THE MINOR PLANET BULLETIN

BULLETIN OF THE MINOR PLANETS SECTION OF THE ASSOCIATION OF LUNAR AND PLANETARY OBSERVERS

VOLUME 35, NUMBER 2, A.D. 2008 APRIL-JUNE

THE ROTATION PERIOD OF 913 OTILA

Quintin Schiller
Department of Astronomy, University of Wisconsin
Madison, WI 53706 USA
qgschiller@wisc.edu

Dr. Claud H. Sandberg Lacy
Center for Space and Planetary Sciences, University of Arkansas
Fayetteville, USA

(Received: 11 September Revised: 14 November)

Images of 913 Otila were taken by the NF/ Observatory, New Mexico, during June and July, 2007. Lightcurve analysis narrowed the rotational period determination to an integer divisor of 1.005 days. The most likely rotational period appears to be 0.20100 ± 0.00001 days, or 4.8024 ± 0.0002 hours. Peak to peak amplitude was 0.47 magnitude.

The authors selected the target from the list of asteroid photometry opportunities Warner (2007). 913 Otila was discovered by K. Reinmuth on May 19, 1919 in Heidelberg, Germany.

Images were taken remotely using the NF/ Observatory 10 km outside of Silver City, NM. The telescope is a redesigned Group 128, 24" classical cassegrain with a 2K x 2K pixel CCD made by Kodak. All exposures were R-filtered. Observations occurred on nine nights between June 24 and July 17, 2007, at a magnitude of 13.9-14.5. However, only four nights yielded usable data.

The images were analyzed with an application written by Lacy for Macintosh computers, NFO-Asteroid. The program automatically measures each image by locating the asteroid and selected comparison stars; measuring the brightness of the asteroid, comparison stars, and sky brightness; and computing differential magnitudes. The measurements from different nights were combined by allowing for nightly magnitude shifts as a result of distance and aspect variations.

The observations yielded 81 data points and were analyzed by software written by Lacy (Mac.Period). The program computed the scatter in potential lightcurves, i.e. the sum of the absolute differences in magnitude between two adjacent phase points for a given rotational period. The lightcurves which produced a minimum of scatter were considered as possible rotational periods. Minima of scatter were found at five different rotational periods, each an integral sub-multiple of 1.005 days.

By re-phasing the data to fit one of the minimum scatter frequencies, one can observe a lightcurve of the object for the predicted period. This was done for figure 1. Using Mac.Period, the time between similar features was calculated to be 1.005 days. The results of re-phasing the data show that similar features reappear at almost exactly the same time each night, thus it is postulated that the same face of the asteroid was measured for all observation nights. Due to the short observing timescale of eleven days, not enough time was allowed for the asteroid to become out of sync with the time of observations. This suggests the object made exactly one complete rotation between observations. However, the same results would be observed if the object made two rotations between observations, or three, or more. Thus, the exact rotational period can be determined to be a sub-multiple of 1.005 days. These possible periods are: 1.00502 ± 0.00006, 0.50333 ± 0.00002, 0.33501 ± 0.00002, 0.25125 ± 0.00001, and 0.20100 ± 0.00001 days.

Based solely on the scatter value, we cannot distinguish among these possible rotational periods because all have identical scatter values. It seems plausible, however, that there should be no more than 2 minima per rotation. This would imply that the correct rotational period is likely to be 4.8024 hours. Figure 1 shows the light curve assuming this rotational period.

References

Warner, Brian et al. (2007) Minor Planet Bulletin **34**, 50-51.

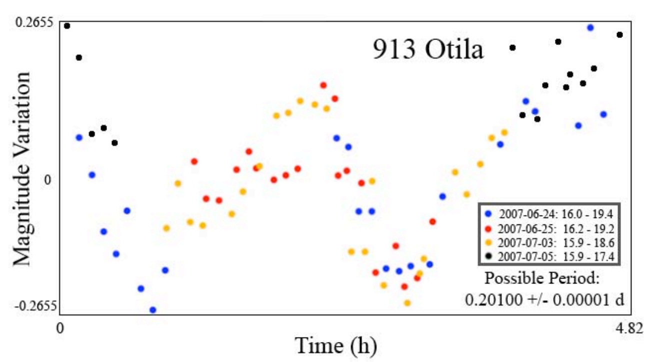


Figure 1: Lightcurve of 913 Otila with period of 0.20100 days

ASTEROID LIGHTCURVES FROM THE CHIRO OBSERVATORY

Dr. Maurice Clark
Department of Physics
Montgomery Community College
Rockville, MD 20877
maurice.clark@montgomerycollege.edu

(Received: 28 November)

Asteroid period and amplitude results obtained at the Chiro Observatory in Western Australia are presented for asteroids 3885 Bogorodskij, 4554 Fanynka, 7169 Linda, 7186 Tomioka, (9928) 1981 WE9, (24391) 2000 AU178, and (43203) 2000 AV70.

Chiro Observatory is a private observatory owned by Akira Fuji near Yerecion in Western Australia. (MPC 320) The main instrument is a 300mm f/6 Newtonian. An SBIG ST-8XE CCD, binned 2x2, was used with this telescope. All images were unfiltered and were reduced with dark frames and sky flats.

The asteroids observed were chosen from the Collaborative Asteroid Lightcurve Link (CALL) home page that is maintained by Brian Warner. Image analysis was accomplished using differential aperture photometry with MPO Canopus. Period analysis was also done in Canopus, which implements the algorithm developed by Alan Harris (Harris et al. 1989). Differential magnitudes were calculated using reference stars from the USNO-A 2.0 catalog and the UCAC2 catalog.

Results are summarized in the table below. The data and curves are presented without additional comment except where circumstances warrant. Column 3 gives the range of dates of observations and column 4 gives the number of nights on which observations were undertaken.

7186 Tomioka I observed this asteroid on five nights between June 11 and 17, 2007. Attempts to derive a two-peak lightcurve were inconclusive. The data would fit a single peak curve with a period of 7.309, and that is included here for future observers. This is an asteroid that could benefit from international collaboration.

24391 2000 AU178. This asteroid was observed on four nights between August 6 and 18, 2006. Despite repeated attempts, no simple solution to the lightcurve could be found. The best result was the lightcurve included here. This curve 3 or possibly 4 peaks of varying heights, and a period of 5.436 hours. Certainly much more work is required for this asteroid.

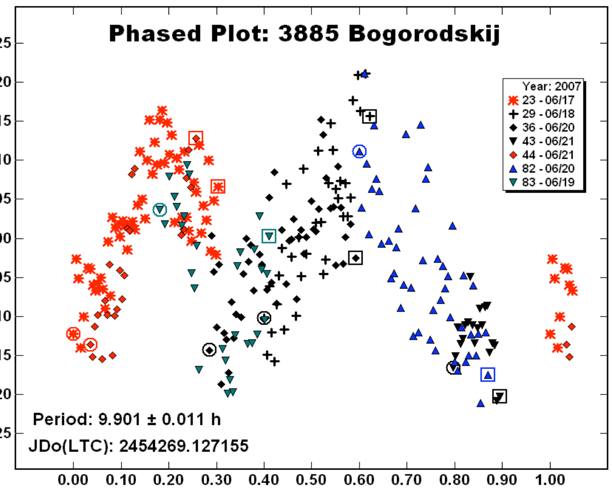
43203 2000 AV70. This asteroid was observed on five nights between June 17 and 21, 2007. Assuming a normal double peaked lightcurve, the best period found was 14.83 hours; however, coverage of this period was not complete. A plot of half this period is included and shows a good agreement. So, I would expect that the 14.83 hour period is close to the actual.

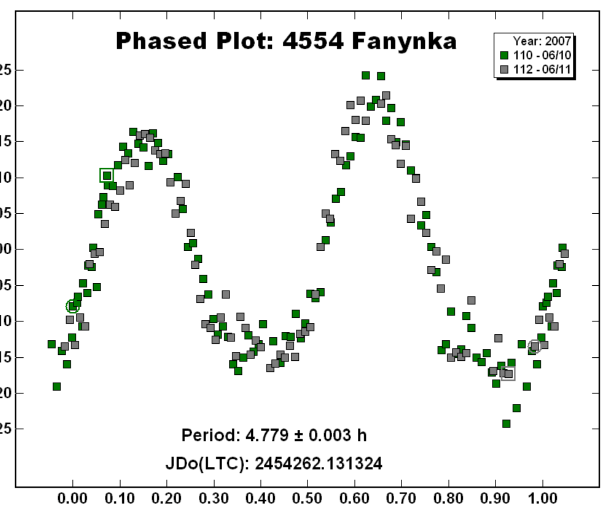
Acknowledgments

I would like to thank Lance Taylor and Akira Fujii for access to the Chiro Observatory, and Brian Warner for all of his work with the program "MPO Canopus."

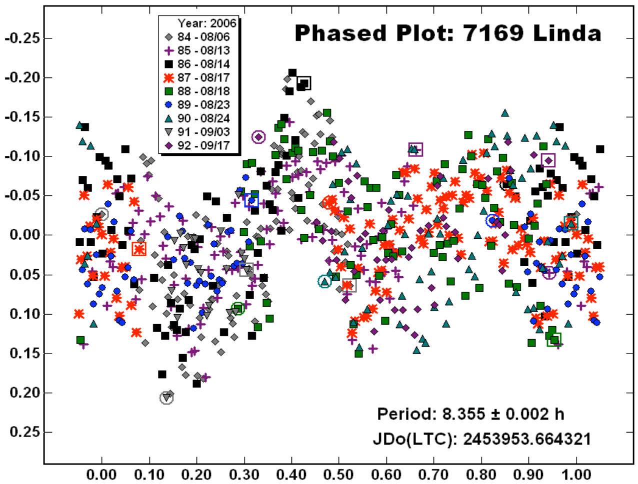
References

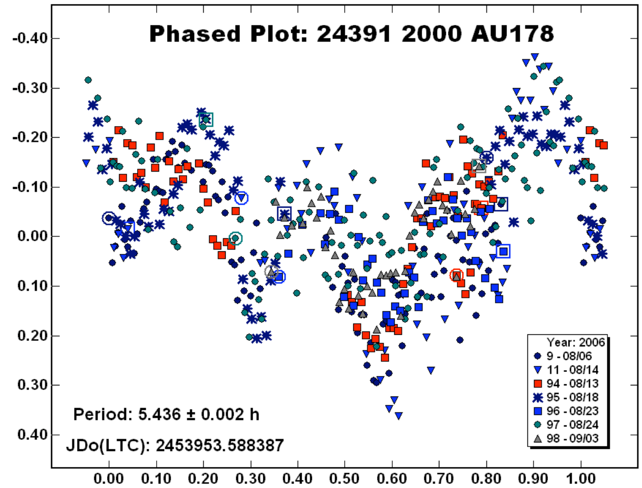
Harris, A. W., et al. (1989). "Photoelectric Observations of Asteroids 3, 24, 60, 261, and 863." *Icarus* **77**, 171-186.

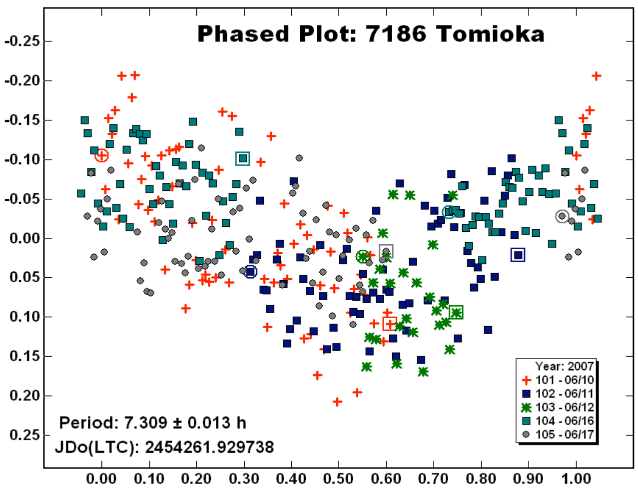


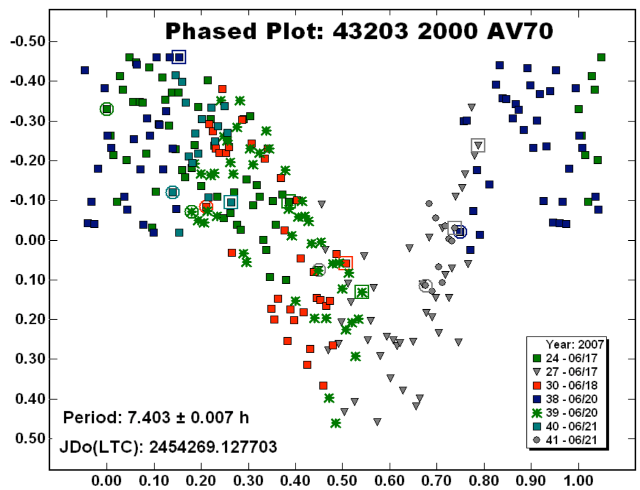


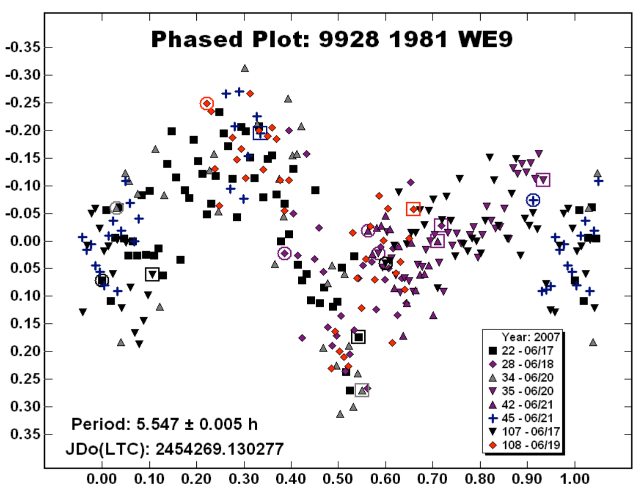
#	Name	Date Range	Sessions	Per (h)	Error (h)	Amp (mag)	Error (mag)
3885	Bogorodskij	Jun 17 – Jun 21, 2007	5	9.901	0.011	0.36	0.05
4554	Fanynka	Jun 10 – Jun 11, 2007	2	4.779	0.003	0.4	0.02
7169	Linda	Aug 06 – Sep 17, 2006	9	8.355	0.002	0.33	0.05
7186	Tomioka	Jun 11 – Jun 17, 2007	5	7.309(?)	0.013	0.3	0.05
9928	1981 WE9	Jun 17 – Jun 21, 2007	5	5.547	0.005	0.55	0.04
24391	2000 AU178	Aug 06 – Aug 18, 2006	4	5.436	0.002	0.65	0.03
43203	2000 AV70	Jun 17 – Jun 21, 2007	5	14.83	0.03	0.9	0.05

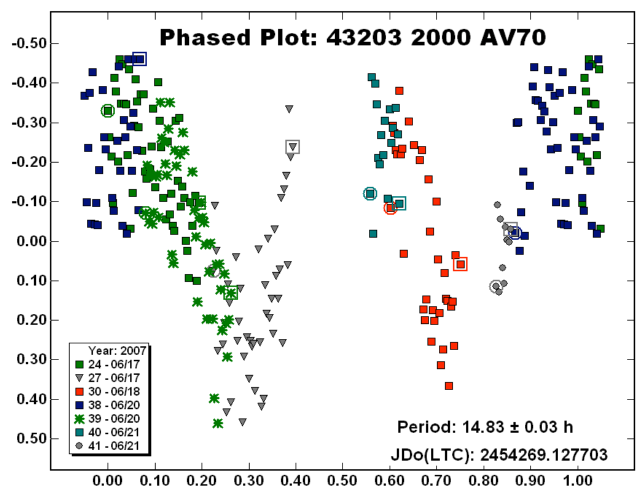

Phased Plot: 7169 Linda
Year: 2006
84 - 08/06
85 - 08/13
86 - 08/14
87 - 08/17
88 - 08/18
89 - 08/23
90 - 08/24
91 - 09/03
92 - 09/17
Period: 8.355 ± 0.002 h
JDo(LTC): 2453953.664321


Phased Plot: 24391 2000 AU178
Year: 2006
9 - 08/06
11 - 08/14
94 - 08/13
95 - 08/18
96 - 08/23
97 - 08/24
98 - 09/03
Period: 5.436 ± 0.002 h
JDo(LTC): 2453953.588387


Phased Plot: 7186 Tomioka
Year: 2007
101 - 06/10
102 - 06/11
103 - 06/12
104 - 06/16
105 - 06/17
Period: 7.309 ± 0.013 h
JDo(LTC): 2454261.929738


Phased Plot: 43203 2000 AV70
Year: 2007
24 - 06/17
27 - 06/17
30 - 06/18
38 - 06/20
39 - 06/20
40 - 06/21
41 - 06/21
Period: 7.403 ± 0.007 h
JDo(LTC): 2454269.127703


Phased Plot: 9928 1981 WE9
Year: 2007
22 - 06/17
28 - 06/18
34 - 06/20
35 - 06/20
42 - 06/21
45 - 06/21
107 - 06/17
108 - 06/19
Period: 5.547 ± 0.005 h
JDo(LTC): 2454269.130277


Phased Plot: 43203 2000 AV70
Year: 2007
24 - 06/17
27 - 06/17
30 - 06/18
38 - 06/20
39 - 06/20
40 - 06/21
41 - 06/21
Period: 14.83 ± 0.03 h
JDo(LTC): 2454269.127703

LIGHTCURVE ANALYSIS OF TEN MAIN-BELT ASTEROIDS

Michael Fauerbach, Scott A. Marks
Egan Observatory, Florida Gulf Coast University
10501 FGCU Blvd.
Fort Myers, FL 33965 USA
mfauerba@fgcu.edu

Michael P. Lucas
Department of Geology
University of South Florida, Tampa, FL 33620 USA

(Received: 27 December)

We report lightcurve periods for ten main-belt asteroids observed at the Evelyn L. Egan Observatory: 26 Proserpina, 78 Diana, 242 Kriemhild, 287 Nephthys, 348 May, 368 Haidea, 446 Aeternitas, 872 Holda, 905 Universitas, and 1013 Tombecka.

The Evelyn L. Egan Observatory is located on the campus of Florida Gulf Coast University in Fort Myers, Florida. Details on the equipment and experimental methods can be found in Fauerbach and Bennett (2005). The data were analyzed with MPO Canopus version 9, which employs differential aperture photometry to determine the values used for analysis. The targets were chosen by comparing well-placed asteroids to the list of known lightcurve parameters maintained by Harris and Warner (2007). We focused our observations mainly on those asteroids for which only one prior – sometimes incomplete or inconclusive – measurement had been published. The exceptions were 242 Kriemhild and 287 Nephthys, which have been observed previously at the Egan Observatory, and for which we plan to combine our data with that of additional observers for spin-axis determination and shape-modeling. Preliminary results of these efforts have been presented at the 39th DPS meeting (Marks et al. 2007). These two asteroids were observed at large phase angles on both sides of opposition.

26 Proserpina. Previous published periods for this asteroid, based on partial and/or sparsely populated lightcurves, ranged from 6.668 h (Riccioli et al. 2001) to 13.13 h by Scaltriti and Zappala (1979). Here, we report the first complete and densely-populated lightcurve for 26 Proserpina. Our derived period of 13.106 ± 0.001 h is in excellent agreement with that derived by Scaltriti and Zappala and should remove any ambiguity of the actual period.

78 Diana. The asteroid was observed for a single night during which we were able to obtain complete coverage of more than one entire rotation. Our derived period of 7.318 ± 0.001 h is in reasonable agreement with the value of 7.225 h reported by Harris and Young (1989) and in good agreement with 7.300 ± 0.001 h reported by Licchelli (2006). Fleenor (2007) observed the asteroid a few days after us and derived a slightly longer period of 7.346 ± 0.001 h.

242 Kriemhild. In order to obtain the largest possible phase angle coverage on both sides of opposition, we observed it over a time span of almost three months. The derived period of 4.545 ± 0.001 h agrees well with previous results.

287 Nephthys. In order to obtain the largest possible phase angle coverage on both sides of opposition, we observed it over a time span of almost two months. The derived period of 7.605 ± 0.001 h agrees well with previous results.

348 May. At the time of our observations, only one previous lightcurve of this asteroid with a period of 7.385 h existed (Behrend 2007). This is in excellent agreement with our result of 7.384 ± 0.001 h. Stephens (2007) and Sauppe et al. (2007) observed the asteroid during the same time and received similar results, highlighting again the importance of using the CALL website to avoid multiple observations of the same object.

368 Haidea. At the time of our observations, only one previous lightcurve of this asteroid with a period of 8.642 h existed (Behrend 2007). However, our data does not support this and, instead, we derived a period 9.823 ± 0.001 h.

446 Aeternitas. Only one previous lightcurve of this asteroid based on a partial lightcurve existed (Florczak et al. 1997). This prior result of 15.85 ± 0.01 h is in reasonable agreement with our period of 15.736 ± 0.001 h.

872 Holda. Lagerkvist et al. (1998) reported an “ambiguous” period of either 6.78 or 7.2 h, whereas Behrend (2007) reported a period of 5.94 h. Our period of 5.941 ± 0.001 h is in agreement with the latter, as well as the period derived by Brinsfield (2007) using data taken immediately after ours.

905 Universitas. Only one prior lightcurve of this asteroid based on a partial lightcurve existed (Wisniewski et al. 1997). They reported a period of around 10 hours. We derive a period of 14.157 ± 0.003 h.

1013 Tombecka. Only one prior lightcurve of this asteroid based on a partial lightcurve existed (Weidenschilling et al. 1990), with a period of 6.0 hr. Our measured period of 6.053 ± 0.002 hr is in excellent agreement with this previous measurement.

References

Briensfield, J. W. (2007). *Minor Planet Bul*. **34**, 108-108.

#	Name	Date Range (mm/dd/yyyy)	Data Pts	Phase	L_{PAB}	B_{PAB}	Per (h)	PE
26	Proserpina	11/08/2007 - 12/07/2007	707	20.2,16.2	113.9,117.6	3.2,3.7	13.106	0.001
78	Diana	12/28/2006	211	15.7	122.2	7.5	7.318	0.001
242	Kriemhild	01/18/2007 - 04/12/2007	467	10.8,7.5,21.7	136.1,142.6	-14.1,-10.5	4.545	0.001
287	Nephthys	02/08/2007 - 04/11/2007	806	14.6,9.2,15.5	168.4,170.3	4.2,7.6	7.605	0.001
348	May	04/17/2007 - 05/18/2007	338	5.4,13.7	198.8,199.5	11.4,10.4	7.384	0.001
368	Haidea	11/09/2007 - 12/04/2007	470	8.5,15.9	26,-27.7	2.9,1.8	9.823	0.001
446	Aeternitas	10/25/2006 - 11/18/2006	402	6.4,15.0	18.5,19.8	-4.9,-3.3	15.736	0.001
872	Holda	04/16/2007 - 05/18/2007	238	5.6,17.7	191.1,196.1	0.3,-1.6	5.941	0.001
905	Universitas	11/07/2007 – 11/10/2007	357	13.8,15.4	24.0,-24.4	-0.8,-0.7	14.157	0.003
1013	Tombecka	11/14/2006 - 11/18/2006	181	10.5,12.1	27.9	1.6	6.053	0.002

Behrend, R. (2007). *http://obswww.unige.ch/~behrend/page_cou.html*

Fauerbach, M. and Bennett, T. (2005), *The Minor Planet Bulletin* **32-2**, 34-35.

Fleenor, M. L. (2007). *Minor Planet Bul*. **34**, 66-67.

Florczak, M., Dotto, E., Barucci, M. A., Birlan, M., Erikson, A., Fulchignoni, M., Nathues, A., Perret, L., and Thebault, P. (1997). *Planet. Space Sci*. **45**, 1423-1435.

Harris, A.W. and Young, J.W. (1989). *Icarus* **81**, 314-364.

Harris, A.W., and Warner B.D. (2007). *http://cfa-www.harvard.edu/iau/lists/LightcurveDat.html*

Lagerkvist, C.-I., Belskaya, I., Erikson, A., Schevchenko, V., Mottola, S., Chiorny, V., Magnusson, P., Nathues, A., and Piironen, J. (1998). *Astron. Astrophys. Suppl. Ser*. **131**, 55-62.

Licchelli, D. (2006). *Minor Planet Bul*. **33**, 11-13.

Marks, S.A, Fauerbach, M, Behrend R., Bernasconi, L., Bosch, J. Conjat, M., Rinner, C., and Roy, R. (2007). “Shape Models of Small Solar System Bodies.” *Bull. Amer. Astron. Soc*. **39**, 483-483.

Riccioli, D., Blanco, C., and Cigna, M. (2001). *Planetary and Space Sci*. **49**, 657-671.

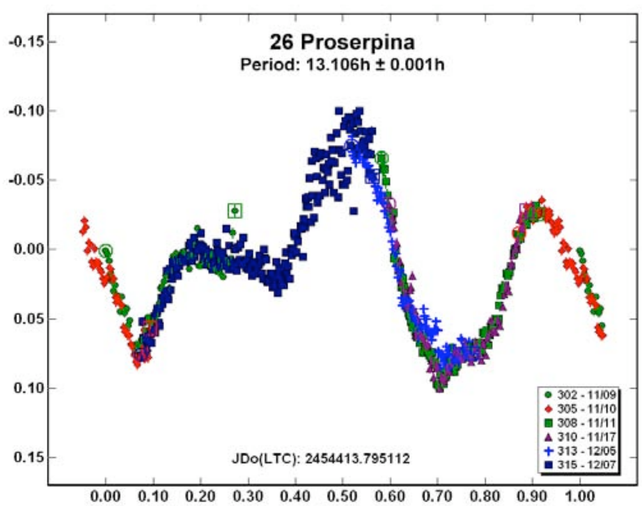
Scaltriti, F. and Zappala, V. (1979). *Icarus* **39**, 124-130.

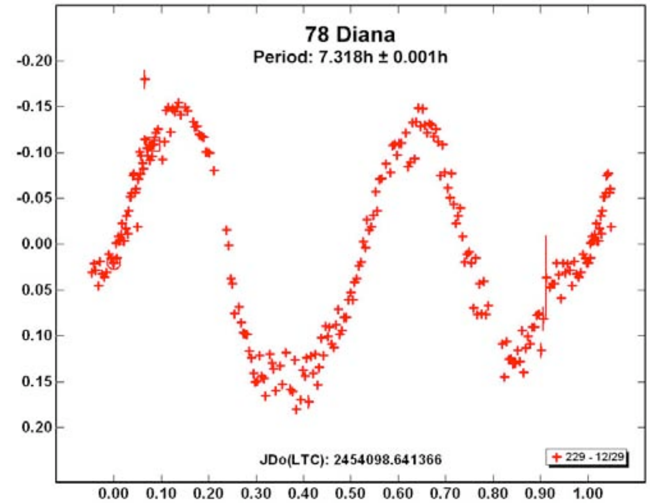
Stephens, R. D. (2007). *Minor Planet Bul*. **34**, 102-103.

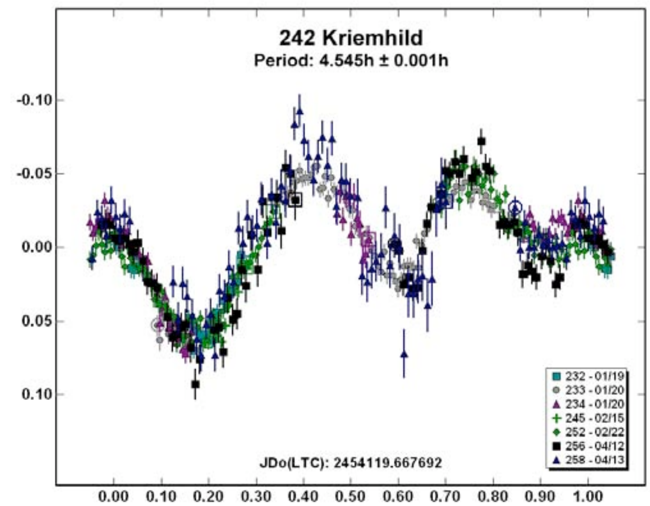
Sauppe, J., Torno, S., Lemke-Oliver, R., and Ditteon, R. (2007). *Minor Planet Bul*. **34**, 119-122.

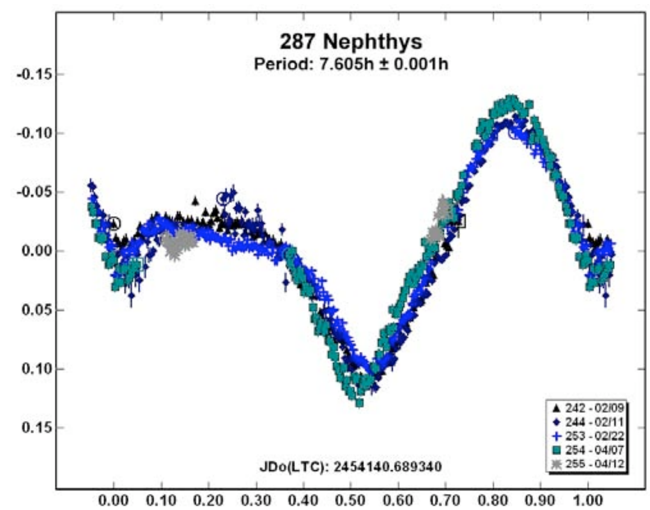
Weidenschilling, S.J., Chapman, C.R., Davis, D.R., Greenberg, R., Levy, D.H., Binzel, R.P., Vail, S.M., Magee, M., and Spaute, D. (1990). *Icarus* **86**, 402-447.

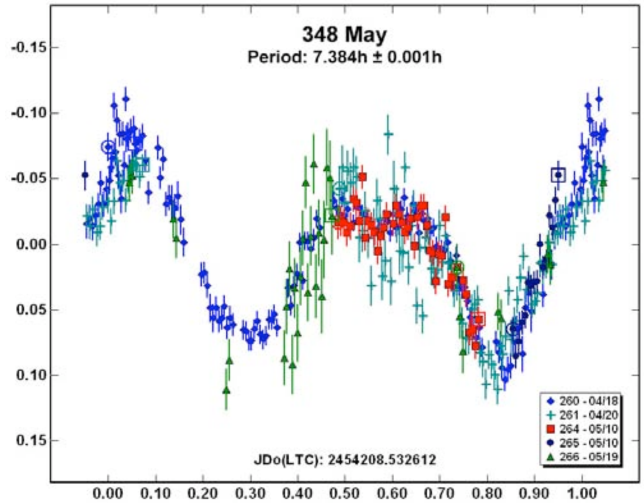
Wisniewski, W.Z., Michalowski, T.M., Harris, A.W., and McMillan, R. S. (1997). *Icarus* **126**, 395-449.

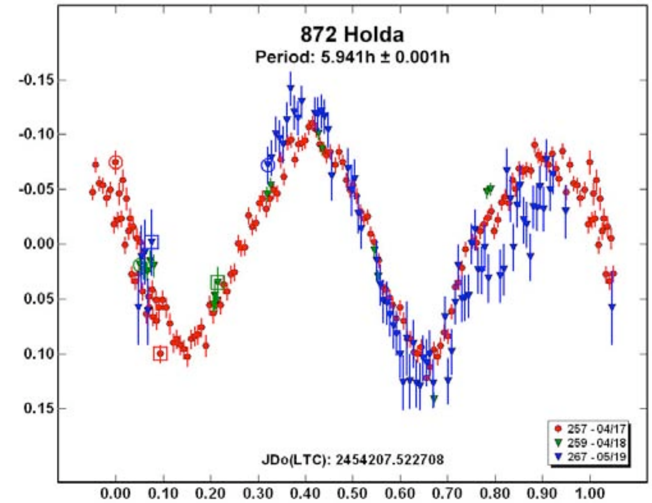


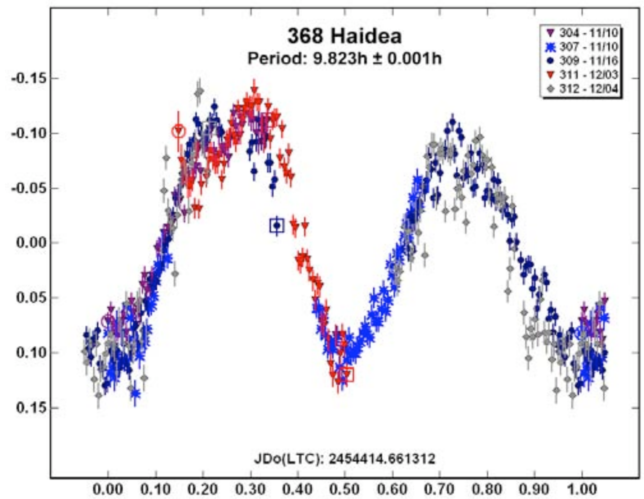


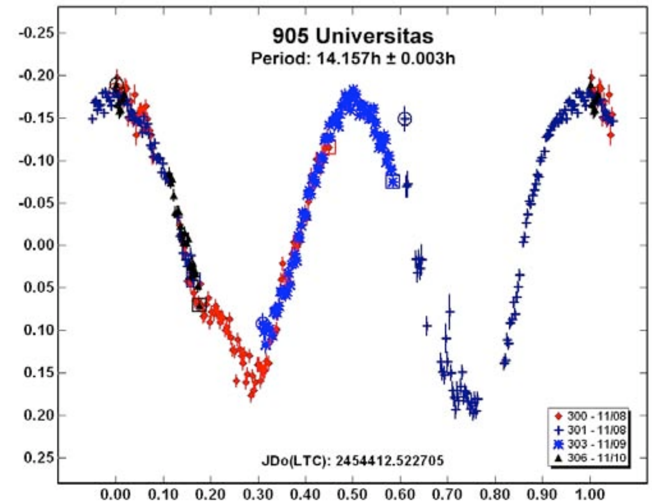


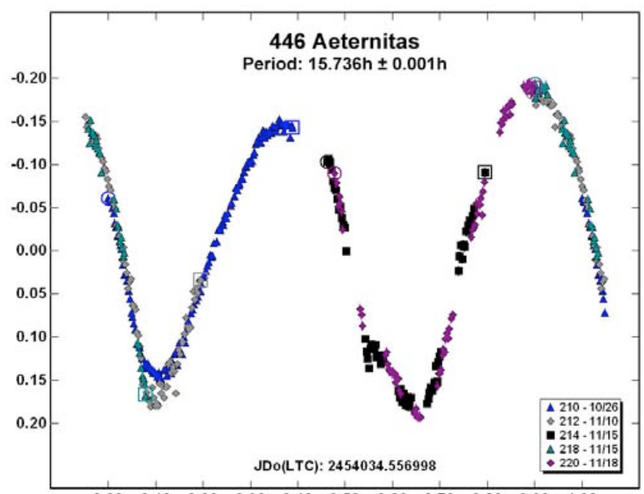


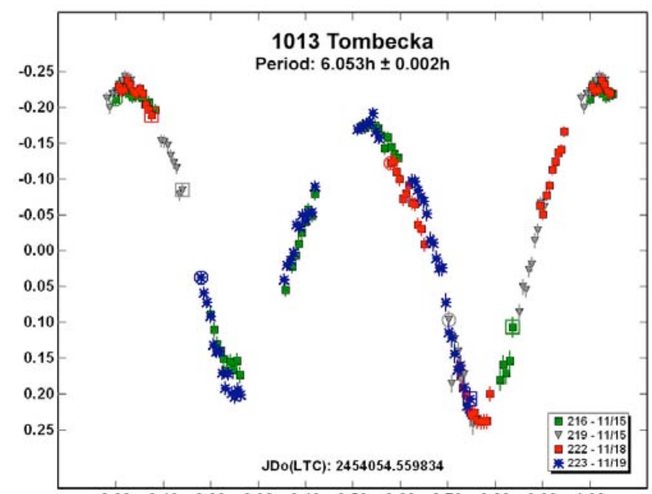

348 May
Period: 7.384h ± 0.001h
260 - 04/18
261 - 04/20
264 - 05/10
265 - 05/10
266 - 05/19
JDo(LTC): 2454208.532612


872 Holda
Period: 5.941h ± 0.001h
257 - 04/17
259 - 04/18
267 - 05/19
JDo(LTC): 2454207.522708


368 Haidea
Period: 9.823h ± 0.001h
304 - 11/10
307 - 11/10
309 - 11/16
311 - 12/03
312 - 12/04
JDo(LTC): 2454414.661312


905 Universitas
Period: 14.157h ± 0.003h
300 - 11/08
301 - 11/08
303 - 11/09
306 - 11/10
JDo(LTC): 2454412.522705


446 Aeternitas
Period: 15.736h ± 0.001h
210 - 10/26
212 - 11/10
214 - 11/15
218 - 11/15
220 - 11/18
JDo(LTC): 2454034.556998


1013 Tombecka
Period: 6.053h ± 0.002h
216 - 11/15
219 - 11/15
222 - 11/18
223 - 11/19
JDo(LTC): 2454054.559834

LIGHTCURVE ANALYSIS OF ASTEROIDS FROM KINGSGROVE AND OTHER COLLABORATING OBSERVATORIES IN THE FIRST HALF OF 2007

Julian Oey
Kingsgrove Observatory (E19)
23 Monaro Ave.
Kingsgrove, NSW 2208 AUSTRALIA
julianoey1@optusnet.com.au

Ric Krajewski
Dark Rosanne observatory
Middlefield, CT USA 06455

(Received: 10 October Revised: 18 November)

Several asteroids were observed from Kingsgrove and other collaborating observatories during the first half of 2007. The synodic periods derived were: 162 Laurentia, 11.8686 ± 0.0004 h; 178 Belisana, 12.321 ± 0.002 h or 24.6510 ± 0.0003 h; 913 Otila, 4.8720 ± 0.0002 h; 1626 Sadeya, 3.4200 ± 0.0006 h; 2275 Cuitlahuac, 6.2892 ± 0.0002 h; and 2006 VV2, 2.43 ± 0.03 h;

The location and instruments used for both Kingsgrove and Leura observatories have been previously documented in Oey et al. (2007) and Oey (2007) respectively. Dark Rosanne observatory is located at Middlefield, CT, USA. The telescope used was a Schmidt-Newtonian 8" telescope mounted on a Meade equatorial platform. It was operating at f/4 when coupled with a Meade DSI Pro CCD camera. With its 9.6x7.5 micron pixel size, the camera provided a field of view of 20'x15' at 2.2"/ pixel.

All images were taken with clear filter. Period analysis was done using MPO Canopus and all data was light time corrected. Targets 2275 Cuitlahuac and 2006 VV2 and were provided from the Photometric Survey of Asynchronous Binary Asteroids in Pravec (2006) whereas 162 Laurentia, 178 Belisana, 913 Otila, 1626 Sadeya and were selected from the list of Potential Lightcurve Targets in the CALL website managed by Warner (2007). Aspects of the minor planets are summarized in the table below. Additional comments if any are discussed separately. No previous photometric studies were done on 2275 Cuitlahuac or 2006 VV2.

162 Laurentia. The period was previously determined to be 11.87 ± 0.02 h by J. Piironen et al. (1994) who called for further observations to determine its spin axis. Recent observations done on this asteroid by Behrend et al. (2007) showed a period of 11.880 ± 0.004 h with an amplitude of about 0.33 mag. After posting a not on the CALL site, Oey was contacted by Krajewski who offered to collaborate in an effort to obtain an accurate period determination. Since the period was initially shown to be close to commensurate with 24 hr, observer from different longitudes can more quickly resolve any aliases by effectively extending runs made on the same day. This helps avoid half-period ambiguities if the curve happens to be nearly symmetrical. The synodic period was determined to be 11.8686 ± 0.0004 h with an amplitude of 0.40 ± 0.05 m, agreeing well with the previous results.

178 Belisana. The lightcurve data were collected over a time span of more than two months and showed a synodic period of 12.321 ± 0.002 h and amplitude of 0.10 ± 0.03 m, in perfect agreement with the previously published data by Harris et al. (1992). However there was also another possible solution of 24.6510 ± 0.0003 h. The uncertainty arose from the issue with aliases compounded with the relatively short lengths of each session. Collaboration with observers from another continent will be needed to resolve the ambiguity.

2006 VV2. The lightcurve for 2006 VV2 was obtained during its recent close approach. Data were taken over five hours and all segments were internally linked to a fixed reference. The zero-point was obtained in a photometric sky several nights later.

References

Behrend, R. (2007). Observatoire de Geneve web site, http://obswww.unige.ch/~behrend/page1cou.html

Harris, A.W., Young, J.W., Dockweiler, T., Gibson, J., Poutanen, M., and Bowell, E. (1992). "Asteroid lightcurve observations from 1981". *Icarus (ISSN 0019-1035)*, **95**, 115–147.

Oey, J. (2007). "Lightcurve Analysis of 1495 Helsinki," *Minor Planet Bulletin* **34**, 2.

