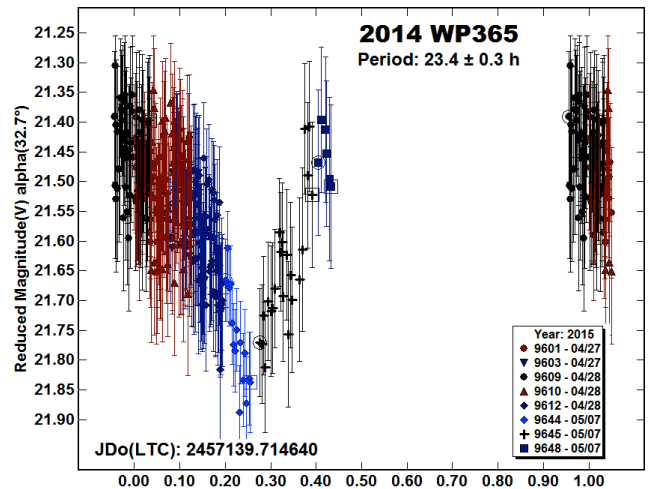


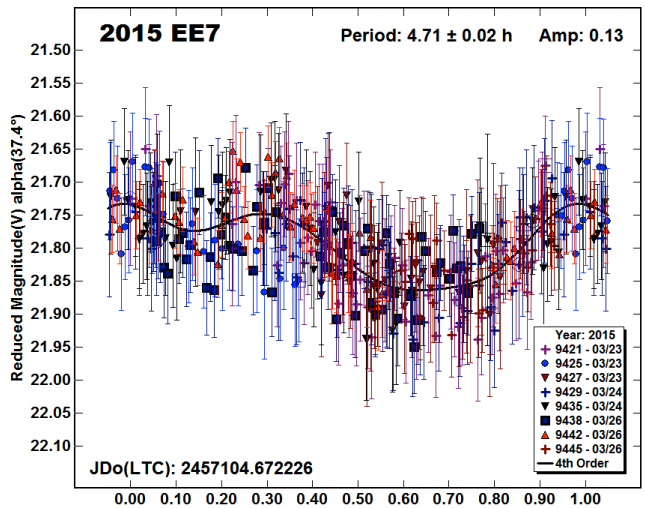
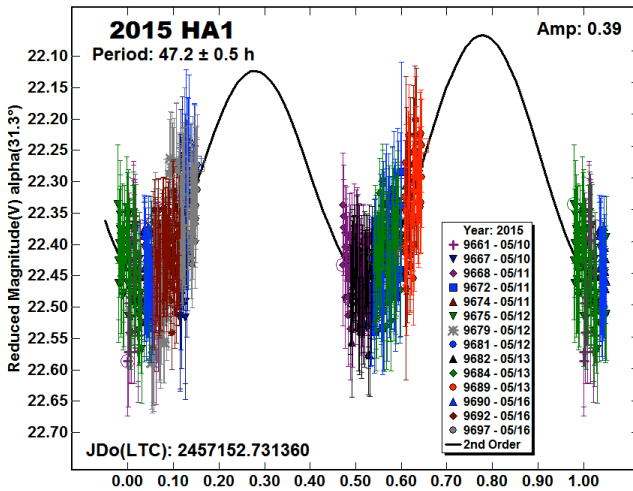
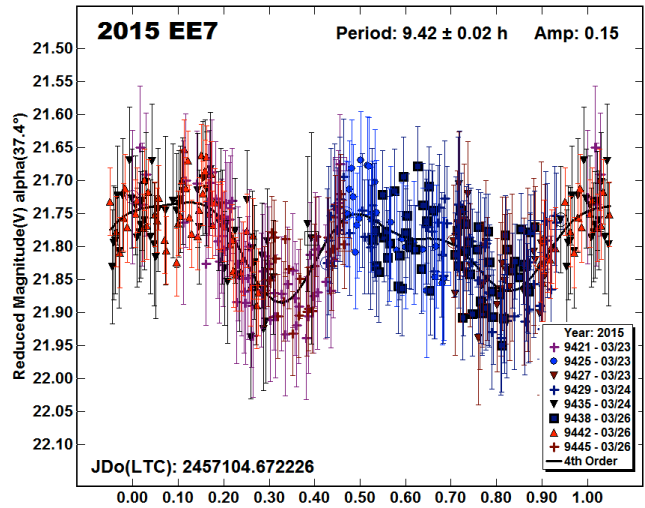
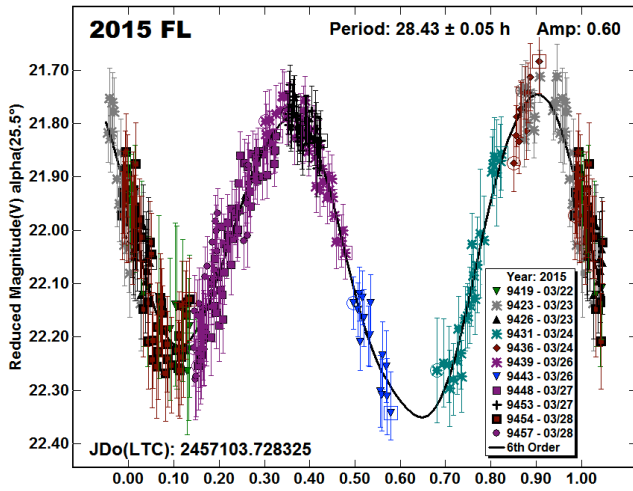
2000 HD74, 2012 LC1, 2014 WP365, 2015 FL, and 2015 HA1. Here is a quintet of first-time results. The solutions for 2000 HD74 and 2012 LC1 are considered secure. The combination of amplitude and phase angle for each virtually precludes anything other than a bimodal solution.

The solution for 2014 WP365 is based on examining other periods commensurate with an Earth day. None of them produced reasonable fits or slopes of Fourier model curve. Furthermore, given the approximate amplitude, the phase angle is not so excessive as to believe that the true solution has a bimodal shape.

The same reasoning applies to 2015 FL and so its solution is considered secure, especially since the lightcurve is fully-covered save a small gap near the second minimum.

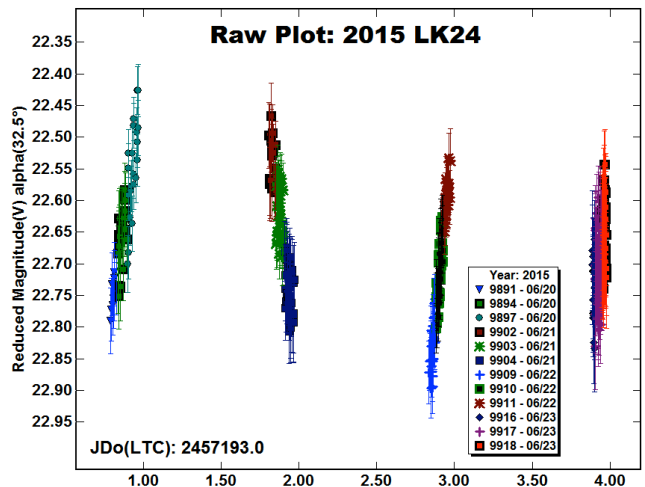
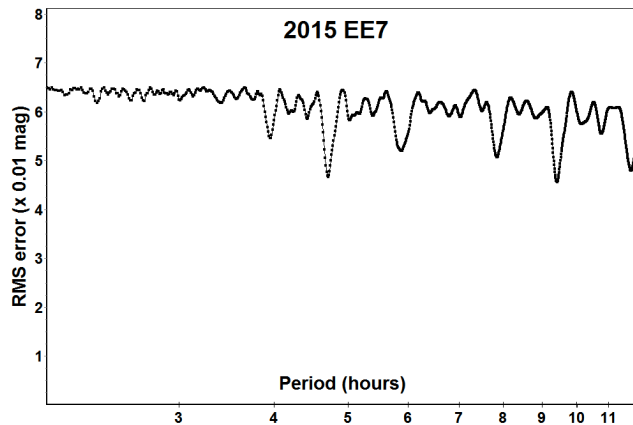
The arguments for the 2015 HA1 solution are similar to those for 2014 WP365 in that the slopes for other Earth-day commensurate periods were not reasonable and the combination of the phase angle and amplitude again nearly assure a bimodal solution.





2015 EE7. There were no previous results in the LCDB to guide the analysis for this NEA. The period spectrum shows a handful of plausible periods, some being the half-period of the longer values.

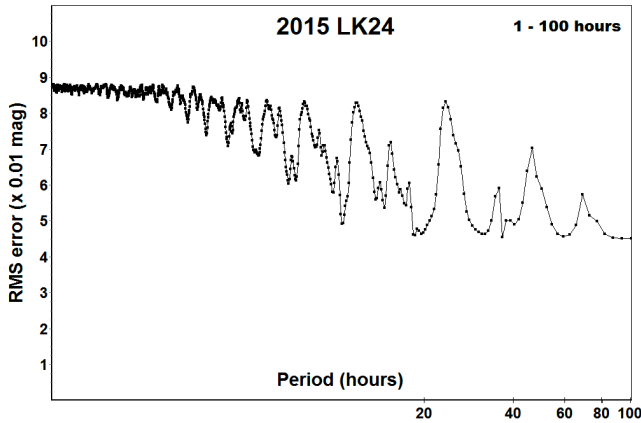
2015 LK24. The 2015 apparition was the closest one through 2050 (0.05 AU). The next close approach is 0.12 AU in 2037 July. Until then, the asteroid doesn't reach $V < 21$. This made the 2015 apparition a "once in a lifetime event." Unfortunately, it was not a lucky one.



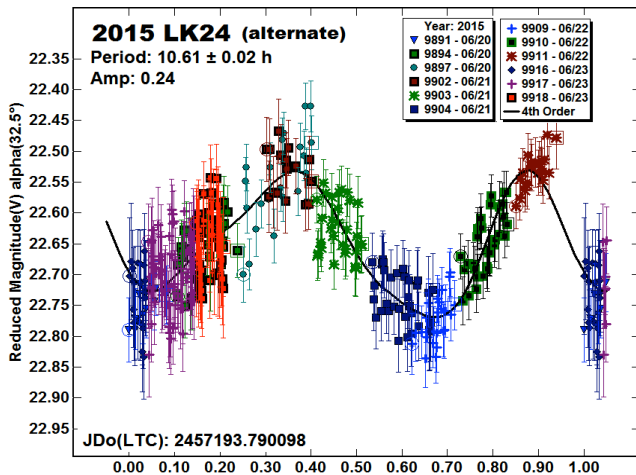
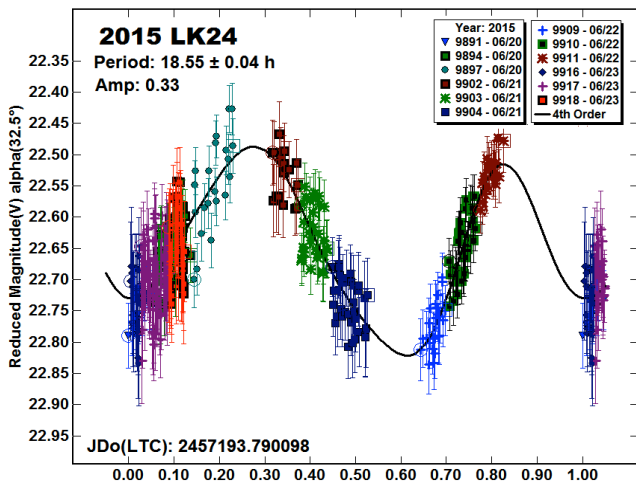
The two lightcurves are phased to the preferred period of 9.42 h (because of the asymmetry of the shape) and its half-period at 4.71 h. Assuming a limit of $V < 19$, the next chance to observe 2015 EE7 is not until 2035 March when it will be $V \sim 15.8$ at -20° declination.

A raw plot of the data from 2015 June 20-23 favors a long period. The plots for the individual nights show only a steady rise or fall with no indication of a short period. The period spectrum bears this

out. However, radar observations (Patrick Taylor, private communications) indicated a somewhat short period and nothing like the original solution from the PDS data of about 33 hours.

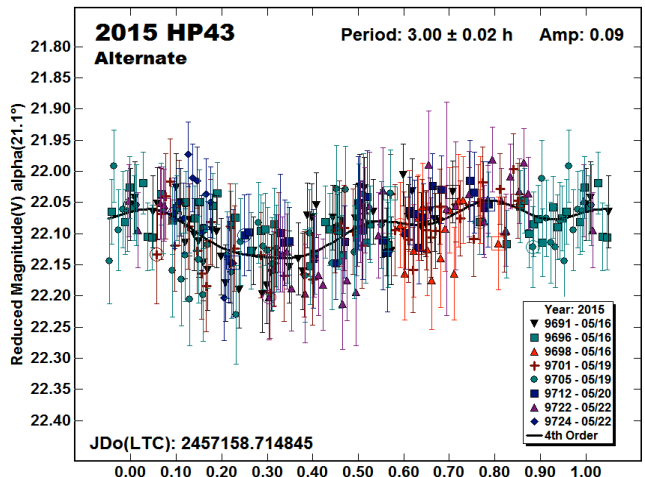
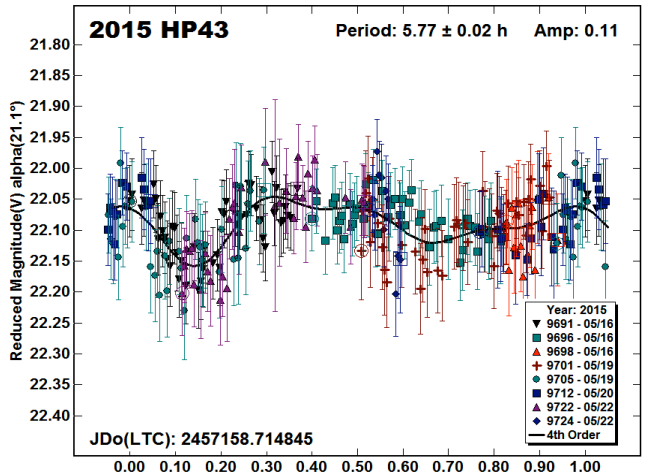
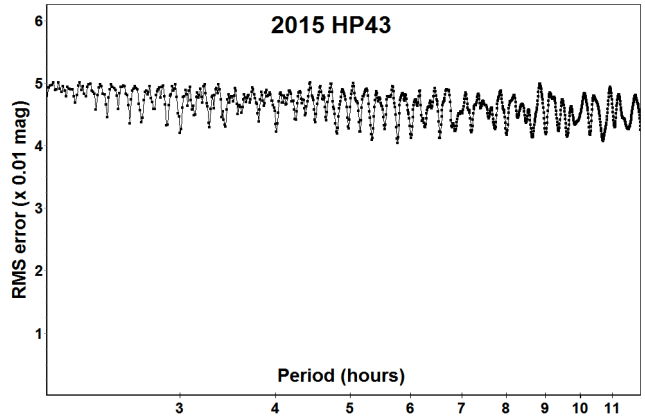


After manipulating some zero points, but by no more than 0.1 mag, two solutions of $P < 24$ hours emerged. The more likely is at 18.55 hours. This is based on the slope of the data having a better fit to the slopes of the Fourier model curve. This is not so much the case with the solution of 10.61 hours, especially at the second maximum. Additional analysis of the radar data is pending, at which time it's hoped that the optical and radar solutions become more consistent with one another.



2015 HP43. There was no previous entry in the LCDB for 2015 HP43. As the period spectrum shows, there was no one solution that stood out. The two lightcurves represent the best fit solution at 5.77 hours and its almost half-period of 3.0 hours. Neither solution is considered very reliable. This is a good example of what can happen when the error bars are nearly the same or greater than the amplitude of the lightcurve.

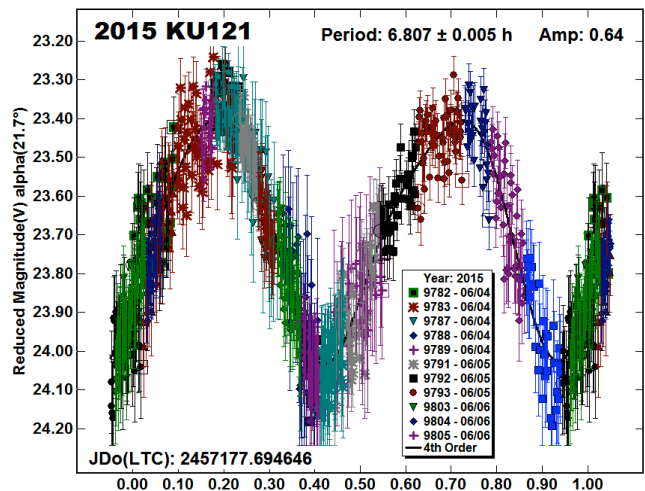
The asteroid won't be $V < 21$ again through 2050. As is often the case with near-Earth asteroids, the photometric opportunities for a given asteroid, even with a large backyard telescope, can be few and far between.

