

ASTEROID LIGHTCURVE ANALYSIS AT THE PALMER DIVIDE OBSERVATORY: 2008 MAY - SEPTEMBER

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Lightcurves for 32 asteroids were obtained at the Palmer Divide Observatory (PDO) from 2008 May through September: 164 Eva, 568 Cheruskia, 1520 Imatra, 1657 Roemera, 1828 Kashirina, 1951 Lick, 3728 IRAS, 4590 Dimashchegolev, 4770 Lane, 4868 Knushevia, 4937 Lintott, 5427 Jensmartin, 5577 Priestley, 6271 Farmer, 6602 Gilclark, (6618) 1936 SO, 6901 Roybishop, 6911 Nancygreen, 7285 Seggewiss, 7516 Krancj, 7778 Markrobinson, 8021 Walter, (9068) 1993 OD, (9731) 1982 JD1, (9873) 1992 GH, (14465) 1993 NB, (16960) 1998 QS52, (17010) 1999 CQ72, (33896) 2000 KL40, (101430) 1998 VE32, and 2004 FQ5. It is suspected that 6901 Roybishop may be a binary asteroid after at least two possible “mutual events” were observed.

Observations of 32 asteroids were made at the Palmer Divide Observatory from 2008 May through September. One of four telescopes/camera combinations was used: 0.5m Ritchey-Chretien/SBIG STL-1001E, 0.35m SCT/FLI IMG-1001E, 0.35m SCT/ST-9E, or 0.35m SCT/STL-1001E. All images were 1x1 binning, resulting in a scale of approximately 1.2 arcseconds per pixel. All exposure were guided and from 120–240 s. Most observations were made with no filter. On occasion, e.g., when a nearly full moon was present, an R filter was used to decrease the sky background noise. All images were measured using *MPO Canopus* employing differential aperture photometry. Period analysis was also done using *MPO Canopus*, which incorporates the Fourier analysis algorithm developed by Alan Harris (Harris et al. 1989).

The results are summarized in the table below, as are individual plots. The data and curves are presented without comment except when warranted. Columns 6 and 7 give the range of values, or average if the range was relatively small, for the Phase Angle Bisector (PAB) longitude and latitude respectively. Columns 8 and 10 give the period and amplitude of the curve while columns 9 and 11 give the respective errors in hours and magnitudes. An “(H)” follows the name of an asteroid in the table if it is a member of the Hungaria group/family, which is a primary target of the PDO observing program.

The plots are “phased”, i.e., they range from 0.0 to 1.0 of the stated period. Most of the plots are scaled such that 0.8 mag has the same linear size as the horizontal axis from 0.0 to 1.0. This is done for two reasons: 1) for easier direct comparison of amplitudes and, 2) to avoid the visual impression that the amplitude of variation is greater than it actually is, which can create the impression of a physically implausible lightcurve. There are some cases where the scale has been modified, those being mostly for low amplitude lightcurves, where the above scaling would have resulted in a nearly flat plot void of almost all detail and information. Even so, the vertical scale has been expanded as little as possible to avoid creating misleading interpretations.

164 Eva. The period of 13.672 h found here agrees with that found by Schrober (1982), who reported a period of 13.66 h and 0.36 mag amplitude from observations in 1979 September.

568 Cheruskia. Blanco *et al.* (2000) reported a period of 14.654 h. The data obtained at PDO do not support that, finding instead a synodic period of 13.209 h.

1520 Imatra. The data obtained at PDO do not support the period of 5.23 h reported by De Sanctis (1994).

1657 Roemera. Wisniewski (1997) found a period of 4.5 h. The PDO data suggest a period of 34 h.

1951 Lick. Wisniewski (1997) found a period of 4.424 h while Pravec (2008) observed the asteroid in late 1997 and early 1998 and found an average period of about 5.300 h. The PDO period of 5.2974 h agrees with Pravec’s findings.

4937 Lintott. Asteroid Lintott was worked previously at PDO (Warner 2005) when a period of 3.123 h was found. This follow up work for future modeling revises the period to 3.1258 h.

6271 Farmer. This Hungaria member was worked by the author in 2005 (Warner 2006). At that time, an uncertain period of 35.8 h was reported. The data from 2008 give a reasonably secure period of 8.01 h. Forcing the data from 2005 to a solution near this result found 8.30 h. However, that earlier data set is much noisier, due mostly to crowded star fields, and so any period found from the 2005 set is suspect. Thus a period near 8.01 h is preferred.

6901 Roybishop. Two strong attenuation events and one possible weak one were captured during the 2008 apparition. Bad weather conditions and a fading magnitude prevented sufficient follow up to confirm that the asteroid is an asynchronous binary and, if so, the associated periods. Making analysis difficult was the fact that the “primary” amplitude was only 0.04 mag, implying a nearly spheroidal shape. Despite this, a period of 4.682 h was found for the assumed primary (this being one of several possibilities). Using that value in a period search on the attenuation events found a period of 17.16 ± 0.01 h. The weak event was ~ 0.04 mag. This implies $Ds/Dp = 0.19 \pm 0.02$.

Independent analysis of the PDO data by Petr Pravec at the Astronomical Institute, Czech Republic (private communications), found different primary and secondary periods. Given the limited data set and overall quality, this not surprising. However, it is agreed that, with at least two separate events, there is sufficient reason to suspect that the asteroid is binary. The results given here are just one of several solution sets and should not be taken as absolute. Instead they should serve as a guide for follow up observations at the next good apparition in 2011.

6911 Nancygreen. Previous work at PDO (Warner 2006) found a period of 5.3 h, but that was uncertain. The 2008 data set give an improved solution of 4.33 h. The earlier data set was not available to check if it could be fit to the new solution.

