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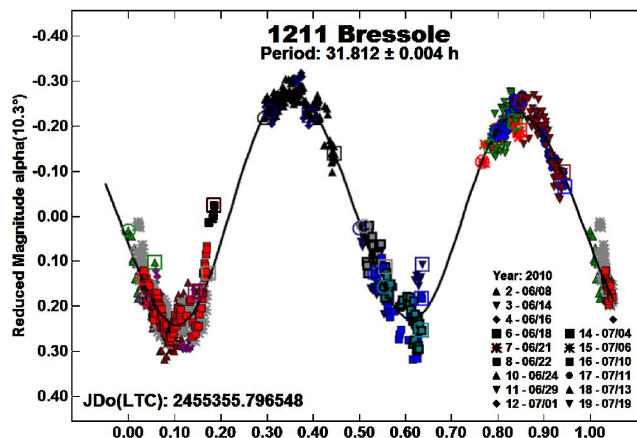


Figure 1. Lightcurve of 1211 Bressole. $\alpha = 10.3$ to 4.0 , $L_{PAB} = 279$, $B_{PAB} = 8$.

ASTEROID LIGHTCURVE ANALYSIS AT THE PALMER DIVIDE OBSERVATORY: 2010 JUNE–SEPTEMBER

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Lightcurves for 30 asteroids were obtained at the Palmer Divide Observatory (PDO) from 2010 June through September: 1373 Cincinnati, 2642 Vesale, 2860 Pasacentennium, 3387 Greenberg, 4116 Elachi, 4440 Tchantches, 4483 Petofi, 4674 Pauling, 5175 Ables, 5968 Trauger, 6087 Lupo, 6163 Reimers, 7087 Lewotsky, 7173 Sepkoski, (11058) 1991 PN10, 15964 Billgray, (21688) 1999 RK37, (33203) 1998 FA57, (45436) 2000 AD176, (46559) 1991 PC1, (49675) 1999 SW27, (49678) 1999 TQ7, (57219) 2001 QY71, (66193) 1999 AF22, (76864) 2000 XR13, (76929) 2001 AX34, (82060) 2000 WX8, (102063) 1999 RR134, (174633) 2003 SM110, and 2006 WL15.

CCD photometric observations of 30 asteroids were made at the Palmer Divide Observatory (PDO) from 2010 June through September. See the introduction in Warner (2010) for a discussion of equipment, analysis software and methods, and overview of the plot scaling. The "Reduced Magnitude" in the plots uses R magnitudes corrected to unity distance by applying $-5 \log(R_r)$ with R and r being, respectively, the Sun-asteroid and Earth-asteroid distances in AU. The magnitudes were normalized to the phase angle given in parentheses, e.g., $\alpha(6.5^\circ)$, using $G = 0.15$ unless otherwise stated.

1313 Cincinnati. Warner (2005) and Behrend (2010) reported periods of $P \sim 5.28$ h based on observations in 2004. New data obtained at PDO in 2010 could not be fit to that period, instead finding $P = 4.930 \pm 0.001$ h. The period spectra from using the 2004 and 2010 data are shown below. Forcing the data from one epoch to the period of the other produces unacceptable results. Additional observations are needed.

2642 Versale. Wisniewski et al. (1997) observed this asteroid in 1987 and reported a period of 7.246 h. The 2010 data from PDO found a period of 5.566 h. Alan Harris (*private communication*) reviewed the original Wisniewski data and determined that the new, shorter period is likely correct.

2860 Pasacentennium. The results here agree with those found by Behrend (2010).

4116 Elachi. Warner (2006) found a period of 38.12 h. The 2010 data give similar results.

4440 Tchantches. The 2010 data represent the fourth apparition at which this asteroid was observed at the PDO (Warner et al., 2006b; Warner and Higgins, 2009). The latest results give $P = 2.790$ h, in good agreement the periods reported from 2005 and 2009. A review of the 2002 data showed that the originally reported period of $P = 6.83$ h (Warner, 2003) was incorrect and that the 2002 data provided a good fit to a period of $P = 2.783$ h.

4483 Petofi. This Hungaria asteroid was previously worked by Angeli and Barucci (1996, $P = 4.480$ h), Wisniewski et al. (1997, $P = 4.4$ h), Brinsfield (2008, $P = 4.33$ h), and Warner (2008, 2009a; $P \sim 4.334$ h). The 2010 PDO observations found $P = 4.3335$ h.

4674 Pauling. This is a known binary asteroid discovered with adaptive optics (Merline et al., 2004). The 2010 PDO observations found $P = 2.533$ h, which is in agreement with previous results (Warner, 2006b; Behrend, 2010).

5968 Trauger. Warner (2006a) reported a period of 7.560 h. A re-examination of the 2005 data favored a half-period of $P = 3.783$ h with an amplitude of 0.10 mag. In 2010, the amplitude of the curve was 0.36 mag, which was hoped would lead to a definitive period solution. However, the derived period of 6.341 h is well-removed from the solutions based on the 2005 data. Neither data set can be reasonably fit to the period found using the other. Given the larger amplitude in 2010, the 6.341 h solution is considered more likely but not conclusive.

7087 Lewotsky. Carbo et al. (2009) reported an amplitude of 0.25 mag but no period. The PDO data give a period of 5.15 h and amplitude of 0.12 mag. However, the curve is noisy and the period solution is still not definitive.

