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35.

## CCD PHOTOMETRY OF ASTEROIDS AT THE BELGRADE ASTRONOMICAL OBSERVATORY: 2008 JANUARY–SEPTEMBER

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Lightcurves for seven minor planets were obtained at the Belgrade Astronomical Observatory in the period 2008 January–September: 541 Deborah, 956 Elisa, 1022 Olympiada, 1071 Brita, 1724 Vladimir, 5010 Amenemhet, and (8567) 1996 HW1.

During the period 2008 January–September, lightcurves of seven asteroids were obtained at the Belgrade Astronomical Observatory (BAO) using a 16-inch Meade Schmidt-Cassegrain telescope operating at  $f/10$ . This was coupled with an Apogee AP47p back-illuminated CCD camera with  $13\ \mu\text{m}$  square pixels operating at  $1\times 1$  binning, producing an image scale of 0.66 arc seconds per pixel. A new equatorial mount installed in 2007 eliminated limitations of the old alt-az setup, enabling longer exposures and observations of fainter targets. All observations were made without filters. Image processing and calibrations were done using *MaxIm DL3* software by Diffraction Limited. Differential aperture photometry with five comparison stars and lightcurve period analysis were conducted in *MPO Canopus* by BDW Publishing. Target selections were made using the Collaborative Asteroid Lightcurve Link (CALL) web-site and “Lightcurve Opportunities” articles from the *Minor Planet Bulletin*. Asteroids having uncertain or unknown lightcurve parameters as well as those with favorable opposition brightness and higher declination (due to horizon restrictions) were crucial criteria for target selection. Objects observed at the BAO during the nine-month period whose lightcurves were obtained in collaboration with other observatories and authors are not presented in here.

541 Deborah. An uncertain ( $U = 1$ ), previously known rotation period of 4.25 hours (Behrend, 2008) was cited in the Potential Lightcurve Targets: 2008 July–September list. Data were gathered from 2008 August 19–September 3 resulting in 9 sessions. A bimodal solution of  $P = 13.91 \pm 0.02$  h based upon Fourier

analysis of our observations in *MPO Canopus* represents, undoubtedly, the most reliable result for period (see the period spectrum, Fig. 1.). A relatively small value of amplitude was derived from the lightcurve:  $A = 0.07 \pm 0.02$  mag.

956 Elisa. Photometric observations of this target were conducted over 13 nights from 2008 July 11–August 11 with the intention of revising a previously known rotation period of 3.9 hours (Behrend, 2008) but stated as uncertain ( $U = 1$ ) on the CALL web-site (Potential Lightcurve Targets: 2008 July–September). As a result, a bimodal lightcurve phased to  $16.5075 \pm 0.0007$  h, with an amplitude of  $0.37 \pm 0.02$  mag was obtained. A new lightcurve published recently based on Matthieu Conjat’s observations (Behrend, 2008), shows a period of  $16.492 \pm 0.006$  h, which is fully consistent with ours.

1022 Olympiada. This minor planet was listed as a potential target on the CALL web-site (Potential Lightcurve Targets January–March 2008) with a remark that the period can be in error by up to 30% or that the period has an ambiguous solution when  $U = 2$ . The first photometric observations of this object were carried out by Warner (1999), who originally published value of  $P = 4.589$  h. This was subsequently revised due to better symmetry of the lightcurve with a shorter period of  $P = 3.83 \pm 0.01$  h (Warner, 2005). Our intention was to check the previous values for the period to see which of the two, if either, was correct. Two observing runs were made on 2008 March 26 and 28. Our analysis found  $P = 3.8331 \pm 0.0006$  h and  $A = 0.35 \pm 0.02$  mag. There is also a good consistency between our result and the values found recently by Warner et al. (2008a) from the single night observations ( $P = 3.822 \pm 0.006$  h,  $A = 0.34 \pm 0.02$  mag).

1071 Brita. This asteroid was selected from the list of potential targets for the period 2008 January–March on the CALL web-site as a bright object during the opposition, marked with  $U = 1$  and only preliminary parameters reported. The previously found amplitude was quite large,  $A = 0.38$  mag. Our observations started on 2008 January 28 when the object was  $V \sim 13.6$ . Eight observing sessions were performed, densely covering the full rotation period. Some observations were carried out in very unfavorable sky conditions – intense moonlight and thin cirrus clouds, which made the final lightcurve noisier than expected. The last session was performed on 2008 March 9. Our analysis of the lightcurve gives  $P = 5.8169 \pm 0.0003$  h and  $A = 0.20 \pm 0.04$  mag.

1724 Vladimir. No parameters have been published previously for this asteroid. As a relatively faint target of about 15<sup>th</sup> magnitude, it was a real challenge for observing. A composite bimodal lightcurve was constructed from the data gathered in 5 sessions

from 2008 March 30 to May 2. From this we found  $P = 12.57 \pm 0.01$  h and  $A = 0.14 \pm 0.03$  mag. A monomodal solution was also found with  $P = 6.29 \pm 0.01$  h. Unfortunately, it was not possible to observe the asteroid longer than approximately 5 hours during a single night due to local observing circumstances. This, combined with the interval between sessions, results in an uncertainty about the number of rotations between sessions. Given the amplitude, the longer period seems more likely but the shorter period cannot be formally excluded. We strongly recommend photometry of this object in the future.

**5010 Amenemhet.** An unsecure solution for the rotation period of this asteroid ( $U = 1$ ) was the primary reason to select it from the Potential Lightcurve Targets for 2008 April-June list despite its relatively faint opposition brightness ( $V \sim 14.9$ ). Data were collected from 2008 May 12–15 resulting in 4 data sets. Our analysis of the obtained lightcurve suggests the rotational period of  $P = 3.390 \pm 0.002$  h, which is close to the previously found period of  $P = 3.2$  h (Angeli et al., 2001). The amplitude derived from the lightcurve is  $A = 0.18 \pm 0.03$  mag. Nevertheless, insufficient coverage of the period with the observations (only one session covers the entire obtained period) and relatively sparse data point out the necessity for further photometric analysis of this object.

**(8567) 1996 HW1.** This is an Amor-type NEO asteroid that passed within 53 lunar distances of the Earth on 2008 September 12. Photometry of this target as a fairly bright “Radar-Optical Opportunity”, easy to reach within longer period of time, was recommended in the *Minor Planet Bulletin* (Warner et al., 2008b). Higgins et al. (2005) previously reported  $P = 8.7573$  h and  $A = 0.25$  mag. Observations of (8567) 1996 HW1 were carried out at the BAO over 4 consecutive nights from 2008 August 11–15. Each single-night dataset was divided into two sessions due to relatively fast apparent motion of the asteroid in the small field of view ( $\sim 12 \times 12$  arc minutes). Our data show  $P = 8.7553 \pm 0.0006$  h, which confirms the previously determined result. However, the amplitude,  $A = 0.82 \pm 0.04$  mag, differs considerably from the value found by Higgins et al., probably due to a different viewing aspect during our observations.

#### Acknowledgments

The authors thank Frederick Pilcher for his helpful suggestions after reviewing some of our lightcurves and Brian D. Warner for his advice concerning the period determination of 1724 Vladimir.

#### References

- Angeli, C.A., Guimaraes, T.A., Lazzaro, D., Duffard, R., et al. (2001). “Rotation Periods for Small Main-Belt Asteroids from CCD Photometry.” *Astronomical Journal* **121**, 2245-2252.
- Behrend, R. (2008). Observatoire de Geneve web site, [http://obswww.unige.ch/~behrend/page\\_cou.html](http://obswww.unige.ch/~behrend/page_cou.html)
- Higgins, D.J., Pravec, P., Kusnirak, P., Masi, G., et al. (2005). “Asteroid Lightcurve Analysis at Hunters Hill Observatory and Collaborating Stations - Autumn/Winter 2005.” *Minor Planet Bulletin* **33**, 8-10.
- Warner, B.D. (1999). “Asteroid Photometry at the Palmer Divide Observatory.” *Minor Planet Bulletin* **26**, 31-33.
- Warner, B.D. (2005). “Revised Lightcurve Analysis for 1022 Olympiada and 3285 Ruth Wolfe.” *Minor Planet Bulletin* **32**, 26.

Warner, B.D., Āurech, J., Fauerbach, M. and Marks, S. (2008a). “Shape and Spin Axis Models for Four Asteroids.” *Minor Planet Bulletin* **35**, 167-171.

Warner, B.D., Harris, A.W., Pravec, P., Āurech, J. and Benner, L.A.M. (2008b). “Lightcurve Photometry Opportunities: July-September 2008.” *Minor Planet Bulletin* **35**, 139-141.

Warner, B.D. and Harris, A.W. (2008c). Potential Lightcurve Targets, 2008 January–March, [http://www.minorplanetobserver.com/astlc/targets\\_1q\\_2008.htm](http://www.minorplanetobserver.com/astlc/targets_1q_2008.htm)

Warner, B.D. and Harris, A.W. (2008d). Potential Lightcurve Targets, 2008 April-June, [http://www.minorplanetobserver.com/astlc/targets\\_2q\\_2008.htm](http://www.minorplanetobserver.com/astlc/targets_2q_2008.htm)

Warner, B.D. and Harris, A.W. (2008e). Potential Lightcurve Targets, 2008 July-September, [http://www.minorplanetobserver.com/astlc/targets\\_3q\\_2008.htm](http://www.minorplanetobserver.com/astlc/targets_3q_2008.htm)

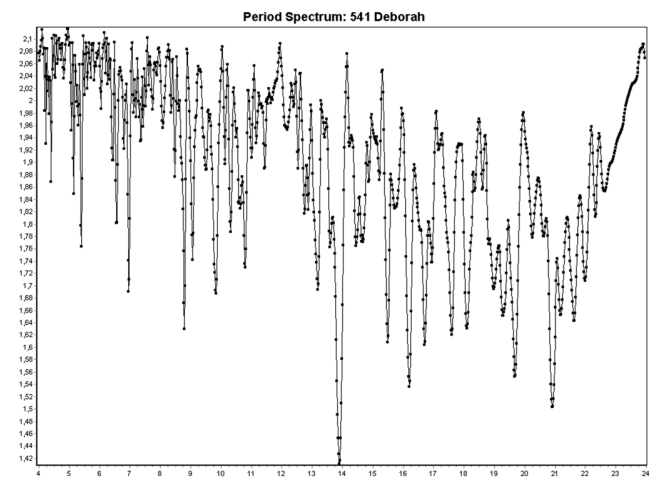
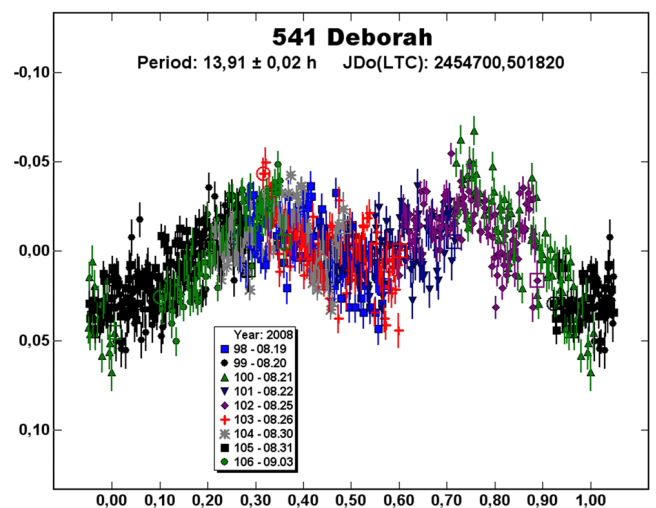
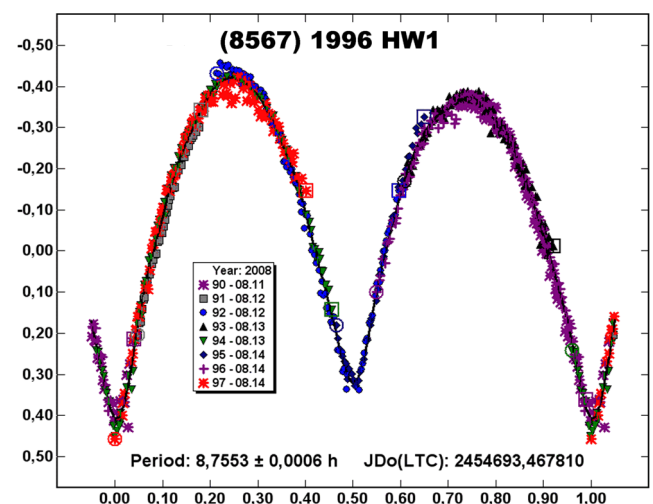
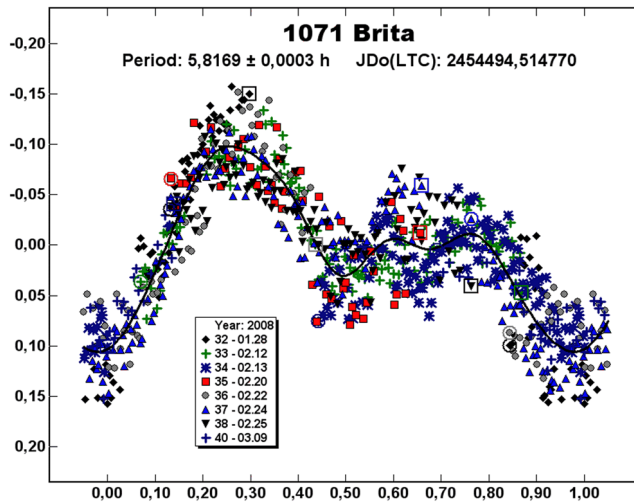
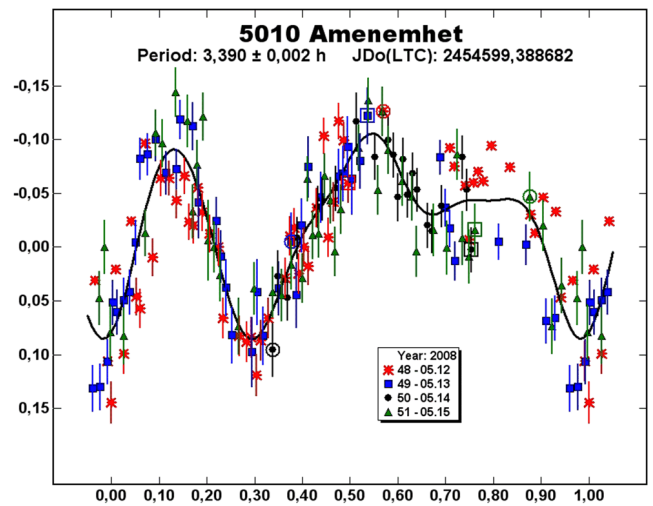
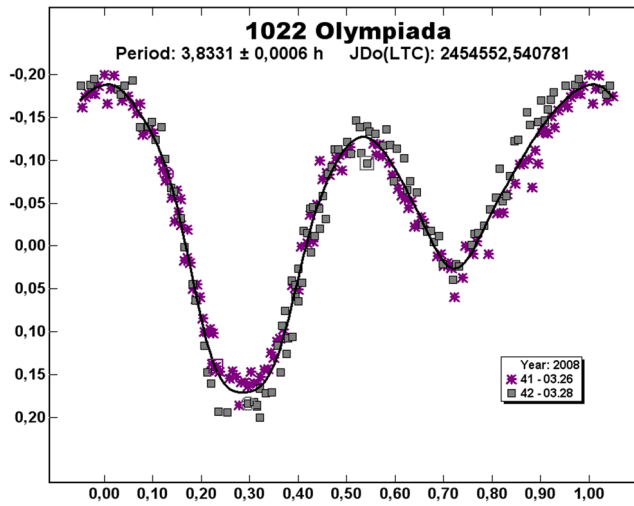
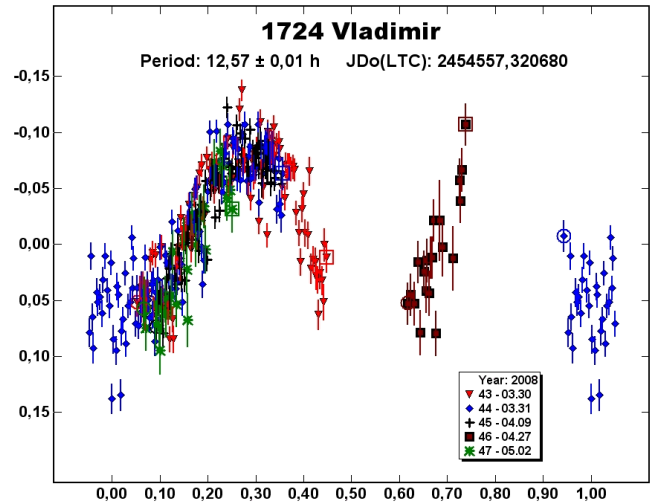
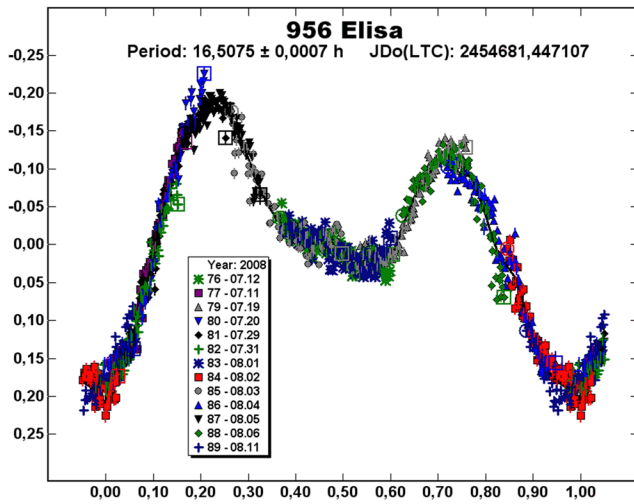


