

NEAR-EARTH ASTEROID LIGHTCURVE ANALYSIS AT CS3-PALMER DIVIDE STATION: 2015 OCTOBER–DECEMBER

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Lightcurves for 36 near-Earth asteroids (NEAs) were obtained at the Center for Solar System Studies-Palmer Divide Station (CS3-PDS) from 2015 October–December.

CCD photometric observations of 36 near-Earth asteroids (NEAs) were made at the Center for Solar System Studies-Palmer Divide Station (CS3-PDS) from 2015 October–December. 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	STL-1001E
Eclipticalis	0.35-m f/9.1 Schmidt-Cass	ML-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). 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 is also done using *MPO Canopus*, which implements the FALC algorithm developed by Harris (Harris *et al.*, 1989).

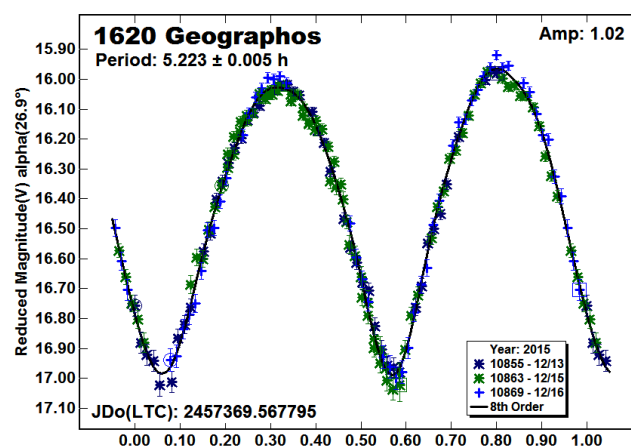
In the plots below, the “Reduced Magnitude” is Johnson V as indicated in the Y-axis title. These are values that have been converted from sky magnitudes to unity distance by applying $-5 \cdot \log(r\Delta)$ to the measured sky magnitudes with r and Δ being, respectively, the Sun-asteroid and Earth-asteroid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

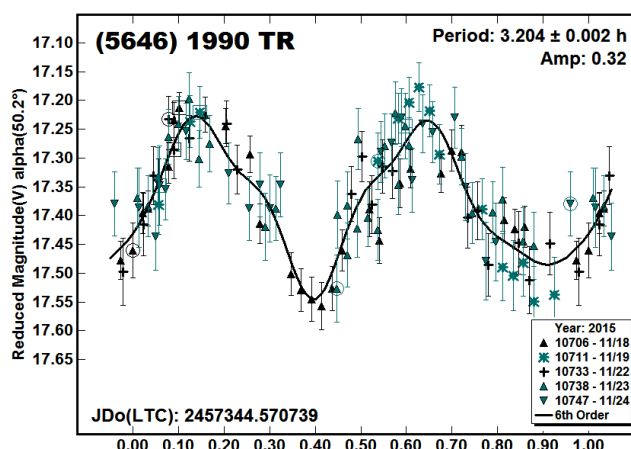
lightcurve database (LCDB; Warner *et al.*, 2009). The on-line version at <http://www.minorplanet.info/lightcurvedatabase.html> allows direct queries that can be filtered a number of ways and the results saved to a text file. A set of text files of the main LCDB tables, including the references with 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 provided as a matter of convenience.

1620 Geographos. The period and shape of this asteroid have been studied in detail (e.g., Hudson and Ostro, 1999; Higgins *et al.*, 2008). The results from the CS3-PDS observations agree well with those earlier findings. The 2015 apparition featured about the minimum lightcurve amplitude previously seen. In some years, the amplitude has been nearly double: 2.03 mag.

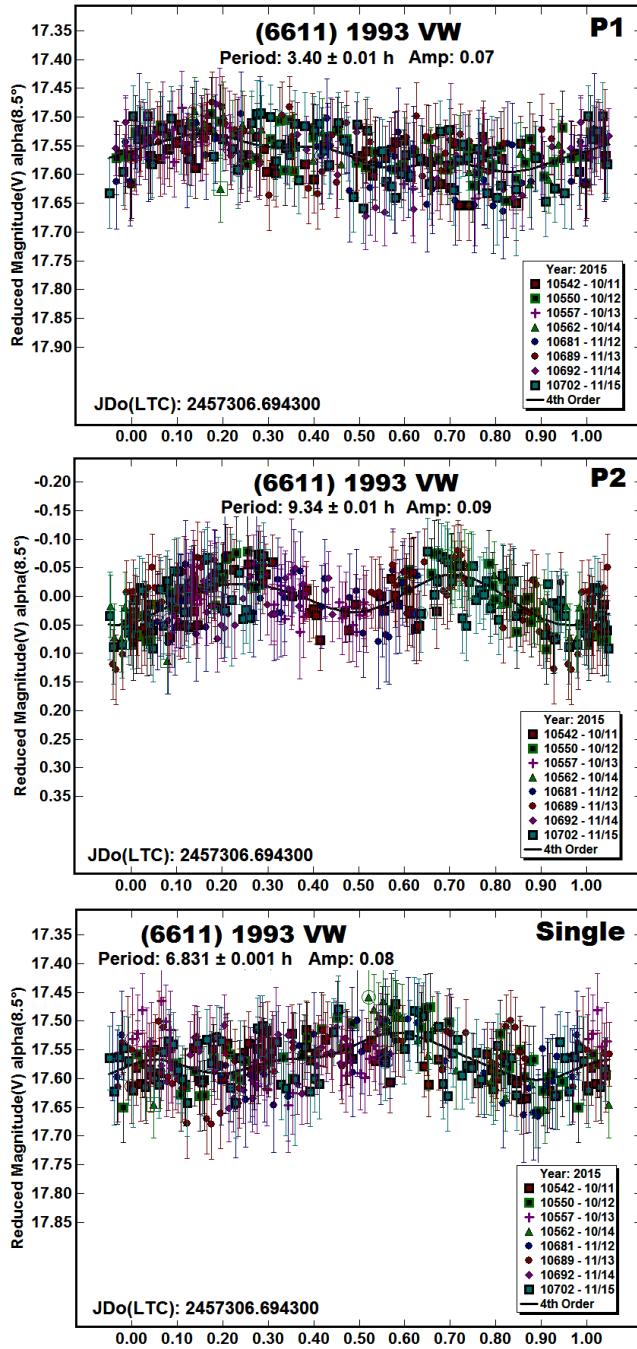


(5646) 1990 TR. This was the second time the author observed 1990 TR, the first being in 2012 (Warner, 2013) when the amplitude was only 0.12 mag. The 0.32 mag amplitude in 2015 would seem to indicate the asteroid presented a more equatorial view. The periods from the two apparitions are in good agreement.

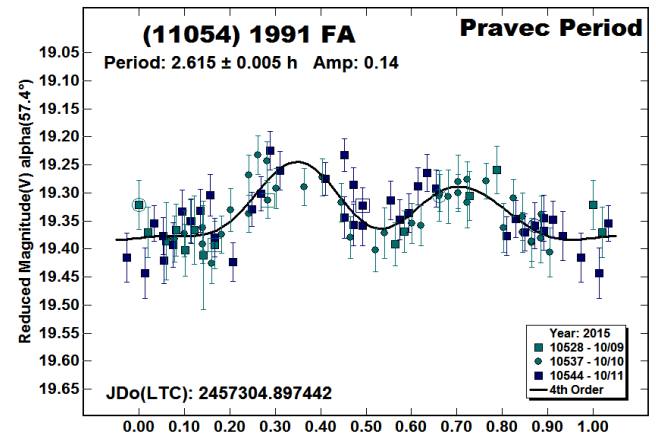
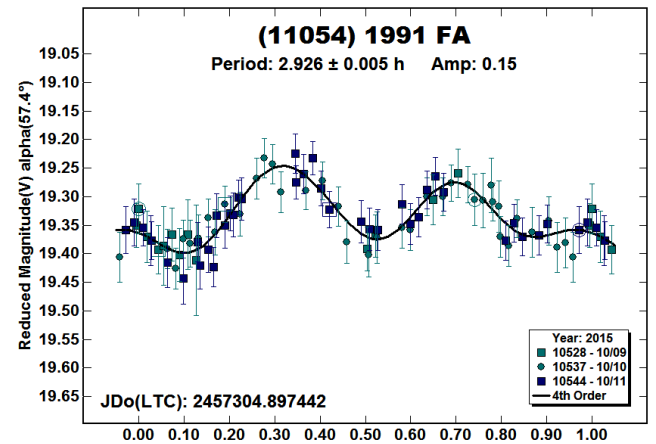
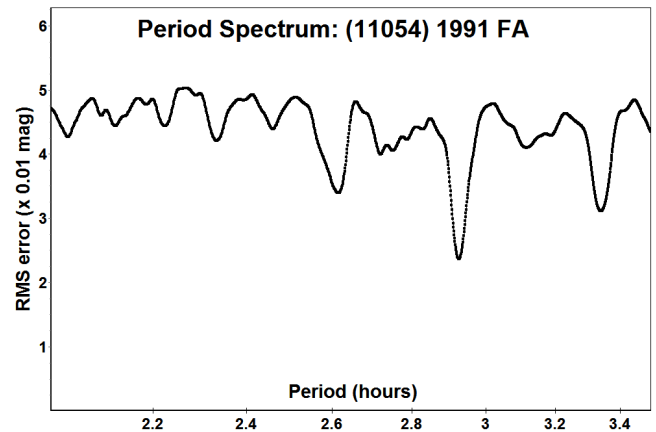


(6611) 1993 VW. Pravec *et al.* (2005web) reported the possibility that this NEA is a binary, finding a primary period of 2.5568 h and a secondary period of 17.19 h. No *mutual events* were seen that would have firmly confirmed the existence of a satellite. Analysis of the CS3-PDS data only added to the mystery. Two possible solutions evolved, one involving two periods, $P_1 = 3.40 \pm 0.01$ h

and $P_2 = 9.34 \pm 0.01$ h, and the other a single period solution of $P_S = 6.831 \pm 0.001$ h. It's worth noting that P_I is almost exactly $1/2 P_S$. All attempts to fit the CS3 data to the periods found by Pravec *et al.* were unsatisfactory.