#	Name	mm/dd 2010	Data Pts	α	L_{PAB}	B_{PAB}	Per (h)	PE	Amp (mag)	AE
1373	Cincinnati (H)	08/21-09/06	153	11.2, 14.2	323	27	4.930	0.001	0.11	0.01
2642	Vesale	08/21-08/27	181	10.9, 11.2	328	17	5.566	0.005	0.12	0.01
2860	Pasacentennium	09/24-09/25	137	13.6	8	18	2.660	0.005	0.17	0.02
3387	Greenberg	08/21-08/29	295	10.5	332	17	2.6941	0.0003	0.10	0.01
4116	Elachi (H)	09/07-09/14	380	13.8, 15.7	332	17	38.3	0.1	1.04	0.03
4440	Tchantches (H)	08/11-08/14	172	17.4, 16.8	337	23	2.790	0.001	0.28	0.02
4483	Petofi (H)	08/13-09/05	237	22.2, 12.8	343	18	4.3335	0.0001	0.86-1.03	0.02
4674	Pauling (H)	09/09-09/11	175	17.6	354	26	2.533	0.003	0.05	0.01
5175	Ables (H)	09/01-09/04	270	23.1, 22.2	16	17	2.798	0.002	0.10	0.01
5968	Trauger (H)	06/19-07/10	78	25.1, 22.0	294	33	6.341	0.002	0.36	0.02
6087	Lupo (H)	07/11-07/16	133	20.2, 17.9	316	14	4.712	0.003	0.66	0.02
6163	Reimers (H)	09/06/09/07	145	27.5	20	14	6.68	0.01	1.22	0.02
7087	Lewotsky (H)	08/15-08/26	177	22.0, 18.8	358	22	5.15	0.02	0.12	0.03
7173	Sepkoski (H)	09/09-09/25	250	19.3, 17.9	357	27	2.4996	0.0003	0.09	0.01
11058	1991 PN10	07/17-07/20	110	22.2, 21.0	320	20	6.517	0.005	0.47	0.02
15964	Billgray	09/07-09/10	155	12.7	348	17	3.571	0.003	0.45	0.02
21688	1999 RK37 (H)	09/03-09/26	361	29.3, 24.9	22	26	5.6960	0.0005	0.80	0.02
33203	1998 FA57	09/15	59	6.3	8	-1	3.0	0.1	0.26	0.03
45436	2000 AD176	06/18-07/06	138	19.7, 22.7	228	16	18.47	0.04	1.15	0.05
46559	1991 PC1 (H)	09/12-09/14	149	10.1, 9.1	2	6	5.168	0.005	0.56	0.02
49675	1999 SW27 (H)	08/31-09/02	155	19.8	2	25	4.994	0.005	0.40	0.02
49678	1999 TQ7 (H)	09/12-09/14	153	5.2, 4.3	352	6	3.957	0.005	0.40	0.03
57219	2001 QY71	09/27-09/28	115	1.7, 1.2	7	0	2.885	0.003	0.28	0.02
66193	1999 AF22	09/12-09/26	153	4.2, 4.0, 6.4	353	6	8.00	0.01	0.26	0.03
76864	2000 XR13 (H)	08/27-09/02	177	19.2, 20.6	327	26	3.892	0.003	0.16	0.02
76929	2001 AX34 (H)	09/01-09/07	439	11.5, 10.1	349	11	36.4	0.5	0.03	0.01
82060	2000 WX8 (H)	08/15-08/31	178	20.6, 23.3	315	16	2.7631	0.0005	0.32	0.02
102063	1999 RR134	09/13-09/16	156	3.1	352	6	7.53	0.02	0.11	0.02
174633	2003 SM110	09/13-09/15	149	4.5	352	6	3.579	0.005	0.19	0.02
	2006 WL15	09/16	24	9.1	6	0	? 6.		0.25	

Table II. Observing circumstances. Asteroids with "(H)" after the name are members of the Hungaria group. 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).

(33203) 1998 FA57. As often happens near the equinoxes, a number of secondary targets can be found in the same field as a primary target. Eventually, circumstances and resources limit which secondary targets can be followed for the necessary amount of time. This outer main-belt asteroid was in the same field as a primary target on one night and could not be worked additional nights. The 0.26 mag. amplitude allows some confidence in the period solution of 3.0 ± 0.1 h.

(76864) 2000 XR13. This Hungaria was previously observed by Warner (2009b), when a period of 3.89 h was found. The 2010 observations confirmed that period. The data from Aug 27 showed what appeared to be a mutual event (occultation or eclipse) due to a satellite. The asteroid was observed on the following six nights but a confirming observation was never made. The images were re-measured and the "event" was confirmed; its cause remains unknown.

(76929) 2001 AX34. The 2010 data alone did not reveal a definitive solution due to a lightcurve amplitude of only 0.03 mag. The results from a previous apparition ($P = 36.2$ h, $A = 0.19$ mag; Warner, 2009c) were used to constrain the solution for 2010.

2006 WL15. This was one of two secondary targets on one night. The other, 11118 Modra, was brighter and kept on the observing list while this one suffered the fate of being "one too many". The lightcurve shows only the raw data, although a rough estimate of 6 h was made on the assumptions of a bimodal curve and that, presumably, about one-quarter of a cycle was observed.