Figure 1. Period spectrum for 541 Deborah





### STEVEN J. OSTRO (1946 - 2008)

We are saddened to note the passing of Steven J. Ostro on December 15, 2008, following a 2.5 year battle with cancer. While not the first to bounce a radar signal off of an asteroid, Steve was arguably the "father" of the science of asteroid radar astronomy, not only in observing from Arecibo and Goldstone, but in developing the computational tools to invert both optical and radar data to produce detailed shape models of asteroids. He also "fathered" the field by attracting and training several of the leading asteroid radar observers who continue this impressive work. He will be greatly missed for his science, his passion to teach others, his convictions to seek the truth in nature, and his strength of character.

### COORDINATED LIGHTCURVE AND RADAR OBSERVATIONS OF 110 LYDIA AND 135 HERTHA

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Observations of the main-belt asteroids 110 Lydia and 135 Hertha were conducted in 2008 using a combination of optical photometry and radar. The photometry was obtained to try to resolve ambiguities regarding diameters and axis orientations when comparing radar observations with previously estimated diameters. For 110 Lydia, we were able to derive a shape and spin axis model that refined previous results and reduced some of the ambiguities. The data for both asteroids confirmed previous period determinations.

Each on their own, optical photometry and radar observations can provide considerable information about the shape, size, and spin axis orientation of asteroids. However, the inversion of each set of data into a shape and spin axis model has certain limitations that can result in ambiguous solutions. For example, lightcurve inversions for asteroids with very low orbital inclinations and/or spin axes near their orbital plane can result in a degenerate solution set of two or four pole orientations. In those cases, the sense of rotation (retrograde or prograde) is often undetermined since the latitude of the pole is highly uncertain. However, the combination of photometric and radar data can often reduce, if not eliminate, the ambiguities. With this in mind, we combined our efforts to produce data sets containing both types of data with the hope of producing more accurate models on two main-belt

asteroids. For a more detailed discussion on the possible ambiguities and other issues arising from lightcurve inversion, see the Kaasalainen et al. references and references therein.

Full analysis of the combined data sets will not be given here; that will be done in a future paper by Shepard. Instead, we will detail only the optical photometry work and initial results.

110 Lydia. This main-belt asteroid was observed by Stephens in 2003 December and again in 2008 November (11-13) at Santana Observatory using a 0.30-m SCT and SBIG STL-1001 CCD camera. Exposures were 60 s using a clear filter. The images were measured and the period analysis was performed using *MPO Canopus*. The 2008 data set yielded a synodic period of  $10.926 \pm 0.001$  h and lightcurve amplitude of  $0.26 \pm 0.02$  mag (Figure 1). The period is in good agreement with those previously reported (e.g., Taylor, 1971; Pray, 2004; Behrend, 2008).

The radar observations created some doubt about the reported size of the asteroid,  $D = 86 \pm 2.0$  km (SIMPS; Tedesco et al., 2002). In part, an uncertainty in the pole position may have contributed to the uncertainty and so we worked on creating a new model using the 2003 and 2008 data from Stephens as well as previous data sets found on the Standard Asteroid Photometry Catalog (SAPC; Torppa, 2008) and Database of Asteroid Models from Inversion Techniques (DAMIT; Āurech, 2008). See Warner et al. (2008) for a description of the modeling process using *MPO LCInvert*. Our results are summarized in Table I along with those previously reported by Āurech et al. (2007). Figure 2 shows two views of the asteroid in its equatorial plane at  $Z = 0^\circ$  and  $Z = 90^\circ$  rotations. Overall, the shape is very similar to that obtained by Āurech. Our slightly more pole-on solution (by  $\sim 10^\circ$ ) seems to reduce some, but not all, of the conflicts between optical and radar data. A detailed analysis is pending.

135 Hertha. The main reason for optical observations of this main-belt asteroid was to provide a recent lightcurve so that the timing of the radar observations could be tied to a specific phase of the lightcurve. Given this purpose, we obtained data on only two nights, 2008 Nov. 16 and 18, in order to establish a sufficiently reliable period and JD zero-point. Warner observed the asteroid using an R filter on the first night and then a V filter on the second to avoid reaching the saturation point on the CCD while allowing the exposures to be long enough to reduce scintillation noise to a manageable level. The derived synodic period for the lightcurve was  $8.406 \pm 0.005$  h with an amplitude of  $0.14 \pm 0.01$  mag. This agrees with previously reported periods (e.g., Lagerkvist, 1995; Torppa, 2003; Behrend, 2008). Initial analysis shows a similar discrepancy between SIMPS and radar-derived diameters.

#### Acknowledgements

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#### References

Behrend, R. (2008). Observatoire de Geneve web site, [http://obswww.unige.ch/~behrend/page\\_cou.html](http://obswww.unige.ch/~behrend/page_cou.html).

Đurech, J., Kaasalainen, M., Marciniak, A., et al. (2007). “Physical models of ten asteroids from observers collaboration network.” *Astron. Astrophys.* **465**, 331-337.

Đurech, J. (2008). Database of Asteroid Models from Inversion Techniques (DAMIT) web site: <http://astro.troja.mff.cuni.cz/projects/asteroids3D/>

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

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

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

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

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

Lagerkvist, C.-I., Erikson, A., Debehogne, H., Festin, L., et al. (1995). “Physical studies of asteroids. XXIX. Photometry and analysis of 27 asteroids.” *Astron. Astrophys. Suppl. Ser.* **113**, 115-129.

Pray, D. (2004). “Lightcurve analysis of asteroids 110, 196, 776, 804, and 1825.” *Minor Planet Bulletin* **31**, 34-36.

Pravec, P., Harris, A.W., Scheirich, P., Kušnirák, P., Šarounová, L., Hergenrother, C.W., and 14 colleagues. (2005). “Tumbling asteroids.” *Icarus* **173**, 108-131.

Taylor, R.C., Gehrels, T., and Silvester, A.B. (1971). “Minor planets and related objects. XXI – Photometry of eight asteroids.” *Astron. J.* **76**, 141-146.

Tedesco, E.F., Noah, P.V., Noah, M., and Price, S.D. (2002). “The Supplemental IRAS Minor Planet Survey.” *Astron. J.* **123**, 1056-1085.

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

Torppa, J. (2008). Standard Asteroid Photometric Catalog web site: <http://www2.astro.helsinki.fi/SAPC/index.jsp/>

Warner, B.D., Ďurech, J., Faurerbach, M., Marks, S. (2008) *Minor Planet Bulletin* **35**, 167-171.

Model	Poles ( $\lambda, \beta$ )	Period (h)
This work	(345, -51) (164, -43)	10.925808 $\pm 0.000002$
Đurech, 2007	(149, -55) (331, -61)	10.92580

Table I. Comparison of inversion model results from this work and Ďurech. The periods are sidereal hours. In our solution, the one with  $\lambda = 345^\circ$  was favored slightly over  $\lambda = 164^\circ$ .

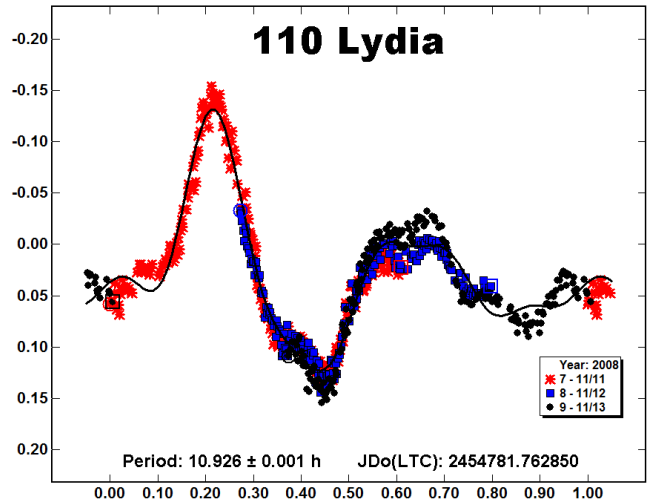


Figure 1. Lightcurve of 110 Lydia in 2008 November.

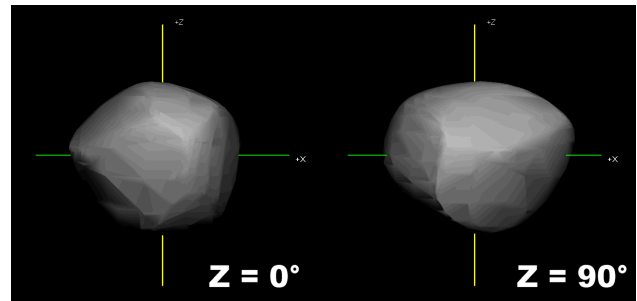


Figure 2. Model of 110 Lydia using 33 lightcurves obtained from 1958 through 2008.

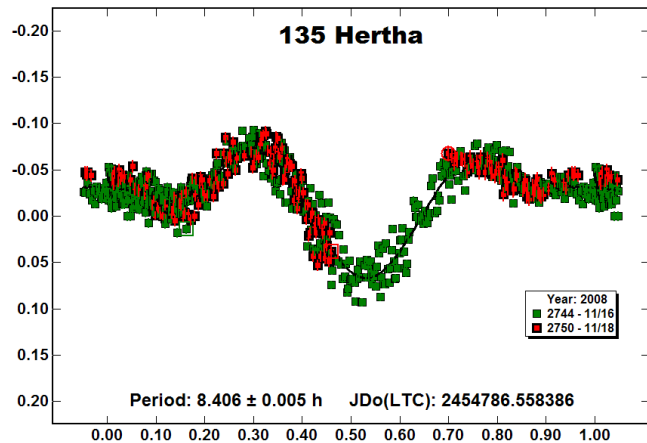


Figure 3. Lightcurve of 135 Hertha in 2008 November.

**PERIOD DETERMINATION FOR 182 ELSA:  
A COLLABORATION TRIUMPH**

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The synodic rotation period and amplitude of 182 Elsa are found to be  $80.088 \pm 0.002$  h and  $0.72 \pm 0.03$  mag.

Prior to this investigation only two lightcurve papers about 182 Elsa appear to have been published. Harris et al. (1980) observed on five nights, 1979 Dec. 3-7, and found a period of  $P \sim 80$  h and amplitude  $A \sim 0.7$  mag. A second set of observations published by Harris et al. (1992) were made on 1981 July 25–Aug. 9 and show only the rising and falling parts of the lightcurve. The amplitude was at least 0.6 mag, but no period could be found.

The three authors agreed to undertake a collaborative investigation of 182 Elsa from their widely separated longitudes. The western observers (Krajewski or Pilcher) could start a photometric run shortly after, or near opposition before the eastern observer (Benishek) ended his and thereby get precise instrumental magnitude adjustments to obtain a de facto lightcurve of up to sixteen hours duration. Benishek at Belgrade Observatory used a Meade 0.4-m LX200 GPS f/10 Schmidt-Cassegrain. An Apogee AP47p CCD was used for the October and November sessions, and a SBIG ST8 for the December session. Krajewski at Dark Rosanne Observatory used a 0.20-m Schmidt-Newtonian reflector operating at f/4 with a SBIG ST-402 CCD. Pilcher at Organ Mesa Observatory employed a Meade 0.35-m LX200 GPS f/11 Schmidt-Cassegrain and SBIG STL-1001E CCD. Differential photometry and lightcurve construction were made by all observers with *MPO Canopus*. This software made sharing and linking of the data much easier.