7516 Kranjc. Pravec (2008) reports a period of 3.96769 h and the possibility that the asteroid is binary after two attenuations were seen but not confirmed. The PDO data did not show any events (but that could be due to different viewing geometry) and found a period of 3.982 h.

#	Name	(mm/dd) 2008	Data Pts	Phase	PAB _L	PAB _B	Per (h)	PE	Amp (mag)	AE
164	Eva	05/11-06/03	381	7.9-13.1	218	17	13.672	0.003	0.04	0.01
568	Cheruskia	08/14-09/04	1123	15.2-11.1	351	23	13.209	0.001	0.10	0.01
1520	Imatra	07/15-07/30	539	6.3	299	14	18.635	0.004	0.27	0.03
1657	Roemera	05/09-06/07	529	18.6-21.7	225	27	34.0	0.1	0.15	0.02
1828	Kashirina	07/21-08/02	251	9.9-12.5	276	17	14.838	0.003	0.42	0.02
1951	Lick	06/30-07/11	119	45.4-40.0	292	39	5.2974	0.0004	0.25	0.03
3728	IRAS	08/02-08/13	148	6.8-7.5	311	17	8.323	0.002	0.21	0.02
4590	Dimashchegolev	07/09-07/28	214	11.6-16.9	278	16	25.4	0.2	0.23	0.03
4770	Lane	06/06-06/28	455	14.4-18.4	243	28	34.75	0.02	0.23	0.03
4868	Knushevia (H)	08/28-09/04	184	14.0-10.6	349	13	4.45	0.01	0.09	0.02
4937	Lintott	08/14-08/22	213	9.3-9.2	326	18	3.1258	0.0002	0.24	0.02
5427	Jensmartin (H)	08/31-09/04	179	26.5-25.2	18	16	5.810	0.001	0.44	0.02
5577	Priestley (H)	05/06-06/06	425	19.4-24.9	223	25	51.9	0.1	0.35	0.05
6271	Farmer (H)	09/19-09/26	172	25.5-24.1	33	31	8.01	0.01	0.18	0.02
6602	Gilclark (H)	09/16-09/18	161	28.6	34	21	4.574	0.004	0.54	0.02
6618	1936 SO (H)	09/16-09/18	185	26.8	30	24	8.297	0.006	0.20	0.02
6901	Roybishop (H)	07/31-09/04	397	13.4-21.8	317	21	4.682	0.002	0.04	0.01
6911	Nancygreen (H)	09/16-09/18	166	26.6	32	5	4.33	0.01	0.10	0.02
7285	Seggewiss	08/12-08/13	100	7.5	321	12	3.460	0.002	0.52	0.02
7516	Kranjc	06/08-06/09	109	14.8	240	11	3.982	0.003	0.15	0.02
7778	Markrobinson	06/10-06/12	205	15.2	264	20	7.230	0.002	0.64	0.02
8021	Walter	08/12-08/22	219	20.7-19.9	336	33	4.84/9.68	0.01	0.07	0.02
9068	1993 OD (H)	09/16-09/17	132	34.0	28	30	3.405	0.004	0.20	0.02
9731	1982 JD1	07/21-08/04	152	8.5-13.1	294	12	2.833	0.001	0.16	0.02
9873	1992 GH (H)	09/18-09/22	194	27.0	33	14	2.925	0.001	0.25	0.02
14465	1993 NB	06/07-06/09	214	11.0	247	17	4.972	0.001	0.50	0.02
14923	1994 TU3	06/30-07/13	124	21.9	293	33	7.300	0.002	0.34	0.03
16960	1998 QS52	09/26-09/29	125	35.1-36.9	20	33	2.900	0.001	0.24	0.02
17010	1999 CQ72	06/10-06/28	270	9.4-15.5	255	14	15.781	0.001	0.63	0.03
33896	2000 KL40 (H)	05/06-05/25	114	22.1-23.9	220	31	24	1	>0.1	
101430	1998 VE32	06/30-07/30	386	35.8-44.0	292	43	40.66	0.02	0.22	0.03
	2004 FQ5	07/31-08/01	141	13.7	310	15	5.047	0.004	0.46	0.02

7778 Markrobinson. The period of 7.230 h found at PDO agrees well with the 7.234 h period found by Behrend (2008).

8021 Walter. The period solution is ambiguous. The two plots show the data phased to the periods of 4.84 and 9.68 h. Neither of these agree with the period of 12 h reported by Behrend (2008).

(9873) 1992 GH. This was worked at PDO as follow up for modeling. The period of 2.925 h agrees with that found in the previous work (Warner 2007, 2.9257 h). Sauppe (2007) also reported a similar period of 2.92 h.

(14465) 1993 NB. The PDO data found a period of 4.972 h, which agrees with that found by Pravec (2008, 4.9703 h) and Behrend (2008, 4.9702 h). Pravec worked the asteroid in mid-May and found amplitude of 0.49 mag; the PDO data from early June found 0.50 mag; the Behrend data from early July found 0.69 mag. During that period, the phase angle increased from 10.2° to 19.0°.

(14923) 1994 TU3. Behrend (2008) found a period of 30 h based on data from two nights in 2001. The PDO data give a reasonably secure period of 7.300 h with 0.34 mag amplitude.

(17010) 1999 CQ72. Behrend (2008) reports a period of 11.772 h and a monomodal curve. Given the large amplitude, this is not likely. The PDO data cannot be made to fit that period but do fit a typical bimodal curve with a period of 15.781 h.