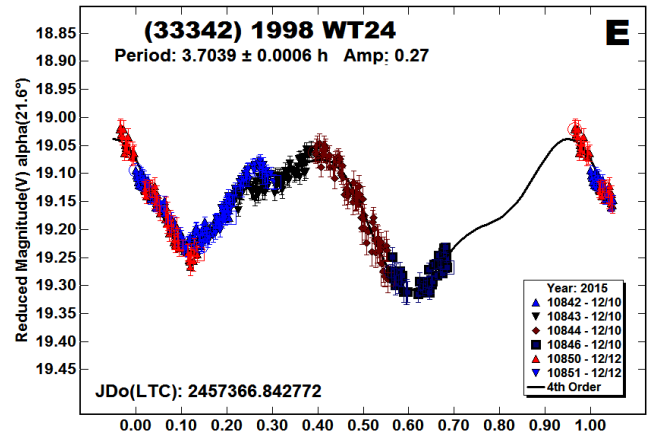
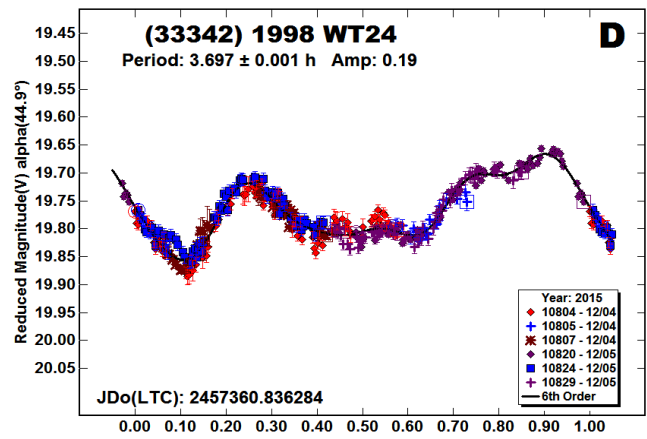
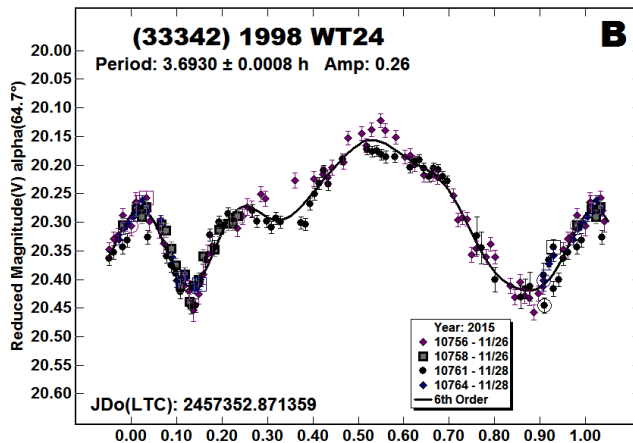
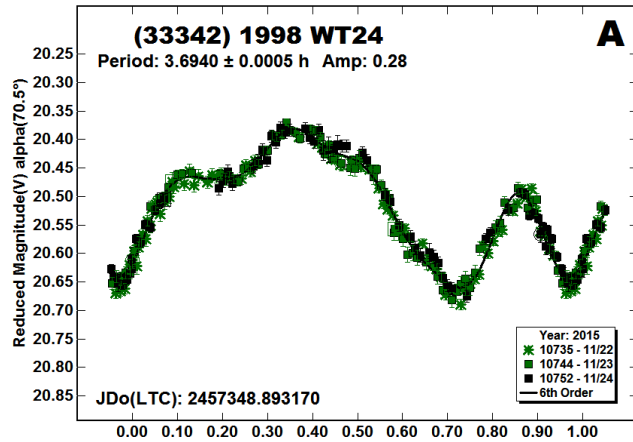
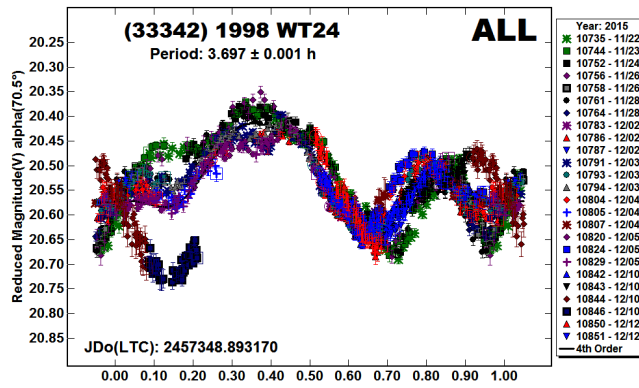
(11054) 1991 FA. Pravec *et al.* (2001web) reported a solution of $P = 2.57223$ h, $A = 0.08$ mag, but no lightcurve is available. Their data set spanned almost two months starting in 2001 November. A period search using the CS3 data, which consisted of three consecutive nights, found a strong solution at 2.926 h and a noticeably weaker one at about 2.6 h. The CS3 were forced to fit a period in the range of 2.5-2.7 h, which found $P = 2.615$ h, $A = 0.14$ mag. However, that solution is not a good fit.



(33342) 1998 WT24. The period and shape of this NEA were well-determined by Busch *et al.* (2008) using radar observations. The 2015 apparition presented a good opportunity to study the evolution of the lightcurve over a three-week span.

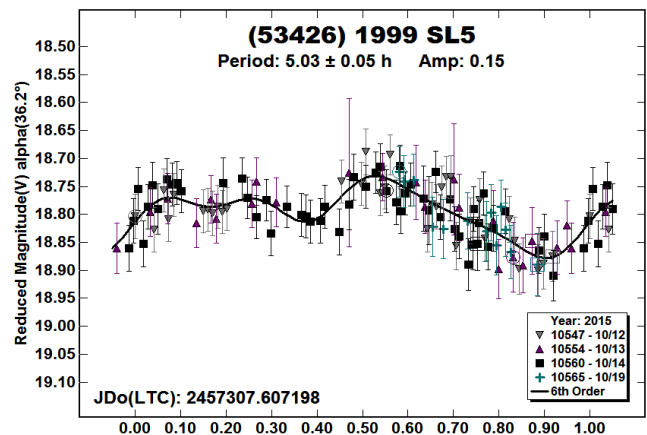
Mid-date	Phase	PABL	PABB
Nov 23	69.8	97.6	-15.6
Nov 27	63.8	97.1	-15.3
Dec 03	49.8	93.3	-14.8
Dec 05	42.5	90.3	-14.4
Dec 11	23.5	70.6	-9.7

Table II. Observing circumstances during the 2015 apparition. The Mid-date is approximate middle of each data set. The phase and phase angle bisector were computed for 0 UT for that date.

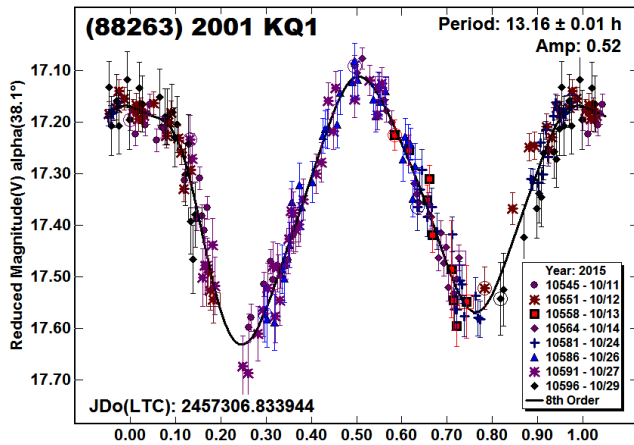


The “All” plot shows what happens when trying to merge data sets with significantly different amplitudes and synodic periods, the latter especially if the total span of the observations covers a large number of rotations. The plots A-E show the evolution of the shape and amplitude of the lightcurve as the phase angle decreased. Overall, the synodic period increased by about 0.01 h from the first observations to the last while the asteroid phase angle decreased towards 0° . This is usually an indication of retrograde rotation, *i.e.*, a pole latitude $\lambda < 0$. The latitude found by Busch *et al.* (2008) was $\lambda = -22^\circ$.

