

ASTEROID LIGHTCURVE ANALYSIS AT THE PALMER DIVIDE OBSERVATORY: SEPTEMBER-DECEMBER 2007

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(Received: 11 January)

Lightcurves for 20 asteroids were obtained at the Palmer Divide Observatory from September-December 2007. 167 Urda; 793 Arizona; 1112 Polonia; 1325 Inanda; 1590 Tsiolkovskaja; 1741 Giclas; 2347 Vinata; 4464 Vulcano; 5720 Halweaver; 7086 Bopp; 7187 Isobe; (8309) 1996 NL1; (10496) 1986 RK; (11904) 1991 TR1; (17738) 1998 BS15; (20936) 4835 T-1; (25332) 1999 KK6; (31793) 1999 LB6; (44892) 1999 VJ8; (52314) 1991 XD. In addition, previously unpublished results from 2000 for (10936) 1998 FN11 are reported.

Observations of 20 asteroids were made at the Palmer Divide Observatory from September through December 2007. One of five telescopes/camera combinations was used: 0.5m Ritchey-Chretien/FLI IMG-1001E, 0.5m Ritchey-Chretien/SBIG STL-1001E, 0.35m SCT/FLI IMG-1001E, 0.35m SCT/ST-9E, or 0.35m SCT/STL-1001E. Depending on the binning used, the scale for the images ranged from 1.2-2.5 arcseconds/pixel. Exposure times were 90–180 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. Guiding was used in almost all cases. All images were measured using MPO Canopus, which employs differential aperture photometry to determine the values used for analysis. Period analysis was also done using MPO Canopus, which incorporates the Fourier

analysis algorithm developed by Harris (1989).

The results are summarized in the table below, as are individual plots. 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 hours and magnitudes. An "(H)" follows the name of an asteroid in the table if it is a member of the Hungaria group or family.

167 Urda. This was previously worked by Slivan (1996) and Behrend (2007), both of whom reported periods similar to that found here. A pole solution was found by Tungalak (2003) and Durech (<http://astro.troja.mff.cuni.cz/projects/asteroids3D/>).

1325 Inanda. Another possible solution is 35.83 ± 0.03 h. The author worked this asteroid previously (Warner 2004) but no definite period was found.

1590 Tsiolkovskaja. The period of 6.737 h agrees with that previously published by Lagerkvist (1978) who reported an amplitude of 0.4 mag.

1741 Giclas. Period agrees with results of Behrend et al. (2007).

7086 Bopp. Behrend (2007) reported a period of 3.40 h for this Hungaria asteroid. The data obtained at PDO do not support that.

7187 Isobe. The author previously worked this asteroid in 2004 (Warner 2005) and found a period of 2.440 h with an amplitude of 0.24 mag. The low amplitude (0.09 mag) in 2007 and relatively

#	Name	Date Range (mm/dd) 2007	Data Pts	Phase	PAB _L	PAB _B	Per (h)	PE	Amp (mag)	AE
167	Urda	11/07–09	543	2.1	49.7	–2.4	13.054	0.002	0.34	0.02
793	Arizona	12/13–17	541	10.9, 12.3	56.1	8.7	7.399	0.002	0.22	0.02
1112	Polonia	09/26–10/26	1091	7.3, 16.4	348.0	8.7	82.5	0.5	0.20	0.03
1325	Inanda	11/02–13	590	25.0, 27.4	359.0	–0.4	20.52 35.83	0.02 0.03	0.12	0.02
1590	Tsiolkovskaja	11/06–08	191	6.3	56.7	–0.6	6.737	0.004	0.11	0.02
1741	Giclas	12/13–16	151	11.1	54.9	0.3	2.938	0.001	0.11	0.02
2347	Vinata	12/13–16	145	12.8	56.7	12.5	4.4835	0.0005	0.32	0.02
4464	Vulcano (H)	11/02–05	245	11.6	45.1	16.6	6.419	0.008	0.12	0.03
5720	Halweaver	12/17–18	330	17.1	78.7	21.6	3.8883	0.0007	0.55	0.02
7086	Bopp (H)	10/16–23	390	24.6, 22.0	55.0	–14.0	29.0	0.1	0.16	0.03
7187	Isobe (H)	11/11–12/16	174	27.5, 18.6	83.7	28.3	2.58	0.01	0.09	0.02
8309	1996 NL1	11/09–17	357	9.3, 5.6	61.7	3.6	19.76	0.02	0.16	0.03
10496	1986 RK	11/08–17	306	2.8, 0.6, 2.5	49.7	1.1	9.876	0.002	0.31	0.02
10936	1998 FN11	10/10–13 (2000)	188	10.7	12.4	12.2	17.3	0.1	0.03	0.02
11904	1991 TR1 (H)	11/02–07	429	6.2	48.9	–1.2	9.123	0.005	0.31	0.03
17738	1998 BS15	12/17–18	197	9.2	76.0	9.8	4.235	0.004	0.10	0.02
20936	4835 T-1 (H)	11/06–15	161	27.4, 30.2	6.4	–2.9	5.697	0.002	0.06	0.01
25332	1999 KK6 (H)	10/04–20	241	14.3, 13.0, 14.0	13.8	16.6	2.4531 4.9062	0.0002 0.0004	0.09	0.02
31793	1999 LB6 (H)	10/19–11/05	504	10.2, 14.6	30.1	–14.2	27.95	0.05	0.28	0.03
44892	1999 VJ8	12/13–16	214	14.2	57.4	12.3	5.872	0.002	0.29	0.02
52314	1991 XD (H)	11/06–07	193	12.6	38.5	–16.1	7.663	0.004	0.56	0.03

