ASTEROID LIGHTCURVE ANALYSIS AT THE PALMER DIVIDE OBSERVATORY: 2011 JUNE - SEPTEMBER

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Lightcurves for 28 asteroids were obtained at the Palmer Divide Observatory (PDO) from 2011 June to September: 903 Nealley, 1103 Sequoia, 2052 Tamriko, 2083 Smither, 2150 Nyctimene, 2272 Montezuma, 2306 Bauschinger, 4125 Lew Allen, 5571 Lesliegreen, (7660) 1993 VM1, 7933 Magritte, (16256) 2000 JM2, (16959) 1998 QE17, (17822) 1998 FM135, (18890) 2000 EV26, (27568) 2000 PT6, (31898) 2000 GC1, (32953) 1996 GF19, (32928) 1995 QZ, (33356) 1999 AM3, (35055) 1984 RB, (54234) 2000 JD16, (60365) 2000 AT109, (62117) 2000 RC102, (67404) 2000 PG26, 70030 Margaretmiller, (140428) 2001 TT94, (282081) 2000 NG. Observations of 70030 Margaretmiller indicate that the asteroid is a probable binary with a secondary period being detected but no mutual events.

CCD photometric observations of 28 asteroids were made at the Palmer Divide Observatory (PDO) from 2011 June to September. See the introduction in Warner (2010a) for a discussion of equipment, analysis software and methods, and overview of the plot scaling. The "Reduced Magnitude" in the plots uses Cousins R magnitudes corrected to unity distance by applying –5*log (Rr) 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°), using $G = 0.15$ unless otherwise stated.

903 Nealley. Warner (2004) observed this asteroid in mid-2004 and found a period of 21.60 h using a data set without internal calibration. The internally-standardized data from 2011 fit periods of 19.72 or 21.52 h about equally well. As shown in the plot for 2004, by adjusting nightly zero points, the data from the earlier apparition fit a period of 19.58 h. The two apparitions differed in phase angle bisector longitude by about 90°. Given the low amplitude and roughly similar lightcurve shape for both apparitions, this favors the conclusion that the spin axis latitude is relatively high and the object somewhat spheroidal in shape.

1103 Sequoia. This well-studied Hungaria (e.g., see Wisniewski 1997; LeCrone *et al.* 2004; Behrend 2006; and Hanus *et al.* 2011) was observed at PDO in 2011 August. The period derived from the latest data is in good agreement with the previous findings.

2083 Smither. Warner (2007a, 2010b) observed this asteroid at two previous apparitions. The 2009 apparition showed possible signs of the asteroid being binary (mutual events) but this could not be confirmed. The observations in 2011 found no definitive evidence of events or a secondary period. The asteroid remains a strong target of interest for future observations.

2150 Nycteimene. Warner (2007a, 2008) previously determined the period for this Hungaria to be approximately 6.12 h. The 2011 observations confirm this and should help find a spin axis and shape model using lightcurve inversion techniques (see Hanus *et al.* 2011 and references therein).

2306 Bauschinger. Behrend (2007) reported a period of 21.64 h. Analysis of the 2011 PDO observations confirm that result.

4125 Lew Allen. This was the third apparition of observations at PDO for this Hungaria (Warner 2007b, 2010b). The most recent period is in close agreement with previous findings.

(7660) 1993 VM1. This Mars-crossing asteroid was observed by Pravec *et al.* (2005) in 2005 April, who reported a period of 5.916 h and amplitude of 0.32 mag. The PDO data analysis gave P = 5.92 h and A = 0.86 mag.

(16959) 1998 QE17. Initial observations indicated the possibility of a second period. However, the full data set, with some minor zero point adjustments, shows a single-periodic curve (Petr Pravec, private communications).

(31898) 2000 GC1. The period of 17.2 h reported here is just one of many that fit the data and should be considered unreliable.

(33356) 1999 AM3. The amplitude of 0.56 mag is based on the Fourier curve, i.e., it's assumed that the second minimum, for which there was no coverage, was not deeper than the first, double-covered, minimum.

(35055) 1984 RB. Warner *et al.* (2010) observed this asteroid in 2010 February and reported a period of 3.658 h with an amplitude range of 0.35-0.44 mag due to observations covering phase angles from 7° to 22°. The 2011 observations at PDO found the same synodic period (to 0.001 h) and, since they were confined to a relatively short time, a fixed amplitude of 0.44 mag.

(60365) 2000 AT109. This Flora member was a "target of opportunity," i.e., in the same field as a planned target. Follow up was not possible. The data show a steady decline over almost 5 h, with a lightcurve amplitude of >0.2 mag. This favors a period of at least 16 h and probably in the range of 1-2 days.