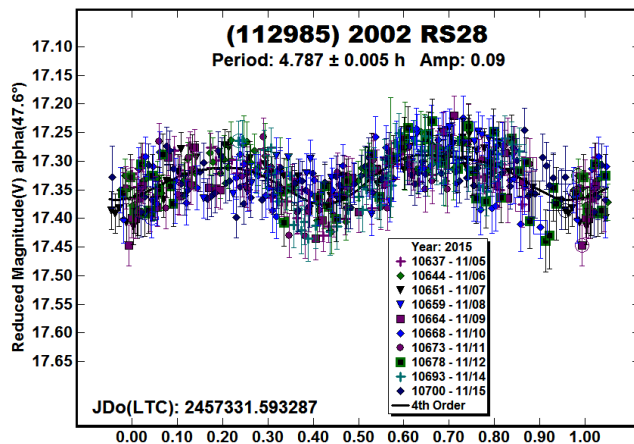
(53426) 1999 SL5. This appears to be the first reported period for this NEA. The solution is reliable for rotational studies but not fully secure. The next good opportunity for follow-up is 2023 August when it will again be at $+59^\circ$ and $V \sim 17.6$.



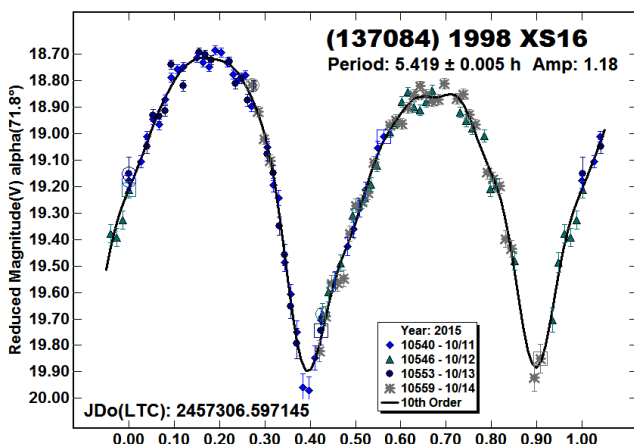
(88263) 2001 KQ1. No previous entries were found in the LCDB for 2001 KQ1. The large amplitude and lightcurve asymmetry virtually assure that the bimodal solution is correct (see Harris *et al.*, 2014).



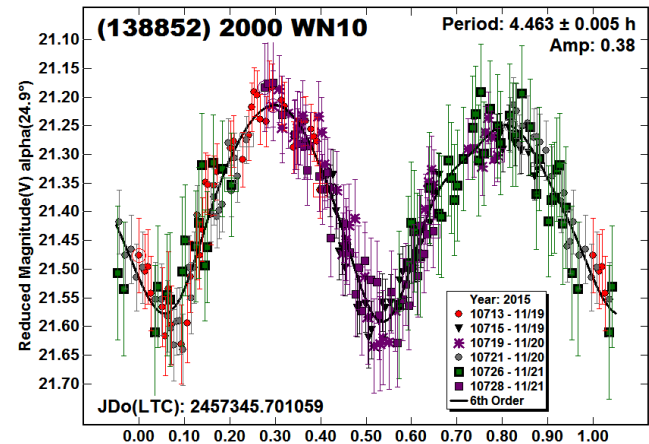
(112985) 2002 RS28. Three different data sets from 2015 gave three different results. The first two (Warner, 2015; 2016) gave ambiguous results. Despite a 0.24 mag amplitude in 2015 July, the data led to three equally-likely solutions, one close the one found using the 2015 November data. The asteroid doesn't get brighter than $V = 17.0$ again until 2025.



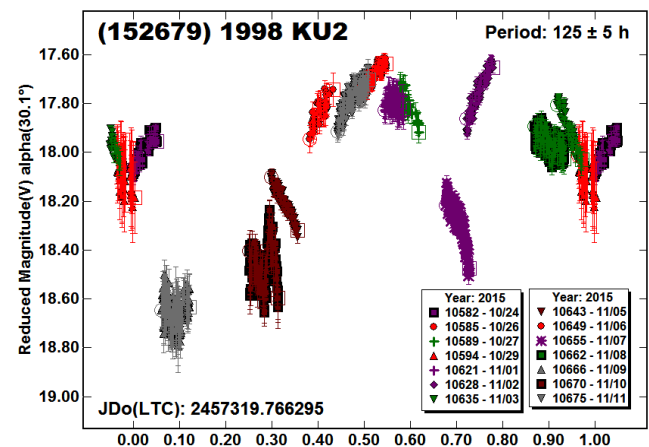
(137084) 1998 XS16. Pravec *et al.* (1999web) found a period of 5.4211 h. The solution here is in good agreement.



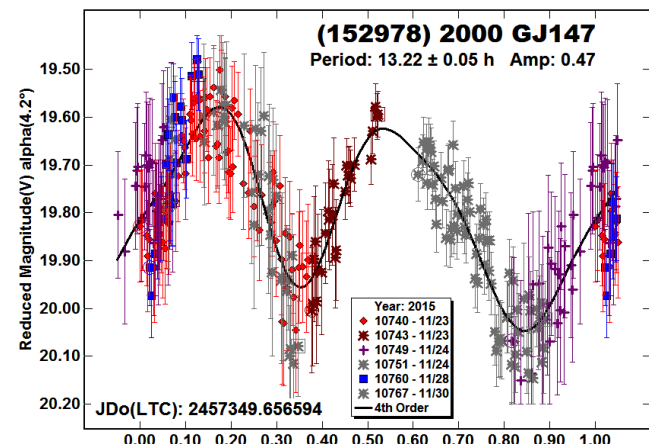
(138852) 2000 WN10. The periods found by Pravec *et al.* (2011web), Skiff *et al.* (2012), and from the CS3 data are in good agreement.



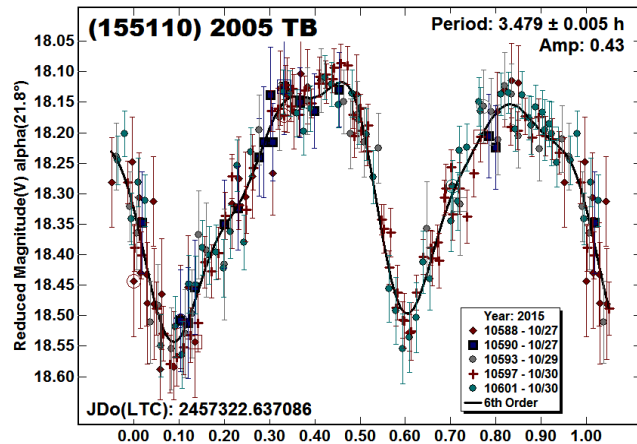
(152679) 1998 KU2. No single period could be found, though one of about 125 h roughly fits a bimodal lightcurve. It's very likely this asteroid is in a tumbling state (non-principal axis rotation, NAPR). See Pravec *et al.* (2014; 2005a).



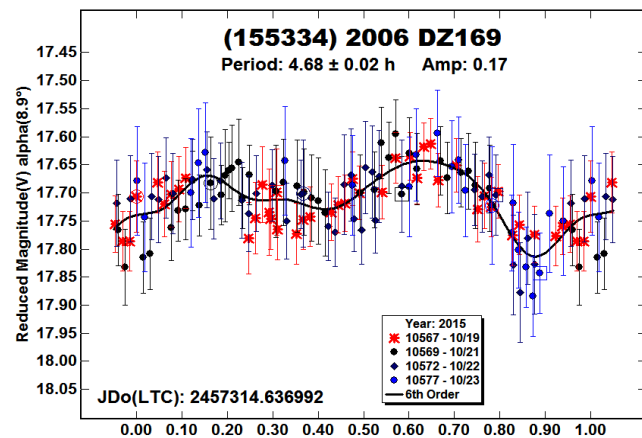
(152978) 2000 GJ147. This appears to be the first reported period for this NEA. Despite the noisy data, the amplitude and low phase angle made the bimodal solution almost certain. The next time the asteroid is brighter than $V = 18.0$ is 2020 November.



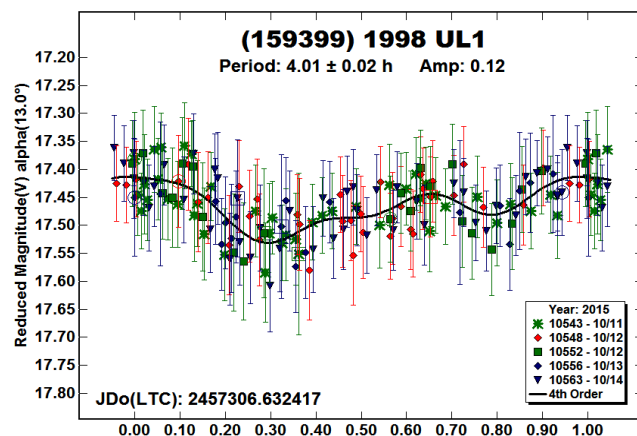
(155110) 2005 TB. There were no previous entries in the LCDB for 2005 TB. The solution is considered secure. The next apparition brighter than $V = 18.0$ is 2025 November, at -62° .