high noise, led to finding a slightly different period of 2.58 ± 0.01 h. The data from neither year could be made to fit the period of the other year.

(10936) 1998 FN11. This asteroid was worked by the author in 2000 but never published, possibly because of the scarcity of data. The period should be considered tentative but at least serves as a guide for future observations.

(25332) 1999 KK6. The adopted period is for a monomodal curve, which is not unreasonable given the amplitude of only 0.06 mag. A bimodal solution was found at 4.9062 ± 0.0004 h. However, the very small odd-order harmonics, narrow maximums, and overall shape of the curve cast some doubt on that solution.

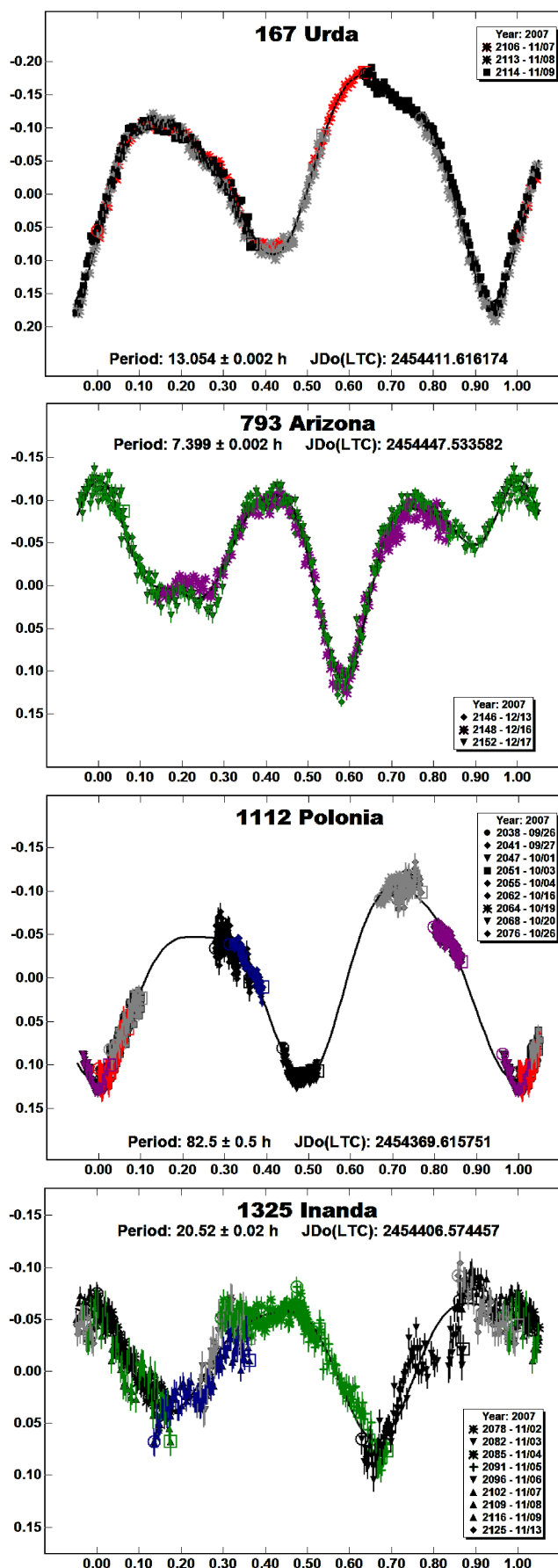
(44892) 1999 VJ8. This asteroid kept pace with 2347 Vinata for several days, making it available for measurements. The trimodal curve appears real given the subtle differences in the two shorter maximums. No shorter period solution worked when trying to force a bimodal solution.