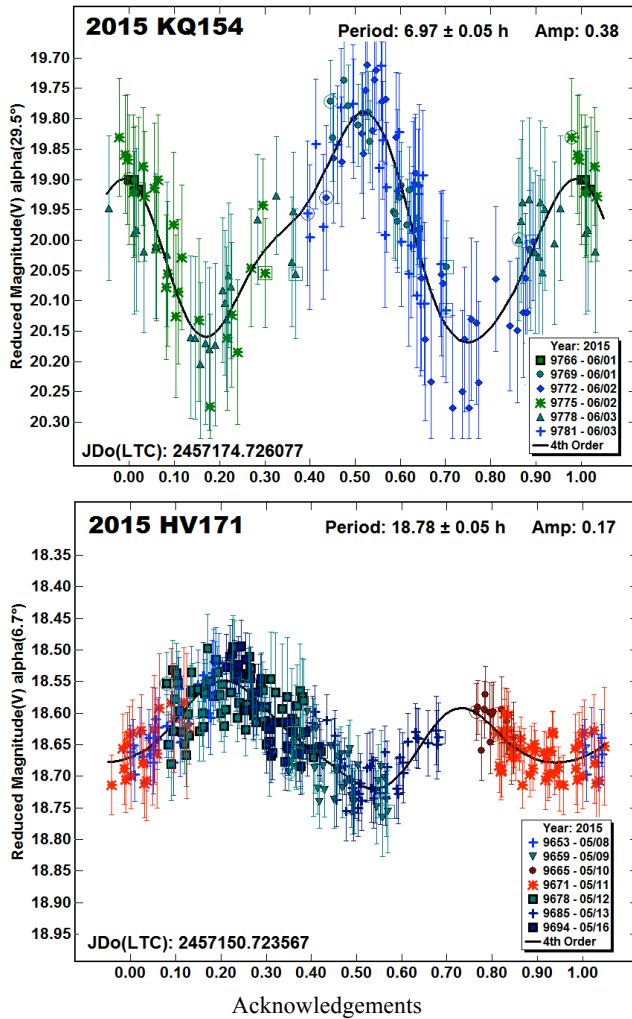


Number	Name	2015 mm/dd	Pts	Phase	L _{PAB}	B _{PAB}	Period	P.E.	Amp	A.E.	Grp
1036	Ganymed	04/29-05/09	925	6.2,4.2	229	8	10.316	0.002	0.09	0.01	NEA
1566	Icarus	06/16-06/20	1512	104.7,58.0	230	23	2.2726	0.0003	0.19	0.02	NEA
1580	Betulia	05/19-05/21	209	63.6,63.5	204	44	6.135	0.005	0.70	0.02	NEA
1980	Tezcatlipoca	05/19-05/26	168	46.8,48.5	307	22	7.251	0.002	1.01	0.03	NEA
2063	Bacchus	04/13-04/21	651	76.7,65.7	161	10	14.544	0.007	0.28	0.02	NEA
4055	Magellan	04/13-04/17	108	38.9,39.3	256	31	7.496	0.005	0.62	0.04	NEA
7889	1994 LX	03/28-04/03	130	52.5,51.1	241	54	2.741	0.002	0.39	0.03	NEA
8176	1991 WA	04/13-04/17	163	60.0,64.3	218	57	7.130	0.005	0.80	0.05	NEA
52750	1998 KK17	05/19-05/22	90	63.8,61.3	185	21	2.28	0.02	0.15	0.03	NEA
85989	1999 JD6	06/07-06/15	133	45.1,44.8	301	17	7.673	0.002	1.13	0.05	NEA
112985	2002 RS28	04/19-04/29	245	11.4,10.2,10.8	221	10	5.94	0.02	0.06	0.01	NEA
140288	2001 SN289	03/29-04/03	209	71.6,76.3	134	20	6.58	0.02	0.34	0.05	NEA
141527	2002 FG7	03/27-03/28	158	12.1,12.8	179	-2	6.306	0.005	0.97	0.03	NEA
152564	1992 HF	05/22-05/25	518	62.7,77.1	238	41	3.276	0.002	0.13	0.02	NEA
159504	2000 WO67	05/26-06/06	207	9.9,15.9	240	11	7.84	0.02	0.2	0.03	NEA
189008	1996 FR3	03/24-03/27	334	78.2,69.0	136	15	5.36	0.02	0.57	0.03	NEA
235756	2004 VC	04/06-04/08	436	34.2,40.3	175	-4	7.18	0.02	0.12	0.02	NEA
345646	2006 TU	04/08-04/12	323	53.1,47.6	172	15	3.05	0.02	0.11	0.03	NEA
380981	2006 SN131	05/26-06/04	147	67.5,72.7	289	21	4.92 ^A	0.01	0.18	0.03	NEA
416186	2002 TD60	04/17-04/21	214	15.0,13.1	211	11	2.8504	0.0005	1.15	0.1	NEA
416224	2002 XM90	04/13-04/17	214	53.1,51.1	202	43	7.639	0.005	0.88	0.05	NEA
425450	2010 EV45	05/19-05/22	99	39.3,39.4	231	26	3.520	0.005	0.27	0.03	NEA
430439	2000 LF6	06/07-06/16	161	30.8,27.1	243	11	14.92	0.02	0.22	0.02	NEA
430544	2002 GM2	03/26-03/28	128	4.7,4.3	186	-4	2.630	0.002	0.34	0.03	NEA
433992	2000 HD74	05/08-05/13	398	19.3,14.0	230	14	9.36	0.02	0.15	0.03	NEA
436775	2012 LC1	04/27-04/28	509	61.5,57.9	219	41	5.687	0.005	0.41	0.02	NEA
	2014 WP365	04/27-05/07	280	32.8,41.9	199	6	23.4	0.3	0.45	0.05	NEA
	2015 FL	03/22-03/28	327	25.5,28.6	172	12	28.43	0.05	0.62	0.04	NEA
	2015 HA1	05/10-05/16	700	31.3,27.3	225	16	47.2	0.5	0.39	0.04	NEA
	2015 EE7	03/23-03/26	367	37.3,36.4	170	20	9.42	0.02	0.15	0.03	NEA
	2015 LK24	06/20-06/23	393	32.2,38.3	285	10	18.55 ^A	0.04	0.33	0.03	NEA
	2015 HP43	05/16-05/22	267	21.0,9.0	235	8	5.77 ^A	0.02	0.11	0.03	NEA
	2015 KU121	06/04-06/06	873	22.3,41.5	240	7	6.807	0.005	0.69	0.05	NEA
	2015 KQ154	06/01-06/03	142	29.6,0.0	130	9	6.97	0.05	0.38	0.04	NEA
	2015 HV171	05/08-05/16	282	6.7,12.9	230	8	18.78 ^A	0.05	0.17	0.03	NEA

Table II. Observing circumstances. ^A preferred period for an ambiguous solution. Pts is the number of data points used in the analysis. The phase angle (α) is given at the start and end of each date range, unless it reached a minimum, which is then the second of three values. If a single value is given, the phase angle did not change significantly and the average value is given. L_{PAB} and B_{PAB} are, respectively the average phase angle bisector longitude and latitude, unless two values are given (first/last date in range). Grp is the orbital group of the asteroid. See Warner *et al.* (LCDB; 2009).

2015 KU121, 2015 KQ154, and 2015 HV171. There no previous entries in the LCDB for this trio of NEAs. The solution for 2015 KU121 is considered secure. The data for 2015 KQ154 are less than ideal, but the individual nights covered a significant part of the adopted period. The phase angle and amplitude strongly favor a bimodal solution. The period spectrum for 2015 HV171 showed a possible solution near 16.5 hours in addition to the adopted period of 18.78 hours. A review of the half-periods showed that only the one at 9.42 hours had a reasonable fit and shape and, in fact, cannot be formally excluded.





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**ASTEROID LIGHTCURVE ANALYSIS AT
CS3-PALMER DIVIDE STATION:
2015 MARCH-JUNE**

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(Received: 4 July)

Lightcurves for 29 main-belt asteroids were obtained at the Center for Solar System Studies-Palmer Divide Station (CS3-PDS) from 2015 March-June. All but three were members of the Hungaria orbital group or collisional family and observed as part of an ongoing program to obtain data for spin axis and shape modeling. One Hungaria, (79472) 1998 AX4 showed signs of having a satellite. Analysis indicates it is a *possible* binary.

CCD photometric observations of 29 main-belt asteroids were made at the Center for Solar System Studies-Palmer Divide Station (CS3-PDS) from 2015 March-June. Table I lists the telescope/CCD camera combinations used for the observations. All the cameras use CCD chips from the KAF blue-enhanced family and so have essentially the same response. The pixel scales for the combinations range from 1.24-1.60 arcsec/pixel.

Desig	Telescope	Camera
Squirt	0.30-m f/6.3 Schmidt-Cass	ML-1001E
Borealis	0.35-m f/9.1 Schmidt-Cass	FLI-1001E
Eclipticalis	0.35-m f/9.1 Schmidt-Cass	STL-1001E
Australius	0.35-m f/9.1 Schmidt-Cass	STL-1001E
Zephyr	0.50-m f/8.1 R-C	FLI-1001E

Table I. List of CS3-PDS telescope/CCD camera combinations.

All lightcurve observations were unfiltered since a clear filter can result in a 0.1-0.3 magnitude loss. The exposure duration varied depending on the asteroid's brightness and sky motion. Guiding on a field star sometimes resulted in a trailed image for the asteroid.

Measurements were done using *MPO Canopus*. If necessary, an elliptical aperture with the long axis parallel to the asteroid's path was used. The Comp Star Selector utility in *MPO Canopus* found up to five comparison stars of near solar-color for differential photometry. Catalog magnitudes were usually taken from the MPOSC3 catalog, which is based on the 2MASS catalog (<http://www.ipac.caltech.edu/2mass>) but with magnitudes converted from J-K to BVRI using formulae developed by Warner (2007b). When possible, magnitudes are taken from the APASS catalog (Henden *et al.*, 2009) since these are derived directly from reductions based on Landolt standard fields. Using either catalog, the nightly zero points have been found to be consistent to about ± 0.05 mag or better, but on occasion are as large as 0.1 mag. This consistency is critical to analysis of long period and/or tumbling asteroids. Period analysis is also done using *MPO Canopus*, which implements the FALC algorithm developed by Harris (Harris *et al.*, 1989).

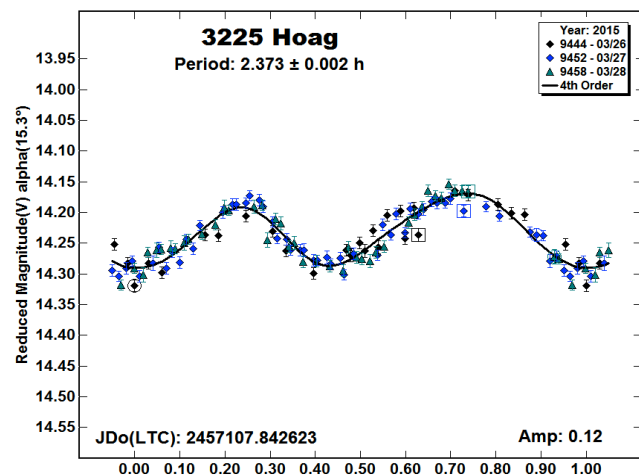
In the plots below, the "Reduced Magnitude" is Johnson V as indicated in the Y-axis title. These are values that have been converted from sky magnitudes to unity distance by applying $-5 \cdot \log(r\Delta)$ to the measured sky magnitudes with r and Δ being,

respectively, the Sun-asteroid and Earth-asteroid distances in AU. The magnitudes were normalized to the given phase angle, e.g., $\alpha(6.5^\circ)$, using $G = 0.15$, unless otherwise stated. The X-axis is the rotational phase ranging from -0.05 to 1.05 .

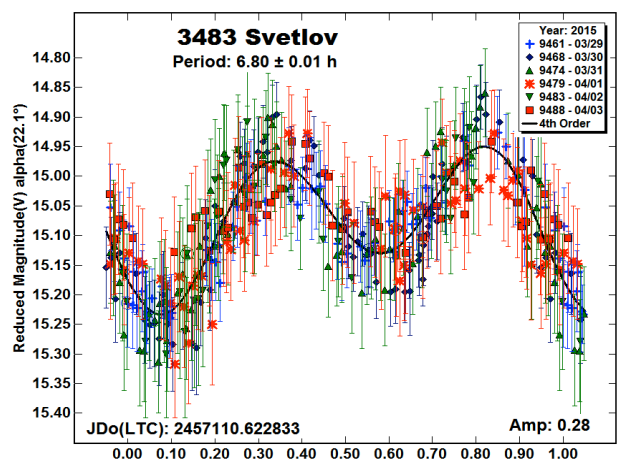
If the plot includes an amplitude, e.g., "Amp: 0.65", this is the amplitude of the Fourier model curve and *not necessarily the adopted amplitude for the lightcurve*. The value is meant only to be a quick guide.

For the sake of brevity, only some of the previously reported results may be referenced in the discussions on specific asteroids. For a more complete listing, the reader is directed to the asteroid lightcurve database (LCDB; Warner *et al.*, 2009a). The on-line version at <http://www.minorplanet.info/lightcurvedatabase.html> allows direct queries that can be filtered a number of ways and the results saved to a text file. A set of text files of the main LCDB tables, including the references with bibcodes, is also available for download. Readers are strongly encouraged to obtain, when possible, the original references listed in the LCDB for their work.

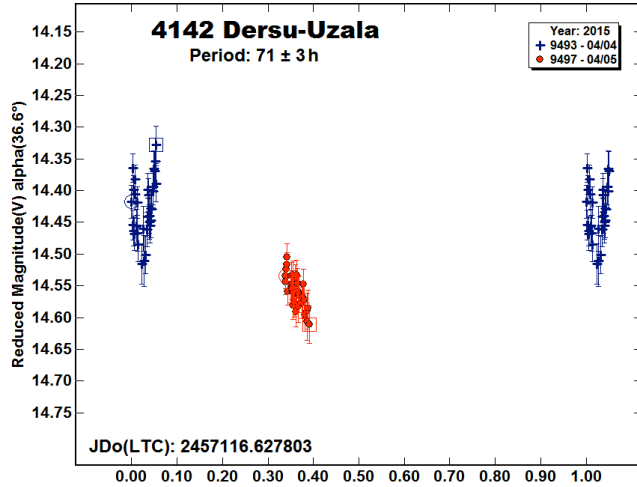
3225 Hoag. This Hungaria member had been observed by the author at four previous apparitions (see the LCDB). Each time, a period of about 2.373 hours was found, as was the case using the 2015 data set.



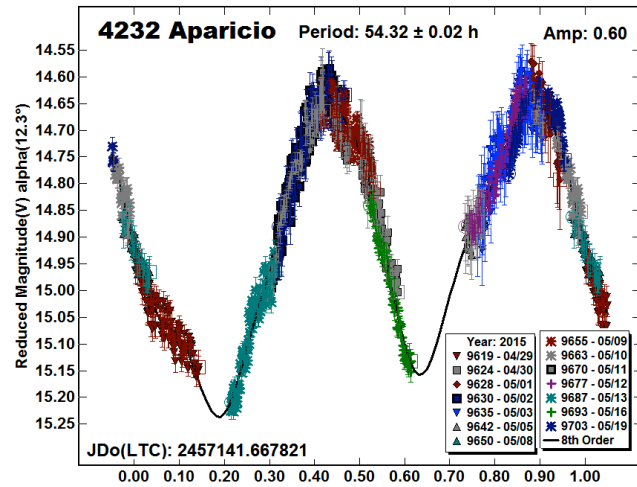
3483 Svetlov. This was the fourth apparition that this Hungaria was observed by the author. The period of 6.80 h found from the 2015 data set agrees within error bars of the previous results.



4142 Dersu-Uzala. The 2015 apparition was a case of “too little, too late.” Observations were not started until well after opposition, when observing runs were a small fraction of the previously reported periods of 71.2 h (Warner, 2007a) or 140 h with the possibility of tumbling (Warner, 2009c). This combined with a nearly full moon lead to abandoning the asteroid after two nights. The lightcurve shows the data forced to a period of 71 h, the one found in 2007. A 2nd order Fourier period search found a period of 64 ± 21 h.



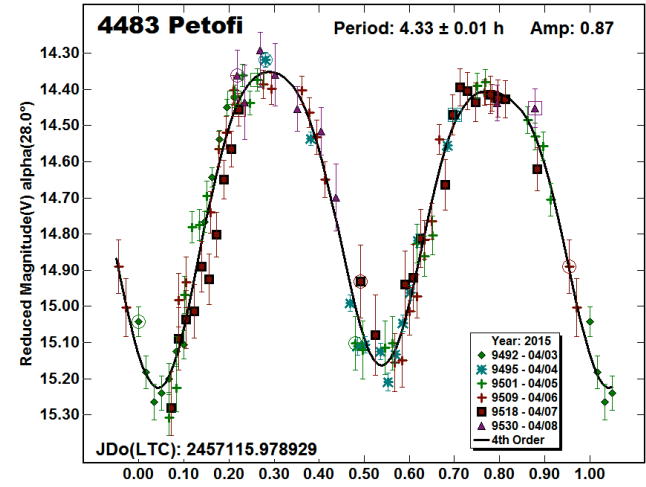
4232 Aparicio. The only previous reported period for this Hungaria was 54.4 h (Warner, 2006b). The results from 2015 support that earlier result.



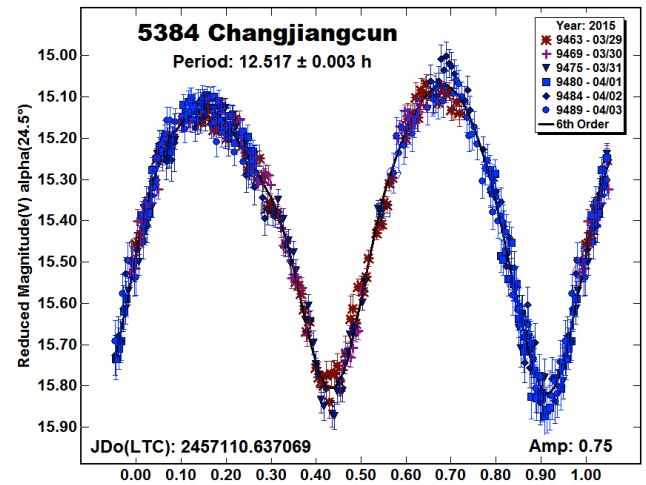
4483 Petofi. This was the fifth apparition that the author observed this Hungaria member. In all cases, the period was found to be close to 4.33 h. A preliminary pole solution in ecliptic coordinates of $(107^\circ, +40^\circ, 4.33299$ h) was reported by Warner (2011).

Whether or not Petofi is a member of the collisional family or just the orbital group is in debate. If using albedo, a family member should have a value of $p_V \sim 0.4$, or consistent with a type E (Warner *et al.*, 2009a). Masiero *et al.* (2012) found $p_V = 0.439$ based on an absolute magnitude of $H = 13.10$. However, the AKARI project (Usui *et al.*, 2011) found $p_V = 0.254$ using $H = 13.0$, which is consistent with a type S asteroid, of which there are a number in Hungaria orbital space. If a value of $H = 13.57$ (Pravec *et al.*, 2012) is used with albedo from Masiero

et al., and the formula by Harris and Harris (1997) is used to update the calculated albedo, this results in $p_V = 0.2872$, close to the value from AKARI. However, this also assumes using a value of $G = 0.42$, which was the value used by Pravec *et al.* to find a revised value for H . The result becomes $p_V = 0.3033$ if using $G = 0.15$. This is still closer to a mid-albedo type object, such as a type S, than to a high-albedo object, such as type E. The true status of Petofi waits for spectroscopic data that can firmly establish its taxonomic type.

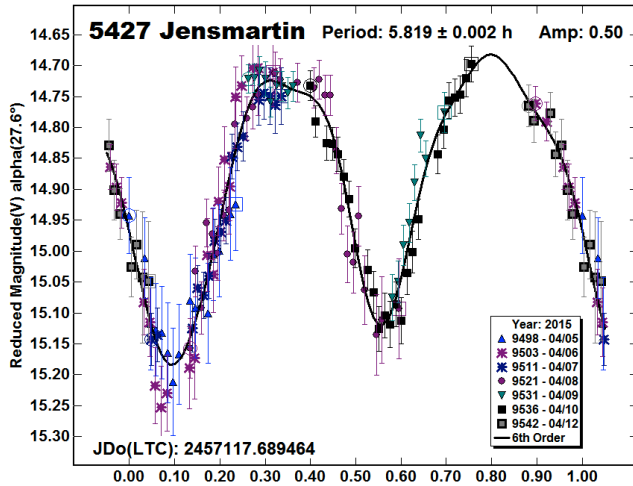


5384 Changjiangcun. Even though a member of Hungaria orbital space, it is almost certainly not a member of the family. IR observations by AKARI (Ususi *et al.*, 2011) and Masiero *et al.* (2012) both show this to be a low-albedo object, $p_V \sim 0.06$, which is more consistent with a type C class. The period found from the 2015 data agrees with previous findings by the author and Behrend (2007).

