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THE LIGHTCURVE OF ASTEROID 5331 ERIMOMISAKI

Caleb Boe, Russell I. Durkee
Shed of Science Observatory
5213 Washburn Ave S. Minneapolis, MN 55410, USA

Silvano Casulli
Vallemare Di Borbona Observatory,
Vallemare di Borbona, ITALY

Dr. Fiona Vincent
School of Physics & Astronomy
University of St. Andrews
North Haugh, St. Andrews KY16 9SS, Scotland, UK

David Higgins
Hunters Hill Observatory
Ngunnawal, Canberra 2913
AUSTRALIA

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Asteroid 5331 Erimomisaki was observed between 2007 Nov. 30 and 2008 Jan. 9. A synodic period of 24.26 ± 0.02 h with a mean amplitude of 0.27 ± 0.02 mag was derived.

Observations of 5331 Erimomisaki were carried out over ten nights between 2007 November and 2008 January. All observations by Boe and Durkee were taken remotely at the Tzec Maun Observatory in New Mexico, USA, using a 355-mm Maksutov-Newtonian operating at f/3.8 along with an SBIG STL-6303 camera at 1.39 arsec/pixel. Casulli used a 0.41-m Newtonian, SBIG ST-9XE at 2.3 arcsec/pixel. Vincent used a 0.31-m SCT, Apogee KX-260 operating at 1.98 arcsec/pixel. Higgins used a 0.36-m SCT, SBIG ST-8E operating at 1.31 arcsec/pixel. All observations were taken unfiltered.

The object was chosen for observation using Brian Warner's Potential Lightcurve Targets on the CALL website. (Warner et al. 2007) Observations taken by Boe and Durkee in early December indicated a period near 24 h. While searching for potential collaborators, Durkee discovered additional observations on Nov 30 and Dec 05-06 taken by Casulli in Italy (Behrend 2007). Email communication with Casulli and Behrend quickly established a collaboration. Durkee and Boe posted a request for additional collaborators on the Minor Planet Mailing List (MPML) Yahoo group. Vincent and Higgins responded with observations on Jan 05 and Jan 09, respectively. The Vincent data were taken under poor conditions, which is reflected by the large error bars. However, the data support the proposed period and were crucial in completing the curve. Analysis was performed using *MPO Canopus*.

Acknowledgments

Thanks to Raoul Behrend for posting Casulli's results on his website and for coordinating the exchange of data.

Special thanks to the Tzec Maun Foundation and its founder, Michael K. Wilson, for providing free access to telescopes for students and researchers.

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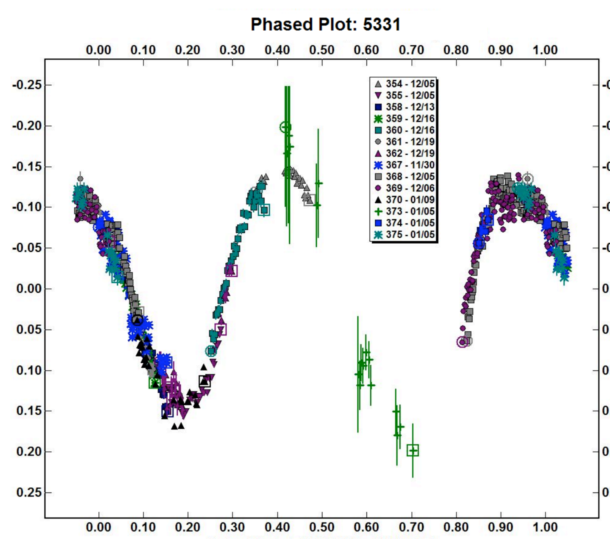

A COLLECTION OF LIGHTCURVES FROM MODRA: 2007 DECEMBER – 2008 JUNE

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: 2008 June 27)

Lightcurve analysis led to rotation periods of main-belt asteroids 651 Antikleia, 653 Berenike, 2363 Cebriones, 12482 Pajka, 23327 Luchernandez, (28292) 1999 CX54, and (74424) 1999 BN. Only tentative results were obtained for rotation periods of 17102 Begzhigitova, 27270 Guidotti, and (74056) 1998 KM9.

Along with photometric observations of principal targets at Modra, all moving targets as faint as magnitude 18 that happen to be in the same field of view are formally processed. The rotation period of faint asteroids cannot always be determined. The result depends mainly on the amplitude of the lightcurve, spin rate, amount of observing time at disposal, and weather conditions. In all, just a small fraction of the observed targets have had lightcurves presented. Among them are usually asteroids with the rotation period derived securely or reasonably securely. Data from only one night and data from very short sessions, unless they are of good quality or done in collaboration with other observers, are omitted. Similarly, a majority of asteroids with the rotation period only tentatively derived are also usually omitted. The dividing line between presenting and omitting targets is quite wide. Here we present lightcurves of several asteroids that were observed from Modra. This time we include some of the tentative results for rotation period with the thought that such information can help photometrists develop good strategies for future apparitions. Table I lists the asteroid we observed along with some aspect data, derived rotation periods, their uncertainties, and amplitudes of the lightcurves. Appropriate lightcurves are in figures, in which correction for light-travel time was applied. The equipment and data procession was described in Galád (2008).

651 Antikleia. Initial linked data indicated a symmetrical lightcurve with a period of 14.250 h. However, additional data allowed us to reject that solution and, instead, confirm the result found by Sada *et al*. (2005), only the amplitude of the lightcurve in our analysis is lower.

653 Berenike was observed before and after opposition. As with 651 Antikleia, linked observations led to an unambiguous solution, though it differs from the formerly derived value of 14.14 h by Binzel (1987).

2363 Cebriones. This asteroid's rotation period was not easily determined. Initial sessions were linked but short. Additional data indicated a period longer than 3.8 h, the tentative period reported by Binzel and Sauter (1992) based on their data. Only after several weeks did we manage to obtain another set of mutually-linked sessions which helped to find, hopefully, an unambiguous value for the rotation period.

12482 Pajka is a Modra discovery. It was brighter than magnitude 17 in 2008 January. Sessions from consecutive nights were linked to the same magnitude level that led to the secure result for the rotation period.

17102 Begzhigitova. Just two pairs of individually-linked sessions were obtained. The asteroid was fainter than magnitude 17 and the amplitude of the lightcurve was probably small. Thus, the rotation period presented here is just tentatively derived and much slower rotations are not ruled out. A more favourable opposition occurs in 2010 November when the asteroid reaches magnitude 16.5.

23327 Luchernandez was observed on two nights before opposition as a magnitude 18 object. Even though it brightened, no other data were added and so we could not resolve the ambiguity in its rotation period. Except for the solution presented here, we found that 5.49 h comparably fits to the data. Other solutions (longer periods) are less probable thanks to the quite large amplitude of the lightcurve.

27270 Guidotti was observed on two nights as a magnitude 17 object. Many solutions for its rotation period are possible, especially from the interval between 2.6 h and ~7 h. We present just one here – formally the best one.

(28292) 1999 CX54 was about magnitude 17 object but high-quality data were obtained. The rotation period was guessed from the very first session, which was long. Other sessions followed after several weeks, which nailed down the value of the rotation period.

Number	Name	Dates yyyy mm/dd	Phases deg	LPAB deg	BPAB deg	Period [h]	Amp [mag]
651	Antikleia	2007 12/14-2008 01/29	11.6,20.4	56	5	20.291 ± 0.003	0.13
653	Berenike	2007 12/13-2008 01/26	02.0,12.0	113	-5	12.4886 ± 0.0007	0.11
2363	Cebriones	2008 04/04-06/01	04.4,09.2	240	18	20.081 ± 0.001	0.22
12482	Pajka	2007 12/13-2008 02/08	02.6,16.6	113	-4	3.9428 ± 0.0001	0.21
17102	Begzhigitova	2008 01/25-02/10	06.6,14.5	114	-3	(5.341 ± 0.001)	0.3
23327	Luchernandez	2007 12/15-17	15.6,16.6	111	-5	4.933 ± 0.007	0.50
27270	Guidotti	2008 03/23-25	07.7,08.8	169	3	(2.6 – 7)	0.3
(28292)	1999 CX54	2008 02/25-04/06	05.6,11.7	168	3	6.4752 ± 0.0001	0.34
(74056)	1998 KM9	2007 12/15-18	14.4,15.6	111	-6	(17.4 ± 0.1)	0.5
(74424)	1999 BN	2008 02/09-11	13.1,13.2	140	24	3.733 ± 0.001	0.28

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.

(74056) 1998 KM9 was observed on three nights along with 23327 Luchernandez, 653 Berenike, and 12482 Pajka even though it was fainter than magnitude 18. Sessions were linked, so we obtained some indication about the amplitude of the lightcurve, which seemed to be quite large. Thus, from many possible solutions for the rotation period that fit observational data, we prefer to select those with two pairs of maxima and minima in the composite lightcurve. We present the best such case from visual inspection, though we still consider our result as tentative.

(74424) 1999 BN was observed during the favourable apparition in 2008 February. It was brighter than magnitude 17 for the first time since discovery nine years ago at our station.

Acknowledgements

We are grateful to Petr Pravec, Ondřejov Observatory, Czech Republic, for his ALC software used in data analysis. 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.

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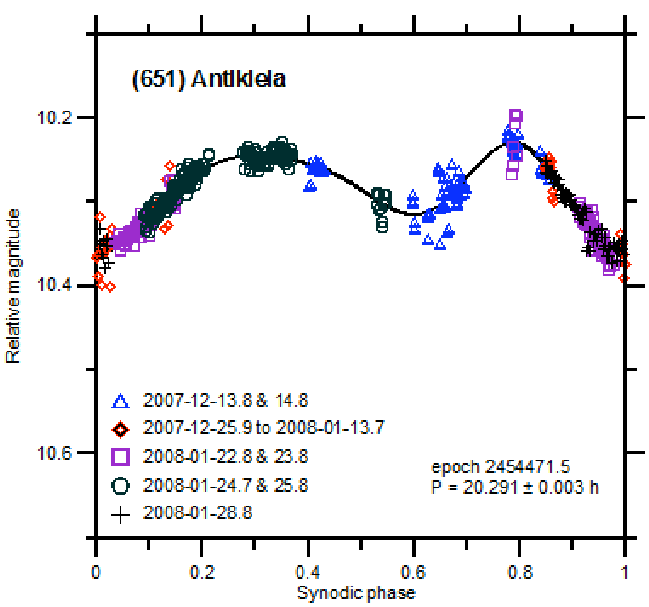

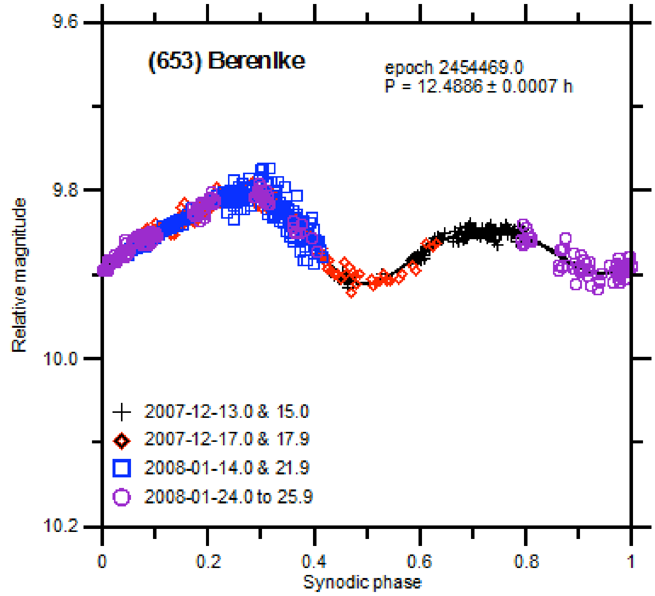

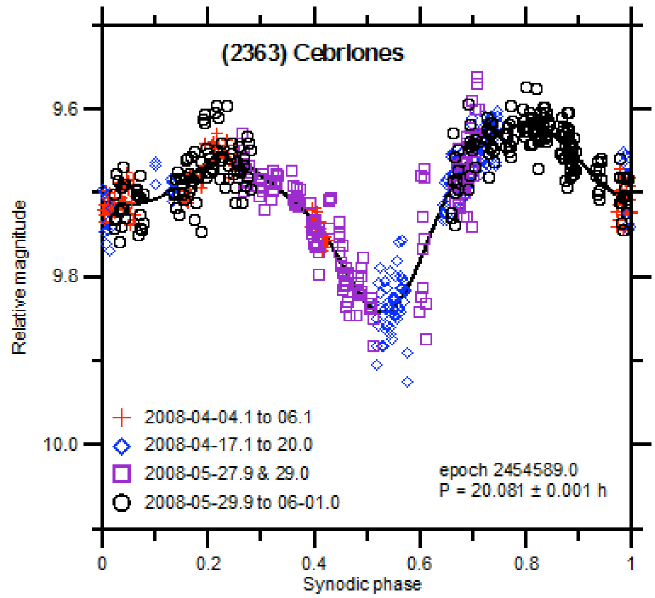

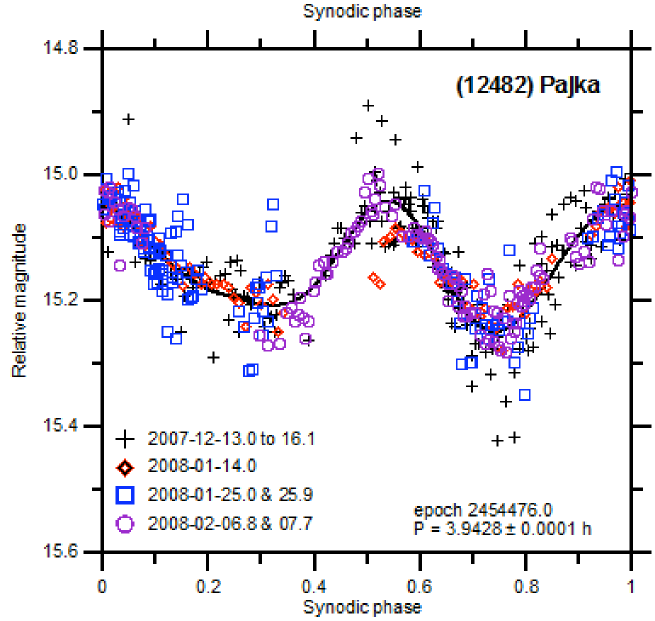

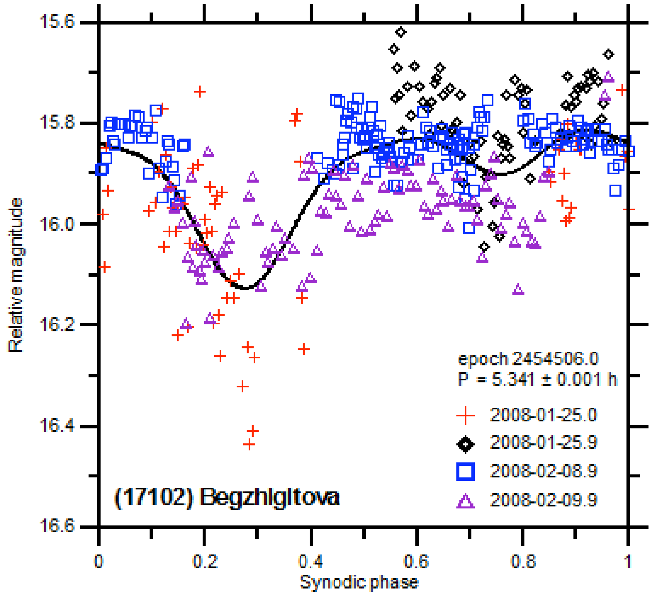
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epoch 2454506.0
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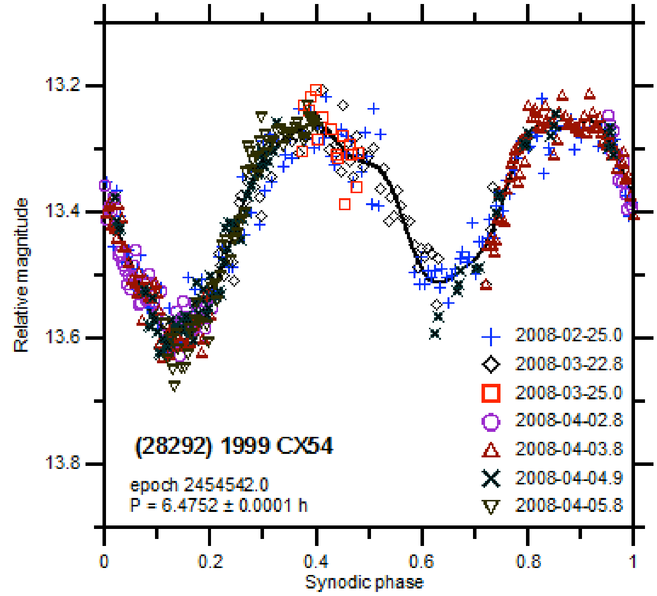
2008-01-25.9
2008-02-08.9
2008-02-09.9
Relative magnitude
Synodic phase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epoch 2454542.0
P = 6.4752 ± 0.0001 h
2008-02-25.0
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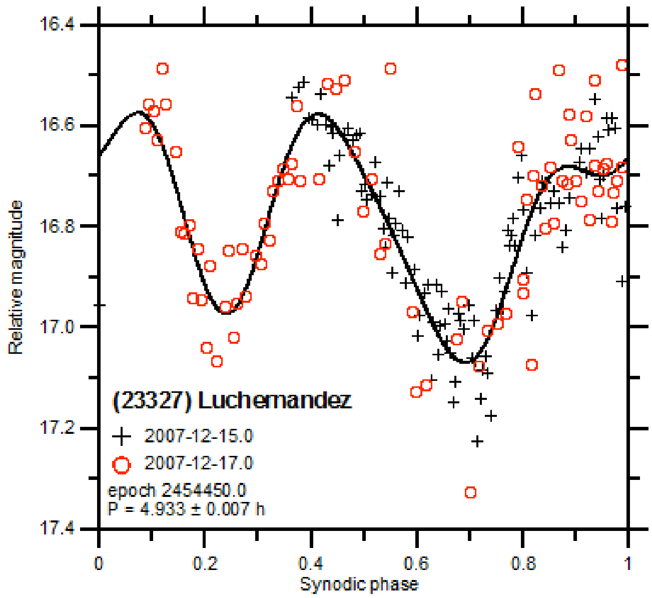
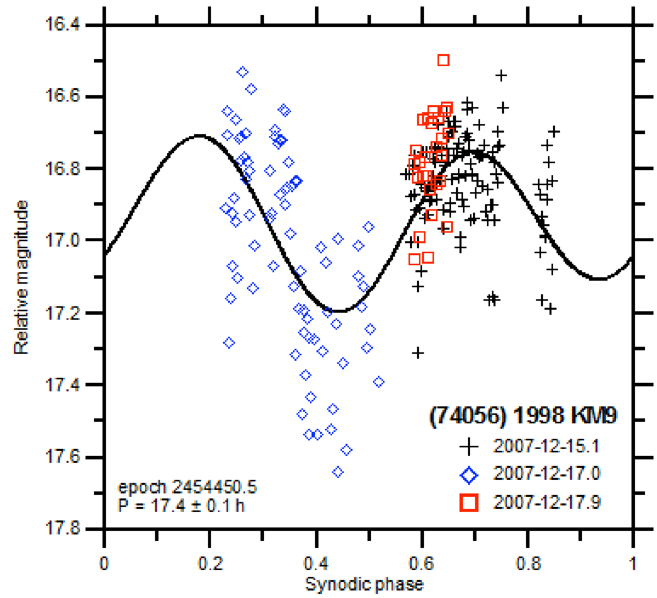
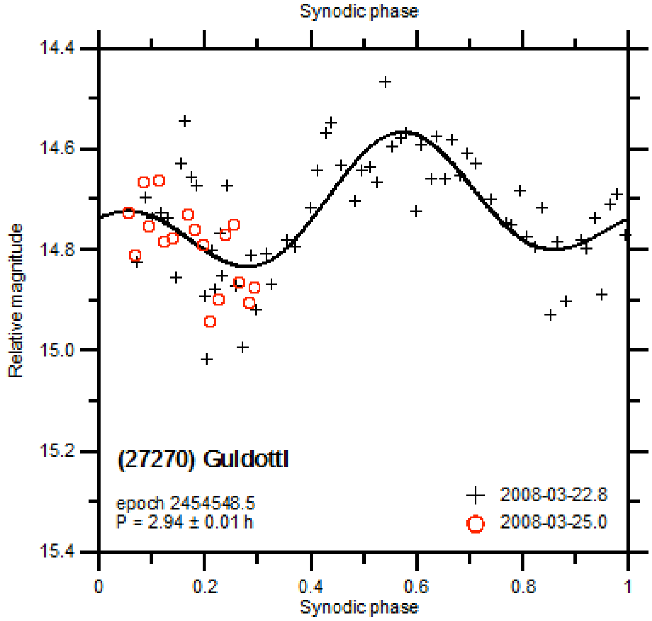
2008-03-25.0
2008-04-02.8
2008-04-03.8
2008-04-04.9
2008-04-05.8
Relative magnitude
Synodic phase


(23327) Luchernandez
2007-12-15.0
2007-12-17.0
epoch 2454450.0
P = 4.933 ± 0.007 h
Relative magnitude
Synodic phase


(74056) 1998 KM9
2007-12-15.1
2007-12-17.0
2007-12-17.9
epoch 2454450.5
P = 17.4 ± 0.1 h
Relative magnitude
Synodic phase


(27270) Guidotti
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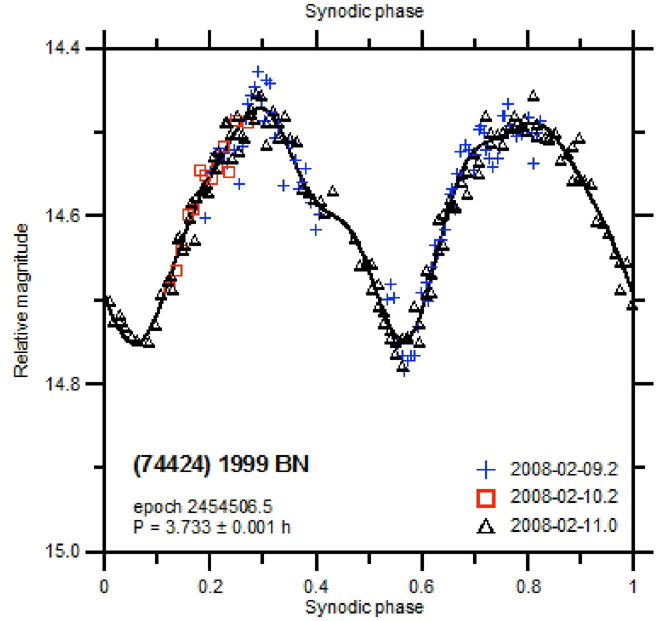
2008-03-22.8
2008-03-25.0
Relative magnitude
Synodic phase


(74424) 1999 BN
epoch 2454506.5
P = 3.733 ± 0.001 h
2008-02-09.2
2008-02-10.2
2008-02-11.0
Relative magnitude
Synodic phase

PERIOD DETERMINATION FOR 161 ATHOR

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

David Higgins
Hunters Hill Observatory (E14)
Ngunnawal ACT 2913, Australia

(Received: 2008 June 16 Revised: 2008 June 23)

New observations at Organ Mesa and Hunters Hill Observatories 2008 March and April show that 161 Athor has a synodic period of 7.281 ± 0.001 h and, during that time, a monomodal lightcurve with amplitude of 0.08 ± 0.02 magnitudes. An approximate pole position is also reported.

Frederick Pilcher and David Higgins each independently targeted 161 Athor in 2008 March. Higgins listed his observations on the CALL website in late March, and the two authors subsequently agreed to combine their observations in a collaborative paper.

Pilcher's observations were made with a Meade 35-cm LX200 GPS Schmidt-Cassegrain (SCT), SBIG STL 1001-E CCD, clear filter, and unguided. Higgins observed with a 0.36-m SCT fitted with a Meade f/3.3 focal reducer and SBIG ST-8E CCD at f/4, clear filter, and guided exposures. For both observers differential photometry and lightcurve analysis were done with *MPO Canopus*, which enabled sharing and linking of data by both observers. The instrumental magnitudes of the combined sessions were freely adjusted to provide the best fit.

Three previous lightcurves have been published. Debehogne and Zappala (1980) obtained the most dense data set on four nights, 1979 Apr. 30-May 4 at longitude 239 degrees, obtaining a bimodal lightcurve with period of 7.288 h, amplitude 0.27 mag, and full phase coverage with one minimum twice as deep as the other. Carlsson and Lagerkvist (1983) observed on five nights, 1982 Mar. 20-24, at longitude 153 degrees. They did not obtain a unique period determination but were able to phase their observations both to 7.288 h with a monomodal lightcurve and to 0.454 d (10.90 h) with a bimodal lightcurve of 0.08 mag amplitude. Harris and Young (1989) obtained 15 data points on 1980 Nov. 6, 16, and Dec. 15 at longitudes 59-52 degrees, which are consistent with a 7.288 h period and extreme range 0.25 mag with only 60% of the full lightcurve covered.

Pilcher and Higgins each obtained lightcurves on seven nights within the interval 2008 Mar. 7–Apr. 27, for a total of 14 lightcurves at longitudes 197 – 185 degrees. Equally good fits are provided by a monomodal lightcurve of period 7.281 ± 0.001 h or a symmetric bimodal lightcurve of period 14.562 ± 0.001 h, both with an amplitude 0.08 ± 0.02 mag. The 7.281 h lightcurve is published here with the data binned into sets of 3 with a time difference no greater than 5 minutes to show a more readable lightcurve.

The large amplitudes observed by Debehogne and Zappala (1980) and by Harris and Young (1989) rule out a quadrimodal 14.56 h period. The new observations rule out the 10.90 h period allowed by the data of Carlsson and Lagerkvist (1983). The only period consistent with all available observations is the one near 7.28 h, which we consider secure. Several other asteroids have shown similar characteristics with their lightcurves, i.e., bimodal, large-amplitude near equatorial aspects and monomodal, small-amplitude near polar aspect. Examples of such behavior can be found for 6249 Jennifer (Warner et. al. 2006) and 35 Leukothea (Pilcher 2008).

The observations in this study at longitudes 197-185 degrees and by Carlsson and Lagerkvist (1983) at longitude 153 degrees have almost identical lightcurve shapes and amplitudes. We consider these to be on opposite sides of the rotational pole and place the pole near longitude 170 degrees or 350 degrees. The latitude of the pole is poorly constrained but probably within 30 degrees of the ecliptic. This pole then places the 0.25 to 0.27 magnitude amplitude observations by Debehogne and Zappala (1980) at longitude 239 degrees and by Harris and Young (1989) at longitude 59-52 degrees, on opposite sides of the sky and near equatorial aspect.

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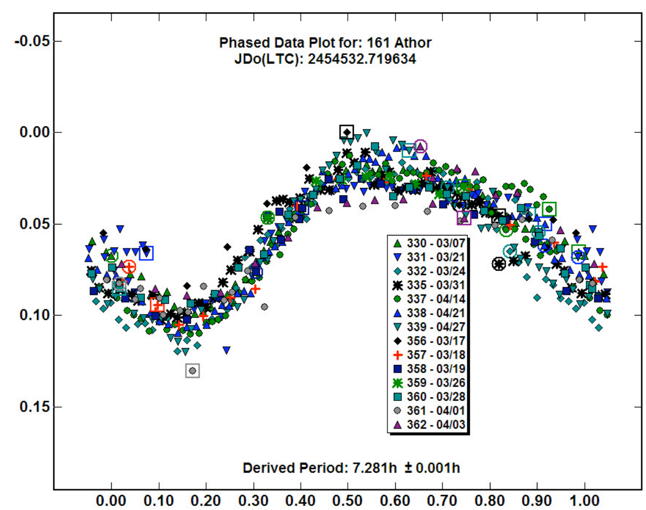

LIGHTCURVE ANALYSIS OF 788 HOHENSTEINA

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

Scott A. Marks, Michael Fauerbach
Egan Observatory
Florida Gulf Coast University
Fort Myers, FL USA

(Received: 2008 June 26)

A collaborative effort from two widely-separated geographical longitudes resulted in three nights of long, continuous observations of 788 Hohensteina. The 14-hour, non-overlapping lightcurve allowed us to constrain the synodic period of the asteroid to 37.176 ± 0.004 h with an amplitude of 0.18 ± 0.03 mag.

Kingsgrove Observatory used a 0.25-m Schmidt-Cassegrain telescope operating at f/5.2 combined with an ST-402ME SBIG CCD camera at 1x1 binning, which gave a pixel scale of 1.40 arc seconds/pixel. All images were unfiltered and 60 s. *MPO Canopus* v.9.4.0.1 software was used for period analysis, which incorporates the Fourier algorithm developed by Harris (1989). Egan Observatory used 0.40-m Ritchey-Chretien telescope operating at f/5.6 on a Paramount ME mount coupled with an Apogee AP7ap back-illuminated camera. This produced a pixel resolution of 2.2 arc seconds/pixel.

788 Hohensteina, a 103-km C-class main-belt asteroid, was listed on the CALL website (Warner 2008) for further improvement in its known synodic period, the quality of which was listed as U = 1+ at the time (Harris and Warner 2008). Previous photometry by Behrend (2008) showed that the period was either 18.435 h or 28.85 h based on two short-duration lightcurves obtained by single observers.

A call for collaborative work was posted on the CALL website after initial data by Oey indicated a difficult, low-amplitude, and slow-rotating asteroid. Fauerbach responded and agreed to assist. From the five nights collected by Fauerbach and 18 nights collected by Oey, there were three nights, May 7, 10, and 14, that each formed a nearly continuous 14-hour lightcurve segment. The segments were not overlapping, being separated by about 2.5 hours. No attempt was made to standardize the zero point of the differential magnitudes. Instead, the data were aligned visually such that tail of the first segment made a reasonable fit with the head of the second segment. This method was deemed sufficiently reliable due to the low amplitude and long period nature of the object. All the data taken initially indicated that the lightcurve amplitude did not exceed 0.10 mag. With no collaboration, this alone could have led the authors to believe that the lightcurve period was approximately that reported by Behrend. However, the session on May 14 showed that the minimum amplitude should be 0.18 mag or more. Based on that assumption, the zero points were adjusted such that data on May 14 represented one minimum and the data from May 7 and 10 represented the second minimum, all the while keeping the overall amplitude at about 0.18 mag. Once the best fit period was obtained by inspection of the period spectrum, the remaining sessions were gradually added to the lightcurve with the net result being the lightcurve presented here, phased to a synodic period of 37.176 ± 0.004 h.

There was also an indication of Non-principal axis rotation (NPA or "tumbling") as suggested by Alan Harris (private communications). Further observations are needed to confirm that possibility.

Acknowledgement

We would like to thank Brian Warner for his effort in helping to decipher the possible period presented from the available data.

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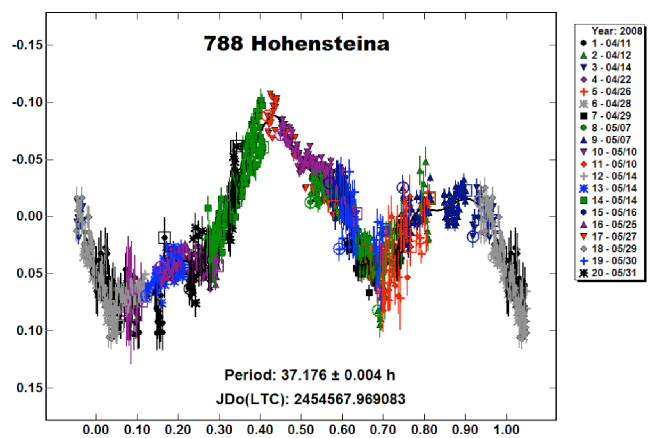

Sessions	Observer	Phase	LPAB	BPAB
1-7	Oey	9.2-5.5	219	12
9,11,14,15, 18,19,20	Oey	6.3-13.1	220	13
8,10,12,13, 16,17	Marks, Fauerbach	6.5-12.5	220	13

ASTEROID LIGHTCURVE ANALYSIS AT THE OAKLEY SOUTHERN SKY OBSERVATORY: 2008 MARCH

Robert Lemke Oliver, Heath Shipley, Richard Ditteon
Rose-Hulman Institute of Technology CM 171
5500 Wabash Ave.
Terra Haute, IN 47803
ditteon@rose-hulman.edu

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Photometric data for 17 asteroids were collected over ten nights of observing during 2008 February and March at the Oakley Southern Sky Observatory. The asteroids were: 170 Maria, 266 Aline, 426 Hippo, 441 Bathilde, 619 Triberga, 701 Oriola, 840 Zenobia, 1175 Margo, 1232 Cortusa, 1297 Quadea, 1309 Hyperborea, 1355 Magoeba, 1505 Koranna, 2120 Tyumenia, 2606 Odessa, 3428 Roberts, and 4254 Kamel.

Seventeen asteroids were observed from the Oakley Southern Sky Observatory on the nights of 2008 February 29 and March 1–6, 9, 10, and 12. From the data, we were able to find lightcurves for eight asteroids. Out of those eight, three were previously unrecorded results, three were reasonably close to previously published periods, and two disagreed with previously published periods.