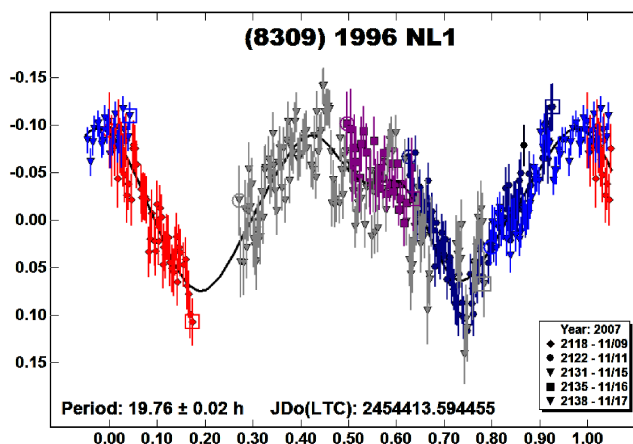
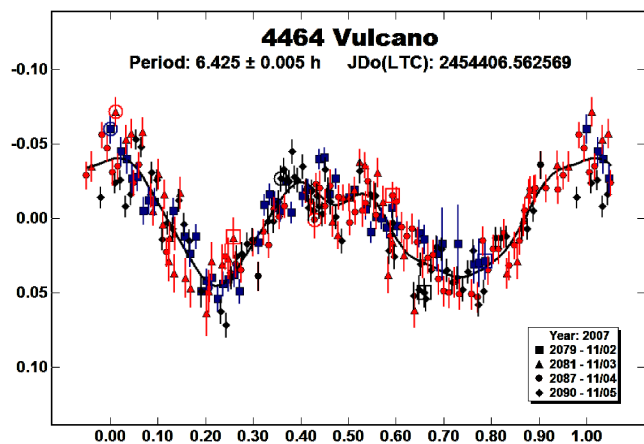
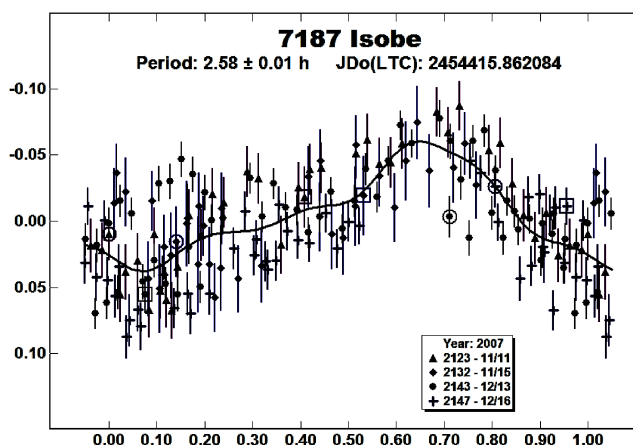
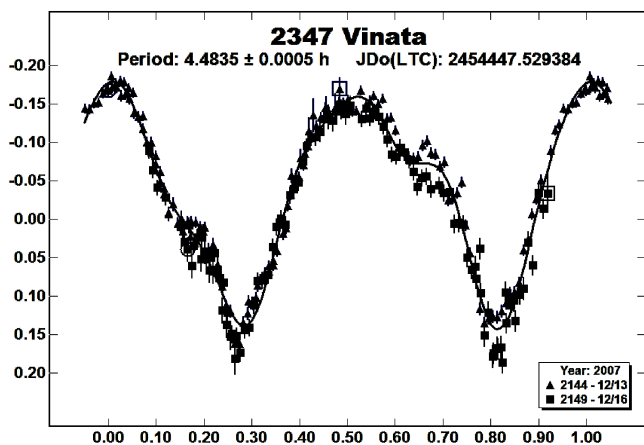
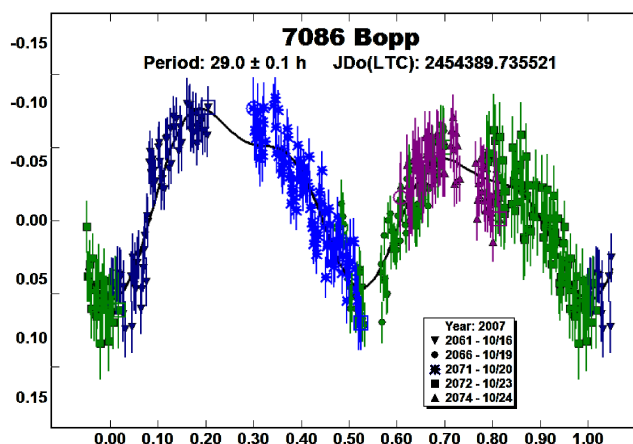
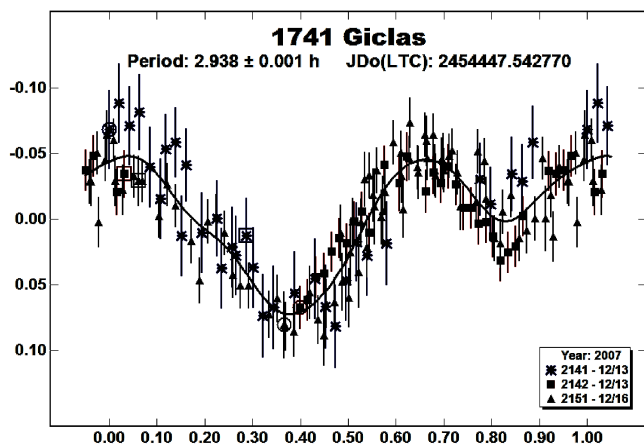
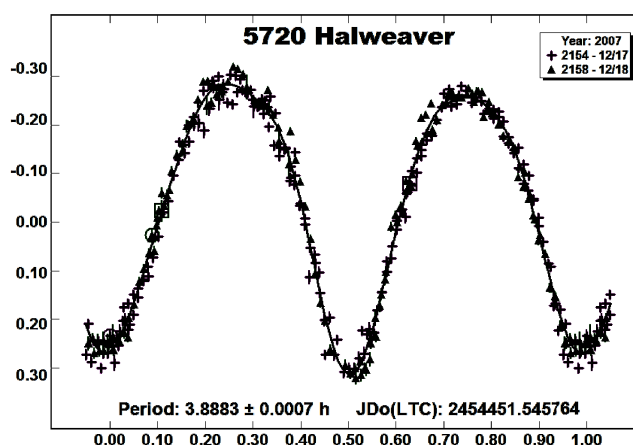
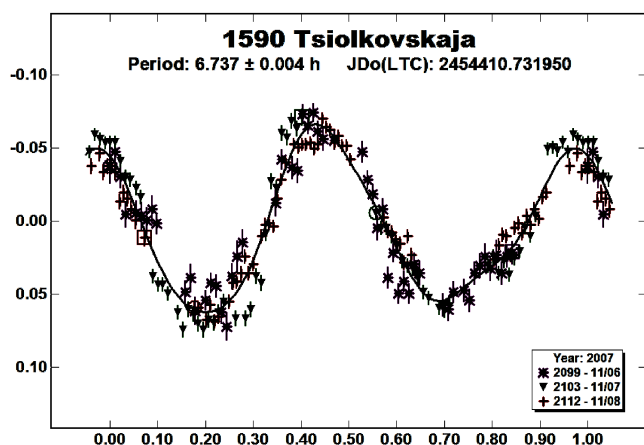
Acknowledgements