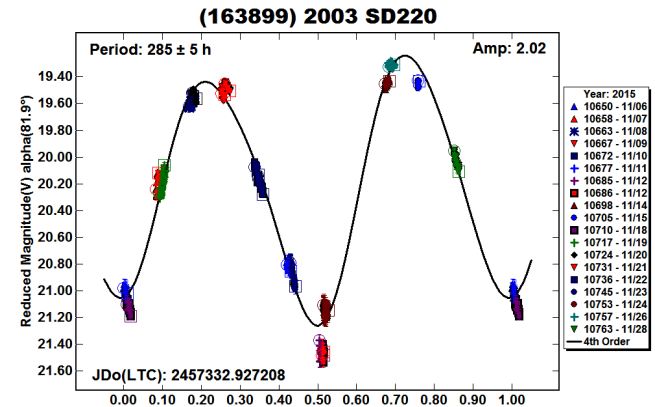
(155334) 2006 DZ169. This NEA was observed at CS3 in 2015 August (Warner, 2016) when the amplitude was 0.21 mag. The amplitude decreased to 0.17 mag for the October observations. This was expected since the phase angle dropped from 42° to 10° and lightcurve amplitude is known to decrease with phase angle (Zappala *et al.*, 1990).



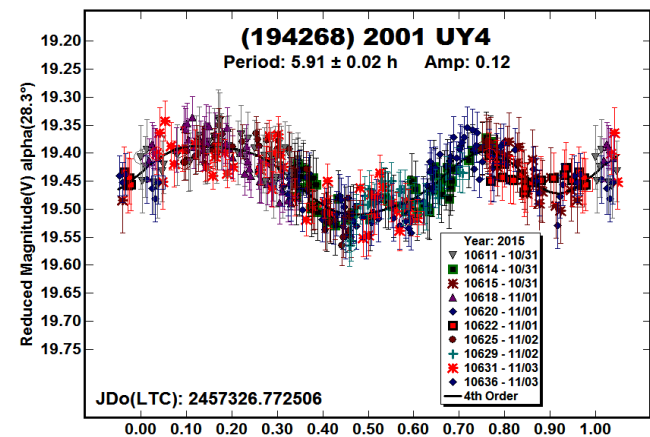
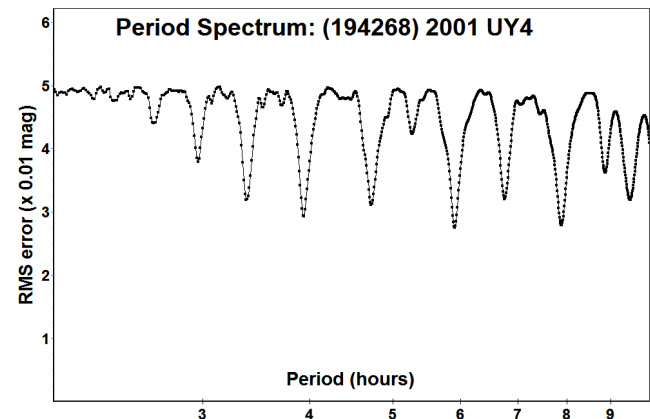
(159399) 1998 UL1. This appears to be the first reported lightcurve for 1998 UL1. While no other solutions were of nearly equal fit to the Fourier model, this period should not be considered definitive.

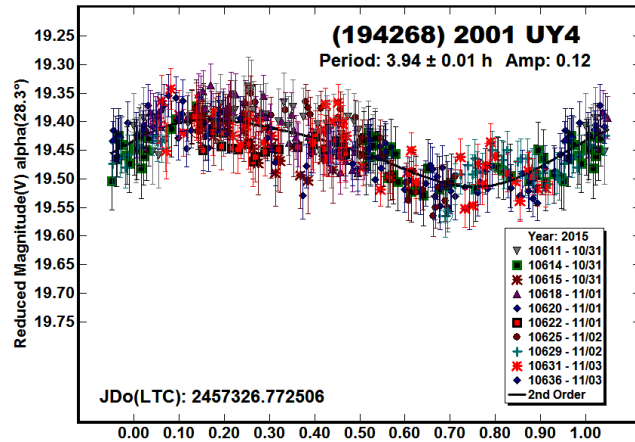
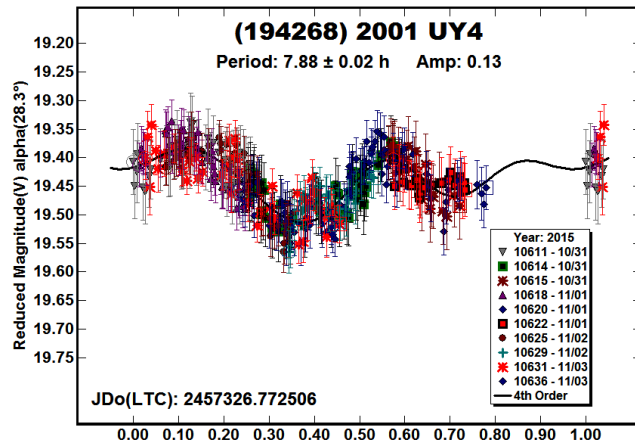


(163899) 2003 SD220. There are very slight hints that this asteroid is tumbling (the slopes of some sessions doesn't quite match the model curve slope). Tumbling would not be unexpected since the approximate damping time to single axis rotation is greater than the age of the Solar System (see Pravec *et al.*, 2014).



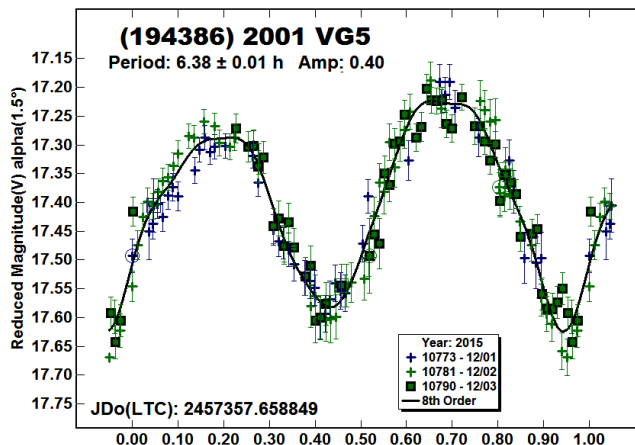
(194268) 2001 UY4. There were no previous entries in the LCDB to help guide the period analysis. As the period spectrum shows, there are several likely solutions, the favored one being 5.91 h. Another solution, at 7.88 h, may be a fit by exclusion, where the Fourier modeling finds a lower RMS by minimizing the number of overlapping data points in the solution. Such a solution is often indicated when there is a significant gap in the lightcurve. It's worth noting that the two periods have an integral ratio of 4:3.



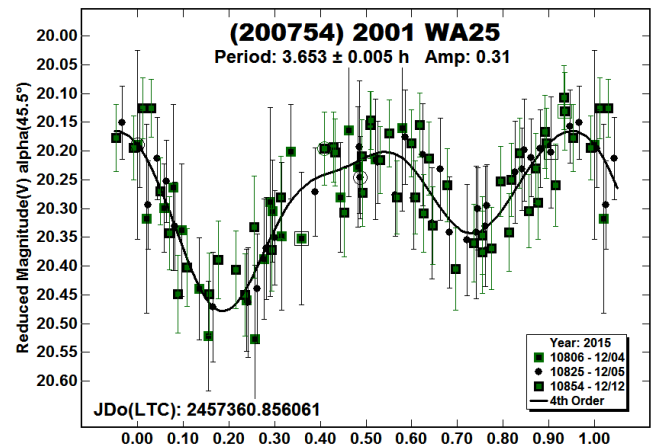


On the other hand, when plotting the half periods of both solutions, the best fit came at 3.94 h, which would favor the 7.88 h solution, assuming a bimodal lightcurve. However, this may not be a good assumption given the low amplitude and phase angle (see Harris *et al.*, 2014).