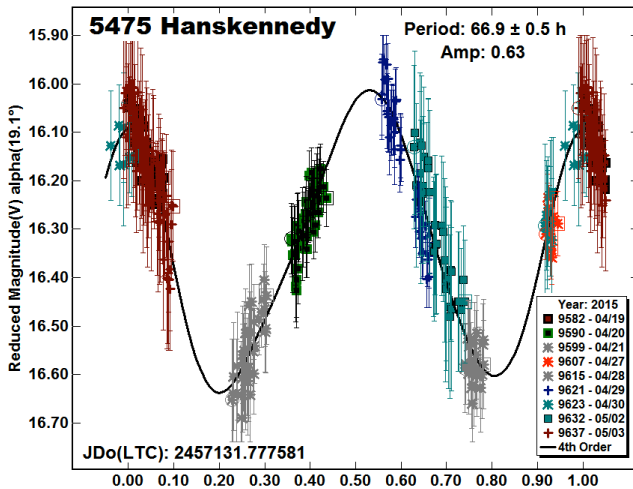


5427 Jensmartin. Analysis by the author at three previous apparitions and by Stephens (2014) all found a period of $P \sim 5.81$ h for Jensmartin, a likely member of the Hungaria family based on an albedo of $p_V = 0.78$ found during the first stage of the WISE mission (Mainzer *et al.*, 2011). This value is a bit excessive, mostly like due to using an incorrect value for H (13.4). Warner (2012a) found $H = 14.0$ and applied the formula from Harris and Harris (1997) to find $p_V = 0.3487$, which is still consistent with a type E asteroid, and so making this asteroid a likely member of the collisional family.

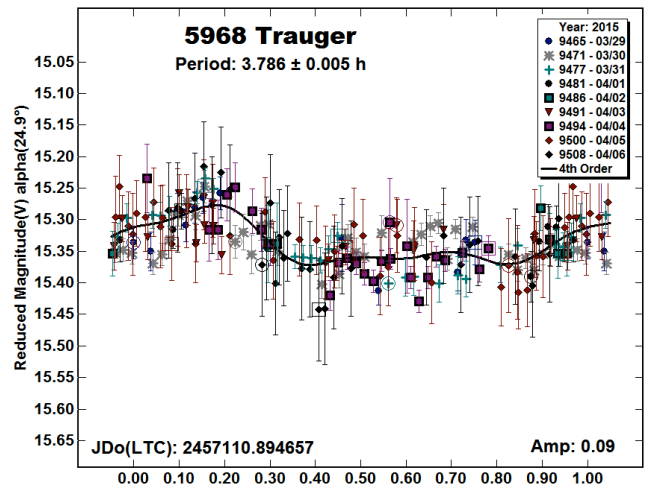
The initial period analysis of the 2015 data found a period of about 5.18 hours, considerably different from the earlier results. After forcing the period to a range between 5.7–6.0 hours and making minor adjustments to the zero points for some of the observing runs, the resulting period spectrum favored a period near 5.8 hours and had a lower RMS fit than with the previous result using the original zero points.



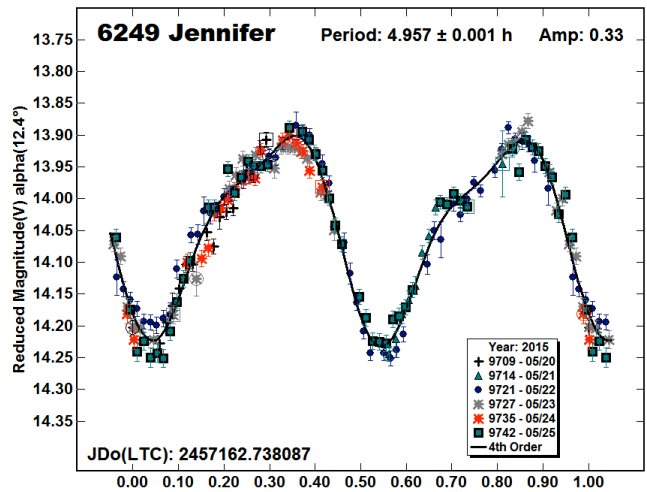
5475 Hanskennedy. This appears to be the first reported lightcurve for this asteroid. The solution is far from definitive but believed to be a valid estimate.



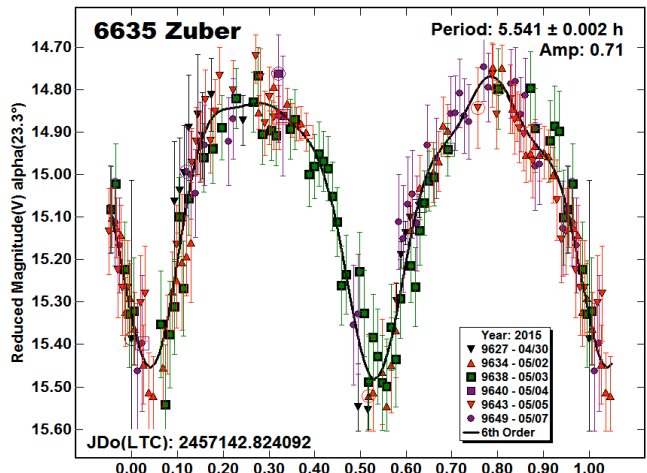
5968 Trauger. Based on previous results by the author (Warner, 2011a; 2012b; 2014a), the amplitude of this Hungaria never exceeds 0.20 mag, which can make the solution at least a little suspect (see Harris *et al.*, 2014). In 2015, the error bars of the individual measurements were on order with the amplitude, adding more to the uncertainty of the period of 3.786 h. However, it does closely agree with earlier results. Mainzer *et al.* (2011) found an albedo more consistent with a type S or similar asteroid, of which there are a large number known to be in Hungaria orbital space.



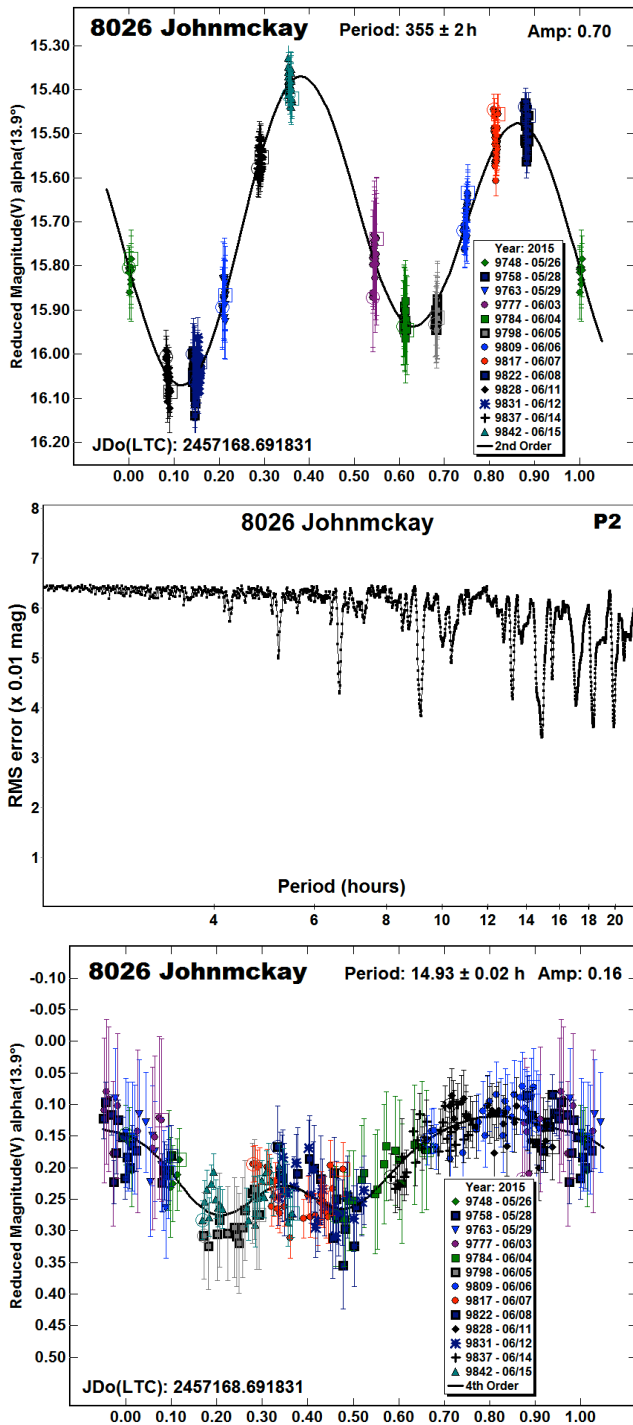
6249 Jennifer. The result of the 2015 analysis closely agrees with previous results by the author (e.g., Warner, 2006b; 2014). Maizer *et al.* (2011) found a high albedo for the asteroid. Even if corrected for a lower value of *H*, the result would still likely make this a type E asteroid.



6635 Zuber. The period of 5.541 h is slightly higher than the previous results of about 5.535 h (e.g., Warner, 2014). This may be the result of the noisy data.



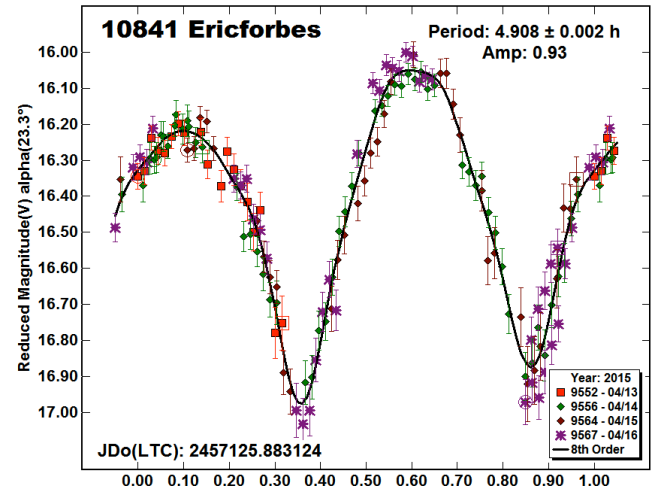
8026 Johnmckay. This Hungaria was reported to be a possible “wide binary” (Warner, 2011b), where the primary has a large amplitude lightcurve with a very long period and a short period, low amplitude component. Those earlier results were $P_1 = 372$ h, $A_1 = 0.9$ mag, $P_2 = 2.2981$ h, $A_2 = 0.10$ mag.



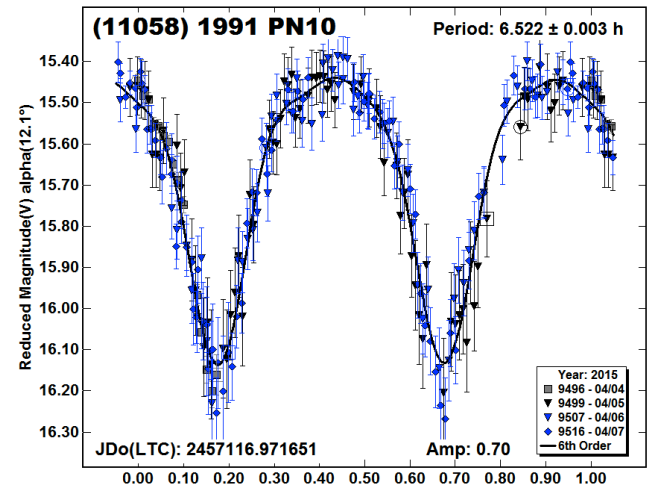
Analysis of the 2015 data again found a long-period, large-amplitude component of $P_1 = 355$ h, $A_1 = 0.7$ mag. Given the incomplete coverage of the long period in both cases, the two results for P_1 can be considered statistically the same. The difference is the solution for the shorter period. As the period spectrum for P_2 shows, the most favored solution is about 14.9 hours and any solution near 2.3 h is essentially non-existent. Zero-

points were moved up and down and in a wide range of values to see if the earlier result could be found, all to no avail. To remove the long period entirely required changes of more than 0.5 mag in many cases, which far exceeds any likely errors in catalog magnitudes. It’s possible that future observations with well-calibrated data from multiple observers might eventually resolve the true nature of this asteroid.

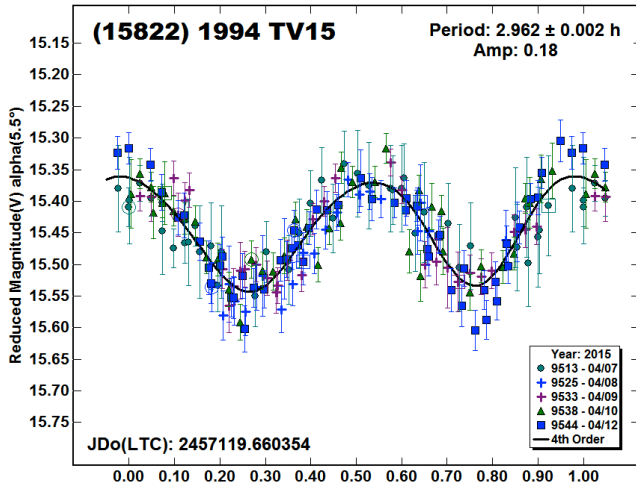
10841 Ericforbes. This appears to be the first reported lightcurve for this Hungaria. The large amplitude and four consecutive nights make the solution highly reliable.



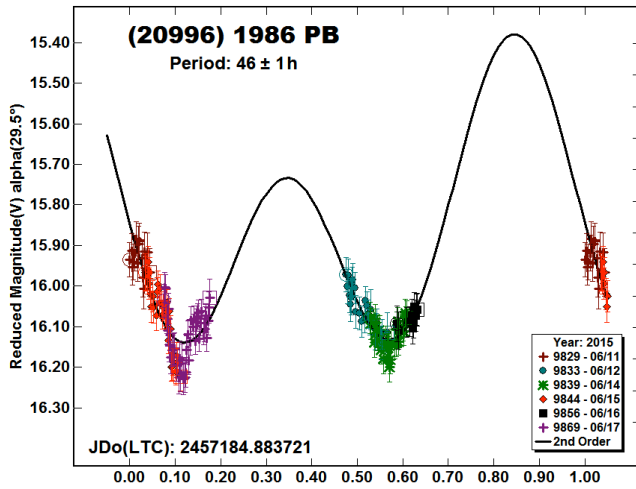
(11058) 1991 PN10. 2015 was the third apparition at which the author observed this Hungaria (Warner, 2011a; 2012b). The period of 6.522 h is consistent with those earlier results.



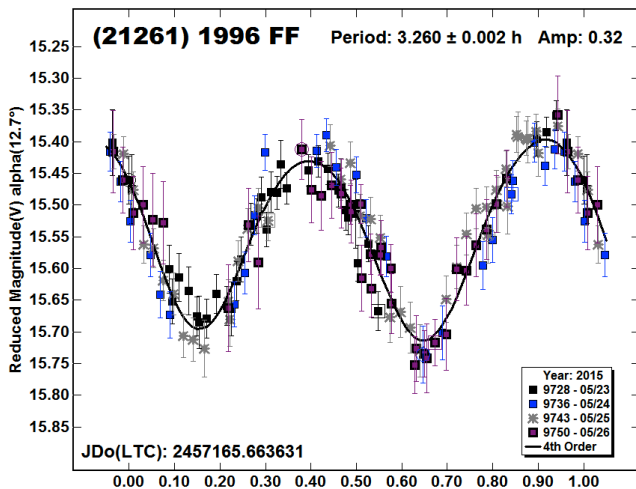
(15822) 1994 TV15. This Hungaria was observed by the author at four apparitions prior to 2015 (e.g., Warner, 2014a). As with the most recent analysis, the period was found to be $P \sim 2.9599$ h. The 2015 apparition showed the lowest amplitude, $A = 0.18$, by almost 0.1 mag, which may give an indication of its pole longitude. The phase angle bisector longitude (PAB, see Harris *et al.*, 1984) was 188° , and so the pole spin axis longitude may be close to that value, or 8° , depending on whether the observations were favoring the north or south pole of the asteroid. Waszczak *et al.* (2015) using data from the Palomar Transit Factory found a similar period. They also reported $H = 15.06$ (assuming $V-R = 0.45$). This is about 0.6 mag fainter than the value in the MPCORB file.



(20996) 1986 PB. The only previous result is 43.6 h (Warner, 2012b). The 2015 data was too sparse to find a reliable period. The plot has been forced to a solution in the range of 40-50 hours.

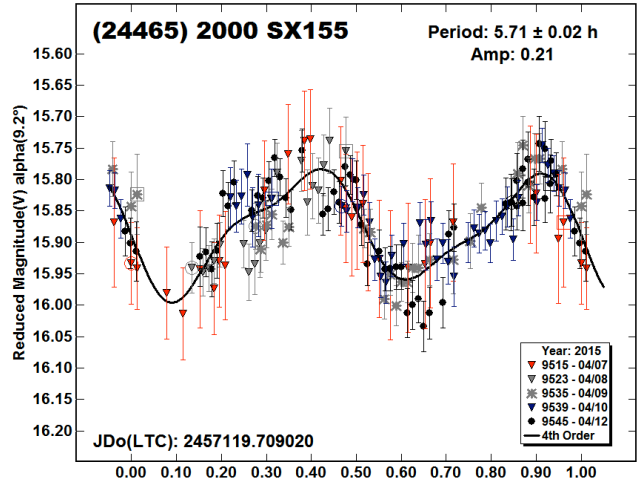


(21261) 1996 FF. This appears to be the first reported lightcurve for this Hungaria. The period makes it a possible candidate for being a binary. Future observations are planned and encouraged.

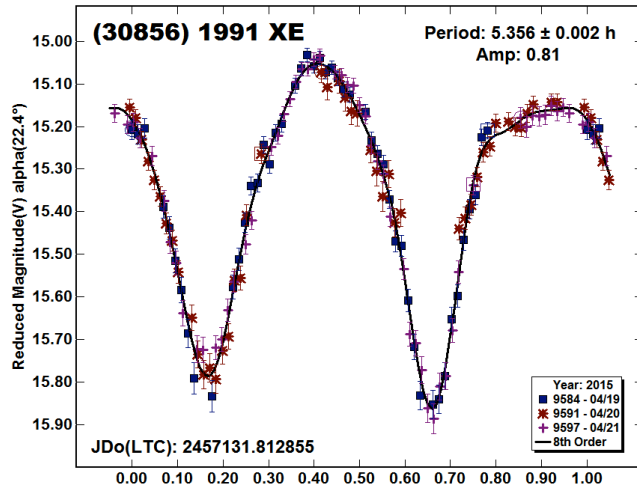


(24465) 2000 SX155. The two previous results from the author (Warner, 2009b, 9.156 h; 2012c, 21.46 h) could not have been

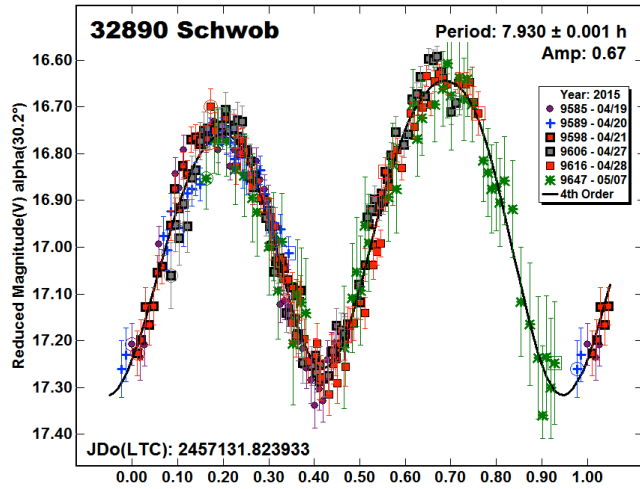
much more different. The 2012 results also included an alternate solution of 19 hours. Analysis of the 2015 data did little to resolve matters. Forcing the data to the previous results were unsatisfactory, the closest being a trimodal solution near 9.69 h. Given the reasonably good, but not perfect, fit to a period of 5.71 h, it should be adopted for the asteroid until more definite proof is available.