70030 Margaretmiller. Named after the author's wife, this asteroid was previously observed in 2003 (Warner 2005) and 2010 (Warner 2010). The original analysis of the 2003 data found a period of 3.98 h. The images were remeasured and data placed on an internal standard system. A revised period of 4.35 h was found (Warner 2010) despite the somewhat noisy data. The 2010 observations (when the asteroid was brighter) found a period of 4.329 h (Warner 2010). There were no signs of a secondary period or mutual events due to a satellite in either of the two apparitions.

The 2011 observations told a different story. While the data could be fit to a period of about 4.329 h, this required removing a secondary period of either 15.8 h or 11.8 h. This secondary period was confirmed with independent observations by Audrey Thirouin at Cala Alto fitted into the PDO data set and analyzed by Petr Pravec and Peter Kušnirak at the Astronomical Institute, Czech Republic (Petr Pravec, private communications). Since there were no mutual events (occultations and/or eclipses) observed, the asteroid can be said to be only a probable and not confirmed binary. Follow-up photometric observations and, possibly, imaging with adaptive optics at future apparitions will be required to confirm the true nature of the asteroid.

Acknowledgements

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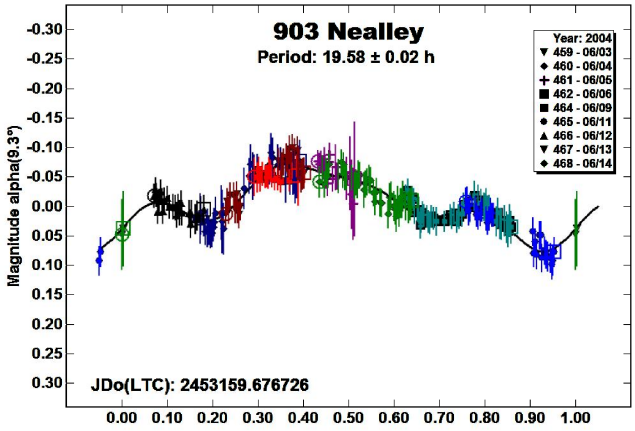
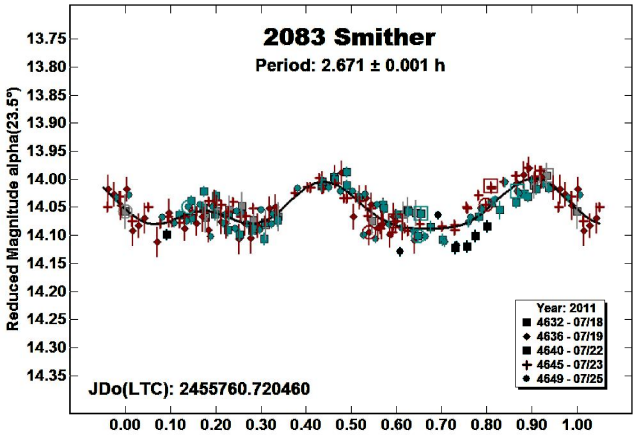
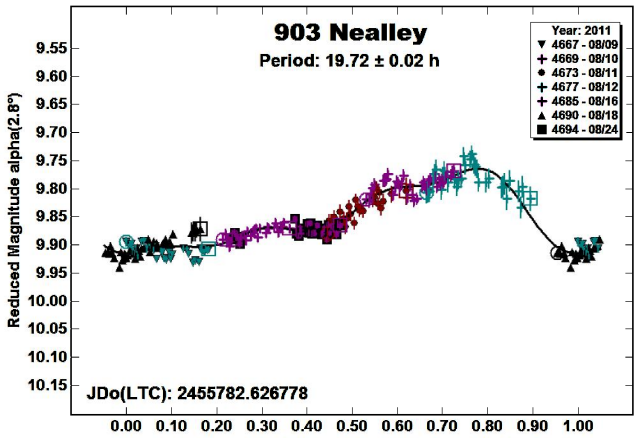
#	Name	mm/dd 2011	Data Pts	α	L_{PAB}	B_{PAB}	Per (h)	PE	Amp (mag)	AE
903	Nealley	06/06-06/14[1]	239	9.9,11.8	228	13	19.58/21.52	0.02	0.15	0.02
903	Nealley	08/09-09/12	160	2.7,12.1	312	6	19.72	0.02	0.15	0.01
1103	Sequoia (H)	08/12-08/13	102	17.3	311	21	3.044	0.005	0.35	0.02
2052	Tamriko	09/11-09/23	148	6.7,10.4	334	9	7.470	0.002	0.15	0.02
2083	Smither (H)	07/18-07/25	203	23.5,21.7	328	23	2.671	0.001	0.10	0.01
2150	Nyctimene (H)	07/16-07/22	124	23.1,22.4	311	35	6.131	0.005	0.61	0.02
2272	Montezuma (H)	08/11-08/16	188	14.4,13.5	323	21	8.183	0.005	1.08	0.02
2306	Bauschinger	08/01-08/24	240	4.1,2.7,7.6	314	5	21.66	0.01	0.69	0.02
4125	Lew Allen (H)	07/16-07/19	121	28.0,27.3	326	20	4.629	0.005	0.45	0.02
5571	Lesliegreen	09/01-09/05	137	4.6,4.1	345	11	6.953	0.005	0.16	0.02
7660	1993 VM1 (H)	07/03-07/18	118	19.9,16.4	305	26	5.92	0.02	0.86	0.03
7933	Magritte	08/01	52	5.8	313	9	3.26	0.05	0.38	0.02
16256	2000 JM2 (H)	06/16-07/16	260	24.3,22.8,23.1	281	33	63.5	0.3	0.98	0.03
16959	1998 QE17	09/11-09/25	340	13.2,7.2	8	7	3.2266	0.0001	0.36	0.02
17822	1998 FM135	08/01-08/05	99	3.8,2.7	315	5	4.613	0.002	0.28	0.02
18890	2000 EV26 (H)	06/28-07/04	87	20.1,20.9	264	32	10.53	0.05	0.20	0.02
27568	2000 PT6 (H)	08/01-08/09	125	17.0,14.0	325	19	3.624	0.002	0.13	0.01
31898	2000 GC1 (H)	08/01-08/10	135	7.6,5.2	313	7	17.2	0.2	0.07	0.01
32928	1995 QZ (H)	08/01-08/24	183	6.0,13.1	315	7	38.9	0.1	0.56	0.03
32953	1996 GF19	09/05-09/23	112	4.0,12.0	339	5	4.329	0.001	0.13	0.01
33356	1999 AM3 (H)	08/25-09/04	347	17.0,16.1	344	22	37.59	0.05	0.92	0.02
35055	1984 RB (H)	07/22-07/25	145	17.9,16.6	327	10	3.659	0.005	0.41	0.02
54234	2000 JD16 (H)	07/22-08/01	112	20.5,19.2	316	28	6.058	0.005	0.39	0.03
60365	2000 AT109	09/20	34	13.9	336	9	>16		>0.2	
62117	2000 RC102	08/30-09/02	164	9.9,9.6	345	25	13.5	0.1	0.09	0.01
67404	2000 PG26 (H)	08/25-09/01	176	15.7,14.7	344	23	5.398	0.001	0.70	0.02
70030	Margaretmiller (H)	08/25-09/22	311	9.6,6.5,11.0	344	10	4.3292	0.0002	0.45	0.02
140428	2001 TT94	08/30-08/31	51	5.5,5.2	345	10	2.5	0.1	0.46	0.03
282081	2000 NG	07/22-07/25	81	22.3,21.1	325	10	6.59	0.02	0.33	0.02