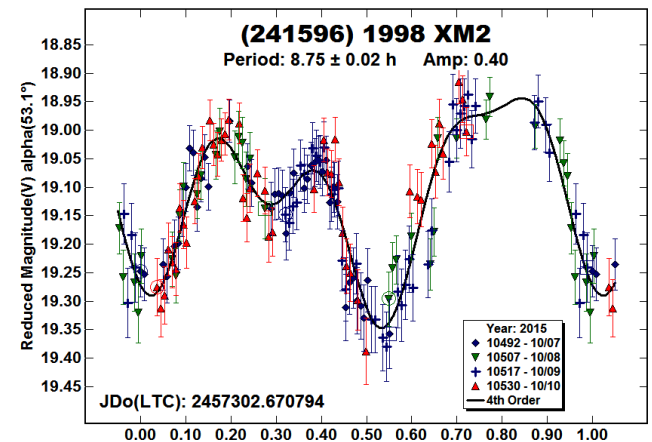
(194386) 2001 VG5. The period for 2001 VG5 has been reported twice before: Polishook (2009; 6.6 h) and Koehn *et al.* (2014; 6.351 h). The results based on the CS3 data are in good agreement with Koehn *et al.*



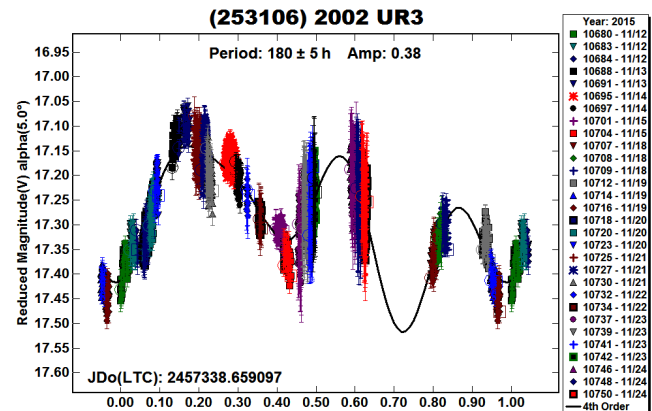
(200754) 2001 WA25. There were no previous entries in the LCDB for this asteroid. The result is considered almost secure. The large scatter in relation to the amplitude leaves the period a little in doubt, but mostly out of a sense of caution.



(241596) 1998 XM2. The interesting shape of the lightcurve for 1998 XM2 may indicate a concavity at one end of an elongated body. Those interested in follow-up will have to wait until 2027 May for it to be $V < 18.0$ again.

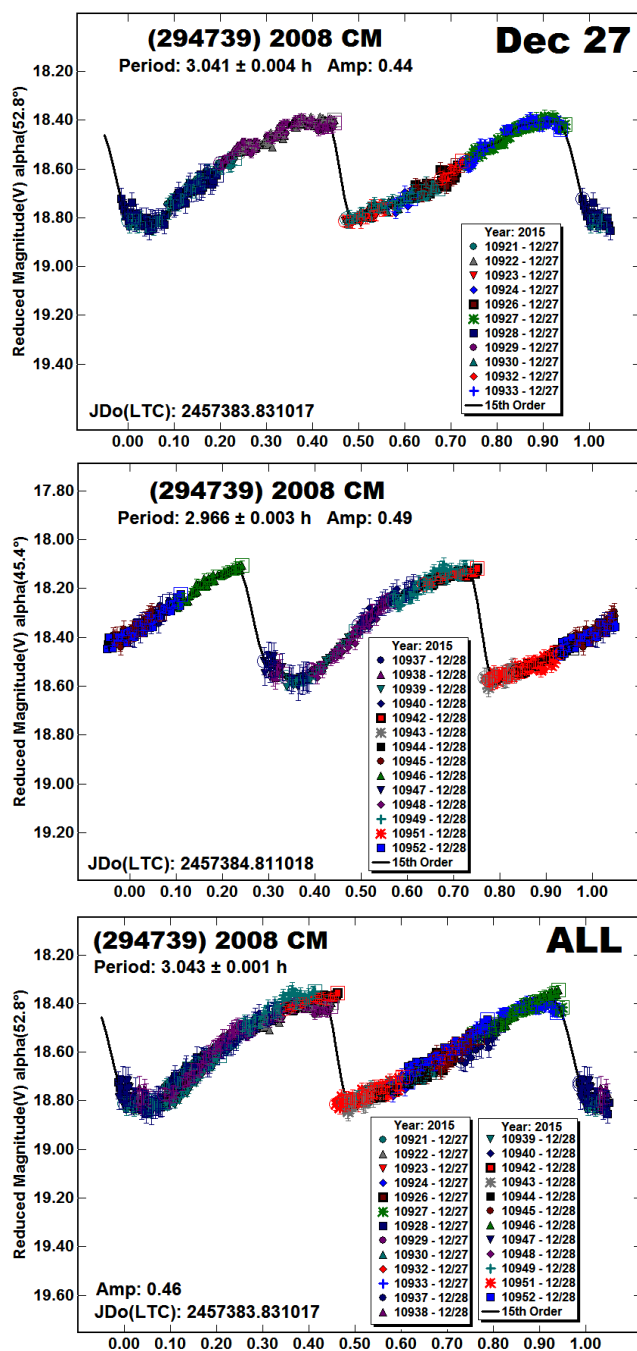


(253106) 2002 UR3. It's very possible that 2002 UR3 is a tumbler. Attempts to find a more bimodal than trimodal solution were unsuccessful. The period is much longer than expected for a damping time equal to the age of the Solar System, making tumbling maybe more likely than not. The 2015 apparition at $V = 15.6$ was brighter than most. It "blazes" through the sky in 2028 when it reaches $V = 14.3$ at $+62^\circ$ declination.



(294739) 2008 CM. This NEA became the subject of intense and detailed radar observations in late 2015. Optical observations were hampered by very fast sky motion and a nearly full moon at the

time of closest approach. The asteroid was observed before (Warner, 2014) when a secure result of $P = 3.054$ h, $A = 0.48$ mag was found.



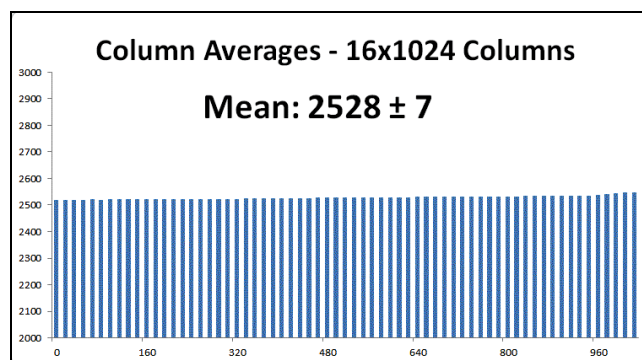
The lightcurves for 2015 Dec 27 and 28 differ in both amplitude and synodic period, with the latter having the shorter period and smaller amplitude. This follows since the phase angle was about $8\text{--}10^\circ$ less on the second day (see Zappala *et al.*, 1990). The combined lightcurve (“All”) gives an average period and amplitude but does not fit the data as well as the individual curves.

The most noticeable feature is the very sharp decline at about 0.45 and 0.95 rotation phase. It’s believed that this is the result in bad timing. During both observing runs, which used exposures of only 10 seconds with a 15-second pause between images and repositioned the telescope every 20 images, the script also forced a

refocusing routine about every hour. This process took anywhere from 3–8 minutes. It *appears* that these breaks were almost synced to the rotation period and so occurred at the same places in the curve throughout each run. That is one explanation.

Another might be that scattered light from a nearly full moon being $30\text{--}40^\circ$ away on the two runs created a gradient across the image and so, as the comp stars moved from right to left, the base differential magnitude would change and then reset when a new set of comparison stars was used. To check on this, two tests were run. The first was to remeasure the images and always use comparison stars on the right side of the image and, if possible, the middle half vertically. This would avoid at least half any gradient change. This did not make a difference. The shifts still occurred at the focusing breaks and the amplitude remained at about 0.4 mag.

The second test was to find the pixel values in a random sampling of images processed with master flat-fields and darks. For each image, the stars were removed leaving (almost) only sky background pixels. The image was then divided into 64 columns that were 16-pixels wide and 1024 pixels high. The average pixel value of the subregions of 16384 pixels was found and then plotted versus starting column, a sample of which is shown here.

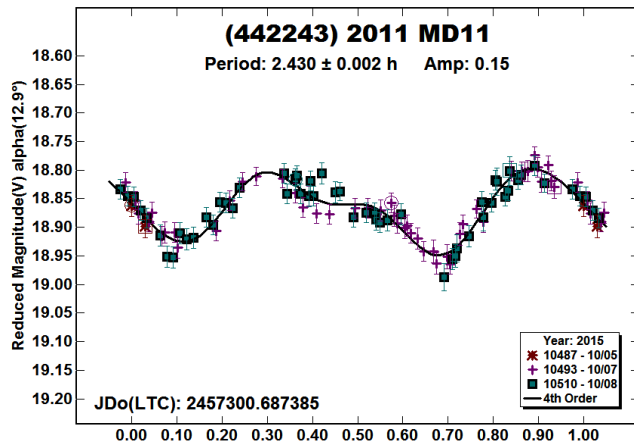


The plot shows a nearly flat response from the left to right side of the image. The standard deviation of the mean of the column averages was 0.2%, or about 0.002 mag. A similar check was done dividing the images into 16-pixel high rows, to see if there was a gradient from top to bottom. The standard deviation was half that for the columns average.