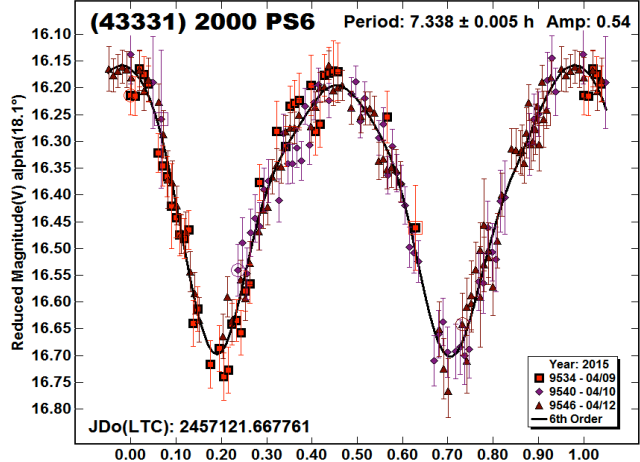
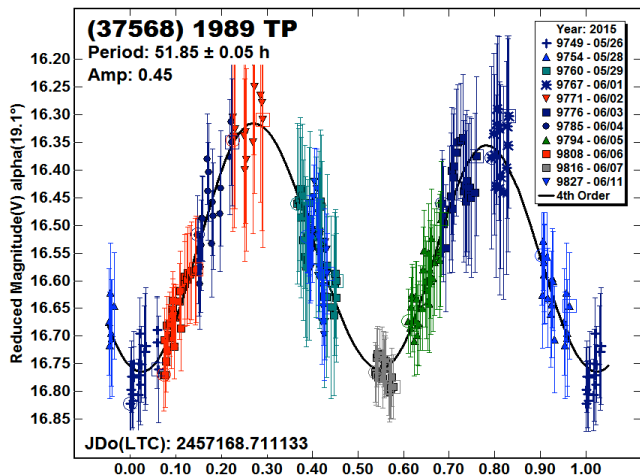
(30856) 1991 XE. The results from four previous apparitions (e.g., Warner, 2012c) ranged from 5.353 to 5.361 h, or statistically the same. The 2015 result is consistent with those.



32890 Schwob. This appears to be the first lightcurve for this Hungaria asteroid. The period solution is considered secure despite the single coverage of the lightcurve from rotation phase 0.80-0.95.

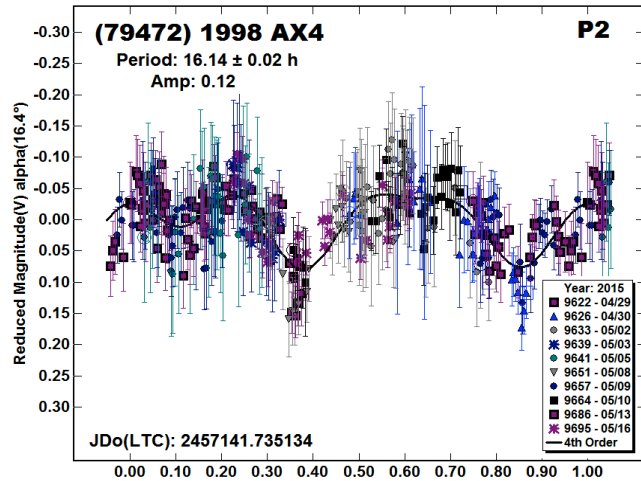
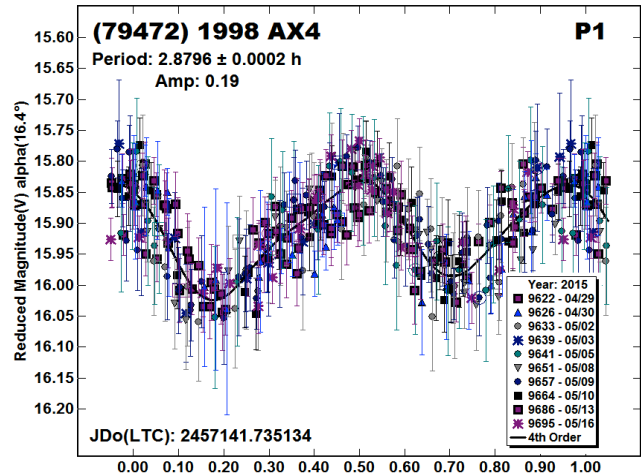


(37568) 1989 TP and (43331) 2000 PS6. No previous results were found in the LCDB for these two Hungarias.



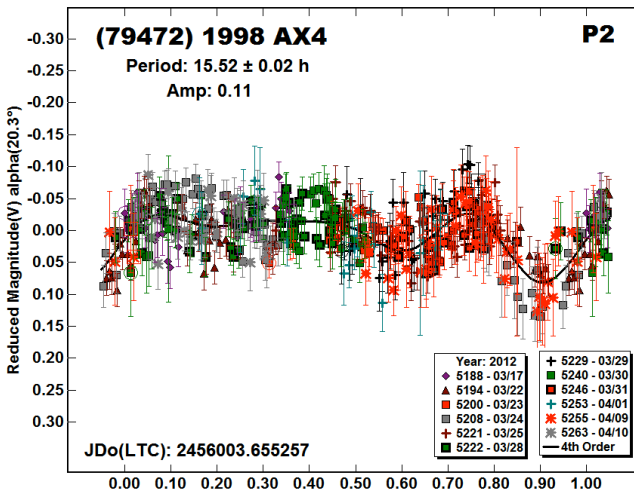
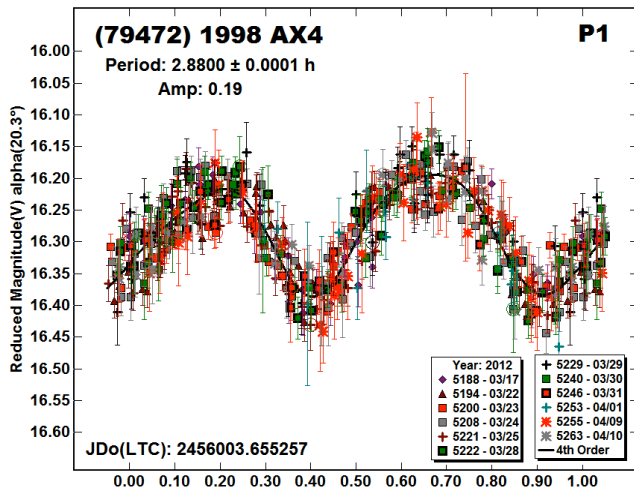
(79472) 1998 AX4. Warner (2012d) found a period of 2.28802 h and amplitude of 0.21 mag. Both of these made the asteroid a good candidate for being a binary. However, no evidence of such was found in the initial analysis of those earlier data.

The 2015 data, however, showed what appeared to be strong indications of a satellite based on deviations from the average lightcurve of a single period solution. A dual period search was run in *MPO Canopus*, with the results being $P_1 = 2.8796$ h and $P_2 = 16.14$ h. The shape of the secondary lightcurve does not appear to show signs of *mutual events*, i.e., occultations and/or eclipses, but instead favors the rotation of an elongated satellite that is tidally locked to its orbital period. The case is not conclusive given the noise in the data and the some irregularities in the secondary lightcurve.

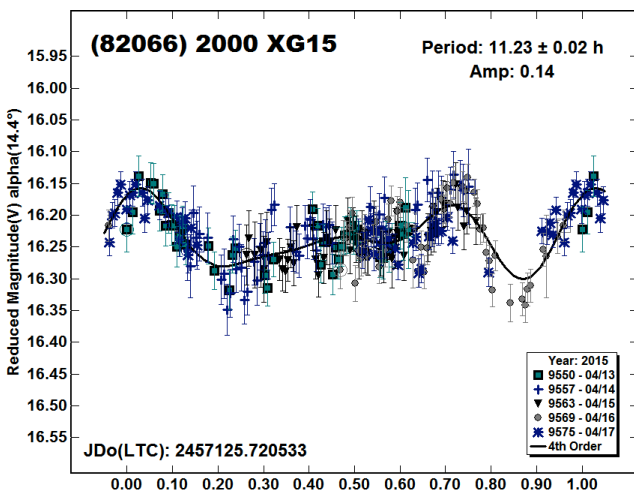


The results of the analysis on the 2015 data prompted another look at the data from 2012. The dual period search found a very reliable solution of $P_1 = 2.8800$ h, in good agreement with the 2015 period. However, the secondary period of $P_2 = 15.52$ h is significantly different. Moreover, the shape of the lightcurve is asymmetric and would not favor the same interpretation of a tidally-locked satellite.

Many attempts were made to force the data from one apparition to fit the solution other, with the constraint that the primary period (P_1) was near 2.880 hours. This included zero point shifts and searching an extended range of possible periods. In the end, the results were the same and the two solution sets cannot be fully reconciled. For now, the asteroid is considered a *possible* binary.

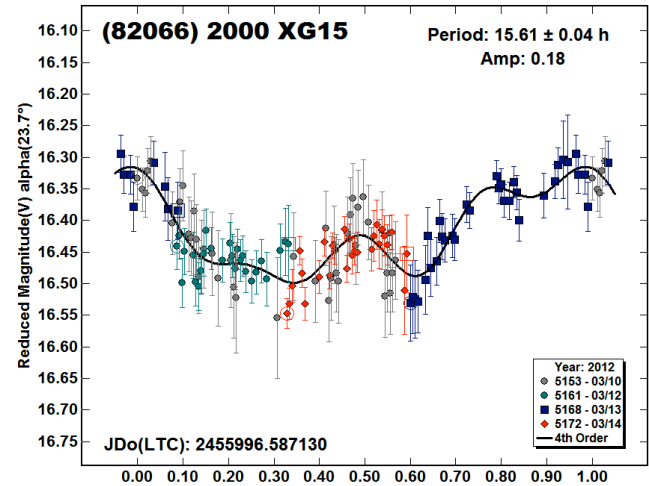


(82066) 2000 XG15. Analysis of the 2015 data favored a period of 11.23 hours. However, the asymmetry of the lightcurve and the single coverage near rotation phase 0.9 prompted a look at a period in the 7-8 hour range, or about 2/3 the favored solution.

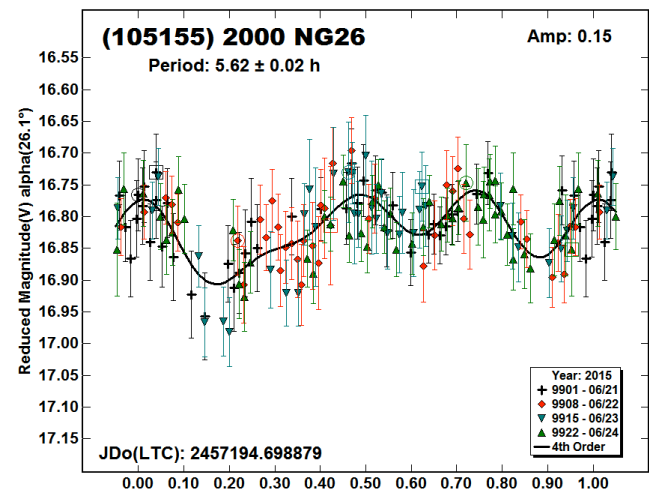


While a fit could be obtained, there were significant deviations from the Fourier curves, especially for the data from April 17. If those data were removed from the solution, the result was a single peak at about 0.2 rotation phase, a minimum at 0.3, and steady, flat-line rise from 0.3 to 1.0. This seemed an improbable solution and so the period of 11.23 hours is adopted for this paper when using the 2015 data.

The author worked the asteroid in 2012 (Warner, 2012c) and a period of 19.07 hours reported. The 2015 data could not be fit to that solution and a new search using the 2012 data was run. The best fit, still not convincing, is to a period of 15.6 hours, which is not commensurate with the period from 2015. The true rotation period for 2000 XG15 remains a mystery.



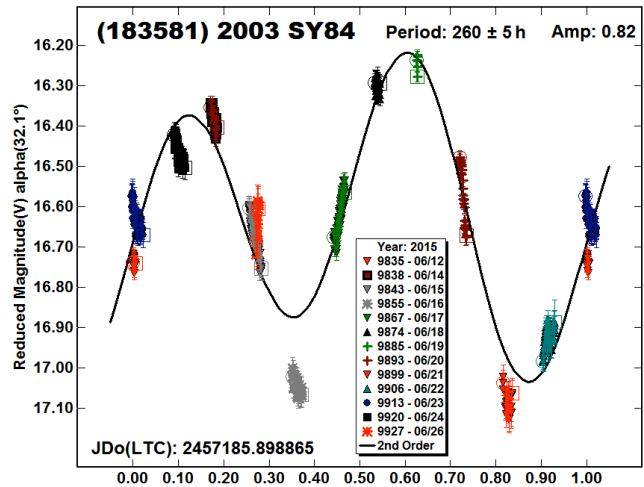
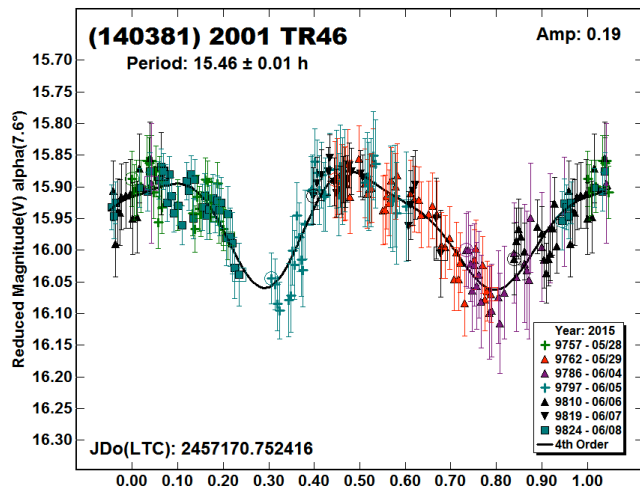
(105155) 2000 NG26. Warner (2012c) worked this asteroid in 2012 February. Analysis found many possible periods with the one of 5.08 h adopted. Analysis of the 2015 data produced a pronounced solution at 5.62 hours. Despite the somewhat unusual shape, not unexpected due to the phase angle and low amplitude, the new result is considered reliable, though not absolutely definitive.



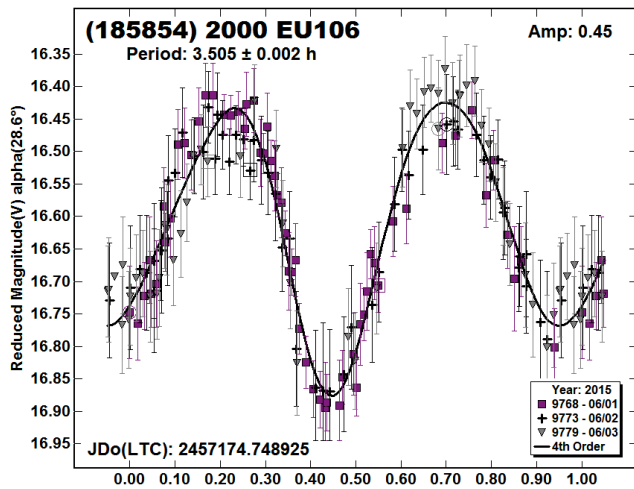
Number	Name	2015 mm/dd	Pts	Phase	L _{PAB}	B _{PAB}	Period	P.E.	Amp	A.E.	Group
3225	Hoag	03/26-03/28	123	15.4,14.5	207	8	2.373	0.002	0.12	0.01	H
3483	Svetlov	03/29-04/03	349	22.1,23.1	156	30	6.80	0.01	0.28	0.04	H
4142	Dersu-Uzala	04/04-04/05	65	36.6,36.6	134	34	71	3	0.65	0.10	H
4232	Aparicio	04/29-05/19	1084	12.3,18.2	216	20	54.32	0.02	0.6	0.03	H
4483	Petofi	04/04-04/08	104	27.9,27.6	248	26	4.33	0.01	0.87	0.05	H
5384	Changjiangcun	03/29-04/03	456	24.5,24.8	174	32	12.517	0.003	0.76	0.03	H
5427	Jensmartin	04/05-04/12	135	27.7,28.6	142	-22	5.819	0.002	0.50	0.03	H
5475	Hanskennedy	04/19-05/03	320	19.2,17.4	225	31	66.9	0.5	0.63	0.05	H
5968	Trauger	03/29-04/05	197	24.9,22.8	226	15	3.786	0.005	0.09	0.02	H
6249	Jennifer	05/20-05/25	179	12.4,15.1	218	2	4.957	0.001	0.33	0.02	H
6635	Zuber	04/30-05/05	143	23.3,22.3	254	27	5.548	0.005	0.67	0.05	H
8026	Johnmckay	05/26-06/15	277	14.0,0.0,23.1	207	7	355 ^P	5	0.66	0.03	H
10841	Ericforbes	04/13-04/16	153	23.3,24.0	178	27	4.908	0.002	0.95	0.05	H
11058	1991 PN10	04/04-04/07	241	12.0,12.4	196	17	6.522	0.003	0.78	0.05	H
15498	1999 EQ4	¹⁴ 12/31-12/31	25	12.0,0.0,12.4	203	1	?				EOS
15822	1994 TV15	04/07-04/12	189	5.6,8.7	188	0	2.962	0.002	0.18	0.02	H
20996	1986 PB	06/11-06/17	156	29.5,28.3	303	26	46	1	0.4	0.1	H
21261	1996 FF	05/23-05/26	145	12.6,13.8	230	16	3.260	0.001	0.31	0.02	H
24465	2000 SX155	04/07-04/12	173	9.2,10.5	190	13	5.71	0.02	0.21	0.03	H
30856	1991 XE	04/19-04/21	150	22.4,21.7	239	20	5.356	0.002	0.80	0.03	H
32890	Schwob	04/19-05/07	277	30.2,25.5	238	35	7.930	0.001	0.67	0.04	H
37568	1989 TP	05/26-06/11	240	19.1,27.1	220	6	51.85	0.05	0.47	0.03	H
43331	2000 PS6	04/09-04/12	184	18.1,18.7	194	26	7.338	0.005	0.53	0.04	H
79472	1998 AX4	04/29-05/16	356	16.4,15.3,15.5	226	26	2.8796 ^P	0.0002	0.19	0.03	H
79472	1998 AX4	¹² 03/22-04/10	457	20.3,22.2	178	34	2.8800 ^P	0.0001	0.19	0.03	H
82066	2000 XG15	04/13-04/17	255	14.4,13.0	213	18	11.23	0.02	0.17	0.02	H
82066	2000 XG15	¹² 03/10-03/14	132	23.6,24.3	152	33	15.6	0.1	0.15	0.03	H
105155	2000 NG26	06/21-06/24	164	26.1,26.1	262	37	5.62	0.02	0.15	0.03	H
140381	2001 TR46	05/28-06/08	214	7.6,13.3	239	5	15.46	0.01	0.22	0.02	H
183581	2003 SY84	06/12-06/26	508	32.1,34.7	262	42	260	5	0.87	0.05	MC
185854	2000 EU106	06/01-06/03	165	28.8,28.6	262	32	3.505	0.002	0.46	0.03	MC

Table II. Observing circumstances. ^{xx} Before a date: observations in 20xx. ^A preferred period of an ambiguous solution. ^P period of the primary in a binary system. The phase angle (α) is given at the start and end of each date range, unless it reached a minimum, which is then the second of three values. If a single value is given, the phase angle did not change significantly and the average value is given. L_{PAB} and B_{PAB} are each the average phase angle bisector longitude and latitude, unless two values are given (first/last date in range). The Group column gives the orbital group to which the asteroid belongs. The definitions and values are those used in the LCDB (Warner *et al.*, 2009). H = Hungaria; MC = Mars-crosser.

