ASTEROID LIGHTCURVE ANALYSIS AT CS3-PALMER DIVIDE STATION: 2013 SEPTEMBER-DECEMBER

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Lightcurves for 31 main-belt asteroids were obtained at the Center for Solar System Studies-Palmer Divide Station (CS3-PDS) from 2013 September through December. The majority of the objects were members of the Hungaria group/family. In many cases, the observations were follow-up to previous apparitions to check for the possibility of undiscovered satellites or to provide additional data for spin axis and shape modeling. Three Hungaria asteroids, 4440 Tchantches, 6602 Gilclark, and 7173 Sepkoski, are *possible* binary candidates while (69406) 1995 SX48 is a *probable* binary candidate. The inner main-belt asteroid (119744) 2001 YN42 may be a rare example of a binary with a relatively short period superimposed on a large amplitude secondary period on the order of hundreds of hours.

CCD photometric observations of 31 asteroids were made at the Center for Solar System Studies-Palmer Divide Station (CS3-PDS) in 2013 September through December. Table I gives a listing of 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
PDS-1-12N	0.30-m f/6.3 Schmidt-Cass	ST-9XE
PDS-1-14S	0.35-m f/9.1 Schmidt-Cass	FLI-1001E
PDS-2-14N	0.35-m f/9.1 Schmidt-Cass	STL-1001E
PDS-2-14S	0.35-m f/9.1 Schmidt-Cass	STL-1001E
PDS-20	0.50-m f/8.1 Ritchey-Chretien	FLI-1001E

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

All lightcurve observations were made with no filter (a clear filter can result in a 0.1-0.3 magnitude loss) and were guided on a field star, resulting in some cases in a trailed image for the asteroid. The exposures varied depending on the asteroid's brightness and sky motion.

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* finds up to five comparison stars of near solar-color to be used in differential photometry. Catalog magnitudes are 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 magnitude or better, but on occasion are as large as 0.1 mag. This reasonably good 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 (or Cousins R) as indicated in the Y-axis title. These are values that have been converted from sky magnitudes to unity distance by applying $-5*\log(r\Delta)$ 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 phase angle given in parentheses, e.g., alpha(6.5°), using $G = 0.15$, unless otherwise stated. The horizontal 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.

Individual Results

64 Angelina. This middle main-belt asteroid was observed in support of radar observations and modeling by Michael Shepard. The period had been well-established beforehand (e.g., Behrend, 2005; Durech *et al.*, 2011). The CS3-PDS data led to a result of $P = 8.75$ h, in near perfect agreement with those earlier results.

2254 Requiem. This appears to be the first reported period for Requiem, a member of the Flora group.

3169 Ostro. The period of this Hungaria asteroid has been reported numerous times in the literature (e.g., Behrend, 2009; Warner, 2009c; 2012b) at about 6.5 h. The reported amplitude has ranged from 0.42 to 1.2 mag. Analysis of the 2013 PDS observations found $P = 6.509$ h and $A = 0.62$ mag.

3823 Yorii. This is an outer main-belt asteroid with an estimated diameter of 14.6 km. No previous entries in the LCDB were found.

4031 Mueller. The 2013 apparition was the third one at which the author observed this Hungaria (Warner, 2009b; 2012a). The period of 2.943 h is in agreement with those earlier findings.

4440 Tchantches. The author observed this asteroid on three previous occasions (Warner, 2006; 2011; Warner and Higgins, 2009). The previous results as well as those from 2013 (the first plot below) give $P \sim 2.79$ h with an amplitude range of 0.21-0.34 mag. These make the asteroid a good candidate for being binary. A review of data from the previous apparitions found that the 2005 data set showed signs of a satellite in the form of "mutual events" (occultations and/or eclipses) that show as attenuations in the principal lightcurve.

The "No Sub" plot for the asteroid shows the data without subtracting any effect due to the supposed satellite. Compare this to the "P1" plot, where those effects have been removed. The "P2" plot shows the data after subtracting the primary. There is a general up-bow trend in the curve, which is often seen with an elongated satellite that is tidally-locked to its orbital period. There are also indicates of the mutual events. Overall, however, these are very weak signs and so the asteroid should be considered at best a

Number	Name	2013 mm/dd	Pts	Phase	L_{PAB}	B_{PAB}	Period	P.E.	Amp	A.E.
64	Angelina	12/13-12/15	1843	3.8,4.7	74	1	8.75	0.01	0.22	0.02
2254	Requiem	11/17-11/18	317	12.2,12.7	36	6	4.430	0.001	0.22	0.02
3169	Ostro	12/09-12/14	401	13.7,10.2	95	-5	6.509	0.001	0.62	0.02
3823	Yorii	10/03-10/09	230	13.9,12.2	46	-6	6.669	0.005	0.26	0.02
4031	Mueller	12/02-12/08	88	33.2,33.2	358	7	2.943	0.001	0.19	0.02
4440	Tchantches	10/21-10/27	578	19.8,18.6	44	28	2.7886	0.0002	0.28	0.02
4440	Tchantches	09/27-11/02^{5}					2.7884*	0.0001	0.31	0.02
5175	Ables	09/25-09/29	206	27.0,26.2	56	5	2.798	0.001	0.09	0.01
6249	Jennifer	12/21-12/23	202	33.9,34.1	34	-6	4.958	0.005	0.49	0.02
6602	Gilclark	12/26-12/30	101	34.1,34.2	29	25	4.569*	0.002	0.39	0.02
7087	Lewotsky	09/29-10/03	212	22.4,20.9	44	5	3.941	0.001	0.29	0.02
7087	Lewotsky	12/27-12/30	172	27.1,27.9	50	-10	3.941	0.001	0.51	0.02
7087	Lewotsky	08/15-08/26^{10}	142				3.942	0.002	0.16	0.02
7173	Sepkoski	10/04-10/24	662	24.3,15.7	51	13	2.5006*	0.0002	0.11	0.02
7505	Furusho	12/21-12/22	356	7.4,6.8	102	2	4.140	0.005	0.52	0.02
9068	1993 OD	11/18-11/26	336	28.6,25.7	79	27	3.407	0.001	0.20	0.02
9873	1992 GH	11/15-11/17	355	31.1,31.1	131	18	2.926	0.003	0.34	0.03
11833	Dixon	11/07-11/13	277	13.4,9.7	65	1	3.594	0.001	0.20	0.03
11941	Archinal	12/02-12/08	156	10.2,6.7	86	3	2.718	0.001	0.18	0.02
11976	Josephthurn	12/15-12/22	319	18.6,18.3	93	27	3.535	0.001	0.15	0.02
11976	Josephthurn	04/22-04/30^{9}	102				3.534	0.002	0.10	0.01
12369	Pirandello	10/03-10/09	318	16.1,14.0	45	-6	3.504	0.003	0.07	0.01
21321	1997 AN2	09/29-10/02	209	5.1,4.2	12	6	13.92	0.03	0.11	0.01
24077	1999 TD233	12/31-12/31	956	5.1,0.0,4.2	0	0	30.86	0.01	0.70	0.05
30856	1991 XE	12/24-12/26	155	31.7,32.0	42	-14	5.358	0.002	1.23	0.03
31173	1997 XF1	11/28-12/25	753	18.4,27.8	44	8	122.8	0.5	0.67	0.03
49667	1999 OM2	12/13-12/15	251	14.3,13.3	104	2	3.487	0.002	0.46	0.02
49675	1999 SW27	11/15-11/17	158	11.1,10.4	60	14	4.998	0.004	0.42	0.03
69406	1995 SX48	12/26-12/31	330	18.9,16.0	123	3	4.486*	0.001	0.15	0.03
82060	2000 WX8	11/13-11/17	315	17.7,17.2	55	24	2.764	0.001	0.20	0.02
86192	1999 SV1	12/21-12/25	224	0.0,10.8	84	-9	7.172	0.004	0.23	0.02
119744	2001 YN42	09/06-10/02	834	16.8,4.3	11	6	7.24*	0.01	0.05	0.01
120578	1995 QV12	09/29-10/22	401	5.1,4.0,10.5	12	6	72.4	0.5	0.51	0.05
134549	1999 RN154	10/05-10/25	312	3.9,11.7	13	7	124.	10.	0.55	0.05

Table II. Observing circumstances. * Solution is for a primary of a binary asteroid (see text). Dates with superscripts <90 are from the year 2000 plus the superscript value. Superscripts >90 are 1900 plus the value. 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).

possible, not probable, binary that warrants careful observations at future apparitions.

5175 Ables. Warner (2011a) reported a period of 2.798 h for this Hungaria. Analysis of the 2013 data found the same result.

6249 Jennifer. This asteroid has been observed several times before by the author (see Warner, 2014). Follow-up observations were made in late 2013, when the phase angle and phase angle bisector had changed significantly, to help with spin axis modeling. For reference, the previously published lightcurve from 2013 September (*A* = 0.10 mag) is shown as well as the one from December (*A* = 0.39 mag).

6602 Gilclark. Previous observations by the author (Warner, 2009a; 2012a) found a period of 4.574 h. The results from 2013 were in good agreement, *P* = 4.5686 h. This asteroid also showed weak indications of a satellite via shallow mutual events and a slight bowing of the secondary period. It should be considered a *possible* binary, not *probable*, and – like 4440 above – should be carefully monitored at future apparitions.

7087 Lewostksy. This Hungaria was observed by Carbo (2009) who reported only an amplitude of 0.25 mag. Observations by the author (Warner, 2011a) found a period of 5.15 h. Observations in 2012 (Warner, 2012b) updated the period to 3.934 h. The asteroid was observed at CS3 on two occasions during the 2013 apparition, first in late September (*P* = 3.941 h, *A* = 0.29 mag; first plot below) and again in late December (*P* = 3.942 h, *A* = 0.51 mag; second plot below). The three most recent results prompted a visit to the original data from 2010. New analysis was able to fit those data to *P* = 3.934 h. Given the low amplitude, relatively noisy data, and the fact that each session was at least three days removed from any other, the small discrepancy should not come as a surprise and the results can be considered the same for statistical studies.