A well-defined minimum was recorded on 2008 Oct. 13, the first night of observation, near 9h UT. From the expected 80-hour period, another minimum was predicted for 9h UT Oct. 23. This was observed as predicted. By this date nearly 70% phase coverage had been obtained, indicating a period slightly greater than 80 hours with the amplitude about 0.75 magnitudes. In the next ten days, through November 2, additional observations completed full phase coverage except for some very small gaps, and the period spectrum graph showed no other minima between 40-120 hours. Most of the observations included in this report had already been obtained at larger phase angles:  $22.8^\circ$  on Oct. 13 down to  $14.4^\circ$  on Nov. 2. These defined the amplitude  $A = 0.72 \pm 0.03$  mag that is plotted in the accompanying lightcurve. A small number of additional lightcurves were obtained, in some cases covering extrema, to further refine the period and provide data useful for future spin/shape modeling. Based on lightcurves obtained from 2008 Oct. 13-2009 Jan. 3, a period of  $P = 80.088$

$\pm 0.002$  h provides a best fit to all data. Observations were binned in sets of 5 separated by no more than 10 minutes to reduce the number of points in the lightcurve and make it more readable.

Lightcurve amplitudes nearly always increase at larger phase angles due to shadowing effects. Lightcurves were obtained at nearly the same lightcurve phase on a linear descending branch and show the following slopes: Oct. 13,  $\alpha = 22.8^\circ$ , and Oct. 23,  $\alpha = 19.0^\circ$ , both with slope 0.072 mag/h; and Dec. 2,  $\alpha = 3.8^\circ$ , slope 0.052 mag/h. While these measurements do not have a high numerical accuracy, they do suggest  $A(0^\circ) \sim 0.55$ -0.60 mag. The ratio of maximum to minimum equatorial radii (a/b) is found from

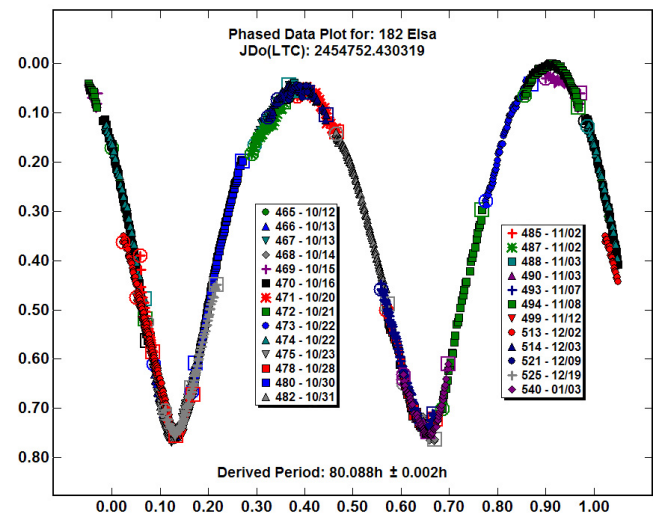
$$a/b \geq 10^{(0.4 \Delta M)}$$

Assuming  $\Delta M = 0.6$  for  $\alpha(0^\circ)$ , this implies  $a/b \sim 1.7$  for the asteroid. The ratio of minimum equatorial to polar radii (b/c) cannot be found from data obtained to date.

References.

Harris, A. W., Young, J. W., Scaltriti, F., and Zappala, V. (1980), "Photoelectric lightcurve and period of rotation of the asteroid 182 Elsa. *Icarus* **41**, 316-317.

Harris, A. W., Young, J. W., Dockweiler, T., Gibson, J., Poutanen, M., and Bowell, E. (1992), "Asteroid Lightcurve Observations from 1981." *Icarus* **95**, 115-147.



**CALL FOR OBSERVATIONS**

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(Received: 2008 Nov 17)

Observers who have made visual, photographic, or CCD measurements of positions of minor planets in calendar year 2008 are encouraged to report them to the author on or before 2009 April 1. This will be the deadline for receipt of reports that can be included in the "General Report of Position Observations for 2008," expected to be published in *MPB* Vol. 36, No. 3.

## MULTI-COLOR PHOTOMETRY OF 1998 BE7

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Multi-color photometry of the high orbital eccentricity asteroid, 1998 BE7, was conducted in the course of Lulin Sky Survey (LUSS) from 2008 October 1 to November 5. These data allowed determination of the rotation period to be  $6.6768 \pm 0.0001$  h, as well as color indices of  $B-V = 0.727 \pm 0.063$ ,  $V-R = 0.405 \pm 0.008$ , and  $V-I = 0.897 \pm 0.009$ . These indices suggest that 1998 BE7 could be a D-type asteroid. Assuming a slope parameter  $G = 0.086$  and albedo ( $p_V$ )  $0.058 \pm 0.004$ , the absolute magnitude  $H$  is estimated to be  $14.773 \pm 0.323$ , with a corresponding diameter of 5.0-7.0 km.

Asteroid 1998 BE7 was discovered by the NEAT program on 1998 January 24 (Williams, 1998) with orbital elements of  $a = 3.08$ ,  $e = 0.51$ . It made close approaches to Earth in 1998 and 2003 but no photometric observations were made due to unfavorable positions. The asteroid made another close approach to the Earth in 2008 November, reaching  $V = 15.3$  mag – the brightest over the decade. Hence, it was chosen for photometric purpose in the course of Lulin Sky Survey (LUSS). From 2008 October 1 to November 5, 10 nights of data were obtained using our 0.41-m Ritchey-Chretien telescope equipped with a 4-mega pixel back-illuminated CCD. Data from two nights were calibrated with standard fields. The data were reduced with Raab's *Astrometrica* and Warner's *MPO Canopus*. The observations clearly yielded a period of  $6.6768 \pm 0.0001$  h (Figure 1). Considering the relatively large magnitude amplitude (about 0.97 mag) and phase angle of the target at the time ( $\sim 25^\circ$ ), it can be suggested that 1998 BE7 has an elongated shape.

BVRI-filter observations of 1998 BE7 and Landolt fields were made on 2008 November 5. This enabled us to measure the asteroid's color indices. The results are  $B-V = 0.727 \pm 0.063$ ,  $V-R = 0.405 \pm 0.008$ , and  $V-I = 0.897 \pm 0.009$ . From the asteroid taxonomic method describe by Bus and Binzel (2002), it can be inferred that the color indices of BE7 are consistent with a D-type asteroid. Since VR-filter observations of BE7 and Landolt fields were obtained on both 2008 October 27 and November 5, it was possible to compute the absolute magnitude based on a given slope parameter  $G$ . Assuming  $G = 0.086$  (Harris, 1989), the absolute magnitude ( $H$ ) is estimated to be  $14.773 \pm 0.323$  (Figure 2). We should point out that there is a systematic error among the

data due to unsatisfactory quality of the standard field observations, which might be as large as 0.15 mag.

The approximate size of an asteroid can be determined by (Warner 2007):

$$\log D = 3.1235 - 0.2H - 0.5 \log(p_V)$$

Where  $D$  is diameter of the asteroid in km,  $H$  is absolute magnitude, and  $p_V$  is albedo of the asteroid. Assuming the asteroid's albedo is  $0.058 \pm 0.004$ , which is based on the assumed type, the diameter is estimated to be 5.0-7.0 km.

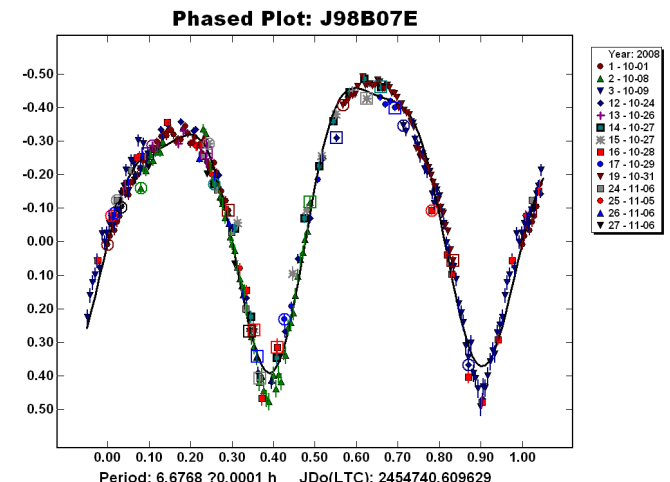
The lack of calibrated observations caused some difficulties when doing our lightcurve analysis, specifically because different solutions were possible by simply adjusting nightly zero points. This becomes a significant issue for targets without a prominent feature in their lightcurve. We recommend that lightcurve data should always be calibrated, at least on an internal system, in order to rule out false solutions.

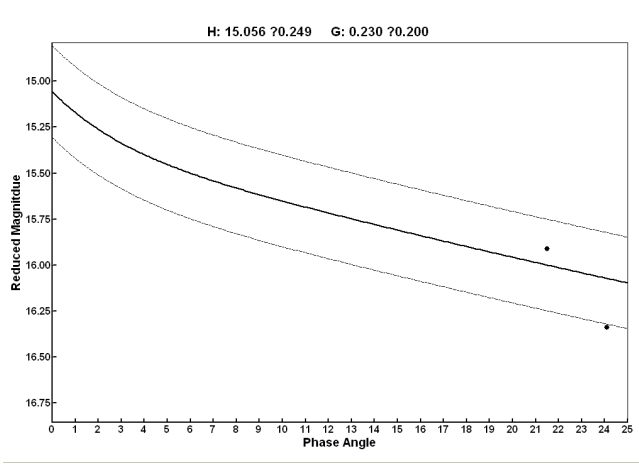
### Acknowledgements

We would like to thank Alan W. Harris and Petr Pravec for their valuable suggestions and comments and Brian D. Warner and Herbert Raab for their data reduction software. We also thank Hsiang-Yao Hsiao and Chi Sheng Lin for their assistance on obtaining the observations. This work is supported by a 2007 Gene Shoemaker NEO Grant from the Planetary Society. The 0.41-m Ritchey-Chretien telescope is operated with support from the Graduate Institute of Astronomy, National Central University.

### Reference

- Bus, S.J., and Binzel, R.P. (2002). "Phase II of the Small Main-Belt Asteroid Spectroscopic Survey: A Feature Based Taxonomy." *Icarus* **158**, 146-177.
- Harris, A.W. (1989). "The H-G Asteroid Magnitude System: Mean Slope Parameters." *Abstracts of the Lunar and Planetary Science Conference* **20**, 375.
- Warner, B.W. (2007). "Initial Results from a Dedicated H-G Project." *Minor Planet Bulletin* **34-4**, 113-119.
- Williams, G.V. (1998). "1998 BE7" *MPEC* 1998-B28.





### DIGEST OF TEN LIGHTCURVES FROM MODRA

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Lightcurve analysis of asteroids 3316 Herzberg, 6377 Cagney, 12880 Juliegrady, 14040 Andrejka, (24222) 1999 XW74, 32776 Nriag, (51840) 2001 OH65, (57478) 2001 SW151, (153462) and (190637) is reported. The lightcurves are noisy since most of asteroids were fainter than magnitude 16. The long rotation period of 14040 Andrejka was estimated with the help of MPC data.

Rotations of asteroids of magnitude 16 are usually studied with a 0.60-m  $f/5.5$  telescope and AP8p CCD-camera at Modra. However, the  $25' \times 25'$  field of view often enables us to study other targets down to magnitude 18 at the same time. The rotation period of such faint asteroids can usually be found only if the amplitude of their lightcurves is large because the noise does not then dominate the total amplitude of the lightcurve. Most of the asteroids presented here are faint with previously unknown rotational properties. The results of lightcurve analysis are summarized in Table I and appropriate lightcurves are in the figures, which include correction for light-travel time.

3316 Herzberg. Only tentative results on the order of 9.6 h for the rotation period and a low amplitude were obtained based on previous observations by Bernasconi in 2006 (Behrend 2009). More recent linked observations at Modra did not shed more light on the result. Since the amplitude of the lightcurve seems to be low ( $< 0.15$  mag), many possible rotation periods fit data. The new tentative result presented here is visually the best one within 2-18 h range. However, linkages to the same instrumental magnitude scale were not perfect and even a tiny shift of individual sessions, or enhancing order of the Fourier fit, produces a completely different best solution.

6377 Cagney and 32776 Nriag. These two asteroids were observed on three consecutive nights as they lay in the same field of view. Their rotation periods were unambiguously derived from those

sessions.

12880 Juliegrady. Ascending and descending branches of the asteroid's lightcurve seem to have been obtained during two consecutive nights. The object was extremely faint (fainter than 18 mag), but the large amplitude of the lightcurve was apparent. The period was estimated assuming two extremes in the composite lightcurve.

14040 Andrejka. As a first discovery with a provisional designation and named after my wife, this object was of special personal interest. It reaches magnitude 17 at a favourable opposition, such as in 2008. Three linked sessions at the end of November revealed just the ascending branch of the lightcurve, indicating a long rotation period ( $P > 200$  h). Two previous short sessions were not linked, so they were of limited use, if at all. No other data were obtained from Modra due to weather and other observations of higher priority. However, the large amplitude and long period encouraged me to examine some observations sent to MPC having one-decimal magnitude estimates. Among them were observations in the V band covering six nights from Steward Observatory, Kitt Peak-Spacewatch, that were promising. In combination with the Modra observations these led to  $P \sim 310$  h. Two more stations, Mt. Lemmon Survey and Catalina Sky Survey, also reported observations in the V band. Despite having only two sessions provided by each of these stations, they were not in contrast with previous estimate for  $P$ . Each of those observations was just shifted by  $+0.20$  mag to fit other data better. The fit was not expected to be perfect in any case since such small, long-period objects are usually tumblers.

(24222) 1999 XW74 and (51840) 2001 OH65. While three sessions were done every other night, some ambiguity in the rotation period exists for both 18 mag targets. Except for the results reported here, a period of 3.6390 h fits data similarly well for the former, while one of 3.215 h fits just as well for the latter. Moreover, (51840) was at the edge of images in the first session.

(57478) 2001 SW151. This asteroid was also a faint 18 mag target with large lightcurve amplitude. Its rotation period was unambiguously derived from just one long session covering more than a full cycle. The second session on the following night refined the previous result.

(153462) 2001 RE2 and (190637) 2000 WE155. Errors for these two 19 mag asteroids were roughly 0.2 mag. Data were linked to the same instrumental magnitude scale since the sessions were obtained on consecutive nights. Despite the fact that the amplitude of the lightcurves appear to be large, they are only estimated and so the rotation periods are far from being unambiguous. Except for the presented tentative results, a period of 8.90 h fits data similarly well for the former, while one of 15.2 h also fits for the latter.