For the ten nights of observing, a 20-inch Ritchey-Chretien optical tube assembly mounted on a Paramount ME was used with a Santa Barbara Instrument Group STL-1001E CCD camera and clear filter. The image scale was 1.2 arcseconds per pixel. Exposure times varied between two and four minutes. 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. 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 with the hopes that we would be able to improve previous results.

As far as we are aware, these are the first reported observations for the period of the following asteroids: 1505 Koranna, 2606 Odessa, and 3428 Roberts. No repeatable pattern was found for the following asteroids: 170 Maria, 266 Aline, 426 Hippo, 441 Bathilde, 701 Oriola, 840 Zenobia, 1232 Cortusa, 1355 Magoeba, and 4254 Kamel. Our data for these asteroids was so noisy we do not feel comfortable even reporting amplitudes. Results from the asteroids with good lightcurves are listed in the table below. Comments have been included if they are necessary.

619 Triberga. Our data are consistent with the period of 29.412 ± 0.003 h found by and Pray (1987).

1175 Margo. Our data disagree with the period 6.0138 ± 0.0002 h deemed most likely by Behrend (2008) but support the period of 12.028 that was listed as another possibility.

1297 Quadea. Our data agree with the period of 6.267 ± 0.001 h found by Behrend (2008).

1309 Hyperbora. Our data give a period that is close to that of 13.95 ± 0.02 h found by Apostolovska et al. (2004).

2120 Tyumenia. Our data are not consistent with the period of 2.769 ± 0.0005 h found by Warner (2005).

Acknowledgement

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

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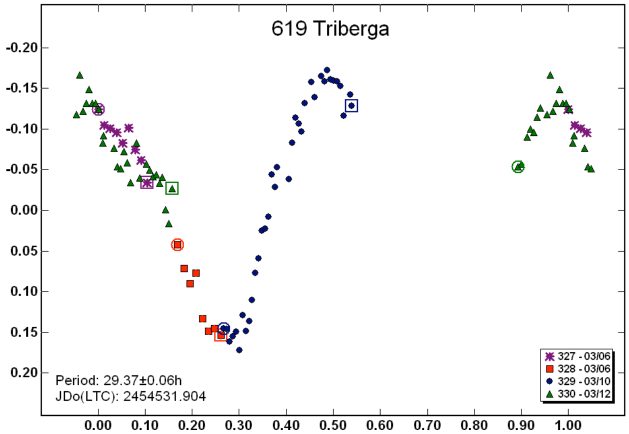
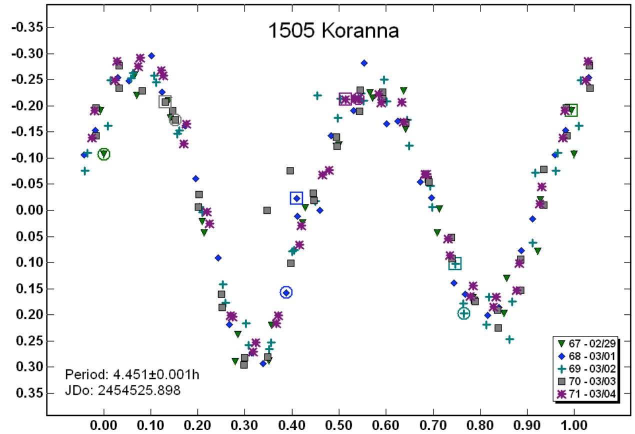
Number	Name	Dates mm/dd 2008	Data Points	Period (h)	Period Error (h)	Amp (mag)	Amp Error (mag)
619	Triberga	03/06, 10, 12	87	29.37	0.06	0.35	0.04
1175	Margo	02/29, 03/01-04	176	11.99	0.03	0.3	0.06
1297	Quadea	03/05, 06, 09	74	6.259	0.005	0.35	0.05
1309	Hyperborea	03/05, 06, 10, 12	108	13.88	0.02	0.45	0.05
1505	Koranna	02/29, 03/01-04	179	4.451	0.001	0.6	0.04
2120	Tyumenia	03/05, 06, 09	76	17.47	0.07	0.45	0.08
2606	Odessa	02/29, 03/01-04	170	8.244	0.002	0.8	0.1
3428	Roberts	02/29, 03/01-04	162	3.278	0.001	0.6	0.06


619 Triberga
Period: 29.37±0.06h
JDo(LTC): 2454531.904
327 - 03/06
328 - 03/06
329 - 03/10
330 - 03/12


1505 Koranna
Period: 4.451±0.001h
JDo: 2454525.898
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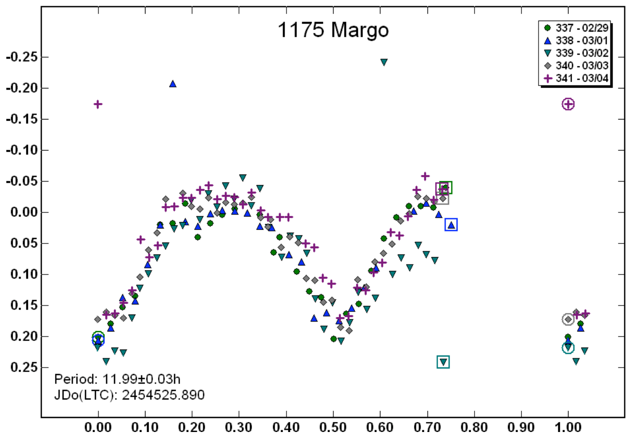
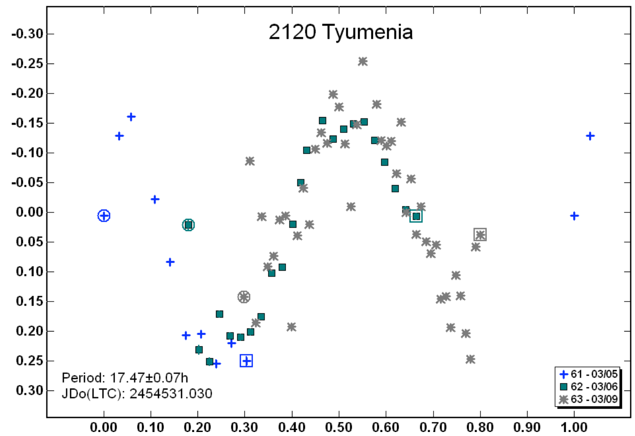
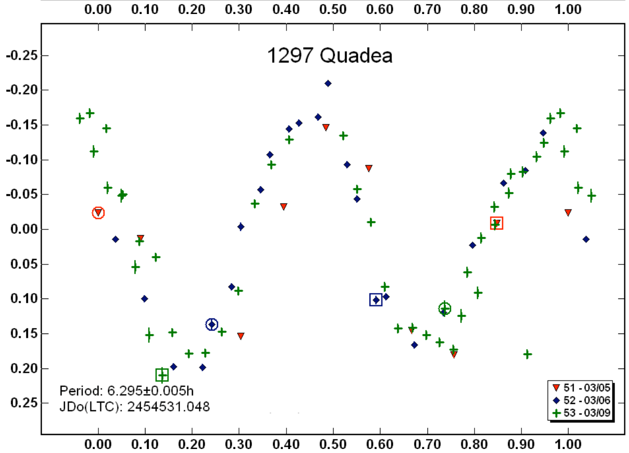
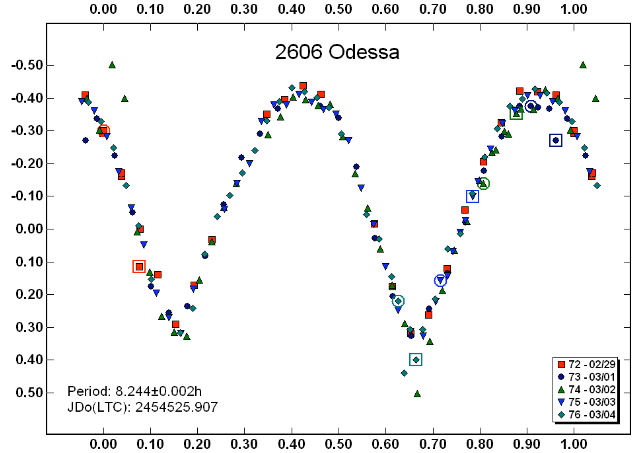
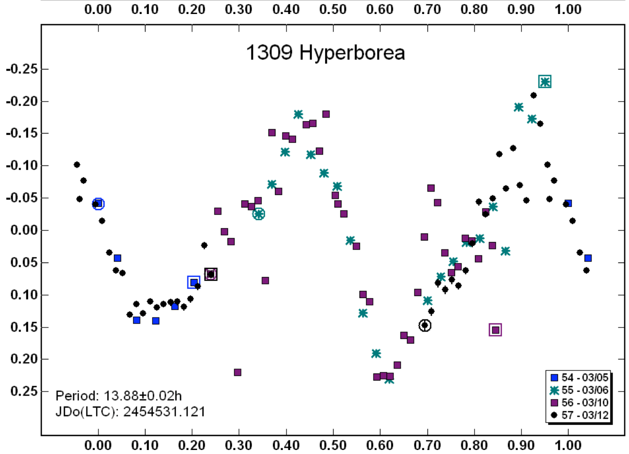
68 - 03/01
69 - 03/02
70 - 03/03
71 - 03/04

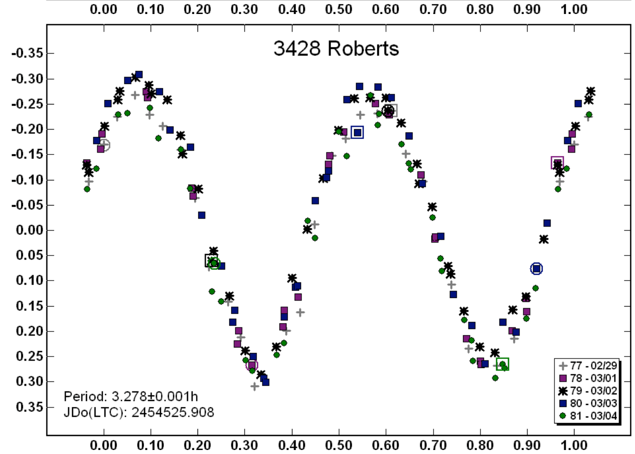

1175 Margo
Period: 11.99±0.03h
JDo(LTC): 2454525.890
337 - 02/29
338 - 03/01
339 - 03/02
340 - 03/03
341 - 03/04


2120 Tyumenia
Period: 17.47±0.07h
JDo(LTC): 2454531.030
61 - 03/05
62 - 03/06
63 - 03/09


1297 Quadea
Period: 6.295±0.005h
JDo(LTC): 2454531.048
51 - 03/05
52 - 03/06
53 - 03/09


2606 Odessa
Period: 8.244±0.002h
JDo(LTC): 2454525.907
72 - 02/29
73 - 03/01
74 - 03/02
75 - 03/03
76 - 03/04


1309 Hyperborea
Period: 13.88±0.02h
JDo(LTC): 2454531.121
54 - 03/05
55 - 03/06
56 - 03/10
57 - 03/12


3428 Roberts
Period: 3.278±0.001h
JDo(LTC): 2454525.908
77 - 02/29
78 - 03/01
79 - 03/02
80 - 03/03
81 - 03/04

LIGHTCURVE ANALYSIS OF 102 MIRIAM, 1433 GERAMTINA, AND 2648 OWA

Thomas Johnson, Katherin Pech, Ryan van Schilfgaarde, Matt Chase, and M. Shane Burns
Colorado College
14 East Cache La Poudre Street
Colorado Springs, CO 80903

(Received: 2008 June 1 Revised: 2008 June 6)

Asteroids 102 Miriam, 1433 Geramtina,and 2648 Owa were observed from NURO facilities in Flagstaff, AZ. Synodic rotation periods were estimated for each asteroid. Miriam's period was estimated to be 15.789 h. We were able to estimate a lower limit the period of Geramtina to be 14 h. Owa's period is 3.563 h

We chose the asteroids 102 Miriam, 1433 Geramtina, and 2648 Owa from the lightcurve opportunities table listed in the *Minor Planet Bulletin* (Warner et al. 2007). These asteroids were chosen to be close to opposition during our observations. We took data on 2007 October 18, 19, and 20 UT.

Observations were conducted at the NURO 31-inch telescope in Flagstaff, AZ (http://www.nuro.nau.edu/). Images were taken using V and R filters with the NASACam CCD camera. This camera uses a 2Kx2K thermoelectrically cooled CCD with a plate scale of 0.5"/pixel on the NURO telescope. Miriam data were gathered on each night of the observing run, while Owa and Geramtina data were gathered only on the nights of the 19th and 20th. Exposure times for Miriam were all 30 s. Times of 60 s were used for Owa and Geramtina. Standard image calibrations and differential aperture photometry were performed using IRAF. A Fourier analysis method similar to that described by Harris et al. (1989) was used to determine the period and amplitude of the light curves.

<u>102 Miriam.</u> The data for Miriam were good and yielded consistent results for all three nights. These results agree with the estimated period published in Warner et al (2007). The data showed a period of 15.789 h.

<u>1433 Geramtina.</u> Results for Geramtina were inconclusive. The data from the 20th were not usable. The useful data from the 19th, however, showed a decreasing trend in magnitude of 0.1 over the 7-hour observing run. This leads to a minimum monomodal period of 14 h or, more likely, a bimodal period of at least 28 h.

<u>2648 Owa.</u> The data for Owa were very good from the nights of the 19th and 20th, and yielded the best results. The data fit a bimodal lightcurve with a period of 3.563 h with a peak-to-peak amplitude of 0.24 mag, although a monomodal period of 1.788 h also fits the data reasonably well. However, the large peak-to-peak amplitude and exceedingly short monomodal period suggest that the 3.563 h period is the better interpretation.

Acknowledgements

We would like to thank Ed Anderson for all his indispensable help during the observing run.

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Warner, B. D., Harris, A.W., Pravec, P., Kaasalainen, M., Benner, L.A.M. (2007). "Lightcurve Photometry Opportunities October-December 2007," *Minor Planet Bulletin* **34**, 130-133.

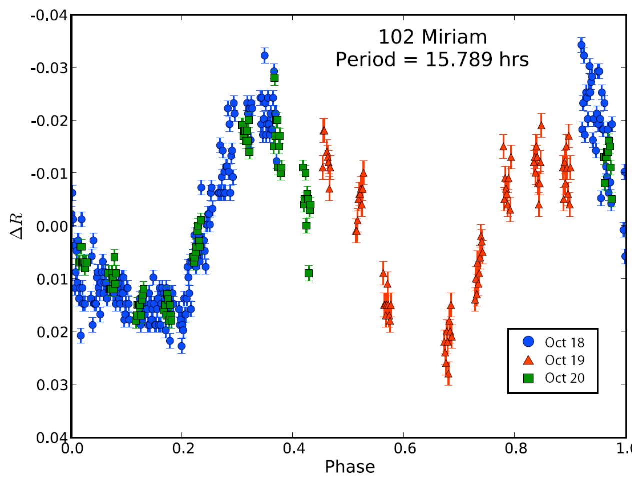


Figure 1. The composite lightcurve of 102 Miriam. The derived rotation period is 15.789 h in concordance with Warner et al (2007).

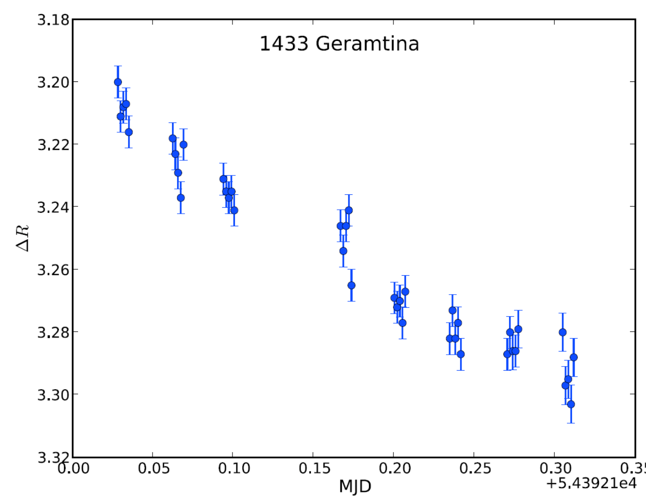


Figure 2. The relative magnitude in the R filter of 1433 Geramtina from one night of observation. The steady downward trend over approximately seven hours leads to the conclusion of a period of at least 14 h.

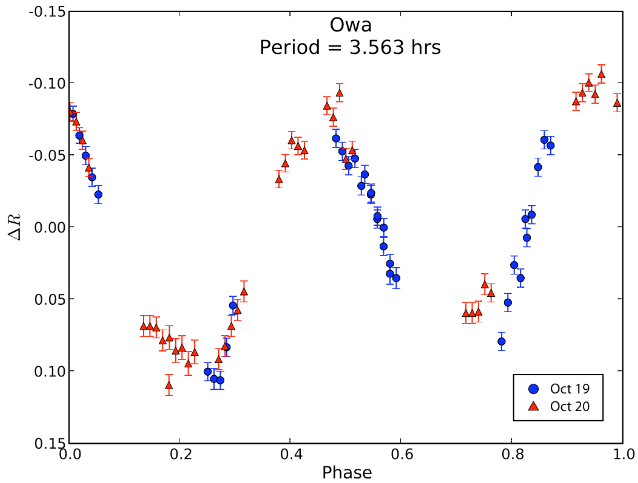


Figure 3. The composite lightcurve of 2648 Owa.

ASTEROID LIGHTCURVE OBSERVATIONS

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

(Received: 2008 June 23 Revised: 2008 July 1)

Asteroid period and amplitude results obtained at the Montgomery College Observatory in Rockville, Maryland, are presented.

Montgomery College is a 2-year community college in Montgomery Country, Maryland. It has an observatory at the Rockville campus that houses a Meade 40-cm f/10 LX200 GPS Schmidt-Cassegrain Telescope (SCT) and a Meade 25-cm f/6.3 LX200 SCT. An SBIG STL-1001E CCD was used with the 40-cm telescope and an SBIG ST-9XE CCD was used with the 25-cm. 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 (2008). 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 UCAC2 catalogs. Results are summarized in the table below, and the lightcurve plots are presented at the end of the paper. The data and curves are presented without additional comment except were circumstances warrant. Column 3 gives the range of dates of observations and column 4 gives the number of nights on which observations were undertaken.

2126 Gerasimovich. Observations of this asteroid were made on four nights, over a three-week period. Initial analysis resulted in a curve with a single peak at around 11.5 h. Later analysis showed that a double-peaked curve with a period of 22.951 h fitted the data equally as well, and so this result is presented here.

4340 Dence. This asteroid was very frustrating to analyze. Observations were made on eight nights over a four-week interval. However, the scatter in the data was relatively large in comparison to the amplitude of variations. The best result that could be achieved was a period of 15.473 h, with two unequal peaks. Due to the scatter in the data, this result is somewhat uncertain.

14659 Gegoriana. This asteroid was also very frustrating to analyze. Observations were made on five nights over a six-week period, but no simple lightcurve was obtained. A noisy, four-peak curve with a period of 6.936 h was the most reasonable solution to the data and so is reproduced here. However, this result is very uncertain. More observations would be very useful at the next opposition.

(16959) 1998 QE 17. Only three nights of observations, over a three-week interval were possible for this asteroid due to the closure of the campus observatory for maintenance. The data could not be fitted to a simple, two-peaked graph. The most reasonable result is the 5.316 h period presented here, which contained four peaks.

Acknowledgments

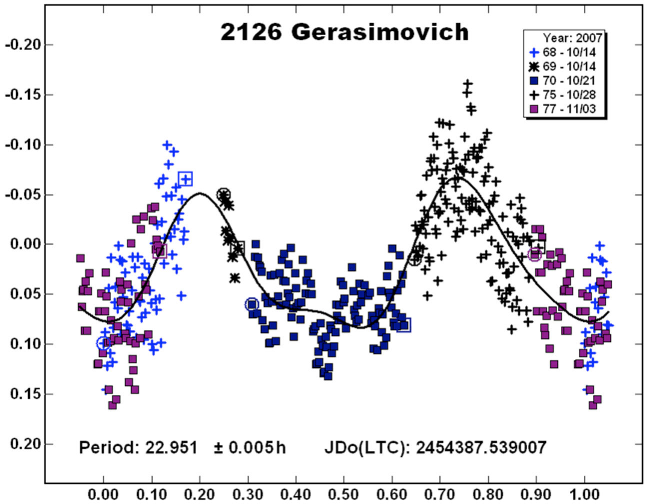
I would like to thank Brian Warner for all of his work with the program *MPO Canopus*.

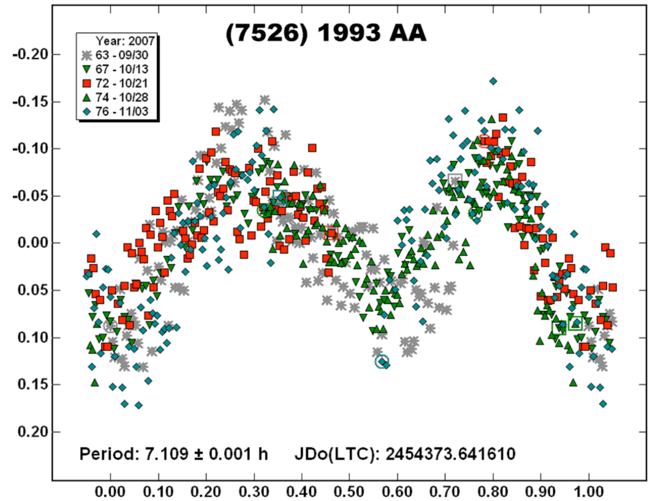
References

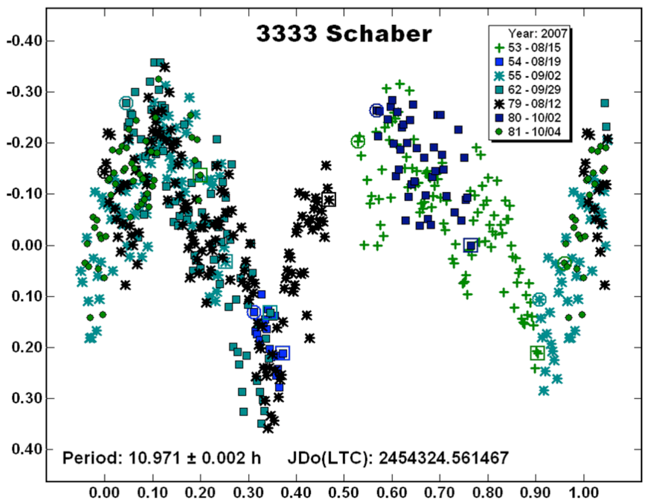
Harris, A. W., et al. (1989). "Photoelectric Observations of Asteroids 3, 24, 60, 261, and 863." *Icarus* **77**, 171-186.

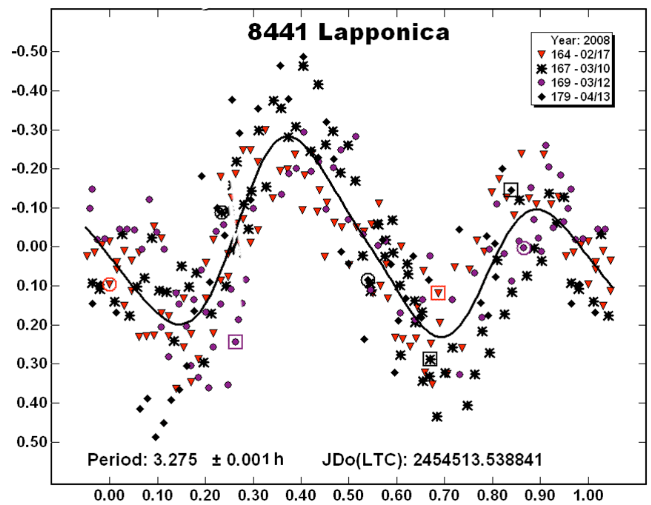
Warner, B.D., Collaborative Asteroid Lightcurve Link web site. http://www.minorplanetobserver.com/astlc/default.htm

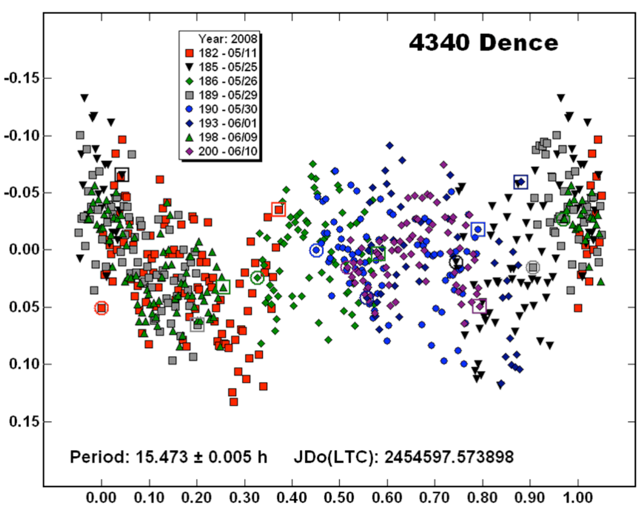
#	Name	Date Range	Sess	Per (h)	Error (h)	Amp (mag)	Error (mag)
2126	Gerasimovich	2007 Oct 14 - Nov 03	4	22.951	0.005	0.25	0.03
3333	Schaber	2007 Aug 16 - Oct 04	7	10.971	0.002	0.65	0.03
4340	Dence	2008 May 11 - Jun 10	8	15.473	0.005	0.2	0.05
(7526)	1993 AA	2007 Sep 30 - Nov 03	5	7.109	0.001	0.3	0.02
8441	Lapponica	2008 Feb 17 - Apr 13	4	3.275	0.001	0.9	0.02
13474	V'yus	2007 Sep 02 - Sep 30	4	6.587	0.001	1.05	0.02
13860	Neely	2008 May 11 - Jun 03	6	9.791	0.002	0.45	0.04
14659	Gegoriana	2008 Feb 03 - Mar 13	5	9.636	0.001	0.55	0.05
15271	1991 DE	2008 Mar 10 - Apr 13	4	6.908	0.001	0.9	0.02
(16959)	1998 QE17	2007 Dec 08 - Dec 20	3	6.316	0.005	0.45	0.02
(18641)	1998 EG10	2007 Oct 14 - Oct 21	2	5.68	0.01	0.75	0.05
(46436)	2002 LH5	2007 Jul 22 - Aug 16	3	3.8836	0.0005	0.65	0.02

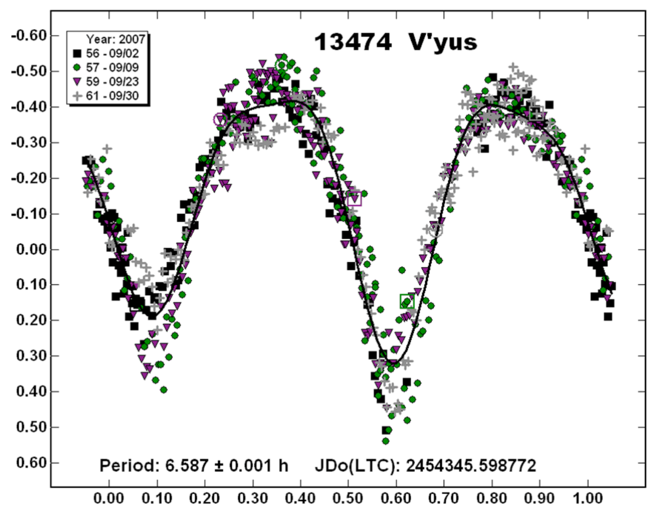

2126 Gerasimovich
Year: 2007
68 - 10/14
69 - 10/14
70 - 10/21
75 - 10/28
77 - 11/03
Period: 22.951 ± 0.005h
JDo(LTC): 2454387.539007

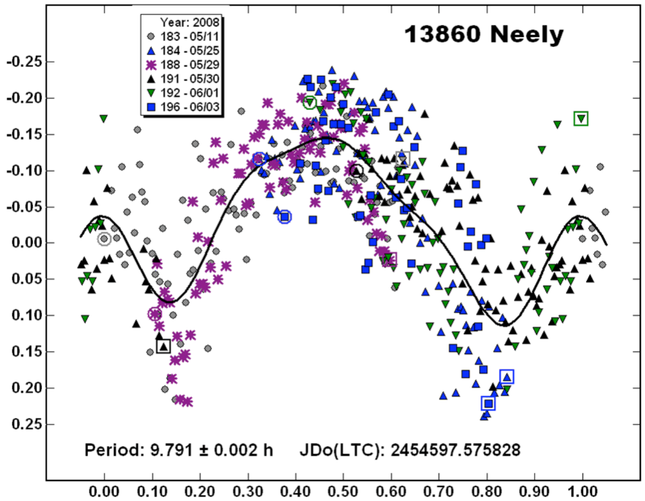

(7526) 1993 AA
Year: 2007
63 - 09/30
67 - 10/13
72 - 10/21
74 - 10/28
76 - 11/03
Period: 7.109 ± 0.001 h
JDo(LTC): 2454373.641610


3333 Schaber
Year: 2007
53 - 08/15
54 - 08/19
55 - 09/02
62 - 09/29
79 - 08/12
80 - 10/02
81 - 10/04
Period: 10.971 ± 0.002 h
JDo(LTC): 2454324.561467


8441 Lapponica
Year: 2008
164 - 02/17
167 - 03/10
169 - 03/12
179 - 04/13
Period: 3.275 ± 0.001h
JDo(LTC): 2454513.538841


4340 Dence
Year: 2008
182 - 05/11
185 - 05/25
186 - 05/26
189 - 05/29
190 - 05/30
193 - 06/01
198 - 06/09
200 - 06/10
Period: 15.473 ± 0.005 h
JDo(LTC): 2454597.573898


13474 V'yus
Year: 2007
56 - 09/02
57 - 09/09
59 - 09/23
61 - 09/30
Period: 6.587 ± 0.001 h
JDo(LTC): 2454345.598772


13860 Neely
Year: 2008
183 - 05/11
184 - 05/25
188 - 05/29
191 - 05/30
192 - 06/01
196 - 06/03
Period: 9.791 ± 0.002 h
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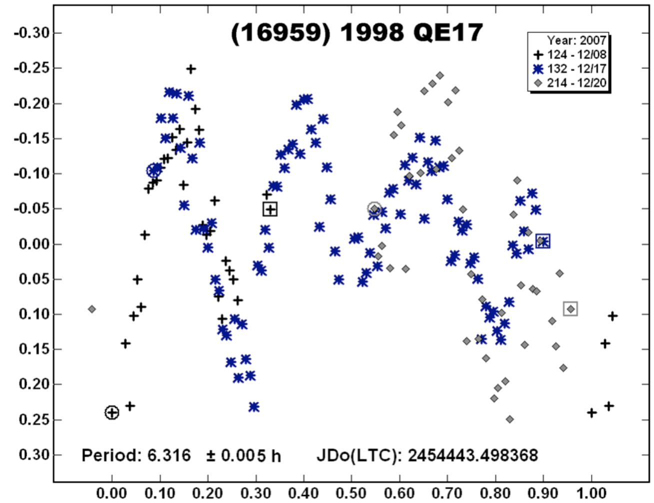
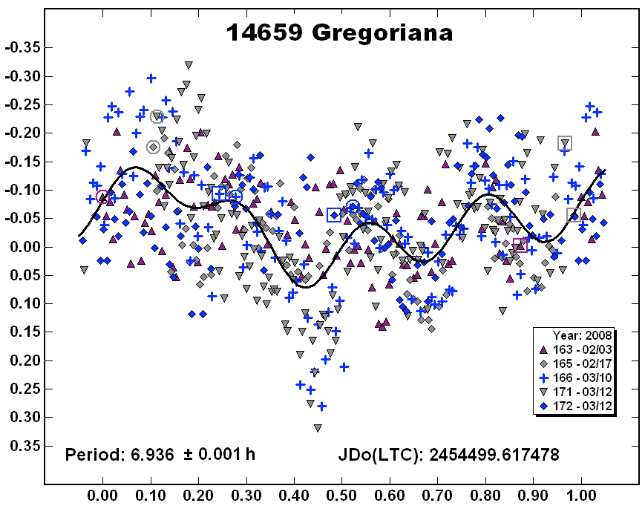
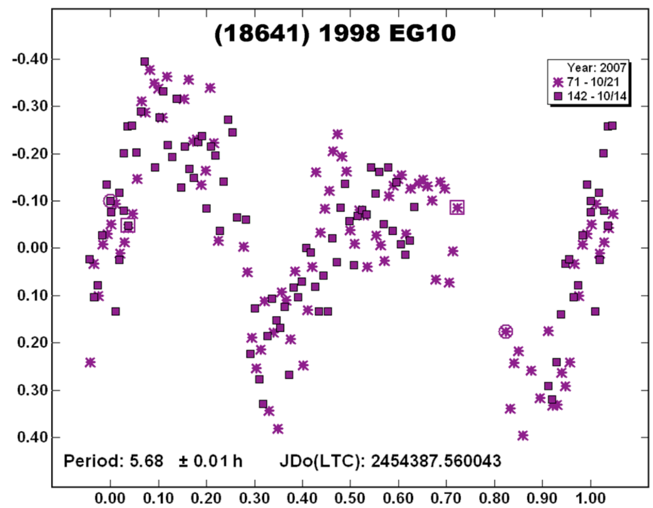

(16959) 1998 QE17
Year: 2007
124 - 12/08
132 - 12/17
214 - 12/20
Period: 6.316 ± 0.005 h
JDo(LTC): 2454443.498368


14659 Gregoriana
Year: 2008
163 - 02/03
165 - 02/17
166 - 03/10
171 - 03/12
172 - 03/12
Period: 6.936 ± 0.001 h
JDo(LTC): 2454499.617478


(18641) 1998 EG10
Year: 2007
71 - 10/21
142 - 10/14
Period: 5.68 ± 0.01 h
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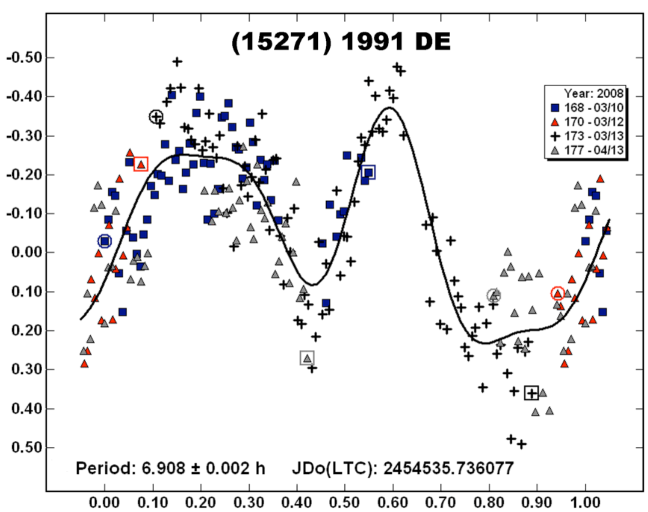
(15271) 1991 DE
Year: 2008
168 - 03/10
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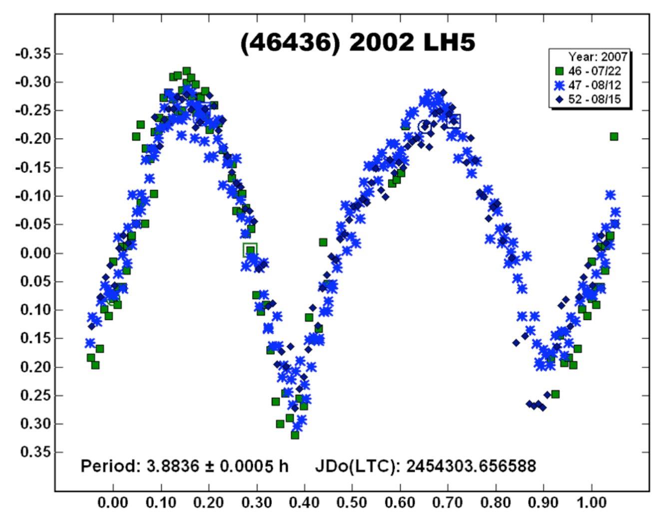
173 - 03/13
177 - 04/13
Period: 6.908 ± 0.002 h
JDo(LTC): 2454535.736077


(46436) 2002 LH5
Year: 2007
46 - 07/22
47 - 08/12
52 - 08/15
Period: 3.8836 ± 0.0005 h
JDo(LTC): 2454303.656588

ASTEROID LIGHTCURVE ANALYSIS AT MENKE OBSERVATORY

John Menke
22500 Old Hundred Rd
Barnesville, MD 20838
John@menkescientific.com

Walt Cooney, John Gross, and Dirk Terrell
Sonoita Research Observatory, Sonoita, AZ

David Higgins
Hunters Hill Observatory; Ngunnawal, Canberra 2913
AUSTRALIA

(Received: 2008 June 4 Revised: 2008 June 20)

The lightcurves for the following asteroids are reported: 305 Gordonia, 316 Goberta, 608 Adolfine, 707 Steina, 710 Gertrud, 1187 Afra, 1216 Askania, 1325 Inanda, 1462 Zamenhoff, 1559 Kustaanheimo, 1671 Chaika, 1999 Hirayama, 2075 Martinez, 2094 Magnitka, 2444 Lederle, 3156 Ellington, 4264 Karljosephine, and 7895 Kaseda. Three of these (707, 1325, and 4264) are slow rotators.