7173 Sepkoski. Previous results for this Hungaria include Warner (2011a, *P* = 2.50 h) and Han (2013, *P* = 2.44 h). Analysis of the data from the 2013 observations at CS3 found *P* = 2.5006 h, *A* = 0.11 mag. This asteroid also showed weak signs of mutual events. The difference between the "No Sub" and "P1" plots below shows little difference given the overall scatter in the lightcurve. The "P2" plot indicates a possible orbital period for a tidally-locked satellite of P_{ORB} = 12.75 h, mostly based on a supposed event at about 0.0 orbital phase. Here again, this should be considered only a *possible* binary and the asteroid be given priority at future apparitions.

7505 Furusho. This Mars-crosser was observed in 2000 by Stephens (2001), who reported *P* = 4.14 h, and by Szekely (2005), who reported the same period. The observations at CS3 led to a result of *P* = 4.140 h.

(9068) 1993 OD. Previous results for this Hungaria include Warner (2009a, *P* = 3.405 h) and Galad *et al.* (2010, *P* = 3.4074 h). The result from the 2013 apparition was *P* = 3.407 h.

(9873) 1992 GH. The author observed this Hungaria on three occasions prior to 2013 (Warner, 2007a; 2009a; 2012a). Sauppe *et al.* (2007) also reported observations. In all cases, the period was close to 2.92 h, which is the same result based on of the 2013 observations at CS3.

11833 Dixon. The results from the 2013 apparition appear to be the first to be reported for this Hungaria member.

11941 Archinal. Li *et al.* (2013) reported a period of 2.717 h for this Hungaria. The results from the 2013 campaign at CS3 are nearly identical, $P = 2.718$ h.

11976 Josephthurn. Analysis of the data from 2013 obtained at CS3 found $P = 3.535$ h (first plot below), nearly identical to the one found earlier by the author (Warner, 2011c), and somewhat the same one of $P = 3.50$ h obtained in 2009 (Warner, 2009d). The original data from 2009 were re-examined, which lead to a revised value of $P = 3.534$ h (second plot).

12369 Pirandello. There were no previous results in the LCDB for this Flora member.

(21321) 1997 AN2. Also a Flora member, there were no previous entries in the LCDB for this asteroid.

(24077) 1999 TD233. There is little doubt that this Hungaria is in non-principal axis rotation, or *tumbling*. Analysis by Petr Pravec, Astronomical Institute, Czech Republic (private communications), found two *possible* periods of about 30.86 and 33.13 h. The plots below show the entire data set forced to these two periods and are for instructive purposes only. These could easily be linear combinations of the two true periods ($1/f1$ and $1/f2$) or integral multiples of one or both. Even with observations from multiple locations that are well-separated in longitude, obtaining the actual periods would be very difficult. In such cases, it must be sufficient to determine that the asteroid is tumbling, the degree it is doing so, and approximate solutions. For a detailed discussion on the analysis and mechanisms of tumbling, see Pravec *et al.* (2005).

(30856) 1991 XE. The 2013 apparition was the fourth time this Hungaria had been observed by the author (Warner, 2007a; 2010b; 2012a). All four results found a period within 0.01 h of $P = 3.56$ h.

(31173) 1997 XF1. The long period of 123 hours and the size of this Hungaria ($D \sim 2.7$ km) favor it being in a tumbling state, i.e., that its damping time was greater than the age of the Solar System (see Pravec *et al.*, 2005). However, there were no obvious indications of this, e.g., a session "leaning the wrong way" and not being able to fit a reasonable single period even with zero point offsets. There were no previous entries in the LCDB.

(49667) 1999 OM2. Warner *et al.* (2011) observed this Hungaria in 2010 and reported a period of 3.48608 h. The 2013 data analysis found $P = 3.487$ h, in good agreement with those earlier results.

(49675) 1999 SW27. The results from the 2013 campaign of $P = 4.998$ h are in good agreement with the author's earlier finding (Warner, 2011a; $P = 4.994$ h).

(69406) 1995 SX48. This Hungaria has a reported period of 2.2431 h (Warner and Stephens, 2011). However, the double period of about 4.48 h could not be formally excluded. Analysis of the 2013 data from CS3 found that the longer period, $P = 4.486$ h, is the correct one, the data providing a very poor fit to the shorter period. Furthermore, the data showed signs of mutual events due to a satellite. The period spectrum for the secondary period shows several nearly equal solutions. The "P2" plot shows the data after subtracting the primary rotation and fit to a period of 16.11 h. This makes a good case for a satellite, having events at 0.0 and 0.5 orbital phase. The attenuation of about 0.04 mag gives a lower limit of $Ds/Dp \geq 0.19 \pm 0.02$. Had the events been flat-bottomed, indicating a total event, then this value would have been the actual effective diameter ratio of the satellite to primary. This can be considered a *probable* binary, maybe even confirmed.

(82060) 2000 WX8. Warner (2011a) observed this Hungaria is 2010, reporting a period of 2.7631 h. The period of 2.764 h found from the 2013 data is in good agreement.

(86192) 1999 SV1. The result of $P = 7.172$ h found from the 2013 observations (plot "P1B") is in good, but not perfect, agreement with the author's earlier result of $P = 7.167$ h (third plot in set). However, as seen in the period spectrum for the 2013 data (plot "2013: P1"), a monomodal solution with a half period of about 3.85 h is nearly as valid. The deciding factor for adopting the longer period was the asymmetry of the 2010 lightcurve at the longer period and that the data forced to the half period give a very poor fit. Given the 7.1-hour period and time span within each data set, the two periods are statistically the same. There were faint indications of a secondary period in the 2013 and so the asteroid should be monitored carefully at future apparitions.

(119744) 2001 YN42. Jacobsen and Scheeres (2011) reasoned that one evolutional path for binary asteroids would result in a system that had a primary with a long period (due to conservation of energy) and a widely-spaced satellite with a relatively short rotation period and an orbital period that is probably very long. Furthermore, the orbital period would probably not be synchronized with either rotation period. The chances of seeing occultations and/or eclipses in such a system would be exceedingly remote. Two systems discovered by the author, 8026 Johnmckay (Hungaria; Warner, 2011b) and (218144) 2002 RL66 (Mars-crosser; Warner, 2010a) show such photometric traits, including the lack of mutual events. (119744) 2001 YN42 (inner main belt) appears to be the third example of this type of system. All three objects have estimated effective diameters of about 3 km or less.

The "P1" plot below (due to the putative primary) shows the large amplitude, long period component, the period being about 625 hours and the amplitude 0.52 mag. It is impossible to see the effects of the other period in this plot. However, if that long period is subtracted from the data, a reasonably good "secondary" period of 7.24 hours is found, as shown in the "P2" period spectrum. The "P2" lightcurve shows a low amplitude (0.05 mag) bimodal solution with a period of 7.24 h, which does not have a half or integral multiple equal to the long period.

As with the two previous cases, the amplitude of the shorter period lightcurve is low, making it difficult to state with certainty that it is does not have observational or systematic origins or is simply an artifact of the Fourier analysis. However, "three is a crowd" and given that such a system is considered not only theoretically possible but likely, it is not as easy to dismiss the results as when there were only one or two examples.

(120578) 1995 QV12. This outer main-belt object was a *target of opportunity*, i.e., in the same field as a targeted asteroid. There were no previous entries in the LCDB. Given the incomplete coverage of the lightcurve, the period of 72.4 h cannot be considered definitive.

(134549) 1999 RN154. There were no previous entries in the LCDB for this Flora member. It was also a *target of opportunity*. Some of the individual sessions seem to be "leaning the wrong way", which may be an indication that the asteroid is tumbling. The period is much greater than one corresponding to a damping time equal to the age of the Solar System, so tumbling would not be unexpected. See Pravec *et al.* (2005) for a thorough discussion of tumbling asteroids.

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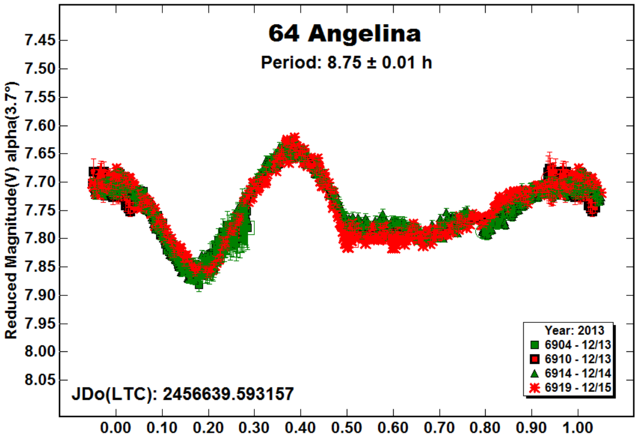
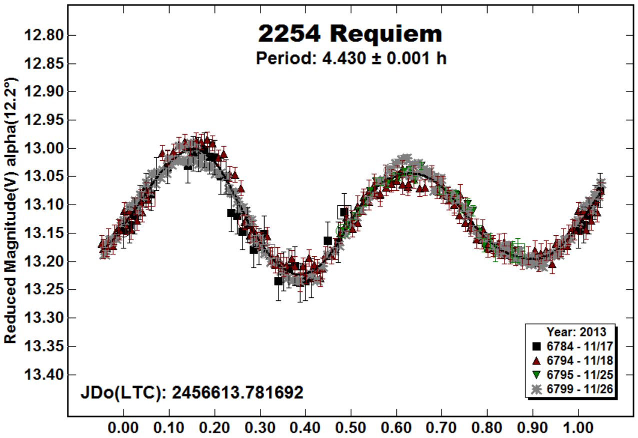
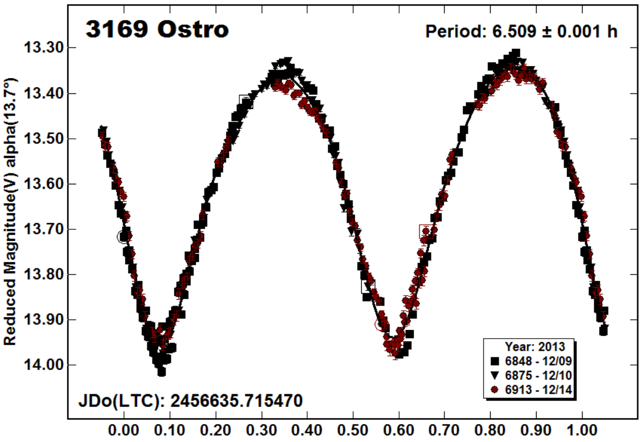
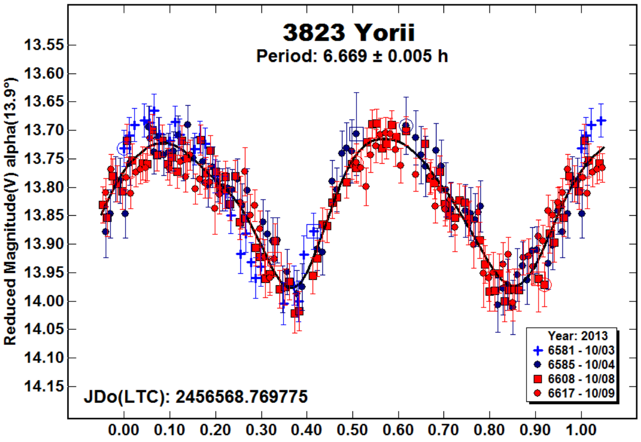
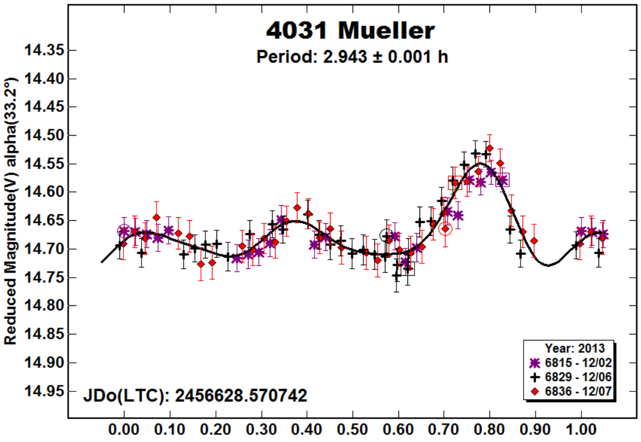
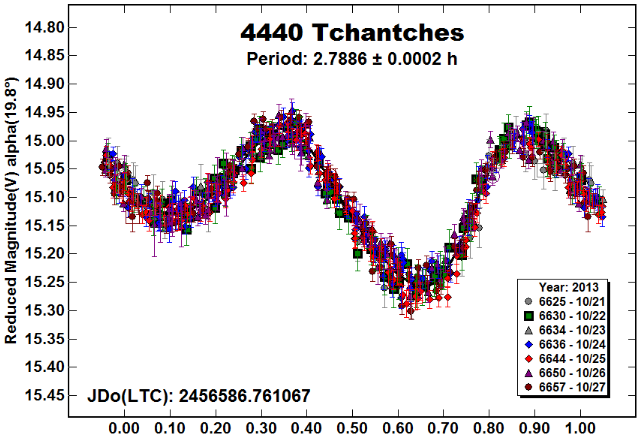