Acknowledgements

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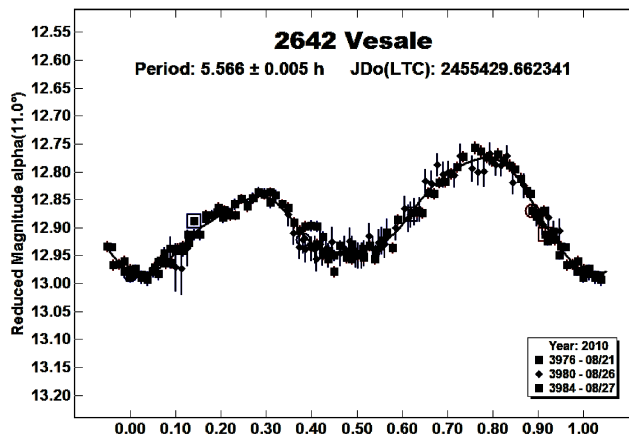
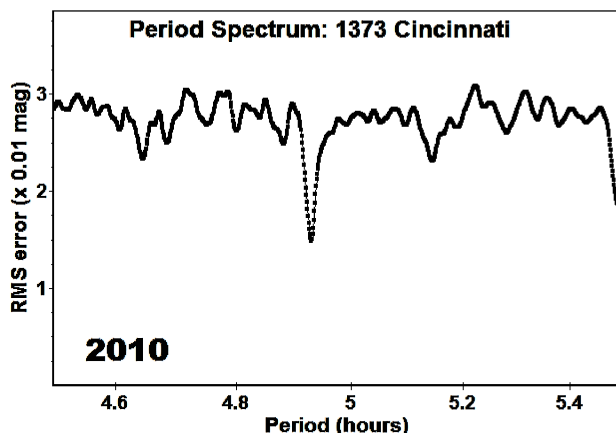
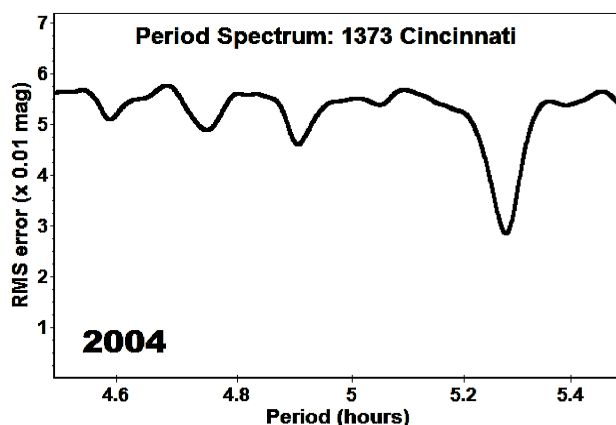
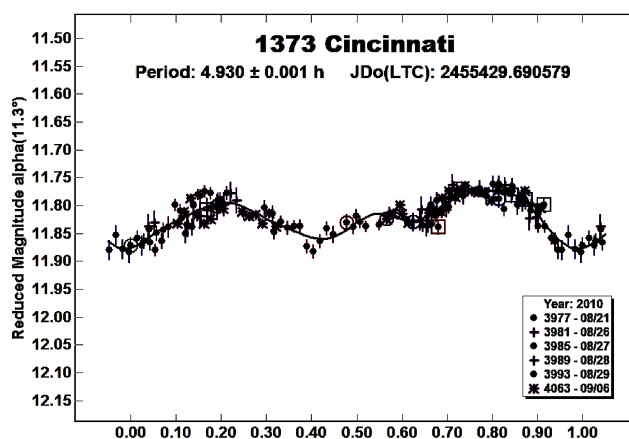
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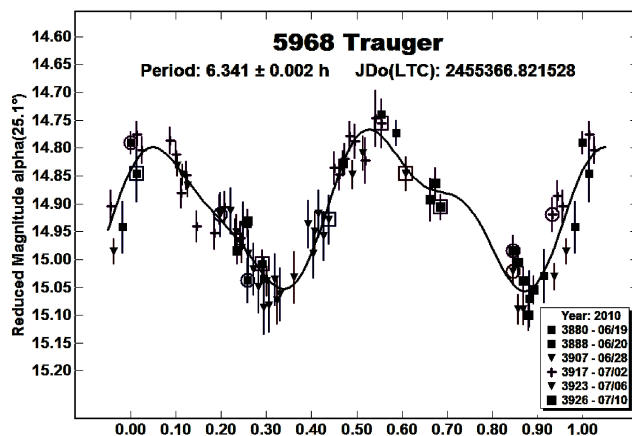