The asteroid program at Menke observatory has been described elsewhere (Menke 2005a) and website (Menke 2008). In brief, a C11 with ST7E camera is used in an automated setup. The data are taken and the images are read using *MaximDL* to create text files of raw intensity values using a digital reference star plug-in. These files are imported into Excel where the data are analyzed. The period is determined by inspection using a data folding process. In the case of slow rotators, Menke also uses a time plot against Julian Day with comparison sine waves to assist in the analysis. Night-to-night calibration was done using a modified Landolt star reference process and/or manual offsets. The data are not light-time corrected. Virtually all targets were taken from the CALL web site lists (Warner 2005).

The results are presented in the table below, followed by the plots of the curves. The plots show data session dates as DXMMDDYY where X is a session number. Where appropriate, comments are provided comments on individual results. In some data sets, interfering stars were removed from the original images using *StarZap* (Menke 2005b), and these are noted with an "SZ" in the name of the session date.

608 Adolfine. Data set D2 was very noisy, but its period and phase are consistent with the remaining data and helped eliminate aliases. The plot uses only the better data sets in order to show the main curve.

707 Steina. This large amplitude (1 mag), extremely slow rotator (414 hr) was done in collaboration with David Higgins in Australia, thus providing a key series of data with minimal calibration issues. The Higgins data were essential for eliminating period aliases. The long-time plot shows the Menke and Higgins data without manual offsets. The baseline magnitude of the sine curve is set to fit the magnitudes of data set D13, with the slope of the sine curve matching the predicted magnitude change as given by *TheSky* software. The residual differences between the Menke data and the curve indicate that there are calibration problems in some of the Menke data sets that could not be resolved. However, the inferred period and amplitude are unambiguous. In the Steina phase plot, manual offsets were introduced and chosen to fit the data to a non-sloped version of the sine curve time plot (not shown), but having the same period and phase as shown in the displayed time plot. The phase space is reasonably well sampled; however, the details of the rotation curve are obviously not continuously sampled.

1325 Inanda. These are data taken in 2003, but due to their complexity were not successfully analyzed until 2007. There were 15 data sessions over 32 days. Some of the sessions were done using the modified Landolt reference star methods but others had no calibration data and required use of manual offsets. Complicating the analysis, the data in the last four sessions (Day12-15) were obviously significantly different from the earlier sessions, that is, their slopes were substantially steeper. A time plot was created because of the difficulty of finding a simple solution. Nightly offsets were adjusted to move the data to fit the sine wave while a phase plot was used to assure that incorrect periods were avoided. Using this method, the fundamental frequency was found to be 70.8 h for a presumed rotation period of 141.6 h. The first two-thirds of the data are consistent with an amplitude of 0.4 mag. However, judging from the steepness of the slopes in the last four sessions, the amplitude apparently exceeded 0.8 mag. If this is correct, Inanda has a strongly asymmetric shape which was coming into view (or illumination) sometime around JD 2452960. Note that Inanda has been listed as having a period of 8 h (Warner 2000), but that was clearly in error.

2075 Martinez. A run of bad weather and a small amplitude made analysis of these data very problematic. Because of the poor data quality, the period and amplitude shown must be considered uncertain.

2444 Lederle. This asteroid was in a crowded star field, and required extensive use of *StarZap* to remove interfering stars from the images, which greatly improved the quality of the results.

3156 Ellington. Although these data are not of high quality, the period and amplitude given are highly certain.

4264 Karljosephine. This slow rotator was done in collaboration with Cooney, Gross, and Terrell of Sonoita Research Observatory (SRO). The SRO data were 5-minute unfiltered integrations. The changing nightly fields were calibrated against each other to put all measurements on the same relative instrumental scale. The data are light-time corrected. The effects of changing phase angle and distance from night-to-night were taken into account, leaving only the period and the slope parameter, G, as variables to adjust to synthesize the light curve. A best fit was obtained with a period of 98.2 ± 1.5 h and a slope parameter of 0.35 ± 0.15. The high slope parameter indicates the asteroid has somewhat higher albedo than typical but not outside normal bounds. The data of Menke were light-time corrected and overlaid on the SRO light curve. The magnitude scale is from Menke's data using his approximate Landolt calibration method. The data of Menke taken alone would indicate that a period of 92.8 h is also possible but this period is not favored with the addition of the internally calibrated SRO data.

7895 Kaseda. This asteroid had a low amplitude as well as being in a very crowded star field. The raw data were nearly useless and required the use of *StarZap* on every data set. Three days of data are shown with different offsets to demonstrate the consistency of the rotation curves.

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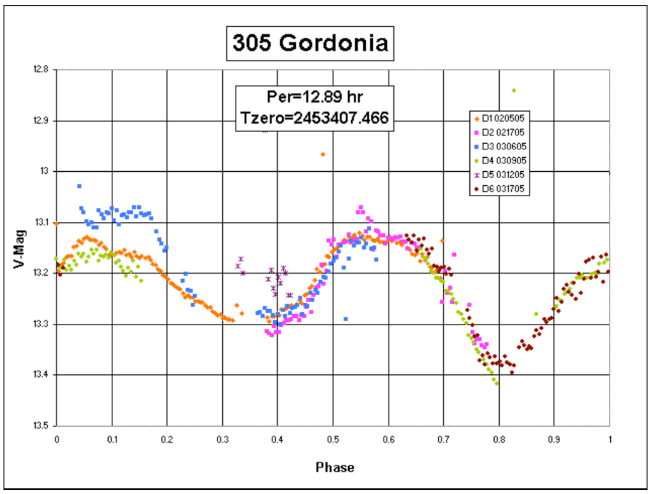
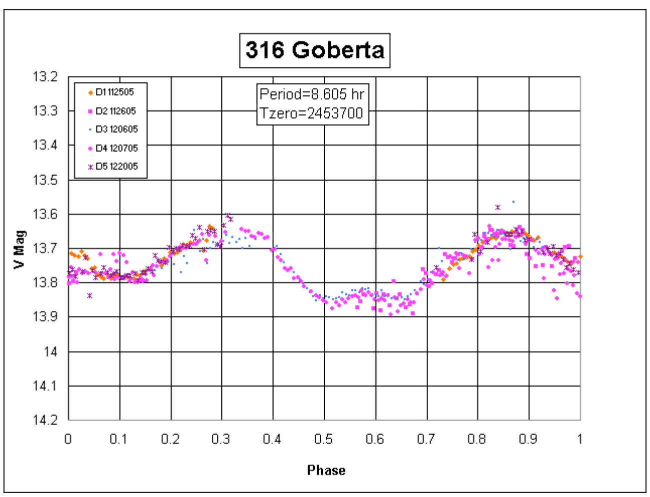
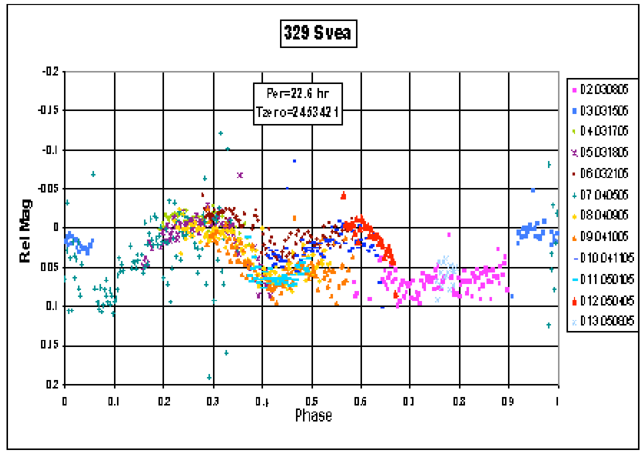
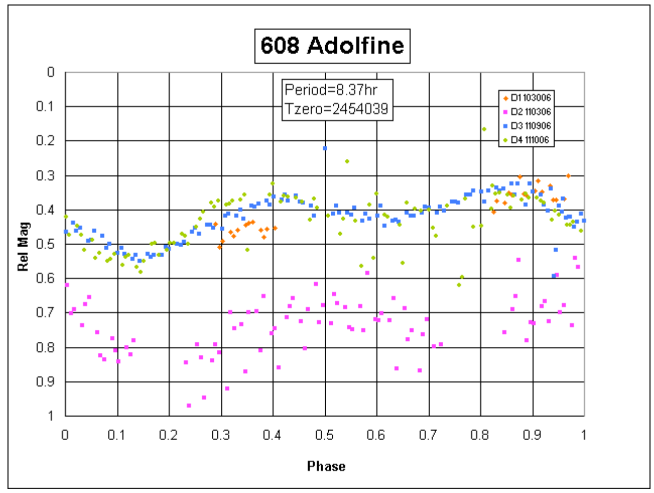
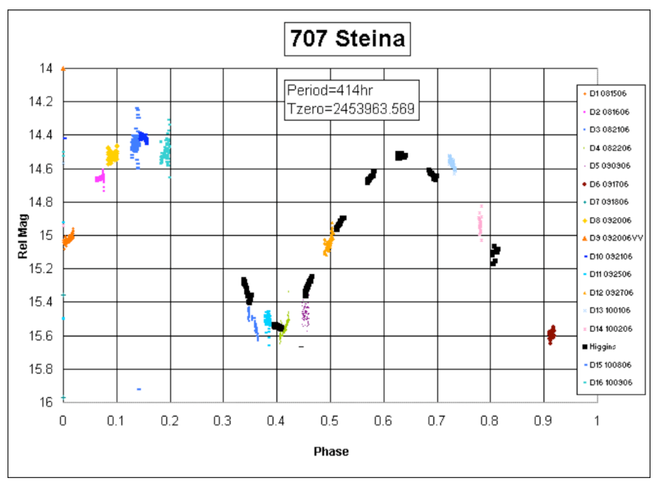
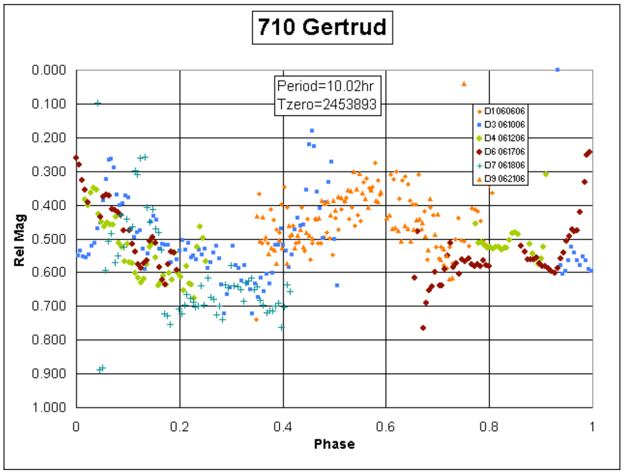


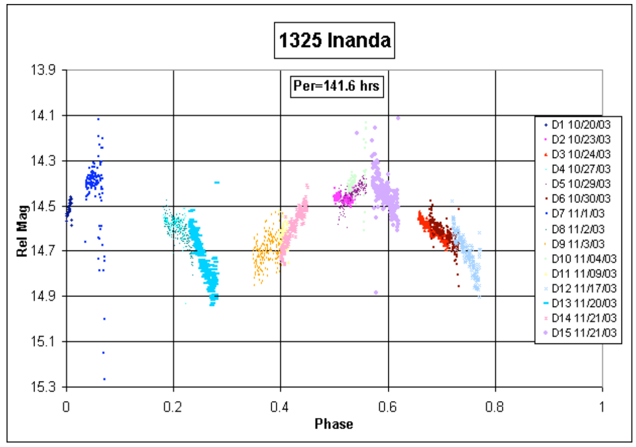


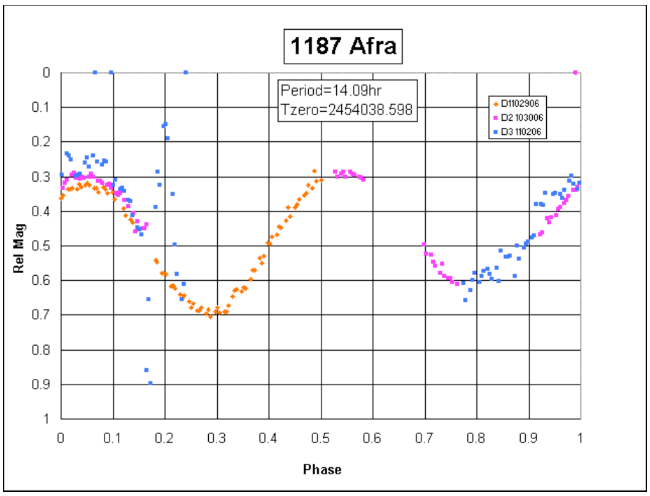


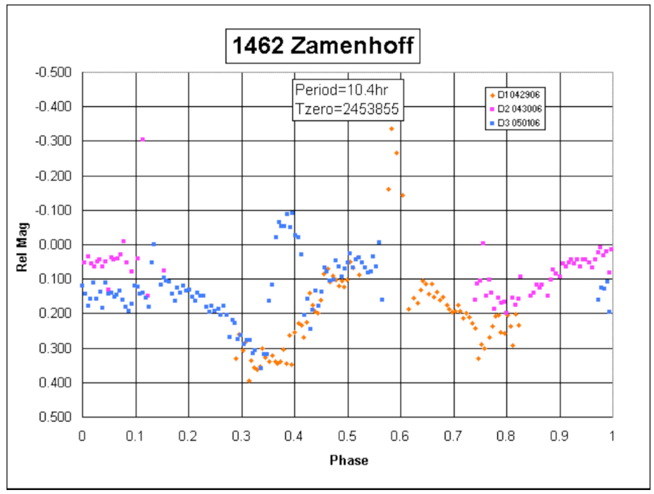


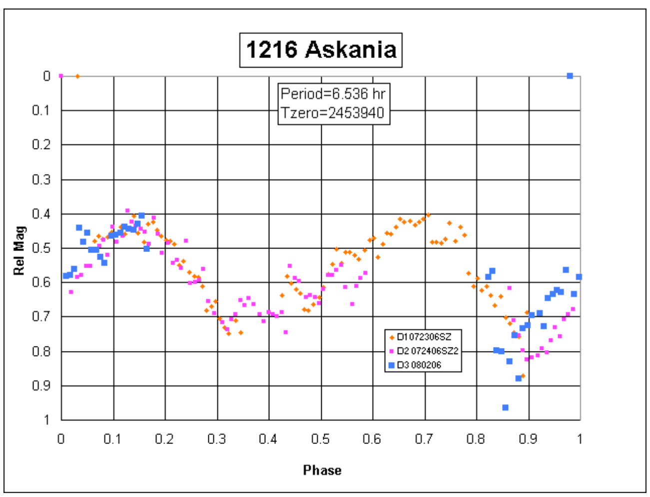


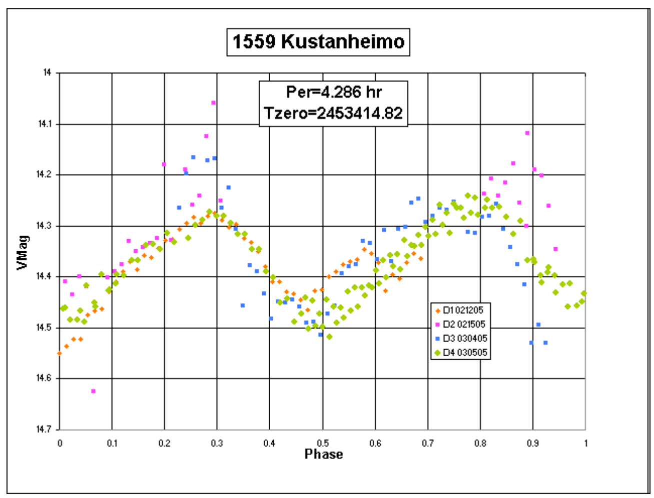

710 Gertrud
Period=10.02hr
Tzero=2453893
D1 060606
D3 061006
D4 061206
D6 061706
D7 061806
D9 062106
Rel Mag
Phase

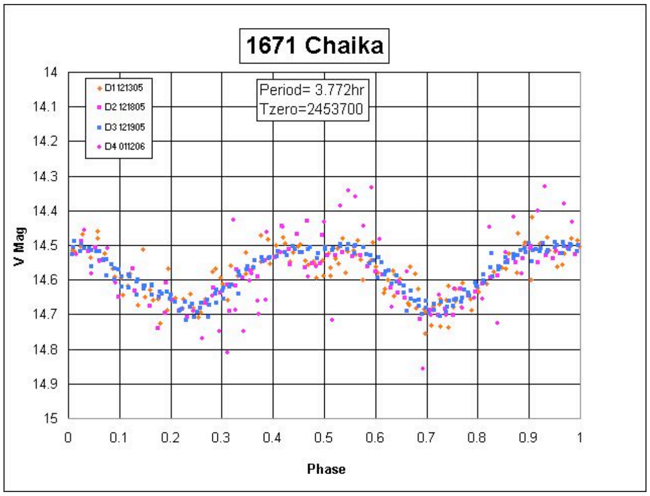

1325 Inanda
Per=141.6 hrs
D1 10/20/03
D2 10/23/03
D3 10/24/03
D4 10/27/03
D5 10/29/03
D6 10/30/03
D7 11/1/03
D8 11/2/03
D9 11/3/03
D10 11/04/03
D11 11/09/03
D12 11/17/03
D13 11/20/03
D14 11/21/03
D15 11/21/03
Rel Mag
Phase

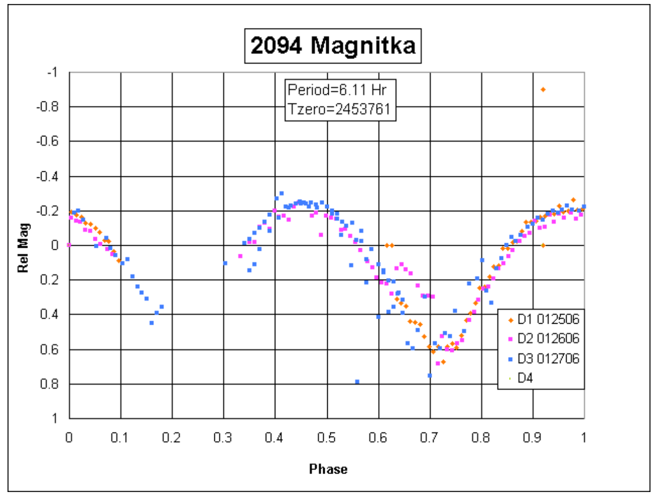

1187 Afra
Period=14.09hr
Tzero=2454038.598
D1102906
D2 103006
D3 110206
Rel Mag
Phase

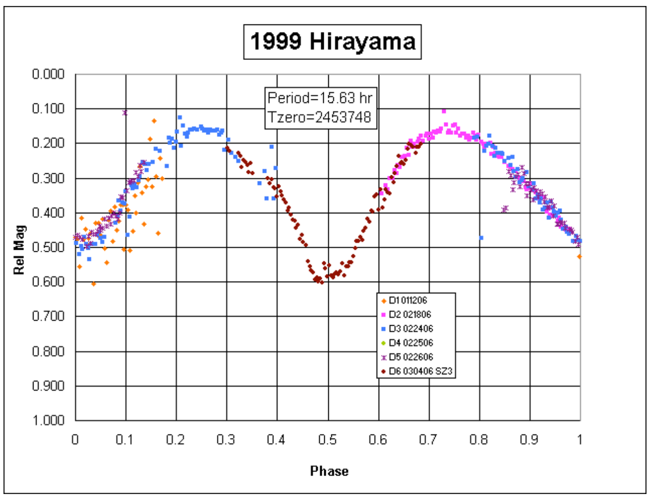

1462 Zamenhoff
Period=10.4hr
Tzero=2453855
D1 042906
D2 043006
D3 050106
Rel Mag
Phase

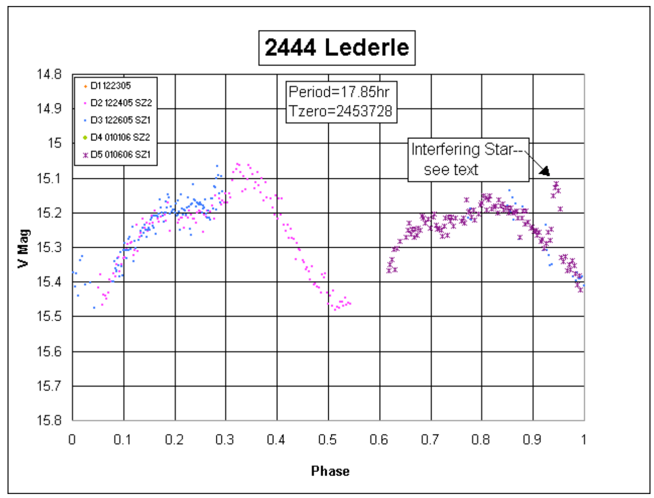

1216 Askania
Period=6.536 hr
Tzero=2453940
D1 072306SZ
D2 072406SZ2
D3 080206
Rel Mag
Phase

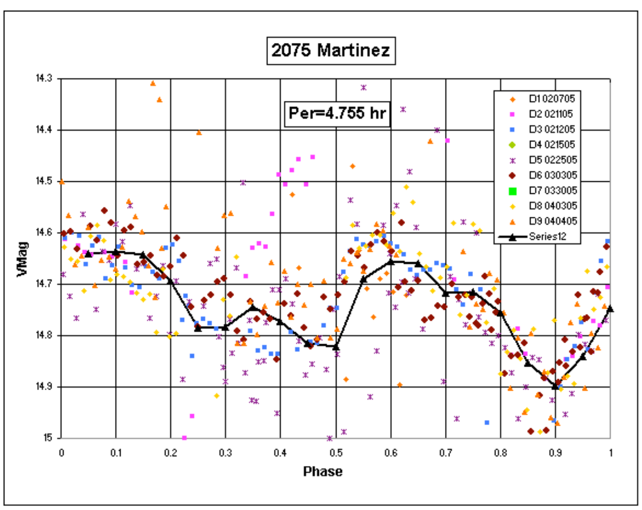

1559 Kustanheimo
Per=4.286 hr
Tzero=2453414.82
D1 021205
D2 021505
D3 030405
D4 030505
VMag
Phase

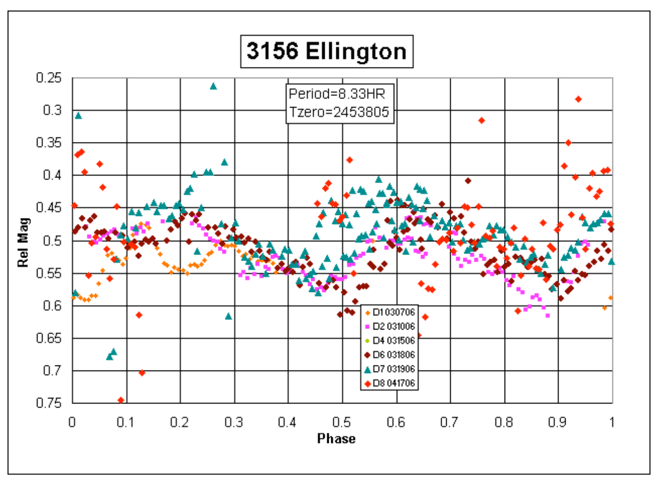

1671 Chaika
Period= 3.772hr
Tzero=2453700
D1 121305
D2 121805
D3 121905
D4 011206
V Mag
Phase

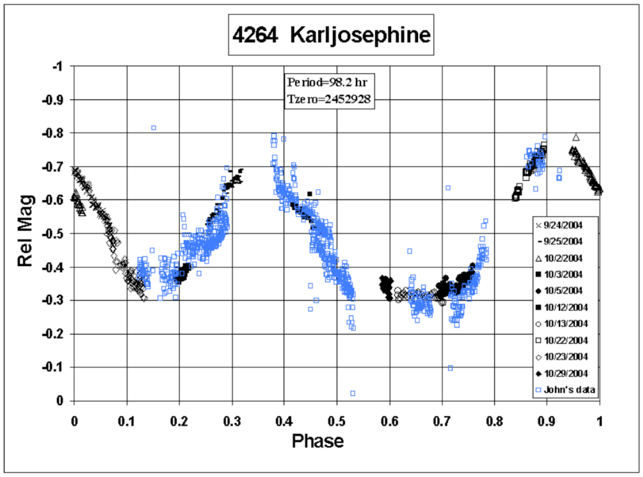

2094 Magnitka
Period=6.11 Hr
Tzero=2453761
D1 012506
D2 012606
D3 012706
D4
V Mag
Phase

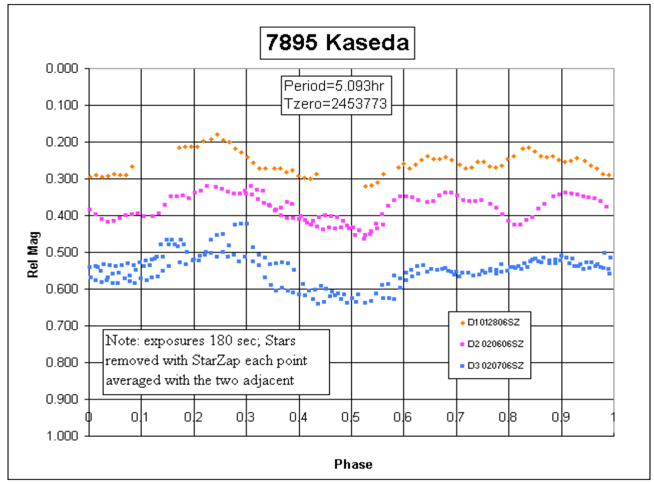

1999 Hirayama
Period=15.63 hr
Tzero=2453748
D1 011206
D2 021806
D3 022406
D4 022506
D5 022606
D6 030406 SZ3
Rel Mag
Phase

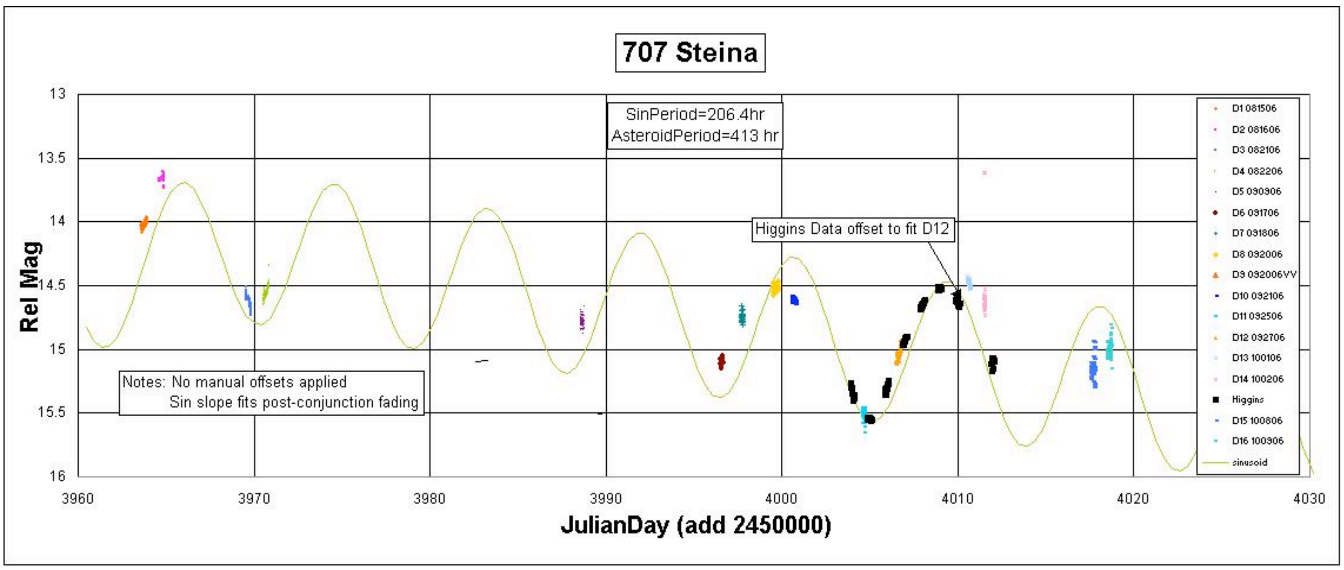

2444 Lederle
Period=17.85hr
Tzero=2453728
D1 122305
D2 122405 SZ2
D3 122605 SZ1
D4 010106 SZ2
D5 010606 SZ1
Interfering Star--
see text
V Mag
Phase

