

LIGHTCURVES OF 4285 HULKOWER, 6867 KUWANO, AND (93768) 2000 WN22

Gary A. Vander Haagen
Stonegate Observatory, 825 Stonegate Road
Ann Arbor, MI 48103
garyvh2@att.net

(Received: 2009 Jul 10)

Analysis of their lightcurves revealed the following periods and amplitudes for three asteroids: 4285 Hulkower, 6.149 ± 0.001 h, 0.68 ± 0.05 mag; 6867 Kuwano, 7.367 ± 0.001 h, 0.55 ± 0.05 mag; and (93768) 2000 WN22, 2.679 ± 0.002 h, 0.33 ± 0.03 mag.

Photometric data for three asteroids were collected using a 36-cm Celestron C-14, SBIG ST-10XME camera, and clear filter at Stonegate Observatory. The camera was binned 3x3, resulting in an image scale of 1.9 arcsec/pixel. Exposures ranged from 60-120 s at -15°C depending upon conditions. All photometric data were obtained and analyzed using *MPO Canopus* (Warner, 2008). Previous asteroid lightcurve data was reviewed in *The Asteroid Lightcurve Database*, (LCDB, Warner, B.D., Harris, A.W., Pravec, P., 2009) with latest revisions at the *Collaborative Asteroid Lightcurve Link* web site (Warner, 2009).

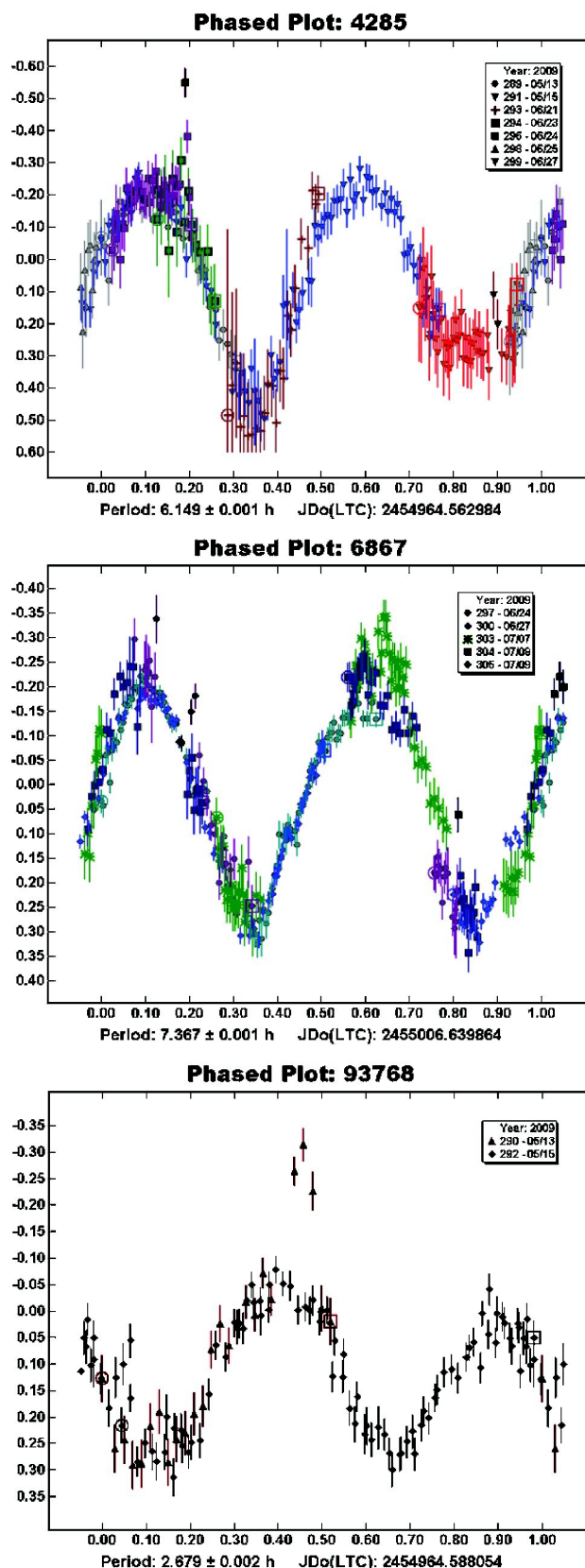
4285 Hulkower. Data were collected from 2009 May 13 through June 27 resulting in 7 data sets and 266 data points. A period of 6.149 ± 0.001 h was determined. Previous data reported by Pravec (2009) indicate a period of 6.150 h and amplitude of 0.58 mag.