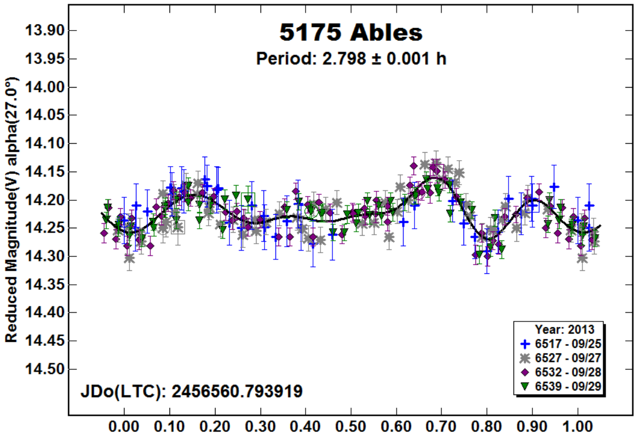


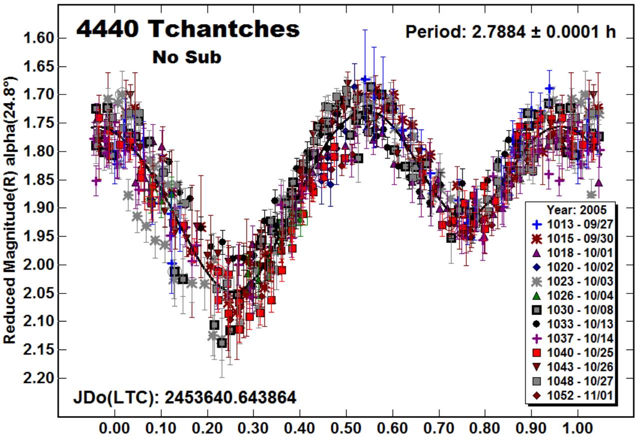


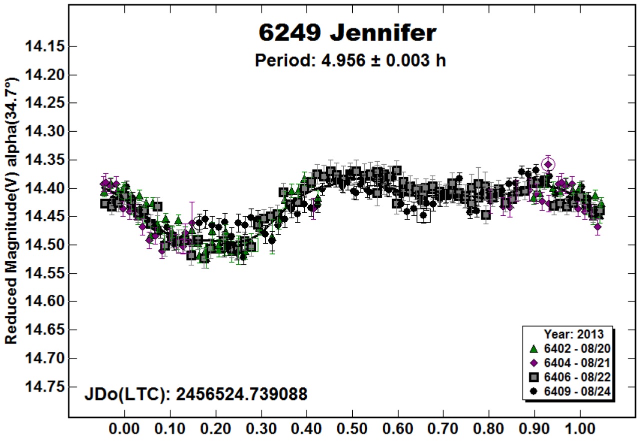


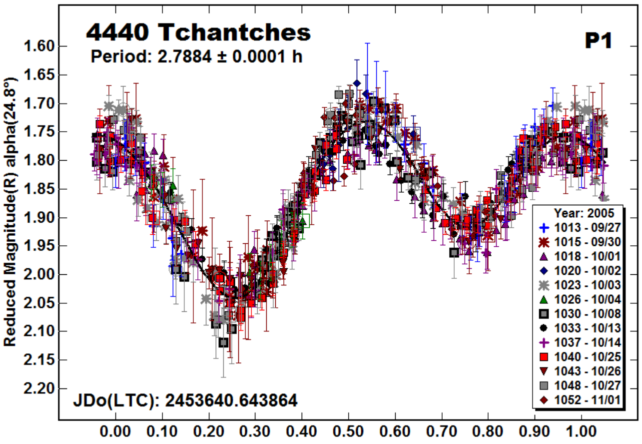


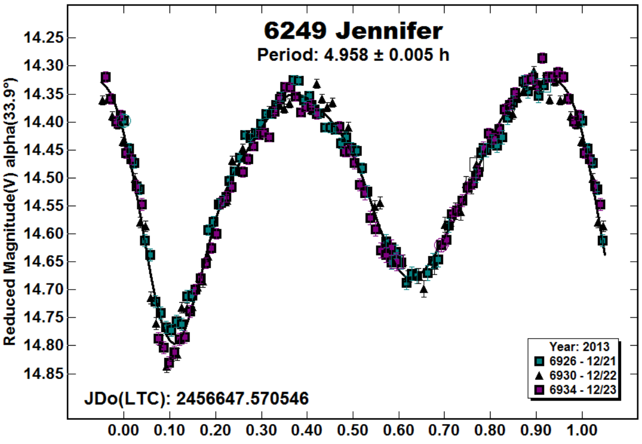

4440 Tchantches
Period: 2.7886 ± 0.0002 h
Reduced Magnitude(V) alpha(19.8°)
14.80
14.85
14.90
14.95
15.00
15.05
15.10
15.15
15.20
15.25
15.30
15.35
15.40
15.45
JDo(LTC): 2456586.761067
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Year: 2013
6625 - 10/21
6630 - 10/22
6634 - 10/23
6636 - 10/24
6644 - 10/25
6650 - 10/26
6657 - 10/27

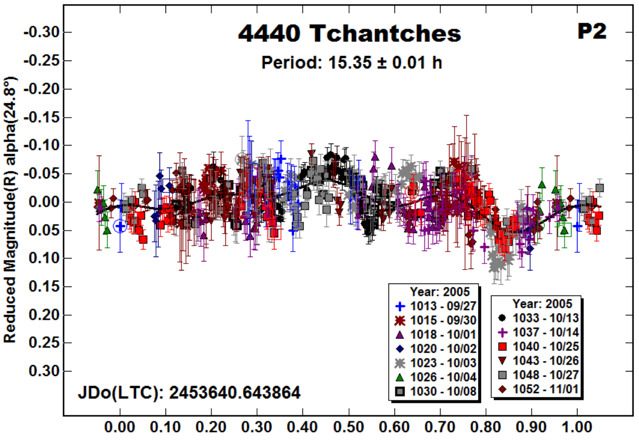

5175 Ables
Period: 2.798 ± 0.001 h
Reduced Magnitude(V) alpha(27.0°)
13.90
13.95
14.00
14.05
14.10
14.15
14.20
14.25
14.30
14.35
14.40
14.45
14.50
JDo(LTC): 2456560.793919
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Year: 2013
6517 - 09/25
6527 - 09/27
6532 - 09/28
6539 - 09/29

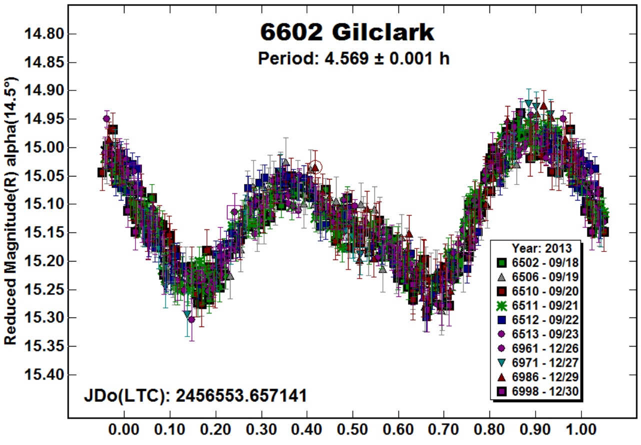

4440 Tchantches
No Sub
Period: 2.7884 ± 0.0001 h
Reduced Magnitude(R) alpha(24.8°)
1.60
1.65
1.70
1.75
1.80
1.85
1.90
1.95
2.00
2.05
2.10
2.15
2.20
JDo(LTC): 2453640.643864
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Year: 2005
1013 - 09/27
1015 - 09/30
1018 - 10/01
1020 - 10/02
1023 - 10/03
1026 - 10/04
1030 - 10/08
1033 - 10/13
1037 - 10/14
1040 - 10/25
1043 - 10/26
1048 - 10/27
1052 - 11/01