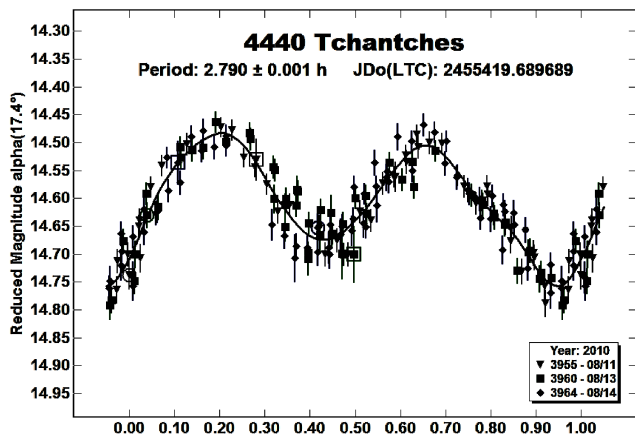
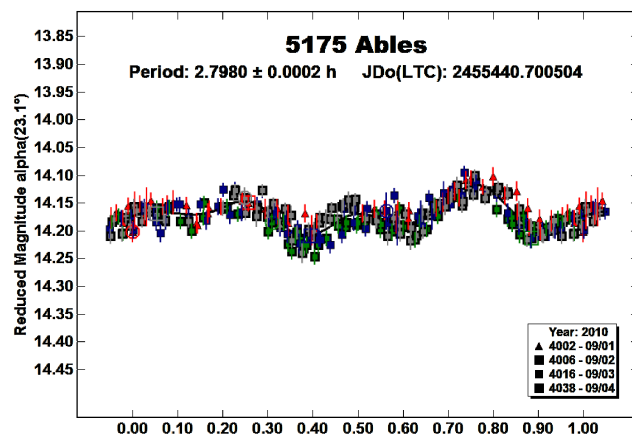
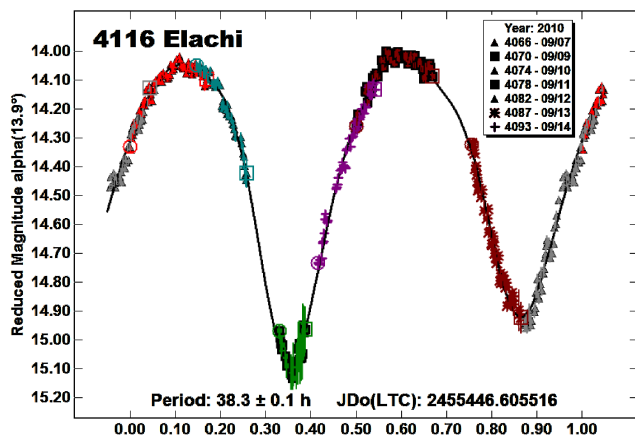
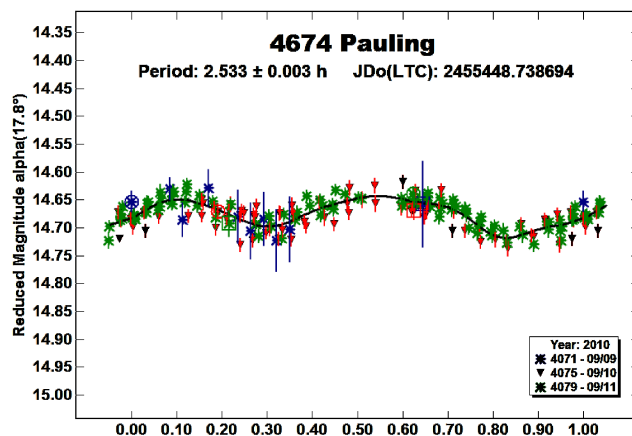
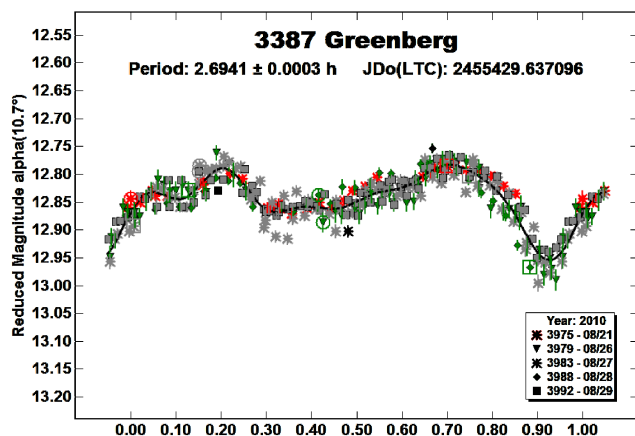
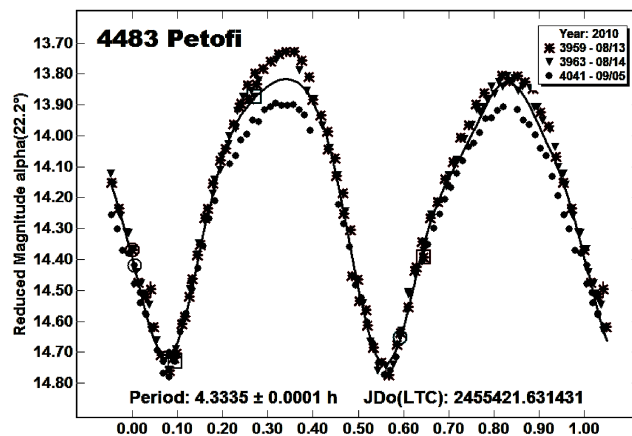
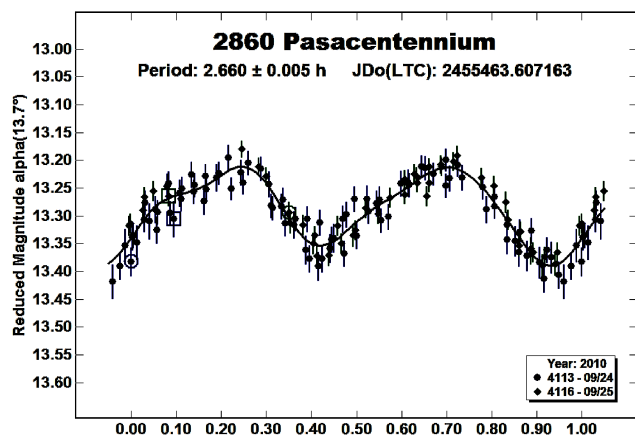
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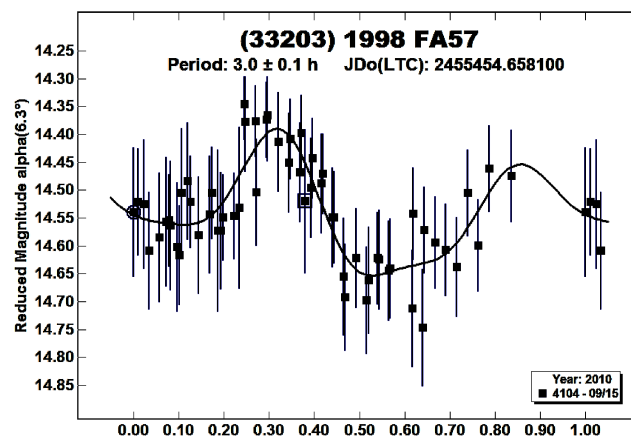