Oey, J., Világi, J., Gajdoš, Š., Kornoš, L., and Galád, A. (2007). "Light Curves Analysis of 8 Asteroids from Leura and other Collaborating Observatories". *Minor Planet Bulletin* **34,** 81–83.

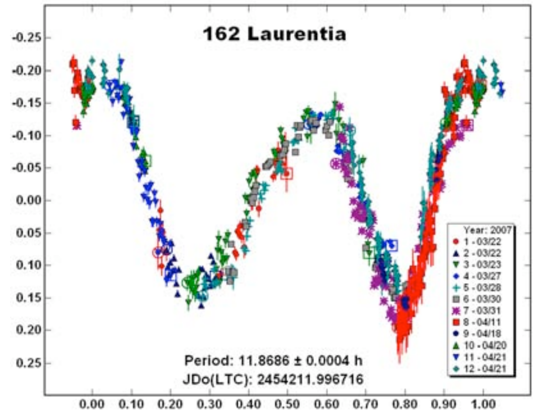
Piironen, J., Bowel, E., Erikson, A., and Magnusson, P. (1994). "Photometry of eleven asteroids at small phase angles". *Astronomy and Astrophsics supplement series* **106**, 587–595.

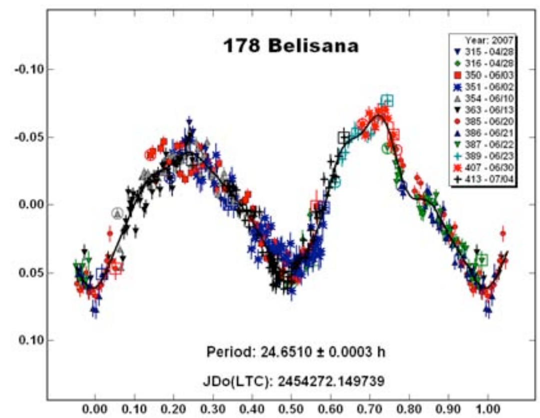
Pravec, P. (2006). "Photometric Survey of Asynchronous Binary Asteroids." http://www.asu.cas.cz/~asteroid/binastphotsurvey.htm.

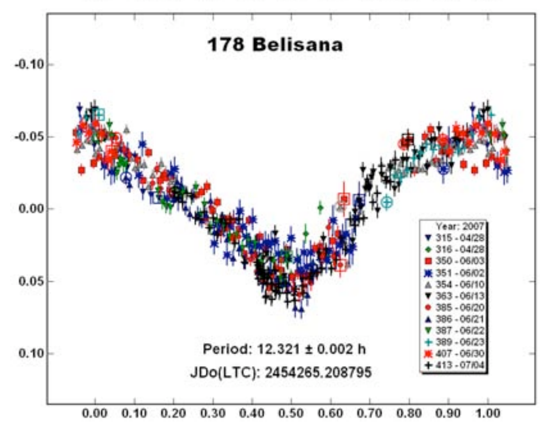
# Name	Obs	Date Range (mm/dd) 2007	Period (h)	Amp (mag)	Phase	LPAB	BPAB
162 Laurentia	1,3	03/22–04/21	11.8686±0.0004	0.40 ± 0.05	2.3,13.0	181	4.0
178 Belisana	1	04/28–07/04	12.321±0.002 or 24.6510±0.0003	0.10 ± 0.03 or 0.13 ± 0.03	14.0,16.7	246	-0.5
913 Otila	1,2	04/20–05/30	4.8720±0.0002	0.20 ± 0.03	19.2,4.8	240	5.0
1388 Aphrodite	1	04/28–06/23	11.9432±0.0004	0.65 ± 0.10	7.7,13.2	237	-1.0
1626 Sadeya	1	01/26–01/30	3.4200±0.0006	0.20 ± 0.04	15.1,14.5	136	-22.0
2275 Cuitlahuac	2	06/20–06/30	6.2892±0.0002	1.05 ± 0.04	17.9,14.0	297	9.0
2006 VV2	1	04/04	2.43±0.03	0.20 ± 0.04	36.8	186	-18.5

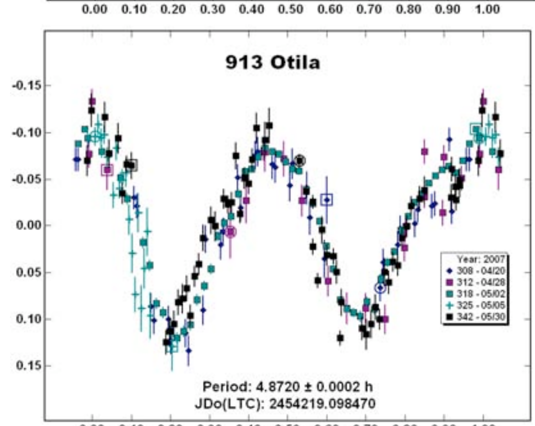
1. Julian Oey, Kingsgrove Observatory. 2. Julian Oey, Leura Observatory. 3. Ric Krajewski, Dark Rosanne Observatory.

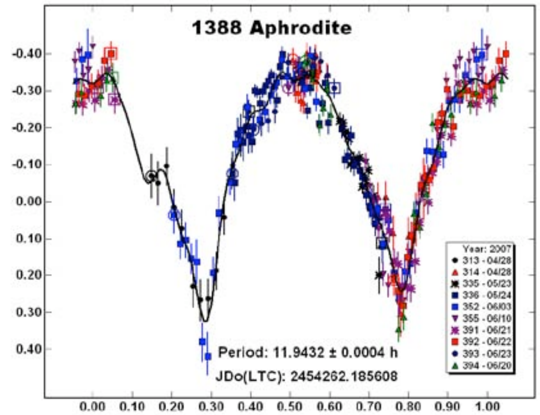
Warner, B.D. (2007). " Potential Lightcurve Targets 2007 April–June."
http://www.minorplanetobserver.com/astlc/targets_2q_2007.htm

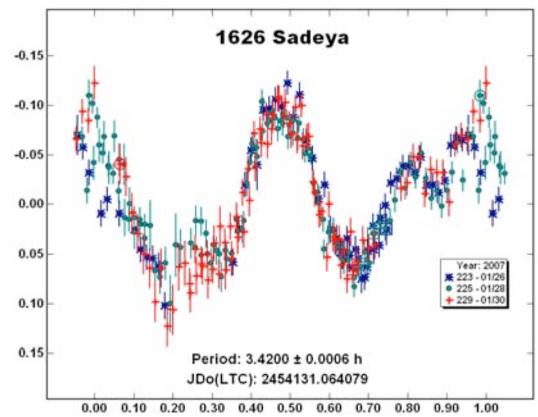


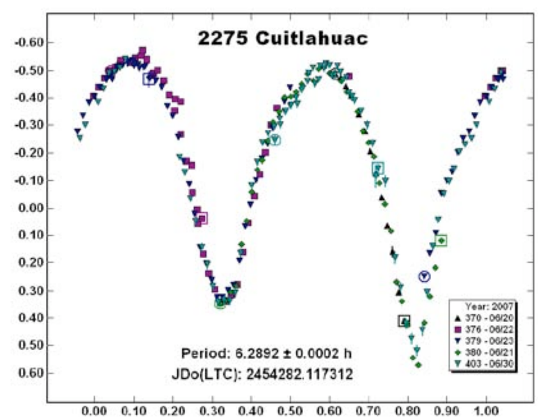


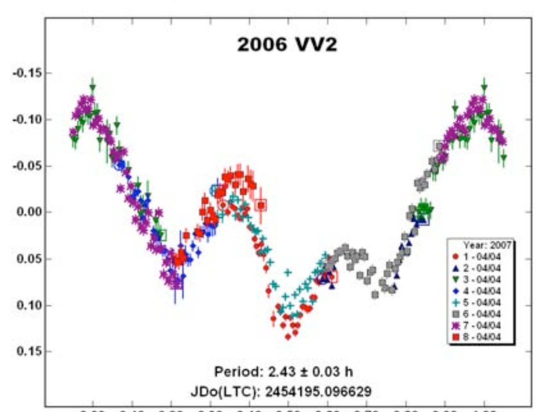












LIGHTCURVES OF MINOR PLANETS 2118 FLAGSTAFF, (15161) 2000 FQ48, AND (46436) 2002 LH5

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

(Received: 15 October)

Lightcurves of 2118 Flagstaff reveal a rotation period of 15.1557 ± 0.0013 hr with amplitude 0.27 ± 0.02 mag, (15161) 2000 FQ48 a period of 6.663 ± 0.001 hr with amplitude 0.10 ± 0.03 mag; (46436) 2002 LH5 a period of 3.884 ± 0.001 hr with amplitude 0.52 ± 0.02 mag.

Photometric data were collected using a 36 cm Celestron C-14, a SBIG ST-10XME camera, and clear filter at Stonegate Observatory. The camera was binned 2x2 with a resultant image scale of 1.3 arc-seconds per pixel. Image exposures were between 60 and 180 seconds at –15C. All photometric data were obtained and analyzed using MPO Canopus (Warner 2006). The three targets were identified from Warner et al. (2007).

2118 Flagstaff. Data were collected from September 25 through October 7, 2007, resulting in five data sets and 461 data points. A period of 15.1557 ± 0.0013 hrs was determined. There are no previously reported data.

(15161) 2000 FQ48. Data were collected from August 3 through October 9, 2007, resulting in seven data sets and 322 data points. Images at 180 seconds exposure were guided using an adaptive optic system and still resulted in excessively noisy data. Several solutions were investigated with the most probable period at 6.663 ± 0.001 hrs. There are no previously reported data.

(46436) 2002 LH5. Data were collected from August 3 through September 14, 2007, resulting in six data sets and 334 data points. A period of 3.884 ± 0.001 hrs was determined. This agrees with results reported by Warner (2007).

Acknowledgments

The author appreciates the help from Brian Warner in better understanding the tricky process of period analysis.

References

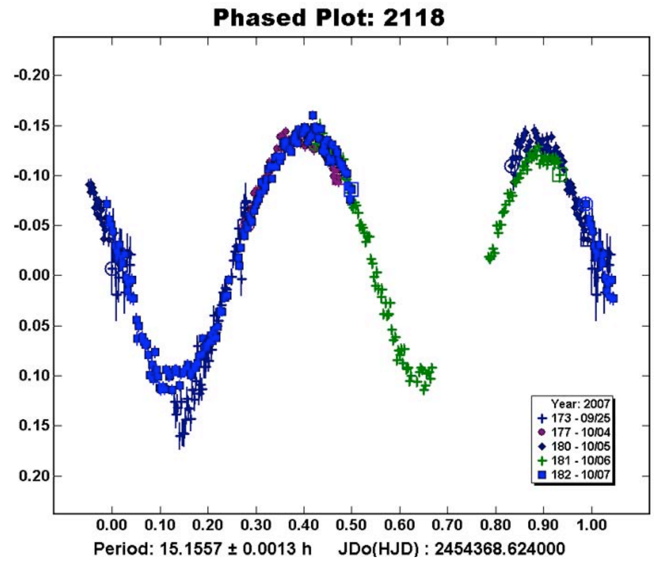
Harris, A.W., Young, J.W., Bowell, E., Martin, L.J., Millis, R.L., Poutanen, M., Scaltriti, F., Zappala, V., Schober, H.J., Debehogne, H., and Zeigler, K.W., (1989). "Photoelectric Observations of Asteroids 3, 24, 60, 261, and 863." *Icarus* **77**, 171-186.

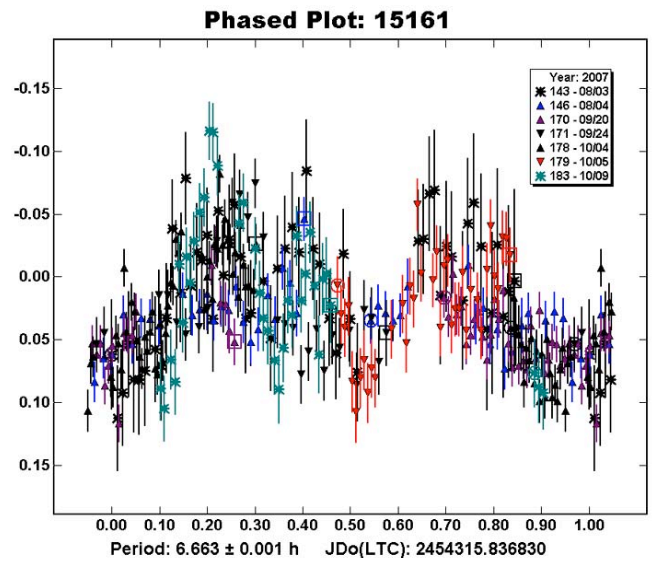
Warner, B.D. (2006). MPO Software, Canopus version 9.2.0.0, Bdw Publishing, http://minorplanetobserver.com/

Warner, B.D. (2007). Asteroid Lightcurve Analysis at the Palmer Divide Observatory: June-October 2007." *MPB* **35,** 56-60.

Warner, B.D., Harris A.W., Pravec, P., Kaasalainen, M., and Benner, L.A.M. (2007). Lightcurve Photometry Opportunities July-September 2007, http://minorplanetobserver.com/

Warner, B.D., Harris A.W., Pravec, P., Kaasalainen, M., and Benner, L.A.M. (2007). Lightcurve Photometry Opportunities October-December 2007, http://minorplanetobserver.com/





CORRIGENDUM: MINOR PLANETS AT UNUSUALLY FAOVRABLE ELONGATIONS IN 2008

Frederick Pilcher
Illinois College
Jacksonville, IL 62650 USA
pilcher@ic.edu

My paper "Minor Planets at Unusually Favorable Elongations in 2008" appearing in *Minor Planet Bulletin* **35**, 7-9 (2008) contains an error. In Table I, asteroid number "137072" should read "137032". The number 137032 is correctly given in Table II. The author thanks Roger Harvey for finding this error.

LIGHTCURVE ANALYSIS OF 1084 TAMARIWA

Pedro V. Sada
Departamento de Física y Matemáticas
Universidad de Monterrey
Av. I. Morones Prieto 4500 Pte.
Garza García, N.L., 66238 MEXICO
psada@.ix.netcom.com

(Received: 15 November)

Photometric observations of 1084 Tamariwa were made during August and September of 2007. Analysis of the data yields a synodic rotational period of 6.1949 ± 0.0002 h and amplitude of ~0.32 mag.

1084 Tamariwa, a C-class main-belt asteroid discovered in 1926 by S.I. Belyavskij, was selected for observation from the list of asteroid lightcurve photometry opportunities (Warner et al. 2007), also posted on the Collaborative Asteroid Lightcurve Link (CALL) website (Warner, 2007a). The present observations were carried out at the Universidad de Monterrey observatory (MPC 720) using a 0.35m telescope and a SBIG ST-9E CCD detector which yielded ~1.7 arcsec/pixel resolution. Unfiltered data were acquired on four nights between 6 August and 9 September. In all cases exposure times were 120 seconds and the detector temperature was set between –7 and –10 C. These observations (totaling 449 useful data points) were made between phase angles 7.4 and 9.1 degrees (through opposition on 19 August). Period analysis of the observations was preformed using Brian Warner's MPO Canopus differential photometry software (Warner, 2007b).

Analysis of the present data results in a synodic rotation period of 6.1949 ± 0.0002 h and amplitude of ~0.32 magnitudes (Fig. 1). This asteroid has been previously observed. Binzel (1987) first reported a tentative rotation period of 7.08 h, an amplitude of 0.27 magnitudes, and an H-value of 10.78, which still stands. DeGraff, Robbins and Gutermuth (1998 & 2000) refined the rotation period to 6.153 ± 0.001 h. Later, Ivarsen et al. (2004) reported a period of 6.19 ± 0.01 h and an amplitude of 0.25 magnitudes based on four nights of observations within the same week in October 2003. During the present opposition Behrend (2007) reported in his website a rotation period of 6.1961 ± 0.0002 h and an amplitude of ~0.42 magnitudes from observations performed by P. Antonini over four nights in October.

It is interesting to note the differences and similarities between the observations reported by Behrend and the present ones. While there is general agreement on the lightcurve shape and rotation period, the uncertainties for the rotation period derived from a formal solution of the data sets seem to be too optimistic in both cases. It is unlikely that the rotation period varied by 0.001 hours in the intervening weeks. The present data can also be phased using the Behrend rotation period; though the resulting lightcurve is not as 'satisfactory'. However, the present data set, obtained over a 33-day span compared with Behrend's 18-day span, may be more sensitive to slight variations in the accuracy of the rotation period. On the other hand, the amplitude difference seems to be real. Comparing further the two well-sampled lightcurves one can also note that the rise from primary minimum seems to develop a 'hump' between the August-September and October observations, while the 'bump' located on the secondary minimum seems to become less pronounced. This is likely due to the irregular shape of the asteroid and the change in observing geometry between data sets. This would be an interesting candidate for further shape-modeling observations.

References

Behrend, R. (2007). "Asteroids and Comets Rotation Curves, CdR." http://obswww.unige.ch/~behrend/page3cou.html.

Binzel, R.P. (1987). "A Photoelectric survey of 130 Asteroids," *Icarus* **72**, 135-208.

DeGraff, D.R., Robbins, A.M., and Gutermuth, R.A. (1998). "Rotation Curves for 13 Asteroids," *Bul. Amer. Astron. Soc.*, **30**, 1390.

DeGraff, D.R., Robbins, A.M., and Gutermuth, R.A. (2000). "Differential Photometry of Six Asteroids: 664, 1084, 2038, 2595, 3227 & 2357," *News Letter of the Astronomical Society of New York*, **5(7)**, 16.

Ivarsen, K., Willis, S., Ingleby, L., Mathews, D., and Simet, M. (2004). "CCD Observations and Period Determination of Fifteen Minor Planets," *Minor Planet Bulletin*, **31,** 29-33.

Warner, B.D., Harris, A.W., Pravec, P., Kaasalainen, M. and Benner, L.A.M. (2007). "Lightcurve Photometry Opportunities. July-September 2007." *Minor Planet Bulletin* **34**, 92-94.

Warner, B.D. (2007a). "Collaborative Asteroid Lightcurve Link." http://www.minorplanetobserver.com/astlc/default.htm.

Warner, B.D. (2007b). MPO Software, Canopus version 9.2.3.1 Bdw Publishing, Colorado Springs, CO.

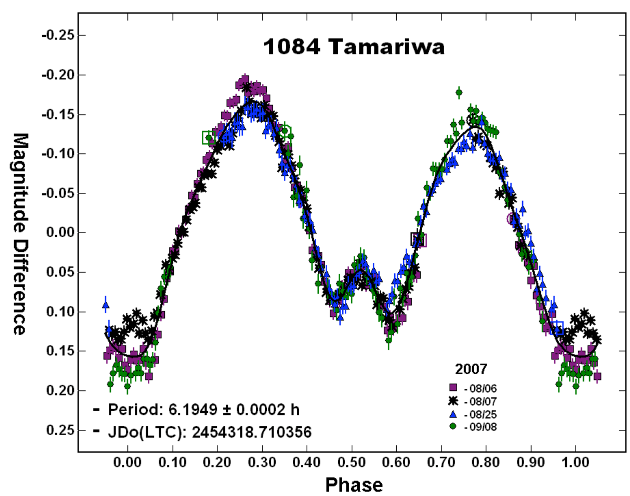


Fig.1: Composite lightcurve of asteroid 1084 Tamariwa derived from the present observations and a rotation period of 6.1949 hr. Epoch is for lightcurve primary minimum.

PERIOD DETERMINATION FOR 35 LEUKOTHEA

Frederick Pilcher
4438 Organ Mesa Loop
Las Cruces, NM 88011 USA

(Received: 16 November Revised: 30 November)

At longitude 357 to 347 degrees 35 Leukothea is found to have a 31.893 ± 0.004 hour period, monomodal lightcurve, and 0.07 ± 0.02 magnitude amplitude. Approximate pole positions and ratio a/b of maximum to minimum equatorial radii are also found.

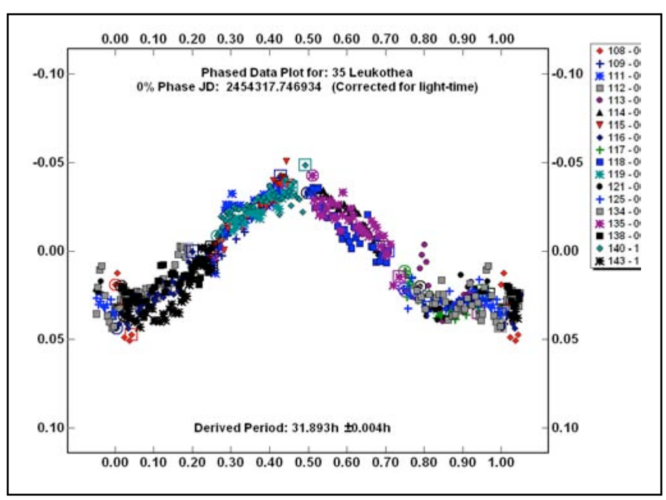
Lightcurves of 35 Leukothea were obtained at the Organ Mesa Observatory on 18 nights 2007 Aug. 5-Oct. 8. Equipment consists of a 35.4 cm Meade LX 200 GPS S-C and SBIG STL 1001-E CCD, with 60 second unguided exposures through a clear filter, differential photometry only. Because of the large number of data points, 3103 for the 18 nights, they have been binned in sets of 5 with time interval not exceeding 10 minutes for the lightcurve, reducing the number to 633. Despite the long interval of observation, including 9 consecutive nights August 12-20, both a 27.355 hour 0.04 magnitude amplitude bimodal lightcurve and a 31.893 hour 0.07 magnitude amplitude monomodal lightcurve are allowed by this study. The lightcurve phased to 31.893 hours is included here.

It should be noted that 31.893 hours is almost exactly a 4:3 commensurability with the Earth's rotation period from the observational viewpoint. The Earth's sidereal rotation period is 23.934 hours, but asteroids near opposition when most lightcurves are obtained retrograde at about 1 minute of right ascension daily. Hence a period of 23.92 hours is synchronous with Earth's in the sense that this is the interval between successive transits of an asteroid. A 31.893 hour period for Leukothea is to 3 decimal places a perfect 4:3 commensurability. This shows clearly on the lightcurve, where 7 to 8 hour photometry sessions possible in this season appear in 4 segments barely or not quite overlapping. The lack of significant overlap between sessions makes more difficult the adjustment of instrumental magnitudes to best fit, and increases the error in the amplitude. It should be noted that the segments centered near phases 0.35 and 0.60 must be lowered about 0.035 magnitudes for the best fitting 27.355 hour lightcurve.

Prior to this study only two photometric investigations of 35 Leukothea appear to have been published. The first, only 50 minutes in duration by Lagerkvist et al. (1987), shows no variation beyond 0.02 magnitude scatter from 8:55-9:45 UT 1985 Mar. 20. The second, by Weidenschilling et al. (1990) from 1988 Dec. 21 and 22, is sufficient to resolve the period ambiguity. Dec. 21 the brightness first slowly, then rapidly decreased by about 0.38 magnitudes from about 4h30m to 11h30m UT. Dec.22 the brightness decreased about 0.05mag from about 2h to 4h UT, then increased by about 0.25mag to 10h30m UT. There is a clearly defined minimum Dec. 22 near 4h and a maximum Dec. 21 indicated near 3h to 4h. This led Weidenschilling et al. to deduce an approximate period of 32 hours, consistent with the current study. A 27.355 hour period applied to Weidenschilling's lightcurve superposes a rising segment with a falling segment, and is also inconsistent with maximum and minimum observed about 24 hours apart. This rules out a 27.355 hour period. The small 0.07m amplitude in 2007 at longitudes 357 to 347 degrees indicates a near polar aspect for 2007, which in turn implies that the 1988 lightcurves at longitude 87 degrees are at near equatorial aspect. The 31.893 hour period with a monomodal lightcurve near polar aspect and bimodal lightcurve near equatorial aspect fully explain both the respective 2007 and 1988 observations. Monomodal lightcurves near polar aspect and bimodal ones near equatorial aspect have been established for other asteroids. Read for example Warner et al. (2006). The 2007 observations by themselves are also explained by a bimodal, symmetric lightcurve of period 63.79 hours. But no reasonable shape model other than the bimodal one can produce 0.38m amplitude as observed in 1988. An approximate 32 hour period produces maximum and minimum 3/4 cycle apart separated by about 24 hours, observed in 1988. An approximate 64 hour period produces adjacent maximum and minimum about 16 hours apart, which conflicts with the 1988 observations and rules out a 64 hour period. Therefore I claim that 31.893 hours is the correct period. The actual error may be considerably greater than the formal error of ± 0.004 hours, particularly because of inaccuracies linking separate nights when there is a high degree of commensurability

This study also provides for 35 Leukothea approximate positions of the rotational pole, and of the ratio a/b of maximum to minimum equatorial radii. It should be remembered that except in unusual circumstances whole disk photometry cannot distinguish between two pole positions at the same angle north or south from the asteroid's orbit and 180 degrees apart in longitude. This ambiguity cannot be resolved here. The two possible pole positions are within 15 degrees of latitude 0 degrees and either longitude 352 degrees (mean longitude of the 2007 observations) or 172 degrees. In either case the 1988 observations were at near equatorial aspect, where the amplitude is a maximum possible. The ratio a/b of maximum to minimum equatorial radii is found from $a/b >= 10^{0.4\ \Delta M}$. For $\Delta M = 0.38$ in the 1988 near equatorial aspect, a/b for 35 Leukothea is approximately 1.42. The ratio of minimum equatorial to polar radii b/c cannot be found from data obtained in 1988 and 2007.

The next opposition of 35 Leukothea is November, 2008. At this time Leukothea will be in near equatorial aspect. An amplitude exceeding 0.3 magnitudes is predicted for this event. From mid-northern latitudes 10 hour photometry sessions will be possible. Lightcurves on 4 successive nights are expected to verify a 31.9 hour period with full phase coverage and a 2 hour overlap. Additional lightcurves will be useful to decrease the ± error in the derived period and enable robust modeling of this asteroid. The author requests any northern hemisphere observers with suitable resources to make these observations.



Following completion of all the above analysis the author sent a machine readable version of all the 2007 photometry observations to shape/spin modeler Josef Durech. He replied (Durech, 2007) that although two oppositions are not sufficient to establish a robust model, "the rotation period of (35) Leukothea is close to 31.9 hours."

Readers please take note that even fragmentary lightcurves, such as those of Leukothea in 1988 by Weidenschilling et al., can be very useful for subsequent studies. Without them the 2007 data alone are compatible with 3 ambiguous rotation periods.

Acknowledgement

The writer wishes to thank the referee, Alan W. Harris, for several helpful suggestions which improved this paper.

References

Durech, J.: 2007, personal communication

Lagerkvist, C.-I., Hahn, G., Magnusson, P., and Rickman, H. (1987). *Astron. Astrophys. Suppl. Ser.* **70**, 21-32.

Warner, B. D., Gross, J., and Harris, A. W. (2006). *Minor Planet Bul.* **33,** 23-24

Weidenschilling, S. J., Chapman, C. R., Davis, D. R., Greenberg, R., Levy, D. H., Binzel, R. P., Vail, S. M., Magee, M., and Spaute, D. (1990). *Icarus* **86**, 402-447.

LIGHTCURVE ANALYSIS OF 1565 LEMAITRE

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

Gary A. Vander Haagen
Stonegate Observatory, 825 Stonegate Road
Ann Arbor, MI 48103

(Received: 14 October)

The authors observed 1565 Lemaitre independently in August and September 2007. The combined data set was used to determine the synodic period. This proved difficult due to the small amplitude of the lightcurve. We propose a synodic period of either 11.403 ± 0.003 hr (monomodal) with the possibility of 22.805 ± 0.007 hr (bimodal) with an amplitude of 0.04 ± 0.01 mag for either. Given the low amplitude, curves with three or more maxima and minima could not be rejected automatically, however period searches for such possibilities were not convincing.

The authors started observing 1565 Lemaitre independently with Warner posting some initial results on the CALL site. After seeing this posting, Vander Haagen contacted Warner and a combined data set was created since neither set alone was producing a confident solution due to the low amplitude of the lightcurve (~0.04 mag) and minor variations in the curve that, at times, rivaled the total amplitude.

Period analysis was done within Canopus using the algorithm based on the FALC program by Harris (1989). Period searches were made from 1 to 50 hours, the shorter period to see if the high frequency variations in some data were significant and the longer since the general trend of the data on some nights was a steady increase or decrease with no obvious extreme point reached. The solutions suggest a synodic period of either 11.403 ± 0.003 hr (monomodal) or 22.805 ± 0.007 hr (bimodal)

Behrend et al. (2007) worked the asteroid in July and August 2007 and had similar difficulties, reporting a period of 2.4 hr. but with low confidence. Given the low amplitude in 2007, it may be safe to presume that the viewing aspect was pole-on and, therefore, the period of 11.403 hr is to be preferred when considering only the Warner/Vander Haagen data set.

Acknowledgements

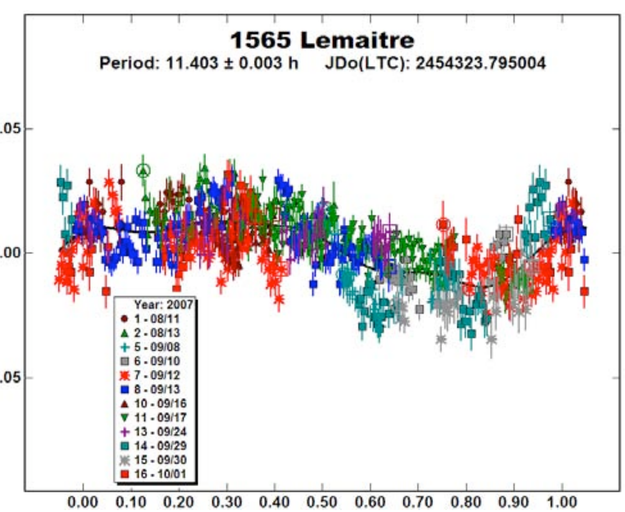
Funding for observations at the Palmer Divide Observatory is provided by NASA grant NNG06GI32G, by National Science Foundation grant AST-0607505, and by a 2007 Shoemaker NEO Grant from the Planetary Society. The SBIG ST-8E used by Hunters Hill was funded by The Planetary Society under the 2005 Gene Shoemaker NEO Grants program.

References

Behrend, R., Leroy, A., Trégon, B., Durivaud, X., and Manzini, F. (2007). Observatoire de Geneve web site, http://obswww.unige.ch/~behrend/page_cou.html.

Harris, A.W., Young, J.W., Bowell, E., Martin, L.J., Millis, R.L., Poutanen, M., Scaltriti, F., Zappala, V., Schober, H.J., Debehogne, H., and Zeigler, K.W. (1989). "Photoelectric Observations of Asteroids 3, 24, 60, 261, and 863." *Icarus* **77**, 171-186.

Harris, A.W., Warner, B.D., Pravec. P., 2007. Asteroid Lightcurve Database, available on the CALL web site, http://www.MinorPlanetObserver.com/astlc/default.htm.



CCD LIGHTCURVE ANALYSIS OF 176 IDUNA

Kevin B. Alton
UnderOak Observatory
70 Summit Ave
Cedar Knolls, NJ 07927

(Received: 28 October)

Clear filter CCD images for 176 Iduna were obtained over ten nights in September 2007. A composite lightcurve was produced and a synodic period of 11.2880 ± 0.0001 h was deduced.

176 Iduna (121 km) is a main-belt asteroid first discovered by C.H.F. Peters in 1887. Infrequently reported, only two other lightcurves from this minor planet are described in the literature. (Riccioli 2001; Hansen and Arentoft 1997).

Equipment included a focal reduced (f/6.3) 0.2-m NexStar 8 GPS SCT with a thermoelectrically cooled (5 °C) SBIG ST 402ME CCD camera mounted at the Cassegrain focus. Clear filter imaging (unbinned for 20 sec) was carried out on a total of ten nights with exposures automatically taken at least every 60 seconds. Image acquisition (raw lights, darks and flats) was performed by CCDSOFT 5 (SBIG) while calibration and registration were accomplished with AIP4WIN (Berry and Burnell 2005). Further image reduction with MPO Canopus (Warner 2006) used at least four non-varying comparison stars to generate lightcurves by differential aperture photometry. Data were light-time corrected but not reduced to standard magnitudes.

A total of 1326 photometric readings were collected over 28.0711 days. Relevant aspect parameters for 176 Iduna taken at the mid-point from each session are tabulated below. MPO Canopus provided a period solution for the folded data sets using Fourier analysis. The synodic period, determined to be 11.2880 ± 0.0001 h, was in good agreement with rotational periods for 176 Iduna published by Hansen and Arentoft (1997), Krajewski (2008), and that found by the "Small-Body Database Browser" at the JPL Solar System Dynamics website. The lightcurve amplitude (~0.35 m) is consistent with findings from Hansen and Arentoft (1997).

Acknowledgement. Thanks to Brian D. Warner for his continued support of MPO Canopus without which this photometric investigation and many others would be extremely tedious.

References

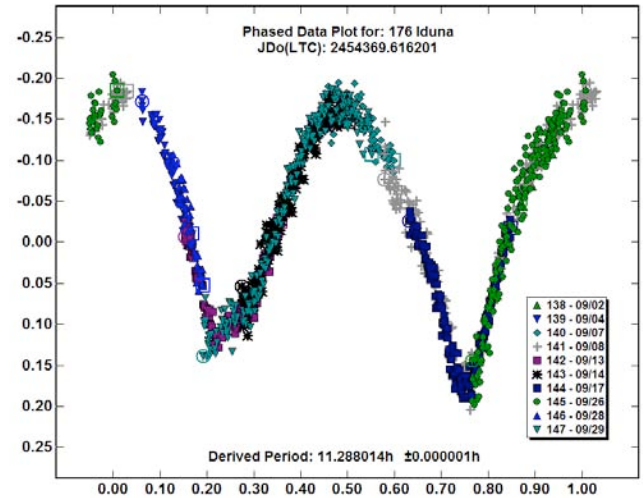
Berry, R. and Burnell, J. (2005). AIP4WIN version 2.1.0, Willmann-Bell, Inc, Richmond, VA.

Hansen, A.T. and Arentoft, T. (1997). "The Rotational Period of 176 Iduna". *Minor Planet Bulletin* **24**, 14.

Krajewski, R. (2008). "Lightcurve Analysis of 176 Iduna". *Minor Planet Bulletin* **35**, 77.

Riccioli, D., Blanco, C. and Cigna, M. (2001). "Rotational Periods of Asteroids II". *Planetary and Space Science* **49**, 656-671.

Warner, B. D. (2006). *MPO Canopus* software, version 9.2.1.0. Bdw Publishing, Colorado Springs, CO.



UT Date (2007)	Obs	Phase Angle	L_{PAB}	B_{PAB}
Sept 02	57	8.3	339.5	19.5
Sept 04	69	8.3	339.5	19.3
Sept 07	98	8.3	339.5	19.1
Sept 08	250	8.4	339.5	19.0
Sept 13	136	9.0	339.5	18.5
Sept 14	145	9.1	339.6	18.4
Sept 17	154	9.6	339.6	18.1
Sept 26	157	11.7	339.8	17.2
Sept 29	46	12.4	339.9	16.8
Sept 30	214	12.6	339.9	16.7

LIGHTCURVES OF MINOR PLANET 2445 BLAZHKO

Stefano Moretti, Salvatore Tomaselli
Bastia Obs. (MPC 197) – ARAR – Ravenna
Via Erbosa – Bastia (Ravenna)
ITALY
stefanomoretti_001@fastwebnet.it

(Received: 12 December)

Lightcurves of 2445 Blazhko performed on Nov. and Dec. 2007 reveal a rotation period of 3.6197 ± 0.0005 h and amplitude of about 0.65 mag.

Our lightcurve of 2445 Blazhko is the first attempt of asteroid photometry observations from Osservatorio Don Molesi – Bastia –Ravenna – Italy (MPC 197). The target was selected from the list of asteroid photometry opportunities published by Warner et al. (2007). This list doesn't show any available information about 2445 Blazhko. In addition, no information was found on the Minor Planet Center "Minor Planet Lightcurve Parameters" web page.

The observations were obtained with a Newtonian telescope D=0.42m and F=2.250m. The CCD camera was an Apogee Alta U260e with 40s of exp. time (S/N >300) and Schuler Clear filter. All the observations were performed on nights of Nov. 30, 2007, and Dec. 5, 2007. On each night, the photometric curve was well-covered (about 3.5 h and 3.3 h). A total of 557 measurements were obtained with the mean error for single measurements varying from about 0.01 mag. on Nov. 30 to about 0.008 mag. on Dec. 05.

Analysis of the combined data sets was made using the MPO Canopus software. The derived synodic rotation period was 3.6197 ± 0.0005 h.

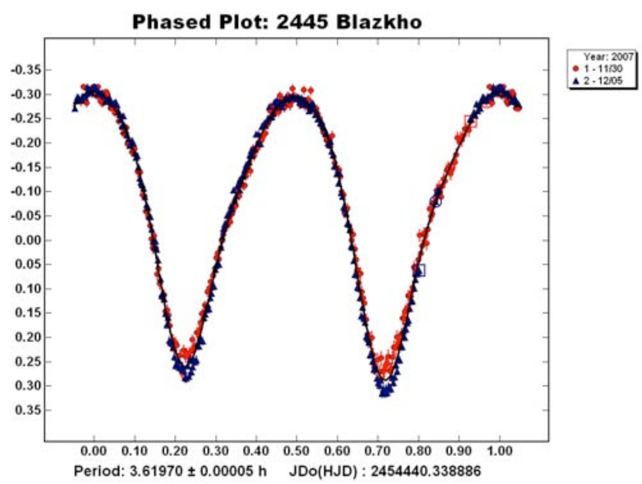
References

Harris, A.W., Warner, B.D. (2006). "Minor Planet Lightcurve Parameters." Updated March 14, 2006. http://cfa-www.harvard.edu/iau/lists/LightcurveDat.html

Warner, B.D. (2006). MPO Software, Canopus version 9.3.1.0, Bdw Publishing, http://minorplanetobserver.com/

Warner, B.D. et al. (2007). Lightcurve Photometry Opportunities Sept.-Oct. 2007, http://minorplanetobserver.com/

UT Date	R.A.	Dec.	V
2007 Nov 30	04 14 46.6	+16 59 01	13.9
2007 Dec 05	04 09 18.8	+17 10 38	14.1



ASTEROID LIGHTCURVE ANALYSIS AT THE OAKLEY SOUTHERN SKY OBSERVATORY – OCTOBER 2007

Steven Torno, Robert Lemke Oliver,
Richard Ditteon
Rose-Hulman Institute of Technology CM 171
5500 Wabash Avenue
Terre Haute, IN 47803
ditteon@rose-hulman.edu

(Received: 7 December)

Photometric data were collected on nine asteroids during six nights of observing in October of 2007 at the Oakley Southern Sky Observatory. The asteroids were: 232 Russia, 967 Helionape, 1119 Euboea, 2291 Kevo, 3544 Borodino, 3628 Boznemcova, 3754 Kathleen, 4078 Polakis, and 8116 Jeanperrin.

The Oakley Southern Sky Observatory is a brand new facility and this paper presents our first results. The observatory is located adjacent to Siding Spring Observatory near Coonabarabran in New South Wales, Australia. It houses a 20-inch Ritchey-Chretien optical tube assembly mounted on a Paramount ME. The CCD camera is a Santa Barbara Instrument Group STL-1001E camera with a clear filter. The image scale is 1.2 arcseconds per pixel. The entire observatory is operated via the internet using custom software written for that purpose.

The exposure times were two minutes for all images. The images were transferred automatically back to Rose-Hulman as they were being recorded. Calibration of the images was done using master twilight flats, darks, and bias frames. All calibration frames were created using CCDSoft. MPO Canopus was used to measure the processed images.

Nine main-belt asteroids were observed over the course of six nights in October 2007. Two asteroids were observed on the nights of October 9, 11, and 12, three were observed on all six nights (October 9 and 11-15), and four were observed on the nights of October 13-15. From the data that were collected, we were able to find lightcurves for six asteroids. Out of the six lightcurves, one was within experimental uncertainty of a previously published period, and five were previously unrecorded results.

Selection of asteroids was based on their sky position about one hour after sunset. Asteroids without previously published lightcurves were given higher priority than asteroids with known periods, but asteroids with uncertain periods were also selected in the hopes that we would be able to validate previous results.