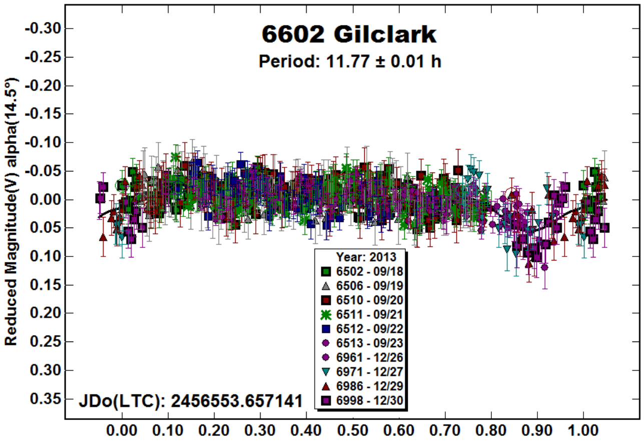

6249 Jennifer
Period: 4.956 ± 0.003 h
Reduced Magnitude(V) alpha(34.7°)
14.15
14.20
14.25
14.30
14.35
14.40
14.45
14.50
14.55
14.60
14.65
14.70
14.75
JDo(LTC): 2456524.739088
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Year: 2013
6402 - 08/20
6404 - 08/21
6406 - 08/22
6409 - 08/24

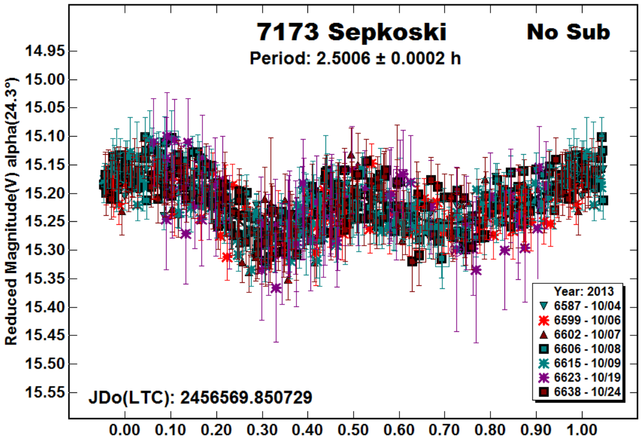

4440 Tchantches
P1
Period: 2.7884 ± 0.0001 h
Reduced Magnitude(R) alpha(24.8°)
1.60
1.65
1.70
1.75
1.80
1.85
1.90
1.95
2.00
2.05
2.10
2.15
2.20
JDo(LTC): 2453640.643864
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Year: 2005
1013 - 09/27
1015 - 09/30
1018 - 10/01
1020 - 10/02
1023 - 10/03
1026 - 10/04
1030 - 10/08
1033 - 10/13
1037 - 10/14
1040 - 10/25
1043 - 10/26
1048 - 10/27
1052 - 11/01

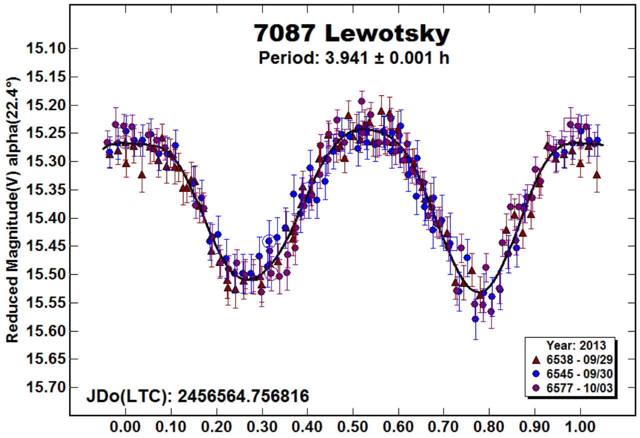

6249 Jennifer
Period: 4.958 ± 0.005 h
Reduced Magnitude(V) alpha(33.9°)
14.25
14.30
14.35
14.40
14.45
14.50
14.55
14.60
14.65
14.70
14.75
14.80
14.85
JDo(LTC): 2456647.570546
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Year: 2013
6926 - 12/21
6930 - 12/22
6934 - 12/23

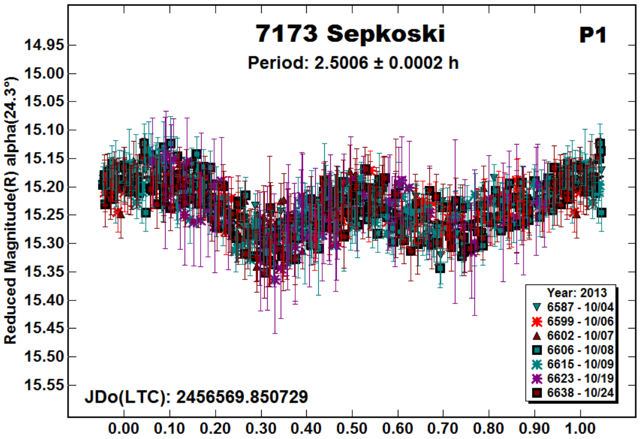

4440 Tchantches
P2
Period: 15.35 ± 0.01 h
Reduced Magnitude(R) alpha(24.8°)
-0.30
-0.25
-0.20
-0.15
-0.10
-0.05
0.00
0.05
0.10
0.15
0.20
0.25
0.30
JDo(LTC): 2453640.643864
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Year: 2005
1013 - 09/27
1015 - 09/30
1018 - 10/01
1020 - 10/02
1023 - 10/03
1026 - 10/04
1030 - 10/08
Year: 2005
1033 - 10/13
1037 - 10/14
1040 - 10/25
1043 - 10/26
1048 - 10/27
1052 - 11/01

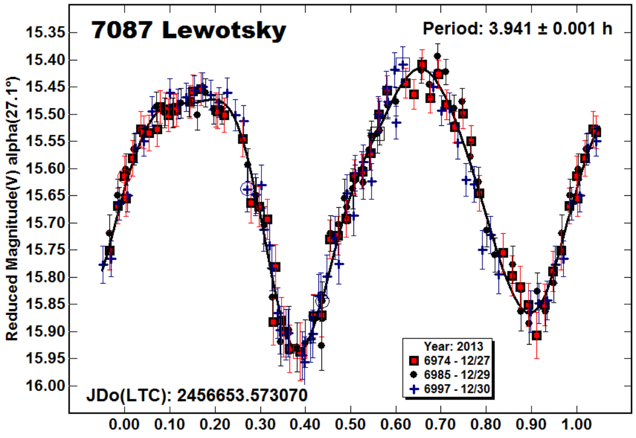

6602 Gilclark
Period: 4.569 ± 0.001 h
Reduced Magnitude(R) alpha(14.5°)
14.80
14.85
14.90
14.95
15.00
15.05
15.10
15.15
15.20
15.25
15.30
15.35
15.40
JDo(LTC): 2456553.657141
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Year: 2013
6502 - 09/18
6506 - 09/19
6510 - 09/20
6511 - 09/21
6512 - 09/22
6513 - 09/23
6961 - 12/26
6971 - 12/27
6986 - 12/29
6998 - 12/30

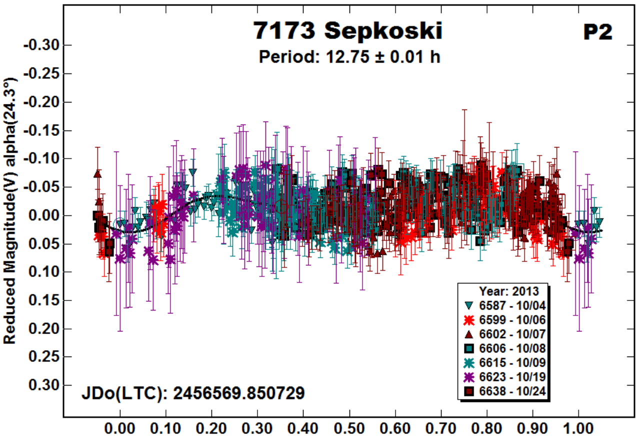

6602 Gilclark
Period: 11.77 ± 0.01 h
Reduced Magnitude(V) alpha(14.5°)
-0.30
-0.25
-0.20
-0.15
-0.10
-0.05
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
Year: 2013
6502 - 09/18
6506 - 09/19
6510 - 09/20
6511 - 09/21
6512 - 09/22
6513 - 09/23
6961 - 12/26
6971 - 12/27
6986 - 12/29
6998 - 12/30
JDo(LTC): 2456553.657141
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

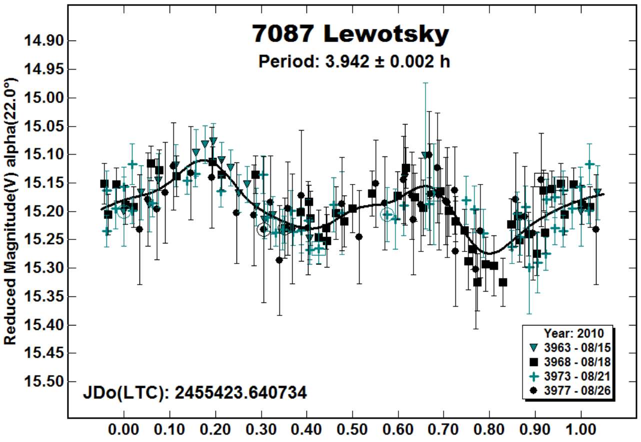

7173 Sepkoski
No Sub
Period: 2.5006 ± 0.0002 h
Reduced Magnitude(V) alpha(24.3°)
14.95
15.00
15.05
15.10
15.15
15.20
15.25
15.30
15.35
15.40
15.45
15.50
15.55
Year: 2013
6587 - 10/04
6599 - 10/06
6602 - 10/07
6606 - 10/08
6615 - 10/09
6623 - 10/19
6638 - 10/24
JDo(LTC): 2456569.850729
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