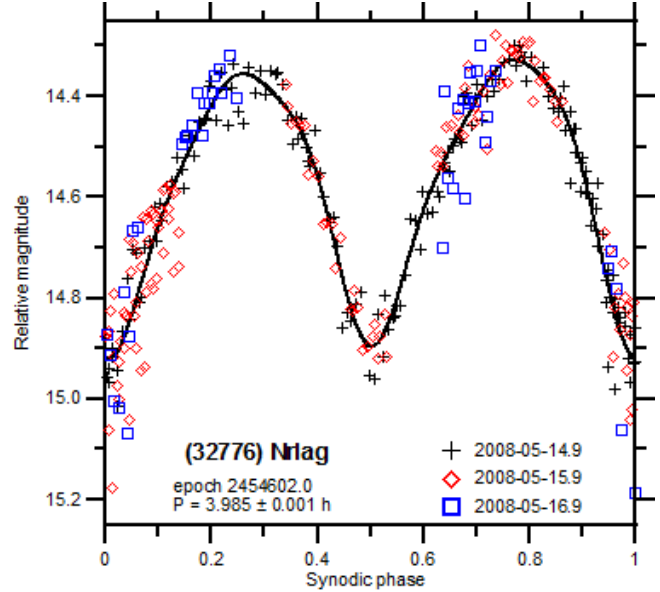
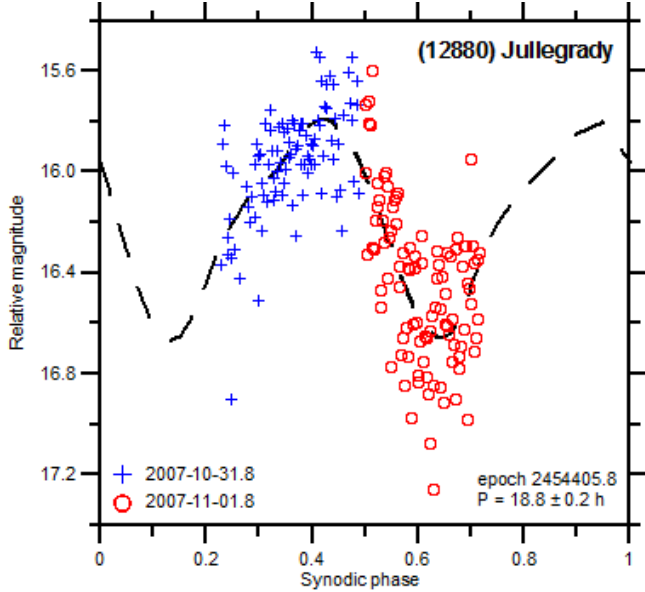
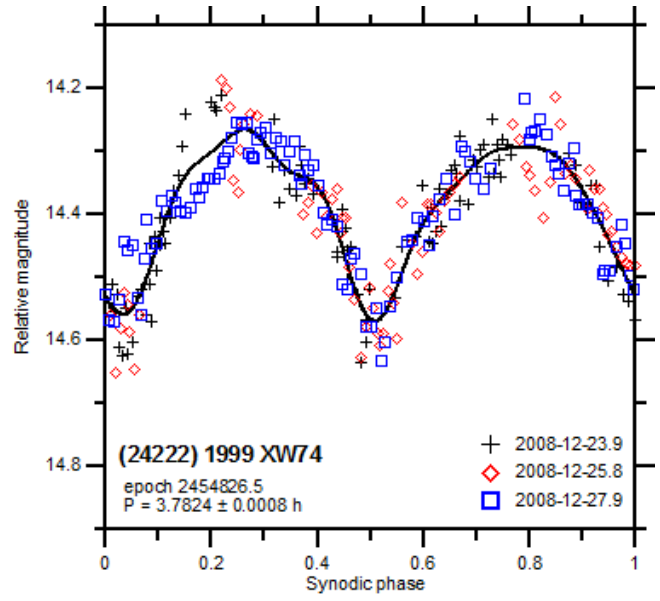
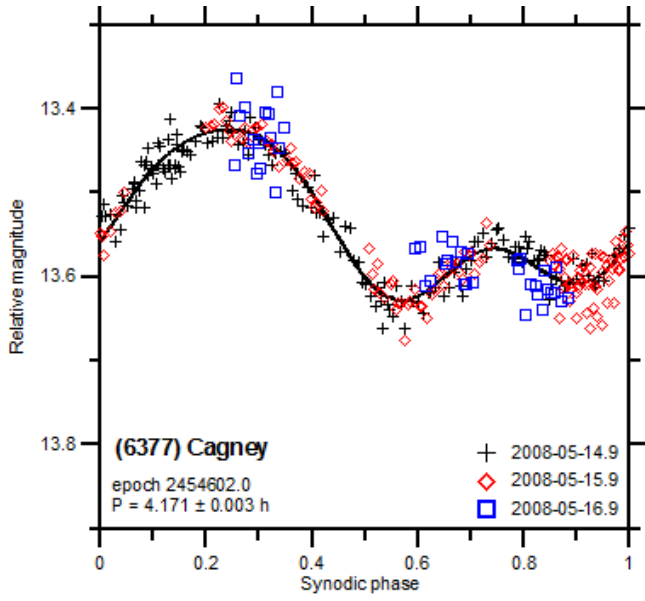
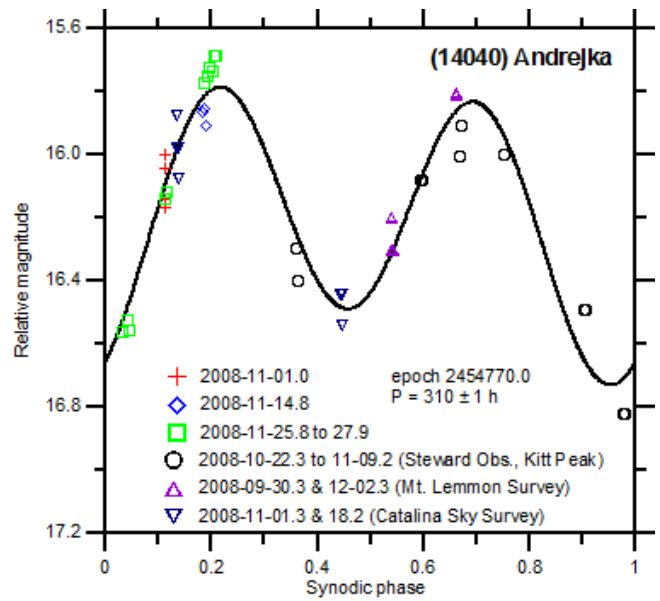
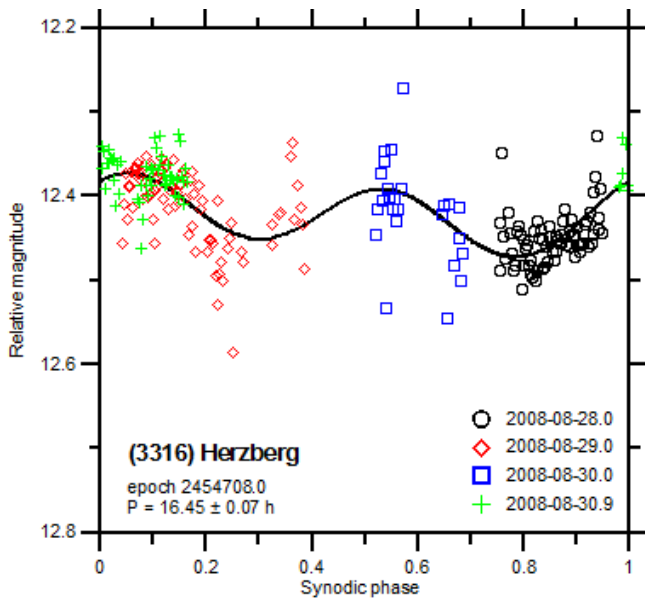
#### Acknowledgements

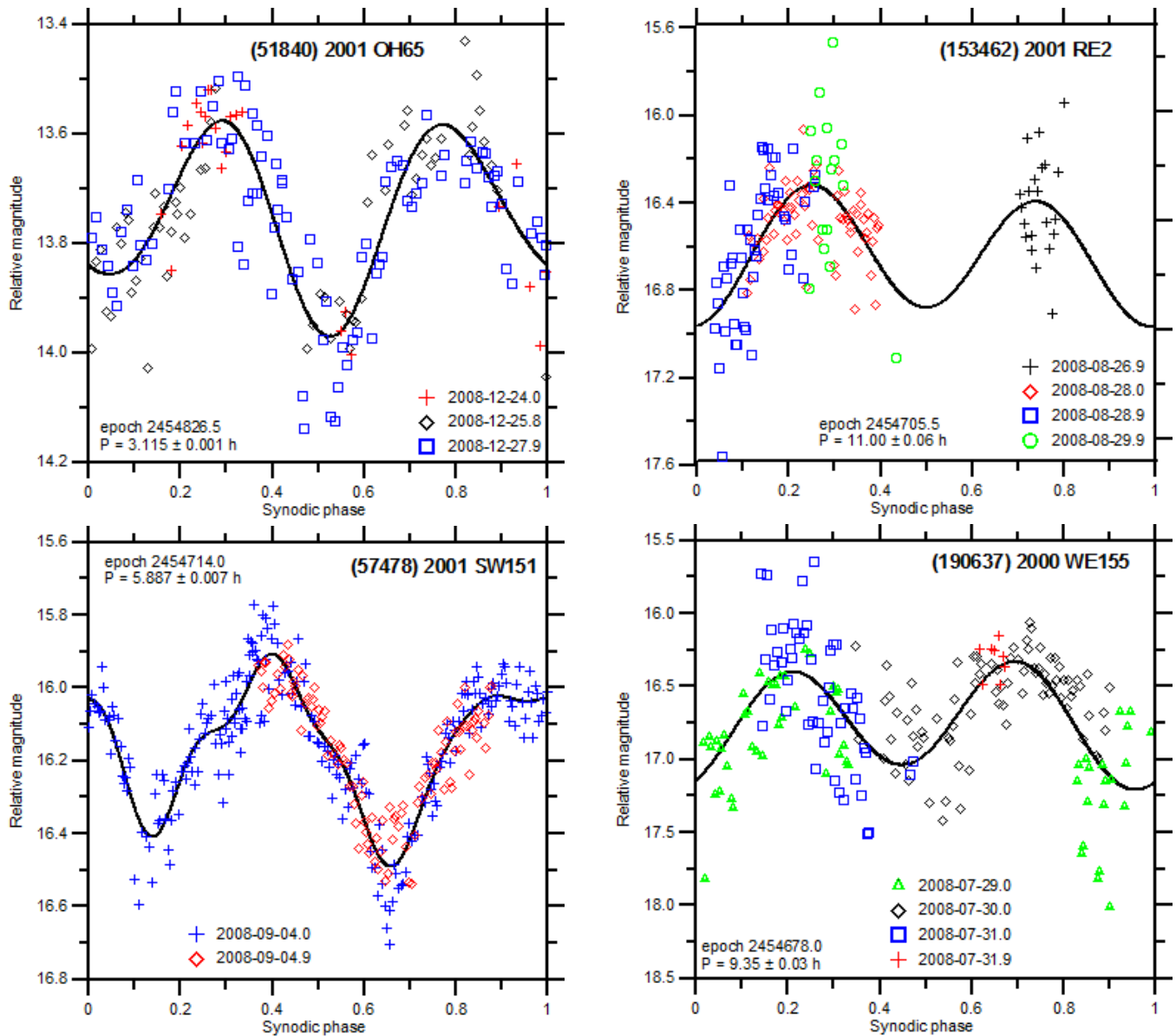
I'm grateful to Petr Pravec, Ondřejov Observatory, Czech Republic, for his ALC software used in data analysis. The work was supported by the Slovak Grant Agency for Science VEGA, Grant 2/0016/09 and the Grant Agency of the Czech Republic, Grant 205/09/1107.

#### References

Behrend, R. (2009). Observatoire de Geneve web site.  
[http://obswww.unige.ch/~behrend/page\\_cou.html](http://obswww.unige.ch/~behrend/page_cou.html)







Number	Name	Dates yyyy mm/dd	Phases deg	LPAB deg	BPAB deg	Period [h]	Amp [mag]
3316	Herzberg	2008 08/28-31	3.3-4.1	345	6	$(16.45 \pm 0.07)$	0.10
6377	Cagney	2008 05/15-17	11.7	236	20	$4.171 \pm 0.003$	0.20
12880	Juliegrady	2007 11/01-02	15.5	0	-1	$18.8 \pm 0.2$	0.9
14040	Andrejka	2008 09/30-12/02	3.6-23.4	46-52	5	$310 \pm 1$	0.95
24222	1999 XW74	2008 12/24-28	4.9-6.7	82	-1	$3.7824 \pm 0.0008$	0.30
32776	Nriag	2008 05/15-17	11.2	236	21	$3.985 \pm 0.001$	0.60
51840	2001 OH65	2008 12/24-28	3.9-5.3	81	-1	$3.115 \pm 0.001$	0.39
57478	2001 SW151	2008 09/04-05	5.6-6.0	351	5	$5.887 \pm 0.007$	0.58
153462	2001 RE2	2008 08/27-30	4.8-6.0	344	6	$11.00 \pm 0.06$	0.7?
190637	2000 WE155	2008 07/29-08/01	8.9-9.8	323	11	$9.35 \pm 0.03$	0.9?

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.

**ASTEROID LIGHTCURVE ANALYSIS AT RICKY OBSERVATORY**

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Lightcurves for 8 asteroids were obtained at Ricky Observatory from 2007 October through 2008 January: 1339 Desagneaux, 1510 Charlois, 2397 Lappajarvi, 3051 Nantong, 3335 Quanzhou, 3407 Jimmysimms, 3971 Voronikhin, and 4512 Sinuhe.

Observations of 8 asteroids were carried out at Bennefeld’s Observatory (MPC H46), which is equipped with a 0.35m Meade LX200GPS telescope operating at f/6.3 coupled to a SBIG ST7-XME CCD camera, resulting in a resolution of ~1.7 arcsec/pixel (binned 2x2). Unfiltered exposure times varied between 30 - 60 s. The asteroids under observation were selected from the list of asteroid lightcurve photometry opportunities (Warner et al., 2007a) which is also posted on the Collaborative Asteroid Lightcurve Link (CALL) website (Warner, 2007b). The students measured the photometric properties of the images using Brian Warner’s *MPO Canopus*, which employs differential aperture photometry to produce the raw data (Warner, 2007c). Period analysis of the raw data was also done using *Canopus*, which incorporates the Fourier analysis algorithm developed by Harris (1984). As well as reporting the synodic rotational period, amplitude, and phase angle of the asteroids, every attempt was made to expand on the knowledge base of the asteroids by reporting where appropriate the minimum axial ratio a/b of an elliptical asteroid and the Phase Angle Bisector in longitude and latitude PAB<sub>L</sub> PAB<sub>B</sub> respectively.