As far as we are aware, these are the first reported observations for

Number	Name	Dates (2007)	Data Points	Period (h)	P.E. (h)	Amp. (mag)	A.E. (mag)
232	Russia	10/13-10/15	38	21.8	0.2	0.2	0.02
967	Helionape	10/13-10/15	45	Not found		0.20	0.05
1119	Euboea	10/9, 10/11-10/15	133	11.41	0.01	0.5	0.02
2291	Kevo	10/9, 10/11-10/15	116	11.971	0.008	0.32	0.03
3544	Borodino	10/9, 10/11, 10/12	85	5.44	0.01	0.65	0.04
3628	Boznemcova	10/13-10/15	42	Not found		0.17	0.04
3754	Kathleen	10/9, 10/11-10/15	89	11.2	0.1	0.2	0.04
4078	Polakis	10/9, 10/11, 10/12	91	4.831	0.003	0.38	0.02
8116	Jeanperrin	10/13-10/15	34	Not found		0.28	0.05

the period of the following asteroids: 232 Russia, 1119 Euboea, 2291 Kevo, 3544 Borodino, and 4078 Polakis. No repeatable pattern was found for the following asteroids: 967 Helionape, 3628 Boznemcova, and 8116 Jeanperrin. This was due to noisy data and a less-than-ideal number of data points.

All results are listed in the table below. Comments have been included if they were necessary.

232 Russia. With the data gathered, we are reasonably certain that this is a long-period asteroid (20+ hours).

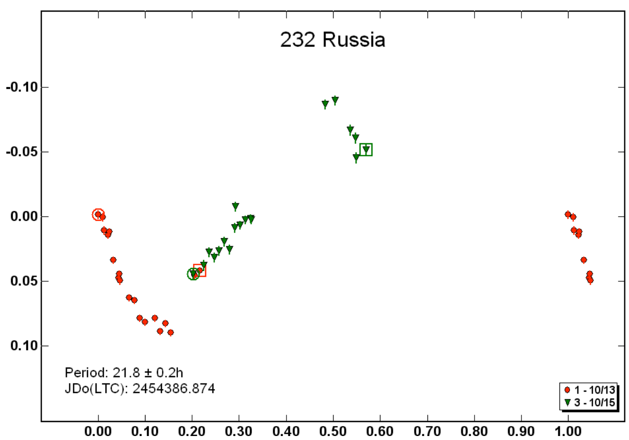
3754 Kathleen. Our data agrees with the 11.1624 ± 0.0096 h period reported by Behrend (2004).

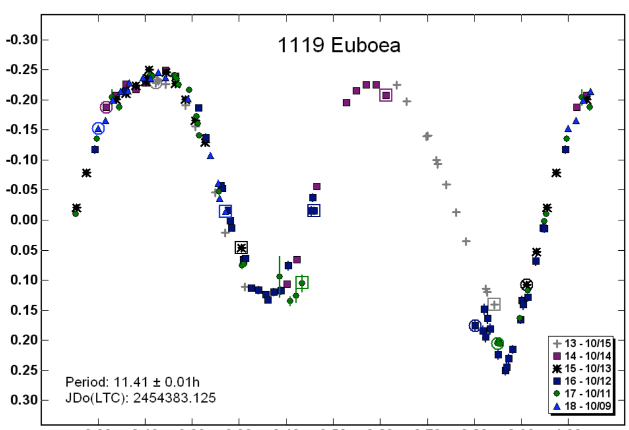
Acknowledgement

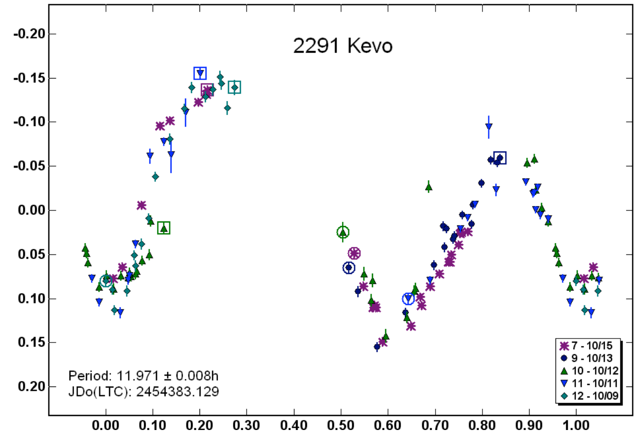
Construction of the Oakley Southern Sky Observatory was funded by a grant from the Oakley Foundation and a generous donation by Niles Noblitt.

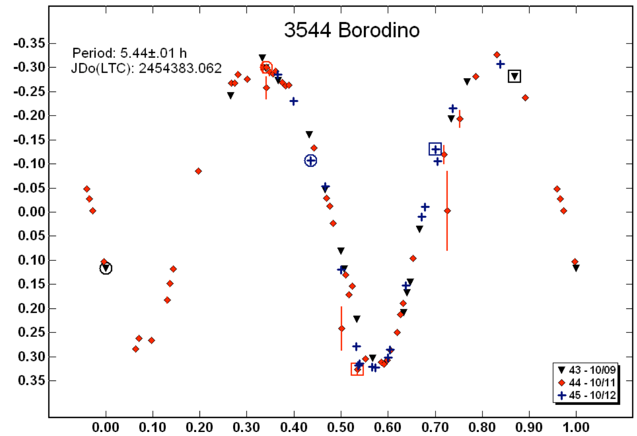
References

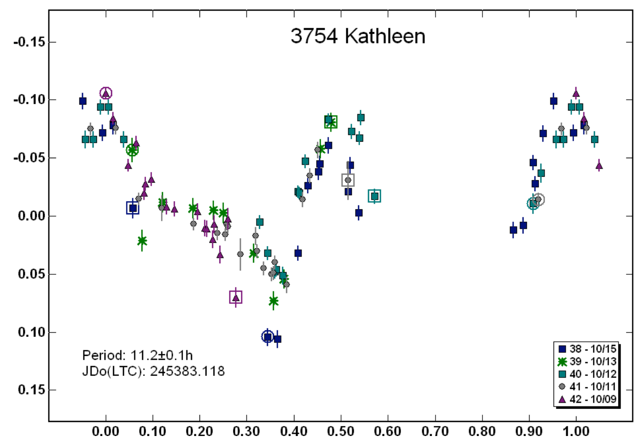
Behrend, R. (2004).
http://obswww.unige.ch/~behrend/page_cou.html

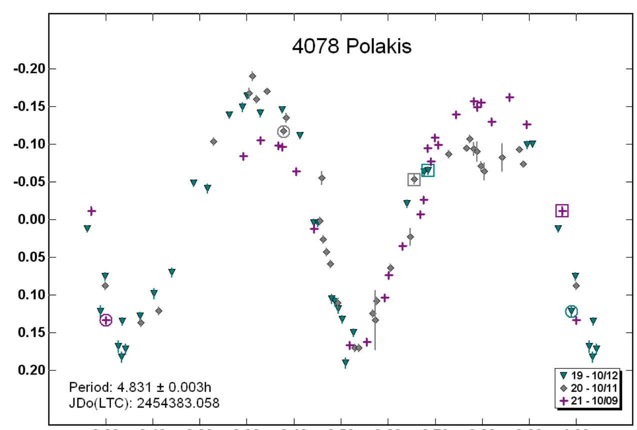












ASTEROID LIGHTCURVE ANALYSIS AT THE PALMER DIVIDE OBSERVATORY – JUNE - OCTOBER 2007

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

(Received: 14 October)

Lightcurves for seventeen asteroids were obtained at the Palmer Divide Observatory from June through September 2007: 176 Iduna, 252 Clementina, 365 Corduba, 589 Croatia, 607 Jenny, 639 Latona, 756 Liliana, 1222 Tina, 1436 Salonta, 3628 Boznemcova, 3873 Roddy, 4483 Petofi, (8348) 1988 BX, (42811) 1999 JN81, (46436) 2002 LH5, (74590) 1999 OG2, and (114728) 2003 HP3. Evidence of 3873 Roddy being a binary asteroid is discussed.

Observations of seventeen asteroids were made at the Palmer Divide Observatory from June through September 2007. One of four telescopes/camera combinations was used: 0.5m Ritchey-Chretien/FLI IMG-1001E, 0.35m SCT/FLI IMG-1001E, 0.35m SCT/ST-9E, or 0.35m SCT/STL-1001E. The scale for each was about 2.5 arcseconds/pixel. Exposure times were 20–300s. Observations were made with a Clear filter. Guiding was used when exposures exceeded 60 seconds.

All images were measured using MPO Canopus, which employs differential aperture photometry to determine the values used for analysis. Period analysis was done using 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 hour and magnitudes. An "(H)" follows the name of an asteroid in the table if it is a member of the Hungaria group or family.

176 Iduna. Hansen (1997) reported a period of 11.289 hr while Riccioli (2001) found 5.630 hr. This asteroid was worked to see if it was possible to determine which period was correct. The data obtained at PDO showed a period of 11.309 ± 0.005 hr, confirming Hansen's findings.

365 Corduba. Ivarsen (2004) previously reported a period of 6.354 hr. The data were tested against this period but one of 6.551 ± 0.002 hr had a slightly lower RMS. This should be tempered by the fact that the PDO lightcurve amplitude was only 0.05 mag and so the period solution could easily be affected by noise in the data or small errors in the zero-point offsets among the sessions.

607 Jenny. The author previously worked this asteroid in 2002 (Warner 2003) where a period of 7.344 hr was reported. Analysis of the data obtained in 2007 showed that a more likely solution is 8.542 ± 0.005 hr. The 2002 data were phased to the original and new periods and the new one gave a better fit to the data. Fitting the 2007 data to the shorter period removed any doubt that 7.344 hr was incorrect. The explanation is probably due to the fact that, in 2002, additional data were obtained 10 days after the first set while, in 2007, a span of four days was involved. The longer span between observing sets lead to a one-half rotation ambiguity.

639 Latona. Previous periods reported for this asteroid (Binzel 1987, Riccioli 2001) were approximately 6.2 hrs. The 6.193 hr period found here confirms those findings.

756 Liliana. Behrend et al. (2007) report a period of 6.152 hr while Szekely (2005) reported 9.362 hr. The PDO data showed a period of 9.262 ± 0.001 hr. Attempting to fit the PDO data to either period proved fruitless. The original Behrend data was very sparse while Szekely had more data. At the time he observed, the

#	Name	Date Range (mm/dd) 2007	Data Pts	Phase	L_{PAB}	B_{PAB}	Per (h)	PE	Amp (m)	AE
176	Iduna	09/26-27	480	11.6	340	17	11.309	0.005	0.38	0.02
252	Clementina	06/24-07/23	266	7.7,15.0	254	10	10.862	0.001	0.44	0.03
365	Corduba	07/23-08/31	234	9.0,18.1	284	15	6.551	0.002	0.05	0.01
589	Croatia	07/23-08/31	201	14.4,18.3	259	12	11.7	0.1	0.16	0.02
607	Jenny	09/26-10/01	146	5.4,6.5	355	12	8.524	0.005	0.21	0.03
639	Latona	09/26-10/01	143	5.1,6.0	359	11	6.193	0.002	0.08	0.01
756	Liliana	07/23-08/26	363	9.3,12.4	304	24	9.262	0.001	0.83	0.03
1222	Tina	08/27-09/05	677	16.5,15.1	347	27	13.395	0.003	0.18	0.02
1436	Salonta	08/31-09/02	196	6.7	338	17	8.870	0.004	0.33	0.02
3628	Boznemcova	09/02-09/19	337	15.8,6.3	1	-4	3.335410	0.000057	0.13	0.02
3873	Roddy (H)	08/09-09/13	531	24.1,18.1	356	31	2.4792	0.0002	0.10	0.02
4483	Petofi (H)	06/24-07/13	155	24.1,26.9	259	37	4.33309	0.00006	1.03	0.02
8348	1988 BX (H)	09/05-10/03	486	23.1,21.2	3	28	n/a	n/a	0.10	0.03
42811	1999 JN81 (H)	07/16-21	168	29.8,30.4	288	38	3.902	0.001	0.14	0.03
46436	2002 LH5	08/11-26	229	16.0,14.5	332	19	3.884	0.002	0.46	0.02
74590	1999 OG2 (H)	09/11-10/04	435	8.6,12.2	354	6	33.273	0.003	0.65	0.02
114728	2003 HP3	10/03	48	11.7	354	3	3.33	0.06	0.20	0.03

lightcurve was close to symmetrical, much more so than the PDO curve. Reviewing the span between observing sessions for Szekely, it appears that he might have encountered a half-rotation ambiguity just as described above for 607 Jenny. The decided asymmetry of the PDO lightcurve helped reveal the possible error. It's the author's opinion that, small as the difference may be, the new period of 9.262 hr be adopted.

1222 Tina. Behrend et al. (2007) report a period of 17.164 hrs. The period found here is 13.395 ± 0.003 hr. Fits to or near the longer period using the PDO data were decidedly wrong.

3628 Boznemcova. This asteroid was worked in cooperation with Richard Binzel et al. to determine the accurate period and lightcurve phase in preparation for observations with the IRTF.

3873 Roddy. The author worked this asteroid in 2006 (Warner 2006) and found a period of 2.4782 hr. Observations on August 9 and 10, 2007, showed unexpected deviations that could not be explained as observation errors. The primary period (see below) was found to be 2.4792 ± 0.0002 hr with a monomodal curve. A bimodal curve with double the period also fit, however the data from 2006 showed a forced-quadramodal curve when fitted to the longer period and so that period was rejected. A dual-period analysis showed the possibility of mutual events due to a satellite with an approximate orbital period of either 23.8 or 47.3 hr. The larger of the two events was about 0.20 mag deep while the smaller was about 0.15 mag deep. This implies an upper-limit size ratio Dsat/Dprimary of 0.36. Additional observations over several weeks failed to capture additional events, therefore the binary nature cannot be confirmed. Future observations are strongly encouraged to help resolve the issue.

4483 Petofi. The period found here is 4.33309 ± 0.00006 hr. This differs slightly from that found by Angeli (1996, 4.480 hr) and Wisniewski (1997, 4.4 hr). Angeli's paper had a sparse data set while the Wisniewski data consisted of one night's run. In the latter paper's discussion on this asteroid, the authors say that their data alone indicated a period near 4.3 hr and that the Angeli period might be due to a cycle ambiguity. For this reason, a compromise period of 4.4 ± 0.1 hr was adopted, one that covered both possibilities as well as the period found here.

(8348) 1988 BX. The plot is phased to a period of 38.56 hr but that cannot be considered reliable. A number of other solutions were found, including 54.8 hr. The data seemed to have higher frequencies (shorter periods) but all attempts to find periods shorter than 20 hours met with no success.

(114728) 2003 HP3. This was in the same field as 74590 on October 03. Its faintness and other targets prevented any follow-up.

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.

References

Angeli, C.A., and Barucci, M.A. (1996). *Planetary and Space Sci.* **44**, 181-186.

Behrend, R. (2007). Observatoire de Geneve web site, http://obswww.unige.ch/~behrend/page_cou.html

Binzel, R.P. (1987). *Icarus* **72**, 135-208.

Hansen, A.T., Arentoft, T. (1997). *Minor Planet Bul.* **24**, 14.

Harris, A.W., Young, J.W., Bowell, E., Martin, L.J., Millis, R.L., Poutanen, M., Scaltriti, F., Zappala, V., Schober, H.J., Debehogne, H., and Zeigler, K.W. (1989). "Photoelectric Observations of Asteroids 3, 24, 60, 261, and 863." *Icarus* **77**, 171-186

Harris, A.W., Warner, B.D., Pravec, P. (2007) Asteroid Lightcurve Parameters,

http://www.MinorPlanetObserver.com/astlc/default.htm.

Ivarsen, K., Willis, S., Ingleby, L., Matthews, D., and Simet, M. (2004). *Minor Planet Bul.* **31**, 29-33.

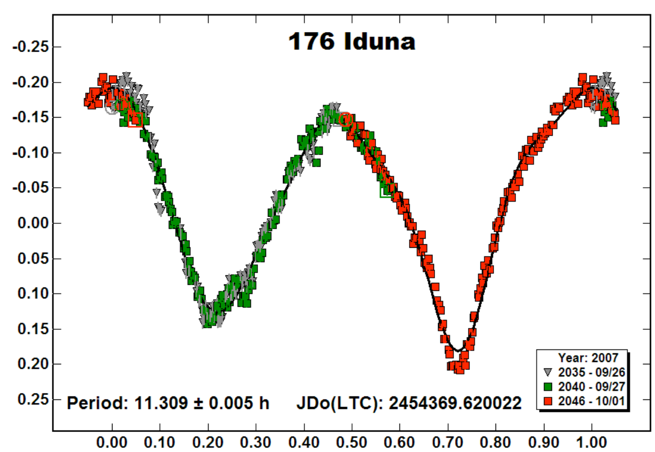
Riccioli, D., Blanco, C., and Cigna, M. (2001). *Planetary and Space Sci.* **49**, 657-671.

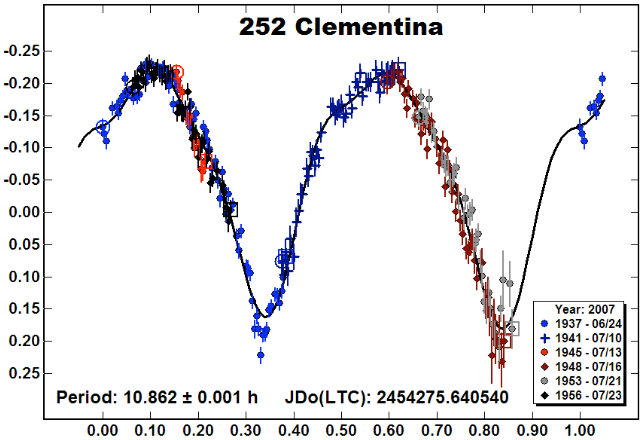
Szekely, P., Kiss, L.L., Szabo, Gy.M., Sarneczky, K., Csak, B., Varadi, M., and Meszaros, Sz. (2005). *Planetary and Space Sci.* **53**, 925-936.

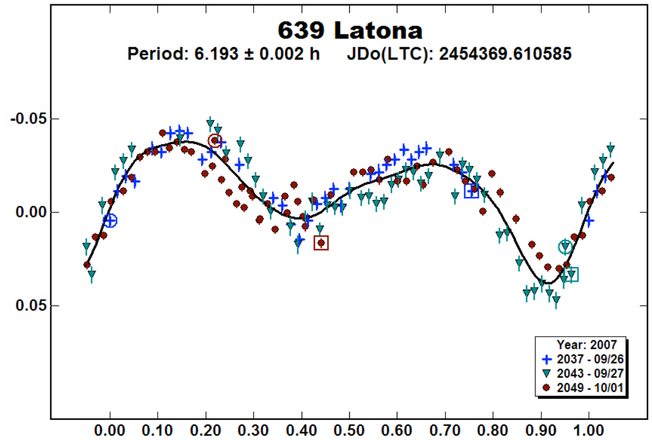
Warner, B.D. (2003). *Minor Planet Bul.* **30**, 33-35.

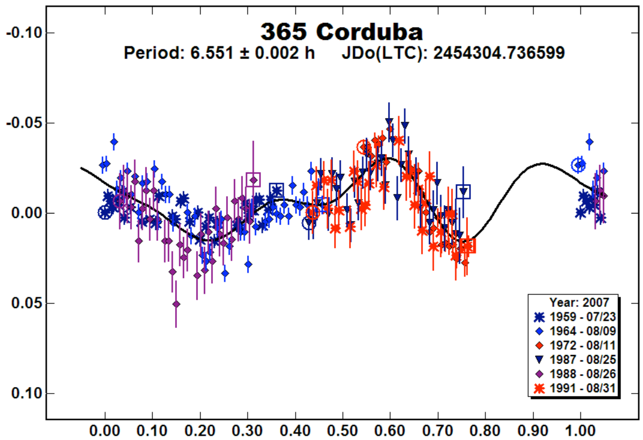
Warner, B.D. (2006). *Minor Planet Bul.* **33**, 58-62.

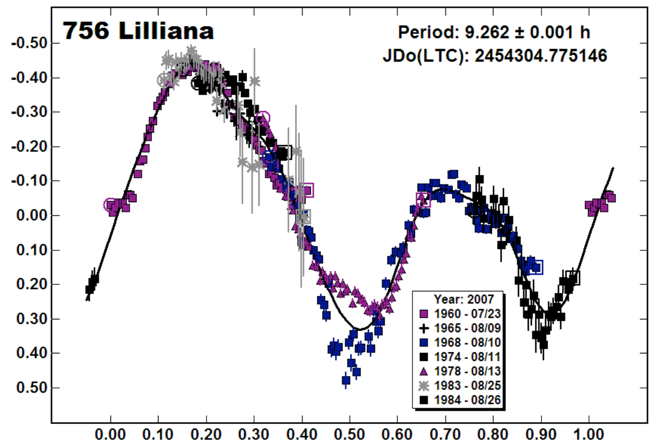
Wisniewski, W.Z., Michalowski, T.M., Harris, A.W., McMillan, R.S. (1997). *Icarus* **126**, 395-449.

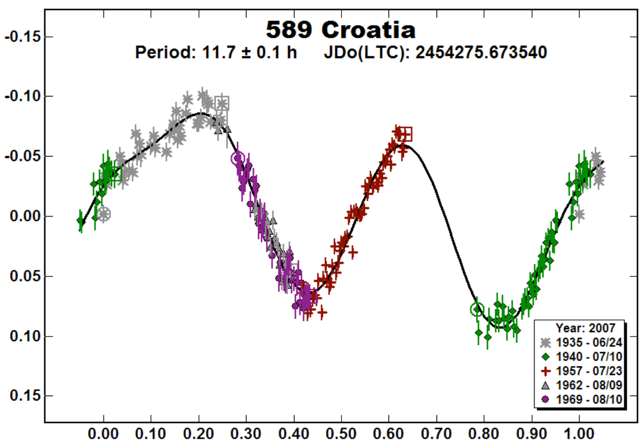


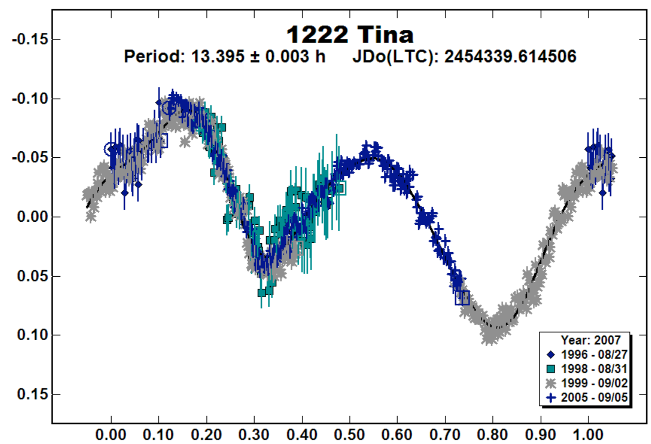

252 Clementina
Period: 10.862 ± 0.001 h
JDo(LTC): 2454275.640540
Year: 2007
1937 - 06/24
1941 - 07/10
1945 - 07/13
1948 - 07/16
1953 - 07/21
1956 - 07/23

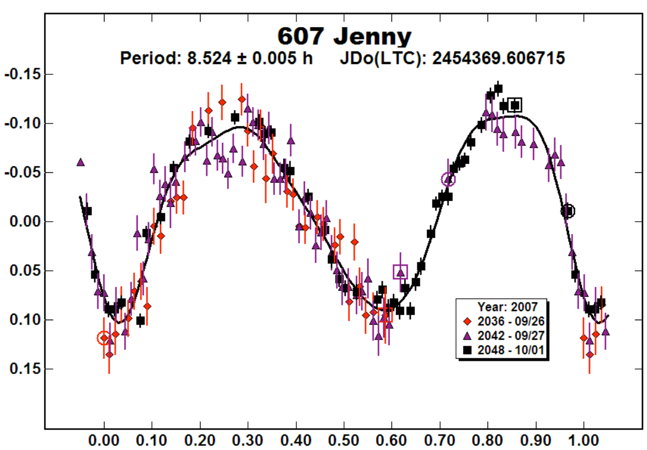

639 Latona
Period: 6.193 ± 0.002 h
JDo(LTC): 2454369.610585
Year: 2007
2037 - 09/26
2043 - 09/27
2049 - 10/01

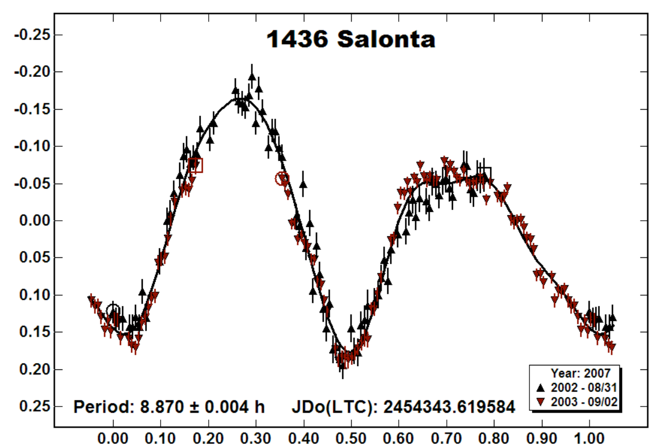

365 Corduba
Period: 6.551 ± 0.002 h
JDo(LTC): 2454304.736599
Year: 2007
1959 - 07/23
1964 - 08/09
1972 - 08/11
1987 - 08/25
1988 - 08/26
1991 - 08/31

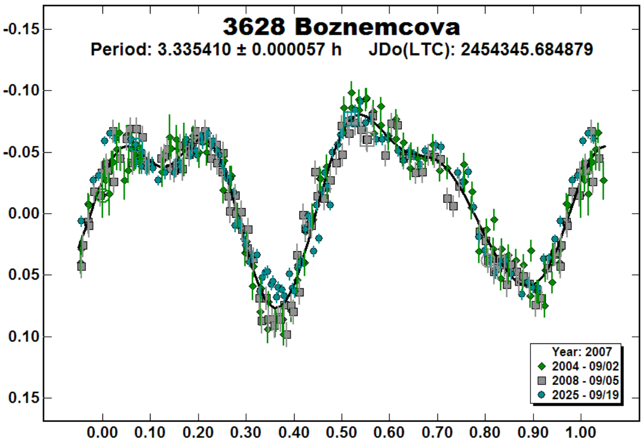

756 Lilliana
Period: 9.262 ± 0.001 h
JDo(LTC): 2454304.775146
Year: 2007
1960 - 07/23
1965 - 08/09
1968 - 08/10
1974 - 08/11
1978 - 08/13
1983 - 08/25
1984 - 08/26

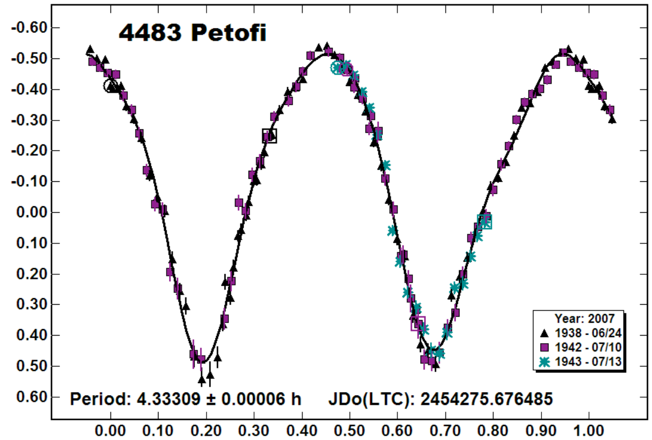

589 Croatia
Period: 11.7 ± 0.1 h
JDo(LTC): 2454275.673540
Year: 2007
1935 - 06/24
1940 - 07/10
1957 - 07/23
1962 - 08/09
1969 - 08/10

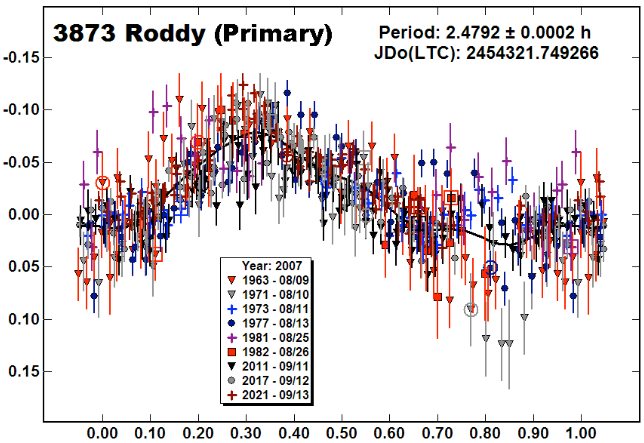

1222 Tina
Period: 13.395 ± 0.003 h
JDo(LTC): 2454339.614506
Year: 2007
1996 - 08/27
1998 - 08/31
1999 - 09/02
2005 - 09/05

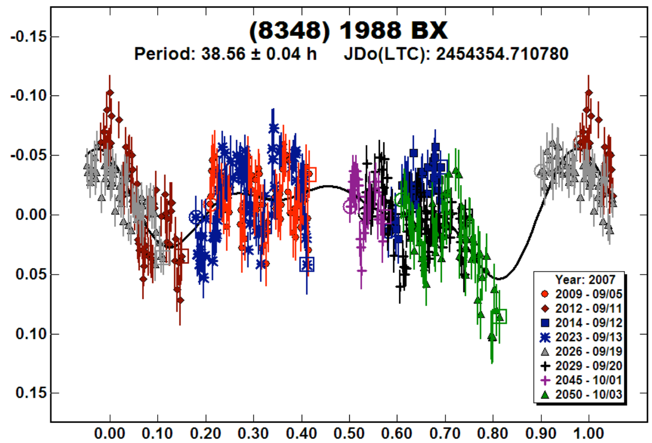

607 Jenny
Period: 8.524 ± 0.005 h
JDo(LTC): 2454369.606715
Year: 2007
2036 - 09/26
2042 - 09/27
2048 - 10/01

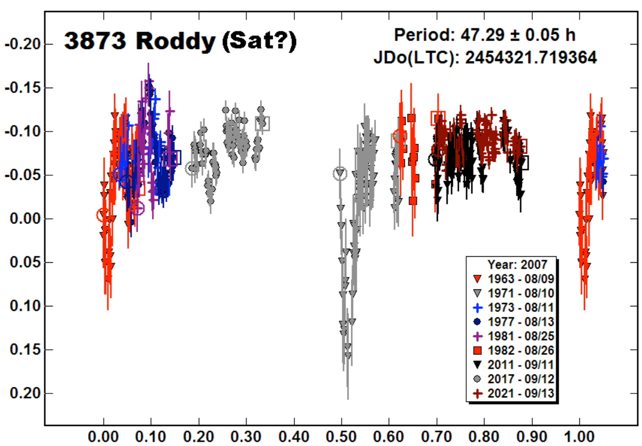

1436 Salonta
Period: 8.870 ± 0.004 h
JDo(LTC): 2454343.619584
Year: 2007
2002 - 08/31
2003 - 09/02

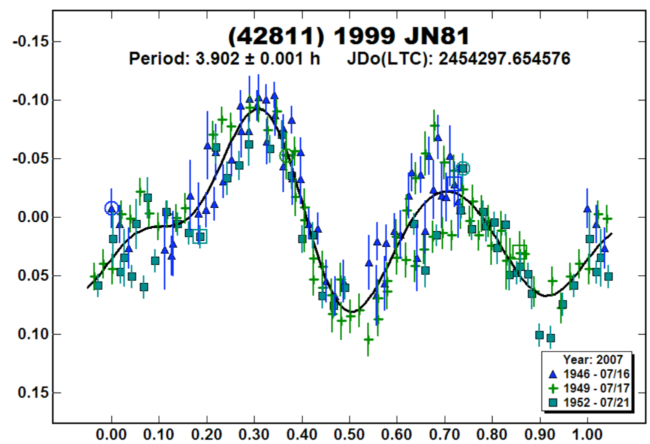

3628 Boznemcova
Period: 3.335410 ± 0.000057 h JDo(LTC): 2454345.684879
Year: 2007
2004 - 09/02
2008 - 09/05
2025 - 09/19

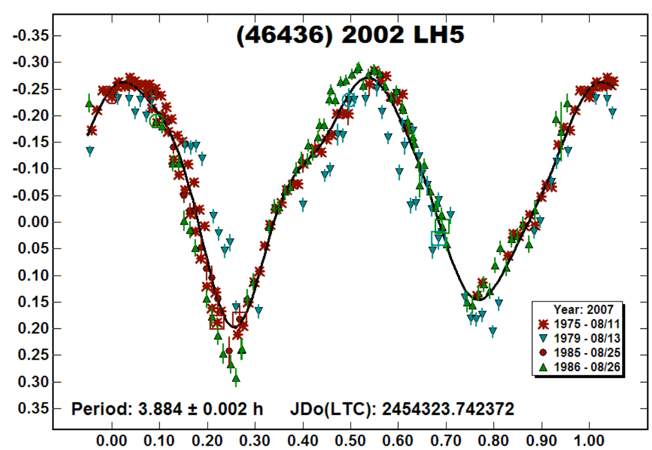

4483 Petofi
Period: 4.33309 ± 0.00006 h JDo(LTC): 2454275.676485
Year: 2007
1938 - 06/24
1942 - 07/10
1943 - 07/13

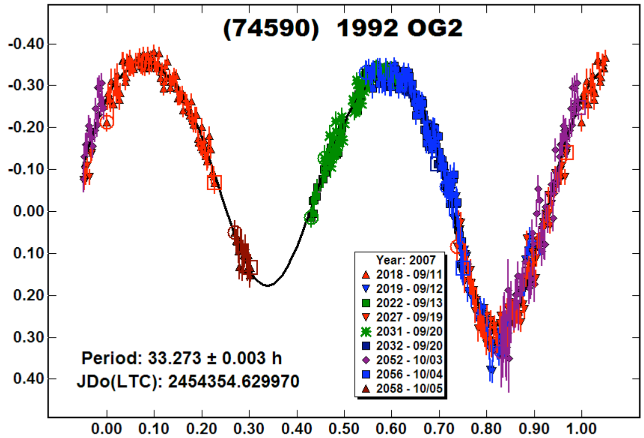

3873 Roddy (Primary)
Period: 2.4792 ± 0.0002 h
JDo(LTC): 2454321.749266
Year: 2007
1963 - 08/09
1971 - 08/10
1973 - 08/11
1977 - 08/13
1981 - 08/25
1982 - 08/26
2011 - 09/11
2017 - 09/12
2021 - 09/13

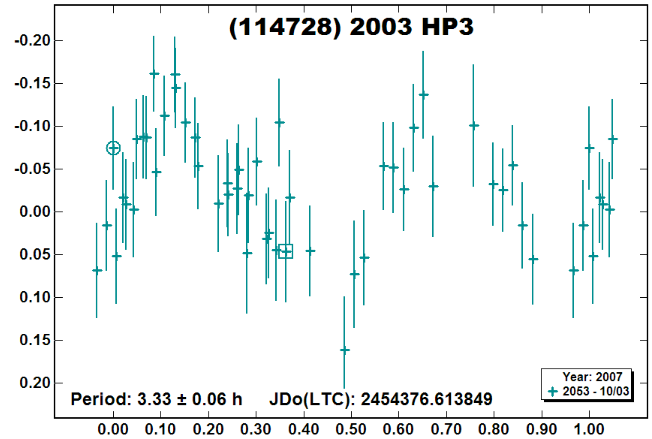

(8348) 1988 BX
Period: 38.56 ± 0.04 h JDo(LTC): 2454354.710780
Year: 2007
2009 - 09/05
2012 - 09/11
2014 - 09/12
2023 - 09/13
2026 - 09/19
2029 - 09/20
2045 - 10/01
2050 - 10/03


3873 Roddy (Sat?)
Period: 47.29 ± 0.05 h
JDo(LTC): 2454321.719364
Year: 2007
1963 - 08/09
1971 - 08/10
1973 - 08/11
1977 - 08/13
1981 - 08/25
1982 - 08/26
2011 - 09/11
2017 - 09/12
2021 - 09/13


(42811) 1999 JN81
Period: 3.902 ± 0.001 h JDo(LTC): 2454297.654576
Year: 2007
1946 - 07/16
1949 - 07/17
1952 - 07/21


(46436) 2002 LH5
Period: 3.884 ± 0.002 h JDo(LTC): 2454323.742372
Year: 2007
1975 - 08/11
1979 - 08/13
1985 - 08/25
1986 - 08/26





ASTEROIDS OBSERVED FROM GMARS AND SANTANA OBSERVATORIES – LATE 2007

Robert D. Stephens
Goat Mountain Astronomical Research Station (GMARS)
11355 Mount Johnson Court, Rancho Cucamonga, CA 91737
RStephens@foxandstephens.com

(Received: 3 January)

Lightcurve period and amplitude results from Santana and GMARS Observatories are reported for 2007 April to June: 180 Garumna (23.890 ± 0.005 h and >0.3 mag.), 493 Griseldis (51.940 ± 0.006 h and 0.43 mag.), 905 Universitas (14.238 ± 0.001 h and 0.31 mag.), 959 Arne (123.7 ± 0.1 h and 0.25 mag.)

The author operates telescopes at two observatories. Santana Observatory (MPC Code 646) is located in Rancho Cucamonga, California and GMARS (Goat Mountain Astronomical Research Station, MPC G79) located at the Riverside Astronomical Society's observing site. Stephens (2006) gives equipment details.

The targets were selected from the list of asteroid photometry opportunities published by Brian Warner and Alan Harris on the Collaborative Asteroid Lightcurve Link (CALL) website (Harris 2007). The author measured the images using MPO Canopus, which employs differential aperture photometry to produce the raw data. Period analysis was done using Canopus, which incorporates the Fourier analysis algorithm (FALC) developed by Harris (1989). All of the targets were suspected of having long periods. For that reason, a new method developed by Warner (2007) and described by Stephens (2008) included in the latest release of Canopus was used to calibrate each session to an internal standard.

180 Garumna. Garumna was reported to have a period of 23.859 h (Behrend 2007). The period obtained here of 23.890 is in good agreement. Because of the close match to 24 hours, only a fraction of the curve could be obtained, including only one extrema. A lower limit of 0.3 magnitude is found, with the actual value likely in the range between 0.4 and 0.5 magnitudes.

905 Universitas. Universitas was previously reported to have a rotational period of 10 h (Wisniewski et al., 1997). Wisniewski and Tedesco (1979) both reported short single night lightcurves of similar appearance. These five lightcurves spanning nine nights present an unambiguous result.

959 Arne. Arne was previously reported to have a period of 8.60 h (Robinson 2002). However, the sparse lightcurve was noisy (Q=1). Immediately apparent from our long sessions showing no extrema was that Arne had a long period. Eventually, several extrema were detected. Using the new method to internally link the sessions together, a period of 123.7 h was derived.

Acknowledgements

Thanks are given to Dr. Alan Harris of the Space Science Institute, Boulder, CO, and Dr. Petr Pravec of the Astronomical Institute, Czech Republic, for their ongoing support of all amateur asteroid. Also, thanks to Brian Warner for his continuing work and enhancements to the software program MPO Canopus, which makes it possible for amateur astronomers to analyze and collaborate on asteroid rotational period projects and for maintaining the CALL Web site which helps coordinate collaborative projects between amateur astronomers.

References

Behrend, R. (2007) Observatoire de Geneve web site, *http://obswww.unige.ch/~behrend/page_cou.html.*

Tedesco, E.F. (1979). PhD Dissertation, New Mex. State Univ.

Robinson, L.E. (2002). "Photometry of Five Difficult Asteroids: 309 Fraternitas, 366 Vincentina 421 Zahringia, 578 Happelia, 959

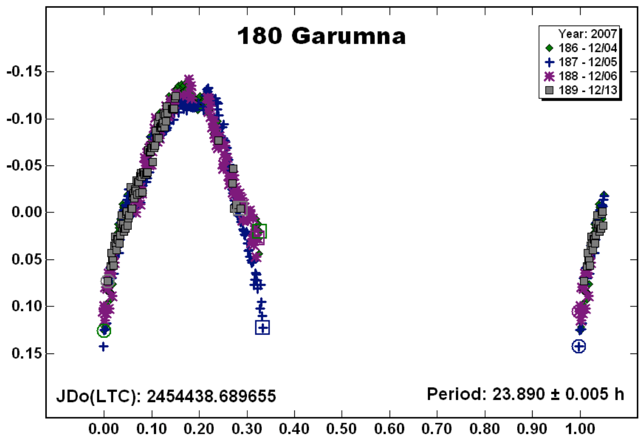
Asteroid	Dates (2007) mm/dd	Sess	Phase	L_{PAB}	B_{PAB}	Per (h)	PE	Amp	AE
180 Garumna	12/04-13	4	8.7,4.2	88.3,88.7	0.8	23.890	0.005	>0.3	
493 Griseldis	09/12-10/09	17	10.2,2.8	11.8,12.3	3.1,5.4	51.940	0.006	0.43	0.03
905 Universitas	10/11-20	5	3.4,1.6,3.2	21.4,22.1	-2.4,-1.9	14.238	0.001	0.31	0.03
959 Arne	10/31-12/03	19	5.8,0.5,9.3	49.2,50.5	-1.2,-0.3	123.7	0.1	0.25	0.05

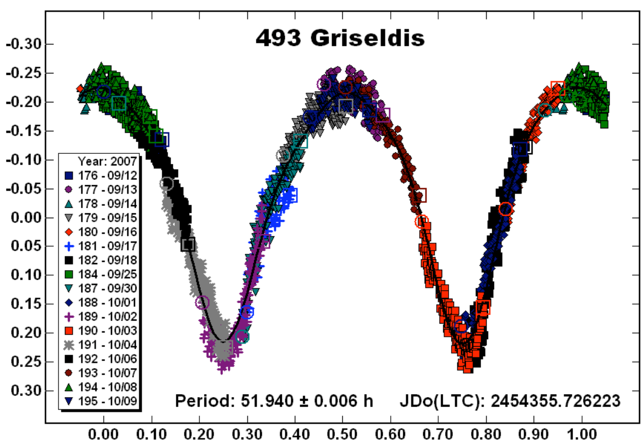
Anne". *Minor Planet Bulletin* **29**, 30-31.