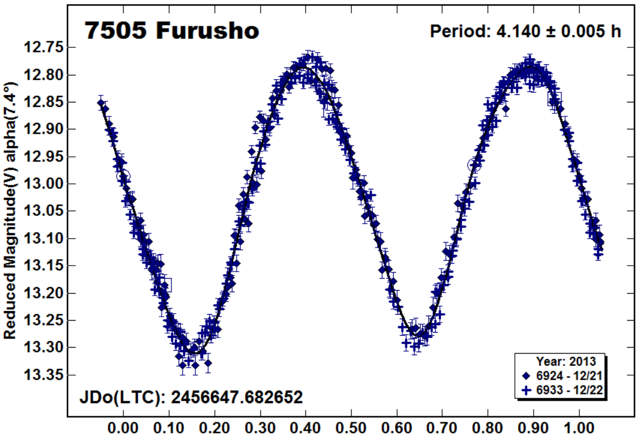

7087 Lewotsky
Period: 3.941 ± 0.001 h
Reduced Magnitude(V) alpha(22.4°)
15.10
15.15
15.20
15.25
15.30
15.35
15.40
15.45
15.50
15.55
15.60
15.65
15.70
Year: 2013
6538 - 09/29
6545 - 09/30
6577 - 10/03
JDo(LTC): 2456564.756816
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

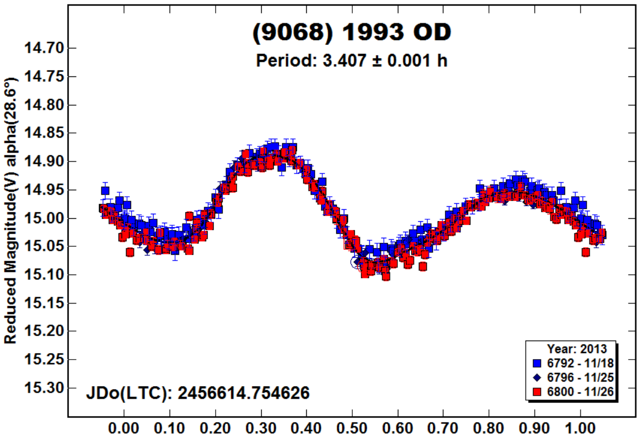

7173 Sepkoski
P1
Period: 2.5006 ± 0.0002 h
Reduced Magnitude(R) alpha(24.3°)
14.95
15.00
15.05
15.10
15.15
15.20
15.25
15.30
15.35
15.40
15.45
15.50
15.55
Year: 2013
6587 - 10/04
6599 - 10/06
6602 - 10/07
6606 - 10/08
6615 - 10/09
6623 - 10/19
6638 - 10/24
JDo(LTC): 2456569.850729
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

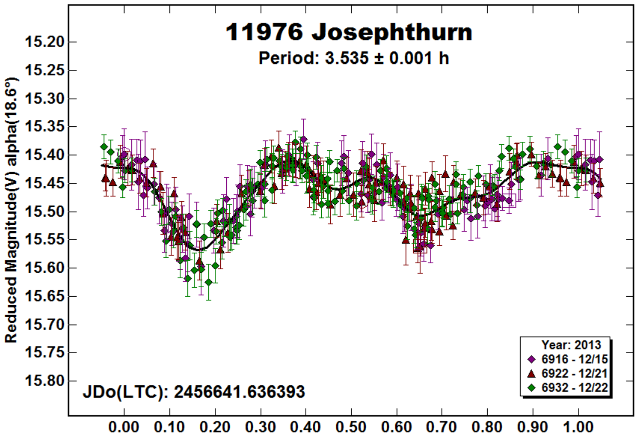

7087 Lewotsky
Period: 3.941 ± 0.001 h
Reduced Magnitude(V) alpha(27.1°)
15.35
15.40
15.45
15.50
15.55
15.60
15.65
15.70
15.75
15.80
15.85
15.90
15.95
16.00
Year: 2013
6974 - 12/27
6985 - 12/29
6997 - 12/30
JDo(LTC): 2456653.573070
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

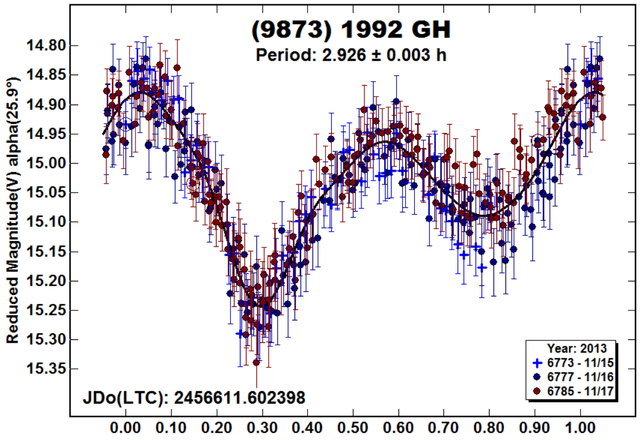

7173 Sepkoski
P2
Period: 12.75 ± 0.01 h
Reduced Magnitude(V) alpha(24.3°)
-0.30
-0.25
-0.20
-0.15
-0.10
-0.05
0.00
0.05
0.10
0.15
0.20
0.25
0.30
Year: 2013
6587 - 10/04
6599 - 10/06
6602 - 10/07
6606 - 10/08
6615 - 10/09
6623 - 10/19
6638 - 10/24
JDo(LTC): 2456569.850729
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

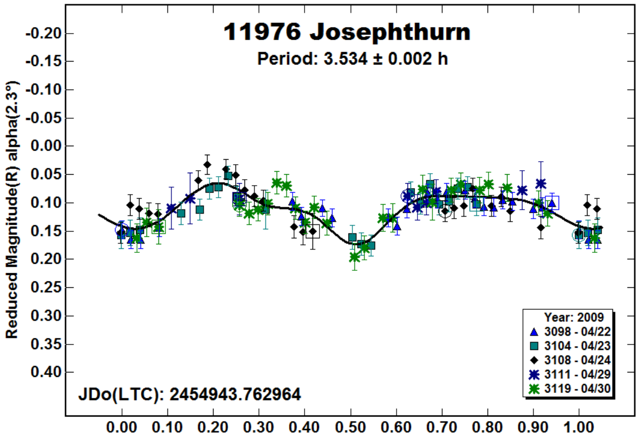

7087 Lewotsky
Period: 3.942 ± 0.002 h
Reduced Magnitude(V) alpha(22.0°)
14.90
14.95
15.00
15.05
15.10
15.15
15.20
15.25
15.30
15.35
15.40
15.45
15.50
Year: 2010
3963 - 08/15
3968 - 08/18
3973 - 08/21
3977 - 08/26
JDo(LTC): 2455423.640734
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

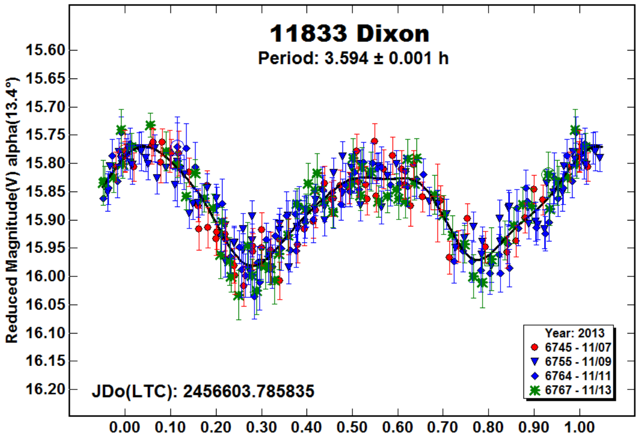

7505 Furusho
Period: 4.140 ± 0.005 h
Reduced Magnitude(V) alpha(7.4°)
12.75
12.80
12.85
12.90
12.95
13.00
13.05
13.10
13.15
13.20
13.25
13.30
13.35
Year: 2013
6924 - 12/21
6933 - 12/22
JDo(LTC): 2456647.682652
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

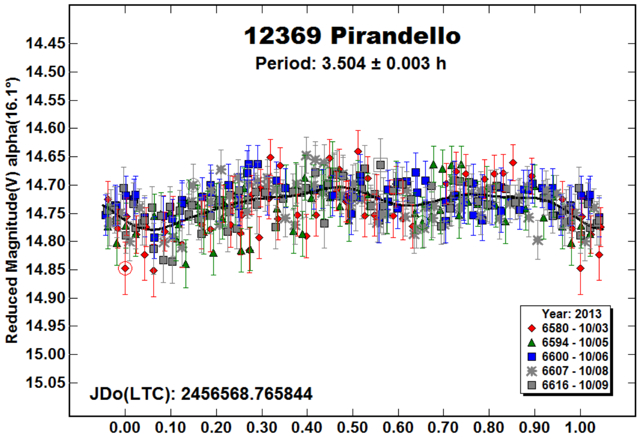

(9068) 1993 OD
Period: 3.407 ± 0.001 h
Reduced Magnitude(V) alpha(28.6°)
14.70 14.75 14.80 14.85 14.90 14.95 15.00 15.05 15.10 15.15 15.20 15.25 15.30
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
JDo(LTC): 2456614.754626
Year: 2013
6792 - 11/18
6796 - 11/25
6800 - 11/26

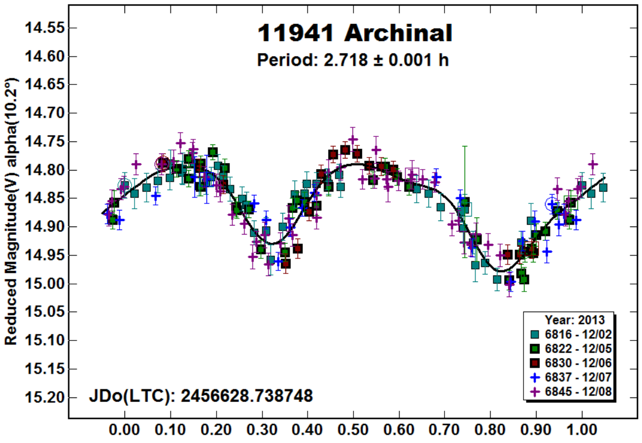

11976 Josephthurn
Period: 3.535 ± 0.001 h
Reduced Magnitude(V) alpha(18.6°)
15.20 15.25 15.30 15.35 15.40 15.45 15.50 15.55 15.60 15.65 15.70 15.75 15.80
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
JDo(LTC): 2456641.636393
Year: 2013
6916 - 12/15
6922 - 12/21
6932 - 12/22