**Determining a/b ratio and Phase Angle Bisector**

An asteroid’s axial ratio a/b reported on in this paper was derived based on the following postulation. Given the intensity of light reflected from an asteroid is proportional to the magnitude of the asteroid and the magnitude of the asteroid is proportional to the surface area from which the light was reflected, then in the case of a triaxial elliptical asteroid, the surface area is proportional to the length of the axes a/b. Consequently, the ratio of the change in maximum and minimum intensities can be logarithmically modeled to yield the minimum axial ratio a/b, mathematically

speaking.

$$\log_{10}\left(\frac{I_a}{I_b}\right) = \log_{10}(2.512)^{(m_a - m_b)}$$

Recalling the general logarithm rule that  $\log_{10}R^S = S \log_{10}R$ , the right side of the equation can be rewritten

$$\log_{10}\left(\frac{I_a}{I_b}\right) = (m_a - m_b) \log_{10}(2.512)$$

Solving the right side equation for the logarithmic term yields

$$\log_{10}\left(\frac{I_a}{I_b}\right) = (m_a - m_b)(0.4)$$

Given the “reverse” nature of the stellar magnitude system 0.4 is replaced with -0.4. Expressing the equation in exponential form yields,

$$\frac{I_a}{I_b} = 10^{(\Delta m)(-0.4)}$$

Where;

- I<sub>a</sub> Intensity of the light at the maximum.
  - I<sub>b</sub> Intensity of the light at minimum.
  - m<sub>a</sub> Maximum magnitude (*a negative value*)
  - m<sub>b</sub> Minimum magnitude.
  - Δm (m<sub>a</sub> - m<sub>b</sub>)
- Note (m<sub>a</sub>-m<sub>b</sub>) will be negative*

Given the direct relationship between the intensity, magnitude, and axial length of an asteroid the ratio of the lengths of the axes can therefore be modeled with the equation.

$$\frac{a}{b} \approx 10^{(m_a - m_b)(-0.4)}$$

The a/b value reported is the minimum value, meaning the axis of rotation could be tilted significantly towards the observer.

The concept of the PAB first proposed by Harris et al. (1984) was an effort to standardize the viewing aspect to determine if the synodic brightening of an asteroid was due in part to its pole position. The values used for calculating the PAB<sub>L</sub> and PAB<sub>B</sub> were obtained from the Jet Propulsion Laboratory’s Solar System Dynamics, Horizons web-interface, (Table Settings 18, 24, 31) (JPL 2008). The equations necessary in determining PAB<sub>L</sub> and PAB<sub>B</sub> are as follows.

$$PAB_L = \frac{(ObsEcLon) - (hEcl - Lon)}{2} + (hEcl - Lon)$$

#	Name	Date Range (mm/dd)	Data Pts	Phase	PAB <sub>L</sub>	PAB <sub>B</sub>	Per (h)	PE	Amp	AE
1339	Desagneaux	2007 11/15-11/18	347	8.82	31.89	10.33	9.380	0.001	0.45	0.02
1510	Charlois	2007 11/29-11/30	303	10.99	46.68	14.87	6.653	0.008	0.30	0.03
2397	Lappajarvi	2008 01/14-01/19	391	3.41	114.86	-7.08	9.05	0.01	0.42	0.01
3051	Nantong	2007 10/20-11/02	317	12.92	33.55	18.41	3.690	0.001	0.24	0.01
3335	Quanzhou	2008 01/27-01/28	472	15.46	96.04	-1.67	4.968	0.003	0.80	0.03
3407	JimmySimms	2008 01/27-02/16	334	7.24	127.24	8.30	6.821	0.001	0.95	0.02
3971	Voronikhin	2007 10/06-10/10	565	12.48	355.04	16.18	5.552	0.001	0.38	0.03
4512	Sinuhe	2008 02/09-02/13	258	17.42	108.54	-0.58	18.000	0.012	0.85	0.01

and

$$PAB_B = \frac{(ObsEcLat) - (hEcl - Lat)}{2} + (hEcl - Lat)$$

Where:

(hEcl – Lon) and (hEcl-Lat) are the geometric heliocentric J2000 ecliptic longitude and latitude of the asteroid, respectively.

(ObsEcLon) and (ObsEcLat) are the Observer-centered longitude and latitude of the asteroid, respectively.

#### Lightcurve Analysis

1339 Desagneaux. A main belt asteroid discovered in 1934 was sampled 347 times over 4 nights to achieve a synodic rotational period of  $9.380 \pm 0.001$  h. The absolute value of the peak-to-peak magnitude differential ( $\Delta M$ ) 0.45 implies an axial ratio (a/b) of 1.51. The reported period agrees closely with Ray who reported a provisional period of 9.3288 h (Behrend 2008).

1510 Charlois. A main belt asteroid discovered in 1939 was sampled 303 times over 2 nights to yield a synodic rotational period of  $6.653 \pm 0.008$  h. Owing to noisy data the absolute value of the peak-to-peak magnitude differential can only be roughly estimated at 0.30 magnitudes. No other lightcurves for this asteroid are known to exist.

2397 Lappajarvi. A main belt asteroid discovered in 1938, Lappajarvi was sampled 391 times over a 4 night period to yield a synodic rotational period of  $9.05 \pm 0.01$  h. The absolute value of the peak-to-peak magnitude differential of 0.42 implies an axial ratio (a/b) of 1.47. No other lightcurves for this asteroid are known to exist.

3051 Nantong. A main belt asteroid discovered in 1974, Nantong was sampled 317 times over a 2 night period to yield a synodic rotational period of  $3.690 \pm 0.001$  h. Although the absolute value of the peak-to-peak magnitude differential is 0.24, the asymmetrical nature of the lightcurve precludes a reliable value on the axial ratio. No other lightcurves for this asteroid are known to exist.

3335 Quanzhou. This main belt asteroid, discovered in 1966, was sampled 472 times over a 2 night period to yield a synodic rotational period of  $4.968 \pm 0.003$  h. Due to the poor SNR and the asymmetrical nature of the asteroid, the 0.80 magnitude differential ( $\Delta M$ ) is an estimate and the a/b axial ratio was not calculated. The authors would like to note that starting at 0.28 phase mark continuing to the 0.39 phase mark (approximately 54 minutes) there was a sudden 0.40 magnitude drop in the lightcurve. No other lightcurves for this asteroid are known to exist.

3407 Jimmysimms. A main belt asteroid discovered in 1973, Jimmysimms was sampled 334 times over a 3 night period to yield a synodic rotational period of  $6.281 \pm 0.001$  h. The absolute value of the peak-to-peak magnitude differential is 0.95, implying an axial ratio (a/b) of 2.40. Behrend (2008) reports a final period of  $6.8184 \pm 0.0014$  h.

3971 Voronikhin. This main belt asteroid, discovered in 1979, was sampled 565 times over a 3 night period to yield a synodic rotational period of  $5.552 \pm 0.001$  h. The absolute value of the peak-to-peak magnitude differential is 0.38. Owing to the irregular

shape of the lightcurve, the axial ratio a/b was not calculated. The authors would like to note that at the 0.80 phase mark, which coincides with the second peak, there is a peculiar 0.08 magnitude drop that last 26 minutes. The magnitude drop occurred on each of the 3 nights during the 6 day span of observations. Previous work on this asteroid by Shipley et al. (2008) produced a synodic rotational period of  $5.41 \pm 0.014$  h.

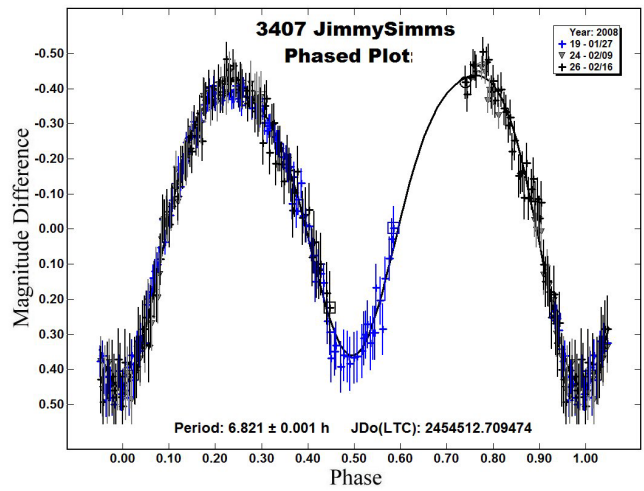
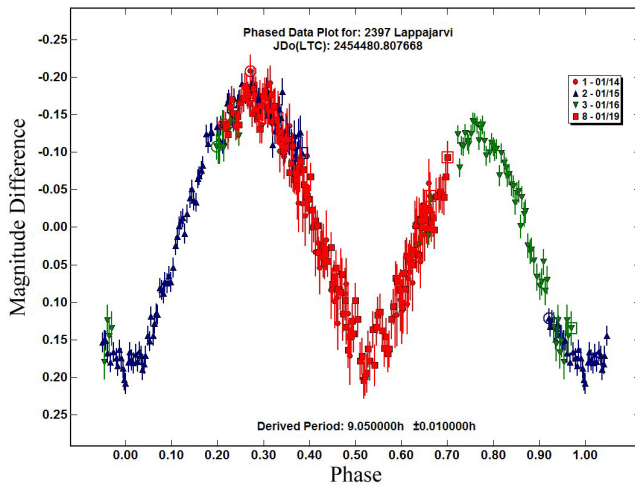
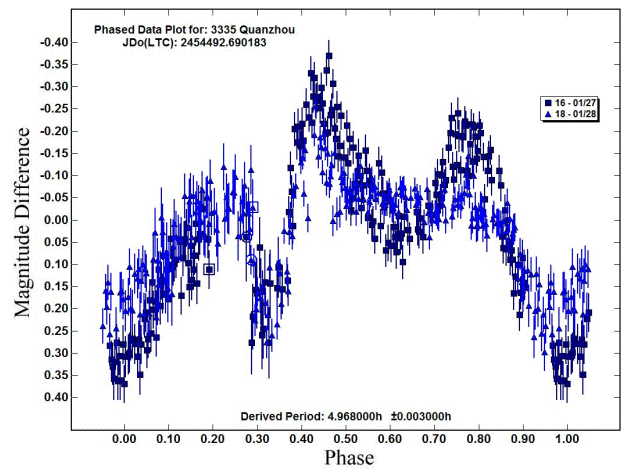
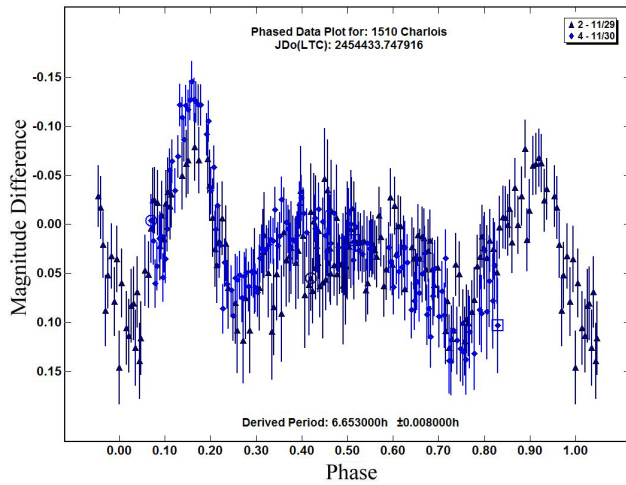
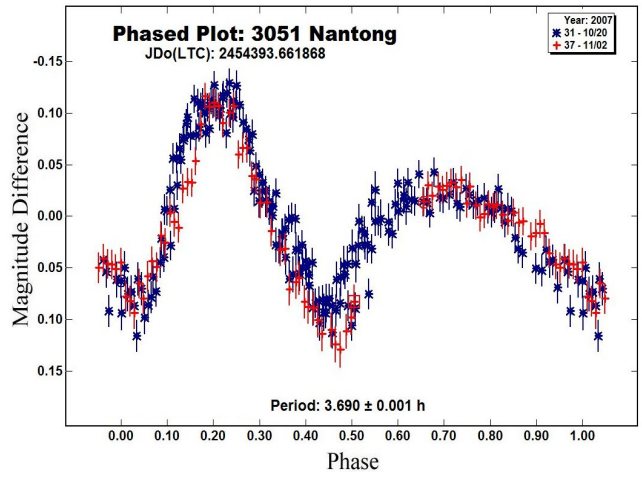
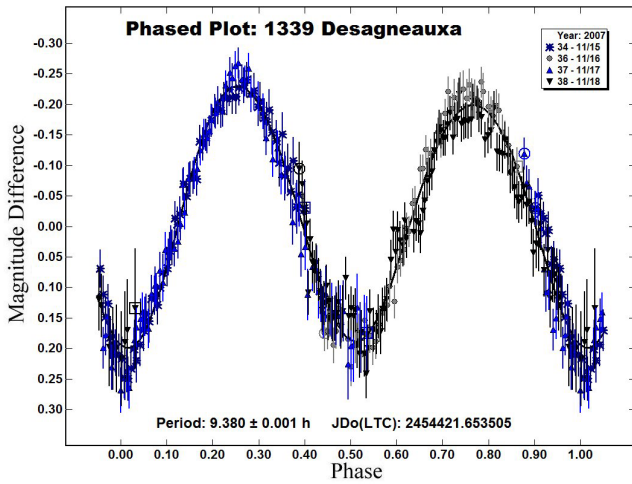
4512 Sinuhe. A main belt asteroid discovered in 1939, Sinuhe was sampled 258 times over 2 nights to yield a tentative synodic rotational period of  $18.000 \pm 0.012$  h. According to the Fourier analysis algorithm, the absolute value of the peak-to-peak magnitude differential is 0.85 and the implied axial ratio (a/b) is 2.18. However, the gap in the lightcurve near the first maximum probably “fooled” the analysis and so the true peak-to-peak range is very likely smaller, possibly on the order of 0.60 mag. No other lightcurves for this asteroid are known to exist.

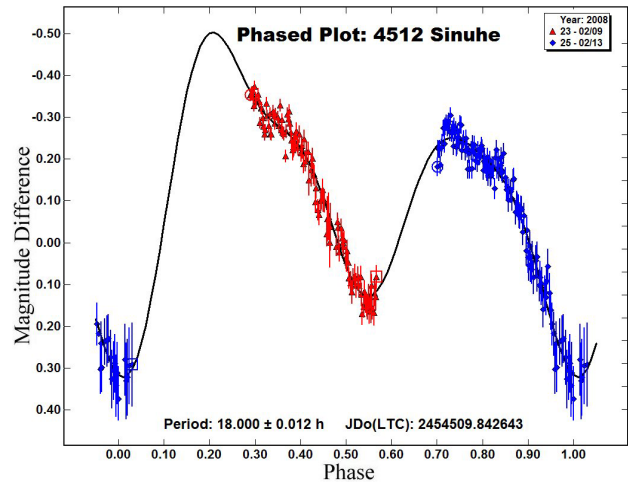
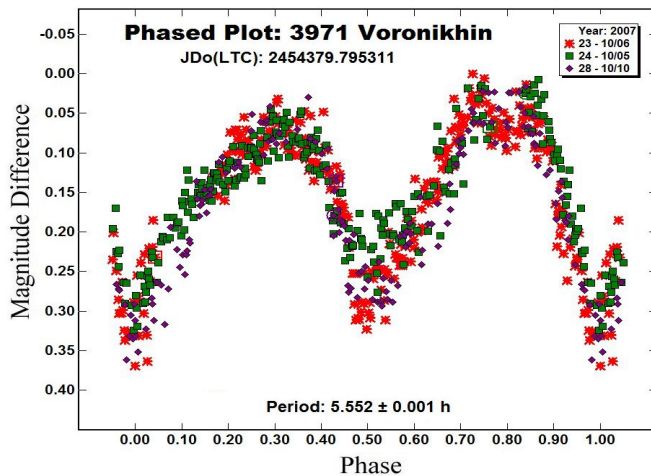
#### Acknowledgements

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#### References

- Behrend, R. (2007). “Asteroids and Comets Rotation Curves, CdR.” <http://obswww.unige.ch/~behrend/page4cou.html>.
- Harris, A.W., Young, J.W., Bowell, E., Scaltriti, F., and Zappala, V. (1984). “Lightcurves and Phase Relations of the Asteroids 82 Alkmene and 444 Gyptis.” *Icarus* 57, 251-258.
- Jet Propulsion Laboratory Horizons Web-Interface, data retrieved 2008 Nov 2, <http://ssd.jpl.nasa.gov/horizons.cgi>
- Shipley, H., Dillard, A., Kendall, J., Reichert, M., Sauppe, J., Shaffer, N., Kleeman, T., and Diteon, R. (2008). *Minor Planet Bulletin* 35, 99-101.
- Warner, B.D., Harris, A.W., Pravec, P., Kaasalainen, M. and Benner, L.A.M. (2007a). “Lightcurve Photometry Opportunities: July-September 2007.” *Minor Planet Bulletin* 34, 92-94.
- Warner, B.D. (2007b). “Collaborative Asteroid Lightcurve Link.” <http://www.minorplanetobserver.com/astlc/default.htm>.
- Warner, B.D. (2007c). MPO Software, Canopus version 9.4.0.3 Bdw Publishing, Colorado Springs, CO.