6867 Kuwano. Data were collected from 2009 June 24 through July 9 resulting in 5 data sets and 364 data points. A period of 7.367 ± 0.001 h was determined. There were no previously reported data on this asteroid.

(93768) 2000 WN22. Data were collected on 2009 May 13 and May 15 resulting in 117 data points. The short visibility and sky conditions precluded any further observations. A period of 2.679 ± 0.002 h was determined. Previous data reported by Pravec (2009) indicate a period of 2.6821 h and amplitude of 0.29.

References

- Pravec, P., Wolf, M., and Sarounova, L. (2009). "Ondrejov Asteroid Photometry Project."
<http://www.asu.cas.cz/~ppravec/neo.htm>
- Warner, B.D. (2008). MPO Software, *Canopus* version 9.5.0.5, Bdw Publishing, <http://minorplanetobserver.com/>
- Warner, B.D. (2009). "Collaborative Asteroid Lightcurve Link" web site: <http://www.minorplanetobserver.com/astlc/default.htm>
- Warner, B.D., Harris, A.W., and Pravec, P. (2009). "The asteroid lightcurve database." *Icarus* **202**, 134-146.



ASTEROID LIGHTCURVE ANALYSIS AT THE PALMER DIVIDE OBSERVATORY: 2009 MARCH–JUNE

Brian D. Warner

Palmer Divide Observatory/Space Science Institute
17995 Bakers Farm Rd., Colorado Springs, CO 80908 USA
brian@MinorPlanetObserver.com

(Received: 2009 Jul 4)

Lightcurves for 19 asteroids were obtained at the Palmer Divide Observatory (PDO) from 2009 March through June: 118 Peitho, 191 Kolga, 193 Ambrosia, 364 Isara, 521 Brixia, 1019 Strackea, 1025 Riema, 3266 Bernardus, 3873 Roddy, 3895 Earhart, 4483 Petofi, 4490 Bamberg, 4795 Kihara, (6250) 1991 VX1, 6493 Cathybennett, 6510 Tarry, 11789 Kempowski, 11976 Josephthurn, (13578) 1993 MK.

Observations of 19 asteroids were made at the Palmer Divide Observatory from 2009 March through June. One of four telescopes/camera combinations was used: 0.5m Ritchey-Chretien/SBIG STL-1001E, 0.35m SCT/FLI ProLine1001E, 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 exposures were unfiltered and guided with exposures of 120–240 s. All images were processed and measured using *MPO Canopus* employing differential aperture photometry. Period analysis was also done using *MPO Canopus*, which incorporates the Fourier analysis algorithm developed by 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. 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 to allow

direct comparison of amplitudes and to avoid the visual impression that the amplitude variation is greater than it actually is, which can create the impression of a physically implausible lightcurve. For low amplitude lightcurves, the scale has been expanded so that the curve is more than a nearly flat line. Even so, this was done as little as possible to avoid creating misleading interpretations. Night-to-night calibration of the data (generally $< \pm 0.05$ mag) was done using field stars converted to approximate Cousins R magnitudes based on 2MASS J-K colors (see Warner 2007 and Stephens 2008).

118 Peitho. Previous findings include Stanzel and Schober (1980, 7.78 h) and Behrend (2009, 7.8033 h). The data obtained at PDO fit a synodic period of 7.823 ± 0.002 h.