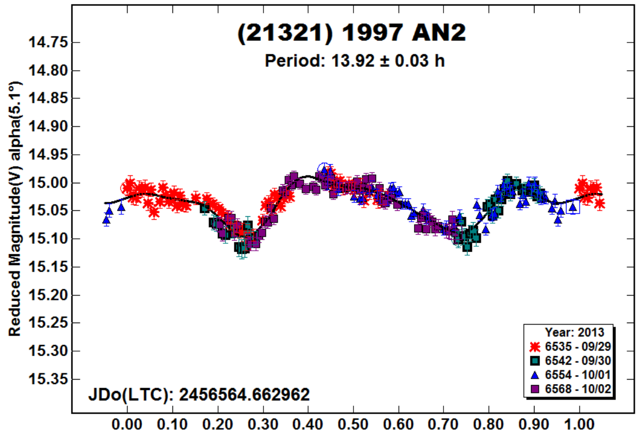

(9873) 1992 GH
Period: 2.926 ± 0.003 h
Reduced Magnitude(V) alpha(25.9°)
14.80 14.85 14.90 14.95 15.00 15.05 15.10 15.15 15.20 15.25 15.30 15.35
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
JDo(LTC): 2456611.602398
Year: 2013
6773 - 11/15
6777 - 11/16
6785 - 11/17

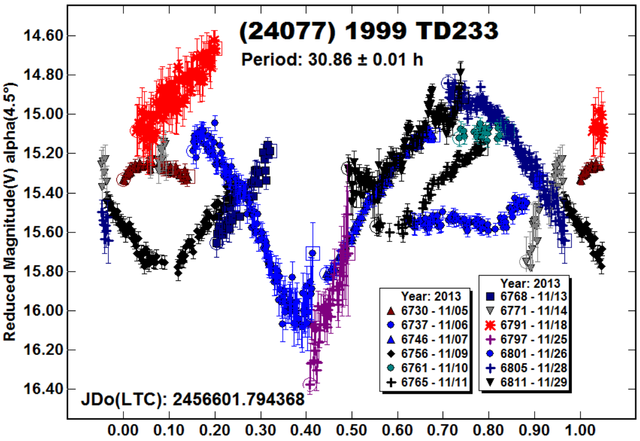

11976 Josephthurn
Period: 3.534 ± 0.002 h
Reduced Magnitude(R) alpha(2.3°)
-0.20 -0.15 -0.10 -0.05 0.00 0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
JDo(LTC): 2454943.762964
Year: 2009
3098 - 04/22
3104 - 04/23
3108 - 04/24
3111 - 04/29
3119 - 04/30

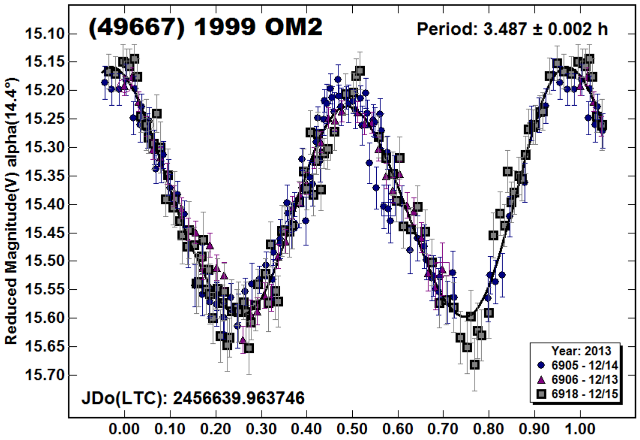

11833 Dixon
Period: 3.594 ± 0.001 h
Reduced Magnitude(V) alpha(13.4°)
15.60 15.65 15.70 15.75 15.80 15.85 15.90 15.95 16.00 16.05 16.10 16.15 16.20
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
JDo(LTC): 2456603.785835
Year: 2013
6745 - 11/07
6755 - 11/09
6764 - 11/11
6767 - 11/13

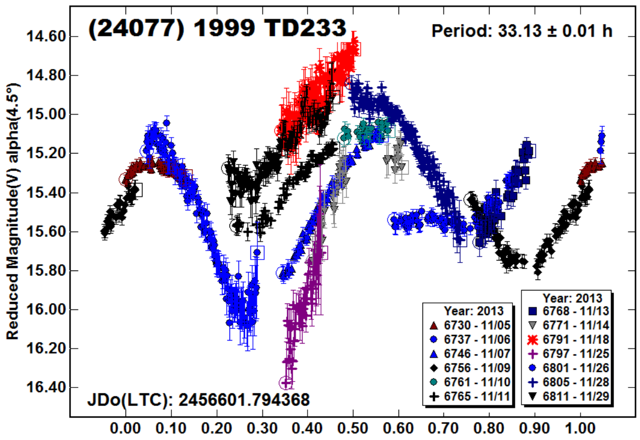

12369 Pirandello
Period: 3.504 ± 0.003 h
Reduced Magnitude(V) alpha(16.1°)
14.45 14.50 14.55 14.60 14.65 14.70 14.75 14.80 14.85 14.90 14.95 15.00 15.05
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
JDo(LTC): 2456568.765844
Year: 2013
6580 - 10/03
6594 - 10/05
6600 - 10/06
6607 - 10/08
6616 - 10/09

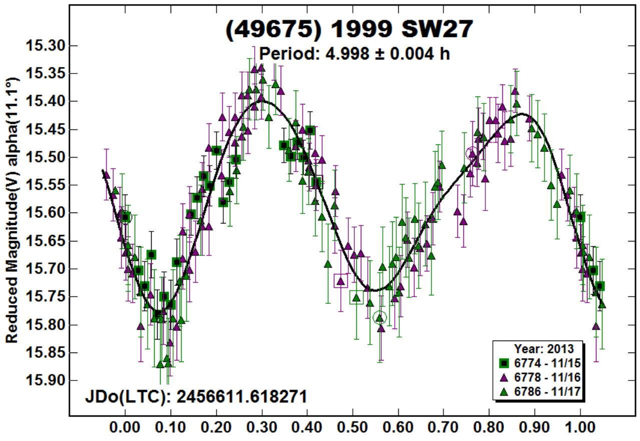

11941 Archinal
Period: 2.718 ± 0.001 h
Reduced Magnitude(V) alpha(10.2°)
14.55 14.60 14.65 14.70 14.75 14.80 14.85 14.90 14.95 15.00 15.05 15.10 15.15 15.20
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
JDo(LTC): 2456628.738748
Year: 2013
6816 - 12/02
6822 - 12/05
6830 - 12/06
6837 - 12/07
6845 - 12/08

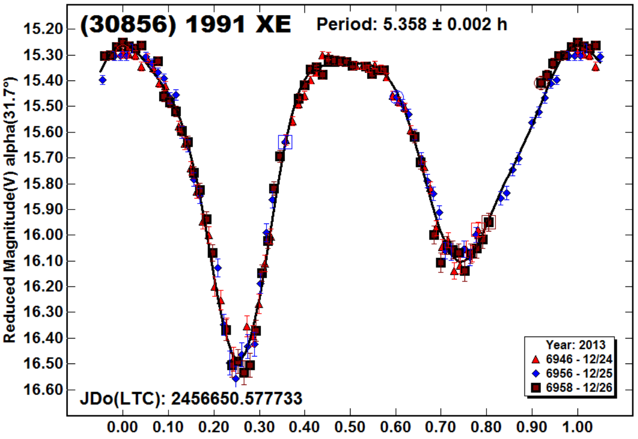

(21321) 1997 AN2
Period: 13.92 ± 0.03 h
Reduced Magnitude(V) alpha(5.1°)
14.75 14.80 14.85 14.90 14.95 15.00 15.05 15.10 15.15 15.20 15.25 15.30 15.35
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
JDo(LTC): 2456564.662962
Year: 2013
6535 - 09/29
6542 - 09/30
6554 - 10/01
6568 - 10/02

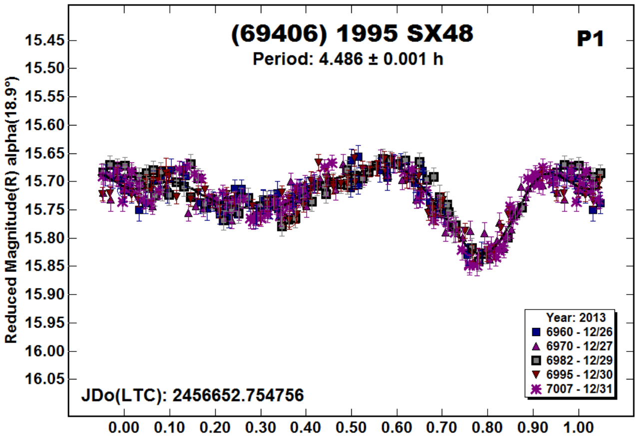

(24077) 1999 TD233
Period: 30.86 ± 0.01 h
Reduced Magnitude(V) alpha(4.5°)
JDo(LTC): 2456601.794368
Year: 2013
6730 - 11/05
6737 - 11/06
6746 - 11/07
6756 - 11/09
6761 - 11/10
6765 - 11/11
Year: 2013
6768 - 11/13
6771 - 11/14
6791 - 11/18
6797 - 11/25
6801 - 11/26
6805 - 11/28
6811 - 11/29
14.60
14.80
15.00
15.20
15.40
15.60
15.80
16.00
16.20
16.40
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

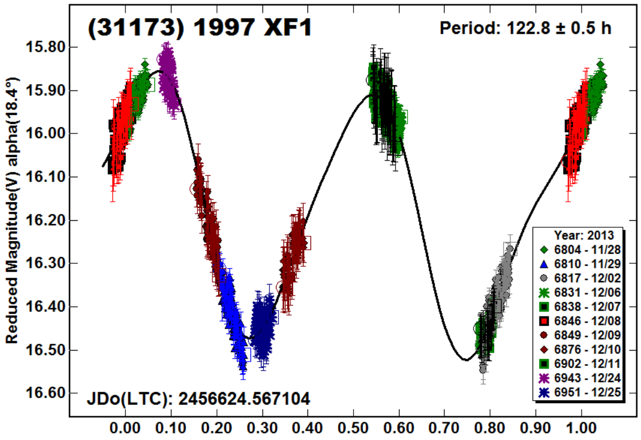

(49667) 1999 OM2
Period: 3.487 ± 0.002 h
Reduced Magnitude(V) alpha(14.4°)
JDo(LTC): 2456639.963746
Year: 2013
6905 - 12/14
6906 - 12/13
6918 - 12/15
15.10
15.15
15.20
15.25
15.30
15.35
15.40
15.45
15.50
15.55
15.60
15.65
15.70
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