### SHAPE AND SPIN AXIS MODEL FOR 683 LANZIA

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New lightcurves of the main belt asteroid 683 Lanzia combined with data collected between 1979 – 2006 have allowed a secure shape model to be developed, refining the spin axis to  $\lambda = 244 \pm 5^\circ$ ,  $\beta = 44 \pm 5^\circ$  and the sidereal period to  $8.62926 \pm 0.00001$  h.

New observations of the main-belt, class C asteroid 683 Lanzia were obtained from the Rattlesnake Creek Observatory in 2008 with the intent of modeling the shape and spin axis of the asteroid. This observatory is equipped with a 0.25-m LX200R OTA and a 0.67 reducer, carrying a QSI 516ws CCD camera, all on a Losmandy/Gemini mount. The present target was chosen from the listings in *The Minor Planet Bulletin's* Shape/Spin Modeling Opportunities column.

A total of 32 lightcurves, dating from 1979 to 2008, were used for modeling. The co-authors generously and promptly shared their previously published observational data (Bernasconi, 2008; Oey, 2006; Stephens, 2004) for this study. The earliest data (Carlsson

and Lagerkvist, 1981; Weidenschilling et al., 1990) were available from the Uppsala Catalogue (Lagerkvist et al., 2001) on the SAPC website (Torppa, 2008). The final set of observations was made by Dunckel in 2008 and is shown in Figure 1. Images were unguided, unfiltered and calibrated with darks and flats. Reductions were done with Brian Warner's *MPO Canopus* software and shape modeling was done with his *MPO LCInvert* program.

Warner (2008a,b) gives details on the data reduction process used here to model 683 Lanzia. The first need is to incorporate data from a number of oppositions covering a breadth of phase angles. These lightcurves were recovered from the literature and the data obtained by the authors. The phase angles ranged from  $7^\circ$  to  $19^\circ$ . Next, an accurate sidereal period must be found (the period history is shown in Table 1). This period was then used to initiate the search routine for a pole solution.

As noted by Warner (2008b) 30 initial poles are tested with the pole solutions and period allowed to float. A valid solution is returned when the chi-squared values are 10% below other solutions. In the present case, two nearly identical solutions were 9.4% below other solutions,  $\lambda = 244.5^\circ/243.8^\circ$  and  $\beta = 43.5^\circ/44.7^\circ$ . These results are reported in Table 2 along with earlier determinations, which did not have the advantage of the additional lightcurves available for this work. Additionally, the pole solution should result in a "dark area" of less than 1%, and here it is 0.3%

Paper	Period (h)	Amplitude
Carlsson (1979)	4.322	0.16
Weidenschilling (1990)	8.6	0.12 – 0.20
Kiss (1999) <sup>a</sup>	4.7139744	0.13
Stephens (2004)	8.63 ± 0.05	0.15
Bernasconi (2004)	8.6244 ± 0.0055	0.15
Oey (2006)	8.631 ± 0.001	0.20
Present work	8.62926 ± 0.00001	0.16
<sup>a</sup> Data not incorporated		

Table 1. History of period determinations

Paper	Lambda <sup>o</sup>	Beta <sup>o</sup>	a / b	b / c
De Angelis (1995)	198/342	±55	1.85	1.00
Kiss (1999)	15/195 ± 25	52 ± 15	1.15	1.05
Present work	244 ± 5	44 ± 5	0.950	1.705

Table 2. History of spin vector solutions

in both cases. Finally, the shape model shown in Figure 3 was generated with shape values of  $a/b = 0.950$ ,  $b/c = 1.705$ . As a last step, lightcurves for the times of observations were generated to confirm the modeling. Figure 2 shows the match with the 1979 data from Carlsson (1981).

The absence of dynamic information from the asteroid prevents any absolute size determination. Furthermore, since the data were treated as relative lightcurves, the c-axis is not formally constrained and so the  $b/c$  ratio is only an estimate. The main source of asteroid diameters is from the Infrared Astronomical Satellite data (Tedesco, 2002) as well as from occultation data. There is no occultation data for 683 Lanzia, and the IRAS analysis gives the diameter as  $83.04 \pm 22.2$  km, an unusually wide range.

An attempt was made to incorporate sparse data from the U. S. Naval Observatory available on the AstDys web site (<http://hamilton.dm.unipi.it/cgi-bin/astdys/astibo>) as outlined in Warner (2008b). In this case, however, inaccuracies in the data apparently affected the result since after adding the separately processed data to the previous data file and searching for a vector solution as noted above, there were 19 differing solutions within 10% of the lowest chi-squared. Thus the model failed to converge and produce a reliable solution.

#### Acknowledgements

The remarkable tools developed by Mikko Kaasalainen, Joseph Āurech, and Brian Warner (Warner 2008a) that allow the amateur community to join professionals in spin and shape modeling of asteroids are to be highly recommended to anyone with the interest and patience to use them.

#### References

- Bernasconi, L. (2008). Observatoire de Geneve web site. [http://obswww.unige.ch/~behrend/page\\_cou.html](http://obswww.unige.ch/~behrend/page_cou.html)
- Carlsson, M., and Lagerkvist, C.-I. (1981). "Physical Studies of Asteroids. I – Photoelectric Observations of the Asteroids 38, 218, 268, 344, 485, 683, 690 and 792." *Astron. Astrophys. Suppl. Ser.* **44**, 15-22.
- De Angelis, G. (1995). "Asteroid Spin, Pole and Shape Determination." *Planetary and Space Science* **43**, 649-682.
- Kiss, L.L., Szabo, Gy., and Sarneczky, K. (1999). "CCD Photometry and New Models of 5 Minor Planets." *Astron. Astrophys. Suppl. Ser.* **140**, 21-28.
- Lagerkvist, C. I., Piironen, and J., Erikson, A. (2001). "Asteroid Photometric Catalogue, Fifth Update." Uppsala Astronomical Observatory.
- Oey, J. (2006). "Lightcurve Analysis of 10 Asteroids from Leura Observatory." *Minor Planet Bulletin* **33**, 96 - 98.
- Stephens, R.D. (2004). "Photometry of 683 Lanzia, 1101 Clematis, 1499 Pori, 1507 Vaasa, and 3893 Delaeter." *Minor Planet Bulletin* **34**, 4-6.
- Tedesco, E.F., Noah, P.V., and Price, S.D. (2002). "Supplemental IRAS Minor Planet Survey." *Astron. J.* **123**, 1056-1085.
- Torppa, J. (2008) "The Standard Asteroid Photometric Catalogue" (SAPC). <http://www2.astro.helsinki.fi/SAPC/index.jsp>.

Warner, B.D., Higgins, D., Pray, D.P., Dyving, R., Reddy, V., and Āurech, J. (2008a). "A Shape and Spin Axis Model for 1600 Vysotsky." *Minor Planet Bulletin* **35**, 13-14.

Warner, B.D., Āurech, J., Fauerbach, M., and Marks, S. (2008b). "Shape and Spin Axis Models for Four Asteroids." *Minor Planet Bulletin* **35**, 167-171.

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

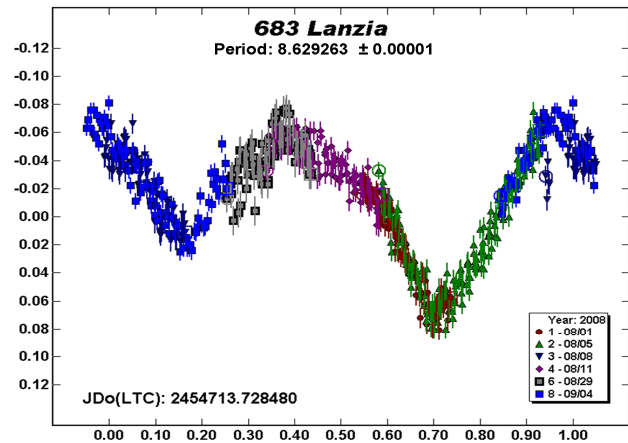


Figure 1. Lightcurve for 683 Lanzia (Present work)

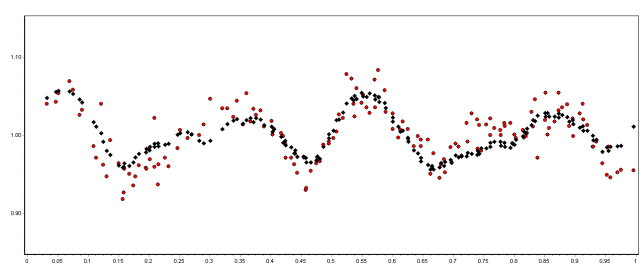


Figure 2. 683 Lanzia model curve (black) vs. 1979 data

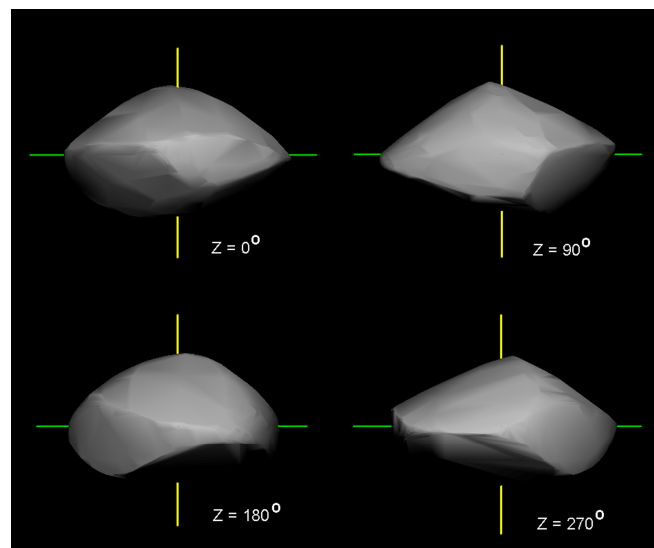


Figure 3. Equatorial view of 683 Lanzia model. North pole is up, and the views are 90° rotations around the Z-axis.

**PHOTOMETRY OF ASTEROIDS 7516 KRANJC, 7965 KATSUHIKO, AND (15515) 1999 VN80 FROM LEURA AND OTHER COLLABORATING OBSERVATORIES**

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Observations of three asteroids were done in collaboration with observers around the world. The derived synodic periods are as follows: 7516 Kranjc,  $3.96776 \pm 0.00005$  h; 7965 Katsuhiko,  $5.3897 \pm 0.0003$  h; and (15515) 1999 VN80,  $4.175 \pm 0.002$  h.

Table 1 details the observations by the authors. The instruments used by the authors are summarized in Table 2. The 1-m Lick observatory Nickel telescope was used by Marchis and Stewart remotely. *MPO Canopus* V.9.4.0.1 software was used for period analysis which incorporates the Fourier algorithm developed by Harris (1989).

**7516 Kranjc.** This main-belt asteroid (MBA) with a previously unknown period was selected from the list provided by Pravec for the Photometric Survey of Asynchronous Binary Asteroids (PSABA, Pravec 2008). Oey started the observations on 2008 April 12. On April 26 an event was captured showing two gradual

0.1 mag attenuations (Fig. 1). These were thought to be the result of the occultation and eclipse of a small satellite. Once confirmed by Pravec, the observers in the PSABA were alerted for follow up observations. However, even after our concerted effort, no other events were detected. Re-analysis of the April 26 data affirmed the absence of any observational anomalies and so confirmed the attenuation. When only one event is detected, the explanation may be the evolution of the position of earth and sun away from the orbital plane of the asteroid-satellite. It's also possible that the mutual events might have occurred outside the observational period, as explained by Pravec et al. (2006). 7516 Kranjc remains a suspect binary and warrants future investigation. The combined sessions with a total of 1686 data points generated a lightcurve with a synodic period of  $3.96776 \pm 0.00005$  h and amplitude of  $0.15 \pm 0.02$  mag. No significant amplitude variations were noted during the course of the two-month campaign.

**7965 Katsuhiko.** This asteroid was put forward by Colin Bembrick as a Southern Hemisphere target at a favorable opposition. Observations by Oey and Crawford were combined to arrive at a synodic period of  $5.3897 \pm 0.0003$  h with amplitude of  $0.40 \pm 0.02$  mag. There were no known previous studies on this asteroid.

**(15515) 1999 VN80.** During a routine observation of minor planet 929 Algunde, Oey noticed that (15515) 1999 VN80 was also in the field. 929 Algunde was a target within Pravec's PSABA program at the time and so a call was put out to group members to see if anyone else had data on 1999 VN80. Vilagi responded and agreed to combine his data with Oey's. Pravec was subsequently approached by R. Behrend for an analysis of the Behrend et al. data (2008) for the possibility of the asteroid being binary. However, that data showed no conclusive characteristics of a binary lightcurve. The synodic period derived from the Oey-Vilagi data was  $4.175 \pm 0.002$  h, which is consistent with the period of  $4.1694 \pm 0.0002$  h derived by Behrend et al.

#### Acknowledgements

We would like to thank Petr Pravec from Ondrejov observatory for providing the amateur community the opportunity to be part of an exciting pro-am collaboration in binary asteroid research. H. Stewart is grateful to the SETI Institute REU exobiology student program which supported her research during part of 2008. The work at Modra Observatory was supported by the Slovak Grant Agency for Science VEGA, Grants 1/3074/06 and 1/3067/06.