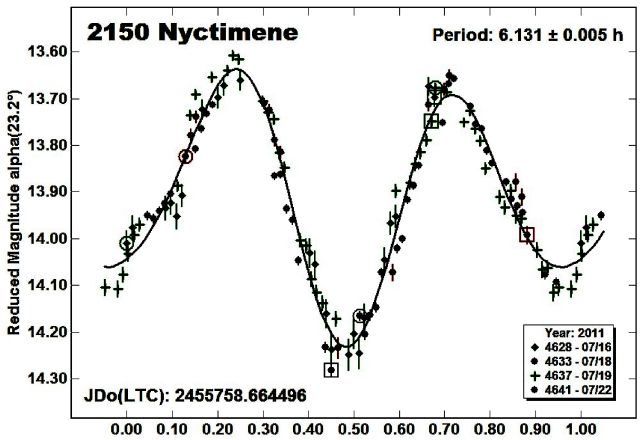
(1)=2004

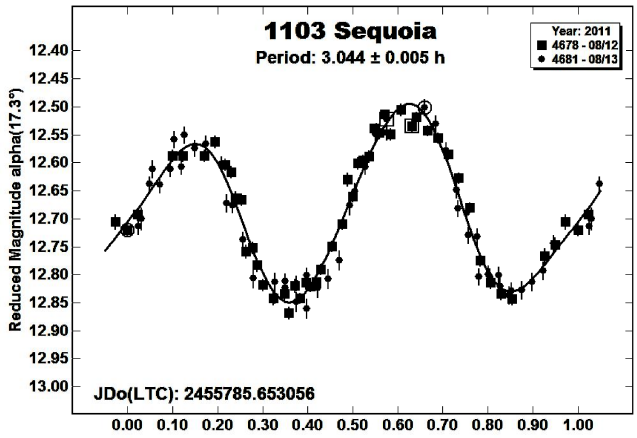
Table I. Observing circumstances. Asteroids with "(H)" after the name are members of the Hungaria group/family. The phase angle (α) is given at the start and end of each date range, unless it reached a minimum, which is then the second of three values. If a single value is given, the phase angle did 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).