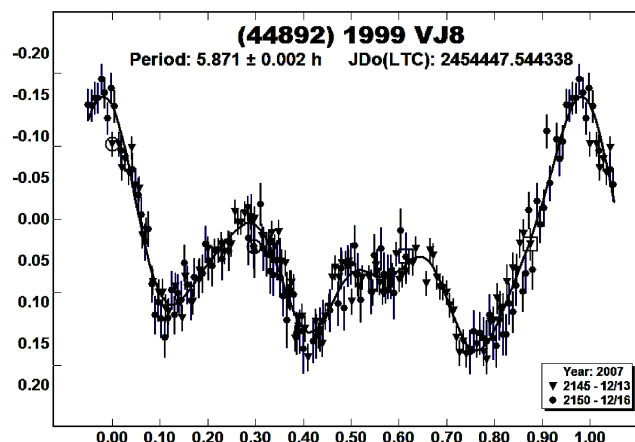
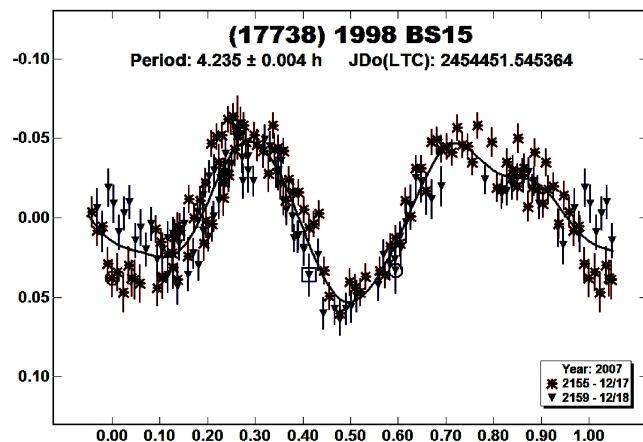
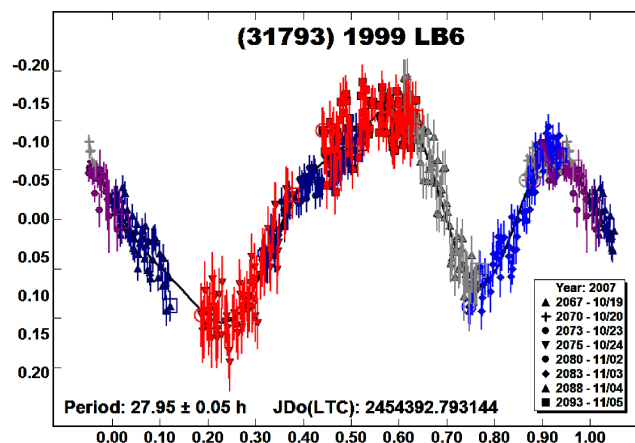
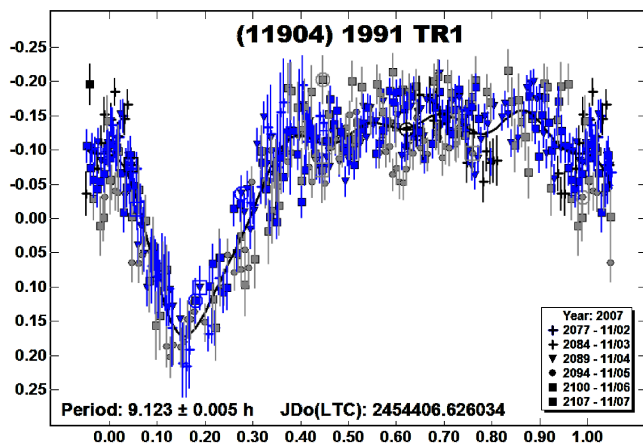
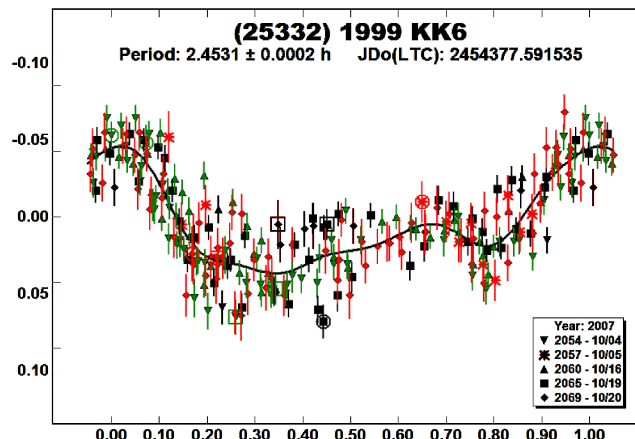
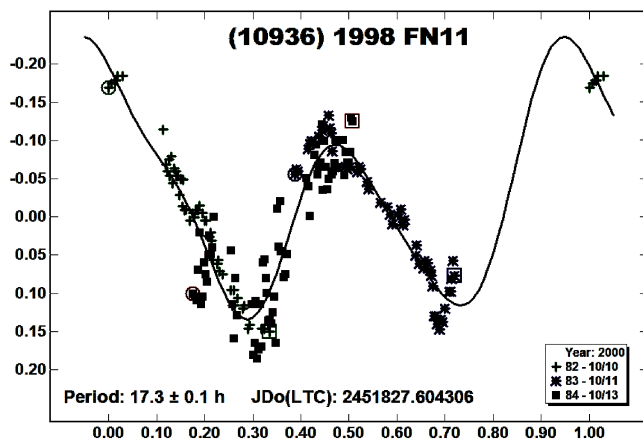
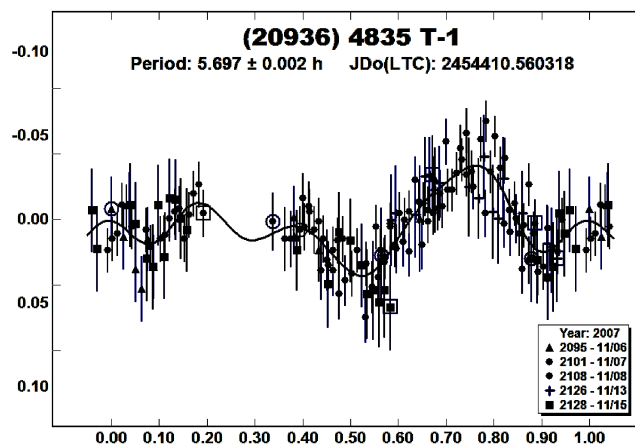
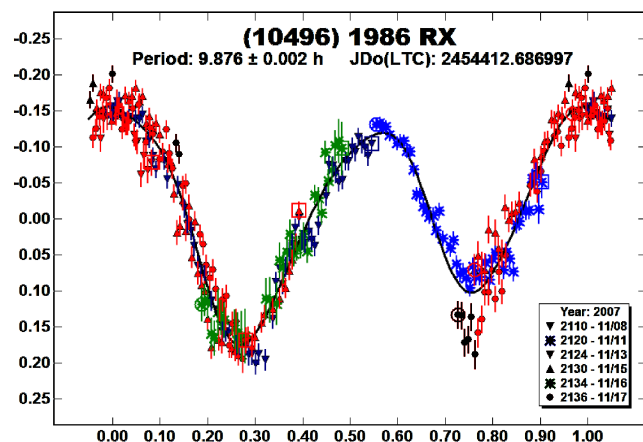
Funding for observations at the Palmer Divide Observatory is provided by NASA grant NNG06GI32G, by National Science Foundation grant AST-0607505, and by a Gene Shoemaker NEO Grant from the Planetary Society. My thanks to Petr Pravec, Ondrejov Observatory, and Alan W. Harris, Space Science Institute, for their help with understanding the interpretation of odd/even harmonic strengths when analyzing the likelihood of lightcurve period solutions.