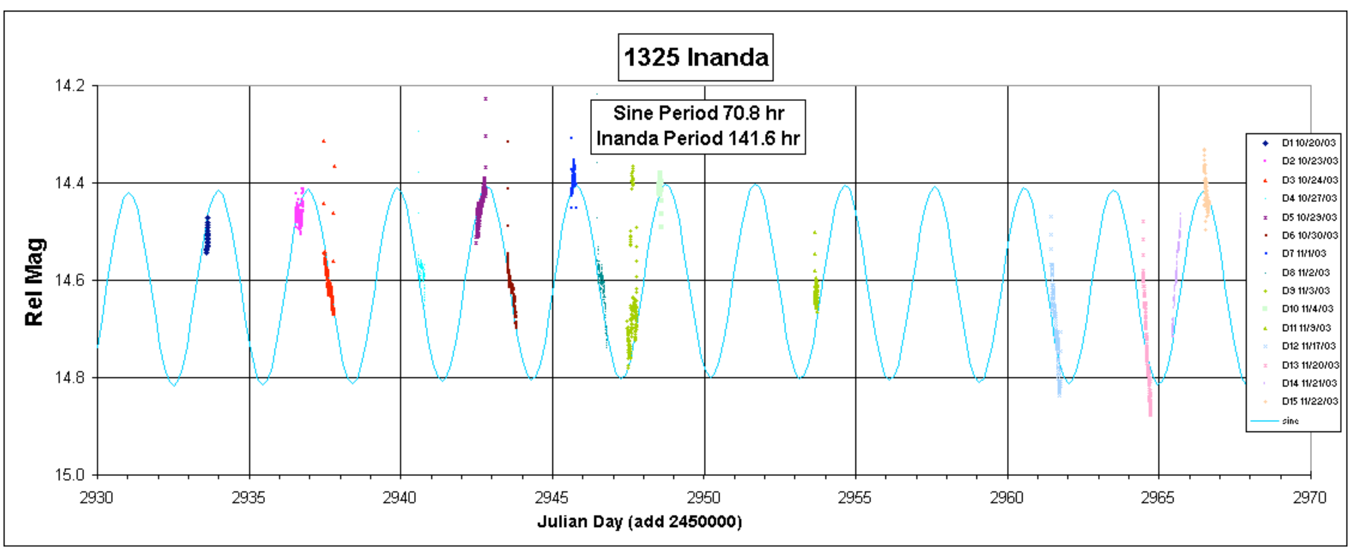

2075 Martinez
Per=4.755 hr
D1 020705
D2 021105
D3 021205
D4 021505
D5 022505
D6 030305
D7 033005
D8 040305
D9 040405
Series12
VMag
Phase


3156 Ellington
Period=8.33HR
Tzero=2453805
D1 030706
D2 031006
D4 031506
D6 031806
D7 031906
D8 041706
Rel Mag
Phase


4264 Karljosephine
Period=98.2 hr
Tzero=2452928
Rel Mag
Phase


7895 Kaseda
Period=5.093hr
Tzero=2453773
Note: exposures 180 sec; Stars removed with StarZap each point averaged with the two adjacent
Rel Mag
Phase


707 Steina
SinPeriod=206.4hr
AsteroidPeriod=413 hr
Higgins Data offset to fit D12
Notes: No manual offsets applied
Sin slope fits post-conjunction fading
Rel Mag
JulianDay (add 2450000)


1325 Inanda
Sine Period 70.8 hr
Inanda Period 141.6 hr
Rel Mag
Julian Day (add 2450000)

Number	Name	Period(h)	Unc	Amp	Unc	DateStart	DateEnd	Span	#Sess	Cov%
305	Gordonia	12.89	0.01	0.17	0.03	02/05/05	03/06/05	32	3	80
316	Goberta	8.605	0.01	0.20	0.05	11/25/05	12/20/05	26	5	100
329	Svea	22.6	0.01	0.10	0.03	03/08/05	05/08/05	61	12	100
608	Adolfine	8.37	0.03	0.25	0.05	10/30/06	11/10/06	11	4	100
707	Steina	414	10	1.00	0.15	08/15/06	10/09/06	55	(1) 23	35
710	Gertrud	10.02	0.03	0.35	0.04	06/06/06	06/21/06	16	6	100
1187	Afra	14.09	0.02	0.40	0.02	10/29/06	11/02/06	4	3	90
1216	Askania	6.536	0.003	0.30	0.03	07/23/06	08/02/06	10	3	100
1325	Inanda	141.6	0.2	0.4/0.8	--	10/20/03	11/21/03	32	15	75
1462	Zamenhoff	10.4	0.1	0.35	0.04	04/29/06	05/01/06	3	3	80
1559	Kustaanheimo	4.286	0.003	0.25	0.05	02/12/05	03/05/05	24	4	100
1671	Chaika	3.774	0.003	0.18	0.03	12/07/05	12/19/05	13	4	100
1999	Hirayama	15.63	0.01	0.45	0.04	01/12/06	03/04/06	53	6	100
2075	Martinez	4.755	0.002	0.30	0.1	02/07/05	03/03/05	27	6	100
2094	Magnitka	6.11	0.02	0.80	0.08	01/25/06	01/27/06	3	3	90
2444	Lederle	17.85	0.02	0.45	0.05	12/23/05	01/06/06	14	5	90
3156	Ellington	8.33	0.01	0.10	0.02	03/07/06	04/17/06	41	7	100
4264	Karljosephine	98.2	1.5	0.45	0.15	09/21/04	11/06/04	46	(2) 23	85
7895	Kaseda	5.093	0.003	0.10	0.02	01/28/06	02/06/06	9	3	100

Note (1) includes 16 sessions by Menke, 8 by Higgins
(2) includes 13 sessions by Menke, 10 by Cooney, Gross, and Terrell

LIGHTCURVE ANALYSIS OF ASTEROIDS 3036 KRAT, 3285 RUTH WOLFE, AND 5448 SIEBOLD

Jacob Hummel, Angela Postma, George C. Sumter, Harold Moore, Samantha Sweet, and Matthew M. Beaky

Department of Physics
Truman State University
100 East Normal Ave.
Kirksville, MO 63501
beaky@truman.edu

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Main-belt asteroids 3036 Krat, 3285 Ruth Wolfe, and 5448 Siebold were observed by the authors. 3036 Krat, observed at Lowell Observatory in 2007 December, was found to have a period of 9.61 ± 0.01 h. For the other two asteroids, both observed at the Truman Observatory in 2007, we found 3285 Ruth Wolfe to have a period of 3.919 ± 0.001 h and 5448 Siebold was determined to have a period of 2.929 ± 0.001 h.

Truman Observatory is located in Kirksville, Missouri, in a rural setting about 1.5 miles from the campus of Truman State University. Observations reported here were obtained with the Observatory's 14-inch Meade LX-200GPS telescope with an attached f/6.3 focal reducer. Truman State University is a member of the National Undergraduate Research Observatory (NURO), a consortium of colleges and universities that shares time on the 31-inch telescope at Lowell Observatory in Flagstaff, Arizona. This telescope is equipped with a 2048x2048 pixel Loral CCD camera. All of the data were analyzed using MPO Canopus (Bdw Publishing) which employs differential aperture photometry. The period analysis was performed within Canopus, using the Fourier analysis algorithm developed by Harris (1989).

3036 Krat. No previous photometry on this asteroid has been published. Photometric measurements of 3036 Krat were obtained at Lowell Observatory over two nights, 2007 December 18 and 20. The asteroid remained at magnitude 14.8 and phase angle 8.4 deg during the observing period. A total of 820 unfiltered images were acquired. The synodic period was determined to be 9.61 ± 0.01 h; the amplitude is 0.38 ± 0.03 mag.

3285 Ruth Wolfe. Warner (2003) initially published a rotational period for 3285 Ruth Wolfe of 6.72 hours but later revised that period to 3.94 hours (Warner 2005). This asteroid was observed at the Truman Observatory over two nights, 2007 October 30 and November 5. A total of 292 unfiltered CCD images were taken with an SBIG ST-402ME CCD camera. During this time the asteroid was near magnitude 14.6, with a phase angle of 10.9 deg on October 30, and 11.5 deg on November 5. Our analysis gives a best-fit synodic period of 3.919 ± 0.001 h and an amplitude of 0.20 ± 0.05 mag. This period and the overall shape of the light curve are consistent with Warner's 2005 measurements.

5448 Siebold. Photometric measurements of the main-belt asteroid 5448 Siebold were obtained on the nights of 2007 March 12 and 19 with an SBIG ST-7XME CCD camera at the Truman Observatory. During this time the asteroid was near magnitude 15, while its phase angle varied from 14 deg on March 12 to 18 deg on March 19. A total of 127 CCD images were acquired with a Bessell V filter. Analysis of the data revealed a bimodal lightcurve with a best-fit synodic period of 2.929 ± 0.001 h and an amplitude of 0.33 ± 0.02 mag.

Acknowledgements

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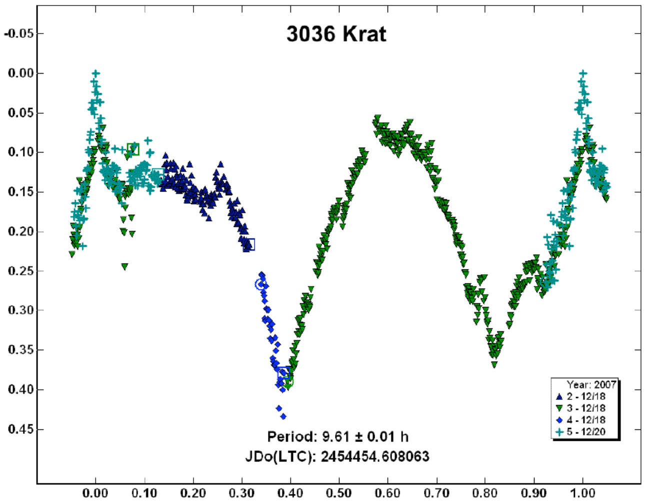

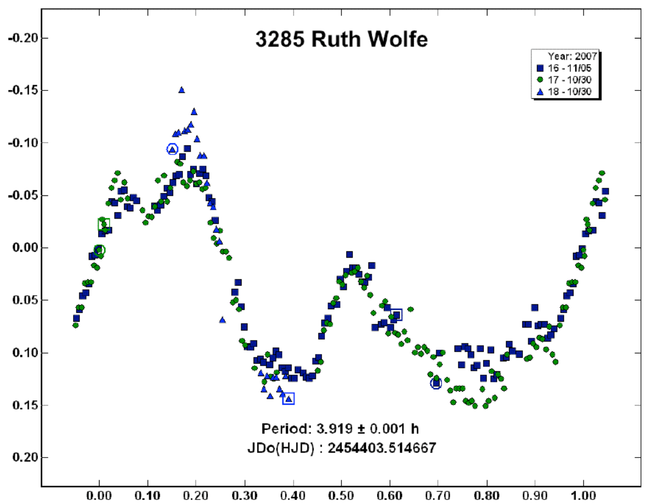

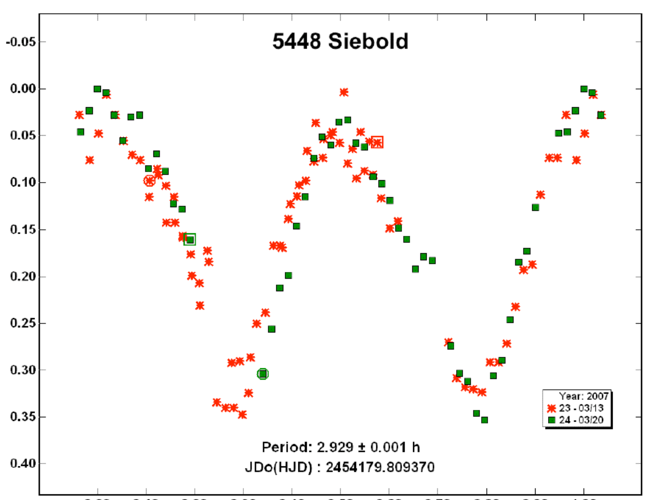

CCD PHOTOMETRY OF THREE SHORT-PERIOD ASTEROIDS FROM THE UNIVERSIDAD DE MONTERREY OBSERVATORY

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

(Received: 2008 July 9)

CCD photometry of three asteroids was obtained at the Universidad de Monterrey Observatory during 2007 April and 2008 March. These asteroids were observed on only one or two nights, but complete lightcurves were obtained due to relatively short rotation periods. The resulting synodic rotation periods and amplitudes are as follows: 811 Nauheima, 4.011 ± 0.006 h, 0.11 ± 0.03 mag; 3787 Aivazovskij, 2.97 ± 0.01 h, 0.18 ± 0.02 mag; and 5474 Gingasen, 3.628 ± 0.005 h, 0.16 ± 0.03 mag.

The observations reported here were made with the Meade 36-cm LX200GPS telescope of the Universidad de Monterrey Observatory (MPC 720). The telescope is permanently mounted in a 6-foot fiberglass automated dome and is operated from a nearby warm room. The CDD used to gather the 811 Nauheima data was an SBIG ST-9E with a 512×512×20μm chip, which yielded an image scale of ~1.7"/pixel and a field-of-view of ~14.6'×14.6' using an f/6.3 focal reducer. The CCD used to gather the 3783 Aivazovskij and 5474 Gingasen data was an SBIG STL-1301E with a 1280×1024×16μm chip. The field-of-view in this case was ~21.1'×16.9' with an image scale of nearly 1"/pixel.

The targets were selected from the list of asteroid photometry opportunities published by Brian Warner on his Collaborative Asteroid Lightcurve Link (CALL) website (Warner 2008). These asteroids were observed only during one or two nights, but the data for each asteroid suggested that they had short rotation periods. Weather and other considerations prevented additional observations. However, the available lightcurves were complete and had enough overlap to derive rotation periods. In all cases the images were obtained unfiltered, guided, and standard dark-current and flat-field corrections were applied. The 811 Nauheima exposures were 4 min, unbinned, and with a detector temperature of –10C. The 3783 Aivazovskij and 5474 Gingasen had exposures of 2 min, were binned 2×2, and the detector temperature varied between –15C and –20C on each session, depending on the ambient temperature. Image measurements and period analysis were performed using *MPO Canopus* (Warner 2008).

<u>811 Nauheima</u> This asteroid was observed on two consecutive nights in 2007 April. Initial analysis of the data suggested a rotation period of about 4 h but, since the resulting lightcurve did not exhibit a standard bimodal behavior and had a small amplitude, the results were labeled as suspect and in need of further observations. This was not possible during the 2007 apparition. The data were reanalyzed in early 2008 using *MPO Canopus* software, and the initial result seemed to stand, thus it is presented here, it being a synodic period of 4.011 ± 0.006 h and an amplitude 0.11 ± 0.03 mag. This asteroid is of particular interest because it belongs to the Koronis family. Recently Slivan *et al.*

(2008) reviewed and published a set of lightcurves for 811 Nauheima taken over the past few years that superseded initial observations by Binzel (1987). Their best data set from the 2004 apparition yields a synodic rotation period of 4.0011 ± 0.0005 h and an amplitude of ~0.20 mag. Galád (2008) also observed 811 Nauheima on four nights during the 2007 apparition (May 2, 3, 4, and 13) and obtained a rotation period of 4.0011 ± 0.0004 h, identical to Slivan et al. (2008), and an amplitude of ~0.13 mag, in agreement with the amplitude reported here.

3787 Aivazovskij This asteroid was observed only on 2008 March 8. The resulting synodic period was 2.97 ± 0.01 h and the amplitude 0.18 ± 0.02 mag. Although it was observed on only the one night, the short rotation period allowed sampling the lightcurve more than twice during the 7-hour observing session. We are confident about the result because of the relatively clean bimodal lightcurve, although at least one more observing session would have substantially decreased the uncertainty in the period. No other reports were found for this asteroid.

5474 Gingasen This asteroid was observed on two consecutive nights during 2008 March. The resulting synodic period was 3.628 ± 0.005 h and the amplitude 0.16 ± 0.03 mag. The asteroid was faint and the resulting low S/N of the individual measurements combined with the small amplitude and irregular shape of the lightcurve make the derived period uncertain, although both observing sessions covered the rotation period more than once. This asteroid is also found on the website maintained by R. Behrend (2008). He reports a provisional rotation period of ~2.91 h and an amplitude of 0.10 ± 0.01 mag from three nights of observations in 2006 by L. Bernasconi, and has classified it as difficult and with low amplitude. This object is labeled with a reliability code of "1-" in the Minor Planet Lightcurve Parameter List (Harris *et al.* 2008), which means that the result may be completely wrong. The result derived from the observations presented here is almost an exact 5/4 multiple of the Behrend rotation period. However, a fit of our data to the Behrend reported period resulted in a less satisfactory lightcurve than the one presented here.

Acknowledgments

We would like to thank the Consejo Nacional de Ciencia y Tecnología (CONACYT) of Mexico for the grant (Fondo Institucional, Apoyo Complementario 2006, No. 52274 – Area I) that made it possible to upgrade the equipment of the Universidad de Monterrey observatory. We also thank Brian Warner for his continuous support of the CALL Website and the *MPO Canopus* software, which really makes asteroid lightcurve work much easier and enjoyable.

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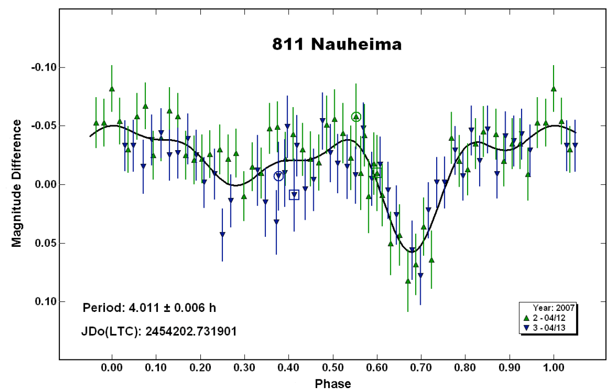

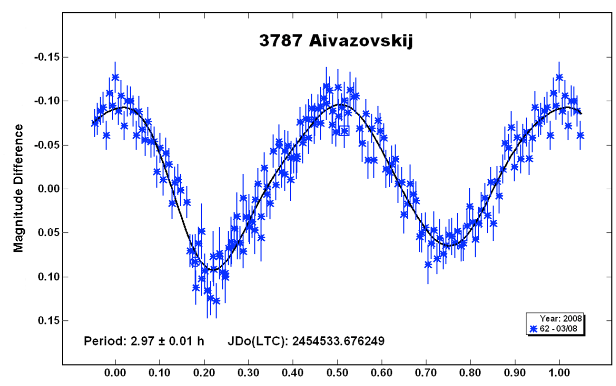

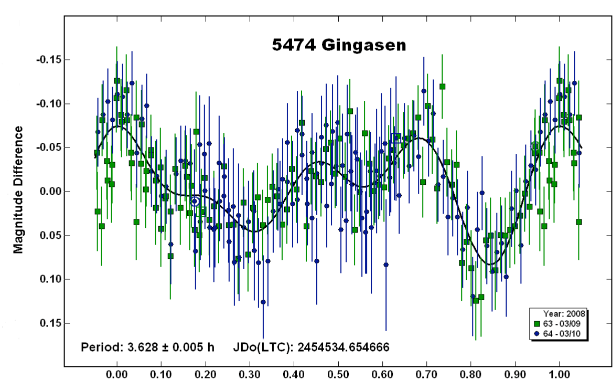

ASTEROID LIGHTCURVE ANALYSIS AT THE PALMER DIVIDE OBSERVATORY: FEBRUARY - MAY 2008

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

(Received: 28 May)

Lightcurves for 22 asteroids were obtained at the Palmer Divide Observatory (PDO) from February to May 2008: 578 Happelia, 1093 Freda, 1324 Knysna, 1528 Conrada, 1817 Katanga, 2001 Einstein, 2048 Dwornik, 2150 Nyctimene, 2491 Tvashtri, 3198 Wallonia, 3800 Karayusuf, 4425 Bilk, (5559) 1990 MV, (6394) 1990 QM2, 6435 Daveross, (11398) 1998 YP1, (12390) 1994 WB1, (24094) 1999 UN60, 26887 Tokyogiants, (27068) 1998 SU74, (31827) 1999 VJ13, and 2002 TD66.

Observations of 22 asteroids were made at the Palmer Divide Observatory from February to early May 2008. One of four telescopes/camera combinations was used: 0.5m Ritchey-Chretien/SBIG STL-1001E, 0.35m SCT/FLI IMG-1001E, 0.35m SCT/ST-9E, or 0.35m SCT/STL-1001E. All images were 1x1 binning, resulting in a scale of approximately 1.2 arcseconds per pixel. Exposure times were 90–240 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 employing differential aperture photometry. 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. A "(B)" follows the name if the asteroid is a member of the Baptistina family. The latter are thought to have been recently formed (160 MY) from a catastrophic collision (Bottke et al., 2007. *Nature* **449**, 48-53) and will be targeted by PDO in the future.

578 Happelia. This asteroid was reported by Robinson (2002) to have a period of 10.061 h while Behrend (2008) reported 4.1 h. Observations by PDO confirm the Robinson period by finding a synodic period of 10.065 h.

1093 Freda. Behrend (2008) reported a period of 10.73 h. The data from PDO did not fit this period but indicated instead a period of 19.67 h.

1324 Knysna. The period of 2.5538 h agrees with the one of 2.56 h found by Behrend (2008).

1528 Conrada. The period of 6.318 h is close to that of 6.321 h reported by Willis (2004).

1817 Katanga. Previously reported periods include 6.35 h (Malcolm 2002) and 7.2165 h (Behrend 2008). The asteroid was worked with the hope of affirming one or the other. Instead, a period of 8.481 h was found. Forced fits to the two previous

#	Name	(mm/dd) 2008	Data Pts	Phase	PAB_L	PAB_B	Per (h)	PE	Amp (mag)	AE
578	Happelia	04/24-28	329	16.2,17.1	169.3	177.6	10.065	0.003	0.16	0.01
1093	Freda	04/15-21	501	6.4,6.8	203.2	16.9	19.67	0.01	0.21	0.02
1324	Knysna	04/29-05/09	79	14.8,19.5	196.8	-6.3	2.5538	0.0005	0.08	0.01
1528	Conrada	05/11-12	183	11.4,11.8	216.4	12.1	6.318	0.001	0.41	0.02
1817	Katanga	04/22-24	237	26.4,26.8	172.8	33.4	8.481	0.003	0.30	0.02
2001	Einstein (H)	03/22-27	431	11.1,14.4	167.3	2.2	5.4846	0.0003	1.02	0.02
2048	Dwornik (H)	03/24-26	221	13.2,13.1	189.8	18.8	8.65	0.02	0.08	0.02
2150	Nyctimene (H)	05/06-10	89	15.0,14.6	237.4	21.1	6.129	0.002	0.59	0.02
2491	Tvashtri (H)	04/29-05/09	202	22.6,23.4	213.5	33.7	4.0847	0.0005	0.06	0.01
3198	Wallonia	04/27-28	71	23.4,23.8	187.2	23.3	7.54	0.01	0.57	0.02
3800	Karayusuf	03/25-04/04	370	26.9,28.8	180.4	27.9	2.2319	0.0001	0.15	0.01
4425	Bilk	03/08-20	144	24.8,27.4	124.6	4.0	5.251	0.001	0.42	0.02
5559	1999 MV	04/27-05/04	133	18.9,21.3	186.7	14.7	14.971	0.004	0.49	0.02
6394	1990 QM2	03/04-11	99	0.7,4.5	163.6	1.8	3.7680	0.0005	0.25	0.02
6435	Daveross (H)	02/27-03/21	172	5.7,19.9	151.6	-3.9,1.9	14.735	0.006	0.10	0.02
11398	1998 YP1	04/04-26	398	63.2,72.8	189,221	43,51	38.58	0.01	0.34	0.02
12390	1994 WB1 (H)	04/26-05/04	278	21.6,21.5	210.7	24.8	15.22	0.01	0.08	0.01
24094	1999 UN60	04/04-22	334	10.4,11.4	198.8	14.3	2.5768	0.0002	0.10	0.01
26887	Tokyogiants	03/25-26	76	9.4,10.0	171.2	5.6	2.876	0.003	0.23	0.03
27068	1998 SU74	03/27-04/04	141	6.8,10.4	177.9	7.2	4.011	0.001	0.21	0.02
31827	1999 VJ13 (H)	04/26-05/04	219	20.7,22.9	198.8	18.1	12.28	0.02	0.05	0.01
	2002 TD66	03/04-11	127	29.9,20.3	147,160	-5.0	9.456	0.002	1.16	0.03

periods were clearly incorrect.

2001 Einstein. This Hungaria asteroid was worked as follow up on earlier work (Warner 2005) for period confirmation and modeling. Unfortunately, there are insufficient sparse data and/or lightcurves from others and so modeling will have to wait until at least the next apparition.

2048 Dwornik. Schevchenko et al (2003) reported a period of 3.664 h with an amplitude of 0.22 mag. The PDO data did not fit that period, the period spectrum strongly favoring the adopted 8.65 h with a minor possibility at the half period of about 4.32 h. However, given the low amplitude of the PDO data, this result should not be considered definitive and additional follow up is needed.

2150 Nyctimene. This was follow up to earlier work (Warner 2007) for future modeling. The periods from each apparition are in agreement.

3198 Wallonia. The period of 7.54 h agrees with the 7.58 h reported by Behrend (2008).

3800 Karayusuf. Observations on March 25 and April 4 showed anomalous decreases in the lightcurve. The durations of the “events” were marginal in terms of being attributable to a satellite. The moon and asteroid’s fading prevented additional follow up. The asteroid should be given attention at the next apparition (April 2010, +35°, 16.2).

(11398) 1998 YP11. Pravec et al (2005) found a period of 38.60 h with a U=3 rating. The period using PDO data, acquired for modeling, was essentially identical.

2002 TD66. This NEA was worked in support of radar observations by M. Nolan.

Acknowledgements

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Warner, B.D. (2007). *Minor Planet Bulletin* **34**, 8-10.

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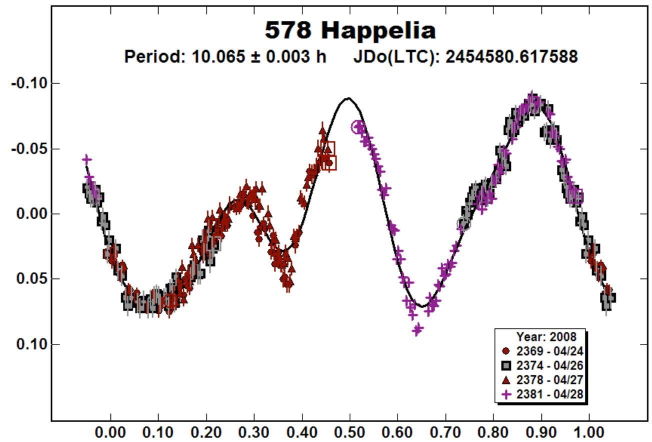
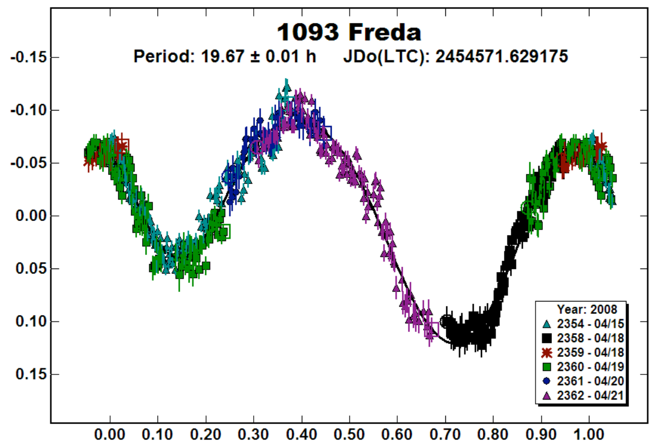
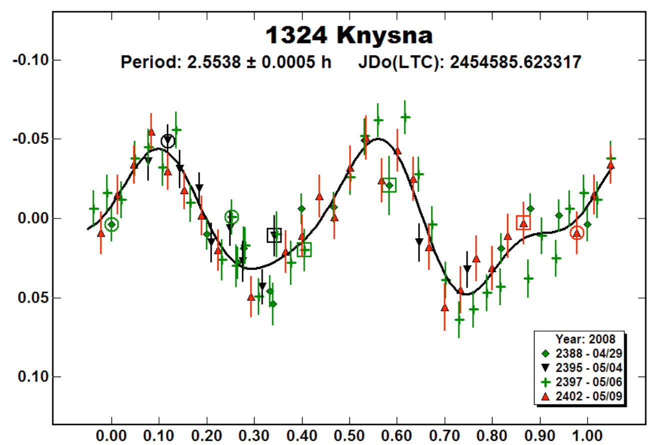
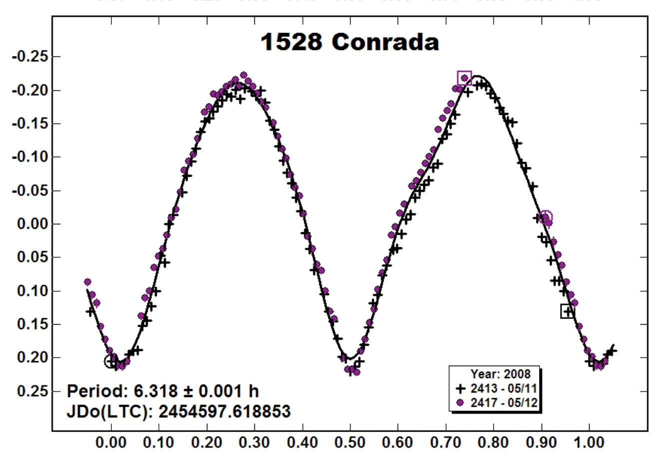
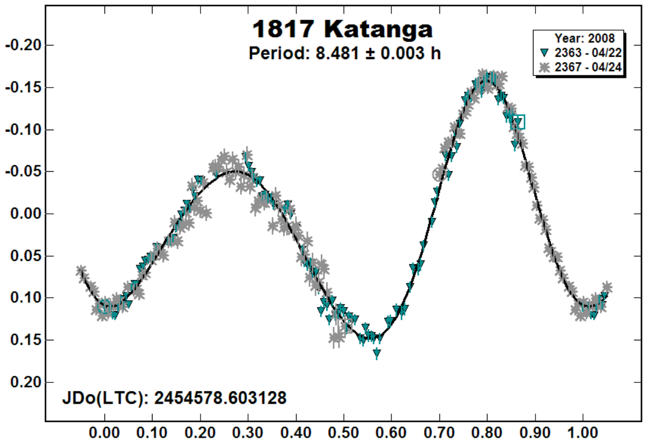
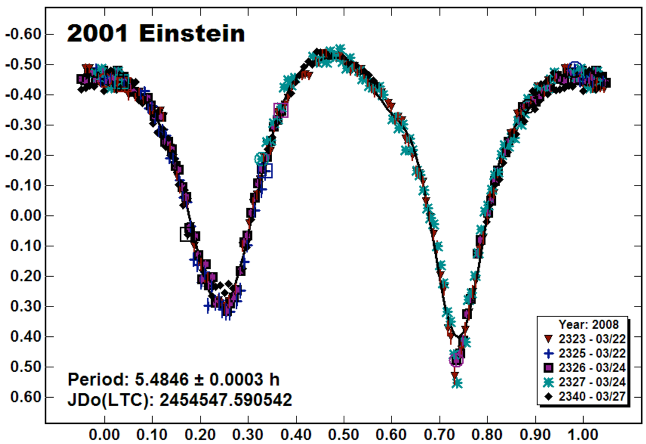


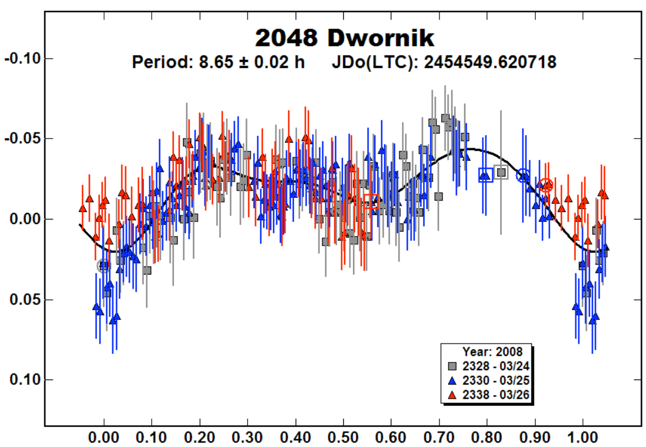


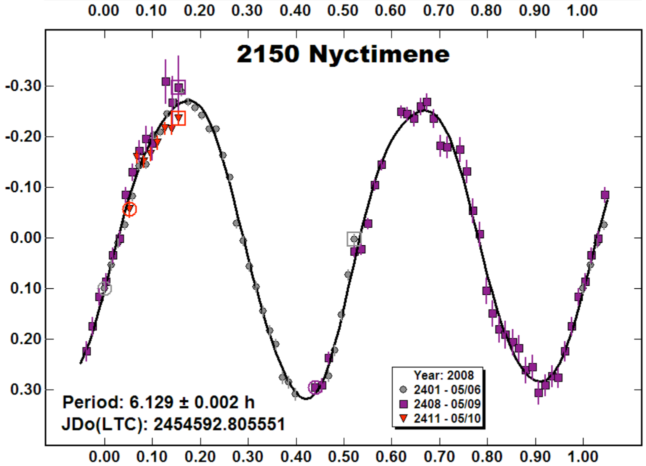


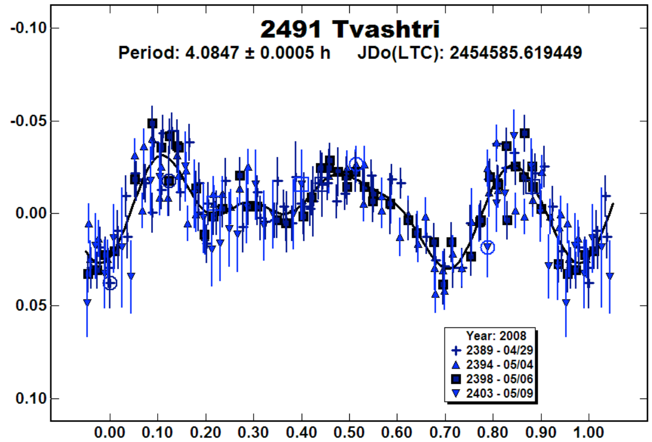


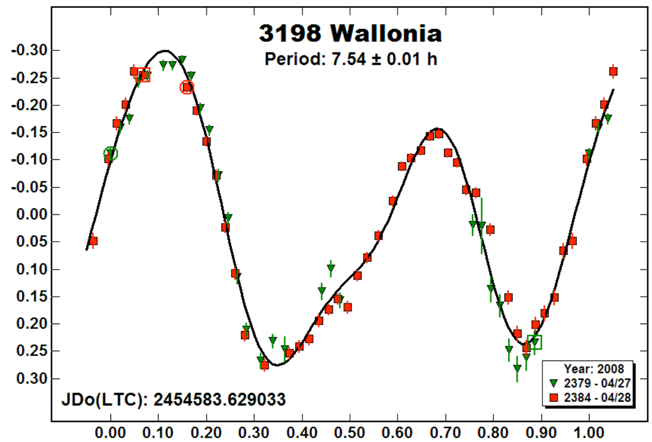

1817 Katanga
Period: 8.481 ± 0.003 h
Year: 2008
2363 - 04/22
2367 - 04/24
JDo(LTC): 2454578.603128

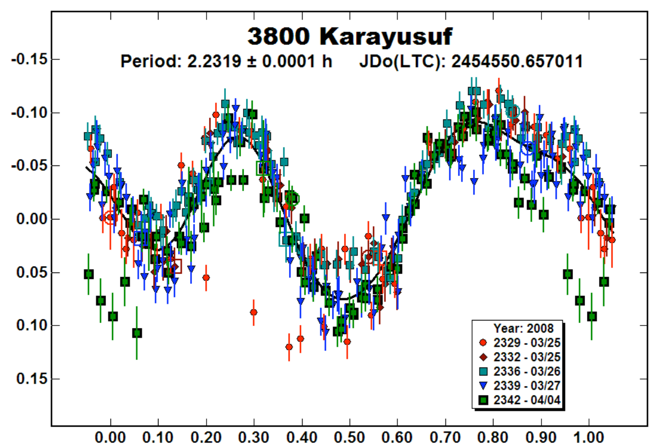

2001 Einstein
Period: 5.4846 ± 0.0003 h
JDo(LTC): 2454547.590542
Year: 2008
2323 - 03/22
2325 - 03/22
2326 - 03/24
2327 - 03/24
2340 - 03/27