#### References

- Behrend, R. (2008). Observatoire de Genève web site. [http://obswww.unige.ch/~behrend/page\\_cou.html](http://obswww.unige.ch/~behrend/page_cou.html)
- Harris, A.W., Young, J.W., Bowell, E., Martin, L.J., Millis, R.L., Poutanen, M., Scaltriti, F., Zappala, V., Schober, H.J., Debehogne, H., and Zeigler, K.W. (1989). "Photoelectric Observations of

Object	Observer	Session No.	Phase (deg)	LPAB (deg)	BPAB (deg)
7516 Kranjc	Oey (1)	1-8, 12-14, 16, 18, 19, 21, 23	19, 8	234, 238	8, 10
7516 Kranjc	Cooney, Gross, Terrell	15, 17	10	237	10
7516 Kranjc	Marchis, Stewart	26-29	13	240	11
7516 Kranjc	Brinsfield	20, 22, 24, 25	9	237	10
7516 Kranjc	Stephens	9, 11	11	237	10
(15515) 1999 VN80	Oey (1)	1, 4	13.4	331	5
(15515) 1999 VN80	Vilagi	2, 3, 5, 6	11.2	331	5
7965 Katsuhiko	Oey (2)	1, 2, 7, 8	15, 12	285	-19, -16
7965 Katsuhiko	Crawford	3-6	13	285	-18

Table 1. Observation details. Oey: 1 = Leura, 2 = Kingsgrove. LPAB and BPAB are Phase Angle Bisector values.



Observatory	Telescope	Camera	Resolution / FOV	Notes / Software
Leura	0.35m f/6.5 SCT	ST9XE	1.80 (15.4 x 15.4)	300s, MPO Canopus
Kingsgrove	0.25m f/5.2 SCT	ST402ME	1.40 (17.9 x 11.9)	300s, MPO Canopus
Sonoita	0.35m f/11 SCT	STL-1001E	1.25 (22.0 x 22.0)	MPO Canopus
Lick	1.0m f/17 Cassegrain	Direct Imaging	0.37 (12.6 x 12.6)	CCD-2, bin 2x2
GMARS	0.35m f/11 SCT	STL 1001E	1.23 (23.0 x 23.0)	Bin 1x1, MPO Canopus
Modra	0.60m f/5.5 reflector	AP8p	1.50 (25.0 x 25.0)	IRAF+custom software
Via Capote	0.35m f/10 Cassegrain	Alta U6	1.43 (24.4 x 24.4)	MPO Canopus
Bagnall Beach	0.28m f/11.5 SCT	ST9E	1.29 (11.0 x 11.0)	MPO Canopus

Table 2. Instrument specifications. Resolution is image scale in arcsecond pixel<sup>-1</sup>; FOV is the field of view in arcminutes. The Notes column gives information such as exposure times, reduction software used, and other equipment details.

Asteroids 3, 24, 60, 261, and 863.” *Icarus* **77**, 171-186.

Pravec, P., Scheirich, P., Kušnirák, P., Šarounová, L., Mottola, S., Hahn, G., Brown, P., Esquerdo, G., Kaiser, N., Krzeminski, Z., Pray, D.P., Warner, B.D., Harris, A.W., Nolan, M.C., Howell, E.S., Benner, L.A.M., Margot, J.-L., Galád, A., Holliday, W., Hicks, Krugly, Yu. N., Tholen, D., Whiteley, R., Marchis, F., DeGraff, D.R., Grauer, A., Larson, S., Velichko, F.P., Cooney Jr., W.R., Stephens, R., Zhu, J., Kirsch, K., Dyvig, R., Snyder, L., Reddy, V., Moorex, S., Gajdoš, Š., Világi, J., Masi, G., Higgins, D., Funkhouser, G., Knight, B., Slivan, S., Behrend, R., Grenon, M., Burki, G., Roy, R., Demeautis, C., Matter, D., Waelchli, N., Revaz, Y., Klotz, A., Rieugné, M., Thierry, P., Cotrez, V., Brunetto, L., and Kober, G. (2006). “Photometric survey of binary Near-Earth Asteroids.” *Icarus* **181**, 63-93.

Pravec, P. (2008). “Photometric Survey of Asynchronous Binary Asteroids.” <http://www.asu.cas.cz/~asteroid/binastphotosurvey.htm>.

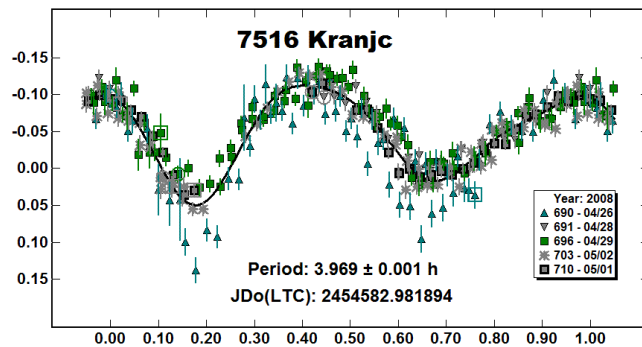


Figure 1. Lightcurve of 7516 Kranjc showing the attenuation.

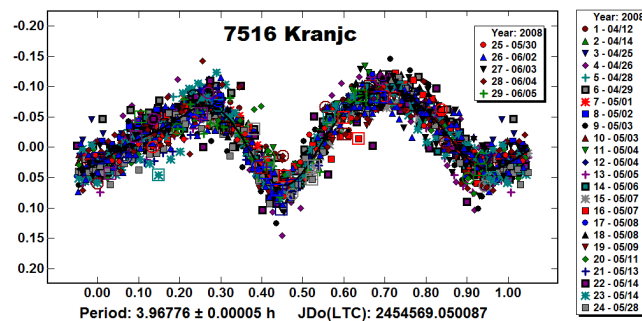


Figure 2. Composite lightcurve of 7516 Kranjc.

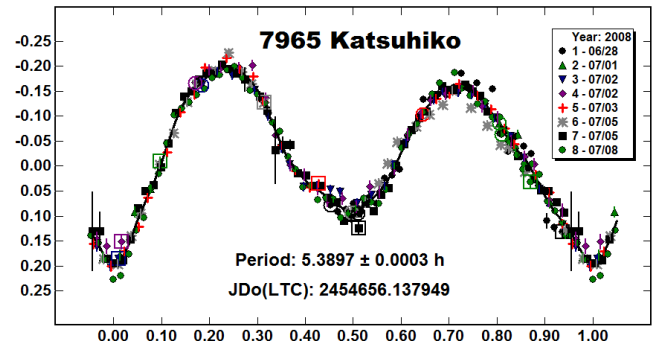


Figure 3. Composite lightcurve of 7965 Katsuhiko.

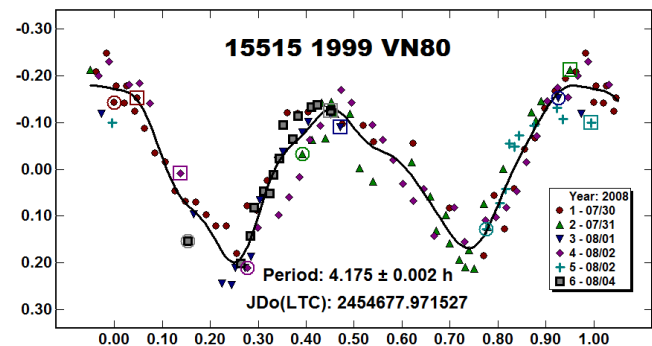


Figure 4. Composite lightcurve of (15515) 1999 VN80.

## LIGHTCURVES FOR 155 SCYLLA AND 2358 BAHNER

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Lightcurve observations have yielded period determinations for the followings asteroids: 155 Scylla,  $7.960 \pm 0.001$  h; and 2358 Bahner,  $10.855 \pm 0.001$  h.

Photometric data were collected using a 36-cm Meade Schmidt-Cassegrain telescope operating at f/6.06 with a focal reducer and Apogee U9 camera at Barnes Ridge Observatory located in northern California. The camera was binned 1x1 with a resulting image scale of 0.86 arc-seconds per pixel. The images for Scylla were taken through a clear filter while those for Bahner were taken through a Johnson-Cousins V filter. All image exposures were 120 seconds at  $-25C$ . All photometric data were obtained with *MaxIm*

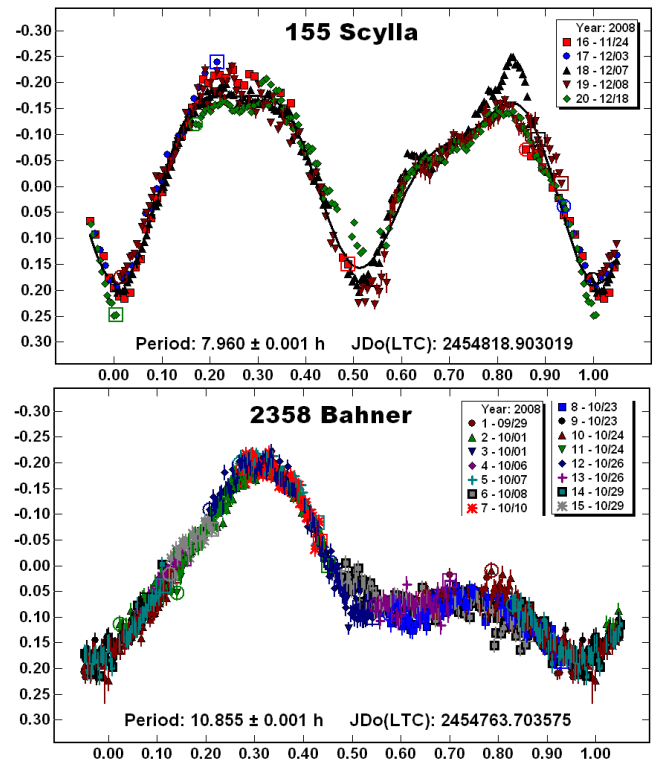
*DL v5* (Diffraction Limited Software) driven by *ACP v5* (DC3 Dreams Software) and analyzed using *MPO Canopus v9.5* (Bdw Publishing). All comparison stars and asteroid targets had at least 100 SNR.

**155 Scylla.** Data were collected from 2008 November 24 through December 18 resulting in 5 data sets and 421 data points. A period of  $7.960 \pm 0.001$  h was determined. A previous lightcurve with a period of  $7.9580 \pm 0.0020$  h and 0.20 mag amplitude has been reported by Addleman et al. (2005).

**2358 Bahner.** Data were collected from 2008 September 29 through October 29 resulting in 15 data sets and 960 data points. A period of  $10.855 \pm 0.001$  h was determined. No previous published lightcurve data have been found.

#### References

Addleman, D., Covele, B., Duncan, A., Johnson, J., Kramb, S., Lecrone, C., Reichert, C., Starnes, H., Twarek, A., Kirkpatrick, E., and Ditteon, R. (2005). "Rose-Hullman Spring 2005 Lightcurve Results: 155 Scylla, 590 Tomyris, 1655 Comas Sola, 2058 Roka, 6379 Vrbs, and (25934) 2001 DC74." *Minor Planet Bulletin* **32-4**, 76-78.



### PERIOD DETERMINATIONS FOR 31 EUPHROSYNE, 35 LEUKOTHEA, 56 MELETE, 137 MELIBOEA, 155 SCYLLA, AND 264 LIBUSSA

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Synodic rotation periods and amplitudes are reported for the following asteroids: 31 Euphrosyne  $5.530 \pm 0.002$  h,  $0.08 \pm 0.01$  mag; 35 Leukothea  $31.962 \pm 0.05$  h,  $0.08 \pm 0.02$  mag with one maximum and minimum per cycle; 56 Melete  $18.147 \pm 0.001$  h,  $0.10 \pm 0.01$  mag with four unequal maxima and minima per cycle; 137 Meliboea  $25.676 \pm 0.001$  h,  $0.16 \pm 0.02$  mag; 155 Scylla  $7.9597 \pm 0.0001$  h,  $0.46 \pm 0.03$  mag; 264 Libussa  $9.2276 \pm 0.0002$  h,  $0.33 \pm 0.03$  mag.

Observations of six asteroids were all obtained at the Organ Mesa Observatory using a 35.4-cm Meade LX 200 GPS S-C and SBIG STL-1001E CCD. Exposures were 60 seconds and unguided through a clear filter. Image measurement using differential photometry and lightcurve analysis were done with *MPO Canopus*. Due to the large number of data points acquired for each target in this study, the lightcurves have been binned in sets of three data points with a maximum of five minutes between points.

**31 Euphrosyne.** Harris et al. (2008) state a period of 5.531 h. New observations on four nights, 2008 Apr. 6–25, show a period of  $5.530 \pm 0.002$  h, amplitude  $0.08 \pm 0.01$  mag.

**35 Leukothea.** Lagerkvist et al. (1987) show no variation beyond 0.02 mag. Weidenschilling et al. (1990) found a lightcurve with amplitude of 0.38 mag. A maximum and a minimum separated by about 24 hours suggested a period near 32.0 hours and ruled out a period near 64 hours. Pilcher (2008) found a monomodal lightcurve of period  $31.893 \pm 0.004$  h, amplitude  $0.07 \pm 0.02$  mag. Bernasconi, as presented by Behrend (2008), obtained lightcurves with an amplitude  $0.38 \pm 0.03$  mag. They did not obtain an independent period determination but did show that their data are consistent with the 31.893 h period by Pilcher (2008). New lightcurves obtained on 11 nights from 2008 Sept. 23–Nov. 20 show a period of 31.962 h, amplitude 0.08 mag with one maximum and minimum per cycle. This period is secure in the sense that no viable alias period is consistent with the observations.

However three factors conspire to make the actual errors larger than the formal errors. These are 1) the 3:4 commensurability with the Earth's rotation period, 2) the small amplitude, and 3) systematic magnitude shifts of asteroid versus comparison stars caused by differential extinction encountered in all-night runs since the comparisons were selected without regard to color index. As a result, instead of the formal errors of 0.003 h and 0.01 mag, a conservative estimate suggests errors of 0.05 h and 0.02 mag are more appropriate.

The combination of small amplitude lightcurves in 2007 (longitude  $\sim 352$  deg) and again in 2008 (longitude  $\sim 42$  deg) with a large amplitude lightcurve in 1988 (longitude  $\sim 87$  deg) indicates that one rotational pole is nearly half-way between 352 and 42 deg, probably within a few degrees of the ecliptic and longitude 17

deg. The existing observations are insufficient to determine whether this is the north or south rotational pole. The next opposition of 35 Leukothea is 2010 January (longitude ~117 deg), when it will be in near equatorial aspect and an amplitude exceeding 0.3 magnitudes should be expected. Observations at that time may yield a more accurate rotation period than is obtainable at the near polar aspects of 2007 and 2008.