(33896) 2000 KL40. The previous work at PDO (Warner 2005) found a period of 23.8 h. Observing circumstances were not favorable this time around, mostly due to bad weather, and so a very limited data set was acquired. The plot shows that data phased to a forced period of 24 h. While the result is plausible, it can hardly be considered conclusive. This is a very good candidate for a collaboration involving sites well-removed in longitude but, if possible, not at intervals of 6, 8, or 12 hours unless long runs are possible.

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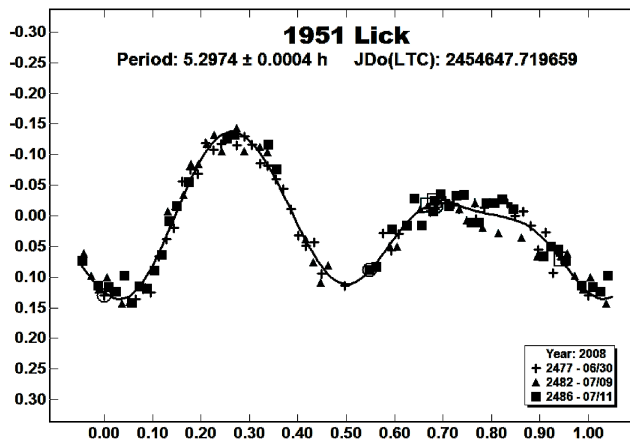
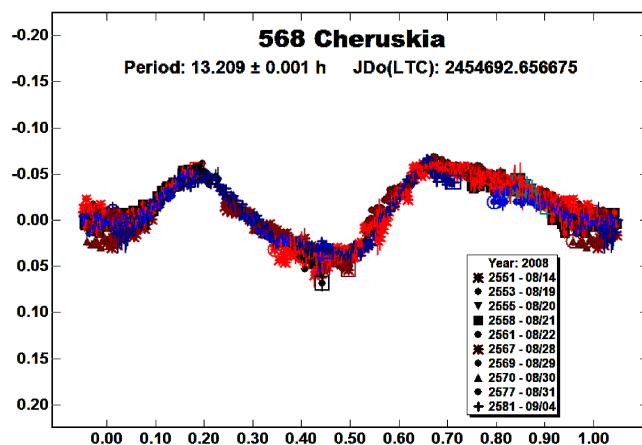
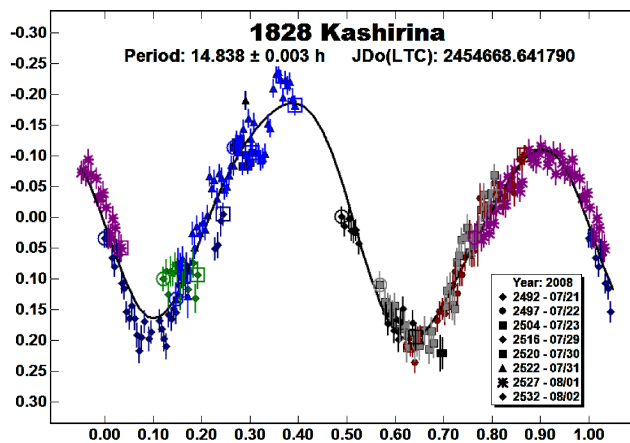
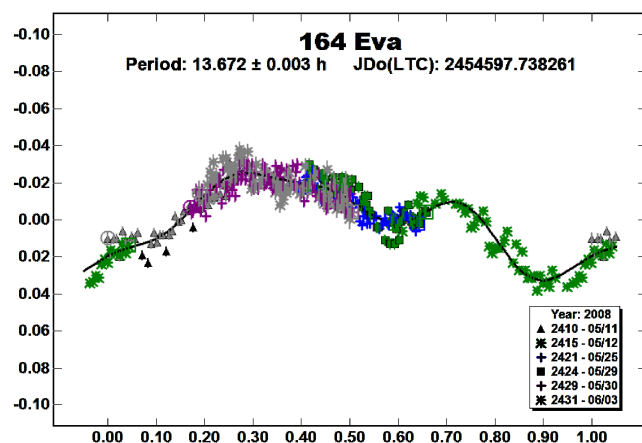
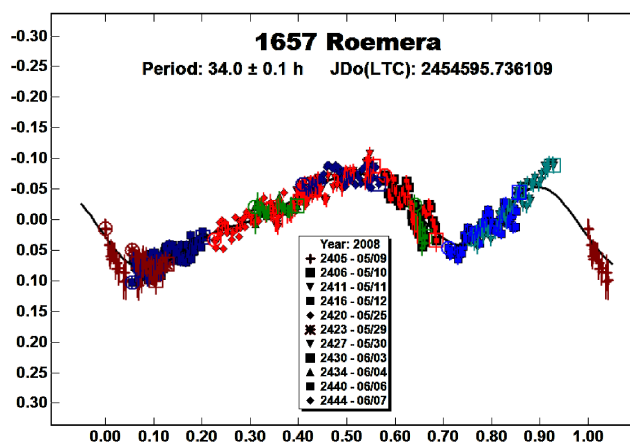
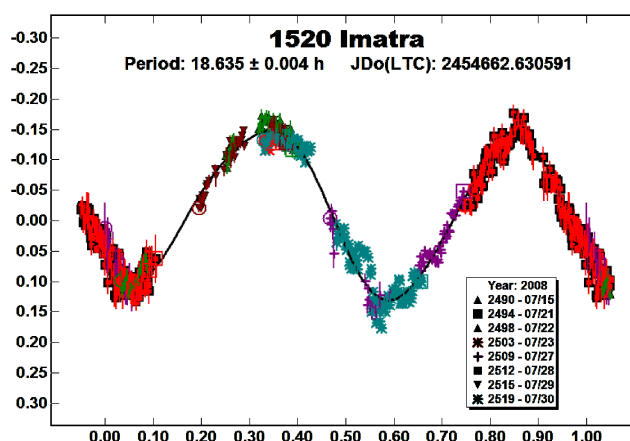
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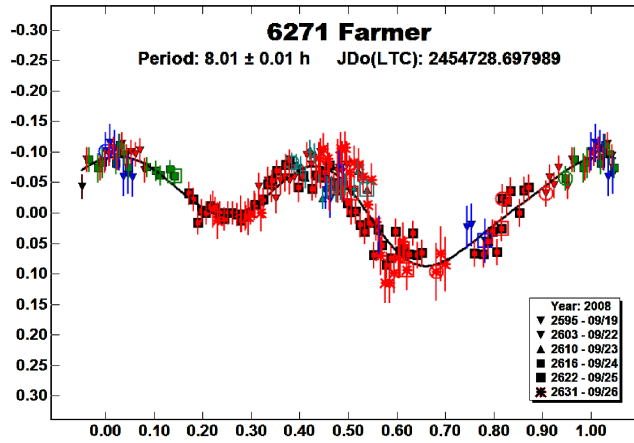
