

ASTEROID LIGHTCURVE ANALYSIS AT THE PALMER DIVIDE OBSERVATORY – MARCH-JUNE 2006

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Lightcurves for 22 asteroids were obtained at the Palmer Divide Observatory from early March through early June 2006: 216 Kleopatra, 314 Rosalia, 618 Elfriede, 633 Zelima, 1064 Aethusa, 1115 Sabauda, 1320 Impala, 1384 Kniertje, 1546 Izsak, 1592 Mathieu, 2047 Smetana, 3318 Blixen, 3642 Frieden, 4077 Asuka, 4985 Weir, 4091 Lowe, 5222 Ioffe, 6296 Cleveland, 5430 Luu, (7563) 1988 BC, 21022 Ike, and (68950) 2002 QF15.

Observations of 22 asteroids were made at the Palmer Divide Observatory from early March to early June 2006. One of three telescopes/camera combinations was used: 0.5m Ritchey-Chretien/FLI IMG-1001E, 0.35m SCT/FLI IMG-1001E, or 0.35m SCT/ST-9E. The scale for each was about 2.5 arcseconds/pixel. Exposure times were 120–240s. Images taken with the 0.5m scope were guided. The operating temperature for the FLI cameras was –30°C while the ST-9E was run between –10° to –20°C, depending on ambient conditions.

When selecting targets, first priority was given to members of the Hungaria group, those being part of an ongoing study at the Palmer Divide Observatory. When no suitable Hungarias were

available, other targets were chosen by comparing the list of known lightcurve periods maintained by Harris and Warner (Harris 2006) against a list of well placed asteroids. Asteroids were often selected with the intent of removing the observational biases against faint objects (due to size and/or distance) as well as those with lightcurves of small amplitudes, long periods, or a complex nature. All images were measured using MPO Canopus, which employs differential aperture photometry to determine the values used for analysis. Canopus was also used for period analysis, using the Fourier analysis algorithm developed by Harris (1989).

The results are summarized in the table below. Individual plots are presented afterwards. The data and curves are presented without comment except when warranted. Column 3 gives the full range of dates of observations; column 4 gives the number of data points used in the analysis. Column 5 gives the range of phase angles. If there are three values in the column, the phase angle reached a minimum with the middle value being the minimum. 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 hour and magnitudes.

216 Kleopatra. This asteroid was observed in support of Lucy Lim of Goddard Space Flight Center, who was doing observations of the asteroid with the Spitzer Telescope in early February. The asteroid has been well studied, with the adopted period being 5.385h (Harris 2006).

618 Elfriede. Weidenschilling (1987) previously reported a period of >6hr. Velichko (1995) found a period of 9.029hr. Attempts to fit the PDO data to that period failed to produce a reasonable fit.