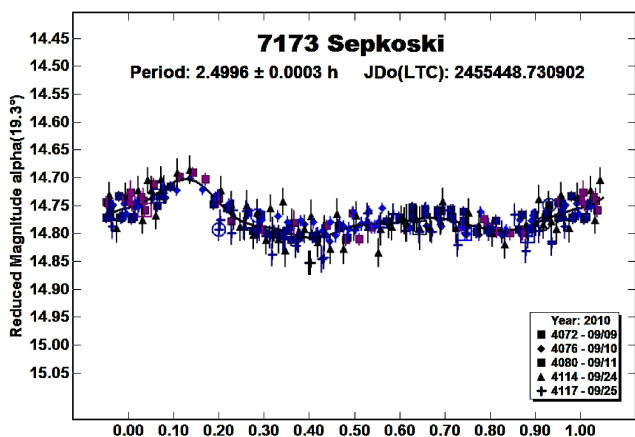
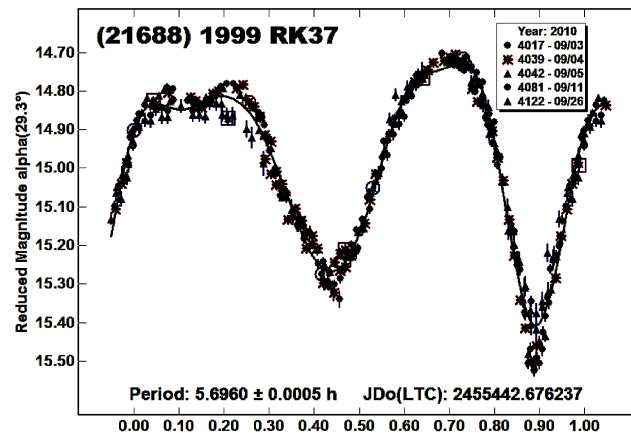
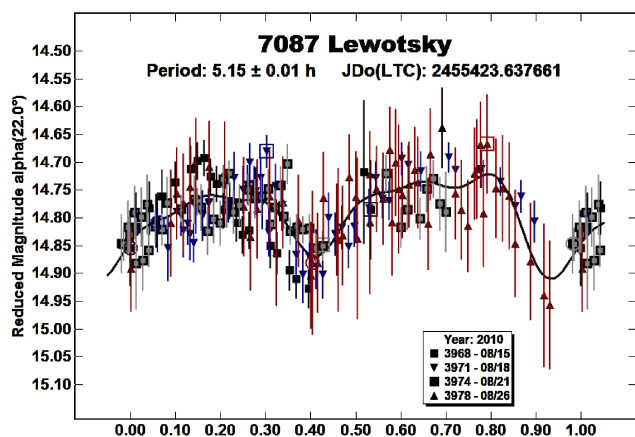
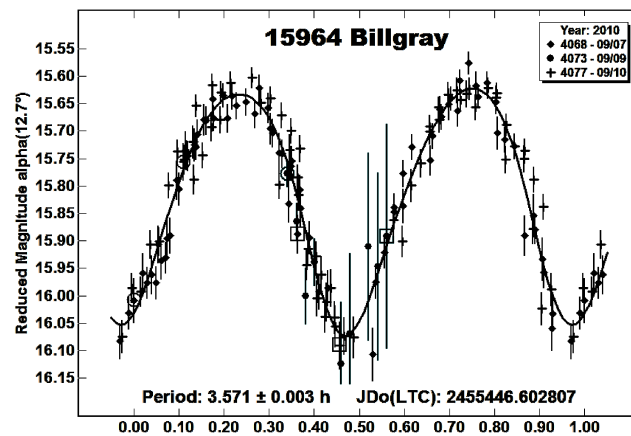
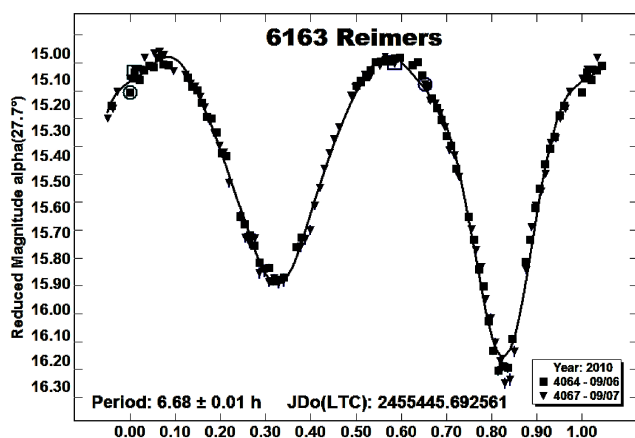
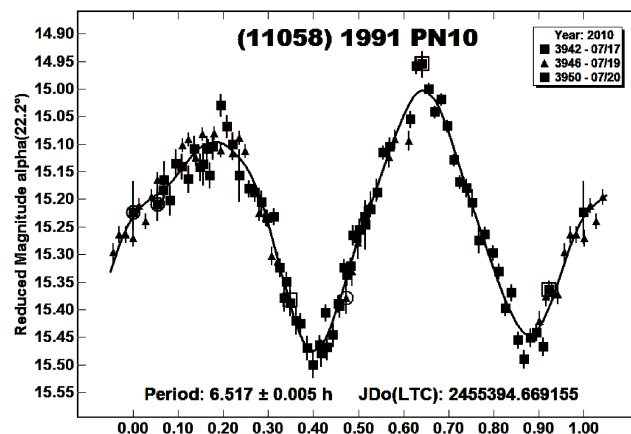
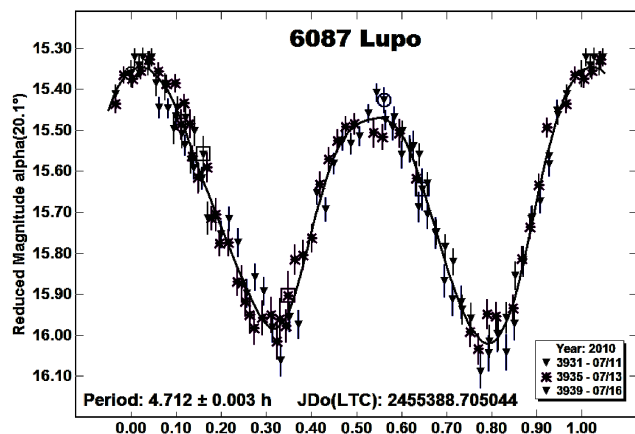