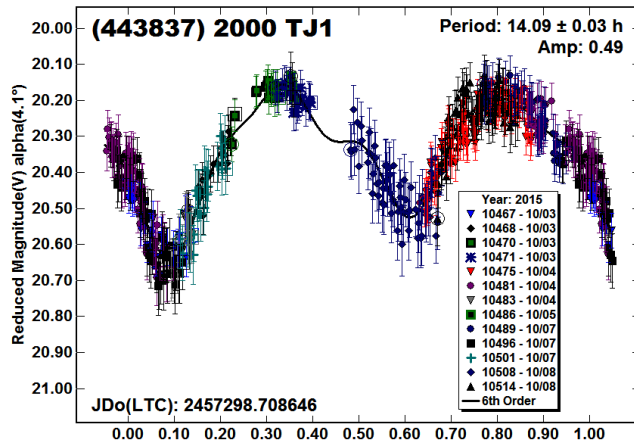
Imaging when there the moon is in the sky can be problematic if the telescope is not well baffled throughout the optical path. However, waiting until the dark of the moon is not always an option. In fact, it often is not. Despite the tests run in this case, the unusual behavior of the lightcurves may have been due to moonlight or other systematic issues other than bad timing. It is worth noting that only one other time has such a problem been seen at CS3 with a fast-moving object where obvious systematic issues could be eliminated. There again, the shifts in the lightcurve were nearly in sync with the breaks for focusing runs.

This highlights the need when working objects with relatively short periods, *i.e.*, $P < 3$ hours, to vary the imaging cadence as much as possible. This means not only random intervals between individual images but, as this case may show, also random intervals between repositioning or refocusing the telescope.

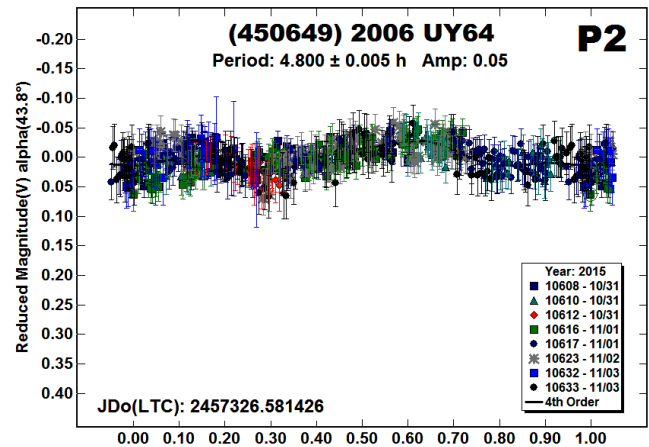
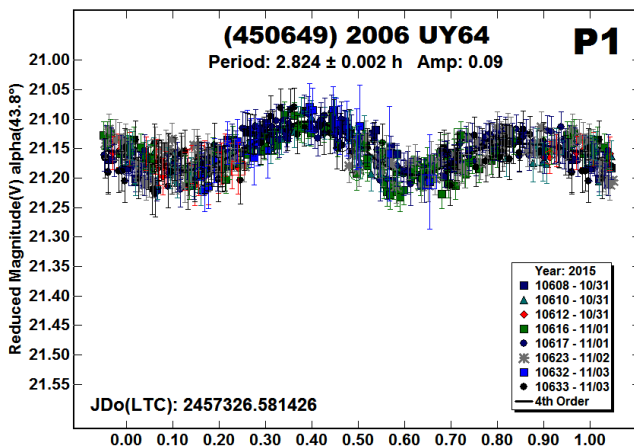
(442243) 2011 MD11. There were no previous entries in the LCDB for 2011 MD11. The period makes it a potential binary asteroid candidate. The next good follow-up opportunity comes in 2019 October at $V \sim 17.7$, Dec $+26^\circ$.



(443837) 2000 TJ1. While there were no previous lightcurve results in the LCDB, it did include an entry from Thomas *et al.* (2014), who reported that the asteroid is of taxonomic type Sq based on warm-Spitzer IR observations. The next photometry opportunity comes in 2020 October when the asteroid will be $V \sim 16.9$ at $+5^\circ$ declination.

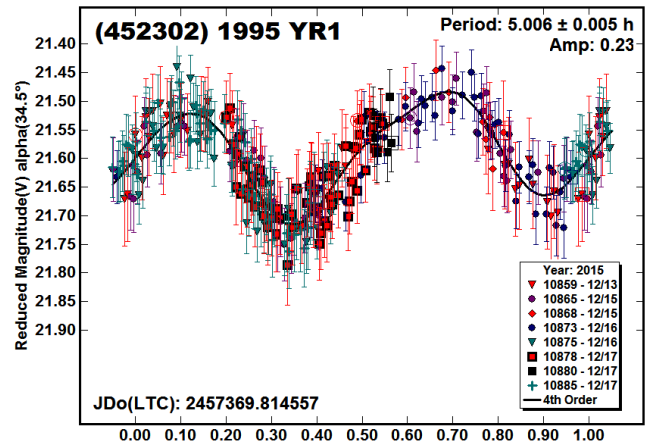


(450649) 2006 UY64. There were no previous entries in the LCDB for 2006 UY64. A single period solution did not quite fit the data. A dual period analysis in *MPO Canopus* found two periods: $P_1 = 2.824 \pm 0.002$ h, $A_1 = 0.09 \pm 0.01$ mag and $P_2 = 4.800 \pm 0.005$ h, $A_2 = 0.05 \pm 0.01$ mag. The shorter period makes the asteroid a good binary candidate.

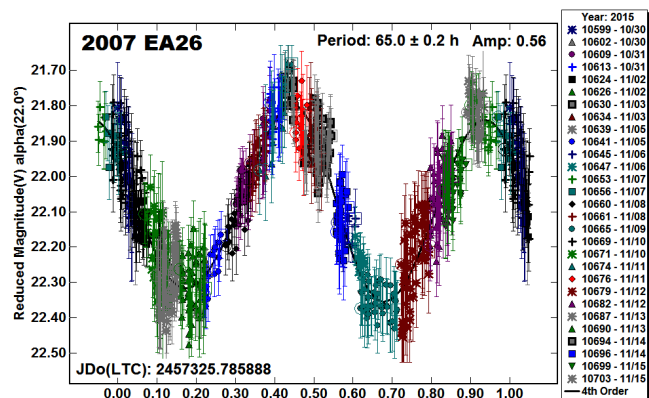


Assuming the second period is valid, it might represent a fully asynchronous satellite, *i.e.*, one where the rotation period is not also the orbital period. The next chance for confirmation by radar or optical observations isn't until 2024 October, when the asteroid will reach a minimum distance of 0.06 AU, $V \sim 14.1$, Dec $+19^\circ$.

(452302) 1995 YR1. This appears to be the first reported lightcurve period for this NEA. The period is considered nearly secure, the small issues being the low SNR and the fact that most observing runs covered less than half a cycle.



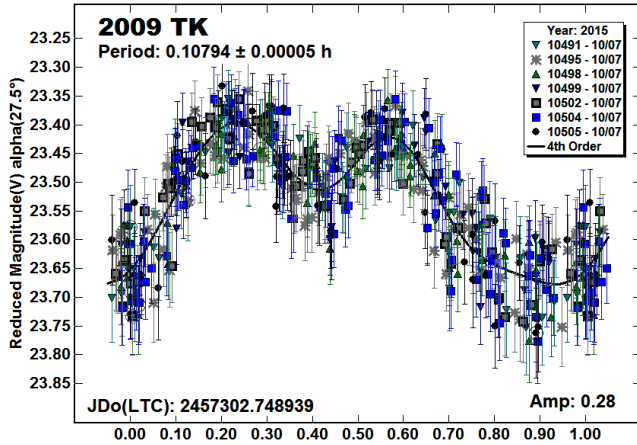
2007 EA26. This appears to be the first reported period for 2007 EA26, an NEA with an estimated diameter of 200 meters.



2009 TK. There were no previous entries in the LCDB for 2009 TK. The estimated size of only 100 meters made it possible that

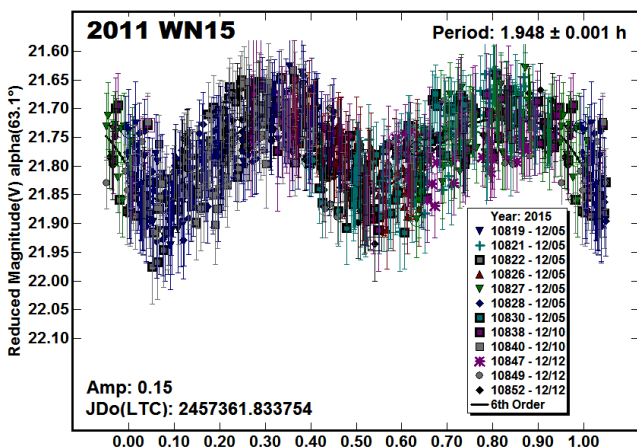
this was a superfast rotator, $P < 2$ h, and so exposures were kept to 30 seconds. Based on Pravec *et al.* (2000), this would avoid rotational smearing as long as the period was about 3 minutes or longer. The short exposures led to a higher than preferred SNR, but proved to be the right choice given the rotation period of just over 6 minutes.

The lightcurve shape is unusual but this may be due in part to the somewhat high phase angle. The double period, $P \sim 0.216$ h was tested. This produced a highly symmetrical lightcurve with both halves matching the one in the plot and was rejected.