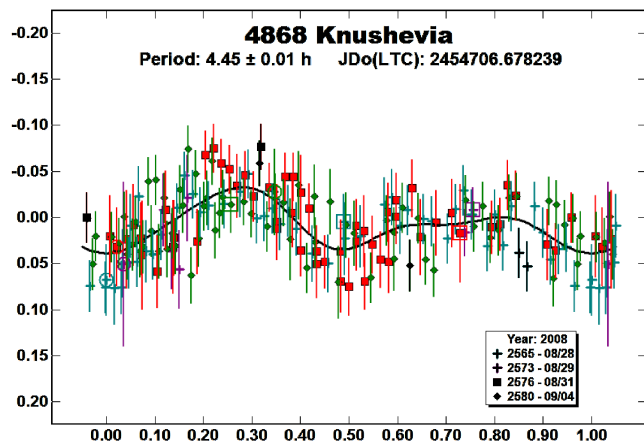
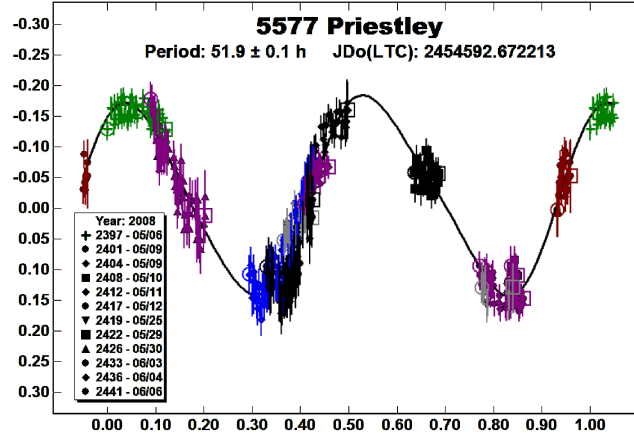
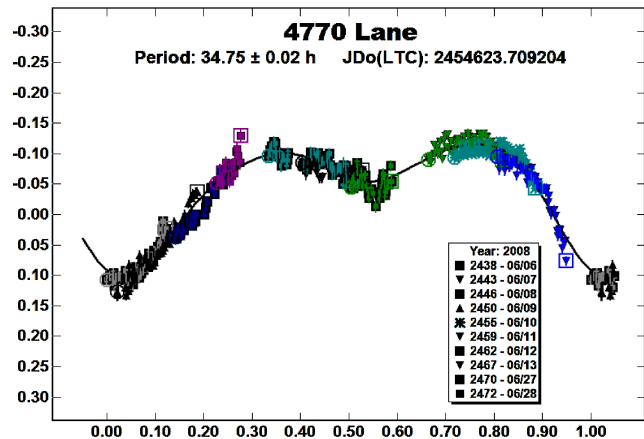
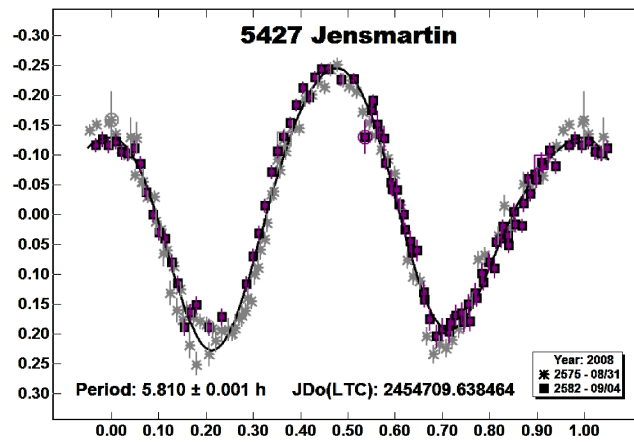
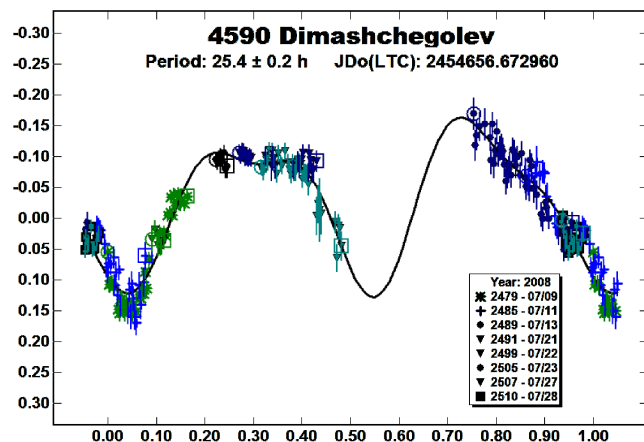
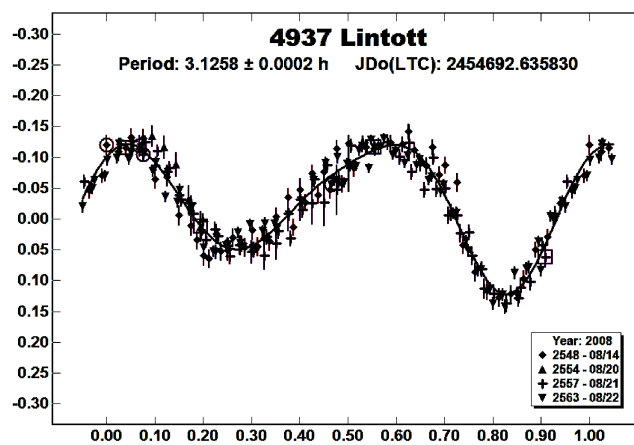
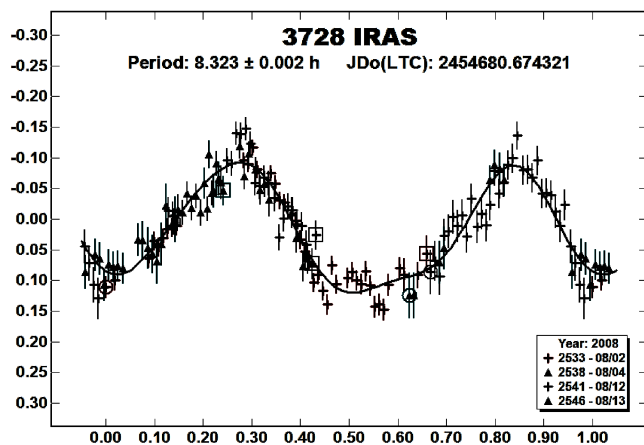
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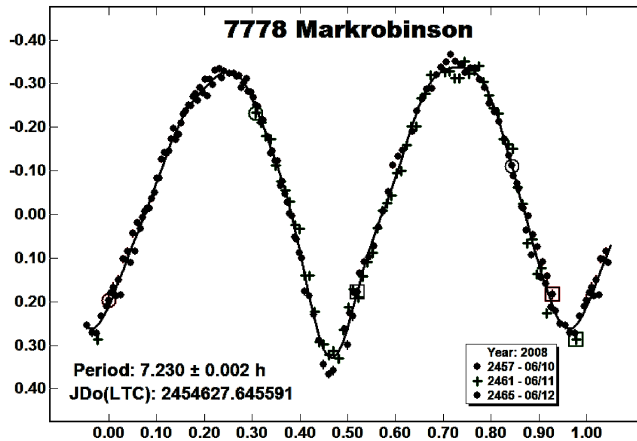
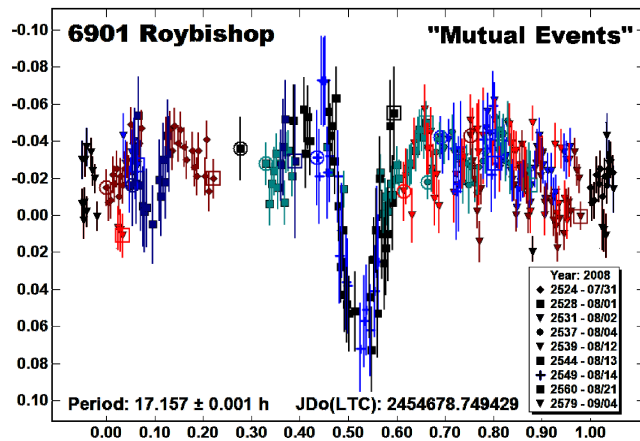
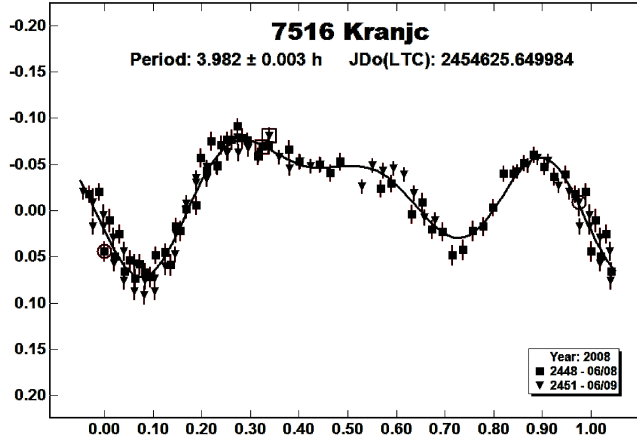