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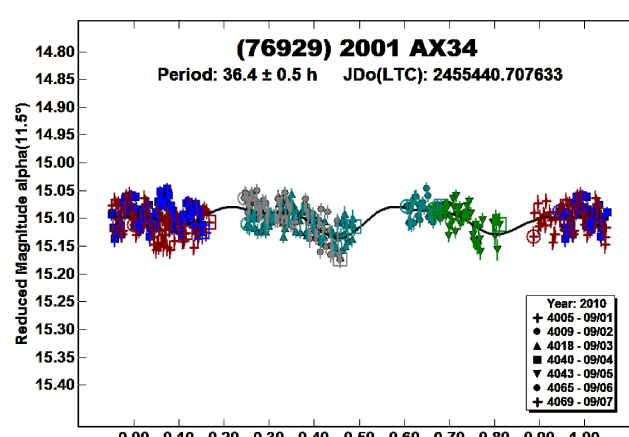
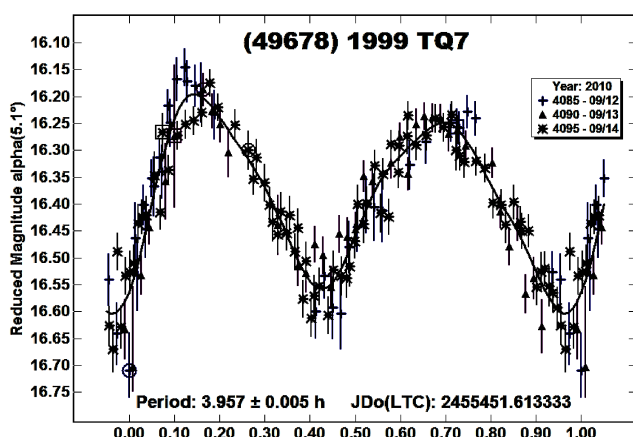
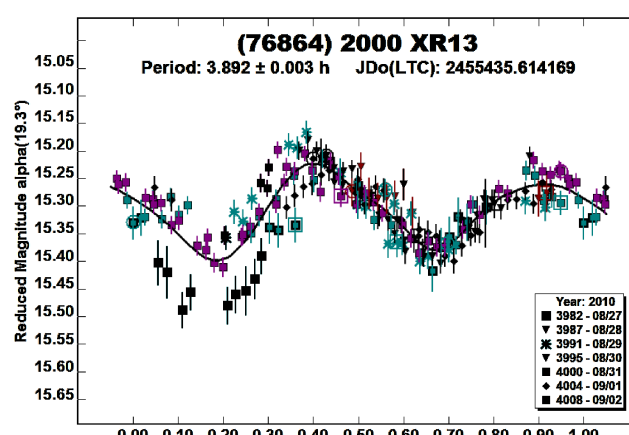
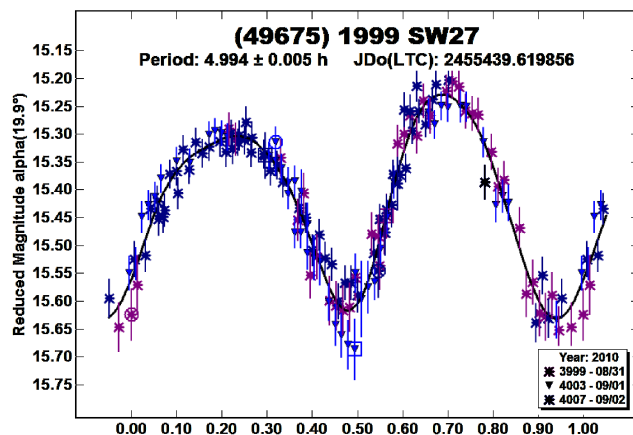
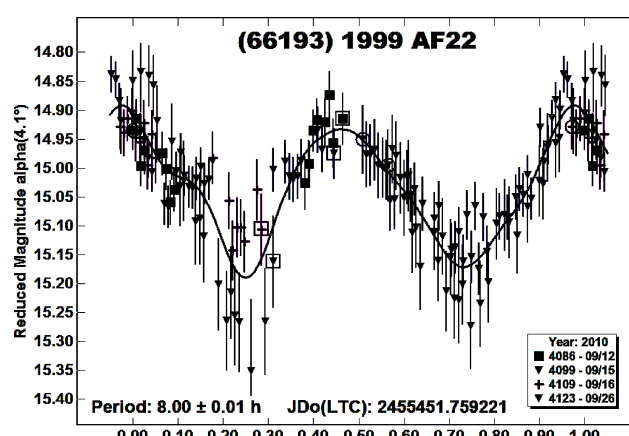
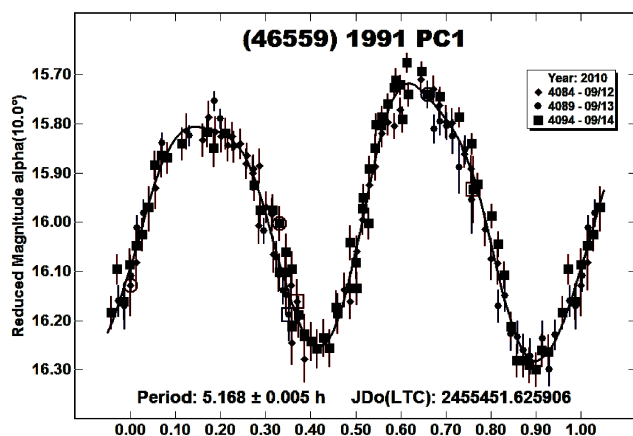
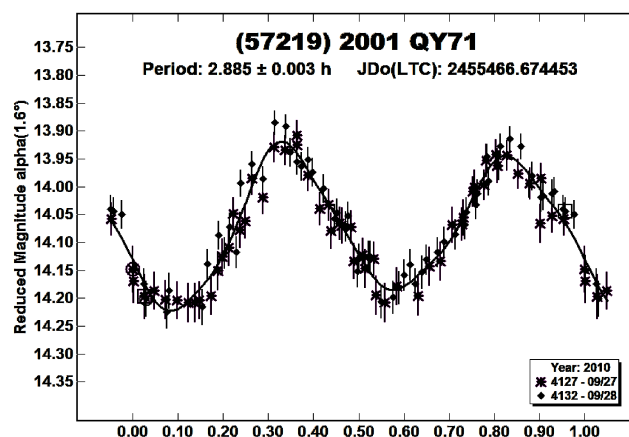