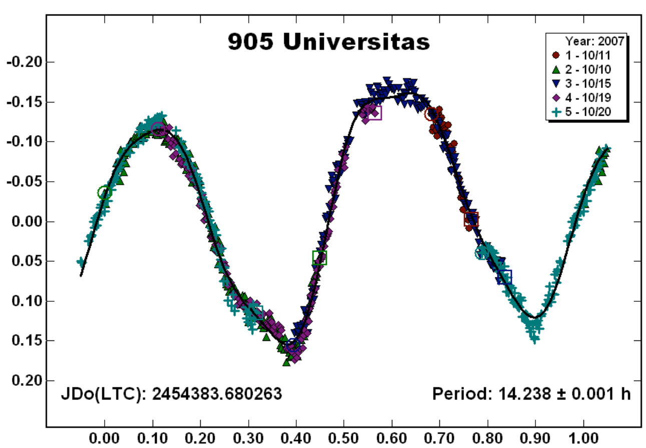
Stephens, R.D. (2006). "Asteroid Lightcurve Photometry From Santana and GMARS Observatories – September to December 2006". *Minor Planet Bulletin* **34**, 31-32.

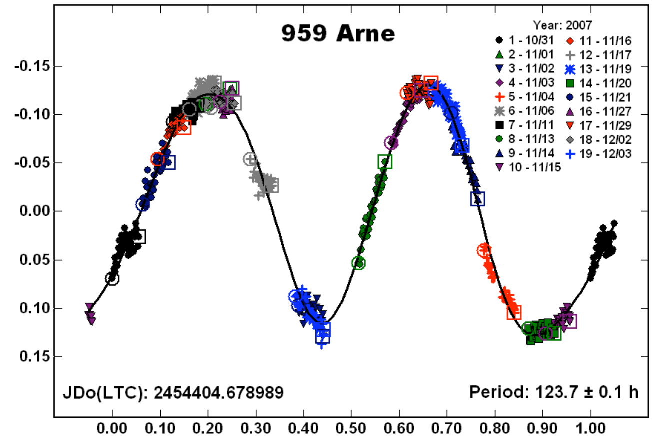
Stephens, R.D. (2008). "Long Period Asteroids Observed from GMARS and Santana Observatories". *Minor Plan. Bull.* **35**, 31-32.

Wisniewski, W. Z., Michalowski, T. M., Harris, A. W., and McMillan, R. S. (1997). "Photometric Observations of 125 Asteroids." *Icarus* **126**, 395-449.









LIGHTCURVE PHOTOMETRY AND SEARCH FOR COMETARY ACTIVITY OF NEA 2007 PU11

Albino Carbognani
Saint-Barthelemy Observatory
Lignan 39, 11020 Nus (Aosta) ITALY
albino.carbognani@alice.it

Petr Pravec
Astronomical Institute
Ondrejov, CZECH REPUBLIC

Yurij N. Krugly
Institute of Astronomy of Kharkiv National University
Kharkiv 61022, UKRAINE

Donald P. Pray
Carbuncle Hill Observatory
Coventry, RI, USA

Štefan Gajdoš
Modra Observatory
842 48 Bratislava, SLOVAKIA

Ninel M. Gaftonyuk
Crimean Astrophysical Observatory,
Simeiz, Crimea, UKRAINE

Ivan Slyusarev
Kharkiv National University
Kharkiv 61077, UKRAINE

(Received: 5 January)

The lightcurve period and amplitude, color indices, and absolute magnitude from a collaborative study are reported for Amor asteroid 2007 PU11: P = 56.8±0.1h; A=0.98±0.03 mag; B-V= 0.85±0.05; V-R= 0.44±0.03; R-I= 0.34±0.03; H= 16.39±0.12. A search for a cometary activity was made with negative results.

Observatories contributing photometry data to this report: Saint Barthelemy (0.81-m f/7.9 reflector, FLI 1001E CCD), Kharkiv (0.7-m f/4 reflector, IMG47-10 CCD), Carbuncle Hill (0.50-m f/4 reflector, ST-10XME CCD), Modra (0.6-m f/5.5 reflector, AP8p CCD), and Simeiz (1.0-m f/13 reflector, Apogee Alta U42 CCD).

Observations were initially started at Kharkiv Observatory on 2007 October 9-12. It became apparent that the period was longer than 24 hours while the amplitude was about 1 magnitude. The asteroid was subsequently observed from Modra Observatory on October 16/17 for 8 hours, Saint Barthelemy Observatory between October 17-21 and November 30, Carbuncle Hill Observatory on October 21/22, and Simeiz Observatory on November 20. The observers from Kharkiv, Modra, Carbuncle Hill, and Simeiz were participating in the "Photometric Survey for Asynchronous Binary Asteroids" coordinated by Pravec (2005). On November 30 the data collected from St. Barthelemy (not sufficient to determine the value of the period), were sent to Pravec, who created a combined data set and was able to determine the synodic period (Figure 1). The period solution is unique, U = 3, so there is no ambiguity and the data fit well with the estimated period.

The mean amplitude of the two minima was 0.93 mag. The large amplitude and uneven minima were probably caused by a combination of: (1) the elongated shape of the asteroid; (2) shadowing effects causing one minimum appearing deeper than the other one; (3) an increase of shadowing effects at the moderate phase angle of the observations. We estimated an approximate lower limit of the equatorial elongation of the asteroid by first correcting the mean amplitude of the two minima (0.93 mag) observed at phase angle 16° to 0° phase angle using the empirical formula by Zappala et al. (1990):

$$A(0°) = A(\alpha)/(1 + m\alpha) \qquad (1)$$

where α is phase angle of observations, and m is a slope parameter. Using m = 0.03/deg, the mean value for S-type asteroids, we found A(0°) = 0.63. This gives an approximate lower limit on the asteroid's equatorial elongation of 1.8.

Observations from Kharkiv Observatory were also taken in B, V, and I bands. After calibration, the following color indices were found: B-V = 0.85 ± 0.05; V-R = 0.44 ± 0.03; R-I = 0.34 ± 0.03. These are typical of an S-type type asteroid. With the calibrated V values and setting the slope parameter G = 0.23, the mean value of an S-type asteroid, we derived a mean absolute magnitude of H = 16.39 ± 0.12 (see Wisniewski et al., 1997; Warner, 2007). It was not possible to establish a definitive G value because there were no data sufficiently near 0° phase, which is required for a proper fit. Finally, using the derived H value and assuming a geometric albedo p_v = 0.18 ± 0.06, in agreement with the asteroid's color indices (Wisniewski et al., 1997), we estimate a mean effective diameter of 1.7 km, ± 26%.

2007 PU11 is on a 4.75 year heliocentric orbit, with perihelion at 1.26 AU and an eccentricity of 0.552. With these values, the Tisserand parameter with respect to Jupiter is T = 3.0. As a general rule (but there are exceptions), the Jupiter Family Comets have a Tisserand's parameter between 2 and 3 while most asteroids have T > 3 (see McFadden and Binzel, 2007). This puts 2007 PU11 on the boundary between asteroids and Jupiter comets. Around October 20, the heliocentric distance of 2007 PU11 was 1.274 AU, close enough to the Sun to present any residual cometary activity. A search for a possible weak coma around the object was made using the unfiltered images of October 18 and 20 from St. Barthelemy and the technique described by Masi et al. (2007). For each day, ten images were stacked (a total exposure of 600 seconds) with and without compensation of the apparent motion of the object. No meaningful deviation was found between the FWHM of 2007 PU11 (about 6 arcsec) and that of stars of similar magnitude in the same field of view.

Acknowledgments

Research on asteroids at St. Barthelemy Observatory is strongly supported by Director, Enzo Bertolini and funded with a European Social Fund grant from the Regional Government of the Regione Autonoma della Valle d'Aosta (Italy). Operations at Carbuncle Hill Observatory are aided by a 2007 Gene Shoemaker Grant from the Planetary Society. The work in Modra has been supported by the Slovak Grant Agency for Science VEGA, Grant 1/3074/06. Yu.N.K. was partly supported by the Main Astronomical Observatory of National Academy of Science of Ukraine.

References

Masi, G., Behrend, R., Buzzi, L., Cremaschini, C., Foglia, S., Galli, G., and Tombelli, M. (2007). "Observing program T3 Finding Comet in the Asteroid Population", *Minor Plan. Bull.* **34**, 123-124.

McFadden, L. and Binzel, R.P. (2007). "Near-Earth Objects" in *Encyclopedia of the Solar System*, pp 283-300. Elsevier.

Pravec, P. (2005). "Photometric Survey for Asynchronous Binary Asteroids" in *Proceedings of the Symposium on Telescope Science* (The 24th Annual Conference of the Society for Astronomical Science), B. D. Warner, D. Mais, D. A. Kenyon, J. Foote (Eds.). More information at the web address: http://www.asu.cas.cz/~asteroid/binastphotsurvey.htm

Warner, B.D. (2006). Lightcurve Photometry and Analysis. Springer.

Warner, B.D. (2007). "Initial Results from a dedicated H-G Project", *Minor Planet Bulletin* **34**, 113-119.

Wisniewski, W.Z., Michalowski, T.M., Harris, A.W., and McMillan, R.S. (1997). "Photometric observations of 125 asteroids", *Icarus* **126**, 395-449.

Zappalà, V., Cellino, A., Barucci, A.M., Fulchignoni, M., and Lupishko, D.F. (1990). "An analysis of the amplitude-phase relationship among asteroids", *Astronomy and Astrophysics* **231**, 548-560.

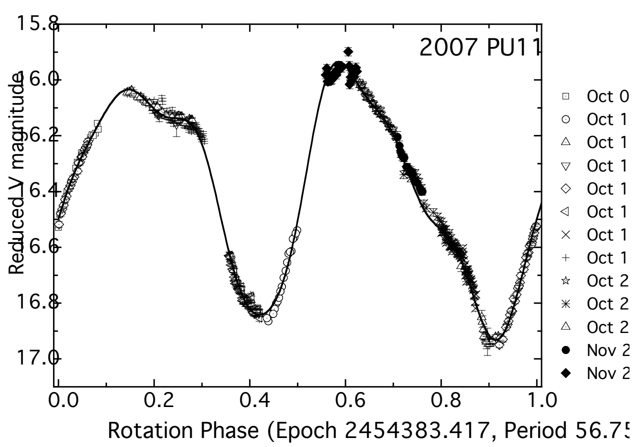


Figure 1. The lightcurve of 2007 PU11 shows a period of 56.8h with an amplitude of 0.98 mag.

SHAPE AND SPIN AXIS MODELS FOR 2 PALLAS (REVISITED), 5 ASTRAEA, 24 THEMIS, AND 105 ARTEMIS

Steven Higley
6385 Georgetown Court, Colorado Springs, CO 80919 USA
higleysteve@yahoo.com

Dr. Paul Hardersen
University of North Dakota, Grand Forks, ND 58202 USA

Ron Dyvig
Badlands Observatory, Quinn, SD 57775 USA

(Received: 3 December)

The authors made photometric observations of 2 Pallas, 5 Astraea, 24 Themis, and 105 Artemis during favorable oppositions from 2003 to 2006. This data, along with previously published lightcurve data available through the Standard Asteroid Photometric Catalogue (SAPC) and other sources, enabled lightcurve inversion to be done to determine the spin axis orientations, the shapes, and very accurate synodic rotation periods of these four minor planets. The results are reported.

Inverting lightcurve data into a shape and spin axis model for an asteroid took a major step forward in the last year with the publication of a Windows-based program, MPO LCInvert (Warner, 2006). Based on the algorithms and code of Mikko Kaasalainen and Josef Durech (Kaasalainen and Torppa, 2001; Kaasalainen et al., 2001; Kaasalainen and Durech, 2007), this advanced tool makes converting lightcurve data into 3-D models accessible to more advanced minor planet researchers without the need for understanding the complicated mathematics.

Criteria for coverage, needed rotation period accuracy and convergence used for this study are explained in the several Kaasalainen et al. references as well as Warner et al. (2007).

2 Pallas Revisited

Torrpa et al. (2003) determined the shape and rotation axis orientation of 2 Pallas. This study obtained lightcurves as a byproduct of extra telescope time during observations of 5 Astraea. In addition, Higley had observed 2 Pallas during the 1978 opposition at the San Diego State University Mount Laguna Observatory (MLO) using the MLO 16-inch (0.4-meter) telescope (an f/18 Cassegrain reflector manufactured by Boller & Chivens) equipped with an RCA 1P21 photomultiplier tube. These data (see Table 1) were added to the 51 lightcurves Torppa et al. (2003) used to explore differences, if any, additional data made.

The rotation period was nearly identical, 7.813222 h versus 7.813225 h, a difference of one-tenth of one second. Similarly, the axis of rotation was determined to be $\lambda = 35.6°$ $\beta = -12.6°$ versus $\lambda = 35°$ $\beta = -12°$ for the first solution and $\lambda = 193.1°$ $\beta = 44.2°$ versus $\lambda = 193°$ $\beta = -43°$ for the second solution. So the addition of data made no substantive difference in the rotation or axial orientation and indeed the shape itself was almost identical. One minor difference was that the first three iterative solutions all favored the retrograde solution and this solution had a χ^2 that was 1.3% lower than the prograde solution, reinforcing this solution as the more favored.

Figure 1 shows good agreement between the model and the unpublished 1978 lightcurve data. Figure 2 shows the shape model for the retrograde solution.

5 Astraea

Astraea was a challenging subject for shape modeling. Table 2 lists the light curve data used. Observations obtained from SAPC (1958 to 1987) were rather sparse, there being only 19 light curves, some of which were rather poorly observed. A literature search provided additional light curve observations from 1983 and 1987. Most welcome was the addition of data from three separate research teams whose leads shared data from the 1997 opposition. This study generated lightcurves from 2006-7. Even with this additional data, Astraea barely meets the criteria for phase and aspect spread.

In fact, there were problems getting the data to converge. The dark facet weight was increased from the default of 0.1 to ~1.0 in order to get the dark facet percentage below 1.0 percent for all model runs. This is indicative of possible minor albedo variations. With over 50 years of observations, getting a highly accurate rotation period was also paramount, and took a great deal of time. The default LCInvert processing time of 50 iterations was not enough for the best solutions, as they continued to significantly converge if the number of iterations was increased – up to 200. The best three solutions were considerably better than the rest. However, there was a significant disagreement between the best solution and the next two. Specifically, β was either ~50° or ~40°, a non-trivial 10° difference.

Having other sources and different types of data can be used to make the light curve inversion more robust. There have been previous pole determinations of Astraea done with other methods (Magnusson, et al., 1989; Harris and Warner, 2006). None of these models had β near 40°, but closer to 50° or –50°. The best solution also looked more realistic. The $\beta \approx 40°$ solutions appeared to be rotating about the long axis – a physical impossibility for a stable asteroid. Finally, there are two HST images and a four-chord occultation of Astraea that provide measurements of possible a/b and b/c ratios of 1.092, 1.128 and 1.097. A $\lambda = 123.8°$ $\beta = 49.7°$ solution, with a rotation period of 16.800828 h is the only solution of the best three that has aspects that match the real-world images.

As mentioned in Warner et al. (2007), a test of the soundness of any particular shape model is that the chi-square (χ^2) value be >10% lower than other solutions. This was the case for the best three solutions. Another test: compare the model lightcurve against the actual data. This is shown in Figure 3. Figure 4 shows the shape model for Solution #1. As can be seen in Figure 3, there is good agreement between the model and actual lightcurve data. There is similar agreement with the data from other oppositions.

Astraea seems to be a rather angular, roughly cut body. There is indication of minor albedo variegation, so the large, flat feature on the upper left of the 0° model aspect of Figure 4 may well be a crater accompanied by albedo markings.

24 Themis

Themis was a straightforward lightcurve inversion and convergence on a shape model occurred rapidly. Table 3 lists the light curve data used. The default dark facet weight of 0.1 kept the dark facet percentage below 1.0 percent for all model runs. The default LCInvert processing time of 50 iterations was sufficient for the best solutions. The best three solutions were considerably better than the rest, and in agreement with each other.

A λ = 120.3° β = 43.7° solution, with a rotation period of 8.37677 h is the best solution. Figure 5 shows good agreement between the model and actual lightcurve data. Figure 6 shows the shape model for the best solution.

Themis appears to be somewhat flattened with no indication of albedo variation across its surface. The flat area across the top of the 0° model aspect of Figure 6 may be a large crater.

105 Artemis

Artemis was observed at the request of Ellen Howell of Arecibo Observatory. The target was the subject of radar observations at that observatory and visual collaboration was requested to correlate radar observations with spectral observations taken at different times. Previous periods of 16.84 h (Schober et al, 1994) and 18.56 h (Schevchenko et al 2002) had been tentatively determined. This campaign determined that the period was in fact 37.16 h, a near-exact doubling of the period determined by Shevchenko et al (2002).

Artemis was of moderate difficulty. Not as difficult as 5 Astraea but requiring a longer iterative process (>100) to obtain an accurate rotation period and convergence on a solution, though the dark facet weight was kept at 0.1. Table 4 lists the light curve data used. Two solutions stood out from the rest: λ = 233.5° β = –42.5° and λ = 240.4° β = 8.9°, with a nearly identical rotation period of 37.15506 h. Since Artemis reaches very high ecliptic latitudes (i = 21.5°) these two pole solutions are approximately the prograde and retrograde solutions of one pole direction rather than the typical ambiguous pair (roughly $\lambda = \lambda + 180°$) typical of targets at low ecliptic latitudes. We prefer the retrograde solution as it has a stronger convergence. Figure 7 shows that there is agreement between the retrograde model and actual lightcurve data. Figure 8 shows the shape model for this solution as well.

Artemis appears to have a much flattened ellipsoidal model being shaped more like a hamburger than a hot dog. This is supported by the only previous determination of the triaxial ellipsoid model of 105 Artemis (Tungaglag et al., 2002) and by occultation data (Dunham, 1999; Sada and Pesnell, 2000). It should be noted, however, that the dimension along the rotational axis is not strongly constrained by this inversion method, especially for low amplitude data (Torppa et al, 2003). Artemis may have a less (or more) flattened shape by ± 10%. The shape model also shows evidence of at least one large crater (upper right of Z = +90° aspect) which is supported by occultation data (Sada and Pesnell, 2000). There is no evidence of significant albedo variation.

Acknowledgements

We wish to thank Brian Warner for his advice and for allowing us to be beta testers for the LCInvert software as well as helping us work through and learn the basic principals of lightcurve inversion.

We are also grateful to Bob Koff, David Higgins, Richard Ditteon, Vasilij Shevchenko, Carlo Blanco and Maria Lopez-Gonzales for sharing raw light curve data for this study.

References

Behrend, R. Observatoire de Geneve web site (2007). http://obswww.unige.ch/~behrend/page_cou.html, accessed 2006

Blanco, C., Cigna, M., and Riccioli, D. (2000). "Pole and shape determinaton of asteroids II." *Planetary and Space Science* **48**, 973-982.

Chang, Y.C. and Chang, C. (1962). *Acta Astronomica Sinica* **10**, 101-111.

Chernova, G. P., Lupishko, D. F. and Shevchenko, V. G. (1994). "Photometry and polarimetry of the asteroid 24 Themis." *Kinematika Fiz. Nebesn. Tel*, **10**, 45-49.

Debehogne, H., Lagerkvist, C.-I. and Zappala, V. (1982). "Physical studies of asteroids. VIII - Photoelectric photometry of the asteroids 42, 48, 93, 105, 145 and 245." *Astronomy and Astrophysics Supplement Series* **50**, 277-281.

Degewij, J., Tedesco, E. F. and Zellner, B. (1979). "Albedo and color contrasts on asteroid surfaces." *Icarus* **40**, 364-374.

Denchev, P., Magnusson, P. and Donchev, Z. (1998). "Lightcurves of nine asteroids, with pole and sense of rotation of 42 Isis." *Planetary and Space Science* **46**, 673-682.

Dunham, D. (1999). "Planetary Occultations for 1999." *Sky and Telescope* **97**, 106.

Gehrels, T. and Owings, D. (1962). "Photometric Studies of Asteroids.IX. Additional Light-Curves." *Astrophysical Journal* **135**, 906.

Harris, A. W., Young, J. W., Bowell, E., Martin, L. J., Millis, R. L., Poutanen, M., Scaltriti, F., Zappala, V., Schober, H. J., Debehogne, H. and Zeigler, K. W. (1989). "Photoelectric observations of asteroids 3, 24, 60, 261, and 863." *Icarus* **77**, 171-186.

Harris, A. W., Young, J. W., Bowell, E. and Tholen, D. J. (1999). "Asteroid Lightcurve Observations from 1981 to 1983." *Icarus* **142**, 173–201

Harris, A. W. and Warner, B. D. (2007). Table based on data published in the *Asteroids II machine readable data base: March 1988 floppy disk version* 2006 by C.-I. Lagerkvist, A. W. Harris and V. Zappalá (National Space Science Data Center, Greenbelt, MD, U.S.A.) and updated by A. W. Harris (SSI) and Brian D. Warner. Accessed 17 Feb 2007 online at http://cfa-www.harvard.edu/iau/lists/LightcurveDat.html

Higgins, D. (2006). "Determining the Synodic Rotation Period of a variety of Main Belt Asteroids." online at http://www.david-higgins.com/Astronomy/study/P200-HET602-DavidHiggins.pdf, accessed 2007

Kaasalainen, J., and Torppa, J. (2001). "Optimization Methods for Asteroid Lightcurve Inversion: I. Shape Determination." *Icarus* **153**, 24-36.

Kaasalainen, J., Torppa, J., and Muinonen, K. (2001). "Optimization Methods for Asteroid Lightcurve Inversion: II. The Complete Inverse Problem." *Icarus* **153**, 37-51.

Kaasalainen, M., Mottola, S. and Fulchignoni, M. (2002). "Asteroid Models from Disk-integrated Data." In *Asteroids III*, (W.F. Bottke, A. Cellino, P. Paolicchi, R.P. Binzel, eds.) pp. 139-150. Univ. Arizona Press, Tucson.

Kaasalainen, M., and Durech, J. (2007). "Inverse Problems of NEO Photometry: Imaging the NEO Population." In *Near Earth Objects, our Celestial Neighbors: Opportunity and Risk*, Proceedings of IAU Symposium 236 (G.B. Valsecchi, D. Vokrouhlický, eds). pp.151-166. Cambridge University Press, Cambridge.

Kaasalainen, M. (2007). http://www.rni.helsinki.fi/~mjk/asteroids.html (see the FAQ and the numerous references)

Koff, R. (2006). Personal correspondence.

Lecrone, C., Duncan, A., and Kirkpatrick, E. (2004). "Lightcurves and periods for asteroids 105 Artemis, 978 Aidamina, and 1103 Sequoia." *Minor Planet Bulletin* **31**, 77-78.

López-González, M. J., and Rodríguez E. (2005). "Lightcurves and poles of seven asteroids." *Planetary and Space Science* **53,** 1147–1165.

Magnusson, P., Barucci, M.A., Drummond, J. D., Lumme, K., Ostro, S.J. Surdej, J., Taylor, R.C., and Zappalà, V. (1989). "Determination of Pole Orientation and Shapes of Asteroids." In *Asteroids II*, (R.P. Binzel, T. Gehrels, M.S. Matthews, eds.) pp. 66-97. Univ. of Arizona Press, Tucson.

Melilo, F. J. (1987). "Photoelectric Photometry of Asteroids 5 Astraea and 22 Kaliope." *Minor Planet Bulletin* **42**, 42-43.

Pravdo, Steven SkyMorph website (2007). http://skyview.gsfc.nasa.gov/skymorph/

Sada, P. V., and Pesnell, W. D. (2000). "Dimensiones del asteroide (105) Artemis derivado de ocultaciones de estrellas." *Ciencia* UANL **3**, 191–195.

Schober, H. J., Erikson, A., Hahn, G., Lagerkvist, C.-I., Albrecht, R., Ornig, W., Schroll, A. and Stadler, M. (1994). "Physical studies of asteroids. XXVIII. Lightcurves and photoelectric photometry of asteroids 2, 14, 51, 105, 181, 238, 258, 369, 377, 416, 487, 626, 679, 1048 and 2183." Astronomy and *Astrophysics Supplement Series* **105**, 281-300.

Shevchenko, V. G., Belskaya, I. N. Krugly, Yu. N. and Chiomy, V. G. (2002). "Asteroid Observations at Low Phase Angles - II. 5 Astraea, 75 Eurydike, 77 Frigga, 105 Artemis, 119 Althaea, 124 Alkeste, and 201 Penelope." *Icarus* **155,** 365–374.

Taylor, R. C. (1978). "Minor Planets and Related Objects. XXIV. Photometric Observations for (5) Astraea." *Astronomical Journal* **83,** 201-4.

Tedesco, E.F. (1979). "Binary asteroids – Evidence for their existence from lightcurves." *Science* **203**, 905-907.

Torppa, J., Kaasalainen, M., Michalowski, T., Kwiatkowski, T., Kryszczy_ska, A., Denchev, P. and Kowalski, R. (2003). "Shapes and rotational properties of thirty asteroids from photometric data." *Icarus* **164**, 346-383.

Tungalag, N., Shevchenko, V. G. and Lupishko, D. F. (2002). "Rotation parameters and shapes of 15 asteroids." *Kinematika I Fizika Nebesnykh Tel.* **18**, 508-516.

van Houten-Groeneveld, I., van Houten and C. J.; Zappala, V. (1979). "Photoelectric photometry of seven asteroids." *Astronomy and Astrophysics Supplement Series* **35**, 223-232.

Warner, B., Higgins, D., Pray, D., Dyvig, R., Reddy, V. and Durech, D. (2008). "A Shape and Spin Axis Model for 1600 Vyssotsky." *Minor Planet Bulletin* **35**, 13-14.

Weidenschilling, S. J., Chapman, C. R., Davis, D. R., Greenberg, R. and Levy, D. H. (1990). "Photometric geodesy of main-belt asteroids. III - Additional lightcurves." *Icarus* **86,** 402-447.

Year	#LCs	~λ	~β	α	References
1978	3	252°	49°	14°	see text
2006	7	275°	28°	16°	see text

Table 1. Additional observing circumstances for 2 Pallas

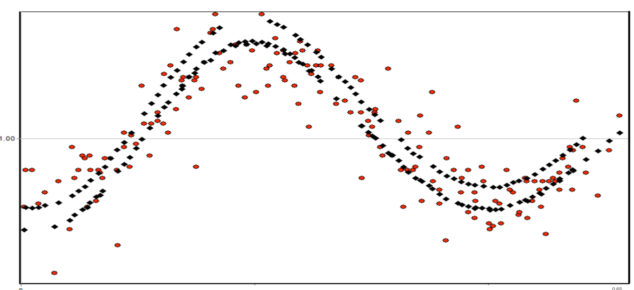


Figure 1. Comparison of model lightcurve (black/dark) versus data from June 1978 (this paper, red/light).

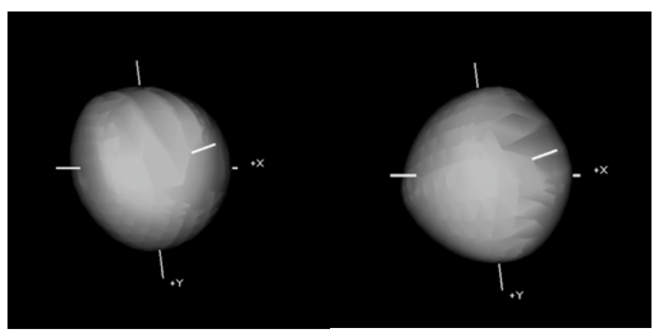


Figure 2. Shape model for 2 Pallas. The left-hand model is Z = 0°; the right-hand is Z = +90°.

Year	#LCs	~λ	~β	α	References
1958	2	120°	-1°	12/20°	1
1962	5	94°	-5°	7/20°	2
1969	2	50°	-8°	19°	3
1975	3	201°	8°	13°	3
1983	4	161°	3°	4°	4, 5
1987	3	135°	-2°	4/17°	4, 6
1997	17	330°	1°	14/20°	7, 8, 9
2006	17	30°	-6°	3/24°	10

Table 2. Observing circumstances for 5 Astraea, 1958-2006. References are 1) Gehrels and Owings (1962), 2) Chang and Chang (1962), 3) Taylor (1978), 4) Weidenschilling, et al. (1990), 5) Harris, et al. (1999), 6) Melilo (1987), 7) Shevchenko, et al. (2002) 8) López-González and Rodríguez (2005), 9) Blanco, et al. (2000), 10) this paper.

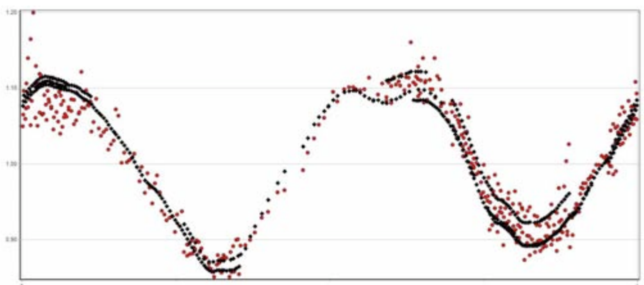


Figure 3. Comparison of model lightcurve (black/dark) versus data from October 2006 (This Study, red/light).

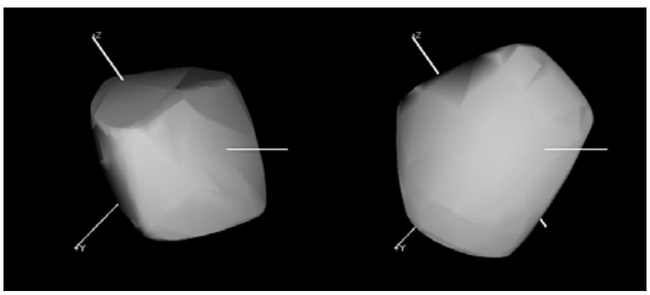


Figure 4. Shape model for 5 Astraea. The left-hand model is Z = 0°; the right-hand is Z = +90°.

Year	#LCs	~λ	~β	α	References
1965	3	250˚	-1˚	2˚	1
1977	2	307˚	-1˚	5˚	2, 3
1979	21	90˚	1˚	0/21˚	4
1992	5	185˚	0˚	0/13˚	5
1995	5	35˚	0˚	0/15˚	6
2005	7	329˚	-1˚	0/5˚	7

Table 3. Observing circumstances for 24 Themis, 1965-2005. References are 1) van Houten Groeneveld et al. (1979), 2) Degewij et al. (1979), 3) Tedesco (1979), 4) Harris et al. (1989), 5) Chernova et al. (1994), 6) Denchev et al. (1998), 7) this paper.

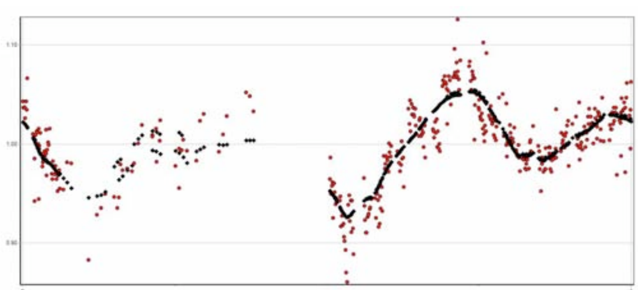


Figure 5. Comparison of model lightcurve (black/dark) versus data from September 1995 (Denchev, red/light).

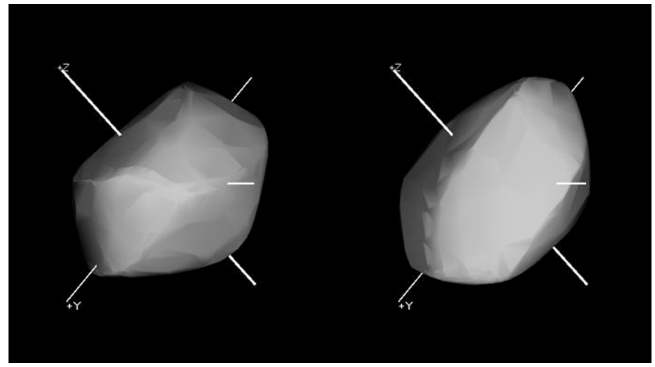


Figure 6. Shape model for 24 Themis. The left-hand model is Z = 0°; the right-hand is Z = +90°.

Year	#LCs	~λ	~β	α	References
1977	1	242˚	33˚	17˚	1
1980	6	136˚	-30˚	13˚	2,3
1996	5	90˚	1˚	0/21˚	4
1999	2	185˚	0˚	0/13˚	4
2003	5	35˚	0˚	0/15˚	5, 6, 7
2006	27	329˚	-1˚	0/5˚	8, 9, 10

Table 4. Observing circumstances for 105 Artemis, 1977-2006. References are 1) Tedesco (1979) 2) Debehogne et al (1982), 3) Schober et al (1994), 4) Tungalag et al. (2002), 5) LeCrone et al. (1994b), 6) Behrend (2006), 7) Pravdo (2007), 8) Koff (2006), 9) Higgins (2006), 10) this paper.

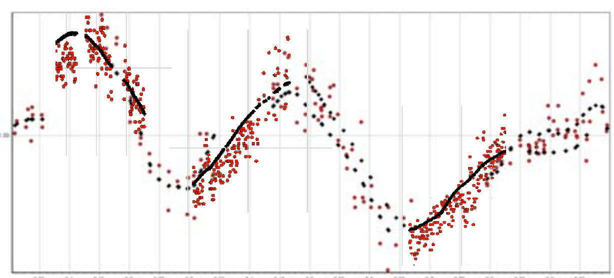


Figure 7. Comparison of model lightcurve (black/dark) versus data from April 2006 (This Study and Higgins, red/light).

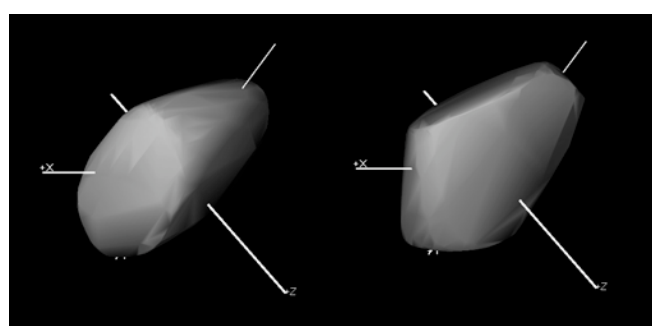


Figure 8. Shape model for 105 Artemis. The left-hand model is Z = 0°; the right-hand is Z = +90°.

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

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

(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 Tungalag (2003) and Durech (*http://astro.troja.mff.cuni.cz/projects/asteroids3D/*).

1325 Inanda. Another solution 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.

References

Behrend, R. (2007). Observatoire de Geneve web site, *http://obswww.unige.ch/~behrend/page_cou.html*.

Gil-Hutton, R., Lazzaro, D., and Benavidez, P. (2007). *Astron. Astrophys*. **468**, 1109-1114.

Harris, A.W., Young, J.W., Bowell, E., Martin, L.J., Millis, R.L., Poutanen, M., Scaltriti, F., Zappala, V., Schober, H.J., Debehogne, H., and Zeigler, K.W. (1989). "Photoelectric Observations of Asteroids 3, 24, 60, 261, and 863." *Icarus* **77**, 171-186

Harris, A.W., Warner, B.D., Pravec, P. (2007) Asteroid Lightcurve Parameters *http://www.MinorPlanetObserver.com/astlc/default.htm.*

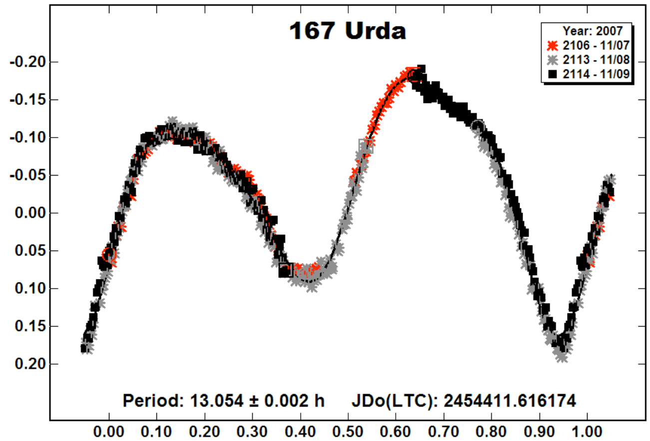
Lagerkvist, C.-I. (1978). *Astron. Astrophys. Suppl. Ser.* **31**, 361-381.

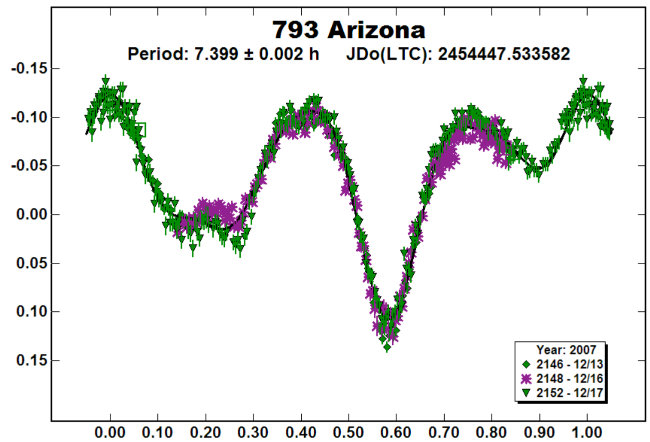
Slivan, S.M. and Binzel, R.P. (1996). *Icarus* **124**, 452-470.

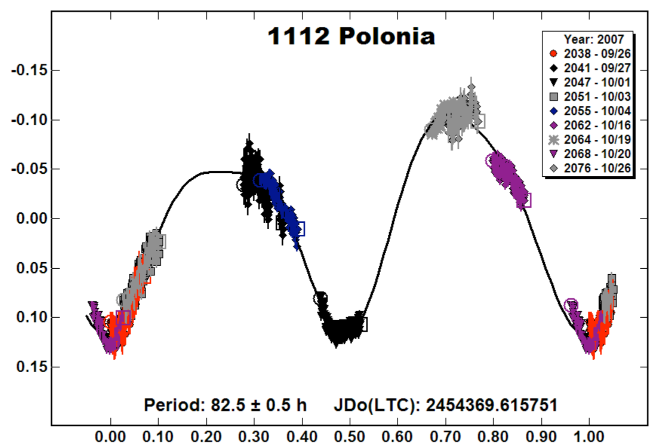
Tungalag, N., Shevchenko, V.G., and Lupishko, D.F. (2003). *Kin. Fiz. Neb. Tel* **19**, 397-406.

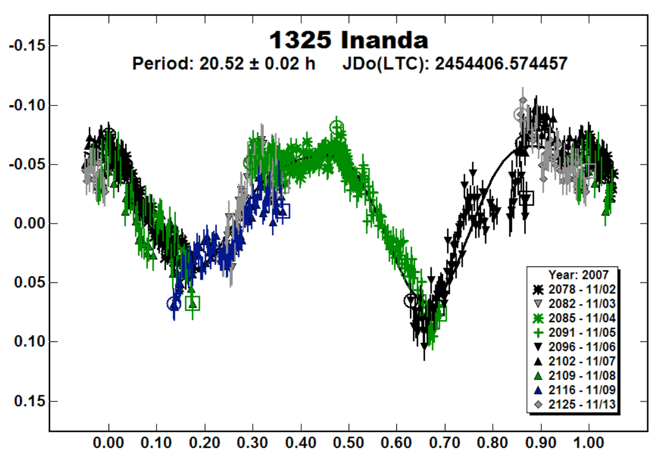
Warner, B.D. (2000). *Minor Planet Bulletin* **27**, 4-6.