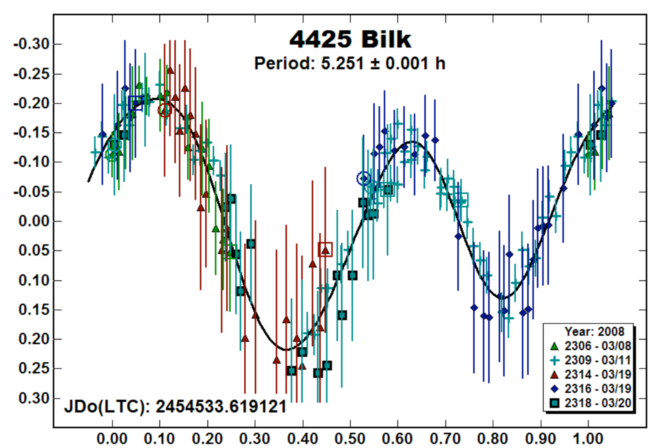

2048 Dwornik
Period: 8.65 ± 0.02 h
JDo(LTC): 2454549.620718
Year: 2008
2328 - 03/24
2330 - 03/25
2338 - 03/26

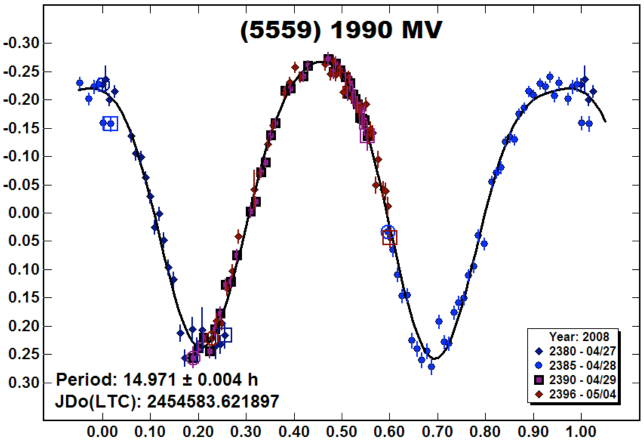

2150 Nyctimene
Period: 6.129 ± 0.002 h
JDo(LTC): 2454592.805551
Year: 2008
2401 - 05/06
2408 - 05/09
2411 - 05/10

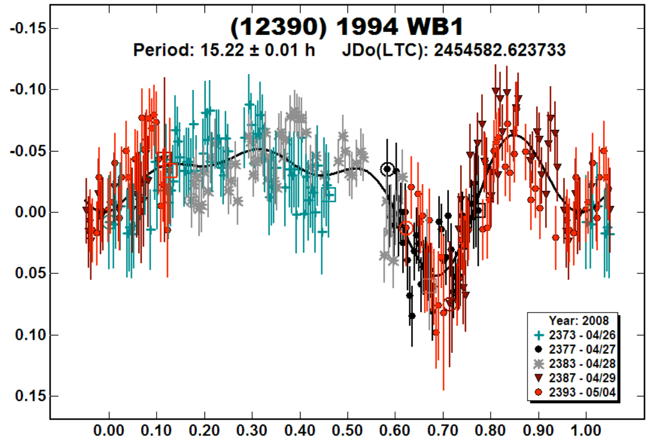

2491 Tvashtri
Period: 4.0847 ± 0.0005 h
JDo(LTC): 2454585.619449
Year: 2008
2389 - 04/29
2394 - 05/04
2398 - 05/06
2403 - 05/09

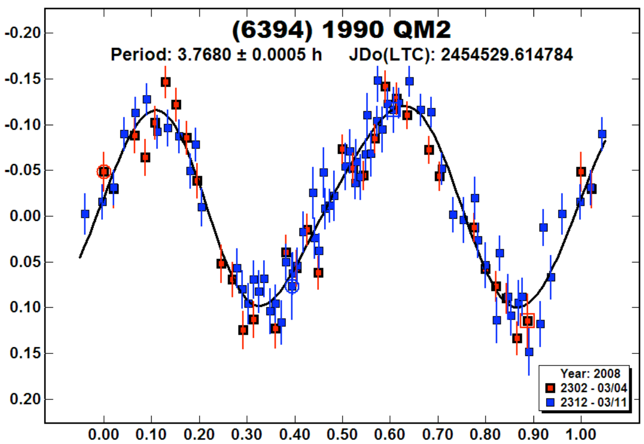

3198 Wallonia
Period: 7.54 ± 0.01 h
JDo(LTC): 2454583.629033
Year: 2008
2379 - 04/27
2384 - 04/28

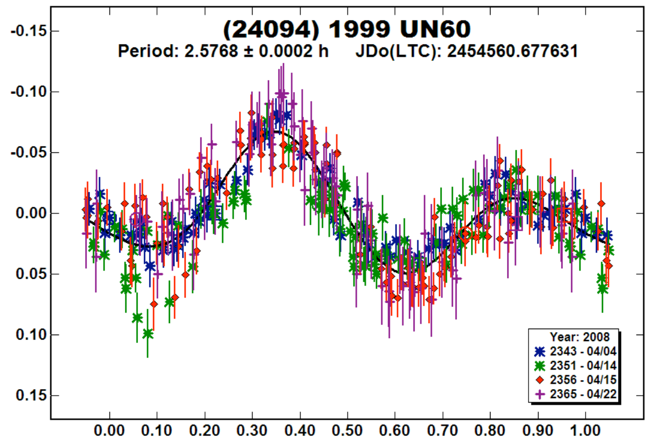

3800 Karayusuf
Period: 2.2319 ± 0.0001 h
JDo(LTC): 2454550.657011
Year: 2008
2329 - 03/25
2332 - 03/25
2336 - 03/26
2339 - 03/27
2342 - 04/04

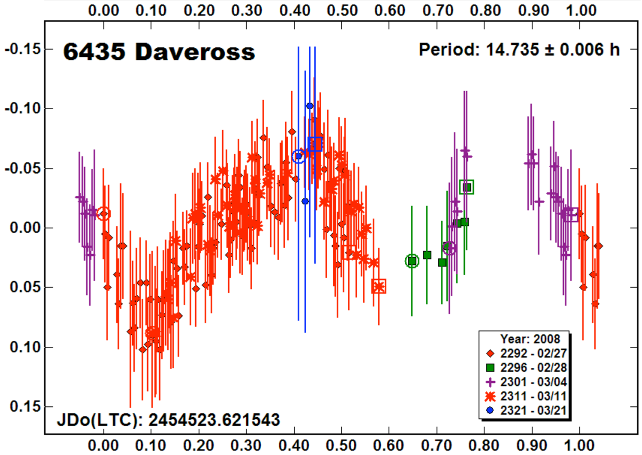

4425 Bilk
Period: 5.251 ± 0.001 h
JDo(LTC): 2454533.619121
Year: 2008
2306 - 03/08
2309 - 03/11
2314 - 03/19
2316 - 03/19
2318 - 03/20

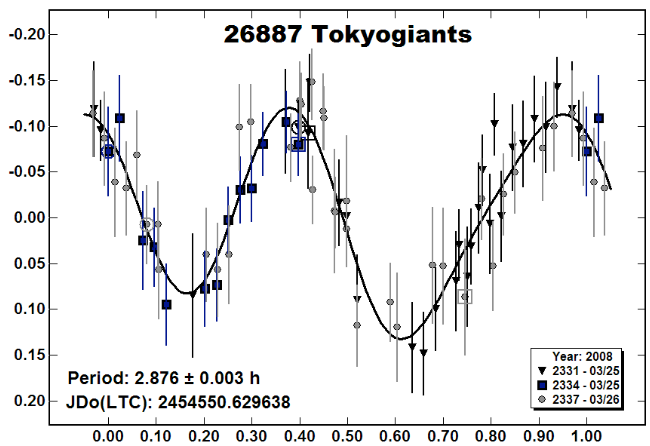

(5559) 1990 MV
Period: 14.971 ± 0.004 h
JDo(LTC): 2454583.621897
Year: 2008
2380 - 04/27
2385 - 04/28
2390 - 04/29
2396 - 05/04

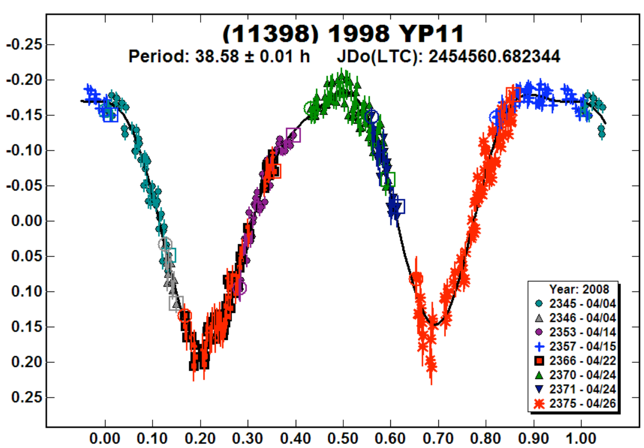

(12390) 1994 WB1
Period: 15.22 ± 0.01 h JDo(LTC): 2454582.623733
Year: 2008
2373 - 04/26
2377 - 04/27
2383 - 04/28
2387 - 04/29
2393 - 05/04


(6394) 1990 QM2
Period: 3.7680 ± 0.0005 h JDo(LTC): 2454529.614784
Year: 2008
2302 - 03/04
2312 - 03/11


(24094) 1999 UN60
Period: 2.5768 ± 0.0002 h JDo(LTC): 2454560.677631
Year: 2008
2343 - 04/04
2351 - 04/14
2356 - 04/15
2365 - 04/22


6435 Daveross
Period: 14.735 ± 0.006 h
JDo(LTC): 2454523.621543
Year: 2008
2292 - 02/27
2296 - 02/28
2301 - 03/04
2311 - 03/11
2321 - 03/21


26887 Tokyogiants
Period: 2.876 ± 0.003 h
JDo(LTC): 2454550.629638
Year: 2008
2331 - 03/25
2334 - 03/25
2337 - 03/26


(11398) 1998 YP11
Period: 38.58 ± 0.01 h JDo(LTC): 2454560.682344
Year: 2008
2345 - 04/04
2346 - 04/04
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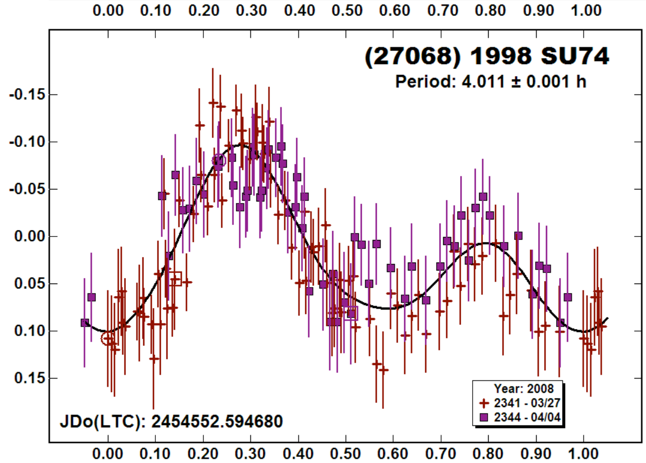
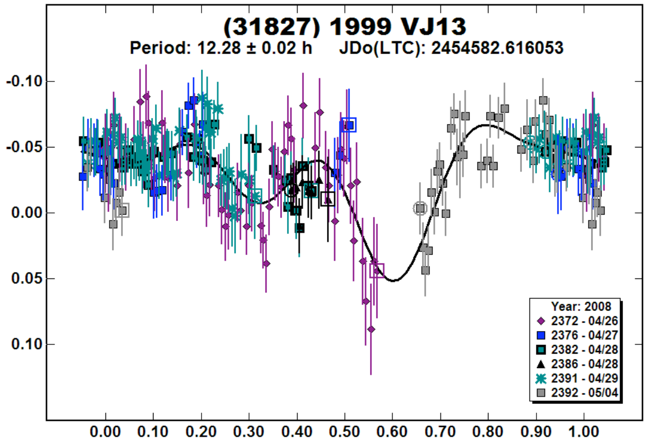
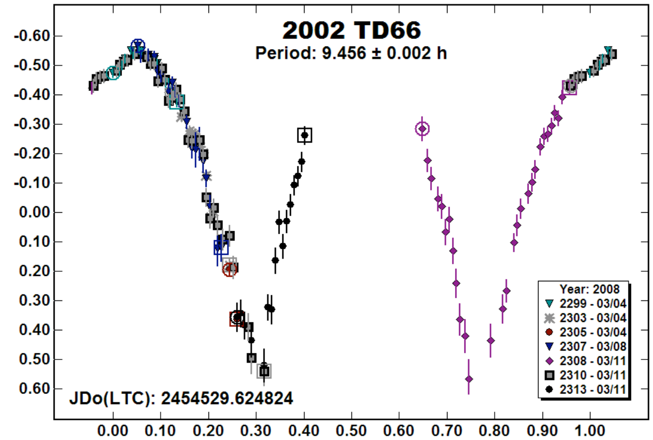
2371 - 04/24
2375 - 04/26


(27068) 1998 SU74
Period: 4.011 ± 0.001 h
JDo(LTC): 2454552.594680
Year: 2008
2341 - 03/27
2344 - 04/04





SHAPE AND SPIN AXIS MODELS FOR FOUR ASTEROIDS

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

Josef Durech
Astronomical Institute
Charles University in Prague
18000 Prague, CZECH REPUBLIC

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

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The authors present shape and spin axis models for four asteroids: 54 Alexandra, 167 Urda, 409 Aspasia, and 1022 Olympiada. The models were constructed using a combination of dense lightcurves and sparse data sets from USNO observations for lightcurve inversion. The use of combined dense and sparse data sets in order to find asteroid models will become more common as next-generation large surveys come on line.

The inversion of asteroid lightcurves into shape and spin axis models has been an on-going problem for many years. In the past decade or so, significant advancements have been made (see Warner 2008a and references therein). Even more recently, the use of "sparse" data sets in combination with typical "dense" lightcurves from two or more apparitions has allowed finding more models in shorter order (see Durech 2008a and references therein).

A "dense" data set is what one usually associates with an asteroid lightcurve, i.e., a large number of data points that cover one or more rotations in a given apparition. Several curves from a single apparition, especially if obtained over a wide range of phase angles, improve the quality of the final modeling solution. A "sparse" data set is a collection of data from many years where there might be only a few data points for a given apparition. If the data are calibrated to a common (internal or external) system, then the entire set can be treated as a single relative data set, thus providing sufficient data for the inversion technique. It has been shown (Kaasalainen 2004) that even sparse data sets alone can find reasonably accurate models.

It will take from 5-10 years after the surveys come on line before the sparse data sets are sufficient to allow independent modeling. Even then, dense curves will be needed to resolve "problem cases", e.g., binary asteroids and otherwise ambiguous solutions. So there should be no fear that the "backyard astronomer" will be forced out of the asteroid lightcurve business anytime in the foreseeable future.

Data and Anaysis

Dense lightcurves for 54 Alexandra, 167 Urda, 409 Aspasia, and 1022 Olympiada were obtained at PDO in late 2007 and early 2008 for the express purpose of modeling. Faurerbach and Fauvuad also observed 54 Alexandra during this same period. Dense curves for the combined data sets were formed from the authors' data and those from the Uppsala Asteroid Photometry Catalog (UAPC, Lagerkvist 2001). For the sparse data, observations by the US Naval Observatory were taken from the AstDys web site (http://hamilton.dm.unipi.it/cgi-bin/astdys/astibo). Durech has found these to be the most reliable magnitude data sets among the current surveys. Even so, the data must be inspected for obvious outliers and other problems. The sparse data magnitudes must also be reduced to unity Earth-asteroid and Sun-asteroid distances by applying –5 * log(Rr). This removes effects due to changing geometry but does not remove those due to phase angle. For this reason, instead of being fixed – as would be done when using only relative, dense lightcurves – the phase coefficients are allowed to float during modeling.

Once the combined sparse and dense data sets were constructed for each asteroid, they were combined into a single data set in *MPO LCInvert*, a program written by Warner that provides a Windows™ user-interface to the original FORTRAN and C code by Kaasalainen and Durech. The core library code, in Delphi Pascal or the original C, is available as free downloads from

http://www.MinorPlanetObserver.com/MPOSoftware/Inversion_SourceCode.htm

The initial, and very critical step, is to find a sidereal period that fits all the data. The synodic period from a single apparition can serve to narrow the search range but that range must be sufficiently wide to assure that the true sidereal period is found. Even on today's fast desktop computers, this can take a day or more if the data set is very large. Once the period is found, a search for pole solutions is done by looking at 30 initial poles (λ = 0°, 60°, 120°, 180°, 240°, 300°; β = –60°, –30°, 0°, +30°, +60°). The pole solution and period are both allowed to float, i.e., they are not forced to maintain the initial values. The result is a set of period/axis solutions and chi-square values, with the most likely solution being the one with the lowest chi-square value, presuming that it is at least 10% lower than any other solution. See Warner (2008a) and Higley (2008) and references therein for a more detailed discussion about the modeling process.

PDO images were reduced and measured in MPO Canopus as was period analysis using an implementation of the Fourier analysis algorithm by Harris (1989). For each combined data set, the dense lightcurves were included twice, thus giving them higher weighting over the sparse data from USNO observations.

The data for all the models presented here will be available on the Database of Asteroid Models from Inversion Techniques (DAMIT, Durech 2008b). This site includes results and data for a growing number of asteroid models. Another catalog of asteroid models, derived from a variety of techniques, can be found on the Poznan Observatory site (Kryszczynska et al. 2008a). See also Kryszczynska et al. (2007).

54 Alexandra. Warner observed this asteroid from PDO in January 2008 using a 0.35-m SCT and SBIG STL-9E. The synodic period was found to be 7.028 ± 0.001 h with a lightcurve amplitude of 0.10 ± 0.01 mag. (Figure 1). In addition to the PDO data, Fauerbach observed the asteroid from 2006 December 27 to 2008 January 20. Twelve lightcurves in the UAPC, dating from 1965-1992, were also used to form the dense data set. The final results of the modeling were (preferred solution first):

Period (sidereal)	Lambda	Beta
7.0226456 ± 0.000004 h	318 ± 10°	+23 ± 5°
	156 ± 10°	+13 ± 5°

Belskaya et al (1993) reported solutions of (160°, +45°) and (290°, +55°). The longitude and latitude errors were chosen to include nearly similar solutions in the model search. The period error was found by estimating the error required to produce a 7.5° rotation error over the total time-span of the observations.

The shape model for the (318°, +23°) solution is shown in Figure 2. A test of the solution is to compare the original lightcurve data with the one generated by the model, phase errors in particular. For larger asteroids not likely subject to rotational torque due to thermal radiation (YORP effect), phase errors are likely due to using the wrong sidereal period in the solution. Figure 3 shows the model's curve (black/dark) versus the original data (red/gray) from data in 1965. The agreement is very good.

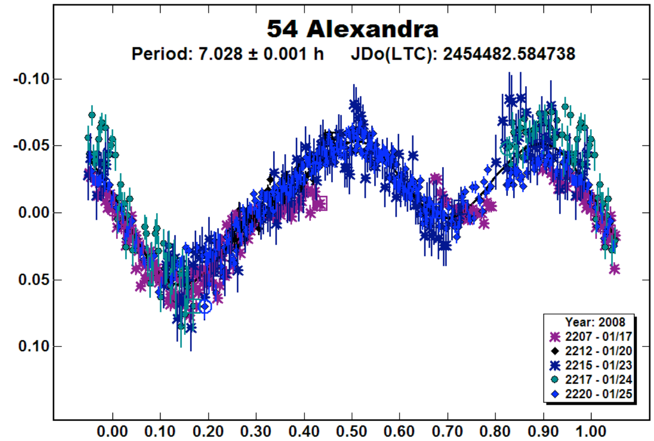

Figure 1. Lightcurve for 54 Alexandra (Warner 2008).

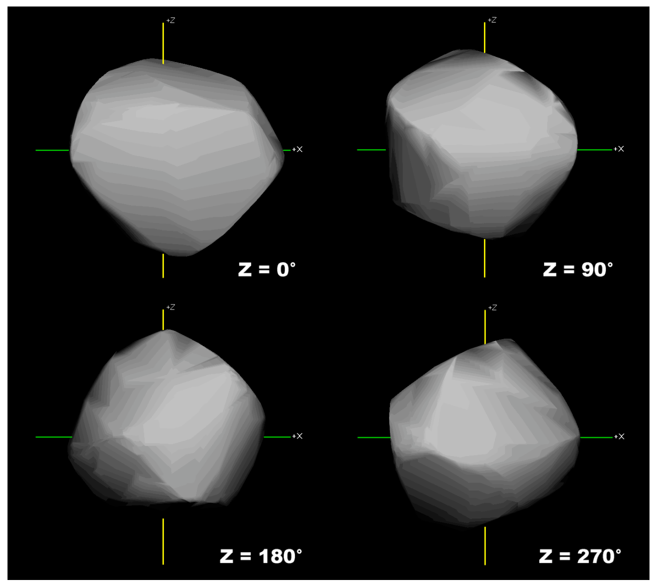

Figure 2. Equatorial view of 54 Alexandra model. The asteroid's north pole is at top. The views are at 90° rotations of the Z-axis.

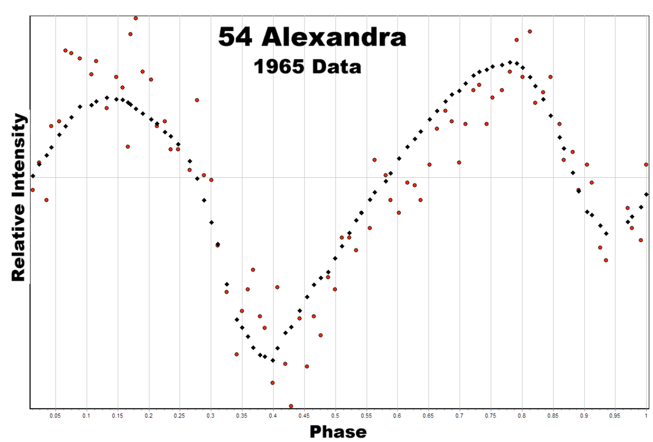

Figure 3. 54 Alexadra model curve (dark) versus 1965 data (light).

167 Urda. This asteroid was observed from PDO in November 2007. Its period and lightcurve were previously reported (Warner 2008b). Data from 16 lightcurves in the UAPC from 1989-1997 were used with the PDO data form the dense lightcurve set. USNO data again formed the sparse data set.

Period (sidereal)	Lambda	Beta
13.06133 ± 0.00002 h	249 ± 5°	-68 ± 5°
	107 ± 5°	-69 ± 5°

Slivan et al (2003) reported an average of two positions to be (222°, –71°).

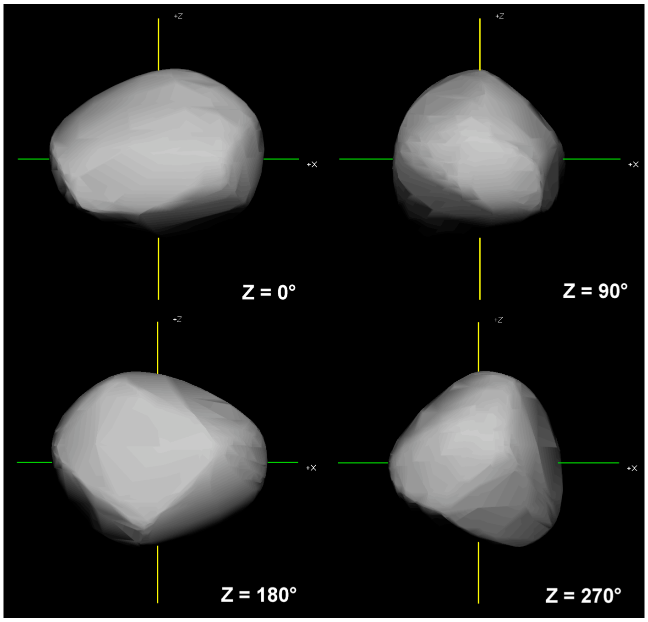

Figure 4. Equatorial view of 167 Urda model. The asteroid's north pole is at top. The views are at 90° rotations of the Z-axis.

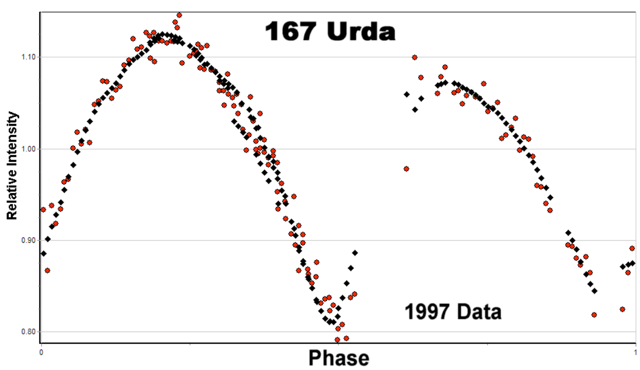

Figure 5. 167 Urda model curve (dark) versus 1997 data (light).

<u>409 Aspasia</u>. This asteroid was observed at PDO in December 2008 using a 0.5-m Ritchey-Chretien and SBIG STL-1001E. The synodic period was determined to be 9.022 ± 0.001 h and the lightcurve amplitude was 0.09 ± 0.01 mag (Figure 6).

Eight lightcurves from 1980-1996 from the UAPC were combined with PDO data to form the dense lightcurve data set. Sparse data was from USNO observations exclusively (Fig. 9). At first, the search by Warner found a "best" solution significantly different from one found by Durech. It was determined that the model search used by Warner was too coarse, allowing better solutions to be overlooked. After modifying the model search code, Warner's best solution (presented here) was nearly identical to that found by Durech. The modeling found two solutions, one being a mirror of the other in longitude, which is a common result when the asteroid's orbital inclination is small.

Period (sidereal)	Lambda	Beta
9.021455 ± 0.000009 h	177 ± 10°	+15 ± 5°
	3 ± 10°	+30 ± 5°

Blanco and Riccioli (1998) reported positions of (73°, +48°) and (216°, +36°).

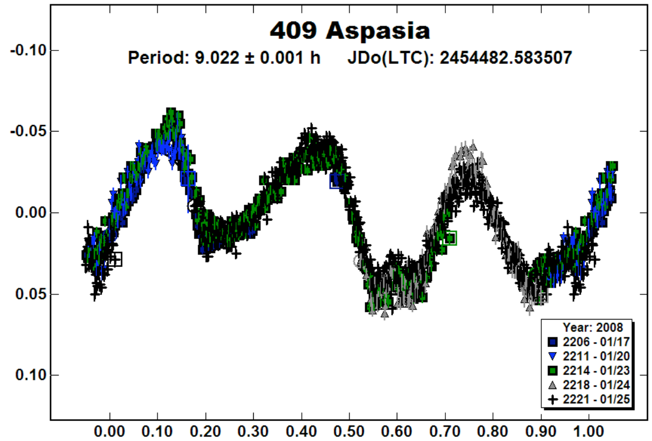

Figure 6. Lightcurve for 409 Aspasia (PDO, 2008).

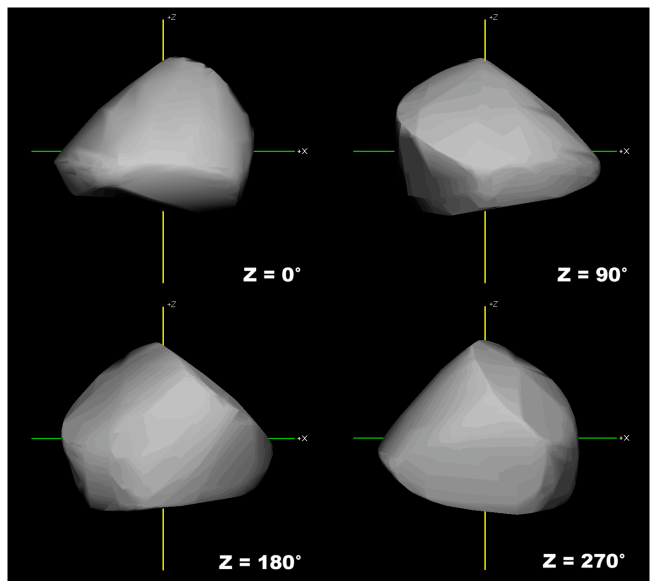

Figure 7. Equatorial view of 409 Aspasia model. The asteroid's north pole is at top. The views are at 90° rotations of the Z-axis.

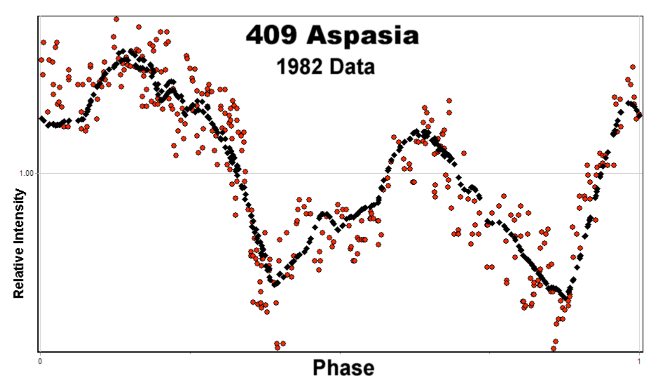

Figure 8. 409 Aspasia model curve (dark) versus 1982 data (light).

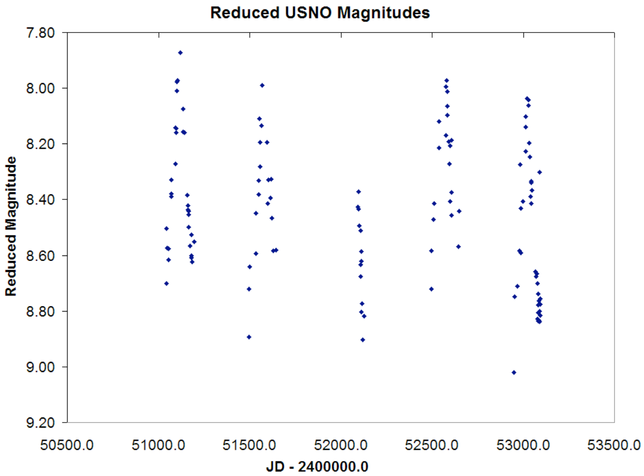

Figure 9. Data for 409 Aspasia from USNO observations. The magnitudes have been reduced to unity Earth-asteroid and Sun-asteroid distances.

1022 Olympiada. This asteroid was observed by Warner in 1999 (Warner 1999) when a period of 4.589 h was reported. That was later revised (Warner 2005) to 3.833 h after a review of the original data. The shorter period was confirmed with a more extensive data set obtained by Warner in 2008 April. Figure 10 shows a lightcurve phased to 3.822 ± 0.006 h based on the 2008 data.