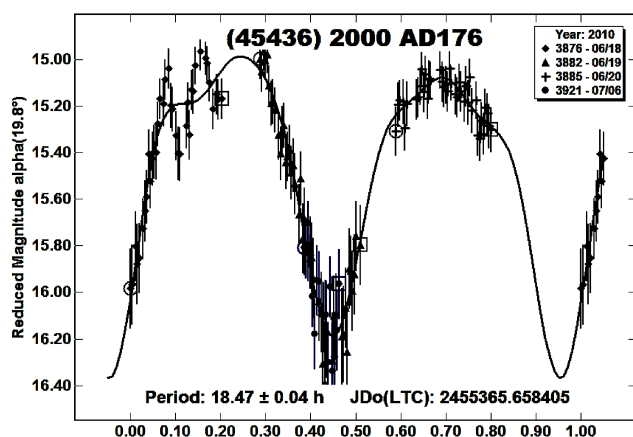
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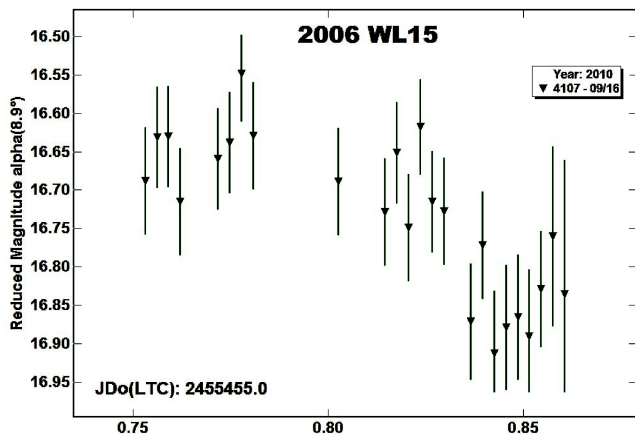
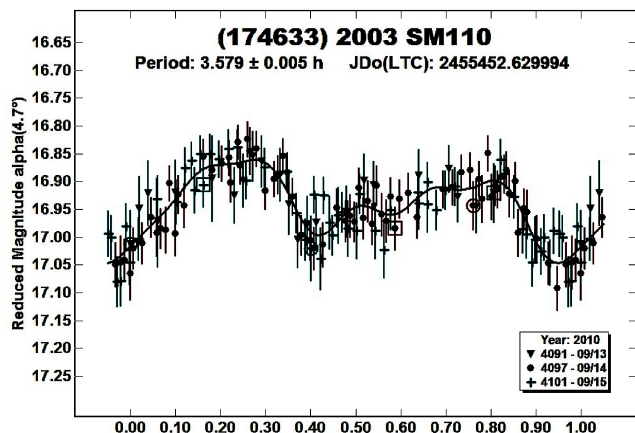
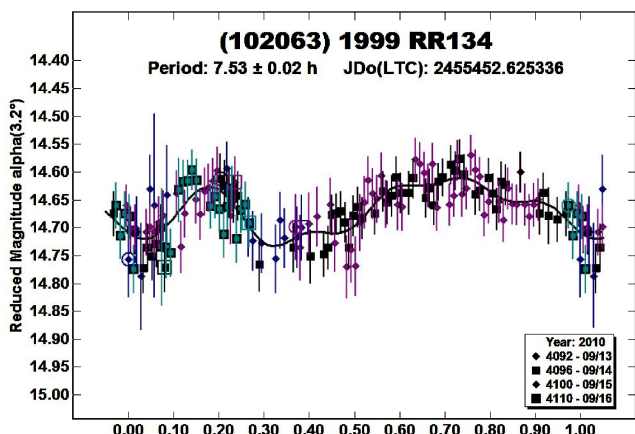
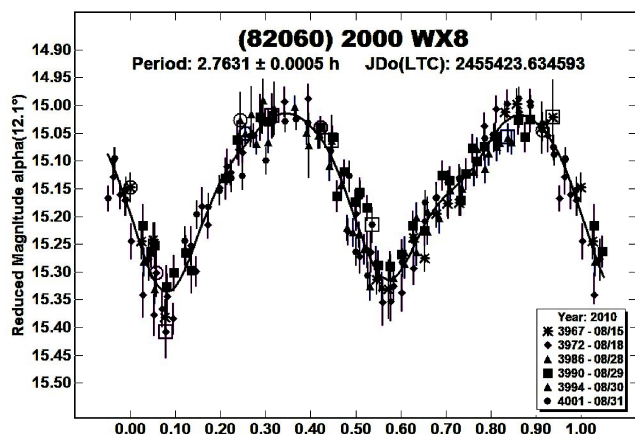
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LIGHTCURVE ANALYSIS OF 1469 LINZIA