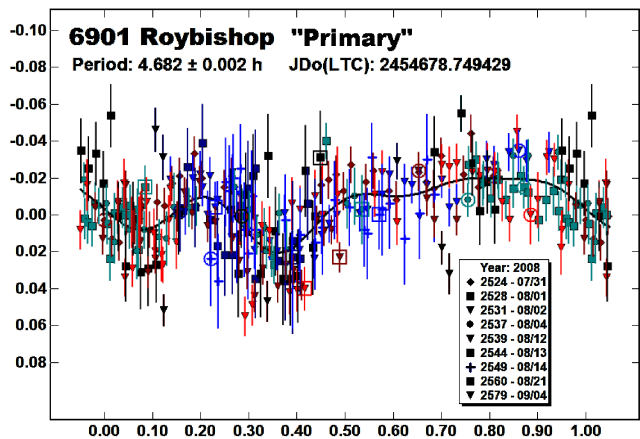
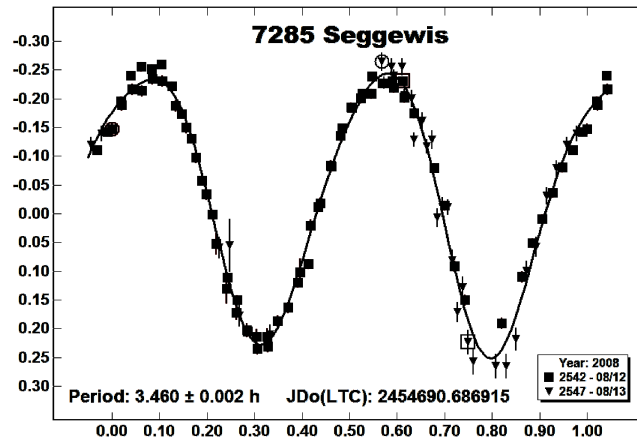
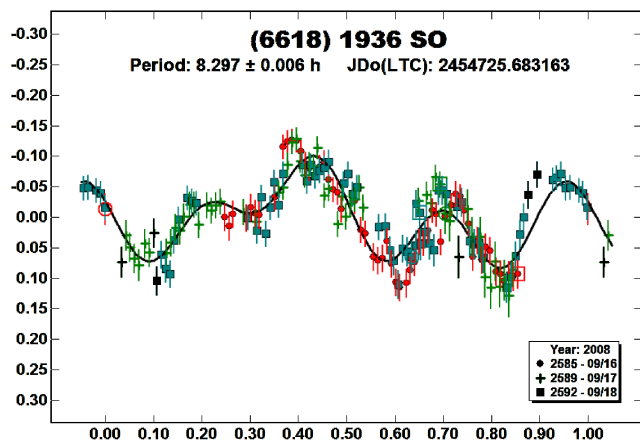
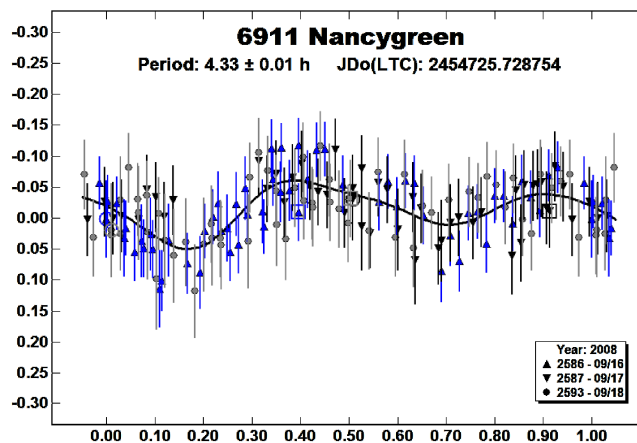
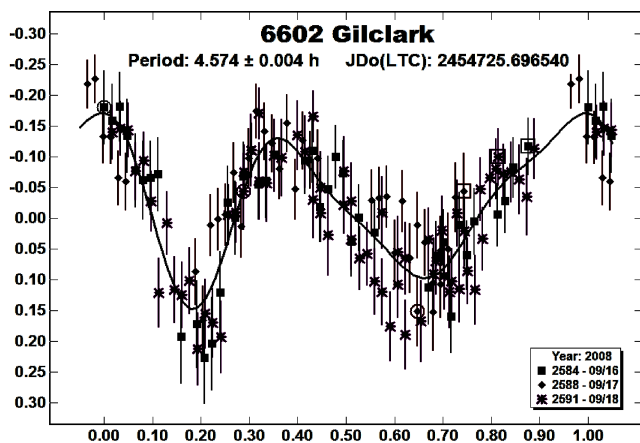
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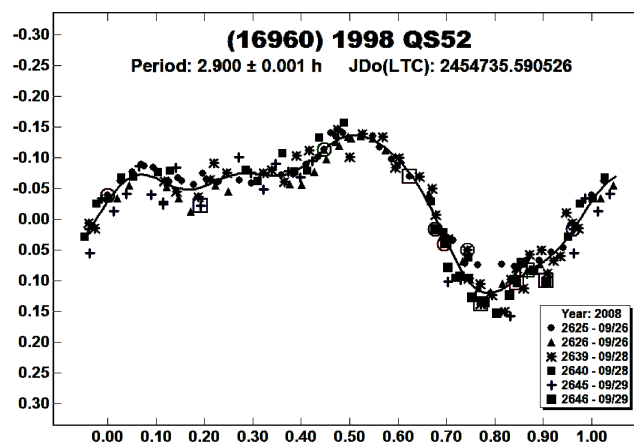
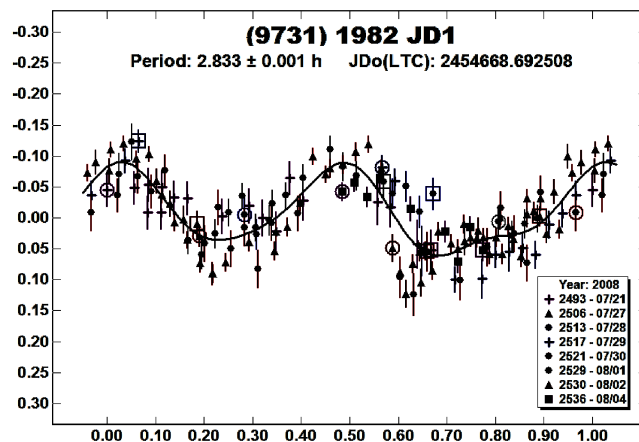
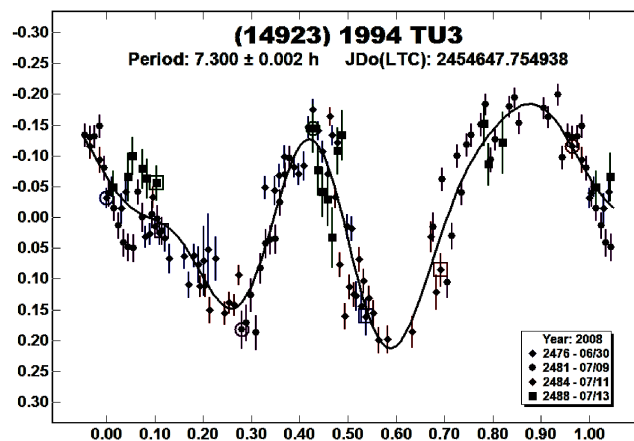
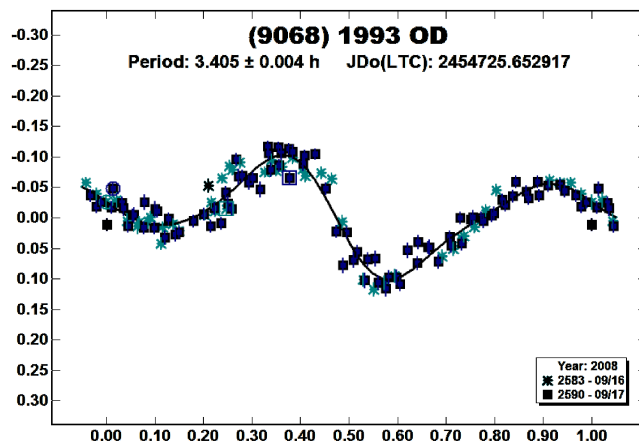
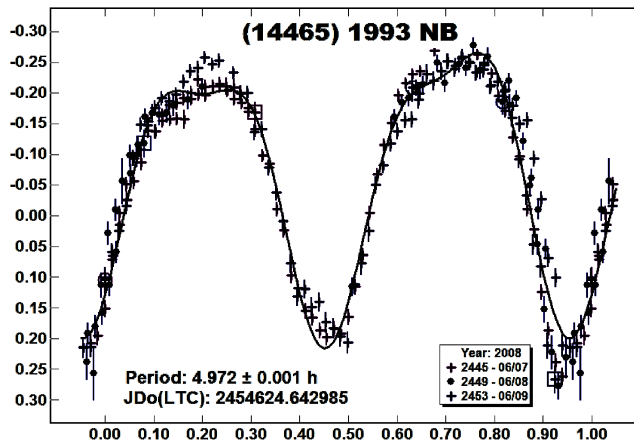