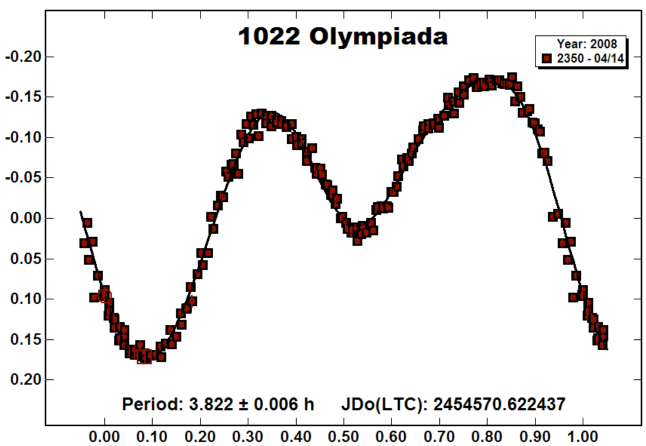

Figure 10. Lightcurve of 1022 Olympiada from PDO in 2008.

The data from the 1999 and 2008 apparitions were combined with sparse USNO data to attempt a shape and spin axis model. Having only two sets of dense lightcurves was an extreme test of the concept of using a limited number of dense curves with a sparse set. The model search found two solutions. The (40, 18) solution theoretical curves fit the actual significantly better, especially in 2008.

Period (sidereal)	Lambda	Beta
3.833594 ± 0.000005 h	40 ± 5°	+18 ± 5°
	250 ± 5°	+71 ± 5°

Neither the DAMIT or Poznan web sites list any previous models for 1022 Olympiada. Figure 11 shows the shape model for the asteroid while Figure 12 shows a fit of the model and 1999 data.

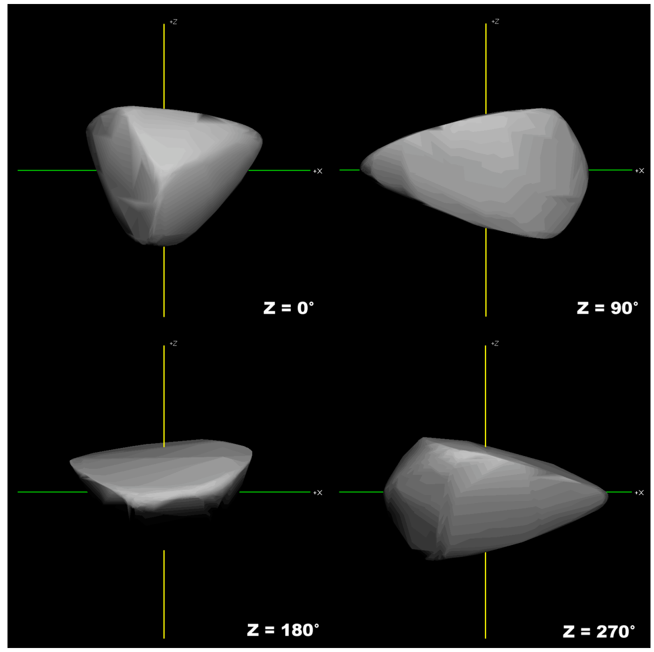

Figure 11. Equatorial view of 1022 Olympiada model. The asteroid's north pole is at top. The views are at 90° rotations of the Z-axis. Note the large "flat" area in the Z=180° view. This may indicate a large crater and/or concavity or it may just be an artifact of the modeling process when using sparse data with a limited number of dense lightcurves.

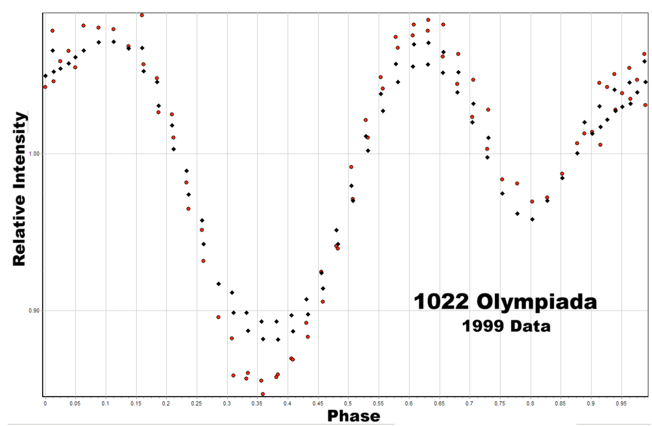

Figure 12. 1022 model curve (dark) versus 1999 data (light).

Conclusions

These four models are examples of what can be done by combining a few dense lightcurves and sparse data from already available sources. It's possible to use dense data from only two apparitions in combination with sparse data, providing the dense data is of higher quality and, preferably, covers a good range of phase angles. Warner has sets of lightcurve data for several asteroids that meet these requirements. Unfortunately, the existing surveys haven't covered any of those asteroids sufficiently to allow a model to be found. It's not often that the professional surveys are lagging behind the backyard astronomer. We hope this paper will serve as inspiration to others to start or continue their work in asteroid lightcurves, keeping in mind that not only are data needed for asteroids with unknown lightcurve parameters but that by working some asteroids just one more time may lead to a successful shape and spin axis model.

Acknowledgements

Funding for Warner is provided by NASA grant NNG06GI32G and by National Science Foundation grant AST-0607505 and by a Shoemaker NEO grant from the Planetary Society. The work of Durech was supported by the grant GACR 205/07/P070 of the Czech grant agency and by the Research Program MSM0021620860 of the Ministry of Education.

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A PRELIMINARY SHAPE AND SPIN AXIS MODEL FOR 595 POLYXENA

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

(Received: 28 April)

Photometric observations made at the Palmer Divide Observatory during the 2006 and 2008 apparitions of the main-belt asteroid 595 Polyxena were combined with dense lightcurves from 1993 included in the Uppsala Asteroid Photometric Catalog and a sparse lightcurve based on data from the USNO to determine a preliminary shape and spin axis model. Two solutions dominated the result set, one prograde ($\lambda = 42°$, $\beta = 8°$) and one retrograde ($\lambda = 222°$, $\beta = -4°$). The uncertainty in each coordinate is ± 5°. The sidereal period was found to be 11.794162 ± 0.000023 h.

The outer main-belt asteroid 595 Polyxena was observed at the Palmer Divide in March 2008 for two reasons: to determine the correct period for the asteroid and to provide a data set for shape and spin axis modeling. A 0.35 m Meade LX-200GPS telescope was equipped with an SBIG ST-9E and Optec focal reducer to obtain 449 data points from 2008 March 19-22. The pixel scale was approximately 2.5 arcseconds/pixel. All images were 120 s, guided, and unfiltered. The images were processed with dark and flat fields and measured in *MPO Canopus*. Period analysis was also done in *Canopus*.

The period of the asteroid had been previously reported as 11.806 h (Hainaut-Rouelle 1995), 8.5 h (Piironen 1998), 15.89 h (Warner 2007), and 46.32 h (Behrend 2008). The lightcurve from the 2006 apparition by the author had an amplitude of only 0.05 mag (Fig. 1) and so could have easily lead to an ambiguous solution. After the period and amplitude were determined with much more certainty using data from the 2008 apparition (P = 11.801 ± 0.001 h, A = 0.51 mag; Fig. 2), the 2006 data were re-examined to see if they would fit the new period. The closest match was found at P = 12.03 ± 0.02 h.

In a forthcoming paper (Durech 2008), it has been shown that a few dense lightcurves (those such as shown in Figs. 1 and 2) combined with so-called "sparse" data sets can often successfully lead to a shape and spin axis model. A "sparse" data set is one comprised of calibrated observations taken over a number of years such that they sufficiently cover the asteroid around its orbit. A check on the AstDys web site (http://hamilton.dm.unipi.it/cgi-bin/astdys/astibo) showed that data from the USNO were available for Polyxena. Durech (2008) has found that, among the current surveys, only USNO data are of sufficient quality for modeling. Fortunately, Hainaut-Rouelle's data were also available, being in the Uppsala catalog (Lagerkvist 2001). This made for three sets of dense lightcurves and the one sparse set. *MPO LCInvert*, written by the author, was used for the analysis, the first step of which is to find an accurate sidereal period based on the complete data set. This search can take some time, e.g., more than a day for Polyxena. Once the period is found, a search routine looks for the best fit among several initial conditions. The search showed seven solutions that were statistically identical and grouped around two specific pole solutions. Those two solutions are show in Table 1. Note that the first solution is prograde and the second is retrograde. The λ and λ+180° solutions are common when the asteroid's orbital inclination is small.

λ	β	Sidereal Period
42° ± 5°	8° ± 5°	11.794162 ± 0.000023 h
222° ± 5°	-4° ± 5°	

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

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. The two models found an average of a/b = 1413. The lightcurves based on both models fit the actual data very well. In particular, they were in perfect phase agreement, indicating that the sidereal period was correct. Both models show a decided flat area at the asteroid's southern pole, possibly indicating a large crater or concavity. Neither the Database of Asteroid Models from Inversion Techniques (DAMIT, http://astro.troja.mff.cuni.cz/projects/asteroids3D/) nor the Poznan data base of spin axis solutions (http://vesta.astro.amu.edu.pl/Science/Asteroids/) had previously reported solutions.

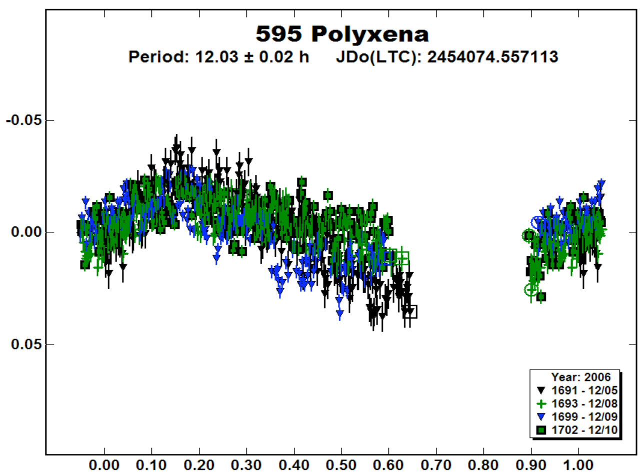

Figure 1. Lightcurve of 595 Polyxena based on data from PDO in 2006.

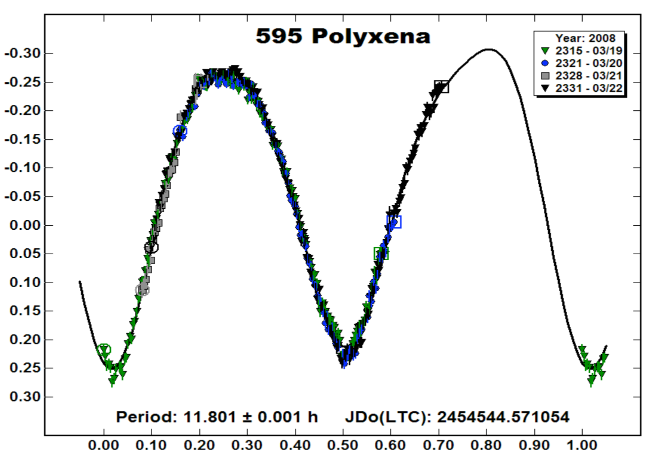

Figure 2. The lightcurve of 595 Polyxena. Palmer Divide Observatory, 2008.

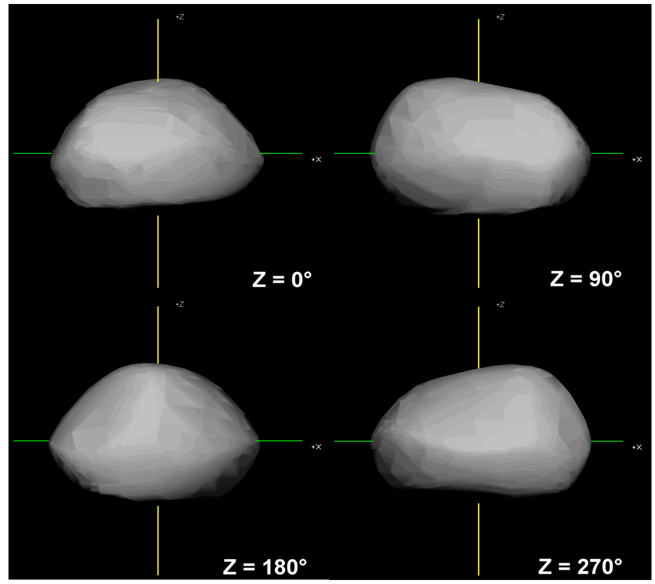

Fig. 3. The 595 Polyxena model showing the asteroid's equatorial view of the (λ = 42°, β = +8°) solution.

Acknowledgements

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LIGHTCURVE ANALYSIS OF 7233 MAJELLA

Greg Crawford
Bagnall Beach Observatory
172 Salamander Way
Salamander Bay NSW, AUSTRALIA
gc@nelsonbay.com

(Received: 2008 July 14)

7233 Majella was observed over eight nights in May 2008. The synodic period was determined as 3.812 ± 0.004 h. The peak-to-peak amplitude was ~0.5 mag.

Minor planet 7233 Majella was discovered by the European Southern Observatory, by G. DE Sanctis, on 1986 March 7 and was named after a national park in Abruzzo, Italy (JPL 2008). At the time of the author's observations, the online list of potential lightcurve targets (Warner *et al.* 2008) showed no data available on the rotational period of this asteroid.

Bagnall Beach Observatory is located on the east coast of Australia. Photometric data were collected by the author on six nights over an interval of eight days, from 2008 May 4-12, using a 0.28m SCT / ST9E CCD with 60-second exposures at 1.29 arc seconds/pixel image scale. The images were measured and analyzed using *MPO Canopus* (Warner 2006), which incorporates the Fourier analysis algorithm (FALC) developed by Harris (1989). Owing to the density of background stars, extensive use was also made of the StarBGone technique within *MPO Canopus* to eliminate the interference caused by faint stars close to the path of the target.

The accompanying plot shows data from all six nights from which a period of 3.812 ± 0.004 h was calculated assuming a bimodal curve. The full period was covered on every night of observations. These initial observations of 7233 Majella suggest it is a fast rotator.

Acknowledgements

Thanks are given to Brian D. Warner for the insights offered in his text on lightcurve analysis (Warner, 2006), his software *MPO Canopus*, and his tutoring of amateurs.

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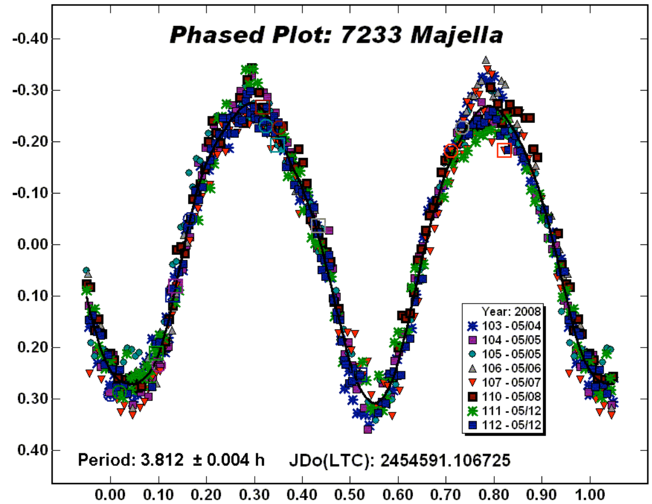

ASTERIOD LIGHTCURVE ANALYSIS OF SUSPECTED BINARY ASTEROIDS

David Higgins
Hunters Hill Observatory (E14)
7 Mawalan Street
Ngunnawal ACT 2913, AUSTRALIA
higginsdj@bigpond.com

Petr Pravec, Peter Kušnirák and Kamil Hornoch
Ondřejov Observatory, Fričova 298
25165 Ondřejov, CZECH REPUBLIC

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

Jozef Világi, Leonard Kornoš and Štefan Gajdoš
Modra Observatory
Department of Astronomy, Physics of the Earth and Meteorology
Bratislava, SLOVAKIA

Marek Husárik, Michal Pikler and Gabriel Červák
Skalnaté Pleso Observatory
Astronomical Institute of the Slovak Academy of Sciences
SK-05960 Tatranská Lomnica, SLOVAKIA

(Received: 2008 June 30)

Photometric observations undertaken by collaborating observatories in the BINAST group have uncovered strong evidence of asynchronous binary nature of minor planet 5474 Gingasen and the synchronous binary nature of minor planet 7369 Gavrilin.

Hunters Hill Observatory is equipped with a 0.35-m telescope as described in Higgins (2005). All observations for this paper were made using a clear filter with guided exposure times of 240 s. *MaxIm DL/CCD*, driven by *ACP4*, was used for telescope and camera control whilst calibration and image measurements were undertaken by *MPO Canopus* version 9.

Carbuncle Hill Observatory is equipped with a 0.35-m telescope as outlined in Pray (2008). Modra Observatory used a 0.6-m f/5.5 reflector with an AP8p CCD camera at the prime focus and 1.5 arcsec/pixel resolution; all observations were taken through a clear filter. Ondrejov Observatory used a 0.65-m f/3.6 reflector with a Moravian Instruments G2 CCD-3200 at the prime focus and R filter. Skalnaté Pleso Observatory used a 0.61-m f/4.3 Newtonian reflector and SBIG ST-10XME CCD camera. Their frames, taken through a Johnson-Cousins *R* filter, were binned 3x3 with 1.6 arcsec per pixel. Data were obtained via differential photometry.

The strategy is to work objects carefully for potential deviations that would indicate the presence of a satellite. Considerable effort was made to identify and eliminate sources of observational errors that might corrupt the observations and lead to false attenuation events. It was particularly important to identify and eliminate data points affected by faint background stars, bad pixels, and cosmic ray hits.

5474 Gingasen. The target was chosen from the Binary Asteroid Photometric Survey list provided by Petr Pravec (2005) and was observed by Hunters Hill and Ondrejov Observatories from 2008 March 7 to 2008 March 14. The Lightcurve Parameter list maintained by Harris and Warner (Harris/Warner 2007) indicates that the target had been previously observed by Behrend where a period of 2.91 h had been identified. The data taken during the current apparition does not fit this period. On receipt of the March 12 data, Kusnirak identified that the target showed indications of two overlapping periods. This was confirmed with the addition of more data from Hunters Hill and a session from Ondrejov. Additional precision follow-up observations were not possible before the target became to faint.

Independent analysis by Kusnirak and Higgins lead us to believe that, despite the absence of mutual (occultation/eclipse) events, 5754 Gingasen is a probable asynchronous binary system. Higgins identified primary (P_1) and secondary (P_2) periods of 3.6236 ± 0.0005 h and 3.1096 ± 0.0002 h, respectively, using the method outlined in Higgins (2008). Kusnirak identified periods of P_1 = 3.6242 ± 0.0003 h and P_2 = 3.1095 ± 0.0009 h. The values obtained by both analysis match within their respective error margins. However, Kusnirak's results are adopted due to their higher precision and the use of a more robust analysis methodology. Plots of the data obtained by Higgins and Kusnirak can be seen at Figure 1. The amplitude (A_1) of period P_1 was found to be 0.18 ± 0.02 mag while the amplitude (A_2) for P_2 was found to be 0.06 ± 0.02 mag. Note that the shorter period is unique only if we assume a bimodal lightcurve.

Since no mutual events were observed, the nature of the binary system cannot be fully resolved. The overlapping periods do, however, indicate the rotational periods of the binary components. In this case it is apparent that either the plane of the secondary component did not cross the Earth or the orbital period of the secondary is long and we didn't happen to observe mutual events at any time.

Assuming a value for G of 0.15 ± 0.2, a value of H_R = 12.70 ± 0.2 was derived.

7369 Gavrilin. The target was chosen from the Binary Asteroid Photometric Survey list provided by Petr Pravec (2005) and was observed by Hunters Hill, Ondrejov, Skalnate Pleso, Modra, and Carbuncle Hill Observatories during the period 2007 December 28 through 2008 February 15.

Most of the observations covered phases outside the events. A part of an event was covered by Hunters Hill before the end of its Feb 12.5 session. The session of Feb 15.8 by Modra covered phases during the lightcurve minimum, but they showed only a marginal attenuation. It appears that observations had already moved almost out of the events geometry. Attenuations were detected on 5 of the 18 nights of observations though two were quite marginal.

Photometric observations reveal that 7369 Gavrilin is a probable synchronous binary system with an orbital period of 49.12 ± 0.02 h and net amplitude of 0.246 ± 0.02 mag. The secondary-to-primary mean diameter ratio, D_2/D_1, is calculated from the magnitude drop (*dm*) of the smaller of the two eclipsing events by

$$D_2/D_1 >= \mathrm{sqrt}(1 - 10^{-0.4dm}) \qquad (1)$$

Mutual eclipse/occultation events show a maximum eclipse depth of 0.12 mag in the smaller of the two observed events. Since we did not observe the eclipse depth rising to this level, only a lower limit on the secondary-to-primary mean-diameter ratio can be determined. Based on Equation 1, we derive a value of D_2/D_1 = 0.32.

Calibrated data obtained and analysed by Ondrejov give an estimated mean absolute magnitude H_R = 13.12 ± 0.15, assuming G = 0.20 ± 0.15.

Acknowledgements

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The work at Modra was supported by the Slovak Grant Agency for Science, VEGA, grants No. 1/3067/06 and 1/3074/06.

Thanks go to Brian D. Warner for his continued development and support for the data analysis software, *MPO Canopus* v 9 and in particular his development of StarBGone which has enabled me (DH) to gather data even in the presence of interfering background stars.

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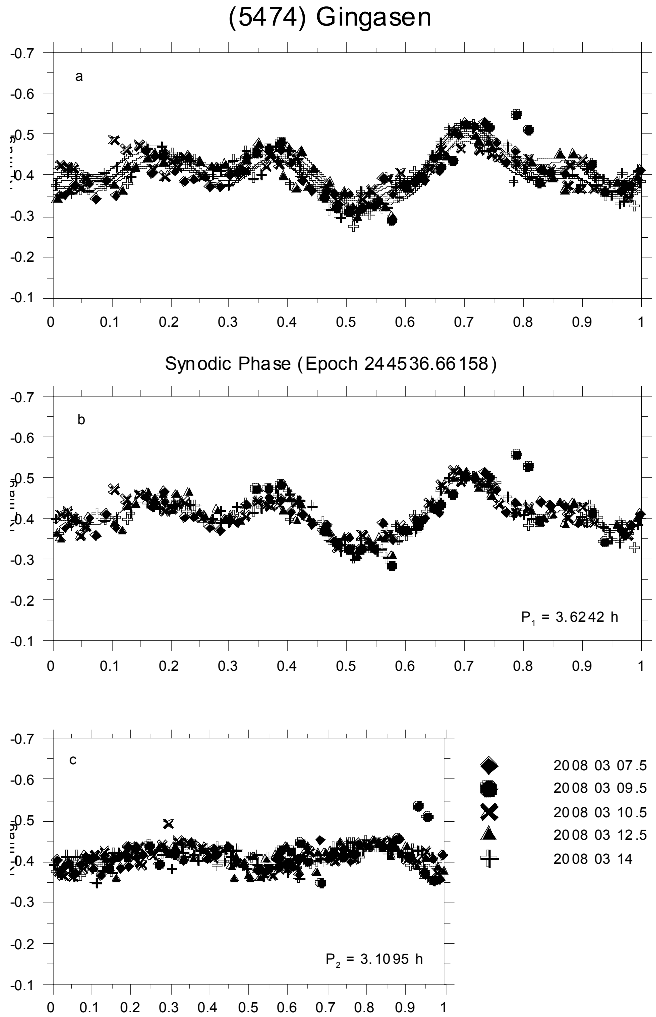
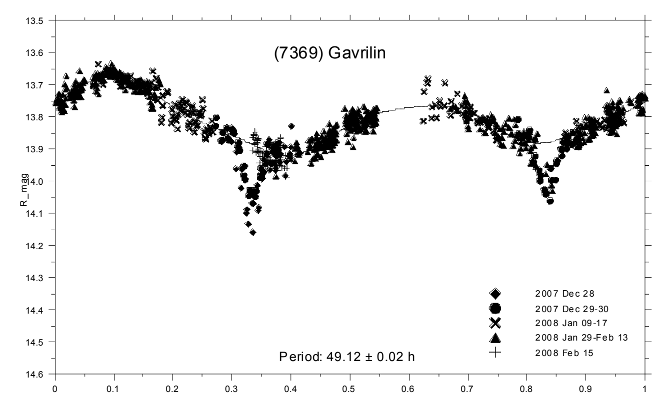


Fig 1: 5474 – Composite Lightcurve, Primary Component and Secondary Component



"DO WHAT YOU CAN PHOTOMETRY": UNFILTERED PHOTOMETRY OF NEOS 2005 PJ2, 2005 WC1, AND 2006 GY2

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: 2008 July 1 Revised: 2008 July 7)

The authors made observations of three Near-Earth Objects (NEOs), 2005 PJ2, 2005 WC1 and 2006 GY2, using clear filter photometry and instrumental magnitude relationships to determine preliminary rotation periods. This study demonstrates the potential utility of what is referred to as "do what you can do" photometry.

The observation of asteroids that come close to the Earth, i.e., Near-Earth Objects (NEOs), by instruments of moderate aperture is often problematic due to the small size and rapid apparent movement of these objects in the sky. To obtain data with a reasonable signal-to-noise ratio (SNR) requires either a long exposure time or unfiltered photometry. These solutions come with their own problems of potential streaking of the image and contamination from fringing (Newton's rings). Even if these issues can be mitigated, comparison star photometric methods are very difficult due to the rapidly changing field of the asteroid over the course of an observation run. In such cases where this is the only way important data can be obtained, observers with moderate instruments are challenged to "do what you can do".

In this study, three NEOs were observed and preliminary lightcurves calculated using instrumental magnitudes and the magnitude/intensity relationship (M/IR) derived from catalog stars. This method is described by Gary (2005) and achieves accuracy of ~0.10 magnitudes by using the UCAC2 catalog and eliminating reference stars with magnitudes >10.5. The *Canopus* software used for the calculations determines the M/IR from these known "reference" stars in the UCAC2 Catalog (Warner 2004).

The clear filter at Badlands Observatory had no IR blocking properties at the time of these observations. This meant that the images were prone to fringing. This non-uniform contribution to the background noise could potentially have made accurate photometry difficult. Still, using a V or R filter would reduce the signal-to-noise ratio (SNR) of the asteroid to unacceptable levels. Therefore it was decided to go with the clear filter and experiment with exposure time.

2005 PJ2 2005 PJ2 is an Apollo asteroid that was discovered by NEAT on 2005 August 4. Although not a radar target, it was categorized as a Potentially Hazardous Asteroid (PHA) and observations were required to accurately determine its orbit for future oppositions and close approaches. With an estimated diameter of 370-840 meters, it was also a rather large PHA. Still, at a closest approach of 0.102 AU, it would be only 16th magnitude and moving about seven arc seconds per second, thus making clear-filter photometry a necessity. However, since the goal was primarily astrometry, this was not a factor at the time. Approximately six hours of data were collected over three nights, 2005 August 28, 29, and September 2. Exposure times were 45 s through a clear filter. Astrometric data were sent to the Minor Planet Center, much improving the orbit of 2005 PJ2 (Dyvig et.al., 2005). In fact, this project and Badlands Observatory were the last observations taken of 2005 PJ2 during the opposition.

The astrometric goal having been accomplished, the data were set aside. The asteroid was moving through a very crowded star field and a lightcurve was impossible to achieve via comparison star methods. However, with the success of the observations of 2005 WC1 (see next section) the data for 2005 PJ2 were reanalyzed. Each image was re-examined and many were eliminated where there was interference from background stars. The results are shown in Figures 1 and 2. Though the data set was sparse because of the large number of rejected images, a possible sinusoidal pattern could be discerned.

Two maxima (marked M1 and M2 in Figures 1 and 2) were identified. For August 27, the difference between the maxima was M2-M1 = 0.8219 h while for August 28 it was M1-M2 = 0.5883 h, which in theory yields a period of 1.4102 h. This figure was used as a starting point to calculate the number of rotations between the maxima and $M2_{28Aug} - M2_{27Aug}$ = 22.8294 h which = 16.189 * 1.4102 h while $M1_{28Aug} - M1_{27Aug}$ = 24.2508 h which is 17.197 * 1.4102 h. If one then iterates this process using 16 and 17 rotations, a good agreement with a period of 1.4268 h is achieved, which gives some confidence to a final period of 1.42 ± 0.03 h.

There are, however, problems with this assessment. The observing run on August 28 is long enough to have shown M2 twice and does not. However, the data are sparse and it is not surprising that double-coverage is lacking. The minima associated with M2, marked as m2 in Figure 2, does show up twice with a period of 1.433 h. Given the rapid oscillations, the shape of the lightcurve is also suspect since it is difficult to reconcile the oscillations with a reasonable asteroid shape. The M1 and M2 points may be anomalous and would be extremely difficult to relate to a realistic change in shape of the asteroid. Part of this is possibly due to the known error (±0.10 magnitudes) of the method used to determine the M/IR. This in itself could introduce a wider than actual variation in the lightcurve. It should also be noted that in a single 24-hour period between observing runs, the amplitude of the lightcurve doubled indicating a rapid change in aspect and orientation.

Therefore, while 2005 PJ2 may indeed be a rapid rotator, the value derived here of its rotation period should not be used without further confirmation.

<u>2005 WC1</u> 2005 WC1 was discovered by LINEAR on 2005 November 21. It was predicted to approach within 0.02 AU (7.7 lunar distances) of Earth on 2005 December 14. Its physical properties were unknown, but assuming an albedo between 0.04 and 0.20, its absolute magnitude of 20.5 suggested a diameter (within a factor of two) of ~250 m. Due to the proximity of its approach and its size, 2005 WC1 was a strong radar target. Goldstone observations were scheduled on December 15 in one very short track, and Arecibo observations were scheduled on December 14. There was an urgent request for astrometric and photometric support of the radar observations.

Due to its proximity to Earth, 2005 WC1 was moving at an apparent rate of approximately one arc second per second. This rate again made differential photometry very difficult since it would be in a new field every fifteen minutes. At its rate of motion, the images showed streaking in ~ 4s exposures; increasing the exposures beyond even ~10 s did not enhance the SNR.

This was "do what you can do" photometry at its most basic. Approximately four-and-a-half hours of data were collected on 2005 December 13 using ten-second exposures and a clear filter when the asteroid was approximately 16th magnitude. The results were more than satisfactory. As shown in Figure 3, the period appeared to be about 2_ hours with an amplitude of almost two magnitudes. This was confirmed by time-sequenced radar images that showed about 40% of a rotation occurring in the one hour observed. The asteroid had a very "blocky: shape (see Figure 4 [Benner, 2005]) that may account for the large amplitude with a single maximum.

<u>2006 GY2</u> 2006 GY2 is an Apollo asteroid discovered by LINEAR on 2006 April 9. It was to make a very close approach to within 0.017 AU (only 6.6 lunar distances) of Earth on May 16. Its physical properties were unknown, but its absolute magnitude of 18.6 suggested a diameter within a factor of two of 600 meters. This NEO was also classified as a PHA by the MPC. Goldstone radar observations were scheduled on May 13 and 16, and Arecibo observations were scheduled on May 15 and 16. Astrometry and photometry support was requested.

This was a very challenging target and early observations were taken on April 23. These were also unfiltered but with a long exposure of 120 s. Identical observations were taken on May 3 while the May 4 observations used 90-second exposures. Observations were not taken during the close approach since the moon was full and would have interfered too much. Though the field was not crowded, the long exposure through a clear filter no doubt increased the noise due to fringing. A period could not be accurately determined before the encounter, though the results and some preliminary periods were sent to the radar investigators. After 2006 GY2 was observed in radar, preliminary images indicated a period less than three hours and that the asteroid had a satellite (see Figure 5 [Benner, 2006]). This was enough of a starting point to enable a better period to be found using the comparison star method. Though the amplitude was quite low (~0.10), a period of two hours 16 minutes was the best fit as shown in Figure 5.

Conclusions

After working these three NEOs, we have preliminarily concluded that under most circumstance, fringing is not a major problem at short to moderate exposures (< 60 s) with magnitudes brighter than ~17 and that the MIR method is "good enough" for photometry of large amplitude objects. We believe this method particularly appropriate for fast-moving NEOs and more work should be done to repeat results.

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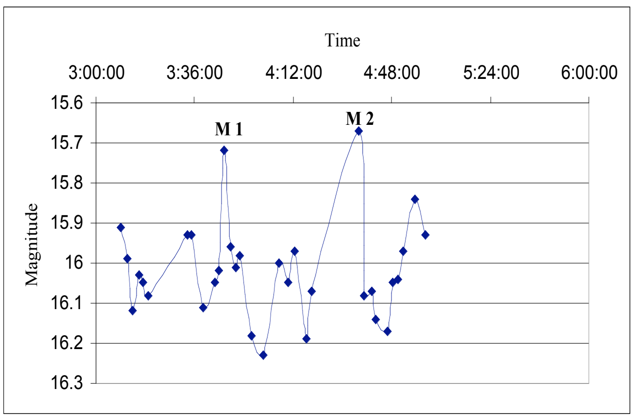

Figure 1. 2005 PJ2 lightcurve 2005 August 27.