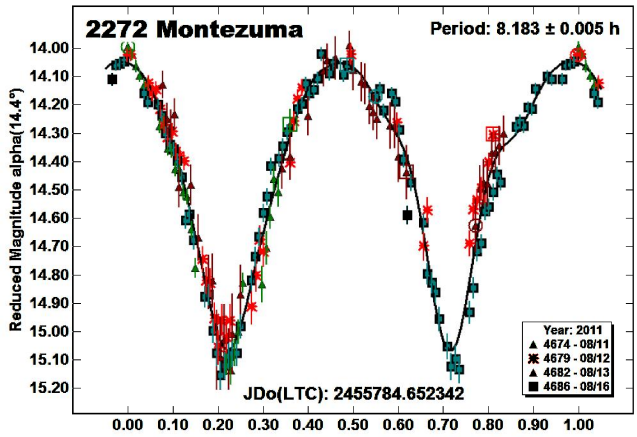


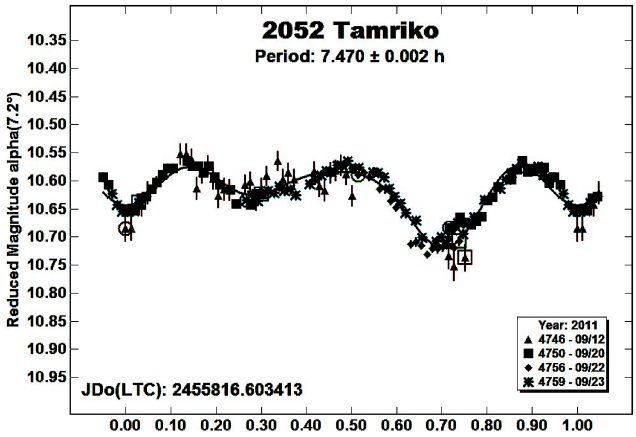


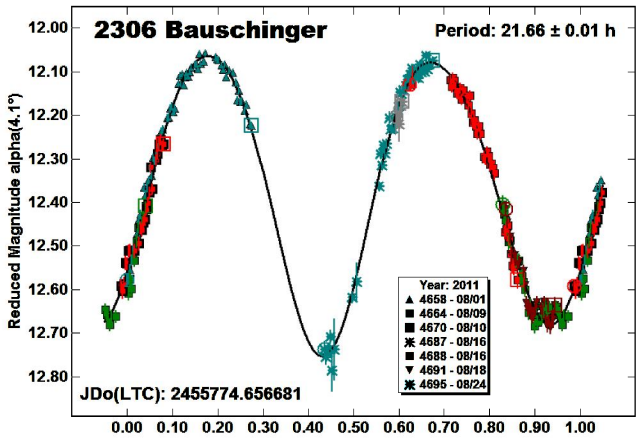


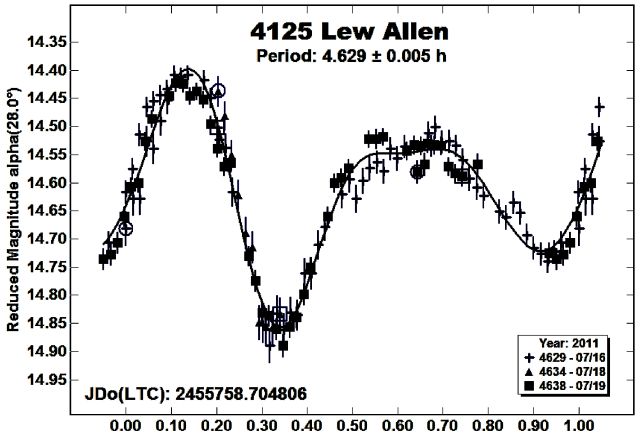


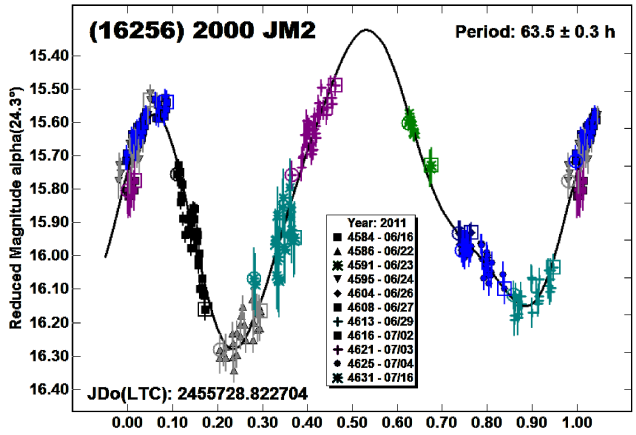


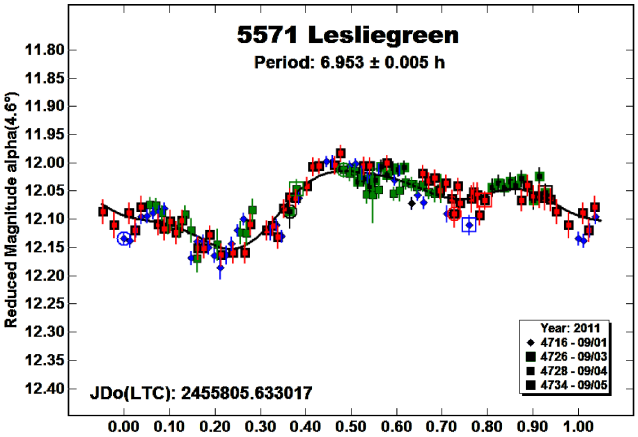


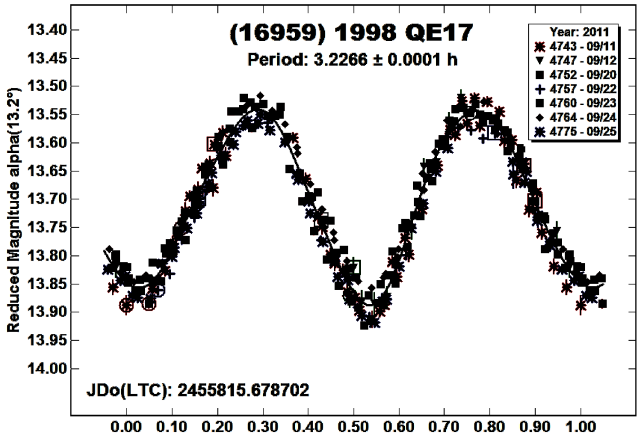


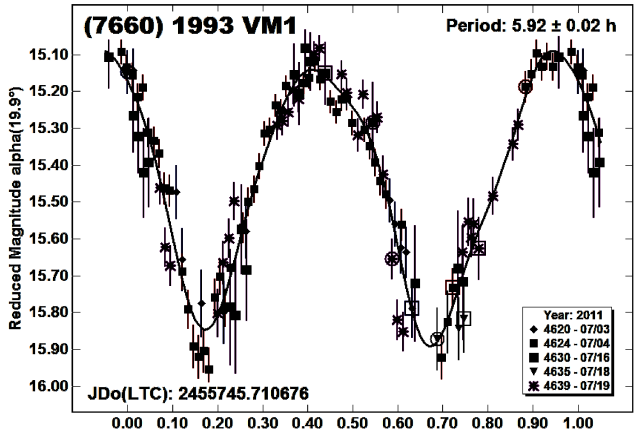


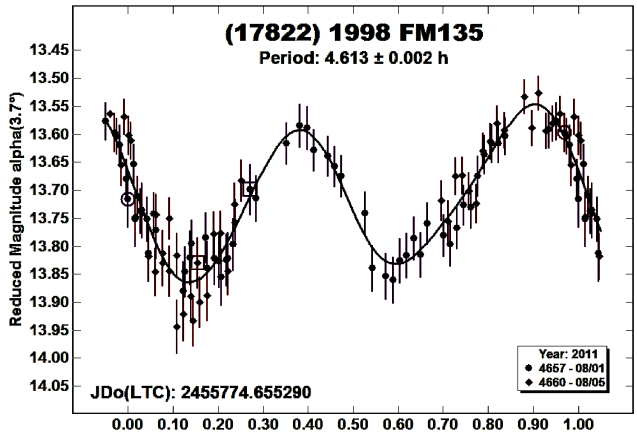


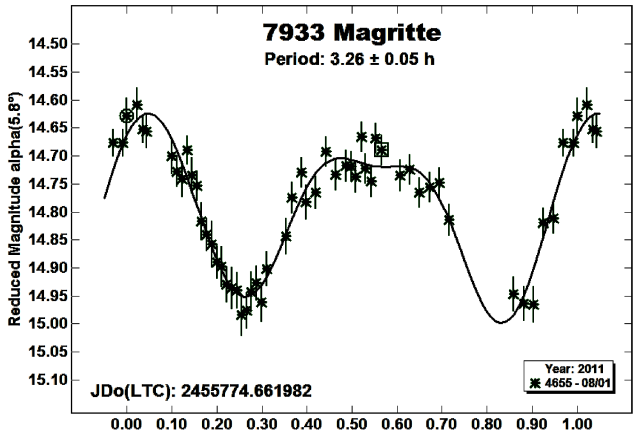


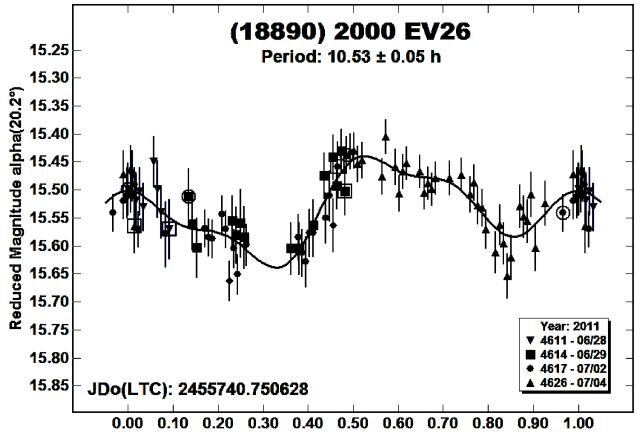