(140381) 2001 TR46 and (183581) 2003 SY84. No entries were found in the LCDB for either Hungaria. The solution for 2001 TR46 is considered secure. 2003 SY84 may be in non-principal axis rotation (NPAR, or tumbling). The slopes of some of the sessions are in conflict with the slope of the Fourier model curve at the time.



(185854) 2000 EU106. Skiff *et al.* (2012) reported a period of 3.50 hours based on observations in 2008. Analysis of the PDS data from 2015 gives a period consistent with that earlier result.



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LIGHTCURVE ANALYSIS OF TWO NEAR EARTH ASTEROIDS

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Two near-Earth asteroids (NEAs) were observed from Cerro Tololo Inter-American Observatory in May and June 2015. 2014 YB35 was found to have a synodic rotation period of 3.277 h with an amplitude of 0.16 mag. (68216) 2001 CV26 has a well-established rotational period of 2.429 h and displayed some weak evidence of mutual events.

Observations of two NEAs, 2014 YB35 and (68216) 2001 CV26 are a byproduct of a study of Jovian Trojan asteroids the authors have been conducting for several years. Observing time was scheduled for 5 nights on the 4-meter Victor Blanco telescope and an additional 10 nights using the 0.9-meter telescope at Cerro Tololo Inner-American Observatory (CTIO). Since the primary Trojan targets became too low to observe with about 4 hours of darkness left, the team elected to observe NEAs rather than allow photons to bounce harmlessly off the dome shutters. Two NEAs were selected.

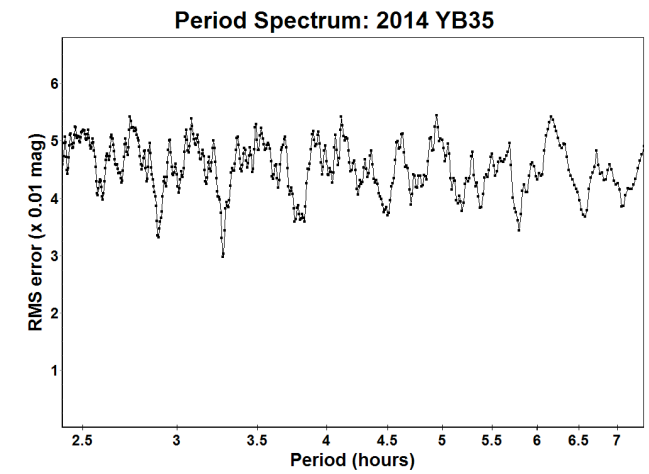
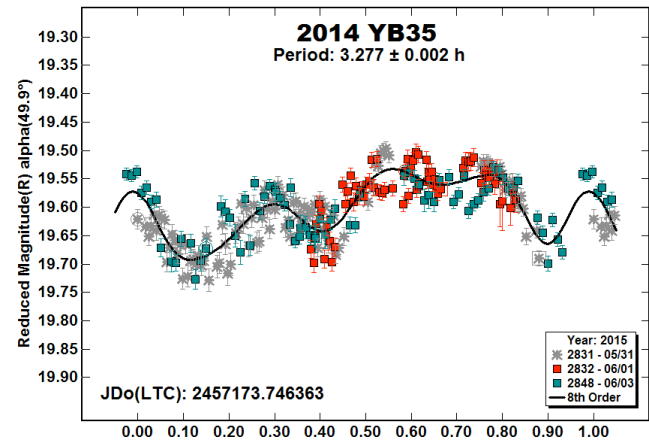
2014 YB35 was observed using the 4-meter Blanco telescope and the Dark Energy Camera (DECam). Exposures 300 seconds through the DECam r filter. Observations of (68216) 2001 CV26 were made with the CTIO 0.9-m SMARTS telescope using a Johnson R filter. All images taken at CTIO were unbinned.

Image processing, measurement and period analysis was done using *MPO Canopus* (Bdw Publishing), which incorporates the Fourier analysis algorithm (FALC) developed by Harris (Harris *et al.*, 1989). Night-to-night calibration of the data (generally $< \pm 0.05$ mag) was done using MPOSC3 catalog provided with *Canopus*,

whose stars are converted to approximate Cousins R magnitudes based on 2MASS J-K colors (Warner 2007).

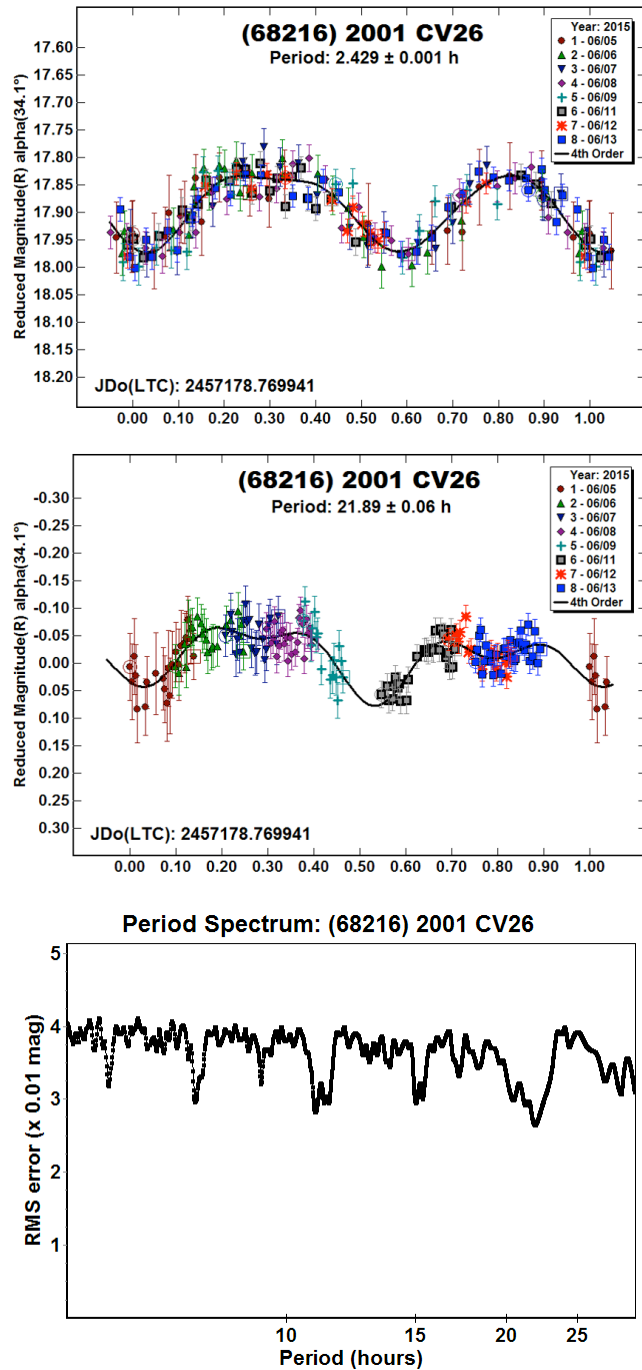
In the lightcurve plots, the “Reduced Magnitude” is Johnson R corrected to a unity distance by applying $-5 \cdot \log(r\Delta)$ to the measured sky magnitudes with r and Δ being respectively, the Sun-asteroid and the Earth-asteroid distances in AU. The magnitudes were normalized to the phase angle given in parentheses using $G = 0.15$.

2014 YB35. No previously reported rotational periods for this NEA could be found in the Lightcurve Database (LCDB; Warner *et al.*, 2009). With an amplitude of only 0.16 mag, it is possible that the lightcurve could have only a single extrema, or three or more extrema (Harris *et al.* 2014). Due to high cirrus clouds, we were only able to follow 2014 YB35 for three nights. However, the complex lightcurve is repeating and not symmetrical favoring the 3.277 h period.



(68216) 2001 CV26. According to the Lightcurve Database (LCDB; Warner *et al.*, 2009) this Apollo has been studied several times before and has a well-established rotational period. Warner (Warner 2013) got a high density lightcurve in March 2013 reporting a period of 2.4290 ± 0.0002 h. Using observations over five nights in August and September 2012, Hill (Hill, 2013) reported the same period. Polishook (Polishook, 2012) reported a period of 2.427 ± 0.004 h from observations obtained on 2 nights in March 2010. Finally Hicks (Hicks *et al.*, 2010) reports a period of 2.409 ± 0.021 h based upon observations obtained in March 2010. We obtained further observations to contribute to a future pole solution and shape model.

On three nights of our run, we noticed data points that seemed to deviate from the Fourier curve with a signature suggestive of a satellite. We did an analysis to solve for two rotational periods and found a single secondary period of 21.89 ± 0.06 h which would fit our data. However, this is a ‘fit-by-exclusion’ solution. There is no overlap of data for the mutual events predicted by this analysis, so the presence of a secondary body is tenuous at best. Radar observations at the Arecibo and Goldstone radio telescopes were obtained several times over the years. The Arecibo signal in October 2009 was very strong which should have detected any satellite (Benner *private communication*). The presence of a satellite remains unproven; it is likely that the aberrant observations on the three nights were observing artifacts.



Acknowledgements

French, Stephens and Connour were visiting astronomers at Cerro Tololo Inter-American Observatory, National Optical Astronomy Observatory, operated by the Association of Universities for Research in Astronomy, under contract with the National Science Foundation. The Cerro Tololo 0.9-m telescope is operated by the SMARTS Consortium. This research was supported by National Science Foundation grant AST-1212115.

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ROTATION PERIOD DETERMINATION FOR 2641 LIPSCHUTZ

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Photometric observations of the main-belt asteroid 2641 Lipschutz performed by the authors from Italy in 2015 April revealed a bimodal lightcurve phased to 21.62 ± 0.03 hours as the most likely solution resulting from the synodic rotation rate for the asteroid.

2641 Lipschutz (1949 GJ) is a main-belt asteroid discovered on 1949 April 4 by the Indiana Asteroid Program, Goethe Link Observatory at University of Indiana, and named in honor of Michael E. Lipschutz, professor of chemistry at Purdue University. It orbits with a semi-major axis of about 2.38 AU, eccentricity 0.13, and a period of 3.67 years; its absolute magnitude is 12.7 (JPL, 2015). Alvarez-Candal *et al.* (2006) determined a spectral classification of S for the asteroid.

A search of the asteroid lightcurve database (LCDB; Warner *et al.*, 2009) indicates that our results constitute the first reported lightcurve observations and results for this object. The asteroid was reported as a lightcurve photometry opportunity in the *Minor Planet Bulletin* (Warner *et al.*, 2015).

Observations at the Astronomical Observatory of the University of Siena were carried out on eight consecutive nights from 2015 April 6-13 using a 0.30-m $f/5.6$ Maksutov-Cassegrain telescope, SBIG STL-6303E NABG CCD camera, and clear filter. The pixel scale was 2.26 arcsec when binning 2x2. Exposure times were 300 seconds for all images. A total of 437 data points were collected. Over the interval of about 8 days, the phase angle ranged from 2.0 degrees before opposition to 3.2 degrees after opposition.

Images were calibrated with bias, flat, and dark frames. Data processing, including reduction to R band and period analysis was performed using *MPO Canopus* (BDW Publishing, 2012). Differential photometry measurements were performed using the Comp Star Selector (CSS) procedure in *MPO Canopus* that allows selecting of up to five comparison stars of near solar-color. Subsequently, additional adjustments of the magnitude zero-points for the particular data sets were carried out in order to achieve the best alignment among them by finding the minimum RMS value from the Fourier analysis.

The period analysis yielded several possible solutions that clearly stand out in the period spectrum (RMS vs. period; Fig. 1) with nearly comparable RMS errors. Despite the period spectrum showing possible solutions at 10.81 h (monomodal lightcurve), 21.62 h (bimodal), and 32.43 h (trimodal), we concluded that the most likely value of the synodic period for 2641 Lipschutz is associated with the bimodal lightcurve phased to 21.62 ± 0.03 hours with an amplitude of 0.24 ± 0.03 mag (Fig. 2).

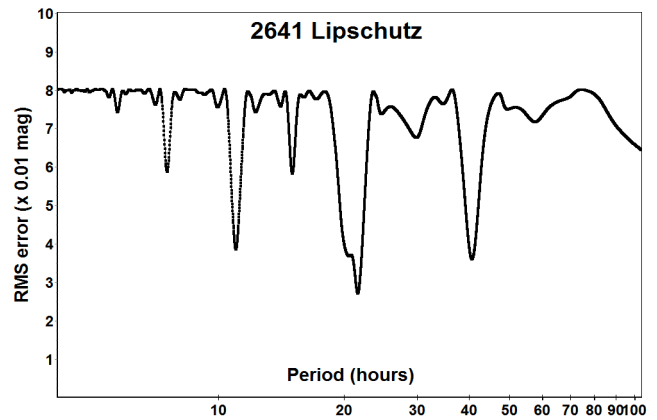


Figure 1. The period spectrum for 2641 Lipschutz shows several possible solutions.

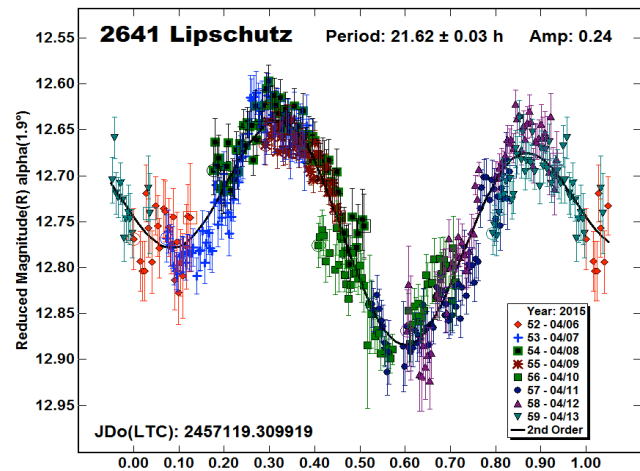


Figure 2. The lightcurve for 2641 Lipschutz phased to the adopted period of 21.62 h.

Acknowledgments

Some observing sessions at the Astronomical Observatory of the University of Siena were attended by Jacopo Soldateschi, a student of the course in Physics and Advanced Technologies, during his internship activities.

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**ASTEROIDS OBSERVED FROM CS3:
RESULTS FOR 1754 CUNNINGHAM AND
7023 HEIANKYO**

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CCD photometric observations of 1754 Cunningham, and 7023 Heiankyo were obtained from the Center for Solar System Studies from 2015 June to July. For 1754, the period of 7.7416 ± 0.0005 hours appears to be about twice the previously reported value. For 7023, our solution of 10.807 ± 0.002 hours matches one previously noted possible solution.

During this calendar quarter, the Center for Solar System Studies (CS3, MPC U81) was mostly focused on studying Jovian Trojan family asteroids. However, once the L4 Trojan cloud was too low to observe, we switched over to ‘targets of opportunity’. The short Northern Hemisphere summer nights, location of the Milky Way and the Full Moon limited the targets which could be selected in late June.

All images were made with a 0.4-m or a 0.35-m SCT using an FLI-1001E or a SBIG STL-1001E CCD camera. Images were unbinned with no filter and had master flats and darks applied to the science frames prior to measurement. Measurements were made using *MPO Canopus* (Bdw Publishing), which employs differential aperture photometry to produce the raw data. Period analysis was also done using *MPO Canopus*, which incorporates the Fourier analysis algorithm (FALC) developed by Harris (Harris *et al.*, 1989). Night-to-night calibration of the data (generally $< \pm 0.05$ mag) was done using field stars converted to approximate Cousins V magnitudes based on 2MASS J-K colors (Warner 2007). The Comp Star Selector feature in *MPO Canopus* was used to limit the comparison stars to near solar color.

1754 Cunningham. This Hilda family member was previously observed by Dahlgren (Dahlgren *et al.*, 1998) reporting a rotational period of 4.285 h. This result was based upon 4 nights of observations in May of 1992 with only about a third of resulting lightcurve having observations from multiple nights. Their reported rotational period appears to be an alias of this year’s secure result, although the ratio cannot exactly be worked out.

7023 Heiankyo. Using sparse data from the Palomar Transient Factory survey, Waszczak (Waszczak *et al.*, 2015) reported three possible periods for this Vestoid family member of 10.819 h, 14.901 h, and 38.948 h. Their 10.819 h period is similar to our period using a much denser dataset.