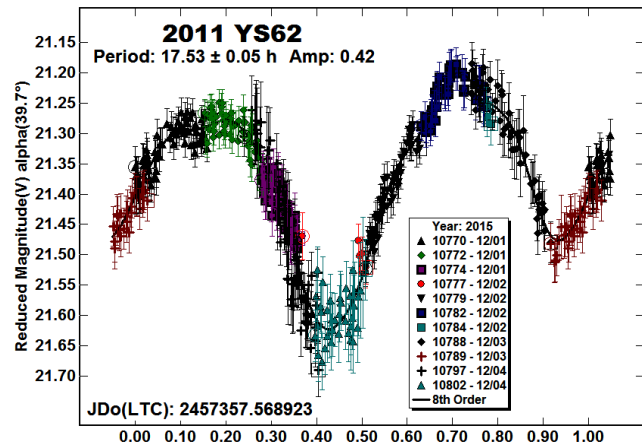


2011 WN15. There were no previous entries in the LCDB for 2011 WN15. The period of just less than 2.1 hours, the so-called “spin barrier” between rubble pile and strength-bound asteroids. This should not be considered overly significant. This asteroid could easily be a rubble pile with sufficient bonding forces to allow it to spin a little faster than might be expected possible. The spin barrier is not a hard-fast but “fuzzy line” at best and depends on any number of factors.

Here is another case where the large scatter in the data was overcome by having a large number of data points in observing runs that each covered a significant part of a cycle.

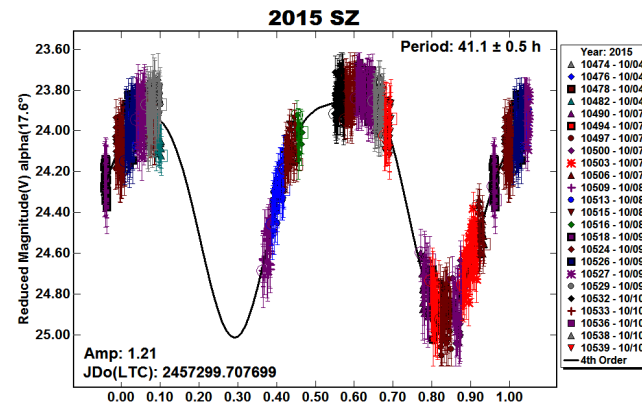


2011 YS62. There were no previous entries in the LCDB for this NEA. The period is considered secure due to the amplitude and asymmetrical shape of the lightcurve.

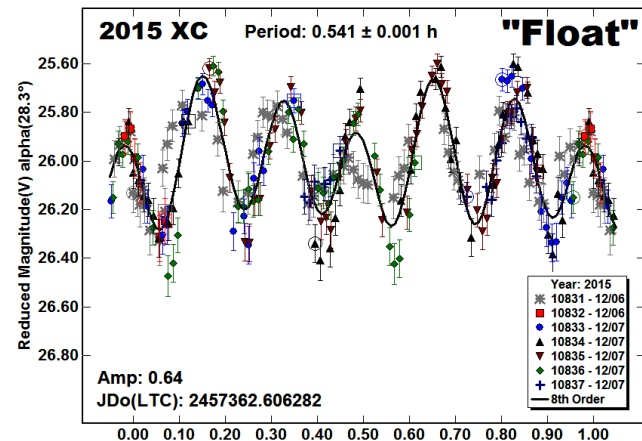


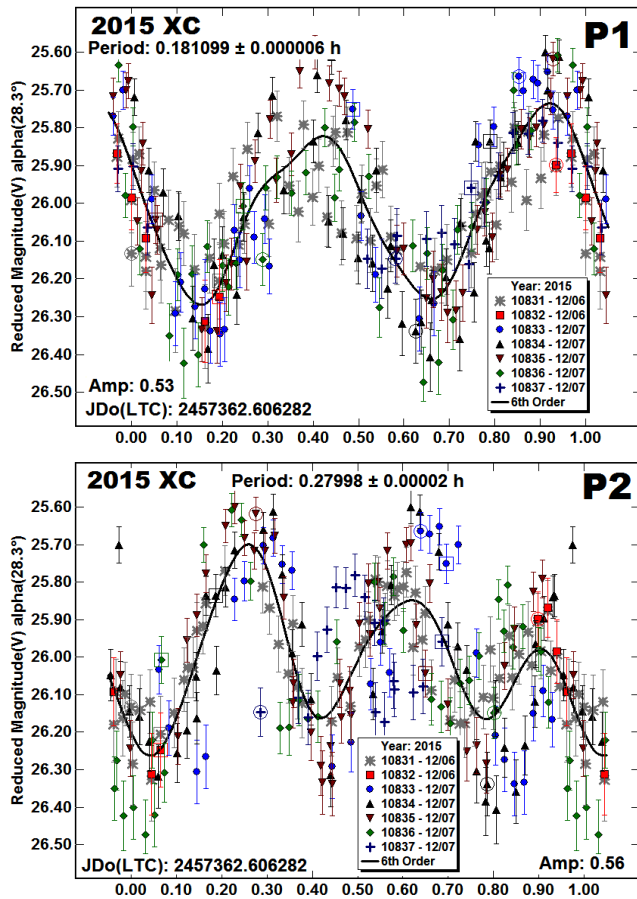
2015 SZ. There were no previous entries in the LCDB for 2015 SZ. While there were no outward signs of the asteroid being a tumbler, it would not be unexpected since the period for a damping time of 4.5 Gy is only 9 hours (see Pravec *et al.*, 2014 and references therein). It's possible that the low SNR data masked small-level tumbling.

Unfortunately, this will be the best result for this NEA for some time. It does not get brighter than $V \sim 21$ nor will it be within reach of existing radar facilities through 2050.



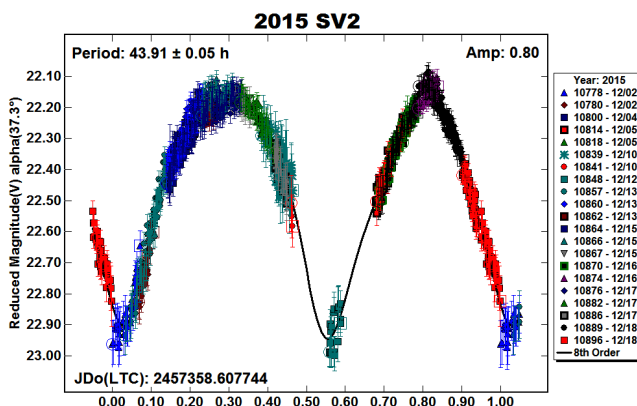
2015 XC. This NEA proved to be a tumbler (Petr Pravec, private communications). The “Float” plot is the best fit solution using the full data set when searching for a single period in *MPO Canopus*.



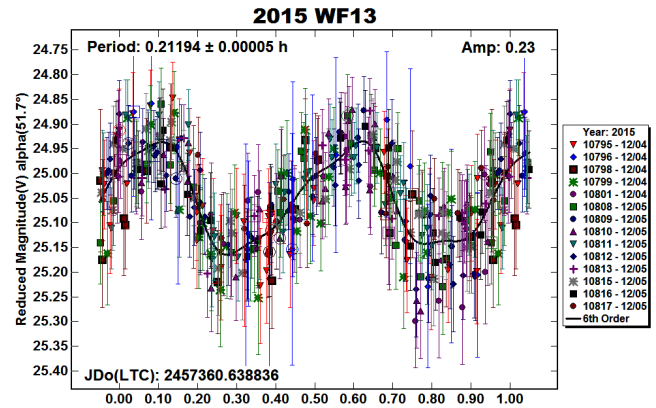


This is very reminiscent of a plot in Harris *et al.* (2014) which was used to demonstrate how a “beat period” could be found for a tumbler with similar periods of rotation and precession. The amplitude of 0.64 mag precludes a complex shape (Harris *et al.*, 2014), adding further evidence for the asteroid being in a tumbling state. Pravec found periods of $P_1 = 0.181099$ h and $P_2 = 0.27998$ h. However, these are not unique and other periods are possible, especially for P_2 . The P1 and P2 plots have been forced to these two periods for comparison purposes only.

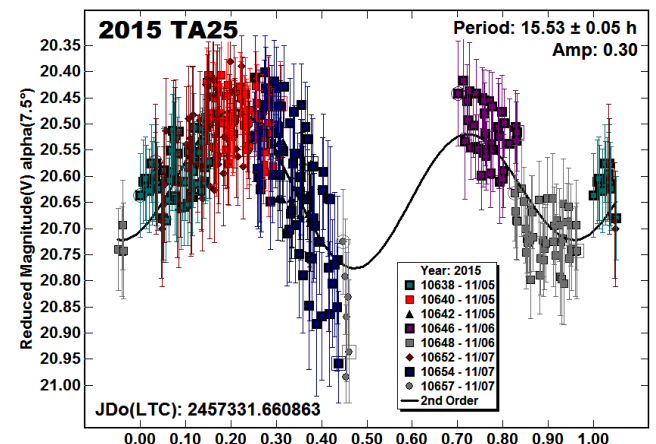
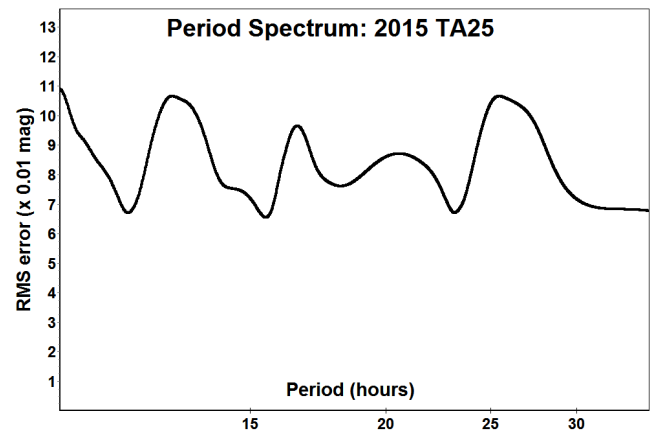
2015 SV2 Here is another long-period NEA that might be expected to show signs of tumbling but does not, at least that can be seen with the existing data set. There were no previous entries in the LCDB. The 2015 apparition was the last one through 2050 where the asteroid will be brighter than $V \sim 20$.