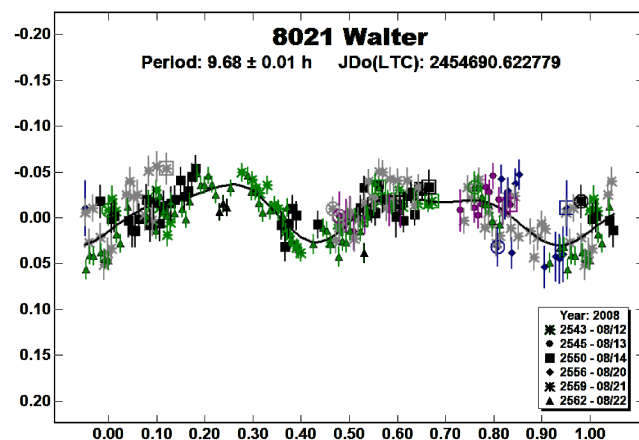
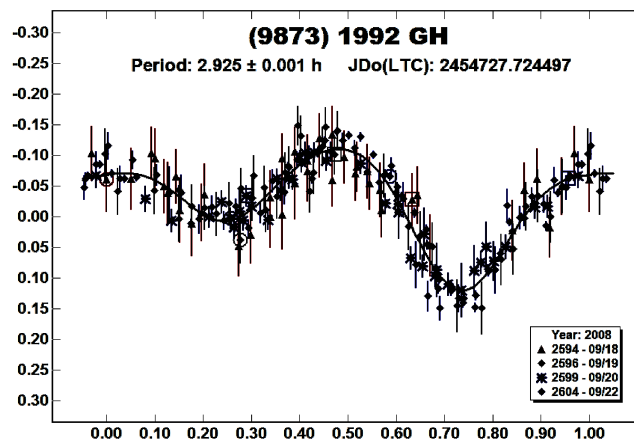
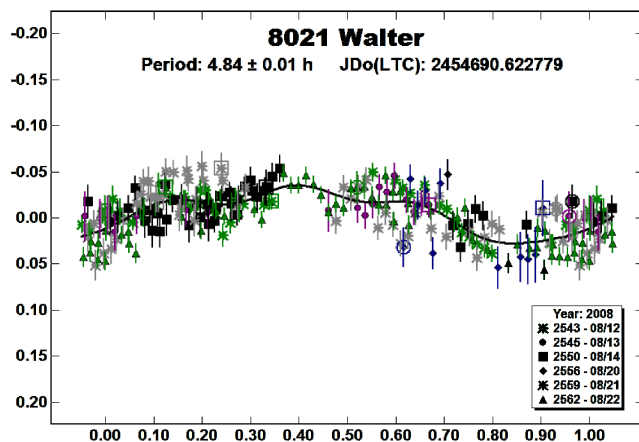
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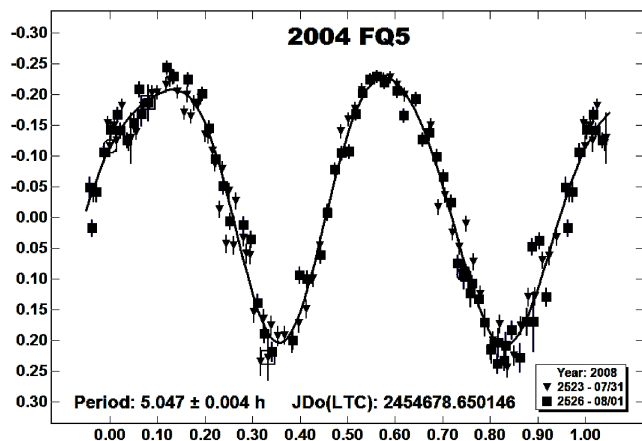
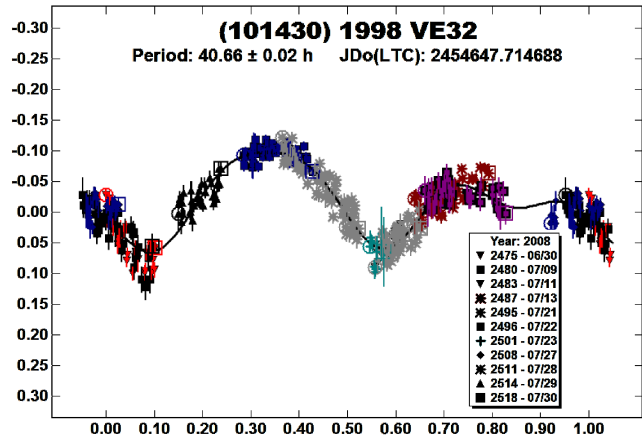
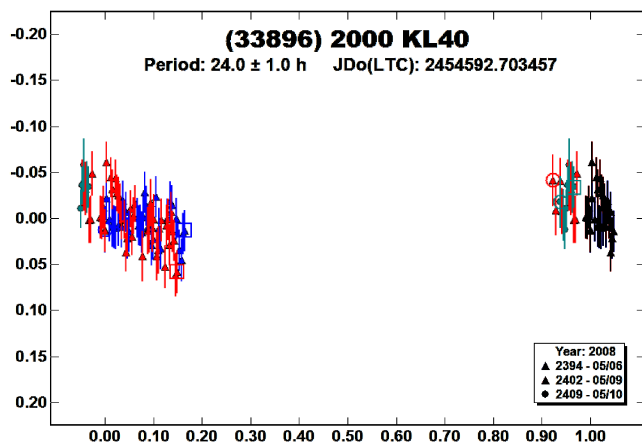
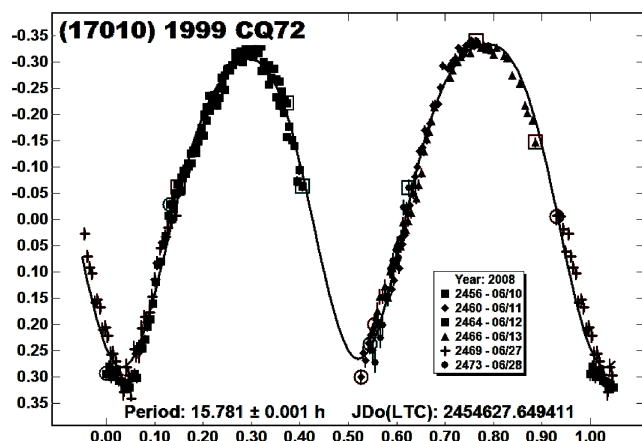
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LIGHTCURVES OF EIGHT SELECTED ASTEROIDS FROM MODRA