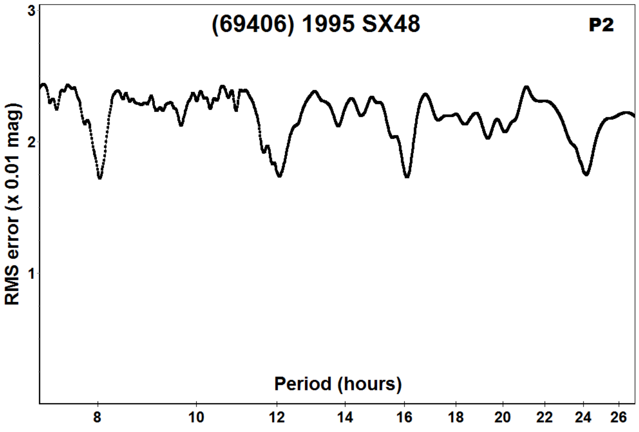

(24077) 1999 TD233
Period: 33.13 ± 0.01 h
Reduced Magnitude(V) alpha(4.5°)
JDo(LTC): 2456601.794368
Year: 2013
6730 - 11/05
6737 - 11/06
6746 - 11/07
6756 - 11/09
6761 - 11/10
6765 - 11/11
Year: 2013
6768 - 11/13
6771 - 11/14
6791 - 11/18
6797 - 11/25
6801 - 11/26
6805 - 11/28
6811 - 11/29
14.60
14.80
15.00
15.20
15.40
15.60
15.80
16.00
16.20
16.40
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

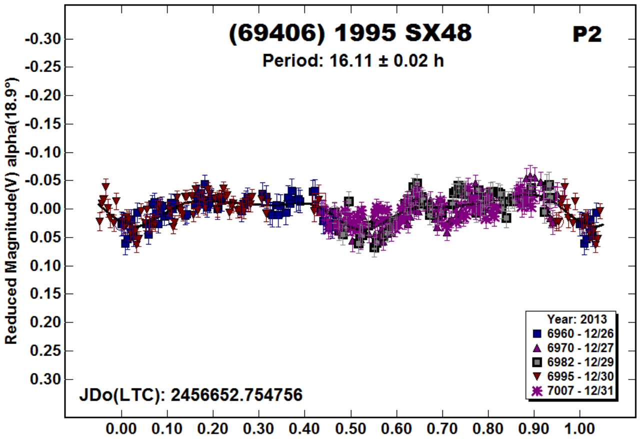

(49675) 1999 SW27
Period: 4.998 ± 0.004 h
Reduced Magnitude(V) alpha(11.1°)
JDo(LTC): 2456611.618271
Year: 2013
6774 - 11/15
6778 - 11/16
6786 - 11/17
15.30
15.35
15.40
15.45
15.50
15.55
15.60
15.65
15.70
15.75
15.80
15.85
15.90
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

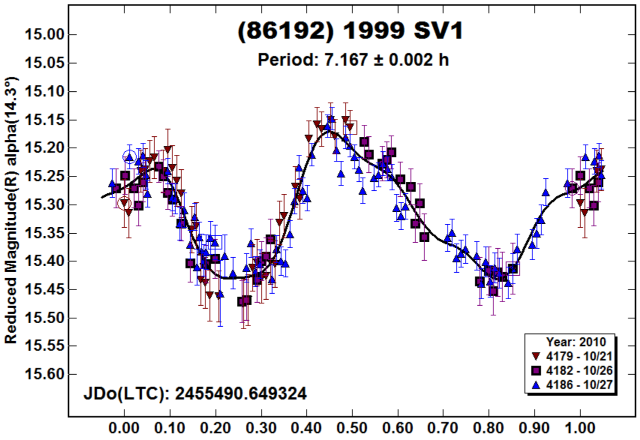

(30856) 1991 XE
Period: 5.358 ± 0.002 h
Reduced Magnitude(V) alpha(31.7°)
JDo(LTC): 2456650.577733
Year: 2013
6946 - 12/24
6956 - 12/25
6958 - 12/26
15.20
15.30
15.40
15.50
15.60
15.70
15.80
15.90
16.00
16.10
16.20
16.30
16.40
16.50
16.60
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

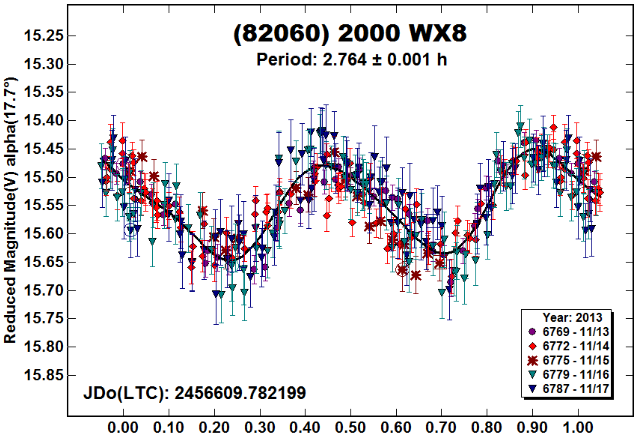

(69406) 1995 SX48
P1
Period: 4.486 ± 0.001 h
Reduced Magnitude(R) alpha(18.9°)
JDo(LTC): 2456652.754756
Year: 2013
6960 - 12/26
6970 - 12/27
6982 - 12/29
6995 - 12/30
7007 - 12/31
15.45
15.50
15.55
15.60
15.65
15.70
15.75
15.80
15.85
15.90
15.95
16.00
16.05
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

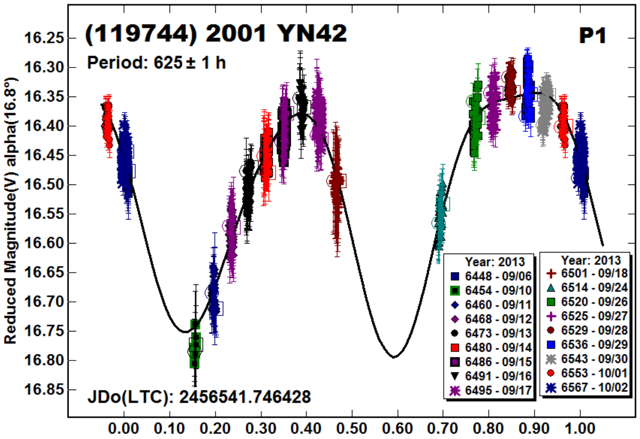

(31173) 1997 XF1
Period: 122.8 ± 0.5 h
Reduced Magnitude(V) alpha(18.4°)
JDo(LTC): 2456624.567104
Year: 2013
6804 - 11/28
6810 - 11/29
6817 - 12/02
6831 - 12/06
6838 - 12/07
6846 - 12/08
6849 - 12/09
6876 - 12/10
6902 - 12/11
6943 - 12/24
6951 - 12/25
15.80
15.90
16.00
16.10
16.20
16.30
16.40
16.50
16.60
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

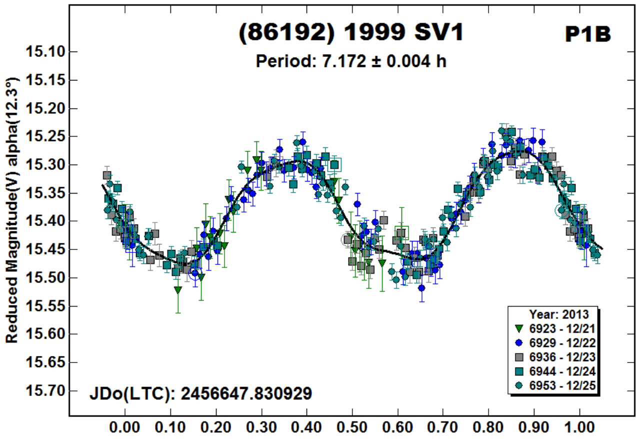

(69406) 1995 SX48
P2
RMS error (x 0.01 mag)
Period (hours)
3
2
1
8
10
12
14
16
18
20
22
24
26

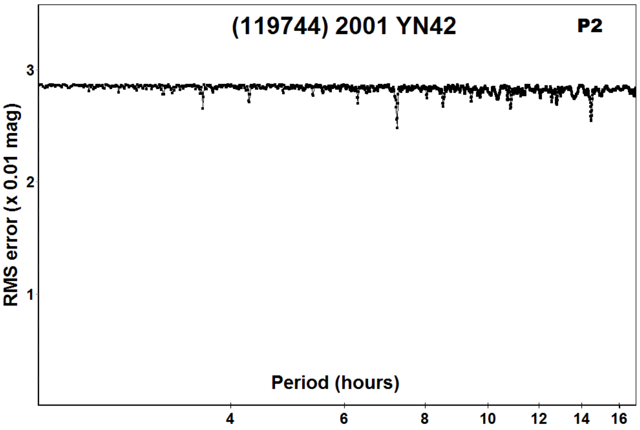

(69406) 1995 SX48
P2
Period: 16.11 ± 0.02 h
Reduced Magnitude(V) alpha(18.9°)
-0.30
-0.25
-0.20
-0.15
-0.10
-0.05
0.00
0.05
0.10
0.15
0.20
0.25
0.30
Year: 2013
6960 - 12/26
6970 - 12/27
6982 - 12/29
6995 - 12/30
7007 - 12/31
JDo(LTC): 2456652.754756
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