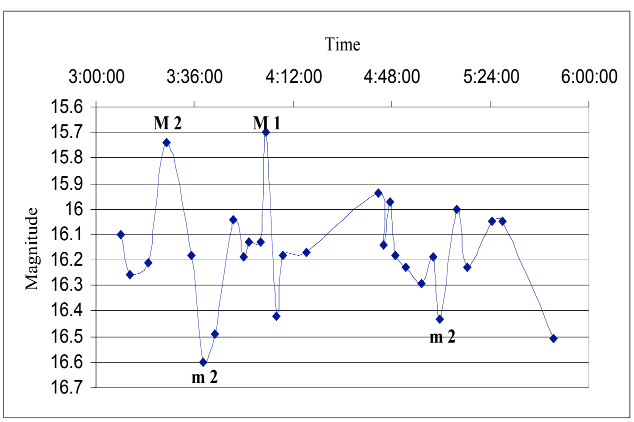

Figure 2. 2005 PJ2 lightcurve 2005 August 28.

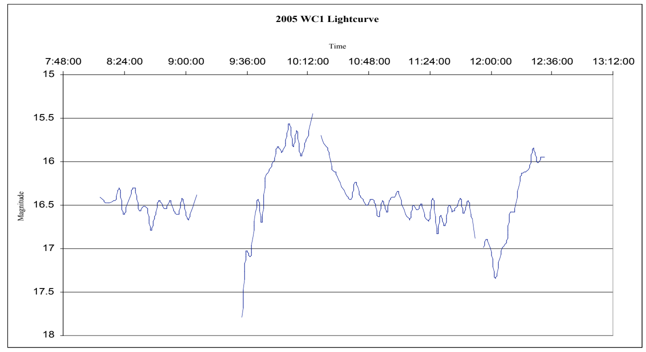

Figure 3. Lightcurve of 2005 WC1.

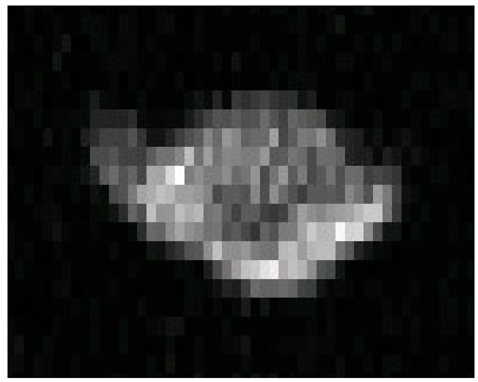

Figure 4. Radar Image of 2005 WC1.

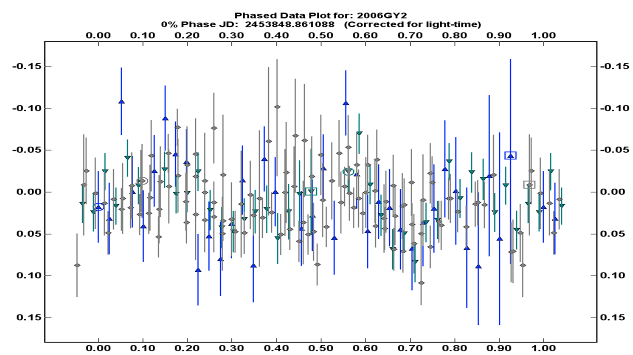

Figure 5. Lightcurve of 2006 GY2.

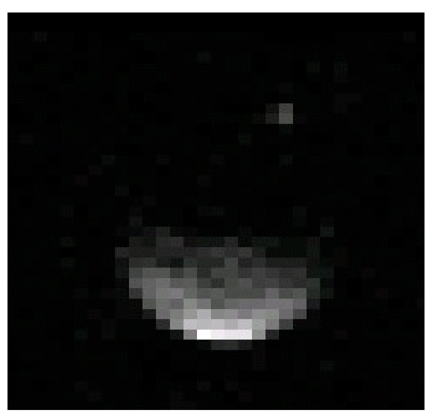

Figure 6. Radar image of 2006 GY2 and its satellite.

ASTEROIDS OBSERVED FROM GMARS AND SANTANA OBSERVATORIES: EARLY 2008

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

(Received: 2008 June 29)

Lightcurve period and amplitude results from Santana and GMARS Observatories are reported for 2008 January to March: 411 Xanthe (11.344 ± 0.002 h and 0.10 mag), 655 Briseis (160.66 ± 0.12 h and 0.40 mag), and (5851) 1991 DM1 (367.52 ± 0.5 h and 0.90 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. Details of the equipment are in Stephens (2006).

All of the targets were chosen 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).

411 Xanthe. Xanthe was reported to have a period of 7.48008 h (Behrend 2007). Images on April 25 were acquired using the 0.30-m Schmidt-Cassegrain (SCT) at Santana Observatory with an SBIG STL-1001 CCD camera. All other images were acquired using the 0.35-m SCT at GMARS.

655 Briseis. The April 6 and 13 data were acquired using a 0.35-m SCT at GMARS with an SBIG STL-1001 CCD camera. All of the other data were acquired using the 0.30-m SCT at Santana Observatory. The data were linked to an internal standard using a method developed by Warner (2007) and described by Stephens (2008) included in the latest release of *Canopus*.

(5851) 1991 DM1. The asteroid was observed well past opposition, which resulted in short nightly sessions. Given the long period, each night mostly represented a single data point and was binned for clarity. The data were linked to an internal standard using *Canopus*. The asteroid displayed some evidence of non-principal axis rotation ("tumbling"). This is not entirely unexpected since, with an estimated size of 12.5 km, if the asteroid had entered a tumbling state at some point, the damping time could be longer than the age of the solar system (Pravec 2005).

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 amateur asteroid research. 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.

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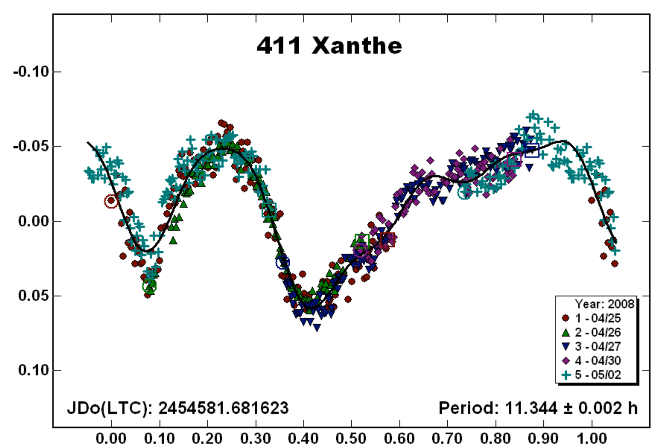
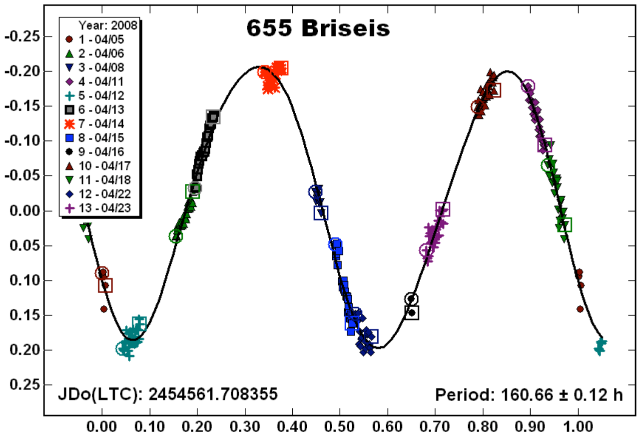
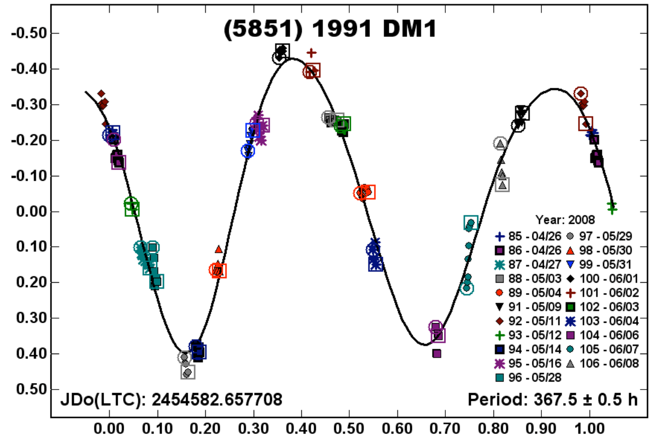


Asteroid	Dates (2008) mm/dd	Sess	Phase	L_{PAB}	B_{PAB}	Per (h)	PE	Amp	AE
411 Xanthe	04/24 – 05/02	5	7.8,8.3	214.8	18.6, 18.4	11.344	0.002	0.10	0.02
655 Briseis	04/05 – 04/23	13	2.8,4.4	203.9,203.7	7.6	160.66	0.12	0.40	0.05
(5851) 1991 DM1	04/26 – 06/08	20	7.7,21.5	207.4,210.5	12.7, 13.7	367.52	0.5	0.90	0.05





ASTEROID LIGHTCURVE ANALYSIS AT THE VIA CAPOTE OBSERVATORY: 2ND QUARTER 2008

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

(Received: 2008 July 21)

Lightcurves for ten asteroids were measured at the Via Capote Observatory from 2008 April through June: 411 Xanthe (7.56 h), 455 Bruchsalia (11.85 h), 742 Edisona (18.52 h), 1633 Chimay (6.58 h), 1793 Zoya (5.753 h), 4215 Kamo (11.67 h), 4399 Ashizuri (2.829 h), 4585 Ainonai (38.31 h), 6274 Taizaburo (3.13 h), and 8132 Vitginzburg (7.28 h).

The observations were made using a Meade LX200 14-inch (356 mm) SCT operating at f/10. The CCD imager was an Alta U6 featuring a 1024x1024 array of 24-micron pixels. All observations were made unfiltered at 1x binning yielding an image scale of 1.44 arc seconds per pixel. All images were dark and flat-field corrected. Images were measured using *MPO Canopus* (Bdw Publishing) and differential photometry. The data were light-time corrected. Period analysis was also done with *Canopus*, incorporating the Fourier analysis algorithm developed by Harris (1989).

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.

411 Xanthe. My results are consistent with those of Riccioli (1995) and Behrend (2008), who both reported a 7.48 h period.

455 Bruchsalia. My results are somewhat different from those reported earlier for this target by Blanco (2000), who measured 10.645 h, but are very similar to results by Koff (2006) and Behrend (2008), who measured 11.838 h and 11.8 h respectively.

742 Edisona. Behrend (2008) reports a similar period of 18.58 h.

1633 Chimay. The accompanying lightcurve plot used binned data (2x, 5 min maximum separation) for a total of 240 points.

4215 Kamo. Data taken on 2008 April 21 were not used for lightcurve analysis due to poor S/N caused by inadequate integration time.

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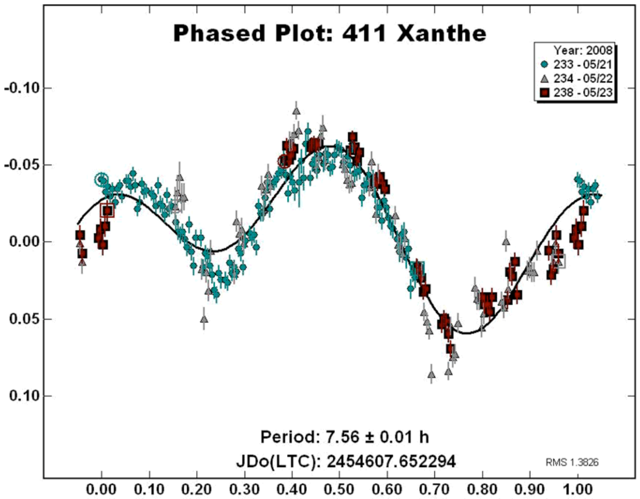
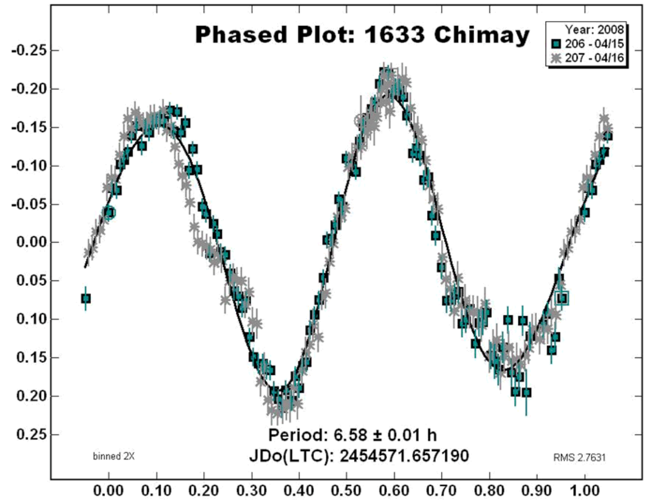
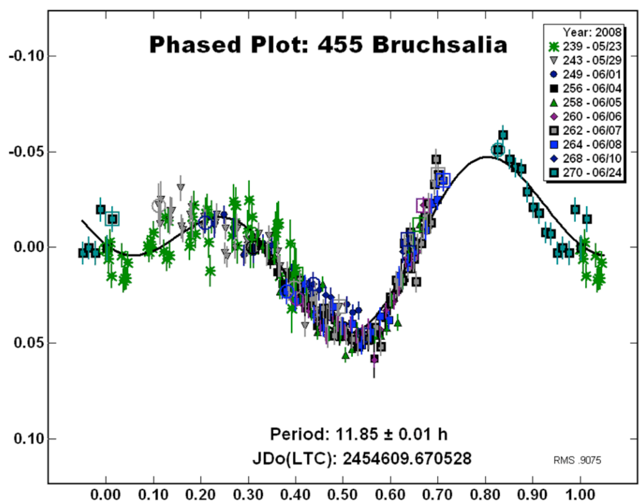
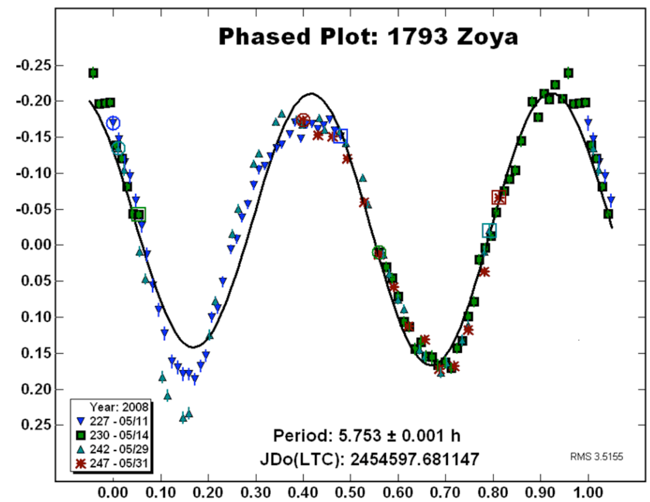
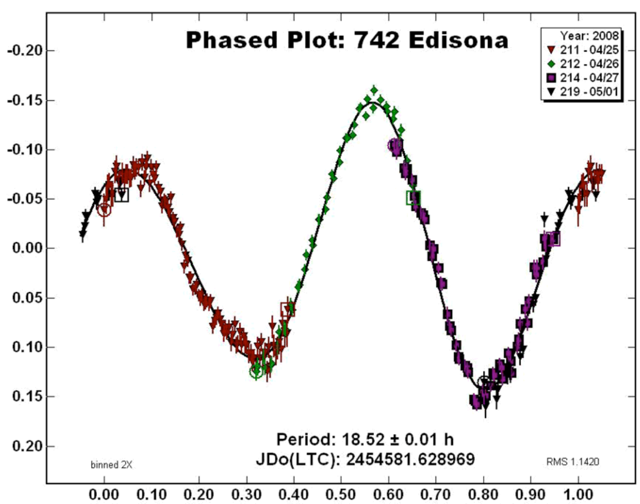
#	Name	Date Range (mm/dd) 2008	Data Points	Phase	L_{PAB}	B_{PAB}	Per (h)	PE	Amp (mag)	AE
411	Xanthe	05/21 - 05/23	253	4.7	250.3	4.3	7.56	0.01	0.12	0.02
455	Bruchsalia	05/23 - 06/24	276	14.8	215.2	7.9	11.85	0.01	1.0	0.02
742	Edisona	04/25 - 05/01	421	8.6	194.2	9.6	18.52	0.01	0.3	0.01
1633	Chimay	04/15 - 04/16	479	9.0	184.8	3.2	6.58	0.01	0.41	0.02
1793	Zoya	05/11 - 05/31	130	10.1	224.0	0.1	5.753	0.001	0.40	0.03
4215	Kamo	04/21 - 05/01	274	12.3	193.6	-5.7	11.67	0.02	0.11	0.02
4399	Ashizuri	06/25 - 06/30	144	7.9	265.0	7.1	2.829	0.001	0.36	0.02
4585	Ainonai	05/30 - 06/06	207	8.45	239.7	5.0	38.31	0.05	0.31	0.01
6274	Taizaburo	06/24 - 07/01	94	23.0	240.6	2.2	3.13	0.01	0.34	0.05
8132	Vitginzburg	06/08 - 06/10	55	13.0	233.5	4.5	7.28	0.02	0.50	0.02


Phased Plot: 411 Xanthe
Year: 2008
233 - 05/21
234 - 05/22
238 - 05/23
Period: 7.56 ± 0.01 h
JDo(LTC): 2454607.652294
RMS 1.3826


Phased Plot: 1633 Chimay
Year: 2008
206 - 04/15
207 - 04/16
binned 2X
Period: 6.58 ± 0.01 h
JDo(LTC): 2454571.657190
RMS 2.7631


Phased Plot: 455 Bruchsalia
Year: 2008
239 - 05/23
243 - 05/29
249 - 06/01
256 - 06/04
258 - 06/05
260 - 06/06
262 - 06/07
264 - 06/08
268 - 06/10
270 - 06/24
Period: 11.85 ± 0.01 h
JDo(LTC): 2454609.670528
RMS .9075


Phased Plot: 1793 Zoya
Year: 2008
227 - 05/11
230 - 05/14
242 - 05/29
247 - 05/31
Period: 5.753 ± 0.001 h
JDo(LTC): 2454597.681147
RMS 3.5155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Year: 2008
211 - 04/25
212 - 04/26
214 - 04/27
219 - 05/01
binned 2X
Period: 18.52 ± 0.01 h
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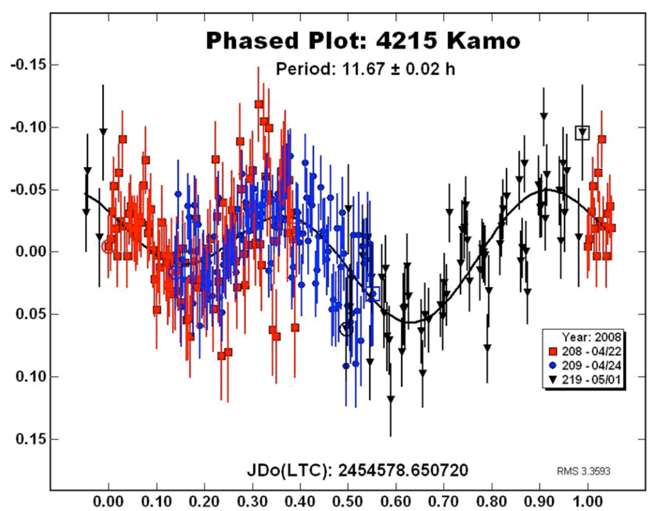
RMS 1.1420


Phased Plot: 4215 Kamo
Period: 11.67 ± 0.02 h
Year: 2008
208 - 04/22
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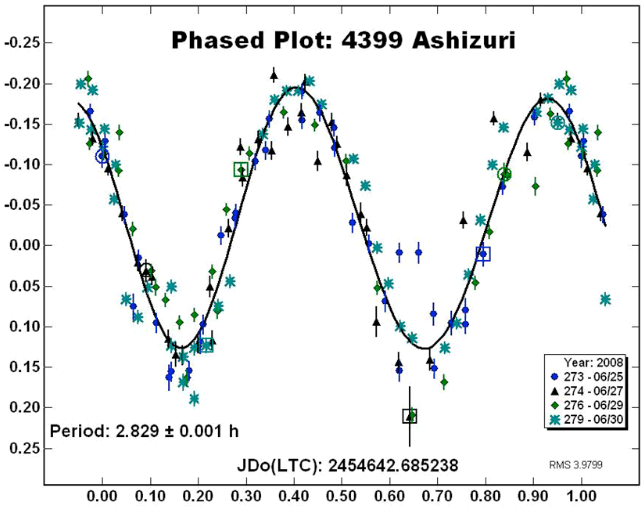
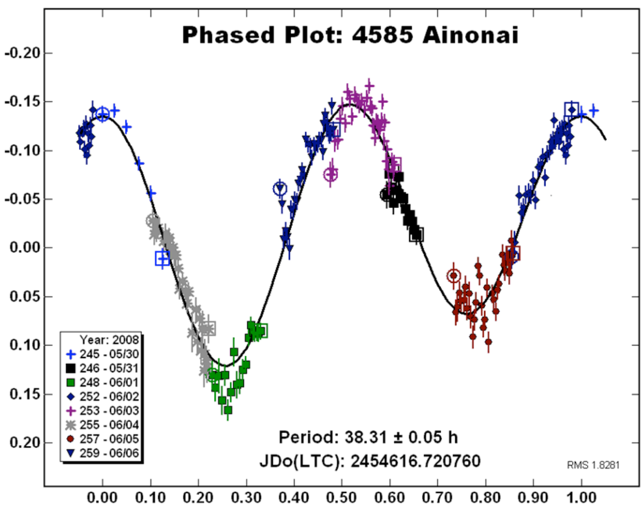
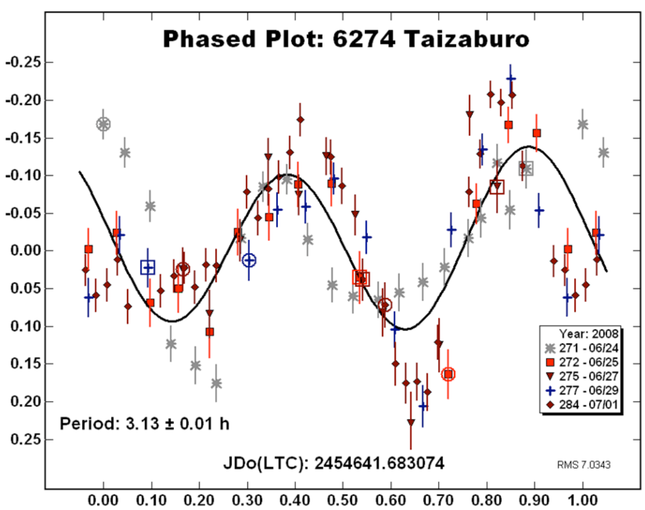
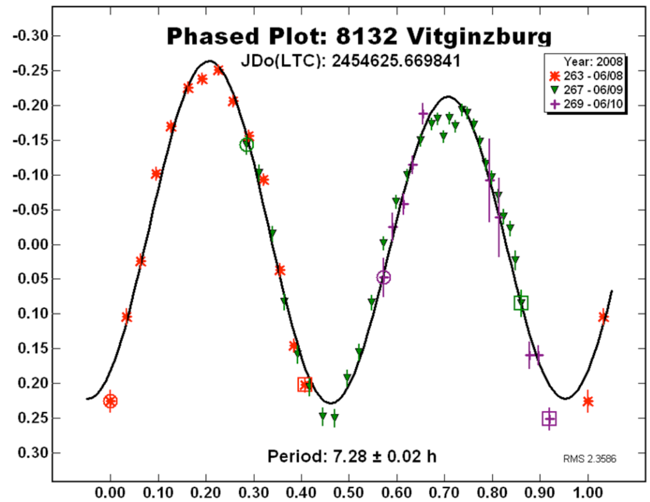
219 - 05/01
JDo(LTC): 2454578.650720
RMS 3.3593









LIGHTCURVE OF BINARY MINOR PLANET 2005 NB7

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

(Received: 28 May)

Lightcurve 2005 NB7 revealed binary characteristics with an orbital period of 15.267 ± 0.094 h with amplitude 0.26 ± 0.05 mag and a primary rotation period of 3.472 ± 0.003 h with amplitude 0.15 ± 0.05 mag. No secondary period was detected indicating tidal lock.

Photometric data were collected using a 36-cm Celestron C-14, an SBIG ST-10XME camera, and clear filter at Stonegate Observatory. The camera was binned 2x2 with a resulting image scale of 1.3 arc-seconds per pixel. Image exposures were 120 s at –15C. All photometric data were obtained and analyzed using *MPO Canopus* (Warner 2007).

Data of the fast moving Potentially Hazardous Asteroid (PHA) 2005 NB7 were collected 2008 May 5, 6, and 7 during the very brief visibility zone resulting in 249 data points. The initial analysis did not include consideration as a binary system. Correspondence with Brian Warner indicated a binary discovery by P. Kusnirak et al. (CBET 1383). Subsequent analysis of the data using the *MPO Canopus* "Dual Period Search" indicated an orbital period of 15.267 ± 0.094 h with amplitude 0.26 ± 0.05 mag and a primary rotation period of 3.472 ± 0.003 h with amplitude 0.15 ± 0.05 mag. The periods agree closely with the P. Kusnirak et al. data for orbital period of 15.28 ± 0.01 h, amplitude of 0.09 mag and primary rotation period of 3.4883 ± 0.0001 h, amplitude 0.13 mag with a tidally locked secondary. Similarly, no secondary period was detected in the noisy data. The substantially larger amplitude of the orbital period can only be partially explained by the uncertainly of a very noisy data set.

Acknowledgments

The author appreciates the help from Brian Warner in noting the binary nature of this asteroid, discovery references, and additional assistance.

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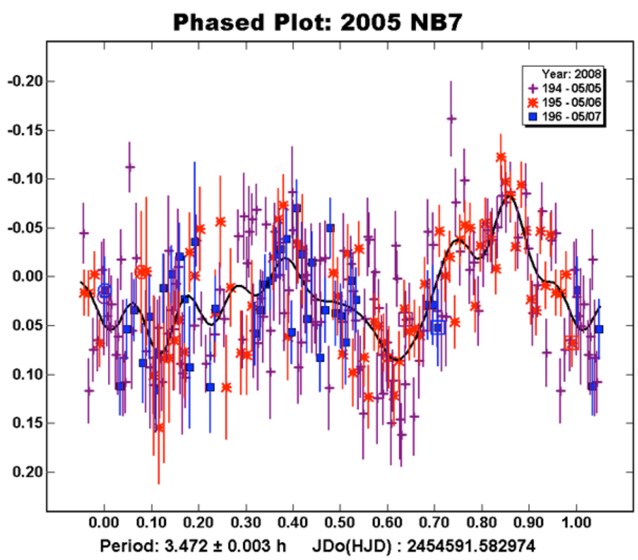

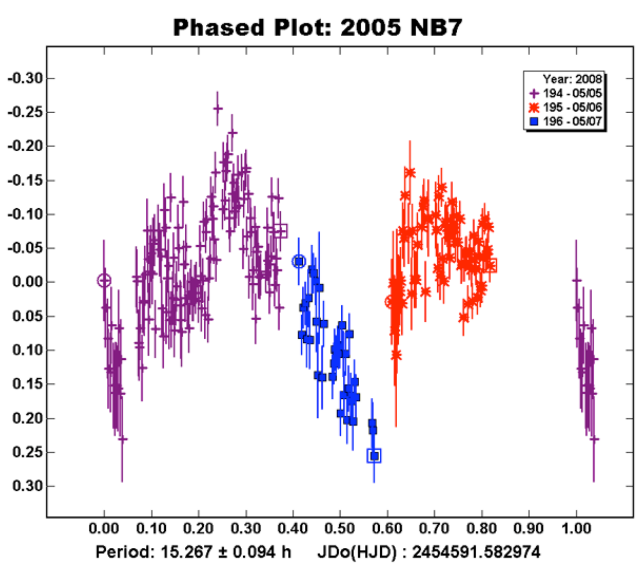

A STUDY OF THE TRINARY NEA 2001 SN263

Alberto Silva Betzler and Alberto Brum Novaes
Projeto "Descobrindo o Céu"
Departamento de Física da Terra e do Meio Ambiente
Instituto de Física, Universidade Federal da Bahia (IF-UFBA)
Salvador, Estado da Bahia, BRASIL
a_betzler@yahoo.com

Julian Hermógenes Quezada Celedon
Departamento de Ciências Exatas
Universidade do Estado da Bahia, Campus I,
Salvador, Estado da Bahia, BRASIL

(Received: 2008 July 7)

The trinary NEA, 2001 SN263, was observed by the authors in 2008 February in Salvador, Bahia, Brazil. Based on the data obtained, the synodic period of the primary body was estimated to be 3.20 ± 0.01h with a lightcurve amplitude of 0.27 ± 0.07 mag. The orbital period of the smaller satellite (0.4 Km) was estimated to be 46.1 ± 0.3 h. The NIR spectrum suggests the object is of type C according to DeMeo classification. Lance, a CO3 type meteorite, is the best analogous meteorite.

The near-Earth asteroid (NEA), (153591) 2001 SN263, which belongs to the Amor dynamic group, was observed by the Arecibo station during 16 days in 2008 February. These observations identified the asteroid as being a triple system. Preliminary data reductions suggest that the components have diameters of 2 km, 1 km, and 0.4 km. The orbit of the larger satellite has a semi-major axis > 15 km and orbital period of 15 days, while the orbit of the smaller satellite has a semi-major axis of ~4 km and orbital period of < 2 d. The larger satellite does not appear to be tidally-locked with its orbit. (Nolan *et al*. 2008).

Because of favorable viewing circumstances, this NEA was chosen to be observed by the "Discovering the Sky" project. Observations were carried out between 2008 February 8 and 11 UT in order to determine the synodic period of the primary. We used a 0.3-m Meade LX200 GPS telescope, operating at f/3.3, combined with a CCD SBIG ST-7XME. The 15-second exposures were through a clear filter and spaced at one-minute intervals. This resulted in an SNR of ~100 when using a photometric aperture of ~1.5x FWHM of nearby non-saturated stars. All images were processed with bias, dark, and flat-field images. Period analysis was done on 280 data points using the Fourier analysis routines in *MPO Canopus* v9.3.0.1, which found a period of 3.20 ± 0.01 h and amplitude of 0.27 ± 0.07 mag (Fig 1). This compares with 3.4250 ± 0.002 h and 0.15 ± 0.02 mag (Higgins 2008) and 3.4251 ± 0.002 h and 0.10 ± 0.05 mag (Oey 2008). While all three are similar, they disagree significantly with the results published by Strajnik (2008) of 5.1900 ± 0.0002 h.

Two mutual events were seen in the observations on February 9 and 10 UT. They may be due to an eclipse of one of the satellites by the primary (Fig. 2) or the transit of a satellite across the primary body disc of the system 2001 SN263 (Fig. 3). The first event showed a drop of 0.63 ± 0.05 mag and duration of 20 min while the second ("transit") showed a drop of 0.92 ± 0.07mag and duration of ~25 min. Each was similar to those observed in eclipsing double star systems in equivalents orbital phases (Hall, 2005). Assuming the two events were due to the satellite, Fourier analysis found an orbital period of 46.1 ± 0.3h (Fig. 4). This is in good agreement with the orbital period determined from the Arecibo data for the smaller (0.4 km) satellite and, therefore, the events are likely due to that object.

A near-Infrared spectrum of 2001 SN263 was obtained on 2007 December 15 by NASA Infrared Telescope Facility (IRTF) at Mauna Kea Observatory in Hawaii. NIR data were collected using SpecX medium-resolution spectrograph (Rayner et al., 2003). The asteroid spectrum covers ~0.75-2.55 μm. These data were obtained within the context of "The MIT-UH-IRTF Joint Campaign for NEO Spectral Reconnaissance" of the Massachusetts Institute of Technology (MIT), the University of Hawaii and NASA IRFT, and are available at *http://smass.mit.edu/minus.html.*

The object spectrum (Fig. 5) presents an absorption feature near 0.9 μm that is offset from features caused by solid or liquid water and from telluric water vapor, as shown by the asteroid (253) Mathilde (Kelley et al. 2007). A morphological analysis suggests a neutral to slightly reddish and featureless spectrum for wavelengths > 0.55μm (Bus et al., 2002), similar to those presented by C type asteroids in different classical taxonomic systems such as Tholen (1984), Howell *et al.* (1994), and SMASS II (Bus & Binzel, 2002). For a wavelength < 2.1μm, the spectrum presents a low albedo typically associated to primitive meteorites like carbonaceous chondrites. The lack of data in UBVR Johnson-Cousins filters meant we could not complete the available NIR spectrum and, so, the DeMeo taxonomic classification procedure (DeMeo, 2007) could not be applied in order to confirm the suggested C type classification for this object. Therefore, 2001 SN263 might belong to any subtype in DeMeo's C asteroid class, which includes the C, Cb, Cg, Cgh, and Ch types.