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We present lightcurve analysis of asteroids 1989 Taty, 2696 Magion, (5376) 1990 DD, 10166 Takarajima, 10207 Comeniana, (12798) 1995 WZ4, (14921) 1994 QA, and (50573) 2000 EX39.

Modra observatory with its 0.6-m f/5.5 reflector and AP8p CCD camera have devoted a considerable amount of observing time to relative photometry of asteroids with unknown or poorly known rotation periods. Targeted asteroids of magnitude 16 and fainter are not exceptions. The serious limitations are in exposures. They are 60 s at most (under special circumstances), but 30 s is used more frequently. In the latter case there is a possibility to add two consecutive images. No filter is used. The field of view of $25' \times 25'$ is appropriate to link data from consecutive nights for main belt asteroids if needed. Some other asteroids are occasionally projected into the field of view.

1989 Taty. The only motivation for observation of this target was the fact that it was one of the brightest asteroids discovered in Slovakia and its rotation period was not secure. Many sessions and several consecutive nights were used to link data. The first data indicated that the period could probably be near 35.1 h, though with some apparent deviations. Warner (2005) with his 3 sessions done two apparitions ago also provided the first estimate to be quite close to that value, namely 39.9 h. Our tentative idea was that this asteroid could be a tumbler, having two periods. As this still can be true, our careful analysis of all our data showed that the actual rotation period could be longer than previous estimates. However, we had to use very high value for the slope parameter, G , of the order of 1 (in comparison to default 0.15 used in most other cases) to obtain reasonable fit of all data. Despite this, some deviations are still present, but this fit is better than that for 35.1 h. Our imperfect linkages could contain systematic errors so the true value of G could be different.

2696 Magion is a slow rotator and probably also a tumbler. Except for the rotation period presented here, we cannot rule out a shorter one near 350 h. Due to the long period, only mean values of magnitudes per session were used.

(5376) 1990 DD. Its unambiguous rotation period was found using short sessions.