2015 WF13 There were no previous entries in the LCDB for 2015 WF13, and likely won't be any more (lightcurves at least) for some time. The NEA won't get brighter than $V \sim 23.6$ through 2050. Fortunately, the amplitude of the lightcurve was sufficient to overcome the low SNR data and allow finding a secure period. The estimated diameter is only 60 meters, and so the superfast period of only 12.7 minutes was not unexpected. Because of its small size, exposures were limited to 30 seconds to avoid rotational smearing (see Pravec *et al.*, 2000).



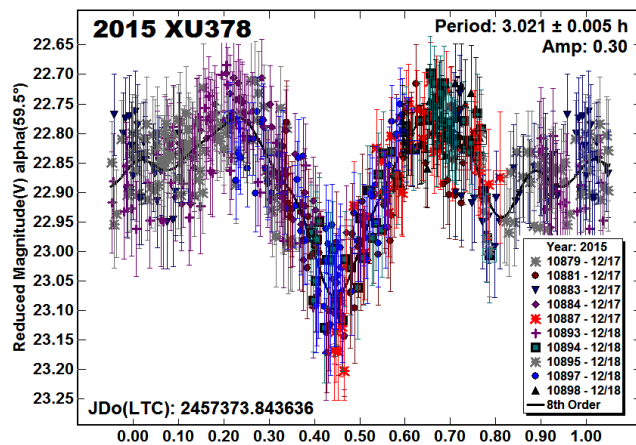
2015 TA25 A limited data set and apparently somewhat long period conspired against finding a reliable solution for 2015 TA25. The period spectrum shows several equally possible solutions. The period of 15.53 h is adopted here based on fitting the data to half-periods and the best fit being near 7.8 hours. There were no previous entries in the LCDB.



Number	Name	2015 mm/dd	Pts	Phase	L _{PAB}	B _{PAB}	Period	P.E.	Amp	A.E.	Grp
1620	Geographos	12/13–12/16	186	26.9, 28.0	51	21	5.223	0.005	1.02	0.03	NEA
5646	1990 TR	11/18–11/24	112	50.1, 49.0	146	3	3.203	0.002	0.26	0.03	NEA
6611	1993 VW	10/11–11/15	340	8.5, 6.9, 21.4	27	5	2.63	0.01	0.05	0.02	NEA
11054	1991 FA	10/09–10/11	88	57.4, 58.0	66	6	2.926	0.005	0.15	0.02	NEA
33342	1998 WT24	11/22–12/12	1400	70.4, 21.7, 32.5	90	-14	3.697	0.001	0.29	0.03	NEA
53426	1999 SL5	10/12–10/19	122	36.1, 32.3	9	32	5.03	0.05	0.15	0.03	NEA
88263	2001 KQ1	10/11–10/29	202	38.1, 35.6	68	4	13.16	0.01	0.52	0.03	NEA
112985	2002 RS28	11/05–11/15	417	47.6, 44.9	321	20	4.787	0.005	0.09	0.02	NEA
137084	1998 XS16	10/11–10/14	123	71.7, 68.6	18	61	5.419	0.005	1.18	0.03	NEA
138852	2000 WN10	11/19–11/21	242	24.8, 23.9	46	-11	4.463	0.005	0.38	0.03	NEA
152679	1998 KU2	10/24–11/11	1291	30.2, 13.6	62	-4	^T 125	5	1.35	0.20	NEA
152978	2000 GJ147	11/23–11/30	279	4.3, 14.3	60	6	13.22	0.05	0.47	0.05	NEA
155110	2005 TB	10/27–10/30	205	21.7, 19.7	31	17	3.479	0.005	0.43	0.03	NEA
155334	2006 DZ169	10/19–10/23	137	9.0, 11.6	15	1	4.68	0.02	0.17	0.03	NEA
159399	1998 UL1	10/11–10/14	166	13.0, 11.2	28	14	4.01	0.02	0.12	0.03	NEA
163899	2003 SD220	11/06–11/28	740	82.0, 80.7, 81.9	100	21	285	5	2.2	0.1	NEA
194268	2001 UY4	10/31–11/03	400	28.2, 21.5	47	-16	7.88	0.02	0.13	0.02	NEA
194386	2001 VG5	12/01–12/03	155	1.5, 3.3	67	0	6.38	0.01	0.4	0.03	NEA
200754	2001 WA25	12/04–12/05	104	45.5, 44.3	109	8	3.653	0.005	0.31	0.04	NEA
241596	1998 XM2	10/07–10/10	167	53.1, 52.1	13	49	8.75	0.02	0.4	0.03	NEA
253106	2002 UR3	11/12–11/23	1650	4.9, 4.1, 22.6	76	-1	180	5	0.36	0.03	NEA
294739	2008 CM	12/27–12/27	982	52.9, 52.9	120	16	3.041	0.004	0.44	0.02	NEA
294739	2008 CM	12/28–12/28	499	45.3, 45.3	119	10	2.966	0.004	0.49	0.02	NEA
442243	2011 MD11	10/05–10/08	102	12.9, 13.1	4	-5	2.43	0.002	0.15	0.01	NEA
443837	2000 TJ11	10/03–10/08	496	3.9, 2.8, 11.8	11	-4	14.09	0.03	0.49	0.04	NEA
450649	2006 UY64	10/31–11/03	536	44.2, 49.7	14	13	2.824	0.002	0.09	0.02	NEA
452302	1995 YR1	12/13–12/17	301	34.5, 40.0	107	-5	5.006	0.005	0.23	0.03	NEA
	2007 EA26	10/30–11/15	548	22.0, 43.6	37	20	65.0	0.2	0.56	0.05	NEA
	2009 TK	10/07–10/07	433	27.7, 27.7	26	-8	0.10794	0.00005	0.28	0.04	NEA
	2011 WN15	12/05–12/12	820	63.3, 18.2	95	9	1.948	0.001	0.15	0.03	NEA
	2011 YS62	12/01–12/04	462	40.0, 43.4	53	19	17.53	0.05	0.42	0.03	NEA
	2015 SZ	10/04–10/09	816	17.7, 30.5	27	0	41	1	1.33	0.10	NEA
	2015 XC	12/06–12/07	244	30.5, 46.9	58	12	^T 0.181099	0.000006	0.55	0.05	NEA
	2015 SV2	12/02–12/18	1004	37.2, 20.4	85	15	43.91	0.05	0.8	0.03	NEA
	2015 WF13	12/04–12/05	361	51.3, 47.7	46	-2	0.21194	0.00005	0.23	0.05	NEA
	2015 TA25	11/05–11/07	335	7.8, 12.1	39	6	^A 15.53	0.05	0.35	0.05	NEA
	2015 XU378	12/17–12/18	562	59.5, 59.7	59	-1	3.021	0.005	0.3	0.04	NEA

Table III. Observing circumstances. ^Apreferred period for an ambiguous solution. ^Pperiod of primary in binary. ^Tdominant period of a tumbler. 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; *Icarus* **202**, 134–146).

2015 XU378. This appears to be the first reported lightcurve for 2015 XU378. The period seems secure, which is fortunate since the asteroid won't be brighter than V ~ 22 mag through 2050.



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RESULTS OF THE 2015 MEXICAN ASTEROID PHOTOMETRY CAMPAIGN

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The 2015 Mexican Asteroid Photometry Campaign was organized at the 2nd National Planetary Astrophysics Workshop held in 2015 March at the Universidad Autónoma de Nuevo León in Monterrey, México. Three asteroids were selected for coordinated observations from several Mexican observatories. We report full lightcurves for the main-belt asteroid 1084 Tamariwa ($P = 6.195 \pm 0.001$ h) and near-Earth asteroid (NEA) 4055 Magellan ($P = 7.479 \pm 0.001$ h). Asteroid 1466 Mundleria was also observed on eight nights but no lightcurve was obtained because of its faintness, a crowded field-of-view, and low amplitude (<0.03 mag).

Planetary astronomy in general is becoming a more popular field of scientific study in Mexico, in part due to the recent establishment of the Mexican Space Agency (<http://www.aem.gob.mx/>). As a consequence, the Universidad Autónoma de Nuevo León, in the city of Monterrey, organized a series of National Planetary Astrophysics Workshops. The first was in 2013 and the second in 2015 (<http://tasp.fcfm.uanl.mx/>).