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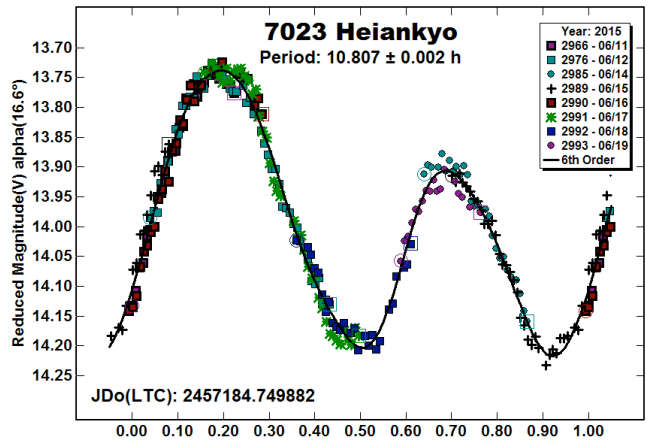
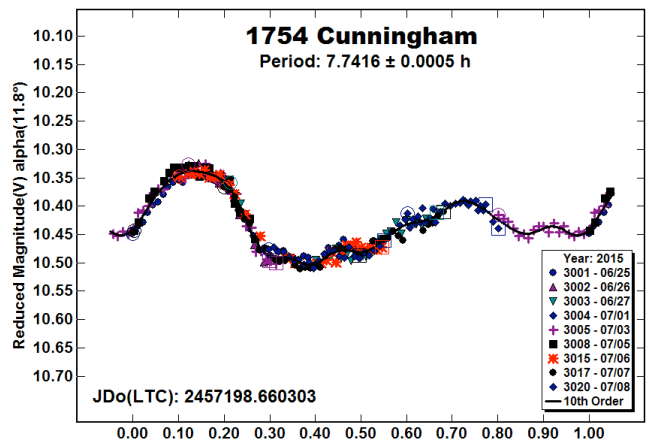
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Acknowledgements

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Number	Name	2015 mm/dd	Pts	Phase	L _{PAB}	B _{PAB}	Period	P.E.	Amp	A.E.	Grp
1754	Cunningham	06/25-06/27	279	11.8, 14.2	240	14	7.7416	0.0005	0.17	0.01	HIL
7023	Heiankyo	06/11-07/08	266	16.6, 19.4	231	7	10.807	0.002	0.48	0.02	V

ROTATION PERIOD DETERMINATIONS FOR 134 SOPHROSYNE, 521 BRIXIA, AND 873 MECHTHILD

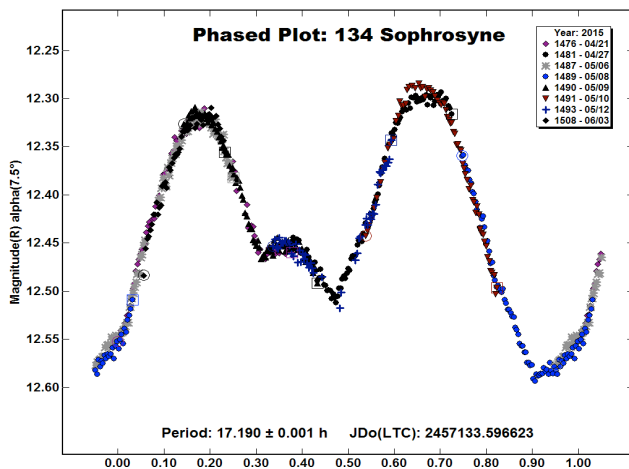
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(Received: 2015 July 6)

Synodic rotation periods and amplitudes have been found for 134 Sophrosyne 17.190 ± 0.001 h, 0.28 ± 0.01 mag; 521 Brixia 28.479 ± 0.001 h, 0.12 ± 0.01 mag; 873 Mechthild 11.006 ± 0.001 hours, 0.23 ± 0.02 mag.

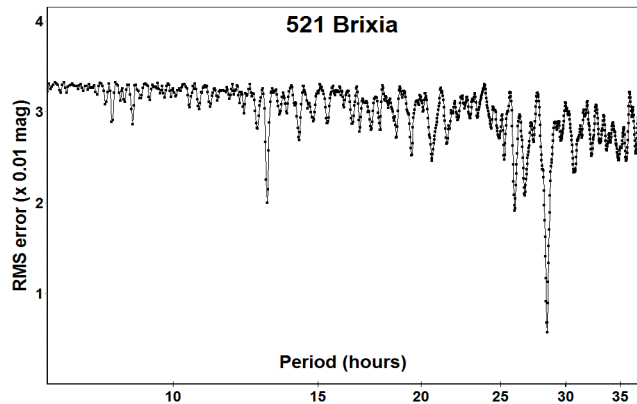
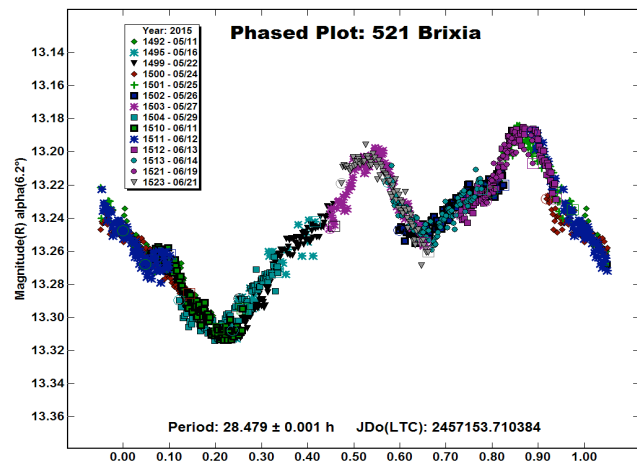
To obtain synodic rotation periods for 134 Sophrosyne, 521 Brixia, and 873 Mechthild, the author at Organ Mesa Observatory used a 35.4-cm Meade LX200 GPS Schmidt-Cassegrain and SBIG STL-1001-E CCD. Photometric measurements and lightcurve construction were done with *MPO Canopus* software. All exposures were 60 seconds, unguided, and made with a clear filter. To reduce the number of 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.

134 Sophrosyne. The only previous photometric lightcurves were obtained in late 1980 and published by Harris and Young (1989), who found a period of 17.196 hours. It was considered useful to obtain another data set after more than 34 years. New observations on eight nights 2015 Apr 21 - Jun 3 provide a good fit to a lightcurve phased to 17.190 ± 0.001 h with amplitude 0.28 ± 0.01 mag. This is in excellent agreement with Harris and Young (1989).

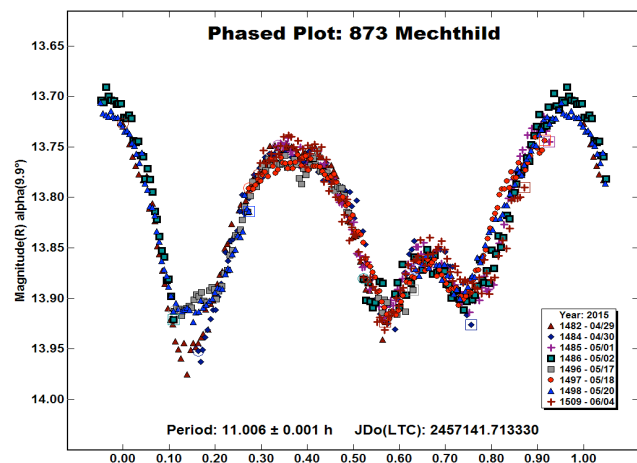


521 Brixia. Previous reported rotation periods are by Surdej *et al.* (1983, >24 hours), Wang *et al.* (2010, 28.2 hours), and Warner (2009), who found his data consistent with possible periods of 9.78, 19.57, or 18.35 h. New observations on 14 nights 2015 May 11 - Jun 21 provide a good fit to an asymmetric bimodal lightcurve of period 28.479 ± 0.001 h with amplitude 0.12 ± 0.01 mag. I also show the period spectrum from 8- 38 hours that rules out all periods within this range except 28.48 h, including all three possible periods suggested by Warner (2009). It is consistent with the lower accuracy findings by Surdej *et al.* (1983) and by Wang *et al.* (2010). The double-period lightcurve, with about 95% phase coverage, features left and right sides that are identical within errors of observation, each of which looks like the 28.48-hour

lightcurve. If the double period were the correct one, it would indicate a shape model for the asteroid that is both very irregular and highly symmetric over a 180 degree rotation. This is extremely unlikely for a real asteroid. The double period may be safely rejected, and the 28.479-hour period can be considered secure.



873 Mechthild. The only previous period determination is an approximate 10.6 hours by Lagerkvist (1978). New observations on eight nights 2015 Apr 29 - Jun 4 provide a good fit to a lightcurve phased to 11.006 ± 0.001 h with amplitude 0.23 ± 0.02 mag. This period is close to the less accurate 10.6 h by Lagerkvist (1978).



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**ROTATION PERIOD DETERMINATION FOR
4149 HARRISON AND (5633) 1978 UL7**

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Analysis of photometric observations of two main-belt asteroids were performed by the authors in Italy from 2015 April to June. Assuming bimodal lightcurves, the synodic periods were: 4149 Harrison, $P = 3.956 \pm 0.001$ h and (5633) 1978 UL7 $P = 7.212 \pm 0.001$ h.

All the observatories involved in this study are located in Italy. Table I lists the observers and equipment used.

Observer	Telescope	Filter	CCD
Franco (A81)	0.2-m f/5.5 SCT	C	SBIG ST-7XME
Marchini (K54)	0.3-m f/5.6 MCT	C	SBIG STL-6303E (bin 2x2)
Papini (K49)	0.25-m f/10 SCT	C	SBIG ST-9XME
Salvaggio	0.24-m f/10 SCT	C	SBIG ST-8XME NABG (bin 2x2)

Table I. Instruments used for observations. SCT: Schmidt-Cassegrain. R-C: Ritchey-Chretien. MCT: Maksutov-Cassegrain.

Each observer calibrated his images with dark and flat-field frames. Photometric processing was performed by one of us with *MPO Canopus* v10.4.7.6 (Warner, 2015). Differential photometry measurements were performed using the Comp Star Selector (CSS) procedure in *MPO Canopus* that allows selecting of up to five comparison stars of near solar-color. Subsequently, the additional adjustments of the magnitude zero-points for the particular data sets were carried out in order to achieve the best alignment between them, *i.e.*, to reach the minimum RMS value from the Fourier analysis.

A search of the asteroid lightcurve database (LCDB; Warner *et al.*, 2009) indicates that these lightcurves might constitute the first complete observations of these objects covering a full synodic period. Similarly, no synodic period rate was found in the literature. Both asteroids were reported as a lightcurve photometry opportunity in the *Minor Planet Bulletin* (Warner *et al.*, 2015).

4149 Harrison is a main-belt asteroid discovered on 1984 March 9 by B.A. Skiff at the Anderson Mesa Station of the Lowell Observatory and is named in honor of George Harrison, the "quiet" Beatle. It orbits with a semi-major axis of about 2.66 AU, eccentricity 0.12, and a period of 4.35 years. According to the WISE satellite infrared radiometry, the diameter is 10.739 ± 0.042 km using an absolute magnitude $H = 12.3$ (Masiero *et al.*, 2012).

Observations were made on five nights from 2015 June 11-26 with a total of 151 useful data points collected over that interval. The phase angle ranged from 9.3° to 12.3° after the opposition. Images were taken unfiltered at Balzaretto Observatory (A81), at Astronomical Observatory of the University of Siena (K54), and at Saronno Observatory.

The period analysis yielded several possible solutions that clearly stand out in the period spectrum (RMS vs. period, Fig. 1) with nearly comparable RMS errors.

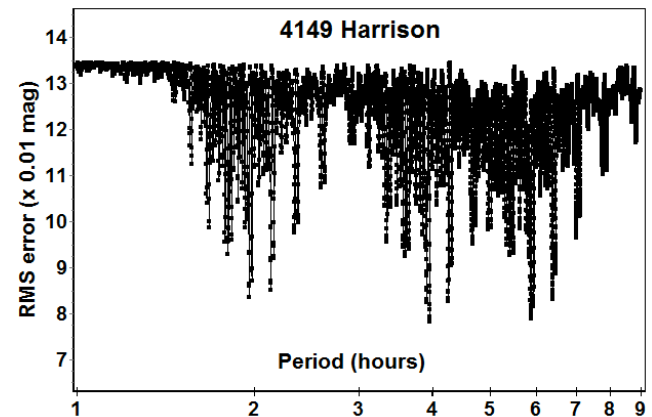


Figure 1. The period spectrum for 4149 Harrison shows several possible solutions with nearly the same error.

Despite the period spectrum showing possible solutions of about 1.95 hours (monomodal), 3.9 hours (bimodal), and 6 hours (trimodal), we concluded that the most likely value of the synodic period for 4149 Harrison is associated with a bimodal lightcurve phased to 3.956 ± 0.001 hours with an amplitude of 0.37 ± 0.03 mag because large amplitudes would be improbable for monomodal or trimodal lightcurves as explained in the *MPO Users Guide* (Warner, 2015).

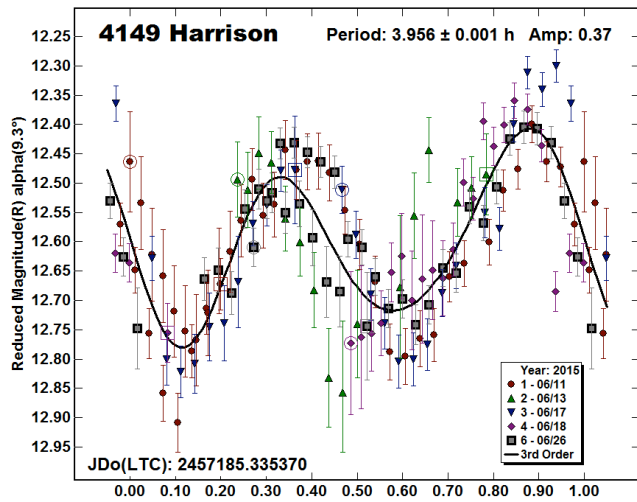


Figure 2. The lightcurve for 4149 Harrison phased to the adopted period of 3.956 ± 0.001 hours.

During period analysis, we found two attenuation events in the lightcurves which cannot be confirmed with the existing data. Observations at future oppositions will be required to verify of the possibility of the asteroid being binary.

(5633) 1978 U7. This main-belt asteroid was discovered on 1978 October 27 by C.M. Olmstead at Palomar. It orbits with a semi-major axis of about 2.15 AU, eccentricity 0.11, and a period of 3.15 years.

Observations were made on six nights from 2015 May 10-24, but only five nights provided a usable data set of 304 data points. During the interval of 14 days, the phase angle ranged from 4.1° to 12.5° after opposition. Images were taken unfiltered at Astronomical Observatory of the University of Siena (K54).

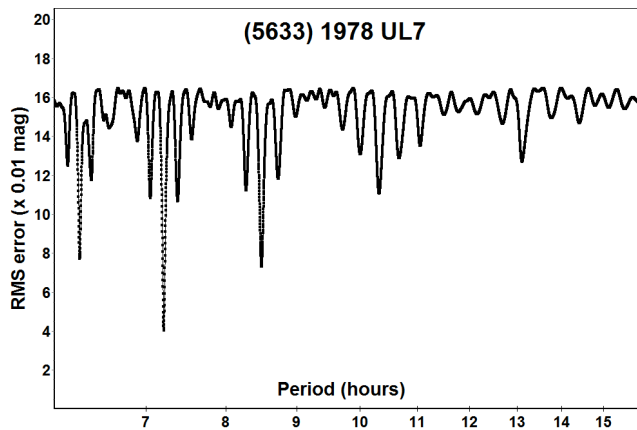


Figure 3. The period spectrum for (5633) 1978 UL7 shows several possible solutions but one is the most prominent.

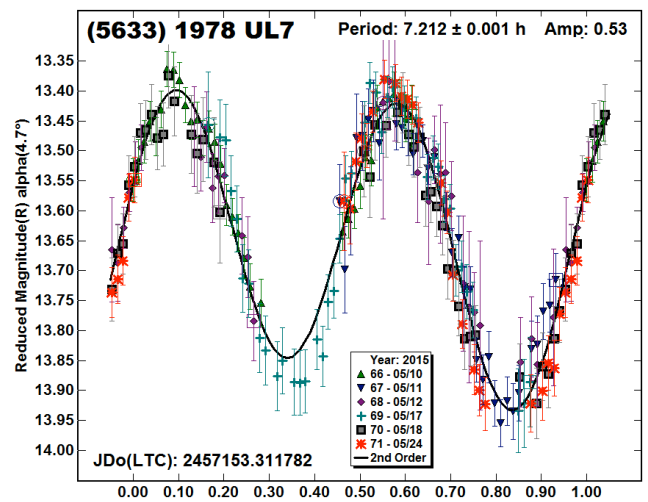


Figure 4. The lightcurve for (5633) 1978 UL7 phased to the adopted period of 7.212 ± 0.001 hours.

The period analysis yielded several possible solutions (Fig. 3) with comparable RMS errors. However we concluded that the most likely value of the synodic period for (5633) 1978 U7 is associated with a bimodal lightcurve phased to 7.212 ± 0.001 h with an amplitude of 0.53 ± 0.03 mag (Fig. 4).

Acknowledgments

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**LIGHTCURVE AND ROTATION PERIOD
DETERMINATION FOR
1492 OPPOLZER AND (9773) 1993 MG1**

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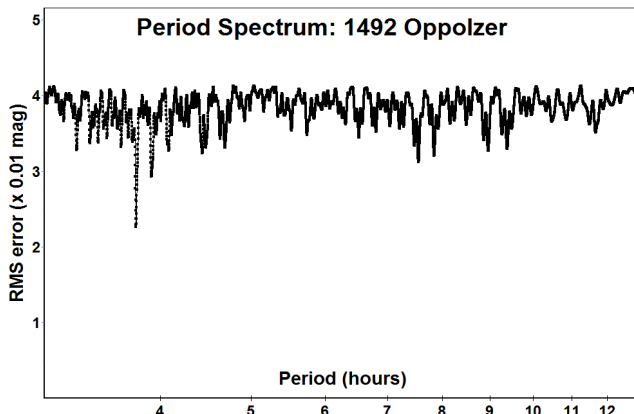
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(Received: 2015 July 13)

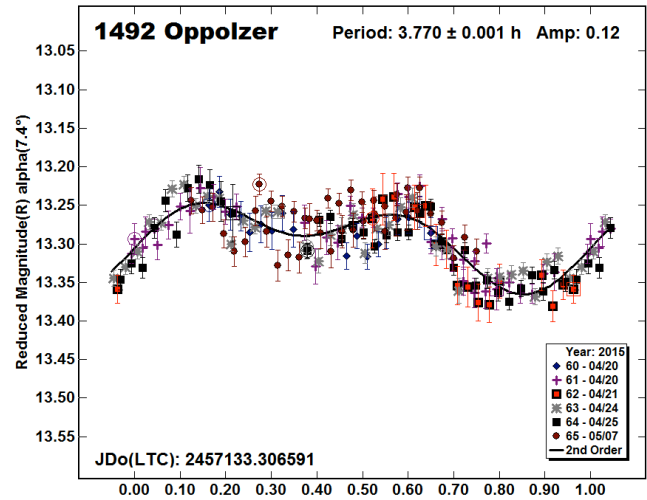
Photometric observations of the main-belt asteroids 1492 Oppolzer and (9773) 1993 MG1 were performed by the authors in 2015 April-July. Analysis of the data revealed bimodal lightcurves for each object. For 1492 Oppolzer, we found a synodic period of $P = 3.770 \pm 0.001$ h; for (9773) 1993 MG1, we found $P = 2.746 \pm 0.001$ h.

1492 Oppolzer (1938 FL) is a main-belt asteroid discovered on 1938 March 23 by Yrjö Väisälä. It is a typical main-belt asteroid with a semi-major axis of about 2.17 AU, eccentricity 0.12, and orbital period of about 3.77 years (JPL, 2015). According to the WISE satellite infrared radiometry (Masiero *et al.*, 2011), the diameter is 12.27 ± 1.5 km based on an absolute magnitude of $H = 12.8$.