193 Kolga. This asteroid was chosen with the hope of resolving which, if any, of the previous solutions was the more likely. These include 27.8 h (Holliday, 2001), 13.7 h (Behrend, 2009), and 13.078 h (Gil-Hutton, 2003). Data at the PDO obtained on 5 nights over a week’s time fit a synodic period of 17.625 ± 0.004 h, or none of the above. Attempts to fit the data to the other periods failed decisively.

193 Ambrosia. The period of 6.580 ± 0.001 h found with PDO data agrees with that found by DeYoung and Schmidt (1996).

364 Isara. The period of 9.156 ± 0.001 h found at PDO agrees with that found by Yang (1965).

521 Brixia. The only previous period was > 24 h reported by Surdej et al. (1983). Unfortunately, the asteroid was not very cooperative for this campaign. Given the low amplitude of 0.11 ± 0.02 mag, it is not possible to say definitively if the solution should be monomodal or bimodal. Assuming the former, a period of 9.78 ± 0.02 h is found. If the bimodal solution is adopted, the period is 19.57 ± 0.02 h, with another possible solution at ~ 18.35 h. Plots of the first two periods are presented below. More data will be needed to solve this asteroid’s rotation rate.

1019 Strackea. Ivanova et al. (2002) found a period of 3.832 h with an amplitude of 0.31 mag. Behrend (2009) reports $P = 3.98$, $A = 0.17$. The former would seem to be conclusive given the amplitude and the 7 nights of data with several of them being

#	Name	mm/dd 2009	Data Pts	α	L_{PAB}	B_{PAB}	Per (h)	PE	Amp (mag)	AE
118	Peitho	05/07–05/14	400	20.8, 21.9	177	6	7.823	0.002	0.15	0.02
191	Kolga	05/07–05/14	319	15.2, 16.4	180	6	17.625	0.004	0.30	0.03
193	Ambrosia	04/10–04/21	450	17.5, 19.9	161	0	6.580	0.001	0.11	0.02
364	Isara	05/07–05/14	416	13.8, 16.1	198	7	9.156	0.001	0.37	0.02
521	Brixia	05/07–05/14	200	19.2	161	11	9.78/19.57	0.02	0.11	0.02
1019	Strackea (H)	04/20–04/22	155	30.1	244	38	4.044	0.002	0.15	0.01
1025	Riema (H)	05/28–05/30	93	26.0	283	34	3.566	0.003	0.11	0.02
3266	Bernardus (H)	03/22–04/07	232	21.5, 20.2	203	36	10.757	0.001	0.63	0.02
3873	Roddy (H)	06/16–06/23	203	9.9, 14.2	252	5	2.480	0.001	0.06	0.01
3895	Earhart	04/20–04/21	146	19.4	224	32	3.564	0.001	0.28	0.02
4483	Petofi (H)	03/28–04/01	124	22.9, 24.0	148	-15	4.334	0.001	0.86	0.02
4490	Bamberg (H)	03/28–04/07	170	23.5, 22.1	221	34	5.823	0.001	1.16	0.02
4795	Kihara	04/23–05/14	249	6.0, 16.3	208	7	16.03	0.01	0.25	0.02
6250	1991 VX1 (H)	05/28–06/24	207	8.4, 22.0	239	10	82.6	0.5	0.78	0.05
6493	Cathybennett (H)	05/28–05/30	114	20.5	261	32	3.490	0.005	0.19	0.02
6510	Tarry	04/21–04/22	187	17.8	205	26	6.370	0.003	0.50	0.02
11789	Kempowski (H)	04/21–04/30	260	16.6, 19.9	193	14	48.6	0.5	> 0.4	
11976	Josephthurn (H)	04/22–04/30	105	2.6	216	0	3.50	0.01	0.08	0.02
13578	1993 MK (H)	05/28–05/30	152	17.2	246	27	7.95	0.03	0.15	0.03

Table I. Observing circumstances. The phase angle 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).

Minor Planet Bulletin 36 (2009)