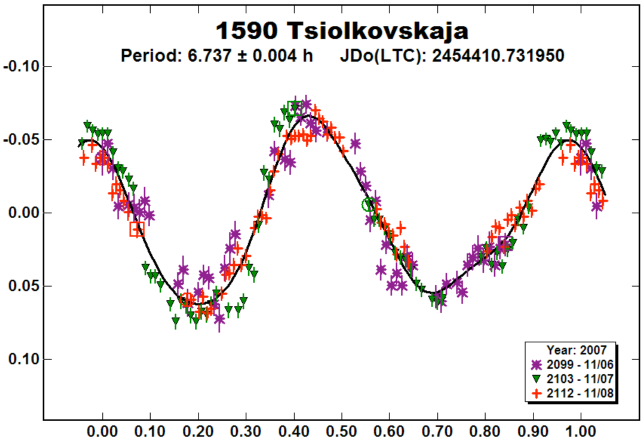
Warner, B.D. (2005). *Minor Planet Bulletin* **32**, 4-7.

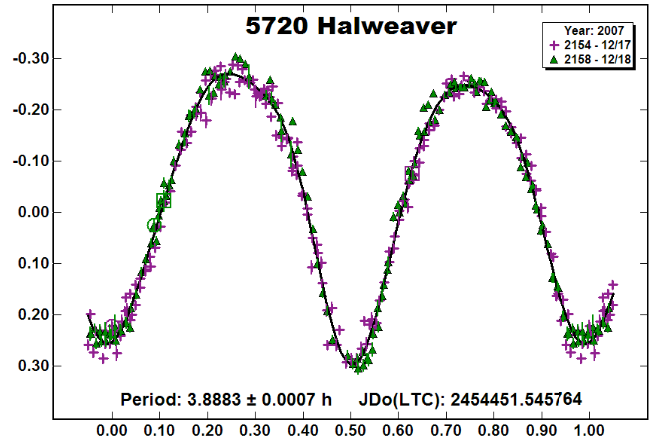


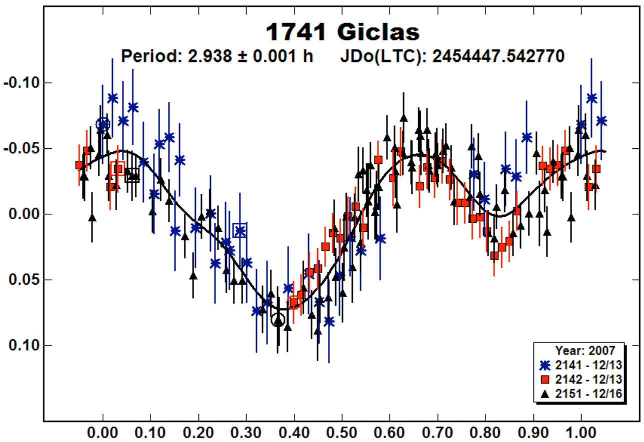


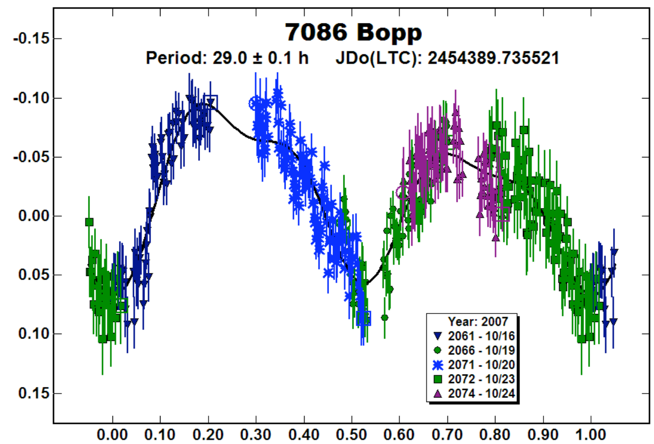


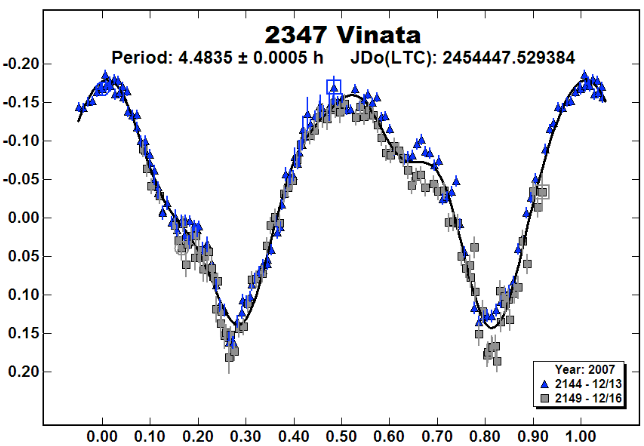


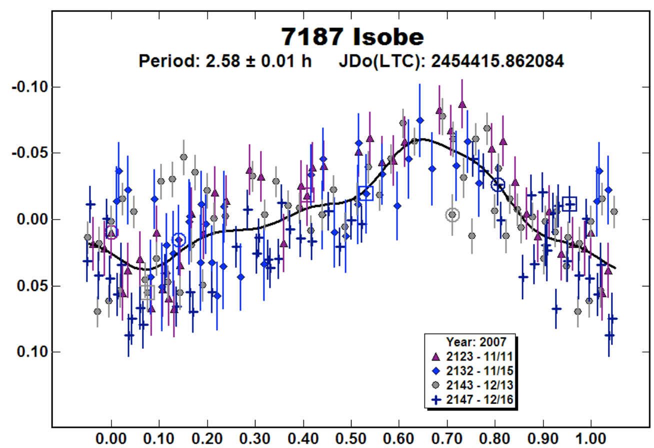

1590 Tsiolkovskaja
Period: 6.737 ± 0.004 h JDo(LTC): 2454410.731950
Year: 2007
2099 - 11/06
2103 - 11/07
2112 - 11/08

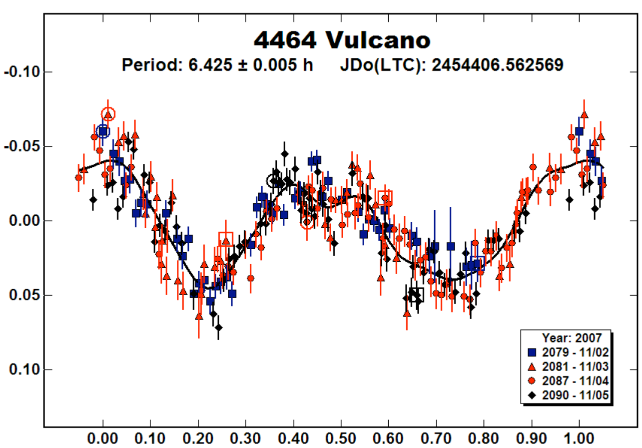

5720 Halweaver
Year: 2007
2154 - 12/17
2158 - 12/18
Period: 3.8883 ± 0.0007 h JDo(LTC): 2454451.545764

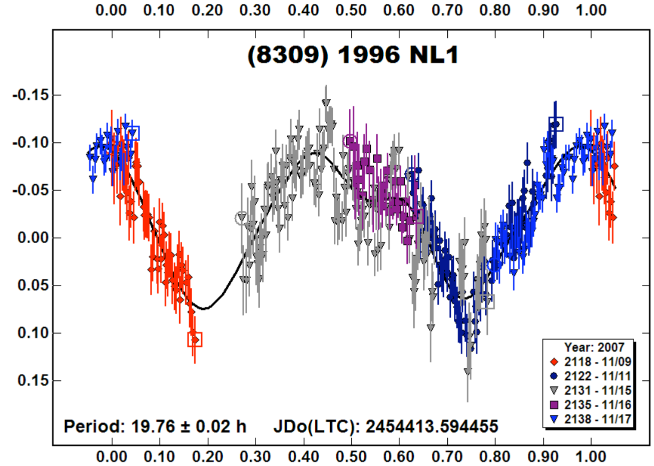

1741 Giclas
Period: 2.938 ± 0.001 h JDo(LTC): 2454447.542770
Year: 2007
2141 - 12/13
2142 - 12/13
2151 - 12/16

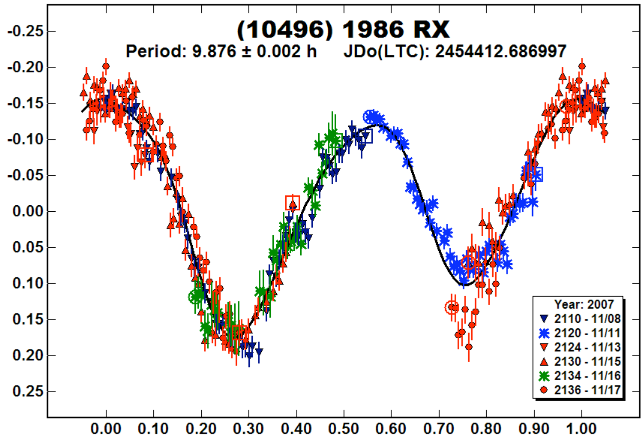

7086 Bopp
Period: 29.0 ± 0.1 h JDo(LTC): 2454389.735521
Year: 2007
2061 - 10/16
2066 - 10/19
2071 - 10/20
2072 - 10/23
2074 - 10/24

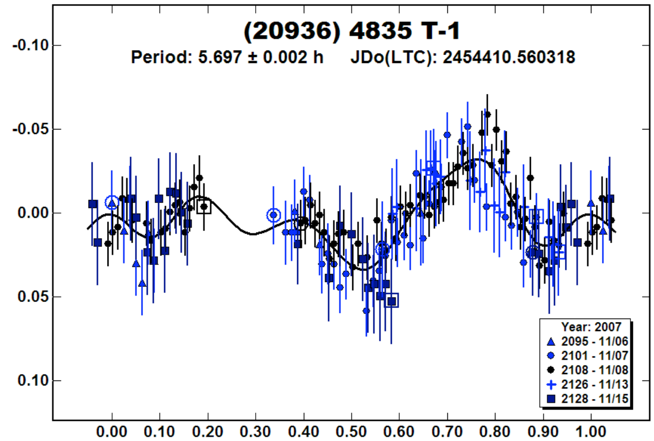

2347 Vinata
Period: 4.4835 ± 0.0005 h JDo(LTC): 2454447.529384
Year: 2007
2144 - 12/13
2149 - 12/16

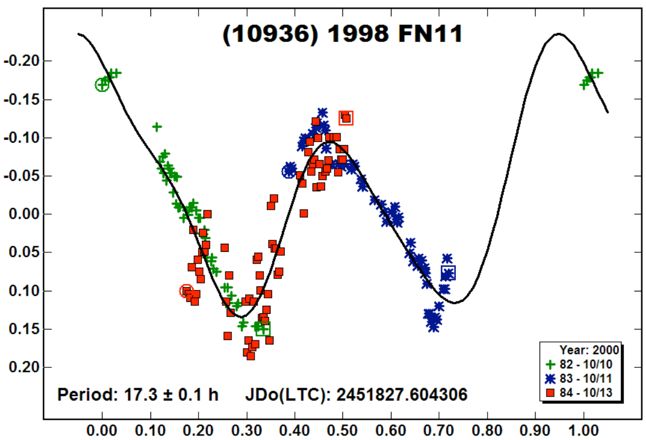

7187 Isobe
Period: 2.58 ± 0.01 h JDo(LTC): 2454415.862084
Year: 2007
2123 - 11/11
2132 - 11/15
2143 - 12/13
2147 - 12/16

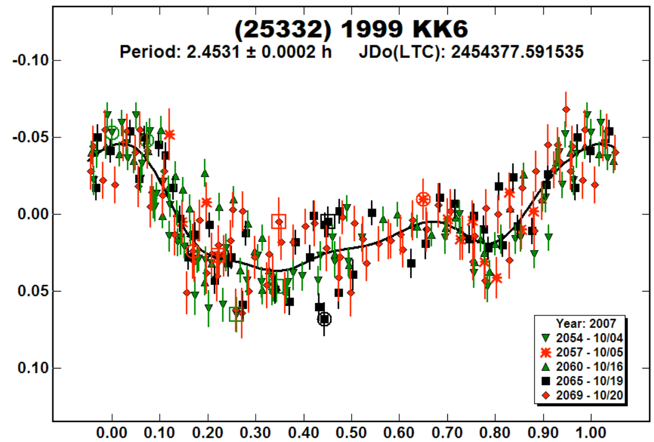

4464 Vulcano
Period: 6.425 ± 0.005 h JDo(LTC): 2454406.562569
Year: 2007
2079 - 11/02
2081 - 11/03
2087 - 11/04
2090 - 11/05

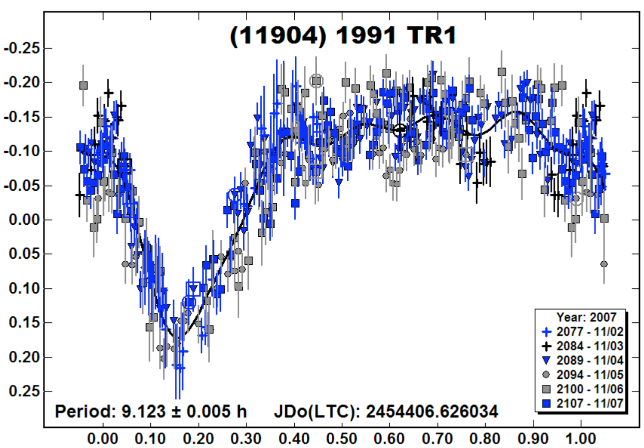

(8309) 1996 NL1
Year: 2007
2118 - 11/09
2122 - 11/11
2131 - 11/15
2135 - 11/16
2138 - 11/17
Period: 19.76 ± 0.02 h JDo(LTC): 2454413.594455

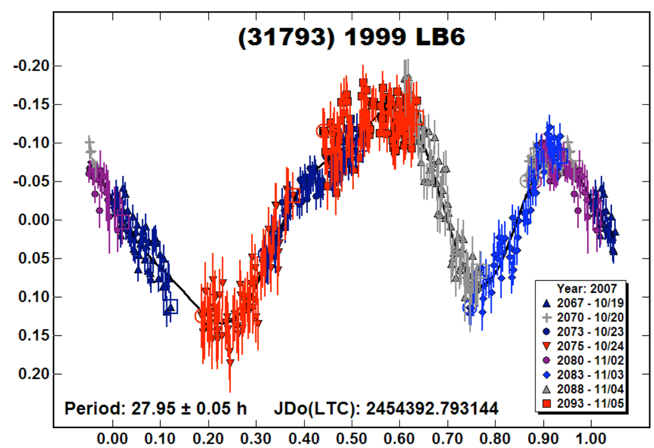

(10496) 1986 RX
Period: 9.876 ± 0.002 h JDo(LTC): 2454412.686997
Year: 2007
2110 - 11/08
2120 - 11/11
2124 - 11/13
2130 - 11/15
2134 - 11/16
2136 - 11/17

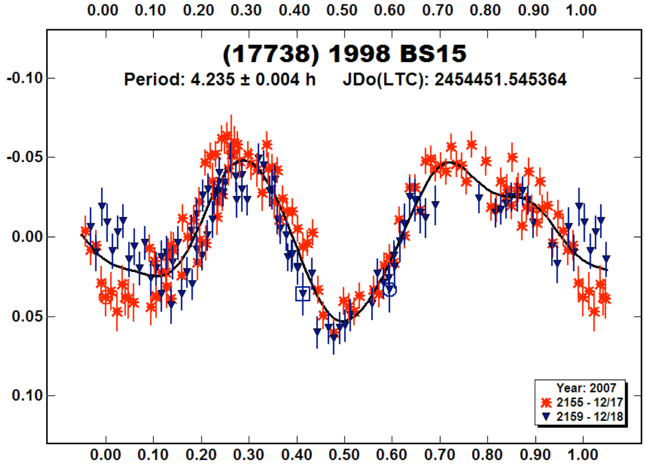

(20936) 4835 T-1
Period: 5.697 ± 0.002 h JDo(LTC): 2454410.560318
Year: 2007
2095 - 11/06
2101 - 11/07
2108 - 11/08
2126 - 11/13
2128 - 11/15

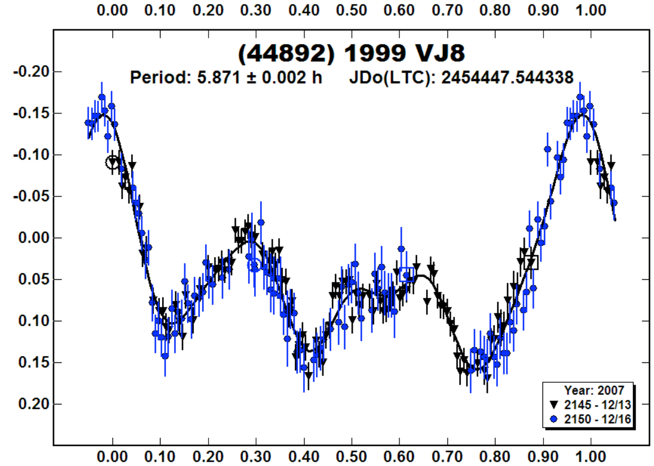

(10936) 1998 FN11
Period: 17.3 ± 0.1 h JDo(LTC): 2451827.604306
Year: 2000
82 - 10/10
83 - 10/11
84 - 10/13

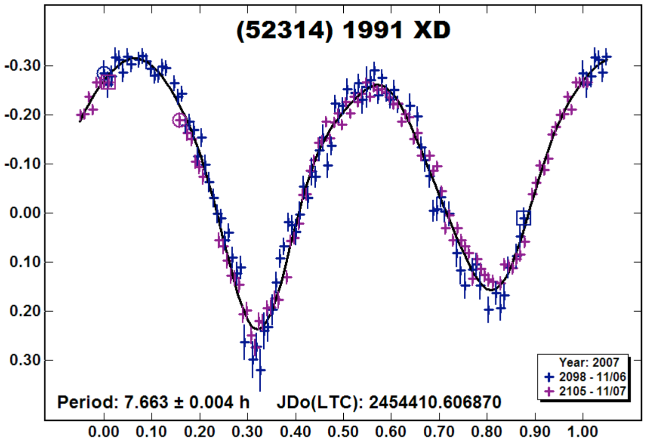

(25332) 1999 KK6
Period: 2.4531 ± 0.0002 h JDo(LTC): 2454377.591535
Year: 2007
2054 - 10/04
2057 - 10/05
2060 - 10/16
2065 - 10/19
2069 - 10/20


(11904) 1991 TR1
Period: 9.123 ± 0.005 h JDo(LTC): 2454406.626034
Year: 2007
2077 - 11/02
2084 - 11/03
2089 - 11/04
2094 - 11/05
2100 - 11/06
2107 - 11/07


(31793) 1999 LB6
Period: 27.95 ± 0.05 h JDo(LTC): 2454392.793144
Year: 2007
2067 - 10/19
2070 - 10/20
2073 - 10/23
2075 - 10/24
2080 - 11/02
2083 - 11/03
2088 - 11/04
2093 - 11/05


(17738) 1998 BS15
Period: 4.235 ± 0.004 h JDo(LTC): 2454451.545364
Year: 2007
2155 - 12/17
2159 - 12/18


(44892) 1999 VJ8
Period: 5.871 ± 0.002 h JDo(LTC): 2454447.544338
Year: 2007
2145 - 12/13
2150 - 12/16



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

Frederick Pilcher
4438 Organ Mesa Loop
Las Cruces, New Mexico 88011 USA
Pilcher@ic.edu

(Received: 20 December)

Periods and amplitudes have been determined as follows: 84 Klio: 23.562 ± 0.001 h, 0.21 ± 0.02 mag; 98 Ianthe: 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 ± 0.001h, 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 Ianthe. 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.

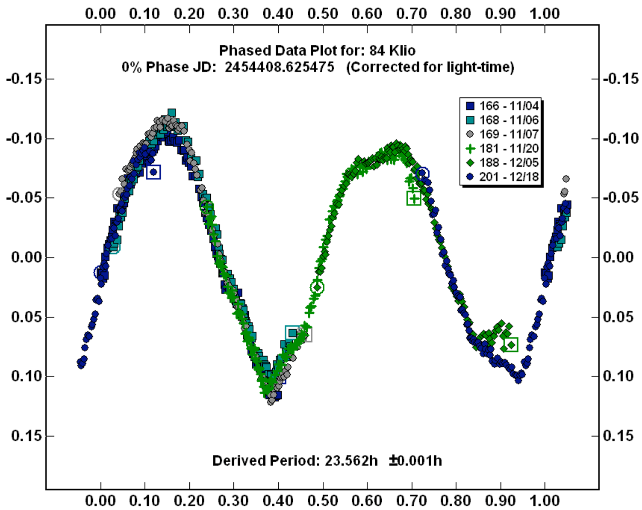
Of four objects included in this study with reliability 1 or 2 as listed by Harris et. al. (2007), three were found to have periods very different from those listed. Of a total of seven such objects studied to date by this writer, five required large corrections. Many of the lower reliability entries 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.

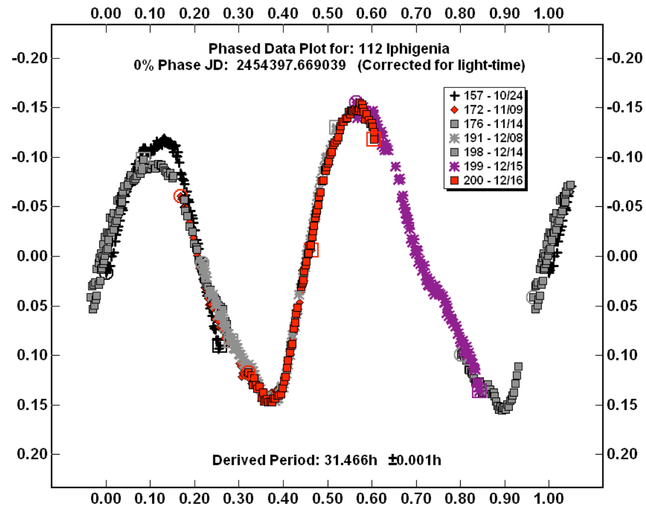
References

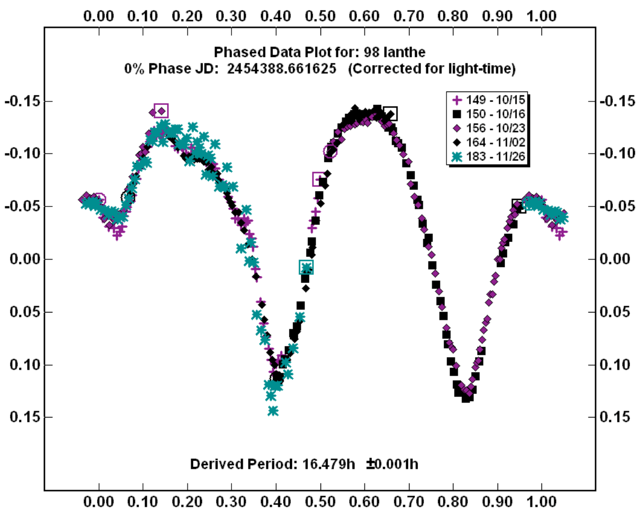
Harris, A. W., Warner, B. D., and Pravec, P., "Asteroid Lightcurve Data Files, Revised 20 April 2007." *http://www.MinorPlanetObserver.com/astlc/default.htm.*

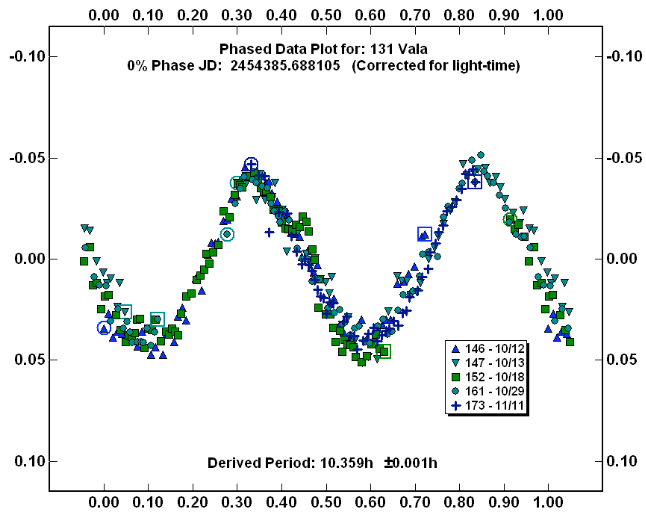
Weidenschilling, S. J., Chapman, C. R., Davis, D. R., Greenberg, R., Levy, D. H., Binzel, R. P., Vail, S. M., Magee, M., and Spaute, D. (1990). *Icarus* **86**, 402-447.

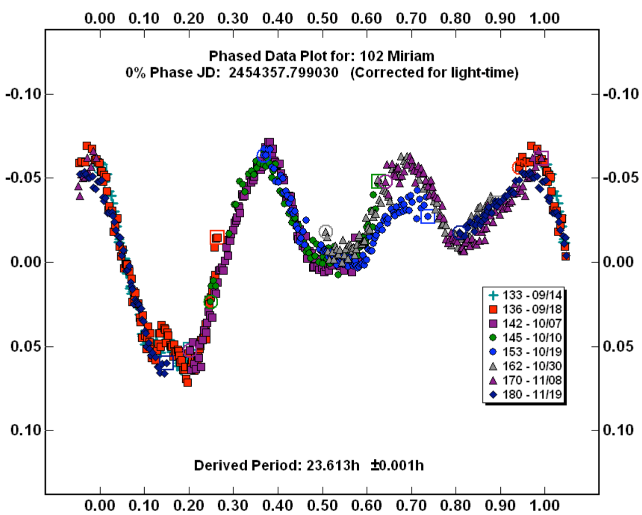
Zeigler, K. W., Monsees, R. D., and Brown, L. (1988). *Minor Planet Bul.* **25**, 13-14.

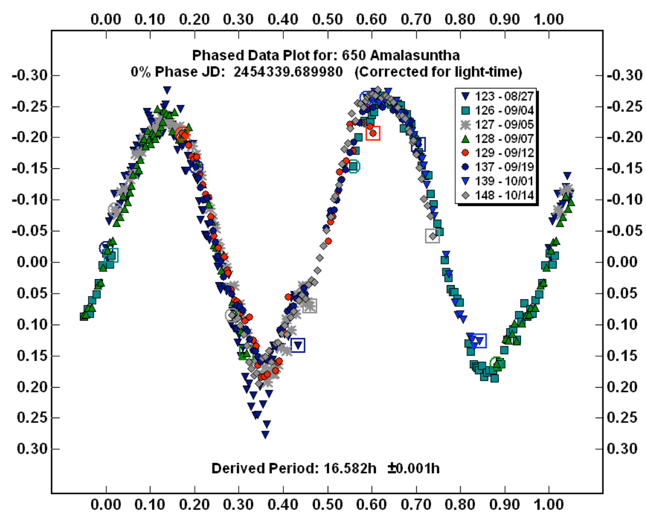

Phased Data Plot for: 84 Klio
0% Phase JD: 2454408.625475 (Corrected for light-time)
166 - 11/04
168 - 11/06
169 - 11/07
181 - 11/20
188 - 12/05
201 - 12/18
Derived Period: 23.562h ±0.001h


Phased Data Plot for: 112 Iphigenia
0% Phase JD: 2454397.669039 (Corrected for light-time)
157 - 10/24
172 - 11/09
176 - 11/14
191 - 12/08
198 - 12/14
199 - 12/15
200 - 12/16
Derived Period: 31.466h ±0.001h


Phased Data Plot for: 98 Ianthe
0% Phase JD: 2454388.661625 (Corrected for light-time)
149 - 10/15
150 - 10/16
156 - 10/23
164 - 11/02
183 - 11/26
Derived Period: 16.479h ±0.001h


Phased Data Plot for: 131 Vala
0% Phase JD: 2454385.688105 (Corrected for light-time)
146 - 10/12
147 - 10/13
152 - 10/18
161 - 10/29
173 - 11/11
Derived Period: 10.359h ±0.001h


Phased Data Plot for: 102 Miriam
0% Phase JD: 2454357.799030 (Corrected for light-time)
133 - 09/14
136 - 09/18
142 - 10/07
145 - 10/10
153 - 10/19
162 - 10/30
170 - 11/08
180 - 11/19
Derived Period: 23.613h ±0.001h


Phased Data Plot for: 650 Amalasuntha
0% Phase JD: 2454339.689980 (Corrected for light-time)
123 - 08/27
126 - 09/04
127 - 09/05
128 - 09/07
129 - 09/12
137 - 09/19
139 - 10/01
148 - 10/14
Derived Period: 16.582h ±0.001h

1453 FENNIA: A HUNGARIA BINARY

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

Alan. W. Harris
Space Science Institute
La Canada, CA USA

Petr Pravec
Astronomical Institute, Academy of Sciences
Ondřejov, CZECH REPUBLIC

Robert D. Stephens
Goat Mountain Astronomical Research Station (GMARS)
Yucca Valley, CA USA

Donald P. Pray
Carbuncle Hill Observatory
Green, RI USA

Walter R. Cooney, Jr., John Gross, Dirk Terrell
Sonoita Research Observatory, Sonoita, AZ USA

Š. Gajdoš and A. Galád
Modra Observatory
Department of Astronomy, Physics of the Earth, and Meteorology
Bratislava, SLOVAKIA

Yurij Krugly
Institute of Astronomy of Kharkiv National University
Kharkiv 61022, UKRAINE

(Received: 7 January)

Photometric observations of the Hungaria asteroid 1453 Fennia show that it is a binary with a primary rotation period of 4.4121 ± 0.0001 h. The amplitude of the primary lightcurve alone is 0.10 ± 0.01 mag. Mutual eclipse occultation events indicate a lower limit of the secondary-to-primary ratio of 0.28 ± 0.02. The orbital period of the system is 22.99 ± 0.01 h.

Observations of 1453 Hungaria were initially made at the Palmer Divide Observatory (Warner) in early November 2007. The lightcurve seemed highly complex, with a quadrimodal solution being considered. Harris reviewed the data and suggested the possibility of a binary asteroid with a primary period of about 4 h. The asteroid was then brought to the attention of the Photometric Survey for Asynchronous Binary Asteroids, headed by Pravec (http://www.asu.cas.cz/~asteroid/binastphotsurvey.htm).

Observations from several observatories were obtained over the period of November 4-22, 2007 (see Table 1). Analysis of the data was conducted by Pravec, who determined that the asteroid was a binary system. In brief, the analysis involves the dissection of the data into at least two linear, additive Fourier curves due to the rotation of the bodies in the system. Eclipses and occultations ("mutual events") are seen as attenuations superimposed on the combined curves (see Pravec et al., 2006).

Obs.	Instrument	Dates UT (Nov 2007)
PDO	0.35m, ST-9E	4-9,11,15-17
GMARS	0.35m, STL-1001E	10
CHO	0.50m, ST-10XME	11-12,14
SRO	0.35m, STL-1001E	18-19
MODRA	0.60m, AP-8	14
UKRAINE	0.7m, IMG47-10	23,24

Table 1. Observatories, instrumentation, and dates of observation.

The final analysis found that the synodic period of the primary is 4.4121 ± 0.0001 h and the amplitude of its lightcurve alone is 0.10 ± 0.01 mag. Mutual events of approximately 0.08 mag showed the orbital period of the system to be 22.99 ± 0.01 h and established a lower limit for the secondary-to-primary ratio of 0.28 ± 0.02. Additional data are needed to refine the Ds/Dp ratio as well as refine the overall model of the system.

Krugly (this paper) found color indices of B-V = 0.86 ± 0.06, V-R = 0.48 ± 0.03, and R-I = 0.49 ± 0.04, which is consistent with an S-class asteroid. With this color index, we obtain a reduced mean magnitude of V(19°.12) = 13.64. Wisniewski (1997), observing at an unusually low (for a Hungaria) phase angle, obtained a reduced magnitude of V(6°.78) = 13.29. It appears that the second half of Wisniewski's one lightcurve may have been in eclipse, so we increase the error estimate to 0.04 to allow for this possibility. A phase curve fit to these two values of V(α) results in a solution of H = 12.86 ± 0.09 and G = 0.32 ± 0.10. Using data from the IRAS survey (Tedesco et al, 2004), the new H-G results, and the method of Harris and Harris (1997), the revised albedo is 0.237 ± 0.033 and new effective diameter of the system is 7.32 km.

The initial confusion regarding the period analysis can now been seen as due to two factors. First, the rotation period of the primary and the orbital period have a nearly 5:1 ratio and, second, that the orbital period is nearly commensurate with the usual interval between observations from a single station, i.e., 24 hours. A single station would have needed several weeks to cover the orbital lightcurve, during which time the eclipse geometry of the system may have changed significantly. This demonstrates the benefits of collaborating stations at well-separated longitudes.

Acknowledgements

Funding for observations at the Palmer Divide Observatory is provided by NASA grant NNG06GI32G, National Science Foundation grant AST-0607505, and by a Gene Shoemaker NEO Grant from the Planetary Society. The work at Ondřejov was supported by the Grant Agency of the Czech Republic, Grant 205/05/0604. Observations at Carbuncle Hill Observatory are supported by a Gene Shoemaker NEO Grant provided by the Planetary Society. The work at Modra was supported by the Slovak Grant Agency for Science VEGA, Grant 1/3074/06. Yu. N. Krugly. was supported in part by the Main Astronomical Observatory of National Academy of Science of Ukraine.

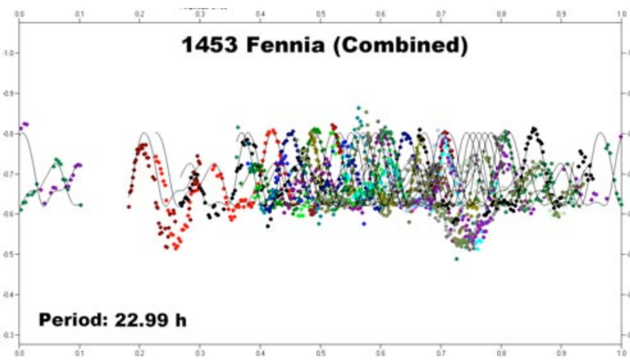
References

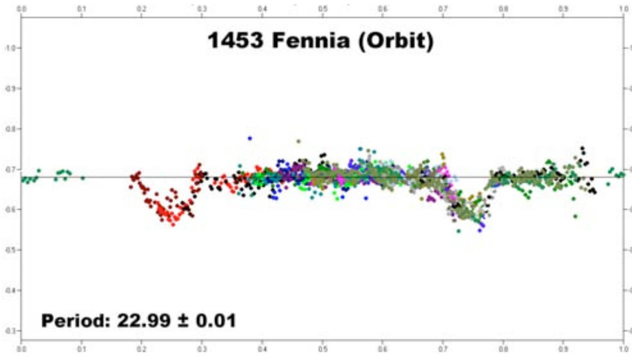
Harris, A.W., and Harris, A.W. (1997). "On the revision of radiometric albedos and diameters of asteroids." *Icarus* **126**, 450-454.

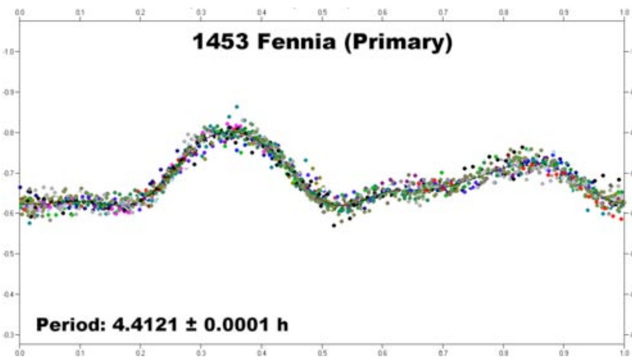
Pravec, P., Scheirich, P., Kušnirák, P., Šarounová, L., and 53 co-authors (2006). "Photometric survey of binary near-Earth asteroids." *Icarus* **181**, 63-93.

Tedesco, E.F., Noah, P.V., Noah, M., and Price, S.D. (2004). “IRAS Minor Planet Survey.” IRAS-A-FPA-3-RDR-IMPS-V6.0. NASA Planetary Data System. http://www.psi.edu/pds/resource/imps.html

Wisniewski, W.Z., Michalowski, T.M., Harris, A.W., andMcMillan, R.S. (1997). “Photometry of 125 asteroids.” *Icarus* **126**, 395-449.







THE ROTATION PERIODS OF 845 NAËMA, 1607 MAVIS, AND (30105) 2000 FO3

Colin Bembrick
Mt Tarana Observatory
PO Box 1537, Bathurst, NSW, AUSTRALIA
bembrick@ix.net.au

Bill Allen
Vintage Lane Observatory
Blenheim, NEW ZEALAND

Greg Bolt
Craigie, WA, AUSTRALIA

(Received: 10 January)

The synodic rotation period of minor planet 845 Naëma was found to be 20.892 ± 0.019 h. Similarly, the period of 1607 Mavis was 6.1339 ± 0.0004 h, and (30105) 2000 FO3 has a period of 7.272 ± 0.004 h. 845 Naëma has a complex lightcurve.

Minor planet 845 Naëma (1916 AS) was discovered by Max Wolf at Heidelberg in November 1916. The diameter is quoted as 57.5 km and the albedo is 0.035 (Guide, 2002). It is an outer main-belt asteroid. 1607 Mavis (1950 RA) is a main-belt object with a quoted diameter of 14.8 km and an albedo of 0.15 (Guide, 2002). It was discovered by E. Johnson at Johannesburg in September 1950. Its relatively high eccentricity means that it approaches Mars at perihelion. Minor planet (30105) 2000 FO3 was discovered by the LINEAR team from Socorro in 2000. It is a Mars crossing asteroid of 12 km diameter (Guide, 2002).

These observations in 2006 and 2007 were conducted from three sites, one in New Zealand and two in Australia. The locations of these sites are listed in Bembrick et al (2004). All observations were made using unfiltered differential photometry and exposures were adjusted so that 1% precision was achieved in most cases. All data were light-time corrected. The aspect data (Tables I, II and III) also show the percentage of the lightcurves observed each night. PAB is the Phase Angle Bisector. No rotation period data were to be found in the latest available lists (Harris and Warner, 2007). All period analyses were carried out using the Peranso software (Vanmunster 2006).

<u>845 Naëma.</u> All but two of the six nights of Bembrick’s data were of poor photometric quality (from 2 to 5% precision) which has led to a noisy lightcurve. Data were analyzed with several routines in Peranso and the spectral window examined, showing significant peaks only at 24 and 12 h. The power spectrum using the Phase Binned Analysis of Variance method showed two very sharp and prominent peaks, the largest at 0.87 d and the aliases at half and twice this period. The derived period of 20.892 ± 0.019 h appears to be the best fit to the available data. This period was used to compile the composite lightcurve (Figure 1), which is complex, having many peaks and troughs and no clear maximum or minimum. This could be another example of an asteroid with a complex lightcurve, such as 562 Salome (Bembrick and Allen, 2007) or 172 Baucis (Bembrick et al 2004), or it could imply non-principal-axis rotation, i.e., tumbling. The period derived may not be correct and further work is required, preferably by observers at widely differing longitudes.

<u>1607 Mavis.</u> Observations by Bembrick and Allen were combined and a period of close to 6 h was determined by visual inspection. This was confirmed and refined by several of the period search routines in Peranso. The final stack yielded a bi-modal lightcurve (Figure 2) with a synodic period of 6.1339 ± 0.0004 h. The peak-to-peak amplitude of 0.5 mag from the composite lightcurve

implies an axial ratio a/b of 1.6, assuming we are viewing at near-equatorial aspect.

(30105) 2000 FO3. Observations by Bembrick and Bolt were combined and analysed by the routines in Peranso. A synodic period of 7.272 ± 0.004 h was determined, yielding a bi-modal lightcurve (Figure 3) that has an amplitude of 0.43 mag, implying an axial ratio a/b of 1.5.

References

Bembrick, C.S., Richards, T., Bolt, G., Pereghy, B., Higgins, D. and Allen, W.H. (2004). "172 Baucis – A Slow Rotator." *Minor Planet Bulletin* **31**, 51-52.

Bembrick, C. and Allen, B. (2007). "The Rotation Period of 562 Salome." *Minor Planet Bulletin* **34**, 3.

GUIDE version 8. 2002. http://www.projectpluto.com

Harris, A.W. and Warner, B.D. (2007). "Minor Planet Lightcurve Parameters." Updated May 06 2007. http://cfa-www.harvard.edu/iau/lists/LightcurveDat.html

Vanmunster, T., 2006. Peranso ver 2.0. http://www.peranso.com

UT Date 2006	PAB Long	PAB Lat	Phase Angle	%Phase Coverage
Sep 12	344.1	-13.7	6.5	26
Sep 13	344.1	-13.3	6.6	30
Sep 15	344.2	-13.6	6.9	34
Sep 17	344.2	-13.5	7.3	20
Sep 19	344.2	-13.4	7.8	30
Oct 02	344.6	-12.7	11.4	36

Table I. Aspect data for Naëma in 2006.