Observations were made on five nights from 2015 April 20 until May 7, with a total of 187 useful data points collected over the interval of 17 days. During that time, the phase angle ranged from 7.7° before opposition to 9.0° after opposition. At the Astronomical Observatory of the University of Siena, data were obtained with 0.30-m $f/5.6$ Maksutov-Cassegrain telescope, SBIG STL-6303E NABG CCD camera, and clear filter; the pixel scale was 2.26 arcsec in binning 2x2. Exposures were 300 and 420 seconds. At Saronno Observatory, data were obtained with a 0.235-m $f/10$ Schmidt-Cassegrain (SCT) telescope, SBIG ST8-XME NABG CCD camera, and no filter; the pixel scale was 1.6 arcsec in binning 2x2. Exposures were 300 seconds.



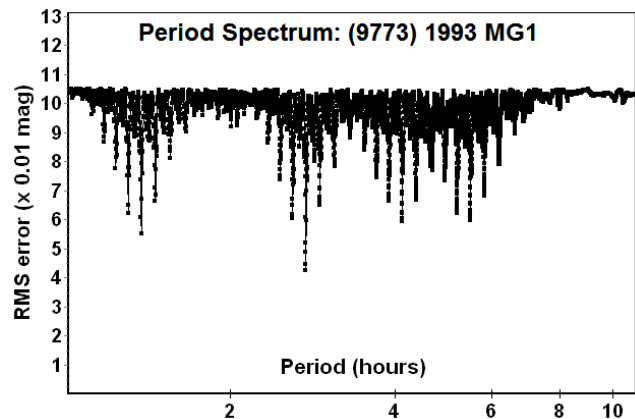
The period analysis yielded several possible solutions with nearly comparable RMS errors that clearly stand out in the period spectrum. We concluded that the most likely value of the synodic period for 1492 Oppolzer is associated with a bimodal lightcurve phased to 3.770 ± 0.001 hours with an amplitude of 0.12 ± 0.02 mag.

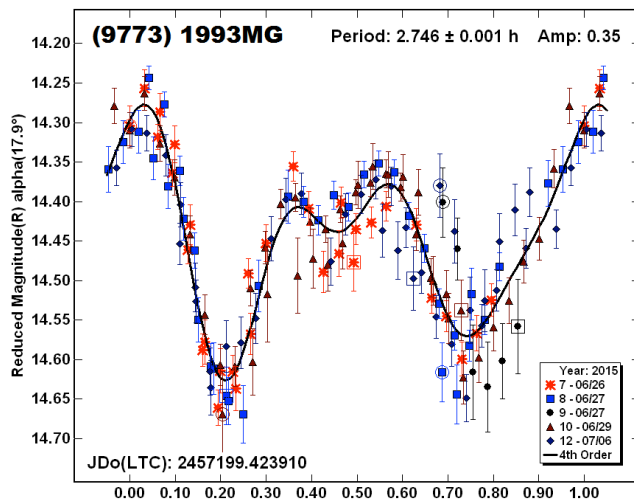


(9773) 1993 MG1 is a main-belt asteroid discovered on 1993 June 23 by Eleanor F. Helin. It is a typical main-belt asteroid with a semi-major axis of about 2.69 AU, eccentricity 0.38, and orbital period of about 4.41 years. Its absolute magnitude is $H = 13.6$ (JPL, 2015).

Observations were made on five nights from 2015 June 26 through July 6, with a total of 159 useful data points collected in an interval of 10 days. The phase angle ranged from 17.9° to 13.0° before opposition. Data were obtained at the Astronomical Observatory of the University of Siena with the same equipment used for 1492 Oppolzer. Exposure times were 300 and 420 seconds.

The period analysis yielded several possible solutions with nearly comparable RMS errors that clearly stand out in the period spectrum. We concluded that the most likely value of the synodic period for (9773) 1993 MG1 is associated with a bimodal lightcurve phased to 2.746 ± 0.001 hours with an amplitude of 0.35 ± 0.04 mag.





A NEW SYNODIC PERIOD FOR 2296 KUGULTINOV

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The minor planet 2296 Kugultinov was observed on 13 nights between 2015 March 13 and April 21. The analysis yielded a synodic period of rotation of $P = 16.850 \pm 0.004$ h and amplitude of $A = 0.23$ mag. This result is in disagreement with a previously reported period of $P = 10.41$ h.

Minor Planet 2296 Kugultinov appeared in the lightcurve opportunities list by Warner *et al.* (2015). Opposition for Kugultinov occurred 2015 March 16.7; it was observed on both sides of this date. A search in the most recent available edition of the Asteroid Lightcurve Database of 2015 May (Warner *et al.*, 2009) lists a single reference to Behrend (2014). That work presents a synodic period of $P = 10.41$ h and amplitude of $A = 0.03$ mag. The quality rating given in the LCDB is $U = 1+$.

Observer KL used a 0.20-m Newtonian telescope fitted with a coma corrector, giving an effective focal length of 890 mm. The camera is an Atik 383L+ with a Kodak KAF-8300 chip and pixel size of 5.4×5.4 μm . Timekeeping was done using *Dimension 4* (Thinking Man Software). Observer JJ used a 0.40-m Newtonian telescope that has an effective focal length of 2006 mm. The camera was a Starlight Express SXVR-H16 with a KAI4022M chip and pixel size of 7.4×7.4 μm . Timekeeping was by a GPS device.

All images were calibrated with master darks and flats corresponding to different filters and binning configurations. For the calibration, JJ used *AIP4WIN* v.2.40 (Berry and Burnell, 2005) and KL used *IRIS* 5.59 software (Buil, 2011).

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The calibrated images were analyzed by KL using *MPO Canopus* (Warner, 2013). The Comp Star Selector utility of *MPO Canopus* was used to select up to five comparison stars of near solar-color for the differential photometry. Great care was exercised to find near solar-color comparison stars in the fields because it became clear that many of the lightcurves were of low amplitude. This was further complicated by the fact that we had to deal with large air masses sometimes larger than 2.7 and never less than 1.68. This forced the use of equal size apertures for target and comparison stars to minimize the effect of changing seeing conditions. Equal size apertures cannot eliminate this effect unless the apertures are large which in turn increased the noise in the photometry but that was the compromise necessary.

Analysis of the first four nights up to March 27 indicated a short period of $P \approx 8.6$ h. The lightcurve of March 30 changed this and forced a solution near $P \approx 16.8$ h. The lightcurve of April 6 supported this longer period. The lightcurve of April 9 also made a nice fit but its downward gradient had a slope that looked suspiciously much like the ones seen on March 13 and 27. Even though the method of derived magnitudes was used some tweaking of *Delta Comp* was needed to trim the phased plot but at the risk of inducing a false solution.

To check if the lightcurve of April 9 could be made to match the ones seen on March 13 and 27, a new search was made by omitting the lightcurves of March 30 and of April 6. A solution of $P \approx 8.6$ h could be found, but only by reducing the number of harmonic terms to two and, even then, the overlapping lightcurves showed some temporal displacement. As soon as the number of harmonic terms was increased, the solution at $P \approx 16.8$ h was better. Using all lightcurves up to April 9 yielded a synodic period $P = 16.85 \pm 0.02$ h. Fortunately, the last five sessions could be analyzed separately from the earlier ones. Sessions 25, 26, 30, and 31 reproduce the global solution at $P \approx 16.8$ h. The period spectrum for these sessions also displays less deep minima at $P \approx 11.5$, 8, and 6 h, but these minima all disappear when adding Session 27. This independent analysis yielded a synodic period $P = 16.8 \pm 0.1$ h. Session 30 is also somewhat a "gold nugget" since it overlaps the lightcurves on both sides of the gap in phase coverage between phase 0.80 to 0.85 that would otherwise have been here (Figure 1). The only place left in the phased plot that does not have overlapping lightcurves is the small gap between 0.30 and 0.35.

1 Date 2015	2 S.ID	3 Obs	4 Bin	5 Exp [s]	6 N.Obs	7 Begin UT	8 End UT	9 Dur [h]	10 SPA [°]	Note
Mar 13	17	JJ	1x1	120	115	20:11	00:09	4.0	1.32	
Mar 19	14	JJ	1x1	120	57	19:40	22:15	2.6	1.52	
Mar 21	21	KL	1x1	300	60	19:30	03:00	7.5	2.36	a)
Mar 27	18	JJ	1x1	120	65	20:20	23:20	3.0	4.90	
Mar 27	19	KL	1x1	300	45	19:27	01:22	6.1	4.90	
Mar 30	23	KL	1x1	300	12	20:20	23:20	1.4	6.14	
Apr 6	20	JJ	2x2	180	42	19:29	22:23	2.9	8.90	
Apr 9	22	JJ	2x2	180	52	19:48	22:25	2.6	10.0	
Apr 13	24	KL	1x1	300	18	20:01	21:57	1.7	11.1	
Apr 15	25	KL	1x1	300	40	20:17	00:43	4.2	12.1	
Apr 16	26	KL	1x1	300	43	20:05	01:03	5.0	12.4	
Apr 17	27	KL	1x1	300	45	20:25	01:11	4.9	12.7	
Apr 19	30	KL	2x2	300	47	20:26	00:49	4.4	13.4	
Apr 21	31	KL	2x2	300	37	21:15	00:34	3.4	14.0	
				Sum:	678			55.2		

Table I. Observations of 2296 Kugultinov

All observations are made through a clear filter. Column titles from left to right. 1: Calendar date [UT] at the beginning of observations, 2: Canopus Session ID, 3: Observer initials, 4: Binning on CCD, 5: Exposure time [s], 6: Number of observations in phased plot, 7: Beginning of observations, 8: Ending of observation, 9: Session duration, 10: Solar Phase angle [°].

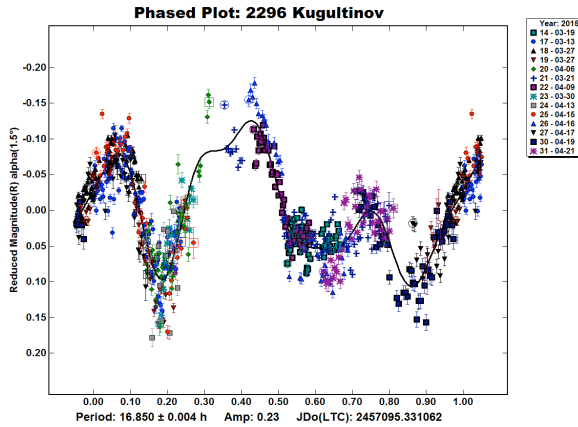


Figure 1. The phased plot using all lightcurves of 2296 Kugultinov with a period of $P = 16.850 \pm 0.004$ h and amplitude of $A = 0.23$ mag.

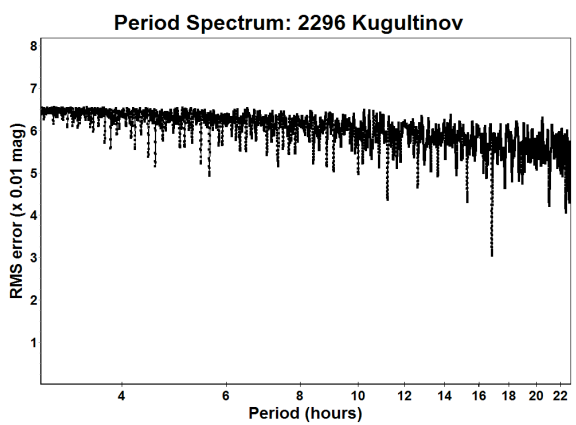


Figure 2. Period spectrum for 2296 Kugultinov. Six harmonic terms were used in 9999 steps of 0.002 h starting at $P_0 = 2.9$ h.

Based on using all lightcurves, we report a new synodic rotation period for 2296 Kugultinov of $P = 16.850 \pm 0.004$ h and amplitude of $A = 0.23$ mag. This result is in disagreement with a previously reported period of $P = 10.41$ h. The data supporting that estimate covers only one maximum and one minimum of an assumed symmetrical bimodal lightcurve. This work does not support that conclusion. The period spectrum for the data presented here (Figure 2) shows that $P = 16.850 \pm 0.004$ h is the only reasonable solution for this data set.

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LIGHTCURVE PHOTOMETRY OPPORTUNITIES: 2015 OCTOBER-DECEMBER

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We present lists of asteroid photometry opportunities for objects reaching a favorable apparition and have no or poorly-defined lightcurve parameters. Additional data on these objects will help with shape and spin axis modeling via lightcurve inversion. We also include lists of objects that will be the target of radar observations. Lightcurves for these objects can help constrain pole solutions and/or remove rotation period ambiguities that might not come from using radar data alone.

We present several lists of asteroids that are prime targets for photometry during the period 2015 October-December.

In the first three sets of tables, “Dec” is the declination and “U” is the quality code of the lightcurve. See the asteroid lightcurve data base (LCDB; Warner *et al.*, 2009) documentation for an explanation of the U code:

<http://www.minorplanet.info/lightcurvedatabase.html>

The ephemeris generator on the CALL web site allows you to create custom lists for objects reaching $V \leq 18.5$ during any month in the current year, e.g., limiting the results by magnitude and declination.

http://www.minorplanet.info/PHP/call_OppLCDBQuery.php

We refer you to past articles, e.g., *Minor Planet Bulletin* **36**, 188, for more detailed discussions about the individual lists and points of advice regarding observations for objects in each list.

Once you’ve obtained and analyzed your data, it’s important to publish your results. Papers appearing in the *Minor Planet Bulletin* are indexed in the Astrophysical Data System (ADS) and so can be referenced by others in subsequent papers. It’s also important to make the data available at least on a personal website or upon request. We urge you to consider submitting your raw data to the ALCDEF page on the Minor Planet Center web site:

http://www.minorplanetcenter.net/light_curve

We believe this to be the largest publicly available database of raw lightcurve data that contains 1.9 million observations for more than 2800 objects.

Now that many backyard astronomers and small colleges have access to larger telescopes, we have expanded the photometry opportunities and spin axis lists to include asteroids reaching $V = 15.5$.

In both of those lists, a line in *italics text* indicates a near-Earth asteroid (NEA). In the spin axis list, a line in **bold text** indicates a particularly favorable apparition. To keep the number of objects manageable, the opportunities list includes only those objects reaching a particularly favorable apparition, meaning they could all be set in bold text.

Lightcurve/Photometry Opportunities

Objects with $U = 3-$ or 3 are excluded from this list since they will likely appear in the list below for shape and spin axis modeling. Those asteroids rated $U = 1$ should be given higher priority over those rated $U = 2$ or $2+$, but not necessarily over those with no period. On the other hand, *do not overlook asteroids with $U = 2/2+$ on the assumption that the period is sufficiently established.* Regardless, do not let the existing period influence your analysis since even high quality ratings have been proven wrong at times. Note that the lightcurve amplitude in the tables could be more or less than what’s given. Use the listing only as a guide.

Number	Name	Brightest			LCDB Data		
		Date	Mag	Dec	Period	Amp	U
9165	Raup	10	03.8	14.5	-2	560.	1.05 2
12331	1992 UH6	10	04.5	15.1	-6	2.727	0.02 1
1237	Genevieve	10	04.9	13.8	-7	16.37	0.17-0.23 2-
1878	Hughes	10	04.9	15.3	+4		
6827	Wombat	10	08.1	15.4	+12	40.1315	0.34 2
3489	Lottie	10	08.6	15.4	+5		
2974	Holden	10	08.8	14.9	+10		
4815	Anders	10	09.2	15.5	+8		
5047	Zanda	10	09.3	15.5	+8		
3811	Karma	10	11.3	14.4	+17	11.52	0.20 2
5840	Raybrown	10	13.9	15.3	+7		
9851	Sakamoto	10	13.9	15.0	-1		
10707	1981 UV23	10	15.2	14.6	-1		
4272	Entsuji	10	15.9	13.8	+3		
3000	Leonardo	10	19.0	15.0	+9		
1016	Anitra	10	20.0	13.6	+13	5.9288	0.28-0.50 2+
3055	Annapavlova	10	21.3	15.4	+21	> 7.	
25282	1998 WR	10	22.1	15.1	-3	11.5129	0.40 2
303142	2004 DU24	10	22.8	15.4	+7		
705	Erminia	10	22.9	12.6	+28	53.96	0.05-0.17 2
18005	1999 JD91	10	23.1	15.5	-5		
26514	2000 CH48	10	23.5	14.9	+7	4.963	0.72 2
5364	1980 RC1	10	25.9	15.1	+18		
6339	Giliberti	10	25.9	15.4	+19		
4273	Dunhuang	10	28.8	15.1	+7		
2343	Siding Spring	10	29.0	13.9	+13		
2941	Alden	10	30.3	15.0	+16		
1654	Bojeva	10	30.9	14.3	+17		0.1
2959	Scholl	10	31.3	14.9	+6	>16.	0.14 1
4950	House	10	31.3	15.4	+4		0.18
6734	Benzenberg	10	31.8	15.3	+8		0.19
11268	Spassky	11	01.5	15.2	+13		
9533	Aleksejleonov	11	01.6	15.5	+11		
9060	Toyokawa	11	02.2	15.4	+18		
5236	Yoko	11	02.7	15.1	+12	2.768	0.30 2+
14890	1991 VG3	11	03.9	15.5	+13		
2787	Tovarishch	11	09.8	15.3	+21		
13487	1981 VN	11	10.9	15.3	+21		
24602	Mozzhorin	11	10.9	15.3	+16		
1001	Gaussia	11	15.9	13.5	+25	9.17	0.04-0.16 2-
5960	Wakkanai	11	16.3	15.1	+20		
25332	1999 KK6	11	16.7	15.4	+5	2.4139	0.06-0.08 2+
46620	1994 ELL	11	16.8	15.5	+10	>20.	0.2 2
838	Seraphina	11	16.9	13.4	+20	15.67	0.07-0.30 2
5226	Pollack	11	17.1	15.3	+14	2.725	0.30 2
28321	Arnabdey	11	17.1	15.2	+20		
2387	Xi'an	11	19.5	15.0	+20	4.2985	0.24 2

Number	Name	Brightest			LCDB Data			U	Num Name	Date	α	V	Dec	Period	Amp	U		
		Date	Mag	Dec	Period	Amp	U											
2947	Kippenhahn	11 20.0	14.6	+24	10.5		0.42	2	80019	1999	HL2	10 14.7	0.26	15.4	+08			
12738	Satoshimiki	11 20.7	15.2	-8	8.7081	0.20-0.25	2+		855	Newcombia		10 14.8	0.46	14.9	+09	3.003	0.35	3
4747	Jujo	11 23.2	15.4	+20					3454	Lieske		10 15.8	0.75	15.0	+07			
2906	Caltech	11 25.6	14.2	+1	12.99		0.16	2	187	Lamberta		10 16.1	0.07	12.7	+09	10.670	0.23-0.32	3
3149	Okudzhava	11 27.0	15.3	+9	2.58		0.3	2	229	Adelinda		10 16.4	0.16	13.2	+09	6.60	0.04-0.30	3
3433	Fehrenbach	11 27.2	14.3	+30	3.9178		0.26	2	30988	2000	WT141	10 18.2	0.54	15.5	+08			
1912	Anubis	11 27.7	15.1	+20	4.6256		0.47	2	3000	Leonardo		10 19.0	0.21	14.9	+09			
11643	1997 AM22	12 01.5	15.5	+15					761	Brendelia		10 19.1	0.05	14.3	+10	57.96	0.25	2+
14625	1998 UH31	12 03.1	14.7	+26	4.4873		0.38	2	4017	Disney		10 19.7	0.29	15.5	+09			
3613	Kunlun	12 06.0	15.3	+23					2042	Sitariski		10 20.0	0.57	15.5	+11			
7302	1993 CQ	12 09.8	15.3	+11	3.2754		0.19	2	417	Suevia		10 21.5	0.44	13.6	+09	7.034	0.06-0.22	3
2545	Verbiest	12 11.1	14.4	+34	10.		0.06	1+	362	Havnica		10 24.7	0.34	11.9	+12	16.92	0.09-0.11	3
3136	Anshan	12 11.1	15.5	+23					3415	Danby		10 26.3	0.46	14.7	+14	5.666	0.09-0.18	3
1249	Rutherfordia	12 11.3	13.4	+23	18.2	0.69-0.81	2+		147	Protogeneia		10 29.3	0.51	12.7	+15	7.8528	0.25-0.28	3
2758	Cordelia	12 15.2	15.5	+29					8579	Hieizan		10 29.7	0.80	15.7	+12			
3115	Baily	12 17.3	13.3	+21	16.22	0.08-0.14	2+		2369	Chekhov		10 29.8	0.31	15.5	+13			
4762	Dobrynya	12 19.4	15.1	+37					3403	Tammy		10 31.4	0.76	15.5	+12	11.85	0.10	1
4904	Makio	12 20.2	15.0	+12	7.83	0.08	2		797	Montana		11 01.1	0.92	13.8	+17	4.5463	0.32-0.50	3
21609	Williamcaleb	12 23.7	15.4	+10	112.		0.5	2	5508	Gomyou		11 01.2	0.20	15.4	+15			
2282	Andres Bello	12 27.3	15.1	+14					11268	Spassky		11 01.4	0.95	15.2	+13			

Low Phase Angle Opportunities

The Low Phase Angle list includes asteroids that reach very low phase angles. The “ α ” column is the minimum solar phase angle for the asteroid. Getting accurate, calibrated measurements (usually V band) at or very near the day of opposition can provide important information for those studying the “opposition effect.” Use the on-line query form for the LCDB

http://www.minorplanet.info/PHP/call_OppLCDBQuery.php

to get more details about a specific asteroid.