The identification of a carbonaceous chondrite analogous meteorite in Gaffey's collection (Gaffey, 2001) with a similar spectral curve to the asteroid was performed by calculating the value of the L1 norm, which was used due to its robustness. The search was carried out in the region of 0.805-1.005 μm, which is centered in ~0.9 μm absorption band. Limiting the search to this region is suggested by Gaffey *et al.* (2002) since adjustment between the spectra of the asteroid and meteorite is not always possible due to (1) the grains size, data collection geometry, and temperature of the sample or (2) the lack of spectral reflectance data on meteorites that were not affected by Earth-weathering. The best match between spectra came by using the one of the Lance meteorite (L1=1.09), see Fig 5. The second best fit occurred with a sample of the Felix meteorite (L1=1.14). Both samples belong to the CO3 type. It can be concluded after this part of the study that the surface of the asteroid 2001 SN263 is doubtless associated with carbonaceous chondrites meteorites.

Acknowledgments

Thanks for the Vitae Foundation, MCT (Ministry of Science and Technology), FTC (Faculty of Science and Technology) and the Institute of Physics of UFBA (IF-UFBA) for supporting the "Discovering the Sky" project.

All (or part) of the data utilized in this publication were obtained and made available by the MIT-UH-IRFT Joint Campaign for NEO Reconnaissance. The IRTF is operated by the University of Hawaii under Cooperative Agreement no. NCC 5-538 with National Aeronautics and Space Administration, Office of Space Science, Planetary Astronomy Program. The MIT component of this work is supported by the National Science Foundation Grant No. 0506716.

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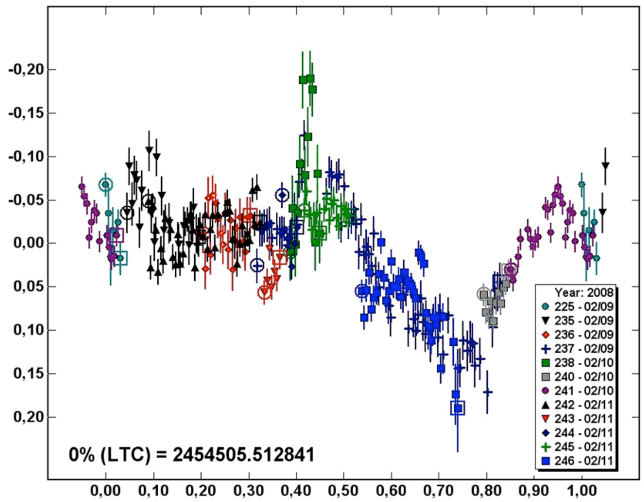

Fig. 1. 2001 SN263 lightcurve phased to 3.20 h. This curve does not include probable mutual events.

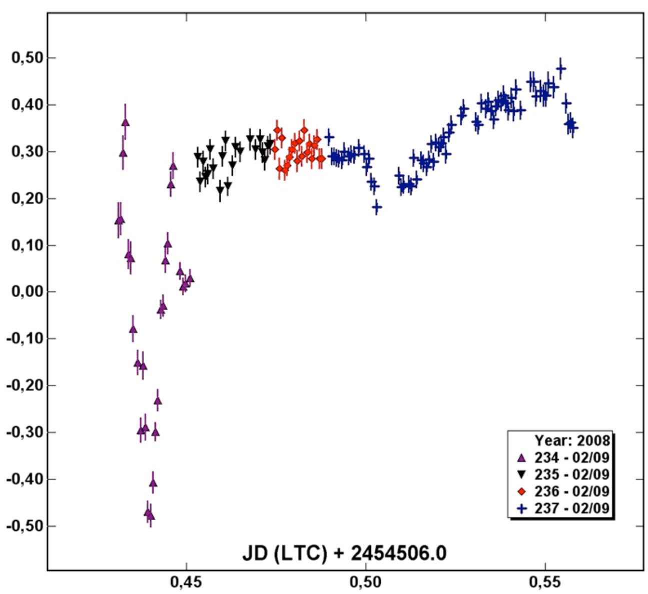

Fig. 2. Lightcurve of eclipse of the smaller satellite by primary.

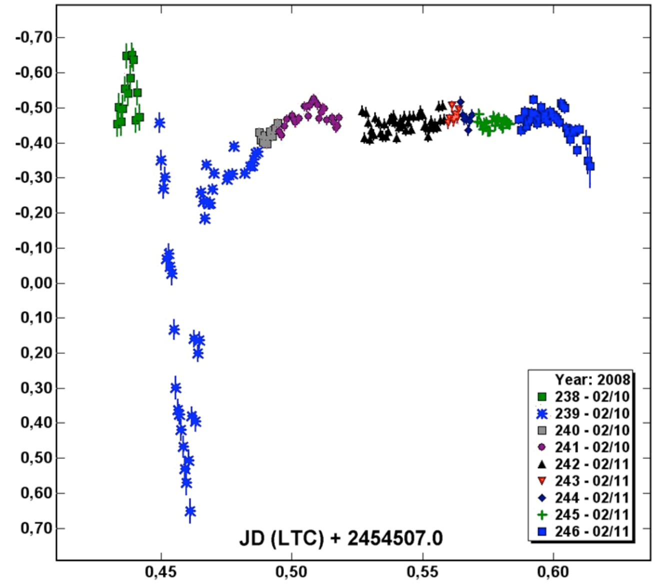

Fig. 3. Lightcurve of the smaller satellite transit over the primary.

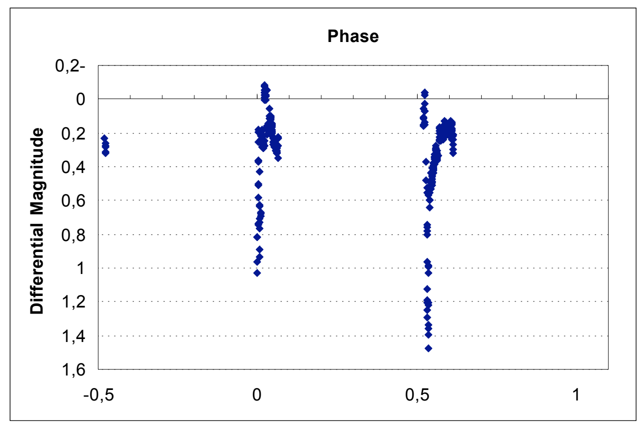

Fig. 4. Adjusted lightcurve of the orbital period of the smaller satellite, phased to 50.3 h.

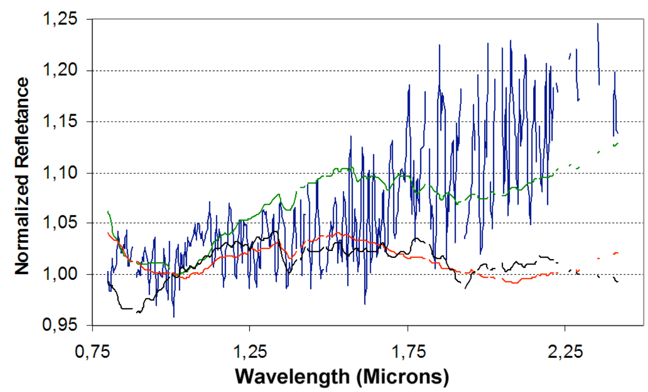

Fig. 5. 2001 SN263 NIR spectrum (blue) compared to the spectrum of the meteorites Lance (green), Felix (red), and Orgueil (black). The spectrum is normalized to the value at 1.0 µm.

THE ROTATION PERIOD OF 1231 AURICULA

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

Greg Crawford
Bagnall Beach Observatory
Salamander Bay, NSW, AUSTRALIA

Bill Allen
Vintage Lane Observatory
Blenheim, NEW ZEALAND

(Received: 2008 July 14)

The synodic rotation period of minor planet 1231 Auricula was found to be 3.9816 ± 0.0006 h. Assuming a near equatorial aspect, the overall amplitude of 0.75 mag implies an axial ratio a/b = 1.99.

Minor planet 1231 Auricula (1931 TE2) was discovered by K. Reinmuth at Heidelberg in October, 1931. The diameter is quoted as 22 ± 4 km and the albedo is 0.084 (Guide 2002). It is an inner main-belt asteroid. No lightcurve data were found in the latest lists of Harris *et al*. (2008).

The observations in 2008 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 (Table I) also show the percentage of the lightcurve observed each night. PAB is the Phase Angle Bisector. All period analysis was carried out using the *Peranso* software (Vanmunster, 2006). The composite lightcurve for 1231 Auricula (Figure 1) displays a simple bi-modal shape with an overall amplitude of 0.75 mag. The synodic period of 3.9816 ± 0.0006 h is a secure result. More than one rotation was observed on a majority of nights. Assuming a near-equatorial aspect, the amplitude implies an axial ratio a/b = 1.99.

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UT Date	PAB Long	PAB Lat	Phase Angle	%Phase Coverage
2008 Apr 01	203.0	-09.5	7.2	157
2008 Apr 04	203.0	-09.7	6.3	72
2008 Apr 09	203.0	-10.0	5.3	156
2008 Apr 10	203.1	-10.0	5.2	138
2008 Apr 11	203.2	-10.1	5.1	126
2008 Apr 12	203.2	-10.2	5.1	102

Table I. Aspect data for Auricula in 2008.

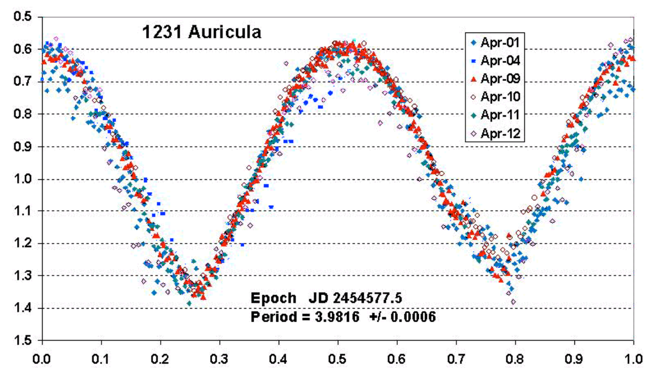

Figure 1. Composite Lightcurve in 2008

MINOR PLANET LIGHTCURVE ANALYSIS OF 1157 ARABIA AND 1836 KOMAROV

Peter Caspari
BDI Observatory
PO Box 194 Regents Park
NSW 2143, AUSTRALIA
pcaspa@hotmail.com

(Received: 2008 July 15)

Minor planet 1157 Arabia was observed over eight nights in 2008 May and June and 1836 Komarov was observed over five nights in 2008 June and July. Rotational periods of 15.225 h with an amplitude of 0.35 mag and 9.695 h with an amplitude of 0.55 mag, respectively, were determined.

BDI Observatory is located 22 km south of Sydney, Australia. The equipment used was a 0.2-m f/6 Newtonian with an SAC-8II CCD camera at prime focus. A typical session lasted from 2.5 to 4 hours. *Astrovideo* was used to capture the unfiltered images, which were dark and flat corrected. Automatic stacking was performed using *DeepSkyStacker* and custom written software. Stacking was required to prevent saturation and to keep the image in the linear portion of the camera's response curve. The resulting images were measured using *MPO Canopus* (Warner 2008a), which uses differential aperture photometry to determine the values used for analysis.

1157 Arabia This asteroid is a main-belt object with an assumed diameter of 65.9 km based on an assumed albedo of 0.04 (Gray 2008). It was selected as a result of importing lightcurve data from the Minor Planet Center's "Minor Planet Lightcurve Parameters" and CALL's "Lightcurve Parameters" (Harris *et al*. 2008) into a data base. The data base was then queried for the brightest minor planet that had no known period and was in a favourable location for BDI Observatory considering light pollution and obstructions. Raoul Behrend's website (Behrend 2008) was also considered. The lightcurves exhibits a typical bimodal curve. *MPO Canopus* was used to determine a period of 15.225 ± 0.005 h and an estimated peak-to-peak amplitude of 0.35 mag.

1836 Komarov. This is a main-belt object with an assumed diameter of 36.2 km based on an assumed albedo of 0.04 (Gray 2008). This target was selected from the CALL's lightcurve targets page (Warner 2008b) since it was relatively bright and in a favourable location for BDI Observatory. The target had no known period. The lightcurve exhibits a typical bimodal curve. *MPO Canopus* was used to determine a period of 9.695 ± 0.005 h and an estimated peak-to-peak amplitude of 0.55 mag.

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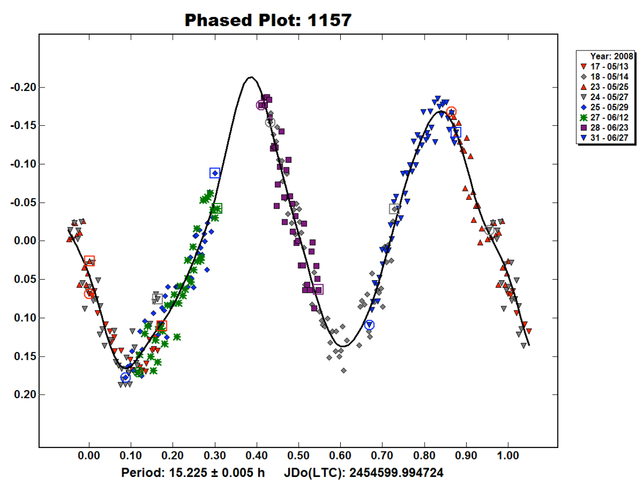

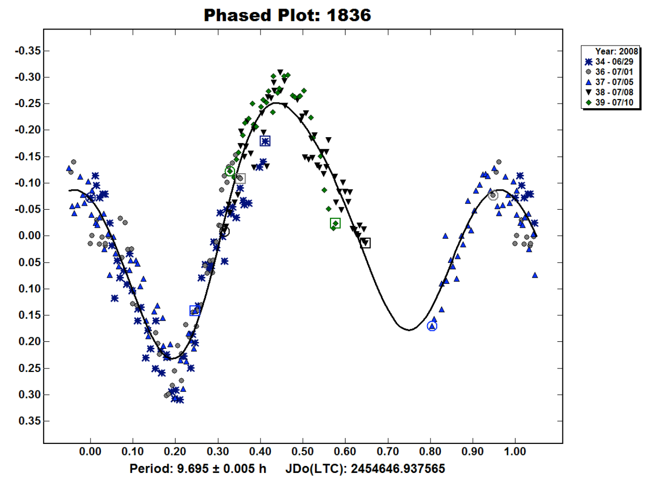

LIGHTCURVE PHOTOMETRY OPPORTUNITIES: OCTOBER-DECEMBER 2008

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 Ondrejov, CZECH REPUBLIC

Josef Durech
Astronomical Institute
Charles University in Prague
18000 Prague, CZECH REPUBLIC
durech@sirrah.troja.mff.cuni.cz

Lance A.M. Benner
Jet Propulsion Laboratory
Pasadena, CA 91109-8099 USA
lance@reason.jpl.nasa.gov

We present here four lists of "targets of opportunity" for the period 2008 October-December. The first list is those asteroids reaching a favorable apparition during this period, 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 is of 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 recommended, meaning that data not differential magnitudes but absolute values put onto a standard system such as Johnson V. If this is not possible or 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 the dates of planned radar observations. Use the on-line services such as those from the Minor Planet Center JPL's Horizons to generate high-accuracy *topocentric* ephemerides.

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 2020) 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 at least on a personal 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

Those doing modeling work should refer to the Database of Asteroid Models from Inversion Techniques (DAMIT) project at the Astronomical Institute of the Charles University, Czech Republic.

http://astro.troja.mff.cuni.cz/projects/asteroids3D

Results and the original data for a large number of asteroid models can be browsed and downloaded at this location.

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Lightcurve Opportunities

#	Name	Brightest Date	Mag	Dec	U	Period	Amp
4940	Polenov	10 01.2	15.0	+ 0			
2543	Machado	10 02.6	13.9	- 8			
7824	Lynch	10 02.9	14.4	- 3			
2358	Bahner	10 04.5	14.7	+11			
1122	Neith	10 04.7	12.8	- 3	1		
7568	1988 VJ2	10 06.8	14.8	+ 9			
18070	2000 AC205	10 08.4	14.3	-13			
1472	Muonio	10 08.5	13.7	+ 1			
2053	Nuki	10 09.1	14.9	+ 6			
6727	1991 TF4	10 10.0	15.0	+ 7			
2335	James	10 12.5	14.6	+ 5			
4332	Milton	10 12.7	13.6	-13	?		
17770	Baume	10 13.1	15.0	- 6			
3555	Miyasaka	10 14.0	14.9	+ 7			
1346	Gotha	10 15.9	13.9	- 5	2	11.19	0.12
16960	1998 QS52	10 17.2	14.1	+61			
4711	Kathy	10 18.1	13.8	-10			
1673	van Houten	10 19.1	14.7	+10			
5397	Vojislava	10 19.4	14.8	+15			
9292	1982 UE2	10 19.6	15.0	+ 8			
21766	1999 RW208	10 19.7	15.0	+15			
7290	Johnrather	10 19.7	14.7	+15			
3416	Dorrit	10 20.1	14.7	+20			
2490	Bussolini	10 20.2	14.4	+13			
4520	Dovzhenko	10 20.4	14.3	+ 3			
3956	Caspar	10 20.4	14.6	+18			
6896	1987 RE1	10 20.5	15.0	+18			
3597	Kakkuri	10 20.8	14.8	+ 7			
7569	1989 BK	10 21.2	14.8	- 7			
8356	Wadhwa	10 22.4	14.4	+46			
7816	Hanoi	10 22.5	14.8	+13	2+	5.18	0.72
674	Rachele	10 22.6	11.0	+ 0	2	30.96	0.16
5526	Kenzo	10 22.9	14.7	+17			
1042	Amazone	10 22.9	14.0	- 1	2	16.26	0.10
343	Ostara	10 26.4	12.7	+12	1	6.42	0.23
6911	Nancygreen	10 27.7	13.4	+ 7	2	5.3	0.52
6000	United Nations	10 30.1	13.8	+ 7			
27851	1994 VG2	10 30.2	15.0	+18			
1169	Alwine	10 30.4	14.8	+18			
1824	Haworth	10 30.9	15.0	+15			
4265	Kani	11 01.0	14.6	+ 6			
6650	Morimoto	11 02.1	14.8	+31	2	13.49	0.24
6514	Torahiko	11 04.1	14.7	+19			
923	Herluga	11 04.2	13.8	+ 5			
2420	Ciurlionis	11 05.1	14.7	+ 8			
27135	1998 XB12	11 06.4	14.8	+38			
5062	Glennmiller	11 08.0	14.9	+20			
1672	Gezelle	11 09.0	13.8	+16	?		
3250	Martebo	11 12.7	15.0	+12			
5343	Ryzhov	11 13.2	15.0	+14			
20439	1999 JM28	11 13.2	14.9	+18			
7574	1989 WO1	11 13.8	15.0	+15			
1720	Niels	11 16.4	14.7	+18	1	9.97	0.15
11978	Makotomasako	11 16.9	14.9	+20			
30767	Chriskraft	11 17.1	14.9	+18			
10318	Sumaura	11 17.4	15.0	+16			
	1998 BE7	11 18.0	15.0	-11			
1015	Christa	11 18.5	13.2	+ 7	2	12.18	0.20
868	Lova	11 18.9	13.0	+11	2	41.3	0.40
1529	Oterma	11 20.0	14.6	+11	2	15.75	0.18
5035	Swift	11 20.1	14.5	+22	2	9.50	0.32
768	Struveana	11 20.8	13.4	+29	2+	8.76	0.26
3629	Lebedinskij	11 21.0	14.7	+19			
691	Lehigh	11 21.4	12.9	+10	2	10.48	0.12
2947	Kippenhahn	11 21.4	14.9	+24			
162900	2001 HG31	11 21.4	14.8	+26			
2666	Gramme	11 22.2	15.0	+ 6			
8141	Nikolaev	11 22.6	14.7	+33			
264	Libussa	11 23.6	11.4	+24	2	9.23	0.03-0.22
5133	Phillipadams	11 23.7	14.2	+12			
53430	1999 TY16	11 24.8	14.8	+27			
182	Elsa	11 26.5	10.7	+18	2		0.7
43100	1999 XV15	11 26.6	14.8	+10			
1560	Strattonia	11 28.0	14.0	+29			
813	Baumeia	11 29.3	14.0	+25	1	7.44	0.02

Lightcurve Opportunities (continued)

#	Name	Brightest Date	Mag	Dec	U	Period	Amp
2657	Bashkiria	11 30.3	15.0	+23			
155	Scylla	11 30.7	13.4	+32	2	7.95	0.12
2973	Paola	12 01.8	14.9	+25			
1359	Prieska	12 03.2	14.4	+24			
299	Thora	12 03.5	13.9	+22	1-		
145	Adeona	12 05.2	10.8	+21	2	8.1	0.08
2463	Sterpin	12 07.9	14.6	+ 0	2	13.44	0.25
4264	Karljosephin	12 08.4	14.9	+16	2	30.96	0.09
22141	2000 VH36	12 08.5	15.0	+16			
5390	Huichiming	12 09.1	13.9	+14	2	33.6	0.25
8085	1989 CD8	12 09.4	14.8	+24	2	7.75	0.20
4797	Ako	12 09.6	14.3	+26			
1596	Itzigsohn	12 11.1	13.6	+19	2	39.72	0.15-0.41
3134	Kostinsky	12 12.6	14.9	+22	2	14.7	0.33-0.38
3260	Vizbor	12 13.9	14.7	+21	2	64.1	>0.3
1375	Alfreda	12 15.7	14.2	+29			
2072	Kosmodemyanskaya	12 17.2	14.7	+31	2	4.4	0.09
29235	1992 EU13	12 17.8	15.0	+33			
1655	Comas Sola	12 18.7	13.3	+16	2	20.4	0.20
3609	Liloketai	12 20.5	14.6	+27			
2132	Zhukov	12 21.1	14.5	+25			
2531	Cambridge	12 23.2	14.7	+20	2-	8.80	0.21
4735	Gary	12 24.0	14.7	+24			
43084	1999 WQ1	12 30.3	14.9	+16			
	2008 EV5	12 26.4	13.2	+29			

Low Phase Angle Opportunities

#	Name	Date	α	V	Dec	Period	AMin	Amax	U
69	Hesperia	10 09.7	0.89	11.0	+04	5.6552	0.12	0.20	4
358	Apollonia	10 10.5	0.97	12.3	+05	long		0.04	1
195	Eurykleia	10 13.1	0.82	12.9	+10	16.521	0.08	0.25	3
104	Klymene	10 13.9	0.55	11.9	+07	8.984		0.3	3
178	Belisana	10 14.1	0.63	12.4	+07	24.6510	0.12	0.18	3
343	Ostara	10 26.4	0.40	12.7	+12	6.42		0.23	1
518	Halawe	10 26.6	0.86	13.4	+11				
425	Cornelia	10 28.2	0.87	14.0	+11	17.56		0.16	2
1296	Andree	10 29.3	0.62	13.3	+15	5.184		0.25	3
32	Pomona	11 04.4	0.17	11.1	+15	9.448	0.13	0.30	4
1672	Gezelle	11 09.0	0.54	13.8	+16			0.2	
401	Ottilia	11 17.0	0.81	13.7	+22	6.049	0.11	0.24	3
21	Lutetia	11 30.5	0.47	10.2	+21	8.1655	0.08	0.25	4
899	Jokaste	12 02.5	0.35	13.1	+23	6.245		0.28	3
10	Hygiea	12 03.5	0.80	10.3	+25	27.623	0.11	0.33	4
299	Thora	12 03.5	0.27	13.9	+22				
145	Adeona	12 05.1	0.68	10.9	+21	8.1		0.08	2
1047	Geisha	12 06.1	0.42	13.3	+22				
857	Glasenappia	12 07.1	0.56	13.7	+21	8.23	0.27	0.35	2
673	Edda	12 11.0	0.84	13.9	+21	14.92		0.12	2
901	Brunsia	12 13.0	0.19	13.7	+24	3.136		0.12	2
570	Kythera	12 15.3	0.51	13.2	+22	8.120	0.15	0.18	2
86	Semele	12 15.9	0.14	11.8	+23	16.634		0.18	3
447	Valentine	12 16.7	0.56	12.8	+25	9.651		0.18	3
277	Elvira	12 17.4	0.37	13.5	+22	29.69	0.34	0.59	4
700	Auravictrix	12 18.1	0.94	13.7	+21	6.075		0.42	3
658	Asteria	12 18.8	0.86	14.0	+26	28.		0.32	1
270	Anahita	12 22.0	0.48	11.2	+22	15.06		0.32	3
431	Nephele	12 22.2	0.35	13.3	+22	9.102	0.02	0.13	3
639	Latona	12 26.7	0.36	12.3	+24	6.22	0.07	0.35	2

Shape/Spin Modeling Opportunities

#	Name	Brightest Date	Mag	Dec	Per (h)	Amp Min	Max	U
69	Hesperia	10 09.7	11.0	+04	5.6552	0.12	0.20	4
334	Chicago	10 19.9	13.1	+05	7.35	0.15-	0.67	2
804	Hispania	11 01.2	11.6	+34	14.845	0.19-	0.24	3
377	Campania	11 12.7	11.9	+14	8.507		0.16	3
133	Cyrene	11 14.2	12.9	+28	12.708		0.26	3
114	Kassandra	11 30.3	11.7	+14	10.758		0.25	3
10	Hygiea	12 03.5	10.3	+25	27.623	0.11	0.33	4
59	Elpis	12 04.3	11.2	+08	13.69		0.1	3
145	Adeona	12 05.1	10.9	+21	8.1		0.08	2
277	Elvira	12 17.4	13.5	+22	29.69	0.34	0.59	4
30	Urania	12 31.	11.9	-01	13.686	0.11-	0.45	3
40	Harmonia	12 31.	11.7	-13	8.910	0.15-	0.36	4
80	Sappho	12 31.	12.1	-04	14.030	0.1 -	0.40	3
487	Venetia	12 31.	13.3	-14	13.28	0.05-	0.30	2

Radar-Optical Opportunities

Use the ephemerides to judge your best chances for observing. Note that the intervals in the ephemerides are not always the same and that *geocentric* positions are given. Use the resources given above to generate updated and *topocentric* positions. In the ephemerides, E.D. and S.D. are, respectively, the Earth and Sun distances (AU), V is the V magnitude, and α is the phase angle.

(164400) 2005 GN59

This is a carry-over from the last issue since it can still be readily observed in early October.

DATE	RA(2000)	DC(2000)	E.D.	S.D.	Mag	α
09/15	22 09.20	+33 38.3	0.142	1.116	14.59	36.7
09/20	21 55.29	+39 20.9	0.114	1.083	14.24	43.7
09/25	21 29.88	+47 49.5	0.088	1.052	13.90	54.0
09/30	20 23.73	+60 49.6	0.066	1.022	13.70	70.1
10/05	16 04.41	+69 56.4	0.053	0.994	14.09	95.1

(137032) 1998 UO1

This is a rapid rotator, P = 2.9 h, with an estimated diameter of about 1.3 km. The amplitude ranges from 0.04 to 0.15 mag. These combined leave open the possibility that the asteroid may be binary. Therefore, high-precision photometry (< 0.02 mag) is urged in order to look for occultation and/or eclipse events.

DATE	RA(2000)	DC(2000)	E.D.	S.D.	Mag	α
09/28	16 32.77	+83 55.5	0.066	1.003	13.87	86.9
10/01	22 02.35	+60 11.4	0.094	1.046	13.77	58.9
10/04	22 20.11	+46 08.3	0.134	1.088	14.27	46.1
10/07	22 26.62	+38 39.8	0.178	1.129	14.80	40.0
10/10	22 30.46	+34 07.9	0.225	1.170	15.29	36.8
10/13	22 33.36	+31 05.9	0.273	1.209	15.73	35.0
10/16	22 35.88	+28 55.2	0.322	1.248	16.13	33.9

(85774) 1998 UT18

This asteroid is a bit fainter than we usually include. However, it may be within reach of larger instruments. Krugly et al (*Icarus* **158**, 294-304) reported a period of 34 h and 0.8 mag amplitude.

DATE	RA(2000)	DC(2000)	E.D.	S.D.	Mag	α
11/10	6 47.05	+ 3 57.2	0.149	1.079	17.10	50.1
11/12	7 02.21	+ 5 57.5	0.140	1.071	16.98	51.5
11/14	7 19.31	+ 8 14.4	0.131	1.062	16.87	53.3
11/16	7 38.60	+10 48.0	0.123	1.054	16.78	55.4
11/18	8 00.32	+13 36.6	0.117	1.045	16.72	57.9
11/20	8 24.60	+16 36.1	0.111	1.037	16.69	60.9
11/22	8 51.41	+19 39.6	0.108	1.030	16.70	64.3

(8567) 1996 HW1

This asteroid is reasonably placed for the entire fourth quarter. Unfortunately, the phase angle doesn't change much, which would help modeling even more. Still, good lightcurves in combination with radar observations should be very helpful for finding the shape and pole direction. The period is about 8.7 h with an amplitude of 0.25 mag as reported by Higgins (*MPB* **33**, 8-10).

DATE	RA(2000)	DC(2000)	E.D.	S.D.	Mag	α
10/01	2 18.02	- 2 05.7	0.157	1.143	12.70	23.9
10/11	2 41.31	- 7 05.4	0.185	1.165	13.07	23.4
10/21	2 53.62	- 9 56.0	0.221	1.197	13.48	22.2
10/31	2 58.98	-10 58.3	0.265	1.235	13.91	21.2
11/10	3 01.10	-10 35.1	0.318	1.280	14.38	21.1
11/20	3 02.67	- 9 11.2	0.381	1.330	14.89	22.2
11/30	3 05.20	- 7 07.7	0.454	1.384	15.42	24.0
12/10	3 09.62	- 4 41.8	0.540	1.440	15.94	26.1

2004 LV3

Given its magnitude and speed, a 1-meter or larger telescope will probably be needed for this asteroid. We can find no reported period and/or amplitude for this asteroid.

DATE	RA(2000)	DC(2000)	E.D.	S.D.	Mag	α
12/20	20 29.50	+43 20.9	0.113	0.962	17.39	97.6
12/22	21 16.00	+40 52.1	0.095	0.969	16.96	95.9
12/24	22 14.29	+35 36.1	0.081	0.976	16.48	92.8
12/26	23 19.89	+26 14.8	0.071	0.983	16.03	87.9
12/28	0 23.37	+13 26.5	0.070	0.991	15.75	81.8
12/30	1 16.93	+ 0 35.2	0.076	0.998	15.76	76.3
01/01	1 58.59	- 9 31.7	0.088	1.006	15.98	72.5
01/03	2 30.13	-16 36.3	0.105	1.014	16.29	70.0

(136849) 1998 CS1

We can find no reported period and/or amplitude for this asteroid.

DATE	RA(2000)	DC(2000)	E.D.	S.D.	Mag	α
12/25	8 18.08	+12 29.5	0.267	1.220	16.50	24.7
12/28	8 22.56	+12 46.3	0.231	1.191	16.11	23.6
12/31	8 28.01	+13 13.2	0.197	1.162	15.68	22.7
01/03	8 35.12	+13 54.9	0.163	1.133	15.19	21.8
01/06	8 45.28	+15 00.9	0.131	1.104	14.64	21.4
01/09	9 01.63	+16 50.6	0.099	1.074	13.99	22.1
01/12	9 33.01	+20 10.7	0.068	1.044	13.25	26.0
01/15	10 53.25	+26 41.2	0.041	1.014	12.53	41.1
01/18	14 43.52	+27 54.7	0.029	0.984	13.19	87.8

(17511) 1992 QN

The rotation period is just under 6 h with an amplitude of 1.1 mag (Pravec, *Icarus* **136**, 124-153).

DATE	RA(2000)	DC(2000)	E.D.	S.D.	Mag	α
12/25	12 29.66	+43 21.2	0.256	1.072	16.54	63.3
12/28	12 56.97	+41 35.6	0.242	1.053	16.49	66.8
12/31	13 24.84	+39 15.0	0.230	1.035	16.46	70.7
01/03	13 52.75	+36 17.0	0.220	1.017	16.47	75.0
01/06	14 20.21	+32 41.4	0.213	0.999	16.52	79.6
01/09	14 46.76	+28 31.3	0.208	0.981	16.61	84.6
01/12	15 12.09	+23 53.2	0.206	0.963	16.75	89.6
01/15	15 36.00	+18 56.7	0.206	0.945	16.92	94.6

2008 EV5

We can find no reported period and/or amplitude for this asteroid. As of mid-2008, the ephemeris uncertainty for late 2008 reaches up to 1340", or almost 0.25°. Hopefully, additional observations will be made before the asteroid reaches conjunction and/or in the months leading up to closest approach so that it's possible to find the asteroid at all, let alone get last minute astrometry for the radar teams.

DATE	RA(2000)	DC(2000)	E.D.	S.D.	Mag	α
12/10	10 15.40	-44 22.7	0.040	0.981	16.25	94.6
12/15	9 58.43	-32 06.1	0.031	0.988	15.20	82.8
12/20	9 36.91	-10 31.3	0.023	0.994	13.99	63.2
12/25	9 07.37	+20 54.0	0.022	1.000	13.16	39.0
12/30	8 26.76	+47 27.8	0.027	1.006	13.43	31.8
01/04	7 35.73	+61 47.2	0.037	1.012	14.27	38.2
01/09	6 41.86	+68 22.7	0.048	1.017	15.05	44.7
01/14	5 55.31	+71 09.0	0.060	1.021	15.68	49.6

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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).

Brian D. Warner (address above) is the *MPB* Acting Editor while Dr. Richard P. Binzel is on sabbatical (*MPB* **35**, p. 141). 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)

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The deadline for the next issue (36-1) is October 15, 2008. The deadline for issue 36-2 is January 15, 2009.