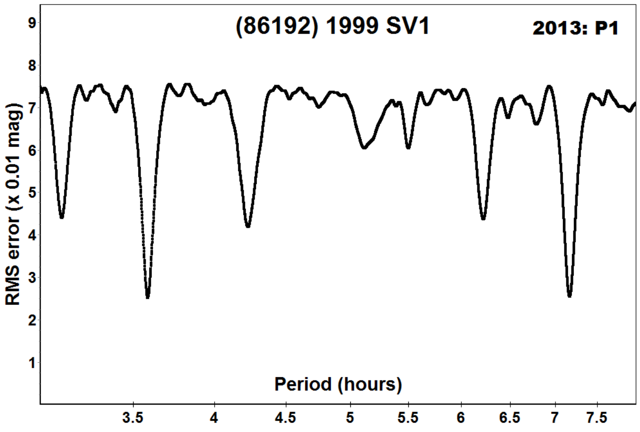

(86192) 1999 SV1
Period: 7.167 ± 0.002 h
Reduced Magnitude(R) alpha(14.3°)
15.00
15.05
15.10
15.15
15.20
15.25
15.30
15.35
15.40
15.45
15.50
15.55
15.60
Year: 2010
4179 - 10/21
4182 - 10/26
4186 - 10/27
JDo(LTC): 2455490.649324
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

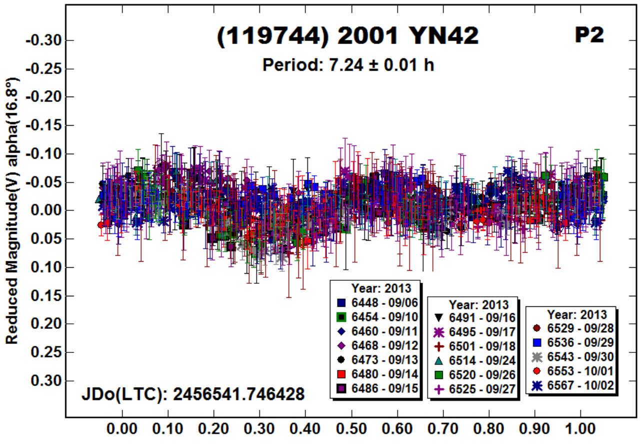

(82060) 2000 WX8
Period: 2.764 ± 0.001 h
Reduced Magnitude(V) alpha(17.7°)
15.25
15.30
15.35
15.40
15.45
15.50
15.55
15.60
15.65
15.70
15.75
15.80
15.85
Year: 2013
6769 - 11/13
6772 - 11/14
6775 - 11/15
6779 - 11/16
6787 - 11/17
JDo(LTC): 2456609.782199
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

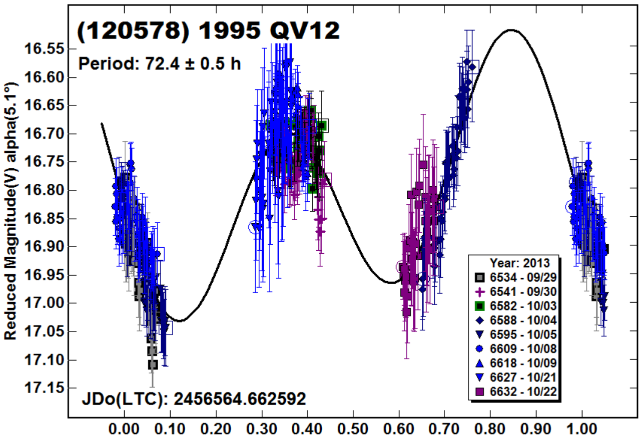

(119744) 2001 YN42
P1
Period: 625 ± 1 h
Reduced Magnitude(V) alpha(16.8°)
16.25
16.30
16.35
16.40
16.45
16.50
16.55
16.60
16.65
16.70
16.75
16.80
16.85
Year: 2013
6448 - 09/06
6454 - 09/10
6460 - 09/11
6468 - 09/12
6473 - 09/13
6480 - 09/14
6486 - 09/15
6491 - 09/16
6495 - 09/17
Year: 2013
6501 - 09/18
6514 - 09/24
6520 - 09/26
6525 - 09/27
6529 - 09/28
6536 - 09/29
6543 - 09/30
6553 - 10/01
6567 - 10/02
JDo(LTC): 2456541.746428
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00

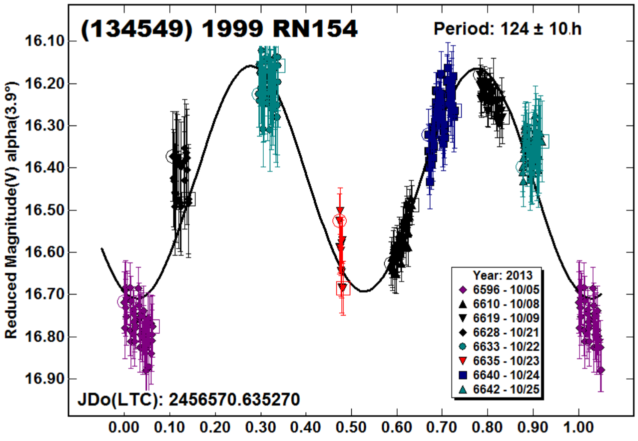

(86192) 1999 SV1
P1B
Period: 7.172 ± 0.004 h
Reduced Magnitude(V) alpha(12.3°)
15.10
15.15
15.20
15.25
15.30
15.35
15.40
15.45
15.50
15.55
15.60
15.65
15.70
Year: 2013
6923 - 12/21
6929 - 12/22
6936 - 12/23
6944 - 12/24
6953 - 12/25
JDo(LTC): 2456647.830929
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00


(119744) 2001 YN42
P2
RMS error (x 0.01 mag)
3
2
1
Period (hours)
4 6 8 10 12 14 16


(86192) 1999 SV1
2013: P1
RMS error (x 0.01 mag)
9
8
7
6
5
4
3
2
1
Period (hours)
3.5 4 4.5 5 5.5 6 6.5 7 7.5


(119744) 2001 YN42
P2
Period: 7.24 ± 0.01 h
Reduced Magnitude(V) alpha(16.8°)
-0.30
-0.25
-0.20
-0.15
-0.10
-0.05
0.00
0.05
0.10
0.15
0.20
0.25
0.30
Year: 2013
6448 - 09/06
6454 - 09/10
6460 - 09/11
6468 - 09/12
6473 - 09/13
6480 - 09/14
6486 - 09/15
Year: 2013
6491 - 09/16
6495 - 09/17
6501 - 09/18
6514 - 09/24
6520 - 09/26
6525 - 09/27
Year: 2013
6529 - 09/28
6536 - 09/29
6543 - 09/30
6553 - 10/01
6567 - 10/02
JDo(LTC): 2456541.746428
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00





ROTATION PERIODS OF 3618 KUPRIN AND 3896 PORDENONE

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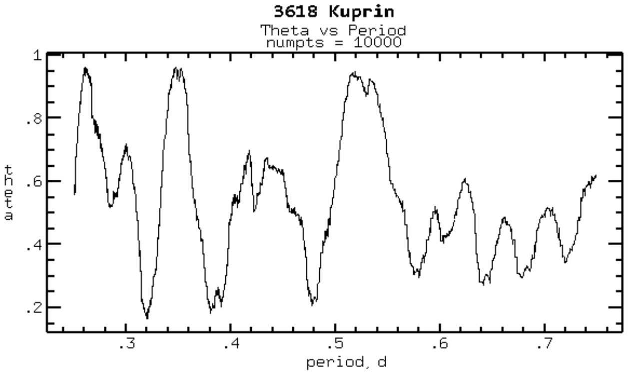
(Received: 15 January)

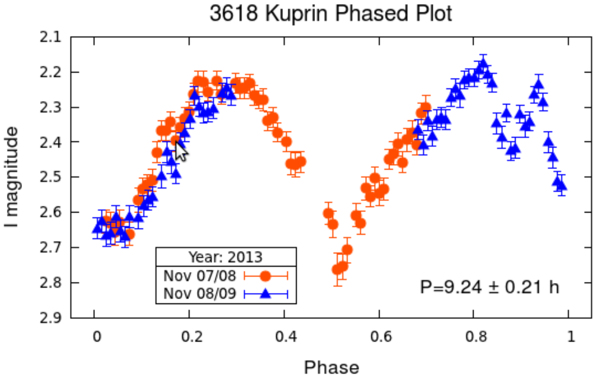
Photometric observations of two main-belt asteroids were obtained in 2013 November. Lightcurve analysis of 3618 Kuprin found a synodic rotation period of 9.24 ± 0.21 h with an amplitude of 0.56 ± 0.04 mag. Further studies of this object are necessary. For 3896 Pordenone, we found a synodic period of 3.995 ± 0.010 h and an amplitude of 0.37 ± 0.04 mag

A field near the ecliptic was imaged on two consecutive nights (2013 Nov 07 and 08) at the Bulgarian National Astronomical Observatory (NAO Rozhen, 41°42′N 24°44′E) as a part of an ultracool dwarf monitoring program. A total of 134 frames in standard I filter were obtained with the 50/70-cm Schmidt telescope (*f*/3.44) and an FLI PL-16803 CCD camera. The duration of each exposure was 300 s. Asteroids 3618 Kuprin and 3896 Pordenone were identified in the field using the Minor Planet Center's MPChecker. Two reference stars were used to calculate differential magnitudes of both minor planets. The aperture was set at 4 arcseconds which yielded a final error in the range of 0.02–0.03 mag. All image processing was done using *IRAF (Image Reduction and Analysis Facility).*

<u>3618 Kuprin.</u> As of 2013 January, there was no lightcurve or rotation period information for this object in the asteroid lightcurve database (LCDB; Warner *et al.*, 2009). Our data are insufficient to determine the period with a high level of confidence. The *IRAF pdm* procedure, which was run within a trial period range from 0.25 to 0.75 d, showed three possible periods: ~0.32 d, ~0.38 d and ~0.48 d. We suggest a synodic period corresponding to *P* = 9.24 ± 0.21 h with an amplitude *A* = 0.56 ± 0.04 mag since this is the only option that accepts the two 4σ lightcurve features at phase ~ 0.9 (on the phased plot) as a local minimum followed by a local maximum rather than data noise.

3618 Kuprin was in opposition in 2013 November and the next closer approach is not until 2018. However, considering the high amplitude of the object, we encourage a more thorough photometric investigation.





<u>3896 Pordenone.</u> A rotation period of 4.009 h obtained by Higgins in 2007 and a maximum amplitude *A* = 0.28 mag are listed in the Asteroid Lightcurve Database (LCDB; Warner *et al.*, 2009). Hanuš *et al.* (2013) found a sidereal period of 4.0037 h. Using the Phase Dispersion Minimization (PDM) technique (Stellingwerf, 1978) we obtained *P* = 3.995 ± 0.010 h, which is in agreement with the