UT Date 2007	PAB Long	PAB Lat	Phase Angle	%Phase Coverage
Sep 16	353.4	-10.9	8.5	43
Sep 18	353.7	-11.0	8.7	129
Sep 20	354.0	-11.2	9.0	128

Table II. Aspect data for Mavis in 2007.

UT Date 2007	PAB Long	PAB Lat	Phase Angle	%Phase Coverage
Aug 03	315.0	-13.8	14.5	119
Aug 04	315.2	-13.9	14.4	115
Aug 07	316.0	-14.0	14.2	43
Aug 08	316.3	-14.1	14.2	77
Aug 09	316.5	-14.1	14.2	53

Table III. Aspect data for 30105 in 2007.

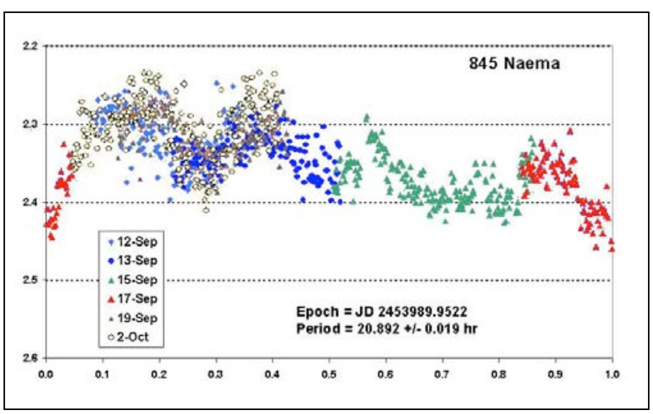


Figure 1. Composite Lightcurve for Naëma in 2006

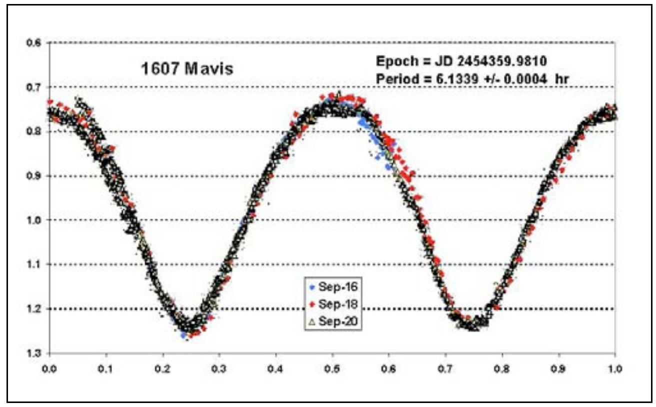


Figure 2. Composite Lightcurve for Mavis in 2007

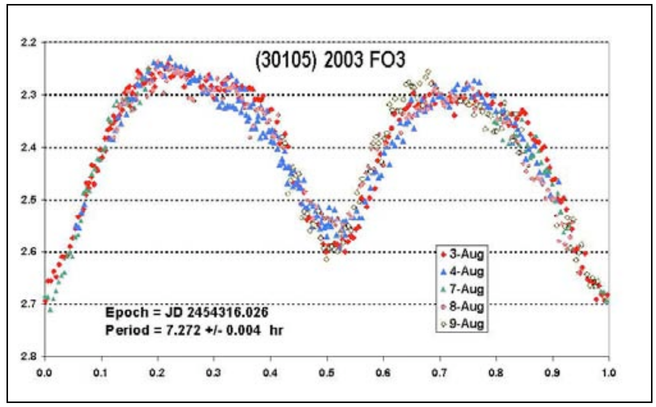


Figure 3. Composite Lightcurve for 30105 in 2007

LIGHTCURVE ANALYSIS OF (21028) 1989 TO

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

Marek Husárik
Skalnaté Pleso Observatory
Slovak Academy of Sciences
SK 059 60 Tatranská Lomnica, SLOVAK REPUBLIC

Petr Pravec
Astronomical Institute, Academy of Sciences, Czech Republic
Fričova 1, CZ-25165, Ondřejov, CZECH REPUBLIC

(Received: 13 January)

The lightcurve of the Phocaea group asteroid (21028) 1989 TO was obtained by the authors in December 2007 and found to have a synodic period of 3.6644 ± 0.0001 h and amplitude of 0.11 ± 0.02 mag.

Authors Warner and Husárik independently began observations of the Phocaea group asteroid (21028) 1989 TO in December 2007. Husárik was working in support of the Photometric Survey of Binary Asteroids group, headed by Petr Pravec (*http://www.asu.cas.cz/~asteroid/binastphotsurvey.htm*). The observations at the Palmer Divide Observatory were made using a 0.5m Ritchey-

Chretien with SBIG STL-1001E CCD camera running at –30°C. Exposures were 120 s using no filter. The pixel scale was approximately 1.2 arcsec/pixel. Skalnaté Pleso Observatory used 0.61-m f/4.3 reflector and SBIG ST-10XME CCD camera with Johnson-Cousins R filter. The frames were binned 3x3, yielding a scale of 1.6 arcsec/pixel. Differential photometry was used to derive the data for period analysis. The combined set of 795 data points presented here was analyzed in MPO Canopus, which uses the FALC Fourier analysis routine developed by Harris (1989).

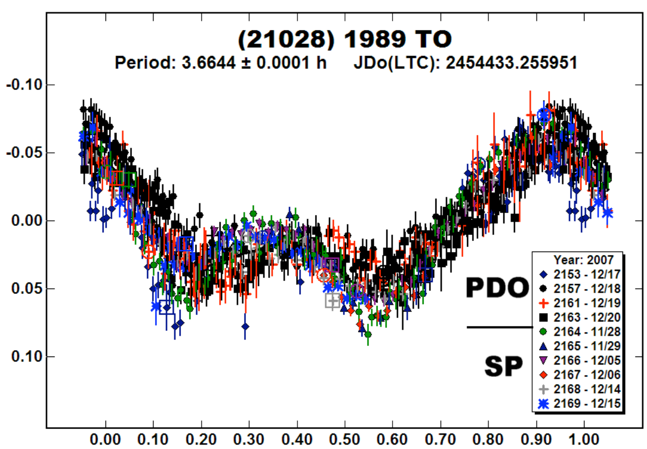
When it was realized that there were independent data sets, they were combined in order to provide a more accurate and definitive solution. Additional observations were made in the latter part of December after a single session (Dec. 17) from PDO showed some anomalous data that might have indicated an eclipse event in a binary system. However, no supporting observations were found and those deviations are now considered spurious. Period analysis in Canopus using only PDO data favored a bimodal curve with a period of about 7.2 h. However, further review by Pravec using the combined data set showed that the values of the harmonic orders in the Fourier analysis were consistent with a shorter period and monomodal curve. His analysis found a period of 3.6644 ± 0.0001 h, which is adopted here. The amplitude of the curve is 0.11 ± 0.02 mag.

Acknowledgements

Funding for observations at the Palmer Divide Observatory is provided by NASA grant NNG06GI32G, National Science Foundation grant AST-0607505, and by a Gene Shoemaker NEO Grant from the Planetary Society. The work at Skalnaté Pleso Observatory (Astronomical Institute SAS, Tatranská Lomnica) was supported by the Slovak Grant Agency for Sciences VEGA, Grant No. 2/7009/27. We thank M. Pikler and G. Červák for observational assistance. The work at Ondřejov was supported by the Grant Agency of the Czech Republic, Grant 205/05/0604

References

Harris, A.W., Young, J.W., Bowell, E., Martin, L.J., Millis, R.L., Poutanen, M., Scaltriti, F., Zappala, V., Schober, H.J., Debehogne, H., and Zeigler, K.W. (1989). “Photoelectric Observations of Asteroids 3, 24, 60, 261, and 863.” *Icarus* **77**, 171-186.



PHOTOMETRIC MEASUREMENTS OF 1084 TAMARIWA AT HOBBS OBSERVATORY

George Stecher, Lyle Ford, Kayla Lorenzen, and Sarah Ulrich
Department of Physics and Astronomy
University of Wisconsin-Eau Claire
Eau Claire, WI 54702-4004
gstecher@uwec.edu

(Received: 7 January Revised: 14 January)

1084 Tamariwa was observed on 3 and 4 August 2007. R and V standard magnitudes were determined. The period of 1084 Tamariwa was found to be 6.22 ± 0.03 h.

The 0.6 m “Air Force” Telescope located at Hobbs Observatory (MPC code 750) near Fall Creek, Wisconsin was used to make measurements of 1084 Tamariwa. 60-second exposures were made in the R and V bands using an Apogee Alta U55 camera and filters from Omega Optical. Additional details on the telescope can be found in Stecher et al. (1999). Images were dark-subtracted and flat-fielded. Photometric transforms were found using Landolt standard stars from the LONEOS catalog and first order extinction coefficients were determined using the modified Hardie method as described in Warner (2006). Data were analyzed using MPO Canopus version 9.3.1.0 (Warner 2007).

The R and V lightcurves for 1084 Tamariwa folded with a period of 6.22 hours are shown in Figures 1 and 2. Representative uncertainties in the magnitude determinations of the data were 0.03 in R and 0.015 in V. We estimate the uncertainty of the period to be 0.03 h. This period gave the best results as determined by inspection and is consistent with the period of 6.19 h reported by Ivarsen *et al*. (2004). The magnitude varied from 13.70 to 13.33 in R and from 14.10 to 13.75 in V. Our lightcurve data can be obtained from http://www.uwec.edu/physics/asteroid/

We thank the Theodore Dunham Fund for Astrophysics, the National Science Foundation (award number 0519006), the University of Wisconsin-Eau Claire Office of Research and Sponsored Programs, and the University of Wisconsin-Eau Claire Blugold Fellow and McNair programs for financial support.

References

Ivarsen, K., Willis, S., Ingleby, L., Matthews, D., and Simet, M. (2004). “CCD Observations and Period Determination of Fifteen Minor Planets”, *Minor Planet Bulletin* **31**, 29-33.

Stecher, G. J., Ford, L. A., and Elbert, J. D. (1999). “Equipping a 0.6 Meter Alt-Azimuth Telescope for Photometry”, *IAPPP Comm.* **76**, 68-74.

Warner, B. D. (2006). *A Practical Guide to Lightcurve Photometry and Analysis*. Springer, New York, NY.

Warner, B.D. (2007). MPO Software, Canopus version 9.3.1.0, Bdw Publishing, http://minorplanetobserver.com/

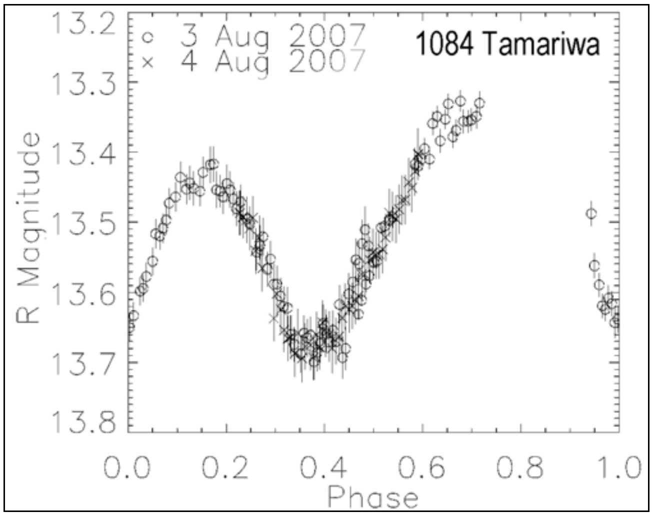


Figure 1: R magnitude composite lightcurve for 1084 Tamariwa. The phase is referenced to JD 2454315 and is corrected for light - travel time.

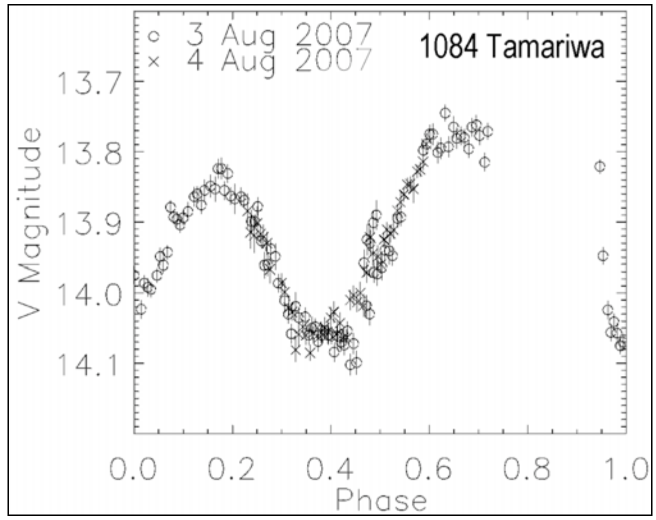


Figure 2: V magnitude composite lightcurve for 1084 Tamariwa. The phase is referenced to JD 2454315 and is corrected for light - travel time.

LIGHTCURVE ANALYSIS OF 176 IDUNA

Richard Krajewski
Dark Rosanne Observatory
38 Lake Shore Drive
Middlefield, Connecticut, USA
kraski55@ yahoo.com

(Received: 17 November)

Observations of asteroid 176 Iduna indicate a synodic period of 11.2877 ± 0.0002 h with an amplitude of 0.43 ± 0.03 mag.

Dark Rosanne Observatory (H98), located in Middlefield, Connecticut, uses a 0.20m Schmidt-Newtonian reflector on a Meade equatorial mount operating at F/4. A Meade CCD imager with a resolution of 2.2”/pixel and clear filter were used. Reductions were done using MPO Canopus by Bdw Publishing.

Asteroid 176 Iduna was chosen for observation after a comparison of favorable apparitions to currently available lightcurve data. Only two studies of lightcurve data for this asteroid were publicly available: one with a bimodal period of 11.289 h and another showing a monomodal period of 5.63 h. The intent of this program was to increase coverage and determine an accurate period.

Observations were begun on September 15, 2007, and completed on November 17, 2007. The combination of a nearly 12 hour period and poor seasonal weather slowed observations, resulting in a phase angle range of 11.7 degrees; however, it appears data were not adversely influenced. A period of 11.2877 ± 0.0002 h with an amplitude of 0.43 ± 0.03 mag was determined, and the possibility of a monomodal option was eliminated. These results are consistent with those of Hansen and Arentoft (1997) and Alton (2008).

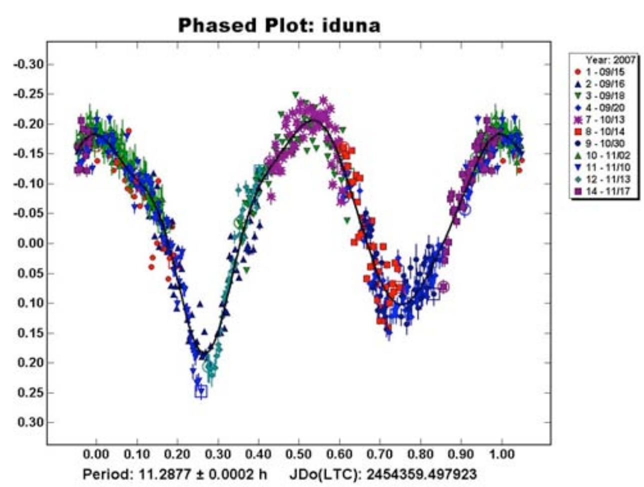
References

Alton, K. B. (2008). CCD Lightcurve Analysis of 176 Iduna. *Minor Planet Bulletin* **35**, 77.

Hansen, A.T. and Arentoft, T. (1997). The Rotational Period of 176 Iduna. *Minor Planet Bulletin* **24**, 14.

Harris, A.W., Warner, B.D., Pravec, P. (2007). “Asteroid Lightcurve Parameters.” http://www.MinorPlanetObserver.com/astlc/default.htm.

Warner, B.D. (2003). *A Practical Guide to Lightcurve Photometry and Analysis*. Bdw Publishing, Colorado Springs, CO.



UT Date	M	PA	LPAB	BPAB
2007 Sep 15	12.1	9.2	339.5	18.3
2007 Oct 13	12.5	15.7	340.7	15.1
2007 Oct 30	12.7	19.0	342.6	12.9
2007 Nov 17	13.0	20.9	345.6	10.7

A SAMPLE OF LIGHTCURVES FROM MODRA

Adrián Galád
Modra Observatory
Department of Astronomy, Physics of the Earth, and Meteorology
FMFI UK, 842 48 Bratislava, SLOVAKIA
and
Astronomical Institute AS CR, 251 65 Ondřejov
CZECH REPUBLIC
galad@fmph.uniba.sk

Leonard Kornoš
Modra Observatory
Department of Astronomy, Physics of the Earth, and Meteorology
FMFI UK, 842 48 Bratislava
SLOVAKIA

(Received: 10 January)

Lightcurve analysis of 929 Algunde, 1487 Boda, 1696 Nurmela, 2857 NOT, 3573 Holmberg, 5653 Camarillo, 6572 Carson, (10328) 1991 GC1, (12706) 1990 TE1, (72290) 2001 BQ15, and (164201) 2004 EC is reported. 1487 Boda is a binary candidate due to an attenuation being observed on one night.

During the course of Photometric Survey for Asynchronous Binary Asteroids (PSABA) about 300 small asteroids from the inner part of the main belt have been observed to date (Pravec, 2008). Their lightcurves are usually published continuously by observers from one or several observatories, including Modra. Here we present lightcurves of several asteroids that were observed solely from Modra. Some of the targets were observed as a byproduct of being in the same field as the principal target. When such new lightcurves seemed to be of interest and the rotation period for the asteroid could be readily determined, we continued observations of the asteroid along with main PSABA targets, even if this meant observing the secondary asteroid when it was not at a favorable opposition. The equipment and data processing at Modra was described in Galád (2008). Our results are summarized in Table I and appropriate lightcurves are in figures, in which correction for light-travel time was applied.

929 Algunde. This is the only PSABA candidate numbered less than 1000. Its taxonomic type is S (Neese, 2005) and it belongs to the Flora family (Zappalà et al., 1995).

1487 Boda was observed along with PSABA target 1696 Nurmela. Five consecutive nights with linked observations indicated a rotation period of about 11.0 h. Another session was added later to refine the result, remove any ambiguity, and to cover unobserved rotational phases. That additional lightcurve, on April 17.9, 2007, had slightly larger amplitude than previous ones by about 0.08 mag (while the accuracy of data was below 0.02 mag), and so observations continued. However, the amplitude was restored to the original value and no other attenuation was observed. The composite lightcurve is shown in the first figure for this asteroid. The suspected attenuation event is seen in the second, which is the result of subtracting the Fourier fit of the data set that excluded the session with the suspected event from the single-session data set that did include the event.

The reason for the observed 1.5 h long attenuation is not clear. It appeared at the beginning of the session, when the asteroid was near the corner of the image and close to a bright star. These may have influenced the data. Since the attenuation stayed the same with different radii of apertures, even when aperture did not contain the star, it may be real and caused by a satellite orbiting the primary body. If true, the orbital period of the satellite may be on the order of several days. It's noteworthy that the primary is not a fast rotator, something usually expected in a binary system. This object was also independently observed by Antonini and Casulli on five consecutive nights in March 2007 (Behrend, 2007). They obtained a synodic rotation period of 11.025 h and amplitude of the lightcurve of 0.21 mag, which are similar to our values, but no clear attenuation seems to be present in their data. The asteroid belongs to the Themis family and its taxonomical type is B (Zappalà et al., 1995, Mothé-Diniz et al., 2005).

1696 Nurmela. Five mutually linked sessions were obtained. The derived rotational period is in perfect agreement with that derived independently by Stephens and Malcolm (2007). Only the amplitude of the lightcurve changed, from 0.33 to 0.42 mag, probably due to the increased solar phase angle. The asteroid belongs to the Flora family (Zappalà et al., 1995).

2857 NOT was a byproduct of other observations though it formally fits PSABA criteria. Several sessions were linked to the same magnitude level, but they were short, or not continuous. Thus, the derived rotation period is ambiguous. In addition to the period given here, a solution of 6.387 h is also plausible and even 5.040 h cannot be ruled out, though it is less probable.

3573 Holmberg was a PSABA target. It belongs to the Flora family (Zappalà et al., 1995). Sessions were not ideally distributed, but the large amplitude enabled precise determination of the rotation period.

5653 Camarillo is a near-Earth asteroid. Despite low-noise data,

Number	Name	Dates yyyy mm/dd	Phases deg	LPAB deg	BPAB deg	Period [h]	Amp [mag]
929	Algunde	2007 03/08-27	13.2,20.5	143	-5	3.31016 ± 0.00009	0.14
1487	Boda	2007 04/06-05/13	9.3,19.0	175	3	11.0147 ± 0.0003	0.24
1696	Nurmela	2007 04/06-10	12.7,14.8	176	3	3.1587 ± 0.0001	0.42
2857	NOT	2007 10/06-20	7.0,12.9	359	-4	5.6343 ± 0.0004	0.28
3573	Holmberg	2006 12/28 - 2007 01/26	18.7,26.2	64	1	6.5431 ± 0.0001	1.03
5653	Camarillo	2004 11/08-12/07	14.8,23.6	73	11	4.8346 ± 0.0002	0.51
6572	Carson	2007 12/14-19	18.2,19.6	45	-3	2.8235 ± 0.0003	0.33
(10328)	1991 GC1	2007 04/20-05/03	18.2,22.8	177	2	15.357 ± 0.004	0.72
(12706)	1990 TE1	2007 10/18-12/15	16.2,30.2	1-18	-4,+4	11.5274 ± 0.0004	0.7
(72290)	2001 BQ15	2007 10/08-21	10.5,14.5	351	9	5.6657 ± 0.0008	0.81
(164201)	2004 EC	2004 03/30-04/09	35.2,41.0	167	29,36	6.4 - 8.5 ?	0.14

Table I. Asteroids with observation dates, minimum and maximum solar phase angles, phase angle bisector values, derived synodic rotation periods with uncertainties, and lightcurve amplitudes.

our sessions were inadequately distributed and quite short. Since a secure rotation period could not be found, we did not publish our results. Moreover, the rotation period was determined securely by Mottola et al (1995). The asteroid was also observed more recently by Cooney et al. (2007). After we realized that our sessions were done independently at nearly the same time, we asked the Cooney group to look at their data. Fortunately, the combined, relative data set lead to an unambiguous and precise value of rotation period and amplitude. We plot just the Modra data in the figure (similarly, we report just the Modra aspect and solar phase data in the table) for clarity and so as not to duplicate published data. However, the Fourier fit was constructed from all eight sessions.

6572 Carson was observed as a byproduct of other observations well after its quite favorable opposition but still well within reach of our system. Data were linked to the same magnitude level.

(10328) 1991 GC1 was a faint target, but the large amplitude of the lightcurve helped find the rotation period nearly unambiguously. Since data from consecutive nights are linked, the less probable value of 11.64 h for the period (again with two maxima in the lightcurve) can be ruled out and the more complex lightcurve is not expected.

(12706) 1990 TE1 was another byproduct of observations. Unfortunately, we didn't cover the whole rotational phase, so the amplitude of the lightcurve is not precisely determined; the uncertainty may exceed 0.1 mag. Assuming maxima are nearly equal, the amplitude would be about 0.4–0.5 mag, but the last session implies about 0.7 mag or more. However, the solar phase angle was much larger at that time and it could be responsible for the increased amplitude (short linked sessions at the end of November do not fit to previous lightcurve). As for the synodic rotation period, the first sessions (up to Nov 6) indicated that it could be about 11.532 ± 0.001 h, which is higher than the period derived from all sessions. The difference is due to very large time span. During that period, the phase angle bisector changed by several degrees.

(72290) 2001 BQ15. According to an ephemeris using the absolute value given by the MPC, this asteroid was slightly fainter than 18 mag and so the errors of data exceeded 0.1 mag. It was only because of the large amplitude and partly linked observations that we were able to find the rotation period. Except for the most probable value (given in the table and figure), we formally cannot rule out periods of 5.067 and 6.420 h (assuming two maxima per cycle). More complex lightcurves are not expected. The error of amplitude determination from the Fourier fit, 0.04 mag, is also larger than usual.

(164201) 2004 EC is a near-Earth asteroid that was observed at its discovery apparition. We can asses the amplitude of the lightcurve from our three sessions but not the rotation period. The one presented in the figure is one of many possibilities. Other possible periods can be seen in the plot of the sum of square residuals versus period. Long sessions could resolve the ambiguity, especially if the data is of similar or better quality than ours and if done in March/April 2004. If the reader knows of such data, he is urged to contact the authors. No favorable window for photometry is expected in the near future for mid-class telescopes.

Acknowledgements

We are grateful to Petr Pravec, Ondřejov Observatory, Czech Republic, for his ALC software used in data analysis, to Walter R. Cooney, Jr., Sonoita Research Observatory, Arizona, for permission to use data of 5653 Camarillo he obtained with collaborators, and to Brian D. Warner, Palmer Divide Observatory, Colorado, for his kind help with language corrections and advice. The work was supported by the Slovak Grant Agency for Science VEGA, Grant 1/3074/06 and the Grant Agency of the Czech Republic, Grant 205/05/0604.

References

Behrend, R. (2007). http://obswww.unige.ch/~behrend/page4cou.html

Cooney, Jr., W. R., Gross, J., Terrell, D., Reddy, V., and Dyvig, R. (2007). "Lightcurve Results for 486 Cremona, 855 Newcombia 942 Romilda, 3908 Nyx, 5139 Rumoi, 5653 Camarillo, (102866) 1999 WA5." *Minor Planet Bulletin* **34**, 47-48.

Galád, A. (2008). "Several Byproduct Targets of Photometric Observations at Modra." *Minor Planet Bulletin* **35**, 17-21.

Mothé-Diniz, T., Roig, F., and Carvano, J. M. (2005). "Reanalysis of asteroid families structure through visible spectroscopy." *Icarus* **174**, 54-80.

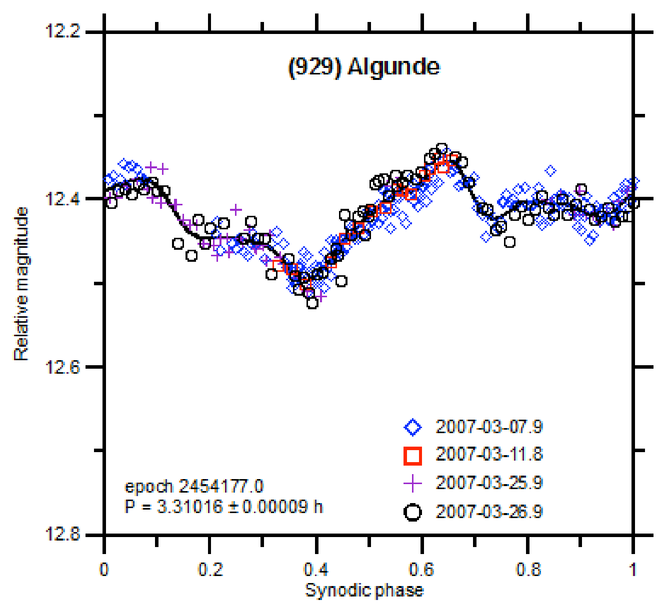
Mottola, S., De Angelis, G., Di Martino, M., Erikson, A., Hahn, G., and Neukum, G. (1995), "The near-earth objects follow-up program: First results." *Icarus* **117**, 62-70.

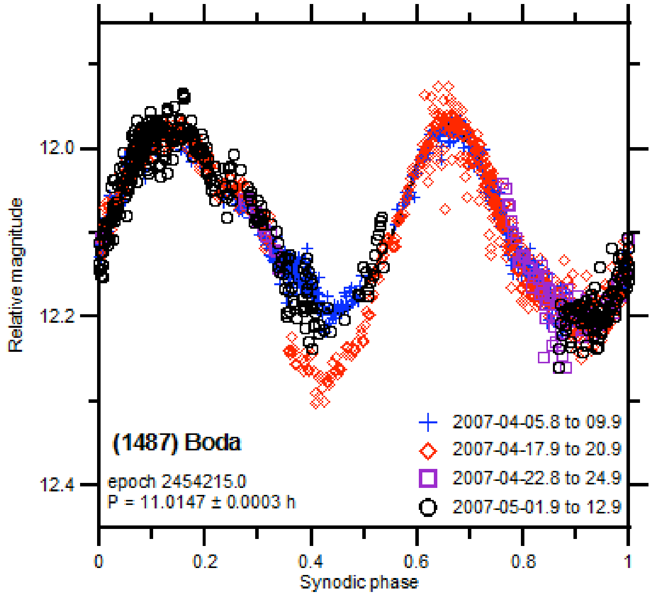
Neese, C. (2005). "Asteroid Taxonomy." EAR-A-5-DDR-TAXONOMY-V5.0. NASA Planetary Data System. http://www.psi.edu/pds/resource/taxonomy.html

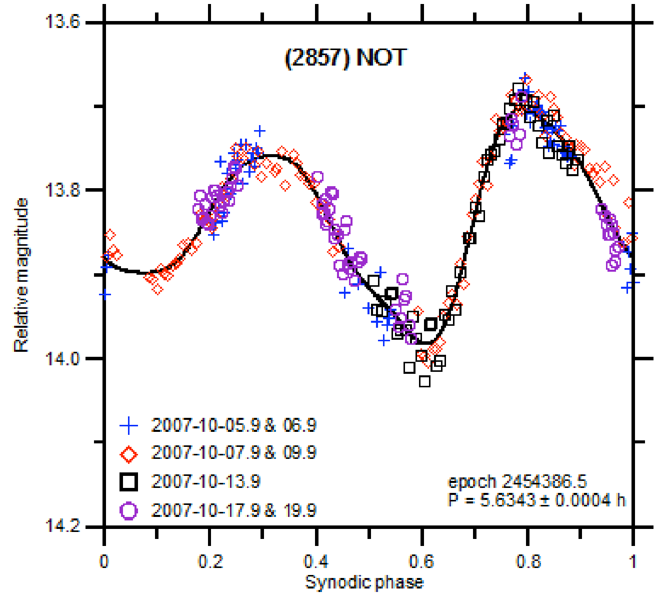
Pravec, P. (2008). http://www.asu.cas.cz/~asteroid/binastphotsurvey.htm

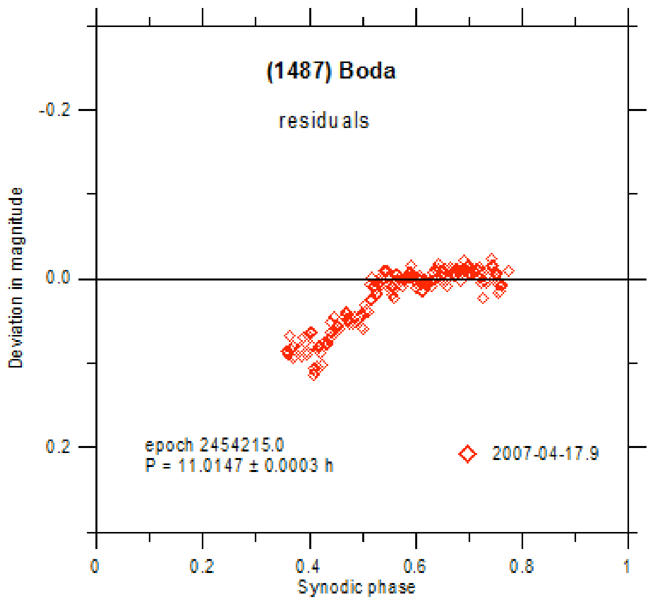
Stephens, R. D. and Malcolm G. (2007). "Lightcurve analysis of 1489 Attila and 1696 Nurmela." *Minor Planet Bulletin* **34**, 78.

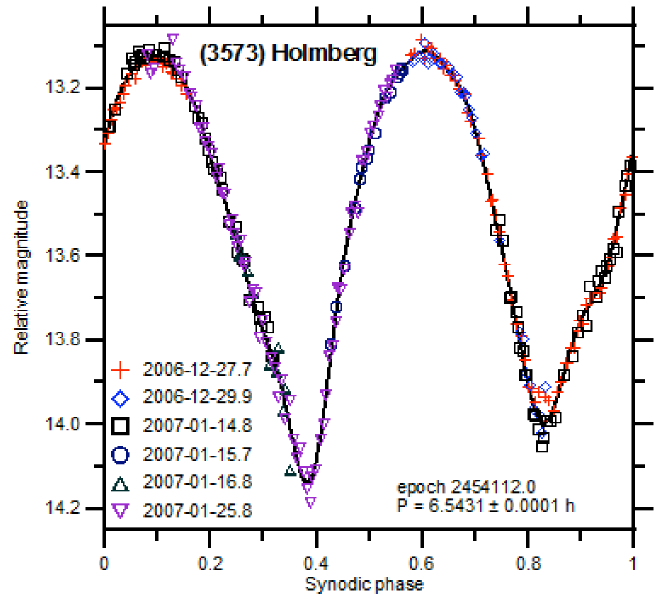
Zappalà V., Bendjoya, P., Cellino, A., Farinella, P., and Froeschlé, C. (1995). "Asteroid families: Search of a 12,487-asteroid sample using two different clustering techniques." *Icarus* **116**, 291-314.

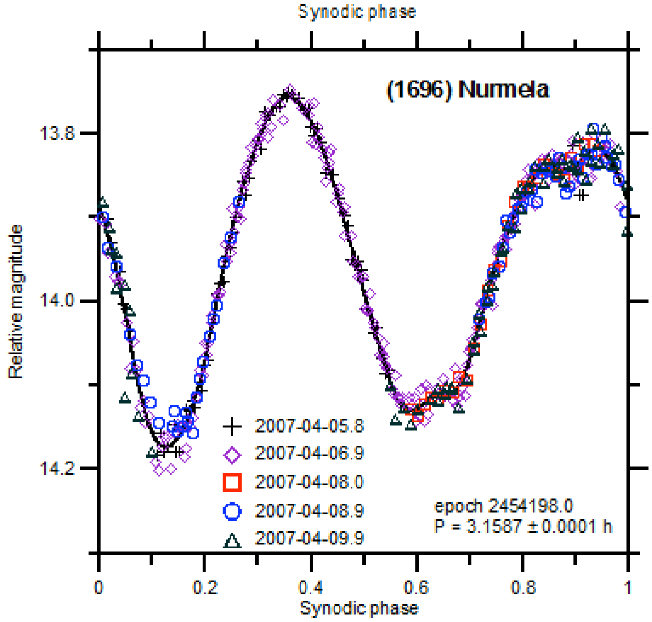


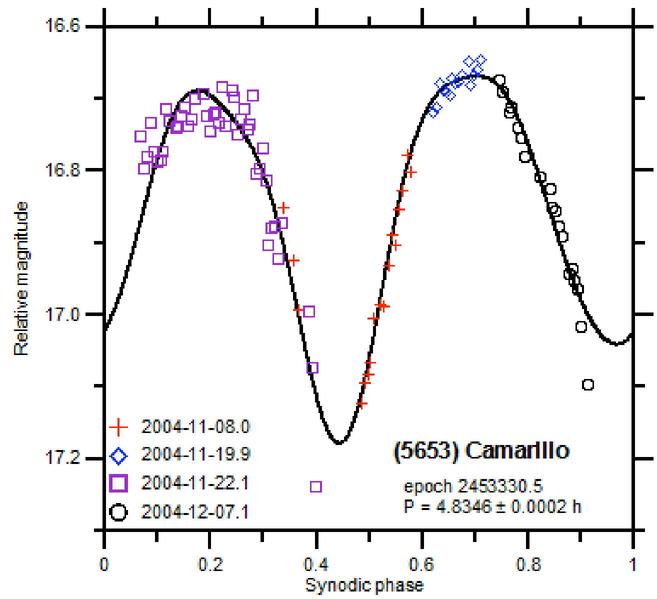

(1487) Boda
epoch 2454215.0
P = 11.0147 ± 0.0003 h
2007-04-05.8 to 09.9
2007-04-17.9 to 20.9
2007-04-22.8 to 24.9
2007-05-01.9 to 12.9
Relative magnitude
12.0
12.2
12.4
0
0.2
0.4
0.6
0.8
1
Synodic phase

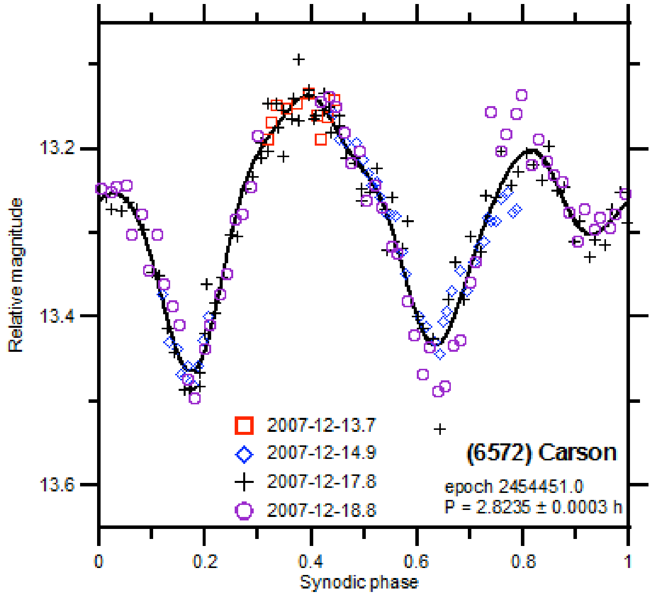

(2857) NOT
2007-10-05.9 & 06.9
2007-10-07.9 & 09.9
2007-10-13.9
2007-10-17.9 & 19.9
epoch 2454386.5
P = 5.6343 ± 0.0004 h
Relative magnitude
13.6
13.8
14.0
14.2
0
0.2
0.4
0.6
0.8
1
Synodic phase

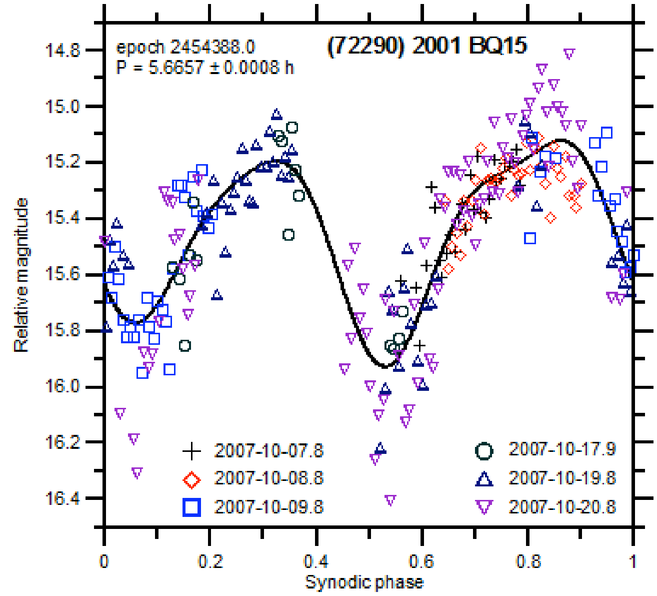

(1487) Boda
residuals
epoch 2454215.0
P = 11.0147 ± 0.0003 h
2007-04-17.9
Deviation in magnitude
-0.2
0.0
0.2
0
0.2
0.4
0.6
0.8
1
Synodic phase

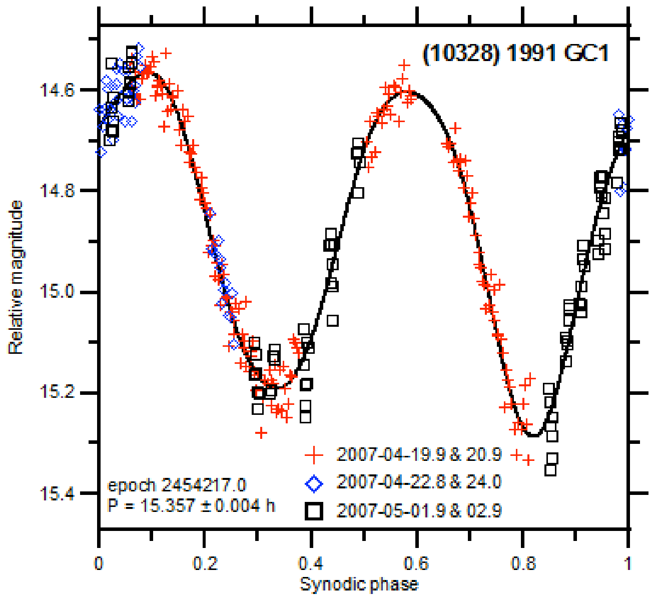

(3573) Holmberg
2006-12-27.7
2006-12-29.9
2007-01-14.8
2007-01-15.7
2007-01-16.8
2007-01-25.8
epoch 2454112.0
P = 6.5431 ± 0.0001 h
Relative magnitude
13.2
13.4
13.6
13.8
14.0
14.2
0
0.2
0.4
0.6
0.8
1
Synodic phase