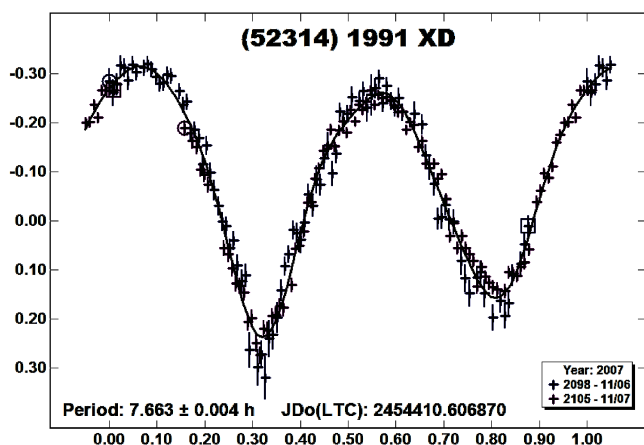
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**PERIOD DETERMINATIONS FOR 84 KLIO, 98 IANTHE,
102 MIRIAM, 112 IPHIGENIA, 131 VALA, AND
650 AMALASUNTHA**

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(Received: 20 December)

Periods and amplitudes have been determined as follows: 84 Klio: 23.562 ± 0.001 h, 0.21 ± 0.02 mag; 98 Ianthé: 16.479 ± 0.001 h, 0.27 ± 0.02 mag; 102 Miriam: 23.613 ± 0.001 h with three unequal maxima and minima per cycle, 0.12 ± 0.02 mag.; 112 Iphigenia: 31.466 ± 0.001 h, 0.30 ± 0.02 mag; 131 Vala: 10.359 ± 0.001 h, 0.09 ± 0.02 mag; 650 Amalasuntha: 16.582 ± 0.001 h, 0.44 ± 0.03 mag.