633 Zelima. Lagerkvist (1978) found a period of 10.0hr using

#	Name	Date Range (mm/dd) 2006	Data Pts	Phase	L _{PAB}	B _{PAB}	Per (h)	PE	Amp (m)	AE
216	Kleopatra	04/02–04/03	283	2.1	193.9	–6.0	5.379	0.002	0.36	0.02
314	Rosalia	04/21–05/02	151	10.7, 12.8	172.3	1.8	20.43	0.02	0.21	0.02
618	Elfriede	05/12–06/02	297	14.6, 16.9	183.6	18.4	14.801	0.001	0.15	0.02
633	Zelima	04/08–04/19	265	3.8, 6.3	194.4	10.0	11.724	0.003	0.14	0.02
1064	Aethusa	03/16–03/31	209	10.3, 14.9	150.8	–9.6	8.621	0.004	0.18	0.02
1115	Sabauda	04/12–04/13	158	17.2	161.1	18.2	6.72	0.01	0.27	0.02
1320	Impala	05/08–05/15	177	8.4, 10.2	217.6	14.0	6.167	0.001	0.52	0.03
1384	Kniertje	03/16–03/31	209	11.8, 16.6	149.7	0.9	12.255	0.004	0.33	0.02
1546	Izsak	04/08–04/10	116	0.9, 1.5	196.4	2.1	7.35	0.006	0.31	0.02
1592	Mathieu	05/02–05/29	490	11.2, 19.9	212.0	16.8	14.23	0.02	0.50	0.02
2047	Smetana	04/09–04/17	219	9.0, 8.7, 9.3	199.2	11.6	2.4969	0.0004	0.12	0.02
3318	Blixen	05/16–05/19	145	9.0, 9.9	216.5	13.3	6.456	0.003	0.20	0.02
3642	Frieden	03/25–04/08	446	7.2, 6.9, 7.9	189.4	14.9	14.491	0.003	0.13	0.02
4077	Asuka	04/23–04/27	202	6.6, 7.7	198.7	10.6	7.919	0.002	0.40	0.02
4085	Weir	05/17–06/02	115	9.7, 15.8	220.2	7.3	14.602	0.005	0.18	0.02
4091	Lowe	03/05–03/31	184	7.8, 14.1	147.8	14.1	12.570	0.005	0.10	0.03
5222	Ioffe	06/02–06/15	283	13.8	261.7	30.6	19.4	0.2	0.27	0.03
5430	Luu	04/06–04/12	188	20.9	199.0	33.7	13.55	0.02	0.06	0.02
6296	Cleveland	06/02–06/27	163	17.6, 15.7, 17.	258.4	22.3	15.38	0.2	0.20	0.03
7563	1988 BC	04/20–04/21	196	11.7	194.6	15.6	6.510	0.006	0.24	0.02
21022	Ike	05/02–05/11	209	22.1	223.7	34.0	7.550	0.001	0.40	0.02
68950	2002 QF15	05/29–06/14	275	46.7, 43.2	259.5	39.4	47.0 (23.5)	0.5	>0.30	0.02

photographic photometry. The PDO data did not produce an acceptable fit when phased to values near that period.

1320 Impala. Behrend et al (2006) reported a period of approximately 4.0hr. A very poor monomodal fit at about 3.55h was found using the PDO data but no reasonable fit to a mono- or bimodal curve could be found around the 4.0hr period.

1384 Kniertje. Behrend (2006) previously reported a period of 9.44hr. Attempts to fit the PDO data to that period found a possible solution at 9.816hr. However, the fit of the data was not quite as good as when the data were phased to the adopted period of 12.255hr, even though the formal error for the larger period was about twice that for the shorter one. On the other hand, the RMS error for the fit of the data to the 12.255hr period was less than for the shorter period by about 2%. The next opportunity to resolve the ambiguity will be in May 2007.

1592 Mathieu. The adopted period is for a monomodal curve. A bimodal solution was found at 28.48hr with a formal error about three times that for the shorter period. The bimodal curve would seem to make better sense given the amplitude of the curve and phase angle (Alan Harris, private communication). However, Petr Pravec (private communication) noted that while the longer period was more plausible, the symmetry of the curve for the shorter period was too good to be dismissed out of hand. Two plots, phased to the two periods, are shown.

2047 Smetana. This is a Hungaria asteroid and so part of the ongoing program at PDO to study these inner main-belt objects. The period tends to make it a candidate for being a binary. However, no evidence was found during this apparition. It should be observed again at the next opportunity, November 2007, when it will be only 15.9 at brightest but still the best apparition until 2012.

4091 Lowe. The low amplitude of the curve made finding a solution difficult. The asteroid's next apparition, May 2007, may provide a larger amplitude curve since the PAB_L will differ by about 90° from the 2006 apparition.

(68950) 2002 QF15. This asteroid was worked in support of radar observations by Michael Shepard, Bloomburg (PA) University. Those observations favored a period of approximately 48hr, based partly on the derived size of the asteroid. Analysis of the optical lightcurve data found almost equally valid solutions 23.5 ± 0.5 hr and 47.0 ± 0.5 hr with the shorter period producing a monomodal curve and the long a bimodal curve. Unfortunately, observations from other stations could not be obtained and the asteroid faded before the period could be resolved with certainty.

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