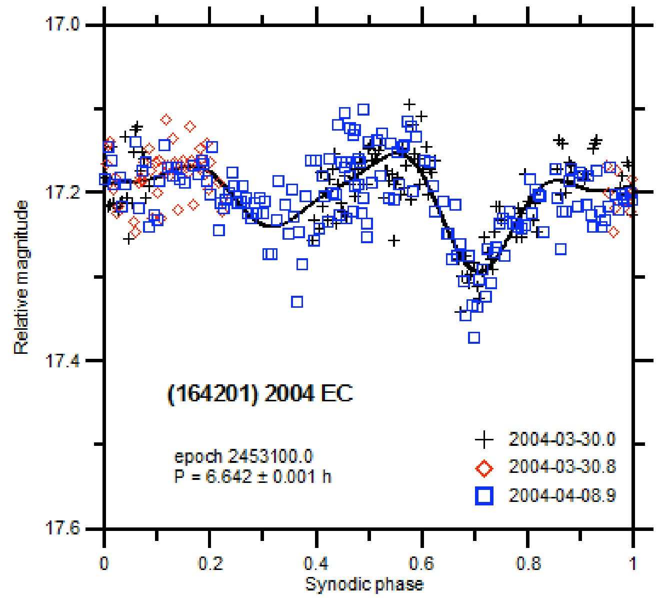

(1696) Nurmela
2007-04-05.8
2007-04-06.9
2007-04-08.0
2007-04-08.9
2007-04-09.9
epoch 2454198.0
P = 3.1587 ± 0.0001 h
Relative magnitude
13.8
14.0
14.2
0
0.2
0.4
0.6
0.8
1
Synodic phase

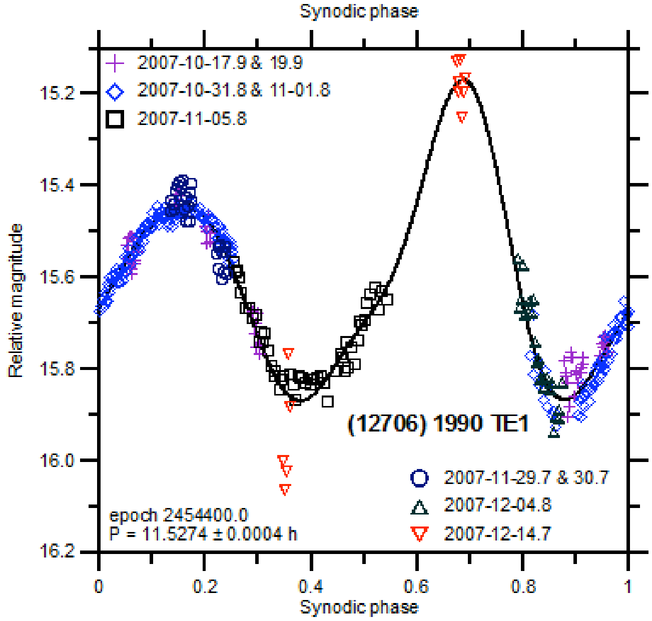

(5653) Camarillo
2004-11-08.0
2004-11-19.9
2004-11-22.1
2004-12-07.1
epoch 2453330.5
P = 4.8346 ± 0.0002 h
Relative magnitude
16.6
16.8
17.0
17.2
0
0.2
0.4
0.6
0.8
1
Synodic phase

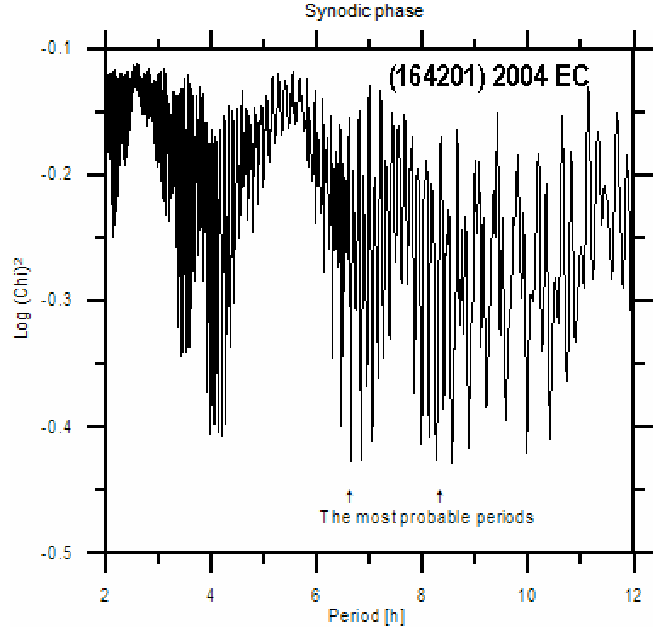

(6572) Carson
epoch 2454451.0
P = 2.8235 ± 0.0003 h
2007-12-13.7
2007-12-14.9
2007-12-17.8
2007-12-18.8
Relative magnitude
Synodic phase


(72290) 2001 BQ15
epoch 2454388.0
P = 5.6657 ± 0.0008 h
2007-10-07.8
2007-10-08.8
2007-10-09.8
2007-10-17.9
2007-10-19.8
2007-10-20.8
Relative magnitude
Synodic phase


(10328) 1991 GC1
epoch 2454217.0
P = 15.357 ± 0.004 h
2007-04-19.9 & 20.9
2007-04-22.8 & 24.0
2007-05-01.9 & 02.9
Relative magnitude
Synodic phase


(164201) 2004 EC
epoch 2453100.0
P = 6.642 ± 0.001 h
2004-03-30.0
2004-03-30.8
2004-04-08.9
Relative magnitude
Synodic phase


(12706) 1990 TE1
2007-10-17.9 & 19.9
2007-10-31.8 & 11-01.8
2007-11-05.8
2007-11-29.7 & 30.7
2007-12-04.8
2007-12-14.7
epoch 2454400.0
P = 11.5274 ± 0.0004 h
Relative magnitude
Synodic phase


(164201) 2004 EC
The most probable periods
Log (Chi)²
Period [h]

LIGHTCURVE ANALYSIS OF AN UNBIASED SAMPLE OF TROJAN ASTEROIDS

Lawrence A. Molnar, Melissa J. Haegert,
Kathleen M. Hoogeboom
Calvin College
1734 Knollcrest Circle SE
Grand Rapids, MI 49546-4403
lmolnar@calvin.edu

(Received: 15 October; Revised: 21 January)

Lightcurve observations of ten Trojan asteroids made at the Calvin Observatory are reported: 1143 Odysseus, 1208 Troilus, 2920 Automedon, 3709 Polypoites, 5144 Achates, 5638 Deikoon, (7352) 1994 CO, (34746) 2001 QE91, (38050) 1998 VR38, and (48438) 1989 WJ2. Synodic rotation periods were determined for all but (7352) 1994 CO, which showed no significant variation. The sample was unbiased with regard to period, and has a median value, 18.9 hours, significantly longer than for similarly sized main-belt objects. This may be evidence for a lower average mass density among the Trojans.

The spin properties of Trojan asteroids have not been extensively studied. For example, the catalog of Harris et al. (2007) has only 14 well determined values. The goal of this project was to study a sample of Trojans unbiased with respect to period length. Data were taken through the spring and summer of 2007. Objects were chosen as observing time allowed based on properties optimizing the chance of successfully determining their periods: proximity to opposition, brightness, and declination. Those asteroids found to vary were pursued for as many at thirteen nights in an attempt to determine every period as well as possible. Secure synodic periods (U = 3) were found for five objects, likely periods with less complete coverage for two (1208 Troilus and 2920 Automedon), and tentative periods (U = 1+) for two (3709 Polypoites and 5638 Deikoon). In every case, we tested all periods shorter than our final values and excluded them as inconsistent with the data. Hence our less secure values may be considered lower limits.

Calvin College operates two identical telescopes (0.4 m OGS Ritchey-Chretiens): one operated remotely in Rehoboth, NM, at an elevation of 2024 m, and a second on our campus in Grand Rapids, MI, at an elevation of 242 m. The Rehoboth telescope has an SBIG ST-10XE camera with a plate scale of 1.31 arcseconds per pixel, while the Grand Rapids telescope has an SBIG ST-8XE camera with a plate scale of 1.58 arcseconds per pixel. For 2007, many Trojans were in opposition in the summer, a time of poorer weather at the New Mexico site, although its darker skies otherwise make it our site of choice. No filters were used, and exposure times ranged from 120 to 300 s. Standard image calibration was done with MaxIm DL. Differential aperture photometry was done both with Canopus 9.3.1.0 (BDW Publishing 2007) and MaxIm DL always using the average of five reference stars with magnitudes comparable to the asteroid. Period analysis was done with Canopus 9.3.1.0 and Peranso 2.20 (Vanmunster 2006), using the Fourier algorithm (FALC) developed by Harris et al. (1989). All times were corrected for light travel. As Trojans have low proper motion, it was possible to directly compare one set of reference stars to the next on adjoining nights. Hence magnitude scales on adjoining nights are tied together (with uncertainty generally less than 0.02 mag). Our results are summarized in the figures and table below, along with additional comments on individual objects as needed.

<u>1143 Odysseus.</u> Each of the data points in this figure represents an average of ten images.

<u>3709 Polypoites.</u> Each of the data points in this figure represents an average of ten images. The reported period, 43.0 ± 0.1 h, is the only one consistent with the data in hand. However, the period is so long that even with nine nights relatively little of the phase range is sampled independently on multiple nights. Further observations are necessary to confirm the period.

<u>(38050) 1998 VR38.</u> Within our uncertainties, these data could be fit either by one or two peaks per cycle. Since the amplitude is 0.37 mag (larger than expected from a pole-on perspective), we consider the bimodal fit more likely.

Since the sample is unbiased with respect to period, it is interesting to compare its median, 18.9 hours, with that of main belt asteroids in the same size range, 60-170 km assuming the typical Trojan albedo found by Fernandez et al. (2003). We explore the median rather than the mean as it is insensitive to the presence of some lower limits. Note also that main-belt asteroids vary little in average rotation across this size range (Pravec et al. 2002). The catalog of Harris et al. (2007) has 396 well-measured objects in this range with a median of 11.5 hours. We use a Monte Carlo calculation to estimate the probability of finding a median as high as that of our Trojan sample from a random selection of nine main belt objects from the catalog: 0.005.

We first considered whether observational bias in the main belt sample could account for the difference. We found the main belt sample is 84% complete (Minor Planet Center 2007). The maximum bias would require the remaining 73 objects all rotate slowly, which would imply a median of 13.0 hours. The likely bias is much less – not enough to resolve the discrepancy with the Trojans. For asteroids in this size range, the spin distribution is a product of collisional evolution, and a longer average period is an indication of a lower average mass density (Harris 1979). If Trojans originated in the outer solar system, as suggested by

#	Name	Date range (2007) (mm/dd)	Images	Period (h)	P. error (h)	Est. amp. (mag)	Observing location
1143	Odysseus	08/13-08/18	340	10.1251	0.0049	0.16	MI
1208	Troilus	04/14-05/15	230	56.172	0.067	0.20	NM
2920	Automedon	07/14-07/23	377	10.2117	0.0015	0.17	NM,MI
3709	Polypoites	07/04-08/08	576	43.0	0.1	0.29	NM,MI
5144	Achates	01/23-02/27	308	5.9583	0.0031	0.32	NM
5638	Deikoon	02/15-03/20	205	19.3964	0.0113	0.14	NM
7352	1994 CO	03/06-03/12	273			<0.10	NM
34746	2001 QE91	03/26-05/11	334	19.6327	0.0016	0.56	NM
38050	1998 VR38	06/13-07/02	504	18.8538	0.0050	0.37	NM
48438	1989 WJ2	04/18-05/15	316	17.6724	0.0045	0.39	NM

Morbidelli et al. 2005, one might expect lower densities. The only well measured Trojan density (0.8 g cm^{-3} for 617 Patroclus, Marchis et al. 2006) is unusually low. A good estimate of average Trojan densities will require much more data.

Acknowledgements

This material is based upon work supported by the National Science Foundation under Grant No. 0126841. We thank the Rehoboth Christian School for the use of their campus as a location for the Calvin-Rehoboth Robotic Observatory.

References

Fernandez, Y.R., Sheppard, S.S., and Jewitt, D.C. (2003). "The Albedo Distribution of Jovian Trojan Asteroids." *Astronomical Journal* **126**, 1563-1574.

Harris, A.W. (1979). "Asteroid Rotation Rates. II. A Theory for the Collisional Evolution of Rotation Rates." *Icarus* **40**, 145-153.

Harris, A.W., Warner, B.D., and Pravec, P. (2007). "Asteroid Lightcurve Data Files." From the CALL homepage, last updated May 12, 2007. http://minorplanetobserver.com/astlc/

Harris, A.W., Young, J.W., Bowell, E., Martin, L.J., Millis, R.L., Poutanen, M., Scaltriti, F., Zappala, V., Schober, H.J., Debehogne, H, and Zeigler, K. (1989). "Photoelectric Observations of Asteroids 3, 24, 60, 261, and 863." *Icarus* **77**, 171-186.

Marchis, F., et al. (2006). "A low density of 0.8 g cm^{-3} for the Trojan binary asteroid 617 Patroclus." *Nature* **439**, 565-567.

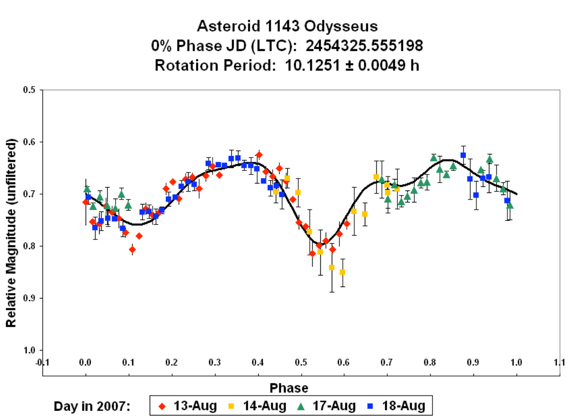
Minor Planet Center (2007). "MPC Orbit Database." From the MPC website, updated 6 August, 2007. http://www.cfa.harvard.edu/iau/MPCORB.html

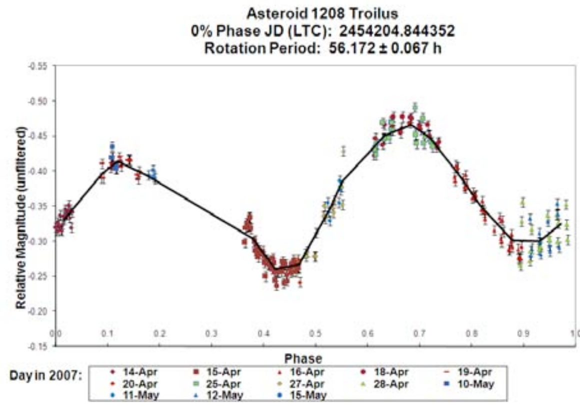
Morbidelli, A., Levison, H.F., Tsiganis, K., and Gomes, R. (2005). "Chaotic capture of Jupiter's Trojan asteroids in the early Solar System." *Nature* **435**, 462-465.

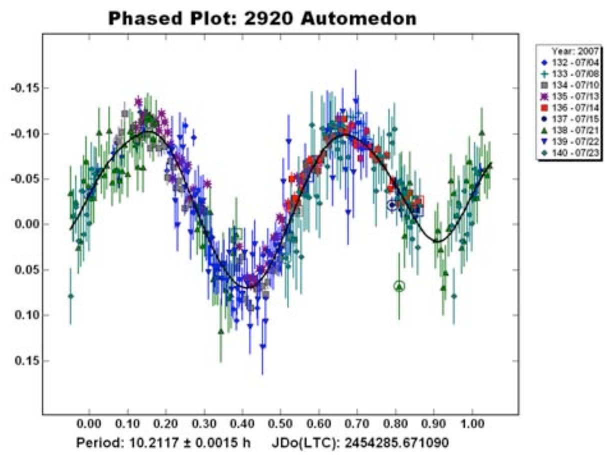
Pravec, P., Harris, A.W., and Michalowski, T. (2002). "Asteroid Rotations." *Asteroids III*, W.F. Bottke Jr., A. Cellino, P. Paolicchi, R.P. Binzel (eds.), Univ. Arizona Press, Tucson, p. 113-122.

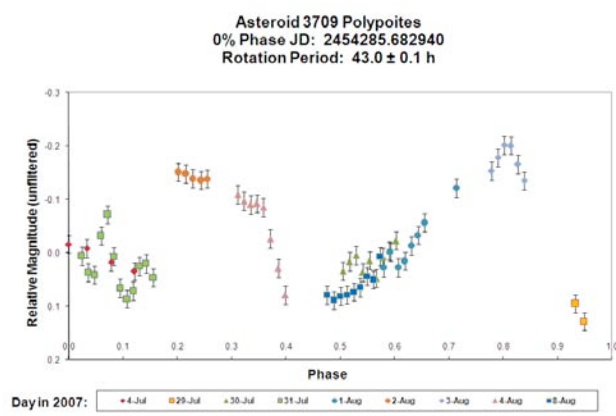
Vanmunster, T. (2006). Peranso Period Analysis Software, Peranso version 2.20, CBA Belgium Observatory.

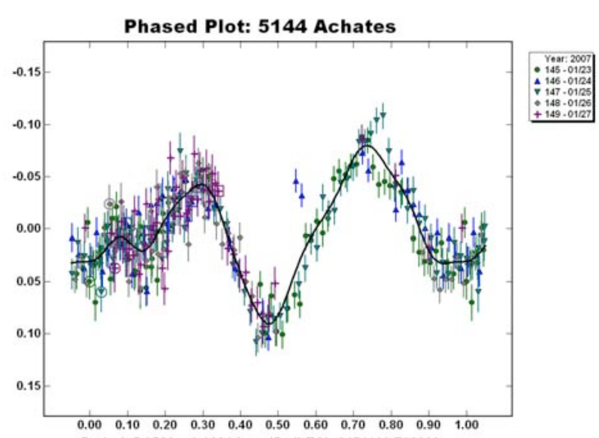
Warner, B.D. (2007). MPO Software, Canopus version 9.3.1.0. Bdw Publishing, Colorado Springs, CO.

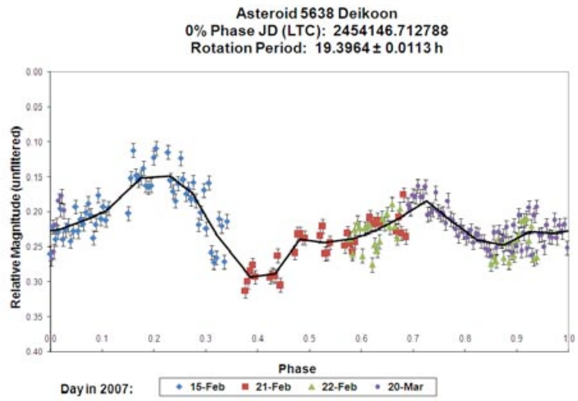


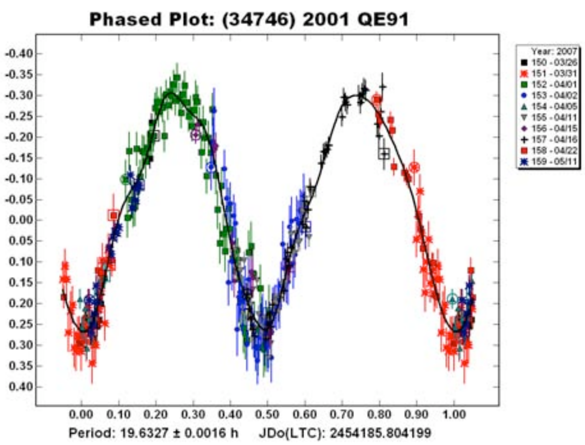


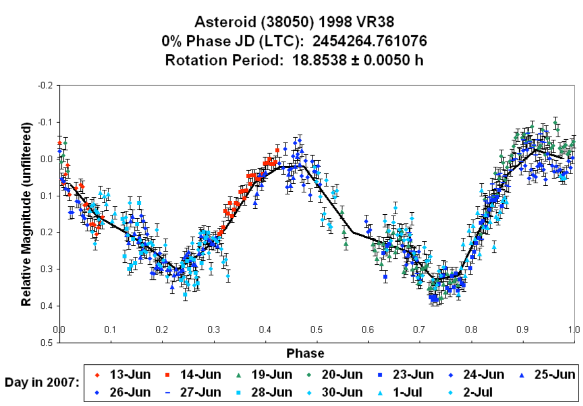


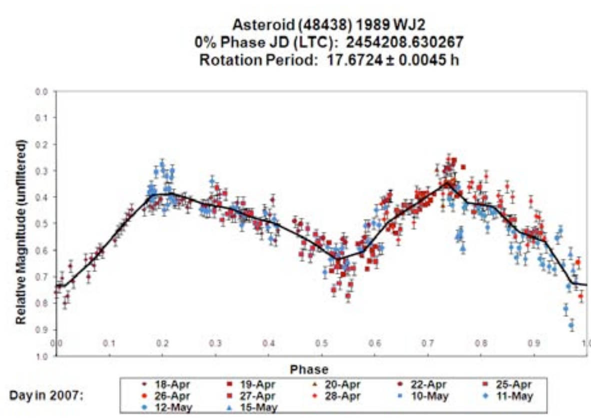












A PRELIMINARY SHAPE AND SPIN AXIS MODEL FOR 76 FREIA

Robert D. Stephens
Goat Mountain Astronomical Research Station (GMARS)
Santana Observatory
11355 Mount Johnson Court
Rancho Cucamonga, CA 91737 USA
rstephens@foxandstephens.com

Brian D. Warner
Palmer Divide Observatory
Colorado Springs, CO 80908 USA

(Received: 4 January)

Photometric observations from the 2007 apparition of main-belt asteroid 76 Freia were combined with those from earlier apparitions to determine a preliminary shape and spin axis model. The combined data set was not extensive, resulting in more than one reasonable solution. Regardless, the solutions showed two consistent results for the pole (geocentric ecliptic coordinates): $\lambda = 139°$, $\beta = +25°$ or $\lambda = 0°$, $\beta = +40°$.

Stephens observed 76 Freia for three nights in December, 2007: December 8 at GMARS (0.35m Modified Ritchey-Chretien); December 11-12 (0.30m Modified Ritchey-Chretien). Both telescopes were equipped with an SBIG STL-1001 CCD camera, yielding a pixel scale of approximately 1.2"/pixel. Exposures were 60 seconds. Over the four-day span, the phase angle decreased from 6°.5 to 5°.0. The Phase Angle Bisector (PAB) remained nearly constant at $\lambda = 91°.5$, $\beta = -2°.3$. The combined data set of 559 points yielded a lightcurve with synodic period of 9.969 ± 0.002 h and amplitude of 0.10 ± 0.01 mag. (Fig. 1). This is in good agreement with previous results, including Harris et al. (1992) and Armstrong et al. (1996).

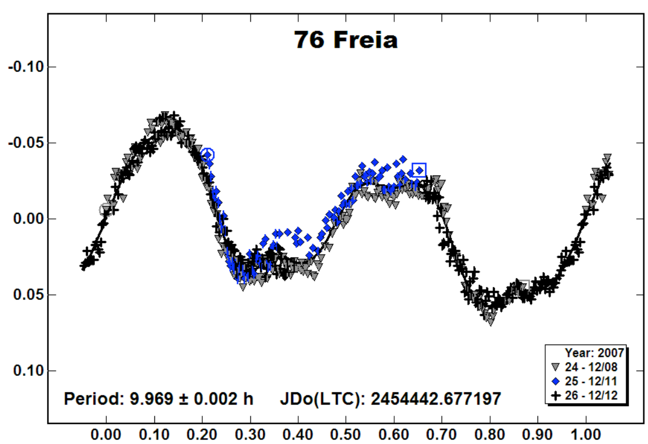


Fig. 1. The lightcurve for 76 Freia based on data obtained in 2007.

Stephens communicated his results to Warner, who reviewed available lightcurve data in the Standard Asteroid Photometric Catalog (http://www2.astro.helsinki.fi/SAPC/index.jsp) and found data from apparitions in 1981 and 1984 (Lagerkvist et al.) along with 1994 (Kryszczynska et al.). While the overall time-span of the data was more than 20 years, the number of lightcurves on the SAPC site was not extensive. A review of the lightcurves by Armstrong and Harris showed them to be fairly sparse and of little additional use. They were not included in this study. Furthermore, all data were within an arc of heliocentric longitude of 180°. Better results are obtained when the data cover as much of the orbit as possible. The next apparition in 2009 continues this trend, being similar to the 1984 observations. Despite these shortcomings, Warner attempted to model the asteroid using MPO LCInvert (Bdw Publishing), which is based on the source code provided by Mikko Kaasalainen and Josef Durech. The documentation and core library source code are available as free downloads on the MPO LCInvert web page.

Analysis and Results

A period search was run on the combined data set, which found a sidereal period of 9.968240 h. This was used as the free-floating period in the subsequent model searches. The initial weighting of the "dark area" (see the several Kaasalainen references) was set to 0.1 for the first search and 0.5 for a second run. This provided a check on the size of the "dark area" in the two models. A tendency for the dark area towards a higher value may indicate albedo variations. In this case, there were no significant tendencies and so the presumption is that the lightcurve variations are due almost exclusively to shape with no significant albedo effects.

The final result of the modeling was to find two dominant pole solutions, at least in the terms that there were several solutions near the two solutions in each group of 15 test conditions. Those two solutions are listed in Table 1, along with an average of the sidereal periods. The preferred solution is given first. The χ^2 values themselves did not have as large of spread as would be liked to assert a definitive solution. Figure 2 shows the model for the preferred solution (139°, +25°) as seen from the asteroid's equatorial plane at local noon.

λ	β	Sidereal Period
139° ± 5°	25° ± 5°	9.968286 ± 0.000009 h
0° ± 5°	40° ± 5°	

Table 1. Poles and periods for the two best shape model solutions.

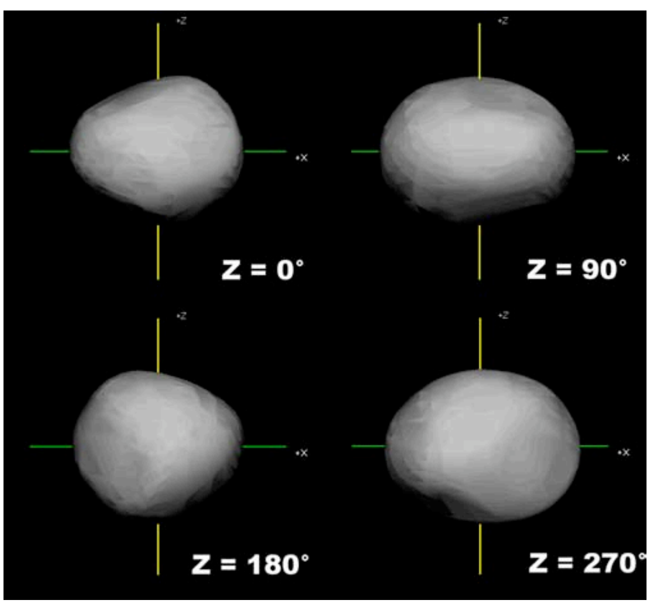


Fig. 2. Equatorial view of (139°, 25°) solution.

The use of relative-only data prevents the modeling process from finding a definitive height of the Z-axis, i.e., the a/c or b/c ratios. Only the a/b ratio is found with any certainty. The theoretical lightcurves of the (139°, +25°) model fit the original data well (Fig. 3), more so than the model curves of the alternate solution (0°, +40°). However, the differences are only just statistically significant and so either solution remains a possibility. The models also show some large flat spots, possibly indicating large craters or concavities.

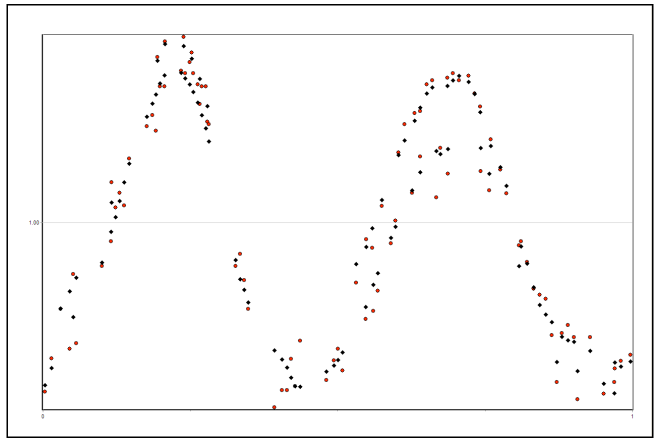


Fig. 3. Comparison of theoretical (black/dark) and actual (red/light) data using 1984 data and best solution from 0.1 initial weighting.

Acknowledgements

Funding for research at the Palmer Divide Observatory is provided by NASA grant NNG06GI32G and by National Science Foundation grant AST-0607505. The authors thank reviewers Mikko Kaasalainen and Steve Higley for their comments and suggestions to improve this paper.

References

Armstrong, J.C., Nellermoe, B.L., and Reitzler, L.E. (1996) *I.A.P.P.P. Comm.* **63**, 59-68.

Bdw Publishing (2007). http://www.minorplanetobserver.com/MPOSoftware/MPOLCInvert.htm

Harris, A.W., Young, J.W., Dockweiler, T., Gibson, J., Poutanen, M., and Bowell, E. (1992). *Icarus* **95**, 115-147.

Kaasalainen, J., and Torppa, J. (2001). "Optimization Methods for Asteroid Lightcurve Inversion: I. Shape Determination." *Icarus* **153**, 24-36.

Kaasalainen, J., Torppa, J., and Muinonen, K. (2001). "Optimization Methods for Asteroid Lightcurve Inversion: II. The Complete Inverse Problem." *Icarus* **153**, 37-51.

Kaasalainen, M., Mottola, S. and Fulchignoni, M. (2002). "Asteroid Models from Disk-integrated Data." In *Asteroids III,* (W.F. Bottke, A. Cellino, P. Paolicchi, R.P. Binzel, eds.) pp. 139-150. Univ. Arizona Press, Tucson.

Kaasalainen, M., Durech, J. (2007). "Inverse Problems of NEO Photometry: Imaging the NEO Population." In *Near Earth Objects, our Celestial Neighbors: Opportunity and Risk*, Proceedings of IAU Symposium 236 (G.B. Valsecchi, D. Vokrouhlick_, eds). pp.151-166. Cambridge University Press, Cambridge.

THE ROTATION PERIODS OF 531 ZERLINA, 1194 ALETA, 1352 WAWEL 2005 HENCKE, 2648 OWA, AND 3509 SANSHUI

James W. Brinsfield
Via Capote Observatory
5180 Via Capote, Thousand Oaks CA 91320
jbrinsfi@gmail.com

(Received: 6 January)

Lightcurves for six asteroids were measured at the Via Capote Observatory from September–December 2007: 531 Zerlina (16.716 h), 1194 Aleta (19.7 h), 1352 Wawel (16.97 h), 2005 Hencke (10.186 h), 2648 Owa (3.56 h), and 3509 Sanshui (13.68 h).

Observations reported here were made using a Takahashi Cassigran at prime focus resulting in a focal length of 136 inches and a focal ratio of f11.5. The CCD imager was an Alta U6 featuring a 1024x1024 array of 24 μ-meter pixels operating at –30°C. All observations were unfiltered and made at 1x binning yielding an image scale of 1.43"/pixel. All images were dark and flat field corrected; however, no other image enhancements were made. Images were measured and period analysis was done using MPO Canopus (Bdw Publishing). All data were light-time corrected. The results are summarized in the table below and include average phase angle information across the observational period. Individual lightcurve plots along with additional comments as required are also presented.

531 Zerlina. Behrend (2006) reports a provisionary rotational period of 8 hours with partial period coverage. Szekely et al. (2005) report a lower limit of 12 hours**.**

1194 Aleta**.** There are no previously published lightcurves.

1352 Wawel. There are no previously published lightcurves.

2005 Hencke. Several of the data sessions were affected by moon light, thus reducing the quality of the measurements. The low apparent amplitude of the lightcurve coupled with the high levels of ambient light (noise) made estimating a rotational period very uncertain. There are no previously published lightcurves.

2648 Owa**.** Pray (2007) reports a very similar period in his study within the Survey for Asynchronous Binaries, although his lightcurve amplitude was reported to be approximately 28% lower than that measured in this investigation. These different values are most likely attributed to the object's phase angle difference between the two measurements, which were approximately 45 days apart (phase angles of 8°.5 and 26°.6, respectively).

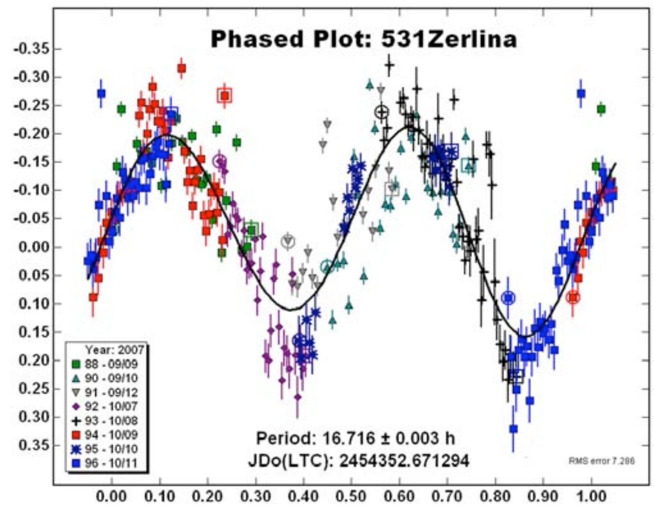
3509 Sanshui**.** Data collected on 22 November were affected by moon light. There are no previously published lightcurves.

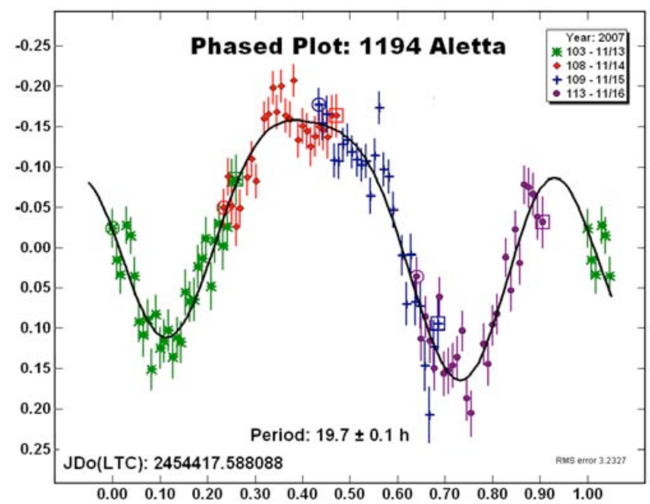
References

Behrend, R. (2008). Observatoire de Geneve web site

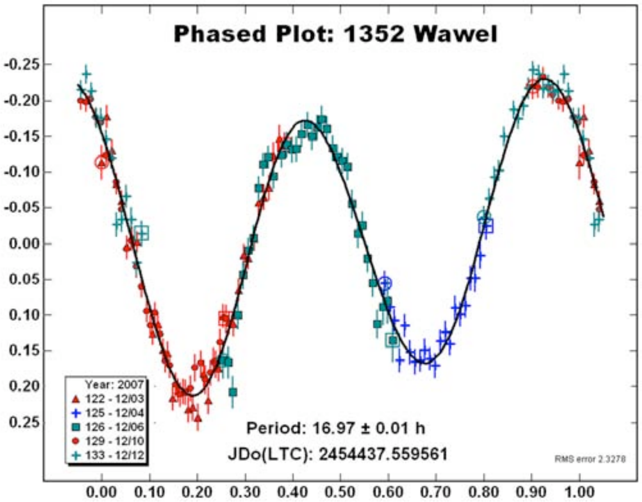
Pray, D. (2007). "Photometric Survey for Asynchronous Binary Asteroids." *http://www.asu.cas.cz/~asteroid/binastphotsurvey.htm*

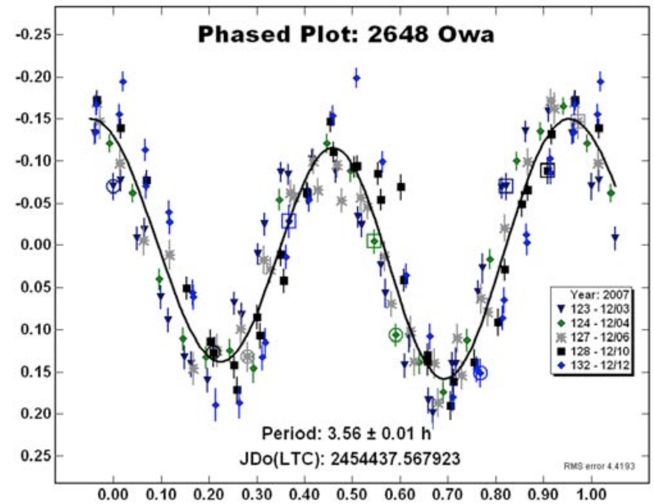
Szekely, P., Kiss, L.L., Szabo, Gy. M., Sarneczky, K., Csak, B., Varadi, M., and Meszaros, Sz. (2005). *Planet. Space Sci.* **53**, 925-936.

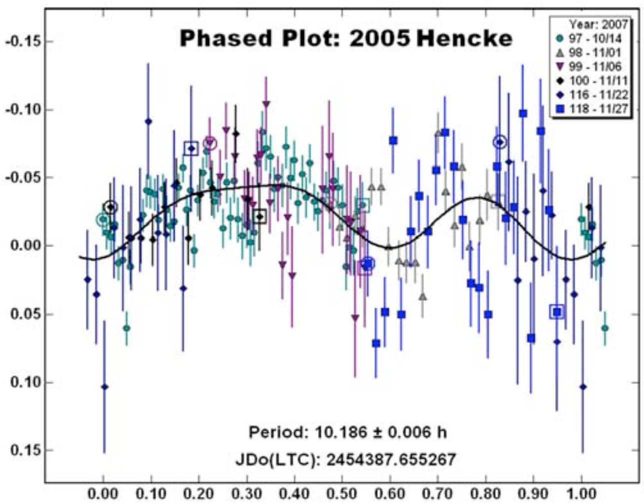


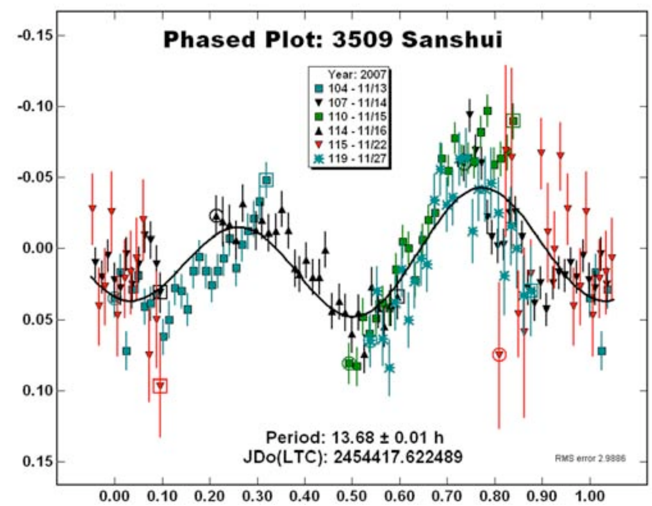


Asteroid	Date Range (mm/dd) 2007	Data Points	Phase	L_{PAB}	B_{PAB}	Per(h)	PE	Amp(m)	AE
531 Zerlina	09/09-10/11	281	18.45	328.5	29.65	16.716	0.003	0.41	0.07
1194 Aleta	11/13-11/16	108	16.65	352.95	11.3	19.7	0.1	0.32	0.05
1352 Wawel	12/03-12/12	152	19.05	24.55	-2	16.97	0.01	0.44	0.02
2005 Hencke	10/14-11/11	163	20.2	359.75	14.85	10.186	0.006	0.08	0.025
2648 Owa	12/03-12/12	151	26.6	30.6	5.35	3.56	0.01	0.32	0.03
3509 Sanshui	11/13-11/27	158	22.65	8.15	5.55	13.68	0.01	0.07	0.02









LIGHTCURVE ANALYSIS OF 669 KYPRIA

Craig S. Bennefeld
Physics Department, Imagine Renaissance Academy of Environmental Science and Math
Kansas City, MO 64125 USA
craig@bennefeld.org

Pedro V. Sada
Departamento de Física y Matemáticas
Universidad de Monterrey
Garza García, N.L., 66238 MEXICO

(Received: 25 December 2007)

Photometric observations of 669 Kypria were made during August and September of 2007. Analysis of the data yields a synodic rotational period of 14.283 ± 0.001 h and amplitude of ~0.60 mag.