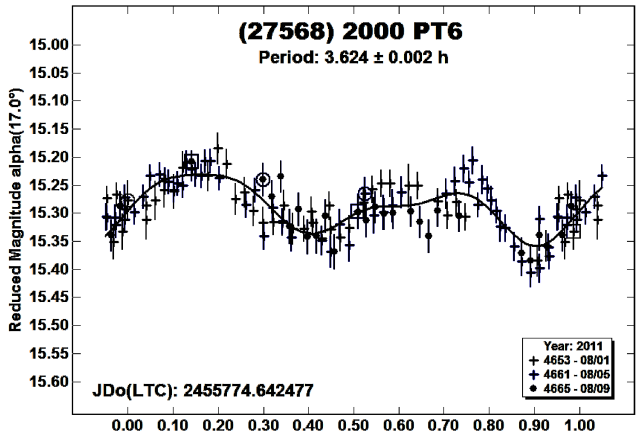


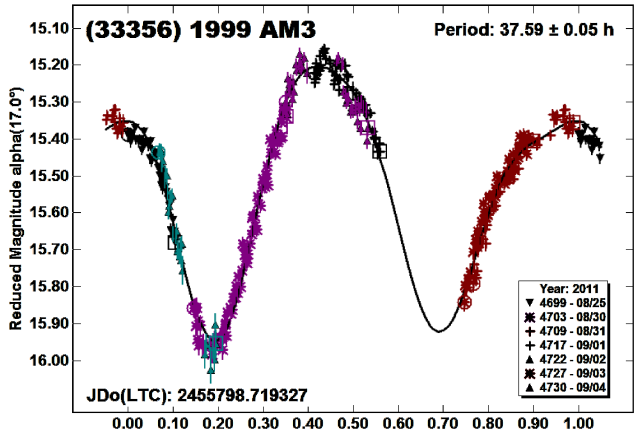


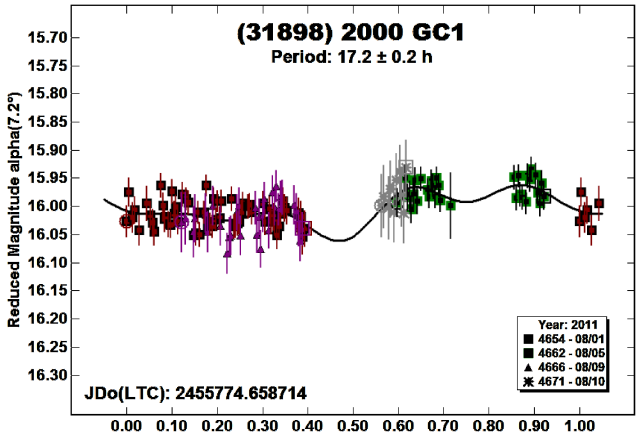


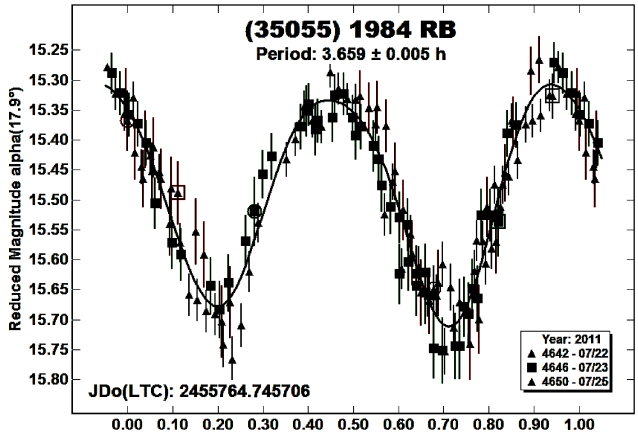


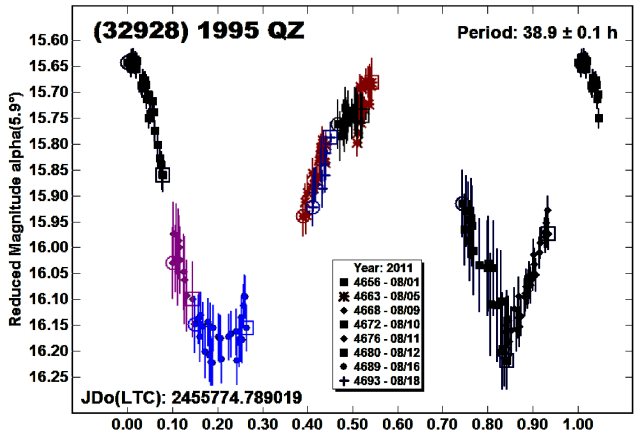


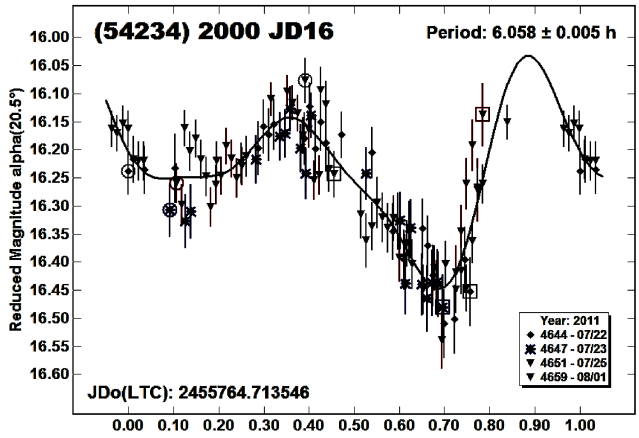


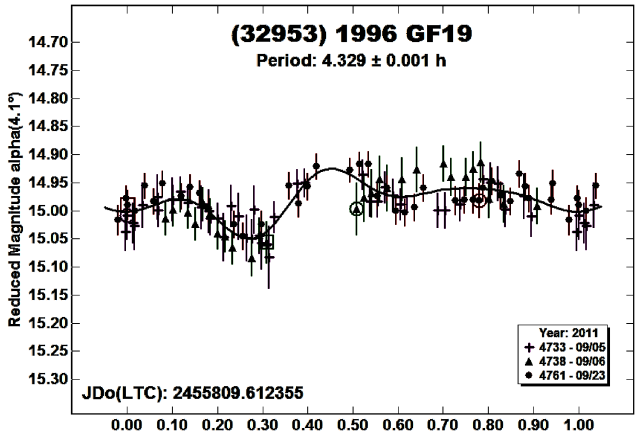


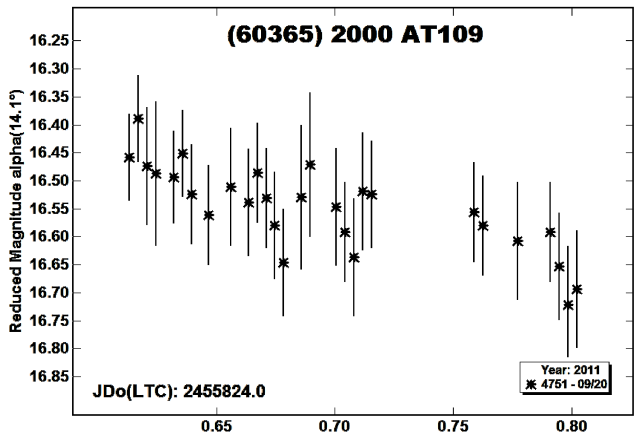


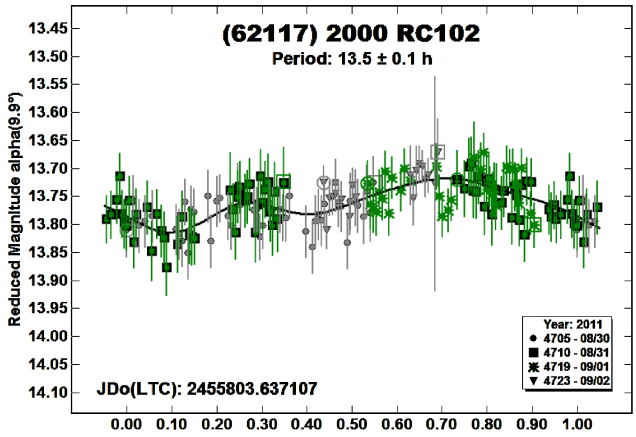


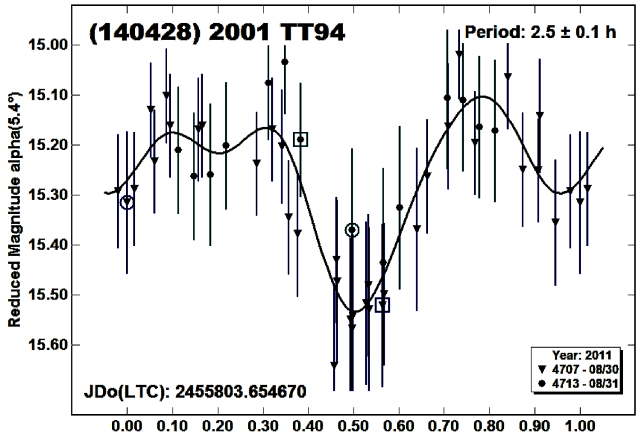


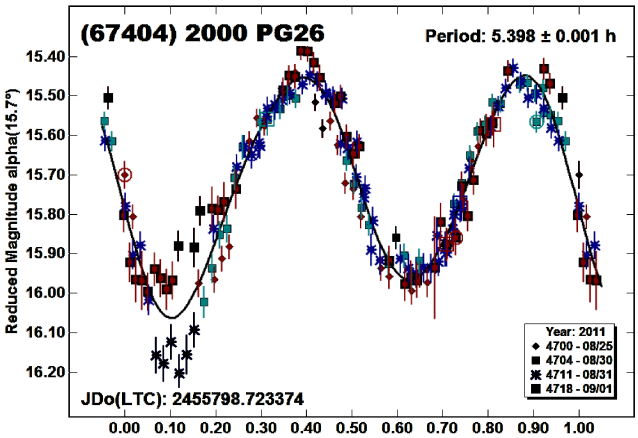