You will have the best chance of success working objects with low amplitude and periods that allow covering at least half a cycle every night. Objects with large amplitudes and/or long periods are much more difficult for phase angle studies since, for proper analysis, the data must be reduced to the average magnitude of the asteroid for each night. This reduction requires that you determine the period and the amplitude of the lightcurve; for long period objects that can be tricky. Refer to Harris, *et al.* (“Phase Relations of High Albedo Asteroids.” *Icarus* **81**, p365 ff) for the details of the analysis procedure.

As an aside, some use the maximum light to find the phase slope parameter (G). However, this can produce a significantly different value for both H and G versus when using average light, which is the method used for values listed by the Minor Planet Center.

Num	Name	Date	α	V	Dec	Period	Amp	U	Num	Name	Date	α	V	Dec	Period	Amp	U	
74	Galatea	10 01.7	0.60	10.6	+04	17.268	0.08-0.16	3	268	Adorea	12 07.8	0.77	12.7	+20	7.80	0.15-0.20	3	
2159	Kukkamaki	10 01.8	0.64	15.1	+05	4.06	0.32	3	579	Sidonia	12 09.0	0.58	12.1	+21	16.286	0.02-0.28	3-	
2899	Runrun Shaw	10 02.7	0.62	14.9	+02				6384	Kerwin	12 09.1	0.26	15.0	+22	3.6203	0.06-0.10	3	
5674	Wolff	10 02.7	0.90	14.8	+02				395	Delia	12 09.2	0.13	14.4	+23	19.71	0.25	2	
215	Oenone	10 02.8	0.29	12.7	+03	27.937	0.18-0.20	3	1576	Fabiola	12 09.3	0.56	14.4	+21	6.7	0.2	2	
32774	1986 VZ	10 02.9	0.53	15.5	+03				2534	Houzeau	12 09.9	0.42	15.1	+22				
1023	Thomana	10 03.0	0.49	13.5	+05	17.56	0.27-0.36	3-	15305	1992 WT1	12 10.5	0.62	15.5	+22				
158	Koronis	10 03.9	0.57	12.8	+05	14.218	0.28-0.43	3	3136	Anshan	12 11.1	0.12	15.5	+23				
13762	1998 SG130	10 04.4	0.54	14.5	+03				2972	Niilo	12 11.9	0.77	15.5	+21				
1878	Hughes	10 04.9	0.07	15.3	+04				580	Selene	12 13.7	0.57	14.1	+21	9.47	0.27	3-	
82	Alkmene	10 05.1	0.35	12.4	+04	12.999	0.18-0.54	3	2555	Thomas	12 14.3	0.23	15.3	+24				
3039	Yangel	10 07.2	0.49	15.5	+04				2476	Andersen	12 14.7	0.14	15.1	+23				
1938	Lausanna	10 07.4	0.85	15.5	+04				1498	Lahti	12 14.9	0.37	15.4	+24	58.	0.8	1+	
1735	ITA	10 08.6	0.75	14.1	+08	12.599	0.27	3-	951	Gaspra	12 16.4	0.77	13.1	+22	7.042	0.2	1.0	3
3489	Lottie	10 08.6	0.34	15.3	+05				1667	Pels	12 16.4	0.23	14.8	+24	3.268	0.20-0.42	3	
2591	Dworetzky	10 09.0	0.25	15.3	+07	12.77	0.45	2	3115	Baily	12 17.3	0.88	13.3	+21	16.22	0.08-0.14	2+	
5047	Zanda	10 09.2	0.72	15.5	+08				20762	2000 EE36	12 21.0	0.06	14.9	+24	8.891	0.46	3-	
586	Thekla	10 10.0	0.42	13.3	+08	13.670	0.22-0.30	3	1078	Mentha	12 21.5	0.61	13.6	+22	85.	0.87	3	
561	Ingwelde	10 11.1	0.43	15.5	+06	12.012	0.38	3	27	Euterpe	12 25.1	0.14	8.4	+23	10.4082	0.13-0.21	3	
2323	Zverev	10 11.9	0.50	15.1	+08	3.921	0.36-0.39	3	1306	Scythia	12 25.8	0.17	13.5	+24	7.525	0.15-0.25	3	
3791	Marci	10 12.2	0.55	15.5	+09				1725	CrAO	12 26.7	0.67	15.3	+21	21.45	0.08-0.28	3	
5840	Raybrown	10 13.9	0.23	15.3	+07				2563	Boyarchuk	12 27.7	0.35	15.4	+22	11.04	0.11	2	
340	Eduarda	10 14.0	0.37	12.9	+07	8.0062	0.17-0.32	3	1209	Pumma	12 31.3	0.43	15.5	+25	8.5001			
162	Laurentia	10 14.4	0.69	13.4	+06	11.8686	0.28-0.35	3										
1894	Haffner	10 14.7	0.46	15.4	+09													

positions are given. Use these web sites to generate updated and *topocentric* positions:

MPC: <http://www.minorplanetcenter.net/iau/MPEph/MPEph.html>

JPL: <http://ssd.jpl.nasa.gov/?horizons>

In the ephemerides below, ED and SD are, respectively, the Earth and Sun distances (AU), V is the estimated Johnson V magnitude, and α is the phase angle. SE and ME are the great circles distances (in degrees) of the Sun and Moon from the asteroid. MP is the lunar phase and GB is the galactic latitude. "PHA" in the header indicates that the object is a "potentially hazardous asteroid", meaning that at some (long distant) time, its orbit might take it very close to Earth.

Some of the targets listed here may be carry-overs from the previous quarter's photometry opportunities article since they are still reachable targets for at least part of the covered quarter-year.

(436724) 2011 UW158 (Oct, H = 19.4, PHA)

This asteroid continues to be an accessible target in early October. It made its closest approach on 2015 July 19 (0.0164 AU) and, at the time this was written in early July, was predicted to be one of the strongest radar target in years. Extensive work by Bruce Gary in 2015 June and July (<http://www.brucegary.net/UW158/>) found, among other things, a period of 0.610843 ± 0.00005 h (or about 36.651 minutes) with an amplitude of 0.52 mag at a phase angle of 80.5° . The amplitude at low phase angles may be considerably less. Don't let the existing results dissuade you from obtaining additional data. Observations in October will be at much lower phase angles and so be helpful for modeling the asteroid when combined with existing data.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
10/01	23 54.8	+23 18	0.27	1.25	18.0	17.3	158	48	-0.87	-38
10/02	23 54.5	+22 56	0.27	1.26	18.1	16.9	159	61	-0.78	-38
10/03	23 54.3	+22 33	0.28	1.26	18.1	16.7	159	74	-0.68	-38
10/04	23 54.1	+22 11	0.28	1.27	18.2	16.4	159	86	-0.57	-39
10/05	23 53.9	+21 49	0.29	1.27	18.2	16.2	159	99	-0.47	-39
10/06	23 53.7	+21 28	0.29	1.28	18.2	16.1	159	111	-0.37	-39
10/07	23 53.6	+21 07	0.30	1.28	18.3	16.0	159	122	-0.28	-40
10/08	23 53.5	+20 46	0.31	1.29	18.3	16.0	159	133	-0.19	-40

3200 Phaethon (Oct-Dec, H = 14.6, PHA)

The period for this NEA is well-known at ~ 3.604 h. Additional observations will help model the asteroid, including a check on whether YORP (a thermal effect) is causing the spin rotation to speed up or down.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
10/01	04 00.6	+42 16	1.66	2.31	18.6	22.4	118	31	-0.88	-8
10/11	03 43.9	+42 44	1.57	2.34	18.4	19.2	130	111	-0.03	-10
10/21	03 21.7	+42 34	1.50	2.36	18.2	15.4	141	115	+0.52	-12
10/31	02 55.8	+41 33	1.46	2.38	18.0	11.6	151	42	-0.84	-16
11/10	02 29.2	+39 37	1.45	2.39	17.9	9.5	156	148	-0.03	-19
11/20	02 05.2	+36 57	1.48	2.40	18.0	10.8	153	67	+0.58	-24
11/30	01 46.1	+33 56	1.54	2.40	18.2	14.1	144	85	-0.81	-28
12/10	01 32.6	+30 58	1.62	2.40	18.5	17.6	132	143	-0.02	-31

(163899) 2003 SD220 (Oct-Dec, H = 16.8, PHA)

The rotation period for this NEA is not known. The estimated diameter is 1.2 km, so it is unlikely that the rotation period is < 2 h. The very large phase angles could make for some unusually shaped lightcurves due to deep shadowing effects.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
10/01	08 58.9	+49 57	0.26	0.94	17.3	96.2	69	79	-0.88	+41
10/11	09 12.0	+49 03	0.25	0.96	17.0	90.6	75	58	-0.03	+43
10/21	09 29.8	+47 32	0.23	0.98	16.7	86.4	80	143	+0.52	+46
10/31	09 50.8	+45 23	0.21	1.00	16.4	83.3	84	58	-0.84	+50
11/10	10 14.7	+42 23	0.19	1.00	16.1	81.3	88	70	-0.03	+55
11/20	10 42.1	+38 04	0.16	1.00	15.7	80.7	90	149	+0.58	+61
11/30	11 14.9	+31 15	0.13	1.00	15.3	82.4	90	46	-0.81	+69
12/10	11 58.3	+19 22	0.10	0.98	14.9	88.5	86	69	-0.02	+76
12/20	13 00.3	-01 48	0.08	0.96	15.0	102.7	73	177	+0.66	+61
12/30	14 30.6	-28 54	0.08	0.94	16.2	121.9	54	72	-0.79	+29

(206378) 2003 RB (Oct-Dec, H = 18.7, PHA)

Pravec *et al.* (2003) reported a period of $P > 16$ h and amplitude $A > 0.2$ mag. The low galactic latitudes may make this a difficult target. The long period makes it a good project for a collaboration of observers at significantly different longitudes.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
10/01	06 55.7	+56 58	0.18	1.01	17.9	81.2	89	61	-0.88	+23
10/11	07 14.8	+54 51	0.21	1.04	18.0	74.2	94	76	-0.03	+25
10/21	07 22.8	+53 15	0.24	1.07	18.1	66.2	101	142	+0.52	+26
10/31	07 21.1	+51 58	0.26	1.11	18.1	57.3	110	39	-0.84	+25
11/10	07 09.7	+50 47	0.28	1.16	18.1	47.6	120	103	-0.03	+23
11/20	06 49.2	+49 16	0.31	1.21	18.1	37.2	132	118	+0.58	+20
11/30	06 23.3	+47 03	0.33	1.27	18.0	26.7	145	37	-0.81	+15
12/10	05 57.5	+44 04	0.37	1.33	18.1	17.3	156	142	-0.02	+10

(413577) 2005 UL5 (Nov, H = 20.0, PHA)

Thomas *et al.* (2014; *Icarus* 228, 217-246) report this is a type Sq asteroid. Given this, the estimated size for the NEA is about 270 meters. The low galactic latitudes will make this a challenge.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
11/10	05 51.3	+03 15	0.11	1.07	17.2	40.3	135	119	-0.03	-12
11/11	05 54.9	+03 04	0.10	1.07	17.0	40.7	135	130	-0.01	-11
11/12	05 59.2	+02 49	0.09	1.06	16.7	41.3	135	140	+0.00	-10
11/13	06 04.6	+02 32	0.08	1.05	16.5	42.2	135	149	+0.02	-9
11/14	06 11.6	+02 10	0.07	1.04	16.2	43.4	134	158	+0.05	-8
11/15	06 21.0	+01 40	0.06	1.03	15.8	45.2	132	162	+0.11	-6
11/16	06 34.5	+00 57	0.05	1.02	15.5	48.1	130	162	+0.18	-3
11/17	06 55.1	-00 08	0.04	1.01	15.1	52.7	126	159	+0.26	+1
11/18	07 30.4	-01 59	0.03	1.00	14.6	60.9	118	156	+0.36	+8
11/19	08 38.2	-05 21	0.02	0.99	14.4	77.2	102	158	+0.47	+21
11/20	10 50.1	-10 15	0.02	0.98	15.2	109.0	70	162	+0.58	+42
11/21	13 23.9	-11 45	0.02	0.97	18.9	144.9	35	147	+0.69	+50

(33342) 1998 WT24 (Nov-Jan, H = 18.0, PHA)

The period for 1998 WT24 is known to be about 3.698 h. This makes it a potential binary candidate, so higher-precision data are encouraged.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
11/01	09 06.6	-05 59	0.19	0.97	17.4	91.1	78	44	-0.75	+26
11/11	08 58.9	-06 07	0.15	1.00	16.6	82.4	89	83	-0.01	+25
11/21	08 43.5	-06 12	0.10	1.01	15.6	72.3	102	139	+0.69	+21
12/01	07 56.9	-05 26	0.06	1.02	13.8	55.5	122	24	-0.72	+12
12/11	04 17.3	+02 24	0.03	1.01	11.3	23.5	156	163	+0.00	-32
12/21	00 01.4	+09 23	0.05	0.99	14.4	81.4	96	28	+0.76	-52
12/31	23 01.3	+09 41	0.10	0.96	16.5	102.2	72	165	-0.70	-45
01/10	22 35.0	+09 06	0.14	0.91	18.0	116.0	57	56	+0.00	-41

3122 Florence (Dec-Feb, H = 14.2, PHA)

Here is another potential binary candidate: the rotation period is known to be 2.358 h. Observations throughout the ephemeris period can help establish the H and G parameters. The estimated size is 4.5 km.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
12/01	11 16.4	+15 09	1.80	1.97	18.1	29.9	84	34	-0.72	+65
12/11	11 23.3	+13 52	1.72	2.01	18.1	29.2	92	87	+0.00	+66
12/21	11 27.3	+12 48	1.63	2.06	18.0	28.0	101	137	+0.76	+66
12/31	11 28.0	+11 59	1.54	2.10	17.8	26.0	111	9	-0.70	+65
01/10	11 24.9	+11 25	1.46	2.14	17.7	23.1	121	120	+0.00	+64
01/20	11 17.7	+11 06	1.39	2.18	17.5	19.3	133	98	+0.82	+63
01/30	11 06.4	+11 00	1.33	2.22	17.3	14.6	146	33	-0.70	+61
02/09	10 51.7	+11 02	1.30	2.25	17.0	9.0	159	164	+0.00	+58

(294739) 2008 CM (Dec-Jan, H = 17.1, PHA)

Warner (2014, *MPB* 41, 157-168) found a period of 3.054 h. The amplitude was 0.48 mag at a phase angle $\alpha = 70^\circ$, about the same as during the first few days of the ephemeris below.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
12/20	14 35.0	+55 09	0.12	0.99	15.7	84.0	89	117	+0.66	+56
12/25	12 11.8	+50 15	0.08	1.01	14.1	68.1	108	80	+1.00	+66
12/30	09 06.6	+15 09	0.06	1.03	12.7	34.9	143	18	-0.79	+37
01/04	07 32.4	-16 45	0.09	1.06	13.8	37.3	139	95	-0.34	+1
01/09	06 50.8	-28 03	0.15	1.08	15.0	44.7	129	133	-0.01	-12
01/14	06 29.6	-32 30	0.20	1.11	15.9	47.7	124	106	+0.19	-18
01/19	06 17.6	-34 29	0.26	1.14	16.5	48.7	120	63	+0.72	-21
01/24	06 10.8	-35 20	0.32	1.17	17.0	48.8	117	59	+1.00	-23

1994 AW1 (Dec-Jan, H = 17.0, PHA)

This is a known binary (Pravec and Hahn, 1997; *Icarus* 127, 431-440). The primary rotation period is 2.519 h. The orbital period of the satellite is 22.3 h, making it difficult for a single station to cover *mutual events* (occultations and/or eclipses), if viewing geometry allows, thoroughly. This would be a good project for a group of observers who are widely separated in longitude.

DATE	RA	Dec	ED	SD	V	α	SE	ME	MP	GB
12/01	20 49.8	+62 58	0.36	1.10	17.8	62.0	99	103	-0.72	+12
12/06	21 30.4	+62 30	0.35	1.11	17.7	60.6	101	111	-0.26	+8
12/11	22 14.4	+61 22	0.34	1.12	17.6	59.1	104	101	+0.00	+4
12/16	22 59.6	+59 21	0.33	1.12	17.5	57.5	106	74	+0.22	+0
12/21	23 43.5	+56 25	0.33	1.13	17.5	56.1	108	54	+0.76	-5
12/26	00 24.0	+52 37	0.32	1.13	17.4	54.8	110	79	-0.99	-10
12/31	01 00.1	+48 08	0.32	1.14	17.4	53.9	111	121	-0.70	-15
01/05	01 31.8	+43 14	0.33	1.14	17.5	53.4	111	145	-0.25	-19

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The deadline for the next issue (43-1) is October 15, 2015. The deadline for issue 43-2 is January 15, 2016.