Observations of six asteroids were made at the Organ Mesa Observatory with a 35.4 cm Meade LX200 GPS S-C and SBIG STL 1001-E CCD. Photometric measurement, differential magnitudes only, and lightcurve construction were by MPO Canopus. All exposures were made with a clear filter, unguided, and 60 s, except for 84 Klio and 102 Miriam whose brightness required 20-30 s exposures. To reduce the number of points on the lightcurves, data points were binned in sets of three with a maximum time difference between individual points of 5 minutes.

84 Klio. Two previous photometric sets are referenced by Harris et. al. (2007), who listed a period 5.80 h, reliability 2. This value is by Zeigler et. al. (1988), who published an irregular trimodal lightcurve with amplitude 0.06 mag that is totally inconsistent with the present study. Weidenschilling et al. (1990) obtained eight data points more than one-half hour apart on 1990 Oct. 20 5h-10h UT, showing a maximum about at 06:40 UT and amplitude 0.08 magnitudes within this interval. That is compatible with the present study. Observations on six nights from 2007 Nov. 4-Dec. 18 show a period of 23.562 ± 0.001 h with an amplitude of 0.21 ± 0.02 mag.

98 Ianthé. Harris et al. (2007) indicate a period of 16.5 h, amplitude 0.32 mag, and reliability 2. Observations made on five nights 2007 Oct. 15-Nov. 26 are in general agreement and

improve the period to 16.479 ± 0.001 h with a somewhat asymmetric bimodal light curve of amplitude 0.27 ± 0.02 mag at the current aspect.

102 Miriam. Harris et al. (2007) show three previous lower quality period determinations near 15.8 h. The first two sessions on Sept. 14 and 18 are in agreement, but following the third run on Oct. 7, a good fit could be obtained only with a period of approximately 23.62 h and a trimodal lightcurve. It thereafter remained to make additional observations at intervals of 8 to 12 days, seeing farther to the right in the lightcurve on each occasion, until complete phase coverage was achieved. The study was concluded with eight lightcurves from 2007 Sep. 14-Nov. 19 showing a period of 23.613 ± 0.001 h, three maxima and minima of different heights, and maximum amplitude 0.12 ± 0.02 mag.

112 Iphigenia. Harris et al. (2007) show a period of 15.783 h, reliability 1. Observations on seven nights 2007 Oct. 24-Dec. 16 cover the entire rotational cycle except for a 70 minute segment on Dec. 14 when the ascending part of the lightcurve was lost as the asteroid passed close to a somewhat brighter star. A period of 31.466 ± 0.001 h with bimodal lightcurve of amplitude 0.30 ± 0.02 magnitudes was found.

131 Vala. Harris et al. (2007) show no previous photometry on this object. Observations on five nights 2007 Oct. 12-Nov. 11 show a period of 10.359 ± 0.001 h and a nearly symmetric bimodal lightcurve of amplitude 0.09 ± 0.02 magnitudes.

650 Amalasuntha. Harris et al. (2007) show no previous photometry on this object. Observations on eight nights 2007 Aug. 27-Oct. 14 show a period of 16.582 ± 0.001 h and amplitude of 0.44 ± 0.03 magnitudes.

Of four objects included in this study with reliability 1 or 2 as listed by Harris et. al. (2007), three were found to have periods very different from those listed. Of a total of seven such objects studied to date by this writer, five required large corrections. Many of the lower reliability entries in the Asteroid Lightcurve Data Files (Harris et. al., 2007) are for objects with long and/or Earth commensurate periods and/or small amplitudes, and for which the small number of data points in the referenced lightcurves are insufficient to obtain unique periods. These require many lightcurves over a long interval of one to two months or longer, full phase coverage, and a dense set of data points for accurate and reliable correction. The lightcurves presented in this paper exemplify the requirements. Studies on these objects beginning well before opposition by observers having the resources to make long term commitments are valuable and productive. It should be just as satisfying to correct an incorrect listing reliably and accurately as to be the first to obtain a period for an object with no previous lightcurve studies.

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