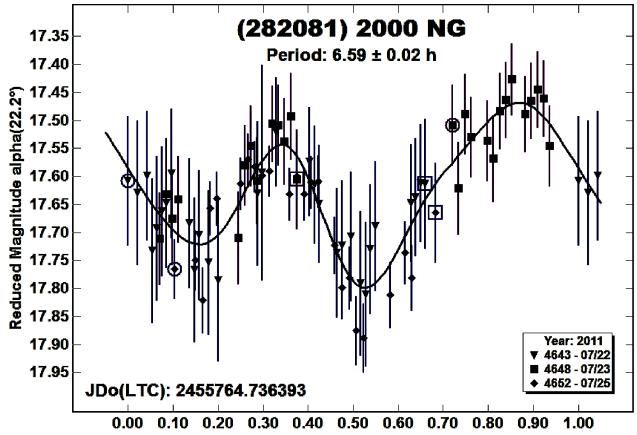


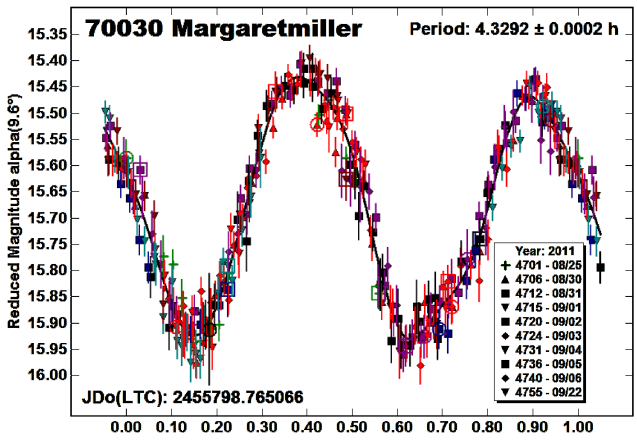


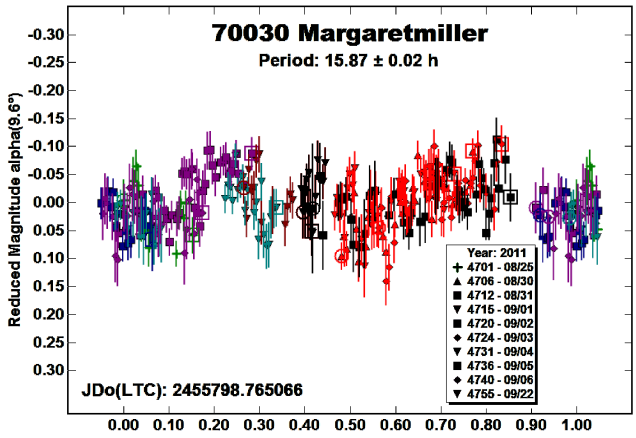












PERIOD DETERMINATION FOR 414 LIRIOPE

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Lightcurve analysis for 414 Liriope was performed from observations obtained during its 2011 opposition. The synodic rotation period was found to be 7.353 ± 0.002 h and the lightcurve amplitude was 0.13 ± 0.05 mag.

As of late 2011 August, only 5 of the first 500 numbered asteroids appeared to have no previously reported rotation periods. This implied a modest improvement (just one asteroid less) compared to the situation prevailing one year before (Alvarez, 2011). One of those elusive 5 asteroids, 414 Liriope, was chosen for observations from CALL web-site (Warner 2011) since it would be favorably placed for a few weeks during its 2011 opposition.

Unfiltered CCD photometric images of 414 Liriope were taken at Observatorio Los Algarrobos, Salto, Uruguay (MPC Code I38) from 2011 August 30 to September 07 using a 0.3-m Meade LX-200R working at ~*f*/6.3 with a focal reducer. The CCD imager was a QSI 516wsg NABG with a 1536 x 1024 array of 9-micron pixels. 2x2 binning was used, yielding an image scale of 1.9 arcseconds per pixel. Exposures were 60 s working at –10C, unguided (except for the last session, when a Lodestar camera and *PHD Guiding*