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Observations of the main-belt asteroid 1469 Linzia at Santana Observatory and Belgrade Astronomical Observatory in 2010 September found a synodic period of 22.215 ± 0.004 h and an amplitude of 0.09 ± 0.02 mag.

Benishek made initial observations of the main-belt asteroid 1469 Linzia at Belgrade Astronomical Observatory. See Benishek (2010) for a general description of Belgrade equipment and analysis methods. Because of poor weather, a request was made to Stephens at Santana Observatory to obtain observations to complete the lightcurve. See Stephens (2010) for a general description of equipment at Santana. Night-to-night calibration of the Santana data (generally $< \pm 0.05$ mag) was done using field stars converted to approximate Cousins R magnitudes based on 2MASS J-K colors (Warner, 2007; Stephens, 2008).

Behrend (2010) reported a single night of observations from 2004 February resulting in a partial lightcurve and a period of approximately 24 h. Blanco (2000) obtained three nights of sparse data in 1994 resulting in a partial lightcurve with a period of 6.067 h. Our data set of 1,639 data points could not be fit to that result. Because Belgrade and Santana are separated by 137 degrees of longitude, we were able to obtain extended runs on two different nights that covered more than half of our derived period. The final analysis of the lightcurve determined a synodic period of 22.215 ± 0.004 h and amplitude of 0.09 ± 0.02 mag.

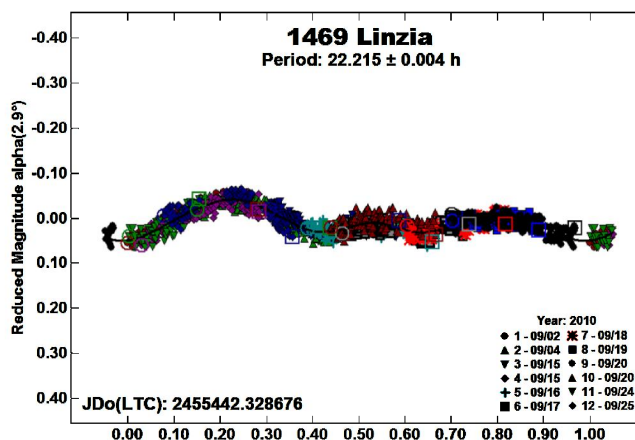


Figure 1. Lightcurve of 1469 Linzia. $\alpha = 4.4^\circ$ to 2.6° , $L_{PAB} = 348^\circ$, $B_{PAB} = 6^\circ$.