669 Kypria, an S-class main-belt asteroid, was independently selected by both authors from the list of asteroid lightcurve photometry opportunities (Warner et al., 2007) which is also posted on the Collaborative Asteroid Lightcurve Link (CALL) website (Warner, 2007a). Bennefeld's observations were carried out at his observatory (MPC H46), which is equipped with a 0.35m Meade LX200GPS telescope operating at f/6.3 coupled to a SBIG ST7-XME CCD camera, resulting in a resolution of ~1.7 arcsec/pixel (binned 2_2). The Universidad de Monterrey (MPC 720) observations were also achieved with a similar 0.35m telescope, but the detector was a SBIG ST-9E which also yielded ~1.7 arcsec/pixel (unbinned). Unfiltered data were acquired on ten nights between August 5 and September 23. These observations, totaling 762 useful data points, were made between phase angles 4.7 and 17.8 degrees. Period analysis of the observations was preformed using Brian Warner's MPO Canopus differential photometry software (Warner, 2007b).

Analysis of the present data results in a synodic rotation period of 14.283 ± 0.001 h and amplitude of ~0.60 magnitudes. Behrend (2007) reports on his website a provisional period of 14.292 ± 0.012 h and amplitude of 0.167 ± 0.017 mag from observations performed in March-April 2006. While there is agreement in the rotational periods of 669 Kypria between the 2006 and 2007 sessions, the amplitude varied by a factor of ~3.5. No other reports have been made for this asteroid.

The resulting bimodal lightcurve was sampled over 90% in phase, with the two maxima and two minima differing by ~0.10

magnitudes from each other. One minimum in particular exhibited an extra increase of ~0.13 magnitudes between the early-August and mid-September data. This may be a real effect due to the change in geometry during the intervening 7-8 weeks between observations as noted in the table, and the shape of the asteroid.

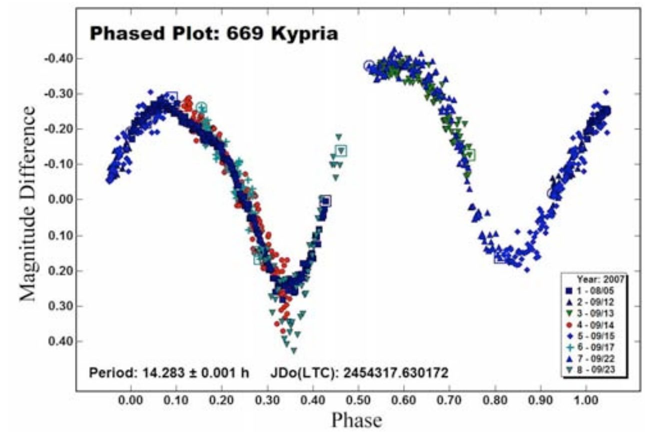
References

Behrend, R. (2007). "Asteroids and Comets Rotation Curves, CdR." *http://obswww.unige.ch/~behrend/page2cou.html.*

Warner, B.D., Harris, A.W., Pravec, P., Kaasalainen, M. and Benner, L.A.M. (2007). "Lightcurve Photometry Opportunities: July-September 2007." *Minor Planet Bulletin* **34**, 92-94.

Warner, B.D. (2007a). "Collaborative Asteroid Lightcurve Link." *http://www.minorplanetobserver.com/astlc/default.htm.*

Warner, B.D. (2007b). MPO Software, Canopus version 9.2.3.1 Bdw Publishing, Colorado Springs, CO.



349 DEMBOWSKA: A MINOR STUDY OF ITS SHAPE AND PARAMETERS

Daniel J. Majaess, Joel Tanner, Jonathan Savoy, Beth Sampson
Graduate Studies, Department of Astronomy & Physics
Saint Mary's University
Halifax, Nova Scotia, Canada
dmajaess@ap.smu.ca ; jsavoy@ap.smu.ca

(Received: 4 January Revised: 13 January)

Photometry of asteroid 349 Dembowska was obtained at a high-latitude aspect, yielding a synodic rotational period of 4.7029 ± 0.0054 h. Lightcurve inversion, performed with the new observations combined with archival photometry, yields an asymmetric elongated ellipsoid as the dominant shape solution. The absolute magnitude and phase coefficient for 349 Dembowska were determined using archival photometry to be $M_v = 6.14 \pm 0.07$ and $\beta_v = 0.022 \pm 0.004$ mag/degree. We estimate Dembowska's diameter (143 km) by adopting a simple formalism to interpret the object's thermal emission and we demonstrate that the spectral energy distribution from the *Two Micron All Sky Survey* and the *Sloan Digital Sky Survey* can be used to reveal the known signature of olivine and pyroxene absorption near 1μm.

Located just prior to the prominent 7:3 resonance with Jupiter, 349 Dembowska is among the larger asteroids in the main belt with an estimated diameter of ~140 km (Tedesco 1989) and is classified as an R-type asteroid from the presence of strong absorption bands of olivine and pyroxene with little or no metals (Gaffey et al. 1993). In this study, observations taken during an epoch of high-latitude viewing were used to deduce the asteroid's rotational period and phased lightcurve parameters. Our photometry was supplemented by archival observations in order to model the asteroid's shape and determine its intrinsic brightness. We also examine the asteroid's spectral energy distribution using data from the *Sloan Digital Sky Survey* (SDSS), the *Two Micron All Sky Survey* (2MASS), and the *Infrared Astronomical Satellite* (IRAS), enabling us to investigate the object's spectral composition and size.

Lightcurve. 349 Dembowska has been well monitored during its passage through ecliptic longitudes of 60°-70° and 230°-240° (Abell & Gaffey 2000, see references therein). The lightcurve exhibits bimodal structure with two maxima and minima separated by nearly 0.4 magnitude. However, during ecliptic longitudes of 150°-160° and 330°-360°, the brightness profile transitions to display only one peak per orbital period and a significant decrease in amplitude is noted. The evolution in the lightcurve morphology may be consistent with a transformation from a near-equatorial viewing perspective to one of high latitude. The need for precision photometry at high latitude inspired this study.

The asteroid was observed on four nights in March 2003 from the Burke-Gaffney Observatory at Saint Mary's University in downtown Halifax, Nova Scotia, Canada. The observatory houses a 0.4m Cassegrain reflector and is equipped with an SBIG ST-8 CCD camera. All images were obtained unfiltered, which allowed a high signal-to-noise ratio during this particular epoch (ecliptic longitude ~155°). Pre-processing and differential photometry were performed using Cyanogen's MaximDL and Mirametrics Mira Pro. The asteroid's motion necessitated different reference stars on each night. Consequently, the data needed to be standardized in magnitude space before a period search could ensue.

A period search was then initiated after removal of spurious data obtained through clouds or during twilight. The period analysis was carried out using Peranso (Vanmunster 2007), which incorporates the FALC algorithm (Harris et al. 1989). A synodic period of 4.7029 ± 0.0054 h was found. Figure 1 shows the data phased to that period. Our result is consistent with, although less precise than, that of Zappala et al. (1979) who obtained a period of 4.70117 ± 0.00007 h. The lightcurve has an amplitude of ~0.1 magnitude, and displays one maximum and minimum per orbital period. There is an obvious plateau that bridges the extrema; this imposed valuable constraints during modeling.

Shape. The asteroid's surface profile was modeled using MPO LCInvert, a GUI package based on the photometric inversion techniques of Kaasalainen & Torppa (2001). For the inversion process our own observations were supplemented by a number of other studies (Table 1) summarized in digitized form in the Asteroid Photometric Catalog (Lagerkvist et al. 2001). A period search was carried out in LCInvert using the entire data set. The result was a sidereal period of 4.701207 ± 0.000058 h, which was adopted for the inversion. The uncertainty is merely the dispersion among the top five solutions with the lowest χ^2 statistic.

A single shape (Fig. 2) consistently emerged among the solutions and can be described as an asymmetric elongated ellipsoid (the canonical potato shape), which generally agrees with the structure of 349 Dembowska as suggested by Torppa et al. (2003). The model fits compare satisfactorily to the observations (Fig 3). However, we were unable to identify a unique pole orientation confidently. Additional observations, especially absolute photometry, should help resolve the ambiguities. Lastly, we note that Abell & Gaffey (2000) have suggested that 349 Dembowska could exhibit albedo variation.

Diameter & Albedo: Veeder & Walker (1995) cite several measurements of the asteroid's diameter and geometric albedo that were derived from IRAS data by adopting a standard thermal model. A weighted mean and weighted standard deviation of their results yields a diameter of 139 ± 9 km and geometric albedo of 0.36 ± 0.05. Alternatively, we decided to assess how parameters determined from a simpler formalism would compare. For a blackbody, the emitted surface flux, $f(s, \nu)$, at a specific frequency is related to the Planck function, $I(\nu,T)$ by: $f(s, \nu) = \pi I(\nu,T)$. For a spherical geometry, the total flux measured at a distance d from a source of radius R is given by: $f(s) = \pi I(\nu,T) (R/d)^2$. A temperature of ~210 K and diameter of ~143 km produced the best fit to the IRAS photometry (Fig. 4). During the fitting process, however, the flux densities produced by the above equation were not convolved with the IRAS filter transmission functions. Testing indicates that the resulting uncertainties are of order ~1-10%, nonetheless, the diameter is in general agreement with the value derived from the more robust standard thermal model.

Spectral Energy Distribution: A profile of the asteroid's spectral energy distribution (SED) was created by using photometry from IRAS (Veeder & Walker 1995), 2MASS (Sykes et al. 2001), and SDSS (Krisciunas et al. 1998). The available observations enabled a broad sampling of the spectrum from the far-infrared to the ultraviolet. To homogenize the set, the data were reduced to unity Sun-Earth distance. The SED (Fig. 5) highlights both the reflected and reradiated regimes along with a prominent absorption feature near 1μm, denoting the likely presence of olivine and pyroxene (Hiroi & Sasaki 2001; Gaffey & McCord 1978). The presence of such minerals may explain the asteroid's high albedo and could place important constraints on the body's formation history since olivine and pyroxene may be found in the mantle of differentiated objects. Lastly, we note the usefulness of the all-sky surveys in determining the spectral composition of minor bodies, which may be of added importance when studying lesser-known objects.

Absolute Magnitude & Phase Coefficient: When an asteroid is not observed at opposition, the flux received is diminished because of fractional illumination and shadowing (for fluxes reduced to unit distance). The effect can be described by a phase function diagram (Fig. 6) from which the absolute magnitude (Mv) and phase coefficient (βv) of the asteroid are determined. In the case of 349 Dembowska, the parameters were derived from the combined data sets of Zappala et al. (1979), Weidenschilling et al. (1987), and di Martino et al. (1987). A linear least squares fit to data with phase angles between 10° and 20°, thus avoiding the oppositional surge, found M_v=6.14±0.07 and β_v = 0.022 ± 0.004 mag/degree. That is consistent with the results of Zappala et al. (1979), confirming that 349 Dembowska is among the brighter asteroids in the main belt.

Acknowledgements

We are indebted to the following individuals for their help: David G. Turner, C. Ian Short, Katrin Jacob, David J. Lane, Daniel U. Thibault, and Eric E. Palmer, who maintains the online asteroid database (*http://epmac.lpl.arizona.edu/*). The authors also acknowledge that the planetarium and telescope control software Earth Centered Universe v5.0 was invaluable in the preparation of this work.

References

Abell, P.A. and Gaffey, M.J. (2000). *Lunar and Planetary Institute Conference Abstracts* **31**, 1291.

diMartino, M., Zappala, V., deSanctis, G., and Cacciatori, S. (1987). *Icarus* **69**, 338,

Gaffey, M.J., Burbine, T.H., and Binzel, R.P. (1993). *Meteoritics* **28**, 161.

Gaffey, M.J. and McCord, T.B. (1978). *Space Sci. Reviews* **21**, 555.

Harris, A.W., et al. (1989). *Icarus* **77**, 171.

Haupt, H. (1980). *Oesterreichische Akademie Wissenschaften Mathematischnaturwis-senschaftliche Klasse Sitzungsberichte Abteilung* **189**, 429,

Hiroi, T. and Sasaki, S. (2001). *Meteoritics Plan. Sci.* **36**, 158.

Kaasalainen, M. and Torppa, J. (2001). *Icarus* **153**, 24.

Krisciunas, K., Margon, B., and Szkody, P. (1998). *PASP* **110**, 1342

Lagerkvist, C.-I., Piironen, J., and Erikson, A. (2001). *Asteroid Photometric Catalogue*, Fifth Update. Uppsala Astron. Obs.

Sykes, M.V., Cutri, R.M., Fowler, J.W., Tholen, D.J., and Skrutskie, M.F. (2001). *Bull. Amer. Astron. Soc.* **33**, 1120.

Tedesco, E. F. (1989). "Asteroid Magnitudes, UBV Colors, and IRAS Albedos and Diameters." In *Asteroids II* (R.P. Binzel, T. Gehrels, M.S. Matthews, eds.) pp 1090-1138. Univ. Arizona Press, Tucson.

Torppa, J., Kaasalainen, M., Michalowski, T., Kwiatkowski, T., Kryszczynska, A., Denchev, P., and Kowalski, R. (2003). *Icarus* **164**, 346.

Vanmunster, T. Peranso Light Curve and Period Analysis Software, http://www.peranso.com.

Veeder, G.J., and Walker, R.G. (1995). VizieR On-line Data Catalog, 7091, 0 (*http://vizier.u-strasbg.fr/viz-bin/VizieR*).

Weidenschilling, S.J., Chapman, C.R., Davis, D.R., Greenberg, R., Levy, D. H., and Vail, S. (1987). *Icarus* **70**, 191.

Zappala, V., vanHouten-Groeneveld, I., and vanHouten, C.J. (1979). *Astron. & Astrophys. Supp.* **35**, 213.

TABLE 1
PHOTOMETRIC STUDIES USED IN THE INVERSION

Study	Date	# Datapoints	Weight
Zappala et al. (1979)	March 11th, 1965	45	1
Zappala et al. (1979)	April 1st, 1965	56	1
Zappala et al. (1979)	April 24th, 1965	50	2
Zappala et al. (1979)	May 6th, 1965	57	1
Zappala et al. (1979)	May 9th, 1965	43	1
Zappala et al. (1979)	May 21st, 1965	61	1
Zappala et al. (1979)	June 3rd, 1965	48	1
Zappala et al. (1979)	June 18th, 1965	59	1
Haupt (1980)	December 31st, 1977	70	2
Weidenschilling et al. (1987)	April 9th, 1984	30	1
Authors	March 10th, 2004	18	1
Authors	March 16th, 2004	93	1
Authors	March 24th, 2004	130	2
Authors	March 28th, 2004	163	2

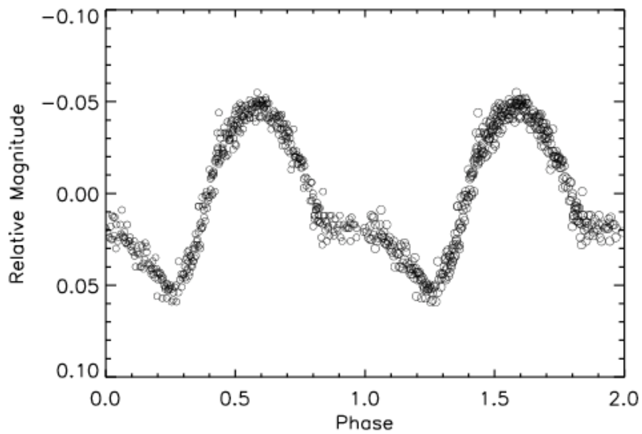


Fig. 1. The lightcurve of 349 Dembowska phased with a rotation period of 4.7029 ± 0.0054 h.

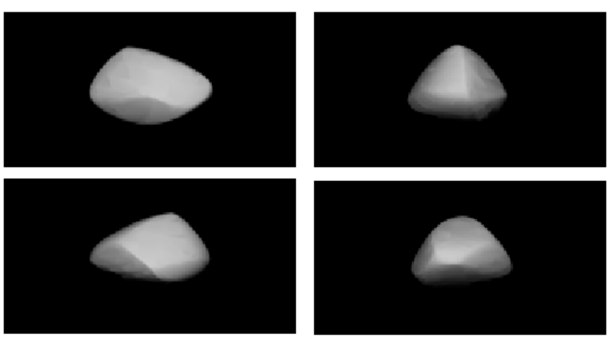


Fig. 2. Shape model of 349 Dembowska. The rotation axis is oriented vertically with Z = 0°, 90° (top row), 180°, and 270° (bottom row).

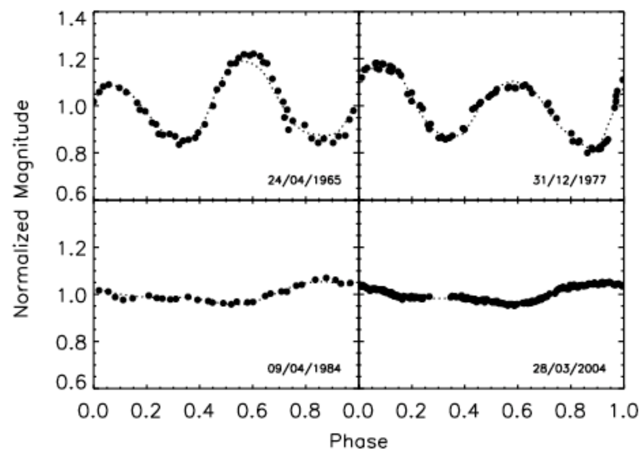


Fig. 3. A sample of photometric observations (filled circles) compared to synthetic light-curves (dotted line). Our photometry of the low amplitude phase is presented in the lower right panel.

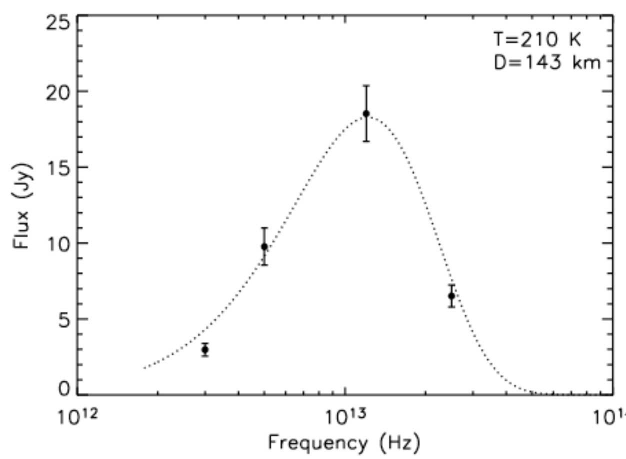


Fig. 4. A temperature of ~210 K and a diameter of ~143 km produce the minimum χ^2 statistic when fitting a modified Planck function to the asteroid's thermal emission (IRAS photometry).

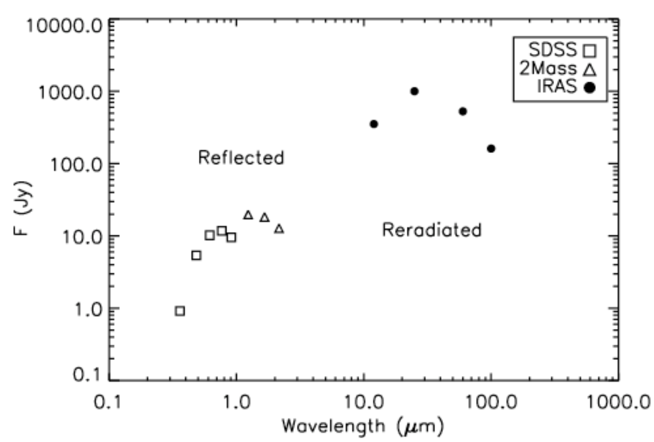


Fig. 5. The spectral energy distribution for 349 Dembowska established from SDSS, 2MASS, and IRAS data. Both the regimes of reflected and reradiated energy are distinctly visible, along with a likely absorption feature near 1μm (olivine & pyroxene).

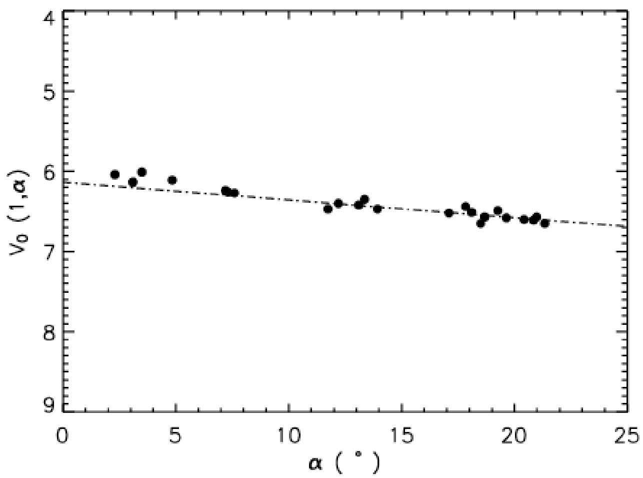


Fig. 6. The phase function for 349 Dembowska compiled from archival photometry. A linear least squares fit to data with phase angles between 10° and 20° gives an absolute magnitude of 6.14 ± 0.07 and a phase coefficient of 0.022 ± 0.004 mag/degree.

CALL FOR OBSERVATIONS

Frederick Pilcher
4438 Organ Mesa Loop
Las Cruces, NM 88011 USA
pilcher@ic.edu

Observers who have made visual, photographic, or CCD measurements of positions of minor planets in calendar 2007 are encouraged to report them to this author on or before April 1, 2008. This will be the deadline for receipt of reports which can be included in the "General Report of Position Observations for 2007," to be published in *MPB* Vol. 35, No. 3.

LIGHTCURVE PHOTOMETRY OPPORTUNITIES: APRIL-MAY 2008

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

Alan W. Harris
Space Science Institute
La Canada, CA 91011-3364 USA

Petr Pravec
Astronomical Institute
CZ-25165 Ondřejov, Czech Republic

Mikko Kaasalainen
Rolf Nevanlinna Institute
FIN-00014 University of Helsinki, Finland

Lance A.M. Benner
Jet Propulsion Laboratory
Pasadena, CA 91109-8099 USA

We present here four lists of "targets of opportunity" for the period 2008 April-June. The first list is those asteroids reaching a favorable apparition during this season, are <15m at brightest, and have either no or poorly constrained lightcurve parameters. By "favorable" we mean the asteroid is unusually brighter than at other times and, in many cases, may not be so for many years. The goal for these asteroids is to find a well-determined rotation rate. Don't hesitate to solicit help from other observers at widely spread longitudes should the initial findings show that a single station may not be able to finish the job.

The Low Phase Angle list includes asteroids that reach very low phase angles. Getting accurate, calibrated measurements (usually V band) at or very near the day of opposition can provide important information for those studying the "opposition effect", which is when objects near opposition brighten more than simple geometry would predict.

The third list contains those asteroids needing only a small number of lightcurves to allow shape and spin axis modeling. Some asteroids have been on the list for some time, so work on them is strongly encouraged so that models can be completed. For modeling work, absolute photometry is strongly recommended, meaning that data, not differential magnitudes but absolute values, put onto a standard system such as Johnson V. If this is neither possible nor practical, accurate relative photometry is also permissible. This is where all differential values are against a calibrated zero point that is not necessarily on a standard system.

When working any asteroid, keep in mind that the best results for shape and spin axis modeling come when lightcurves are obtained over a large range of phase angles within an apparition. If at all possible, try to get lightcurves not only close to opposition, but before and after, e.g., when the phase angle is 15° or more. This can be difficult at times but the extra effort can and will pay off.

The fourth list gives a brief ephemeris for planned radar targets. Supporting optical observations made to determine the lightcurve's period, amplitude, and shape are needed to supplement the radar data. Reducing to standard magnitudes is not required but high precision work, 0.01-0.03mag, usually is. *The* geocentric *ephemerides are for planning purposes only*. The date range may not always coincide with those of planned radar observations. Use the on-line services such as the Minor Planet Center or JPL's Horizons to generate high-accuracy *topocentric* ephemeredes.

MPC: http://cfa-www.harvard.edu/iau/mpc.html
JPL: http://ssd.jpl.nasa.gov/?horizons

Those obtaining lightcurves in support of radar observations should contact Dr. Benner directly at the email given above.

There are several web sites of particular interest for coordinating radar and optical observations. Future targets (up to 2015) can be found at *http://echo.jpl.nasa.gov/~lance/future.radar.nea.periods.html*. Past radar targets can be found at *http://echo.jpl.nasa.gov/~lance/radar.nea.periods.html* This page can be used to plan optical observations for those past targets with no or poorly-known rotation periods. Obtaining a rotation period will significantly improve the value of the radar data and help with 3D shape estimation. Slightly different information for Arecibo is given at *http://www.naic.edu/~pradar/sched.shtml*. For Goldstone, additional information is available at *http://echo.jpl.nasa.gov/asteroids/goldstone_asteroid_schedule.html*.

Once you have data and have analyzed them, it's important that you publish your results, if not part of a pro-am collaboration, then in the *Minor Planet Bulletin*. It's also important to make the data available on a website or upon request. Note that the lightcurve amplitude in the tables could be more, or less, than what's given. Use the listing as a guide and double-check your work.

Special Notice

Recent work analyzing asteroid orbits has found a fascinating list of "asteroid pairs", objects that have nearly identical orbits and, from what can be determined at this point, may have split from a single body a very short time ago (< 100 ky). Most of these are fainter than the usual cutoff for our lists but some may still be within reach of some readers. It's important to obtain data on these objects, lightcurve and spectroscopic, to establish their commonality. If truly twins, explaining their origin could have profound effects on theories regarding binary asteroid formation. A list of objects within this pairs list is available on the CALL web site (*http://www.minorplanetobserver.com/astlc/default.htm*). We urge any one with the means to do so to observe these objects and publish their findings.

Funding for Warner and Harris in support of this article is provided by NASA grant NNG06GI32G and by National Science Foundation grant AST-0607505.

Lightcurve Opportunities

#	Name	Brightest Date	Brightest Mag	Dec	U	Period	Amp
4215	Kamo	04 02.3	15.0	-13	2	12.6	0.21
1856	Ruzena	04 03.0	14.5	- 4			
4350	Shibecha	04 06.9	14.8	– 1			
1231	Auricula	04 12.7	14.8	-21			
1511	Dalera	04 17.1	14.9	– 5			
	2005 NB7	04 19.3	14.7	+64			
976	Benjamina	04 19.4	13.1	-18	2	9.746	0.18
5262	Brucegoldberg	04 20.1	14.7	+10	2	16.430	0.12
1199	Geldonia	04 21.7	14.4	-17			
3029	Sanders	04 22.8	14.8	-19			
1393	Sofala	04 24.0	14.5	- 9			
7514	1986 ED	04 26.0	14.7	-12			
1217	Maximiliana	04 26.6	14.4	- 5			

Lightcurve Opportunities (continued)

#	Name	Brightest Date	Brightest Mag	Dec	U	Period	Amp
2157	Ashbrook	04 28.1	14.7	-24			
5010	Amenemhet	04 28.9	14.8	+ 4	1	3.2	0.14-0.30
788	Hohensteina	04 29.8	12.1	+ 0	2	18.435	0.15
1793	Zoya	05 03.0	14.2	-16	2	7.0	0.4
	2006 LA	05 05.3	15.8	-68			
2193	Jackson	05 07.1	14.2	-20			
6212	1993 MS1	05 08.6	14.4	-17			
13724	Schwehm	05 10.1	15.0	-19			
8132	Vitginzburg	05 13.9	14.9	-10			
5034	Joeharrington	05 16.1	14.6	-27			
6274	Taizaburo	05 16.2	15.0	-14			
6372	Walker	05 19.3	14.5	-17			
898	Hildegard	05 20.3	13.2	-21	1	>24.	>0.3
7233	Majella	05 20.8	14.7	-35			
4585	Ainonai	05 20.9	15.0	-12			
552	Sigelinde	05 22.1	13.3	-25	1	>24.	0.15
2066	Palala	05 23.4	14.5	-15			
5313	Nunes	05 24.7	14.5	-14			
1449	Virtanen	05 26.3	14.0	-11			
1638	Ruanda	06 03.3	13.8	-22	2	8.4	0.06
237	Coelestina	06 03.7	12.4	-19	2	>20.	0.2
2660	Wasserman	06 04.7	14.8	- 5			
1679	Nevanlinna	06 05.3	14.5	+ 5	2	17.94	0.16
3982	Kastel	06 09.2	14.3	-22	2	8.488	0.27
1843	Jarmila	06 10.7	14.0	-25			
4449	Sobinov	06 10.7	15.0	-28			
3608	Kataev	06 12.6	14.9	-24			
1048	Feodosia	06 13.7	12.5	-38	2	10.46	0.14
5002	Marnix	06 14.5	14.5	-22			
13803	1998 WU10	06 14.6	14.9	-21			
4399	Ashizuri	06 15.2	14.8	-15			
2158	Tietjen	06 15.9	14.9	-21			
3214	Makarenko	06 15.9	14.8	-18			
4246	Telemann	06 17.5	14.6	-29	?	?	
1706	Dieckvoss	06 19.2	13.9	-24			
7761	1990 SL	06 21.1	14.5	-39			
5518	Mariobotta	06 21.9	14.2	-14			
1165	Imprinetta	06 24.4	13.7	- 4	2	7.9374	0.20
1677	Tycho Brahe	06 24.6	14.9	-48			
609	Fulvia	06 26.5	14.0	-17	1+	19.0	0.07
2224	Tucson	06 27.1	14.6	-26			
4675	Ohboke	06 27.9	14.7	-26			
7536	Fahrenheit	06 28.7	14.8	-33			
6430	1964 UP	06 29.3	15.0	-26			
2071	Nadezhda	06 30.0	14.7	-26			

Low Phase Angle Opportunities

#	Name	Date	α	V	Dec	Period	AMax	U
175	Andromache	04 03.2	0.17	13.4	-05	7.102	0.30	2
435	Ella	04 04.4	0.20	13.8	-06	4.623	0.38	3
33	Polyhymnia	04 12.3	0.21	13.3	-09	18.601	0.14	3
31	Euphrosyne	04 25.6	0.96	11.5	-17	5.531	0.13	4
397	Vienna	04 29.3	0.98	13.6	-17	15.48	0.20	3
332	Siri	05 01.1	0.26	13.1	-16	6.003	0.10	2
37	Fides	05 02.3	0.87	11.4	-18	7.3335	0.25	4
243	Ida	05 03.9	0.57	13.9	-18	4.634	0.86	4
126	Velleda	05 05.6	0.71	12.4	-18	5.364	0.22	2
565	Marbachia	05 08.9	0.38	13.4	-17	4.587	0.26	3
403	Cyane	05 15.2	0.93	12.8	-21	12.288	0.22	3
138	Tolosa	05 15.8	0.14	11.2	-19	10.101	0.4	4
420	Bertholda	05 16.2	0.39	13.1	-20	11.017	0.28	3
898	Hildegard	05 20.1	0.52	13.3	-21	>24.	0.3	1
936	Kunigunde	05 25.9	0.07	13.7	-21	8.80	0.25	2
803	Picka	05 26.7	0.42	13.8	-22			
586	Thekla	05 30.5	0.28	13.5	-21	10.630	0.24	2
418	Alemannia	06 03.2	0.28	13.2	-22	4.671	0.27	3
1638	Ruanda	06 03.2	0.22	13.9	-22			
49	Pales	06 09.4	0.59	12.6	-25	10.42	0.20	3
1843	Jarmila	06 10.6	0.89	14.0	-25			
20	Massalia	06 11.2	0.35	9.9	-22	8.098	0.27	4
579	Sidonia	06 17.6	0.43	11.5	-25	16.5	0.28	4
116	Sirona	06 18.1	0.78	11.5	-26	12.028	0.42	3
1706	Dieckvoss	06 19.2	0.46	14.0	-24			
106	Dione	06 20.8	0.91	12.1	-26	16.26	0.08	3
19	Fortuna	06 22.7	0.88	10.3	-21	7.4432	0.35	4
147	Protogeneia	06 24.8	0.39	12.4	-22	7.853	0.25	3
348	May	06 28.3	0.55	13.7	-25	7.3812	0.16	3

Shape/Spin Modeling Opportunities

#	Name	Brightest Date	Mag	Dec	Per (h)	Amp Min	Max	U
5	Astraea	4 05.1	9.4	+01	16.800	0.10-	0.30	4
344	Desiderata	4 11.2	11.1	+10	10.77		0.17	3
471	Papagena	4 14.4	11.8	+07	7.113	0.11-	0.13	3
386	Siegena	4 14.5	12.4	+07	9.763		0.11	3
36	Atalante	4 15.6	13.5	-22	9.93	0.15-	0.17	3
480	Hansa	4 21.2	12.1	-26	16.19		0.58	3
31	Euphrosyne	4 25.4	11.4	-17	5.531	0.09-	0.13	4
747	Winchester	5 26.4	13.4	+01	9.402	0.08-	0.13	4
416	Vaticana	6 01.4	10.1	-28	5.372	0.17-	0.38	4
324	Bamberga	6 06.7	10.9	-39	29.43		0.07	3

Radar-Optical Opportunities

In the ephemeredes, E.D. is earth distance (AU), V is the V magnitude, α is the phase angle, and E is solar elongation.

2005 NB7

No lightcurve parameters have been reported for this asteroid, which has an estimated diameter of about 0.6 km. It will be above 16th magnitude for about two weeks in April, reaching a minimum Earth distance of about 0.04 AU in mid-April. Given the rapid motion, many sets of comparison stars may be required and so calibration to at least an internal system will be helpful.

Date 2008	Geocentric RA(2000)	DC(2000)	E.D.	V	α	E
04/10	6 41.85	+14 24.8	0.061	15.97	96.6	80
04/12	6 59.25	+22 54.3	0.053	15.62	95.7	81
04/14	7 25.74	+33 51.2	0.046	15.26	93.5	84
04/16	8 09.59	+46 43.1	0.043	14.92	89.5	88
04/18	9 27.10	+58 47.7	0.043	14.71	84.2	93
04/20	11 29.77	+65 22.2	0.046	14.68	78.8	99
04/22	13 31.34	+64 33.9	0.052	14.80	74.1	103
04/24	14 47.31	+60 14.5	0.060	15.00	70.3	106
04/26	15 30.04	+55 35.3	0.069	15.23	67.3	109
04/28	15 55.58	+51 31.9	0.079	15.46	64.7	111
04/30	16 12.05	+48 09.4	0.090	15.68	62.4	113

(53319) 1999 JM8

This will be a good project for collaboration. It is a suspected "tumbler" with two possible periods: approximately 136 h and 168 h, or 5.6 d and 7 d. Proper analysis requires high quality data that is put on at least an internal system. Data should be sent to Petr Pravec, who has specialized software that can analyze the periods in the complex lightcurves of tumbling asteroids.

While the asteroid is above 16th magnitude for nearly two months, it is never far from the sun, and so observing runs will be short. This is another argument for collaboration among observers at different longitudes. Radar images from the 1999 apparition can be found at *http://echo.jpl.nasa.gov/~lance/1999JM8.html*.

Date 2008	Geocentric RA(2000)	DC(2000)	E.D.	V	α	E
04/21	17 48.44	+14 04.8	0.520	16.14	42.6	117
04/26	18 08.71	+16 28.4	0.475	15.95	45.4	115
05/01	18 31.82	+19 00.1	0.435	15.79	48.8	112
05/06	18 58.40	+21 35.2	0.400	15.64	52.8	109
05/11	19 29.05	+24 05.6	0.370	15.54	57.3	105
05/16	20 04.22	+26 19.7	0.347	15.47	62.4	100
05/21	20 43.83	+28 02.8	0.329	15.46	67.8	95
05/26	21 26.96	+29 00.0	0.319	15.50	73.3	89
05/31	22 11.75	+29 01.4	0.315	15.59	78.4	84
06/05	22 55.86	+28 06.8	0.319	15.72	82.8	79
06/10	23 37.22	+26 26.4	0.329	15.87	86.1	75
06/15	0 14.62	+24 17.0	0.345	16.02	88.1	72
06/20	0 47.73	+21 55.1	0.366	16.15	88.8	70

(90403) 2003 YE45

There are no known lightcurve parameters for this asteroid, which is about 0.9 km. It's best suited for July, but it is included now so that observers can plan accordingly.

Date 2008	Geocentric RA(2000)	DC(2000)	E.D.	V	α	E
07/15	11 57.44	+51 38.7	0.044	15.86	120.1	58
07/20	15 53.55	+59 16.7	0.064	15.08	90.6	86
07/25	17 31.20	+53 18.0	0.095	15.41	76.2	99
07/30	18 08.99	+48 40.1	0.127	15.84	68.2	105
07/31	18 13.84	+47 55.8	0.134	15.93	67.0	106

2005 RC34

There are no known lightcurve parameters for this asteroid, which is about 0.4 km. This one is also best suited for July but is included now for planning purposes.

Date 2008	Geocentric RA(2000)	DC(2000)	E.D.	V	α	E
07/01	17 37.95	-45 47.2	0.130	16.54	23.2	154
07/06	17 45.32	-41 32.0	0.100	15.91	22.5	155
07/11	17 58.26	-33 29.1	0.073	15.10	20.3	158
07/16	18 20.86	-16 33.6	0.050	14.18	18.9	160
07/21	19 01.41	+18 09.6	0.038	14.15	40.1	139
07/26	20 17.11	+54 56.1	0.046	15.47	71.9	106
07/31	22 24.00	+70 39.2	0.066	16.79	86.9	89

THE MINOR PLANET BULLETIN (ISSN 1052-8091) is the quarterly journal of the Minor Planets Section of the Association of Lunar and Planetary Observers – ALPO. Beginning with volume 32, the current and most recent issues of the *MPB* are available on line, free of charge at http://www.minorplanetobserver.com/mpb/default.htm . Subscription information for conventional printed copies is given below.

Nonmembers are invited to join ALPO by communicating with: Matthew L. Will, A.L.P.O. Membership Secretary, P.O. Box 13456, Springfield, IL 62791-3456 (will008@attglobal.net). The Minor Planets Section is directed by its Coordinator, Prof. Frederick Pilcher, 4438 Organ Mesa Loop, Las Cruces, NM 88011 USA (pilcher@ic.edu), assisted by Lawrence Garrett, 206 River Road, Fairfax, VT 05454 USA (LSGasteroid@msn.com). Steve Larson, Lunar and Planetary Laboratory, 1629 E. University Blvd., University of Arizona, Tucson, AZ 85721 USA (slarson@lpl.arizona.edu) is Scientific Advisor. The Asteroid Photometry Coordinator is Brian D. Warner, Palmer Divide Observatory, 17995 Bakers Farm Rd., Colorado Springs, CO 80908 USA (brian@MinorPlanetObserver.com).

The Minor Planet Bulletin is edited by Dr. Richard P. Binzel, MIT 54-410, Cambridge, MA 02139 USA (rpb@mit.edu). Brian D. Warner (address above) is Assistant Editor. The *MPB* is produced by Dr. Robert A. Werner, JPL MS 301-150, 4800 Oak Grove Drive, Pasadena, CA 91109 USA (robert.a.werner@jpl.nasa.gov) and distributed by Derald D. Nye.

The contact for all subscriptions, contributions, address changes, etc. is:

Mr. Derald D. Nye
Minor Planet Bulletin
10385 East Observatory Drive
Corona de Tucson, AZ 85641-2309 USA
(nye@kw-obsv.org)
(Telephone: 520-762-5504)

Annual subscription rates for the *Minor Planet Bulletin* by postal delivery:

	Payment by check	Payment by credit card
North America	$24.00	$25.00
All other	$34.00	$35.00

To minimize our administrative time, please consider subscribing for two years. Users of the on-line *MPB* who are not paid subscribers are encouraged to make a voluntary contribution of $5 or more per year. Checks or money orders should be in US dollars, drawn on a US bank, and made payable to the "Minor Planet Bulletin." To pay by credit card, (Visa, Mastercard, or Discover) please send by mail your credit card number, your name exactly as it appears on the card, and the expiration date. Be sure to specify the desired length of your subscription. Credit card charges will be made through "Roadrunner Mkt, Corona AZ." When sending your subscription order, be sure to include your full mailing address <u>and</u> an email address, if available. The numbers in the upper-right corner of your mailing label indicate the volume and issue number with which your current subscription expires.

Authors are <u>strongly encouraged</u> to submit their manuscripts by electronic mail (rpb@mit.edu). Electronic submissions can be formatted either using a Microsoft Word template document available at the web page given above, or else as text-only. A printed version of the file and figures must also be sent. All materials must arrive by the deadline for each issue. Visual photometry observations, positional observations, any type of observation not covered above, and general information requests should be sent to the Coordinator.

* * * * *

The deadline for the next issue (35-3) is April 15, 2008. The deadline for issue 35-4 is July 15, 2008.