It should be noted that the sessions on Oct. 29 and Nov. 2 (phase ~0.85) and Nov. 20 (phase ~0.60) show deviations from the expected curve. Data from Nov. 18 covering the part of the curve at 0.85 do not show the deviation. It's possible the anomalous data were the result of flat-field problems or differential extinction due to color differences among the comparison stars and asteroid. However, no firm reasons can be given and so the deviations remain unexplained.

56 Melete. Harris and Young (1979) obtained sparse lightcurves with an amplitude near 0.05 mag and an indeterminate period of 13.7 or 19.0 h. Bel'skaya et al. (1993) reported a period of 18.14 h and amplitude ~0.09 mag. Warner (2007) showed a period of  $18.151 \pm 0.002$  h, amplitude  $0.16 \pm 0.03$  mag with four greatly unequal maxima and minima per cycle. New observations on 8 nights from 2008 Oct. 2–Nov. 14 show a period of  $18.147 \pm 0.001$  h, amplitude  $0.10 \pm 0.01$  mag, with four unequal maxima and minima per cycle. This is fully compatible with the determinations by Bel'skaya et al. and Warner.

137 Meliboea. Harris et al. (2008) state respective periods of 15.13, 15.28 (both reliability 2), >16, and >20 hours, amplitude 0.12–0.20 mag, in four separate investigations. Our observations on 11 nights from 2008 Oct. 9–Dec. 12 show a period  $25.676 \pm 0.001$  h, amplitude  $0.16 \pm 0.02$  magnitudes. A period near 15 h is ruled out.

155 Scylla. Harris et al. (2008) state a period 7.958 h, amplitude 0.12 mag, reliability 2. Observations on 7 nights from 2008 Nov. 1–Dec. 21 are equally consistent with periods near 7.96 hours with an asymmetric bimodal lightcurve or 11.94 h with a trimodal lightcurve, almost exactly 1/3 and 1/2 the Earth's rotation period, respectively, with amplitude  $0.46 \pm 0.03$  mag. With the longest possible photometric session less than 11 hours, complete phase coverage for the longer period cannot be achieved from a single location in a single observing season. However, the only realistic shape model than can produce an amplitude as large as 0.46 mag is an elongated one, which yields two nearly equally spaced maxima and minima per rotation. Furthermore, the data phased to 11.94 h show that the two maxima about 8 h apart are identical, again requiring a shape model of unrealistic symmetry. The longer period and trimodal lightcurve can be rejected and a period of  $7.9597 \pm 0.0001$  h can be considered secure.

264 Libussa. Gil-Hutton (1990) found an amplitude exceeding 0.22 mag with a period greater than 8 h. Pilcher and Cooney (2006) reported an amplitude  $0.04 \pm 0.01$  mag, which they interpreted as monomodal in near polar aspect with period  $9.238 \pm 0.001$  h. However, they could not rule out a period twice as great. The new observations on 7 nights from 2008 Oct. 15–Dec. 29 show a period of  $9.2276 \pm 0.0002$  h, amplitude  $0.33 \pm 0.03$  mag, with an asymmetric bimodal lightcurve. This amplitude and irregularity cannot be achieved for any realistic shape model other than one which produces a bimodal lightcurve. Hence the 9.2276 h period can now be considered secure.

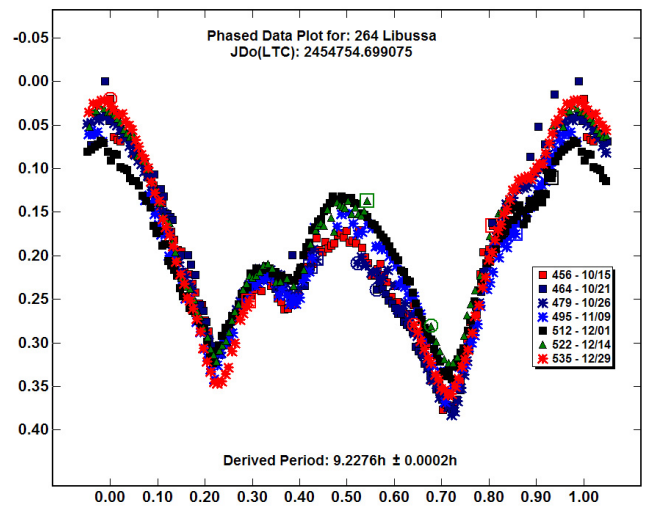
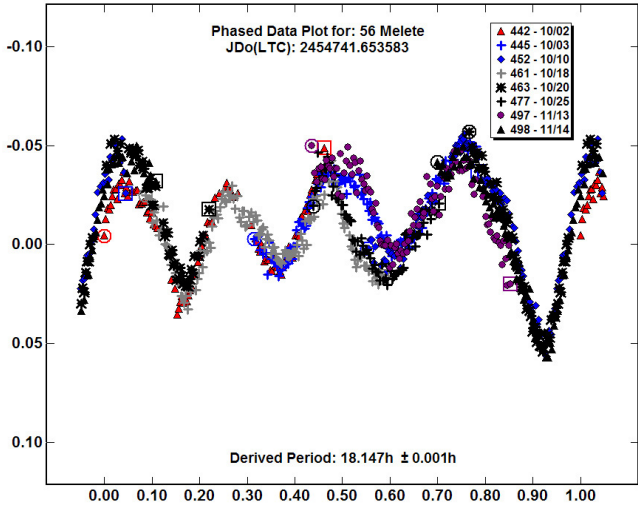
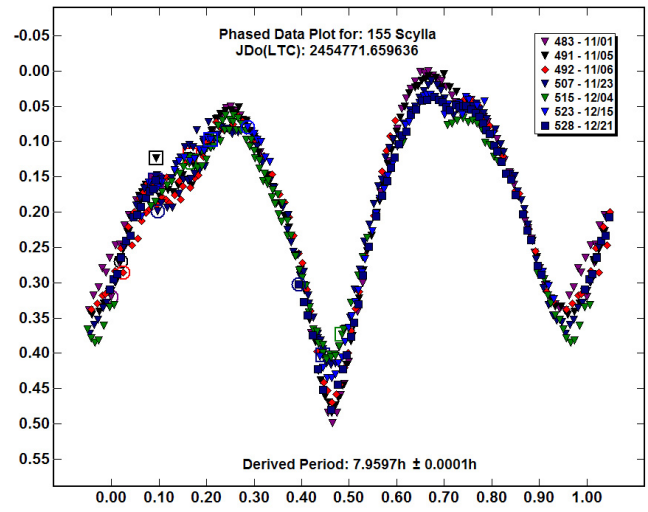
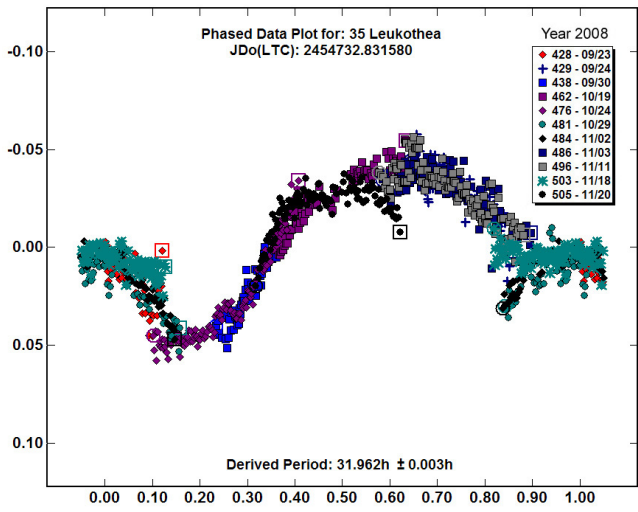
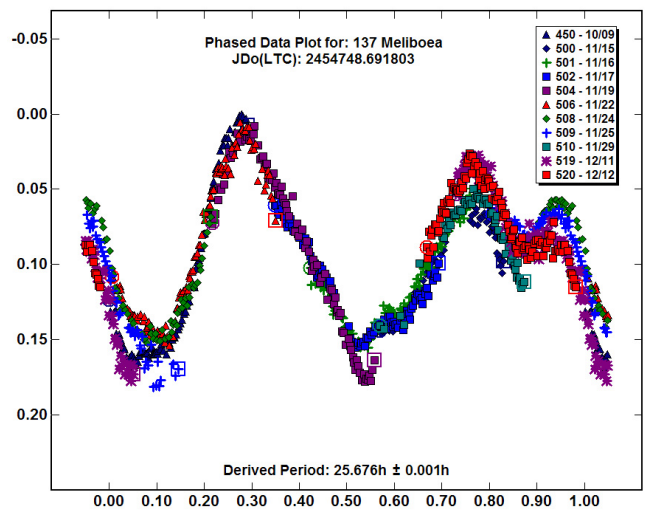
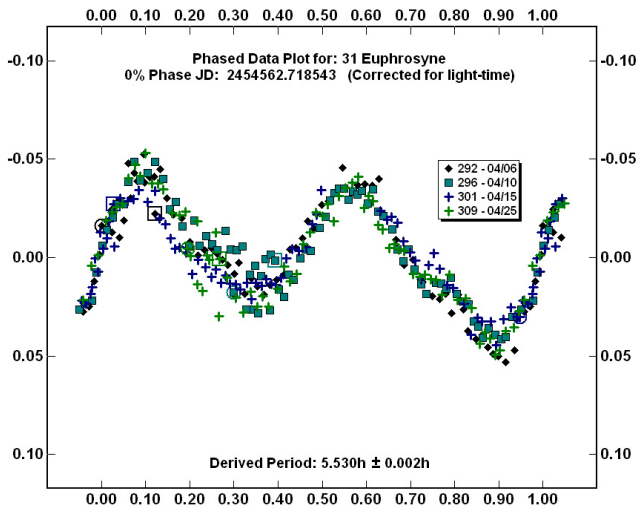
Consider an asteroid in retrograde motion near opposition as usually is occurring when photometric observations are made. If the rotation is direct, the synodic period is shorter than the sidereal period. If the rotation is retrograde, the synodic period is longer than the sidereal period. If, however, the aspect is equatorial and the pole is oriented parallel to the mean motion in the sky (obliquity 90 degrees), then synodic and sidereal periods are the same. This is very nearly the case in late 2008 for 264 Libussa. Therefore, the 9.2276 h period for the 2008 observations near equatorial aspect is closer to the sidereal period than the 9.238 h period for the 2005 near polar aspect observations. The first step in any spin/shape modeling is to obtain an accurate sidereal period. To assist in obtaining that period, this series of observations was continued for 75 days, longer than is commonly done.

#### Acknowledgments

The author expresses his thanks to Petr Pravec, Astronomical Institute, Czech Republic, who provided helpful advice in the analysis of observations for 35 Leukothea and 155 Scylla.

#### References

- Bel'skaya, I.N., Dvignopol, A.N., Erikson, A., Lagerkvist, C.-I., and Oja, T. (1993). "Physical studies of asteroids. XXVII. Photoelectric photometry of asteroids 14 Irene, 54 Alexandra, and 56 Melete." *Astron. Astrophys. Suppl. Ser.* **101**, 507-511.
- Bernasconi, L., in Behrend, R., Observatoire de Geneve web site (2008). [http://obswww.unige.ch/~behrend/page\\_cou.html](http://obswww.unige.ch/~behrend/page_cou.html).
- Gil-Hutton, R. (1990). "V+B Photoelectric Photometry of Asteroids 121 Hermione, 264 Libussa, and 354 Eleonora." *Minor Planet Bull.* **17**, 41-43.
- Harris, A.W., Pravec, P., and Warner, B.D. (2008). "Asteroid Lightcurve Data File: Mar. 10, 2008." <http://www.MinorPlanetObserver.com/astlc/default.htm>
- Harris, A.W. and Young, J. (1979). "Photoelectric Lightcurves of Asteroids 42 Isis, 45 Eugenia, 56 Melete, 103 Hera, 532 Herculina, and 558 Carmen." *Icarus* **38**, 100-105.
- Lagerkvist, C.-I., Hahn, G., Magnusson, P., and Rickman, H. (1987). "Physical studies of asteroids XVI: photoelectric photometry of 17 asteroids." *Astron. Astrophys. Suppl. Ser.* **70**, 21-32.
- Pilcher, F. and Cooney, W.R. (2006). "Provisional Period Determination for 264 Libussa." *Minor Planet Bull.* **33**, 13-14.
- Pilcher, F. (2008). "Period Determination for 35 Leukothea." *Minor Planet Bull.* **35**, 51-52.
- Warner, B.D. (2007). "Asteroid Lightcurve Analysis at the Palmer Divide Observatory: March–May 2007." *Minor Planet Bull.* **34**, 104-107.
- Weidenschilling, S.J., Chapman, C.R., Davis, D.R., Greenberg, R., Levy, D.H., Binzel, R.P., Vail, S.M., Magee, M., and Spaute, D. (1990). "Photometric Geodesy of Main-Belt Asteroids III. Additional Lightcurves." *Icarus* **86**, 402-447.



**LIGHTCURVE RESULTS FOR 99 DIKE, 313 CHALDAEA,  
872 HOLDA, 1274 DELPORTIA, AND 7304 NAMIKI**

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Lightcurves of five asteroids were automatically measured at the Crescent Butte Observatory from 2007 April–May. The rotation period and lightcurve amplitude results are as follows: 99 Dike, 10.360 h and 0.11 mag; 313 Chaldaea, 8.388 h and 0.08 mag; 872 Holda, 5.941 h and 0.20 mag; 1274 Delportia, 5.615 h and 0.045 mag; 7304 Namiki, 8.875 h and 0.71 mag.

The location and instruments used at the Crescent Butte Observatory have been previously reported (Sheridan, 2002). All images were taken through clear filters with reductions performed under Software Bisque's *CCDSoft* and period analysis done with *MPO Canopus* with light-time corrections. The targets were chosen from the list of Potential Lightcurve Targets in the CALL web site managed by Warner (2007).

99 Dike. Dike is a Eunomia family asteroid that was discovered by A. Borrelly at Marseilles, France on 1868 May 28. Data were collected on the nights of 2007 April 10, 22, and 25, resulting in 239 data points. A synodic period of  $10.360 \pm 0.001$  h and amplitude of 0.11 mag were determined. This agrees with Behrend (2008) and Lagerkvist et al. (1992).

313 Chaldaea. Chaldia was discovered by J. Palisa at Vienna, Austria on 1891 August 30. Data were collected on 2007 May 5, 11, and 12, resulting in 296 data points. A synodic period of  $8.388 \pm 0.001$  h and amplitude of  $0.08 \pm 0.01$  mag were determined. The period agrees with those reported by several other authors, including Behrend (2008), Hawkins and Ditteon (2008), and Shevchenko et al. (2008).

872 Holda. Holda is an outer main belt asteroid discovered by M.F. Wolf at Heidelberg, Germany on 1917 May 21. Data were collected on the nights of 2007 April 10, 14, 18, and 20, resulting in 374 data points. A synodic period of  $5.941 \pm 0.001$  h and amplitude of  $0.20 \pm 0.01$  mag were determined. This agrees with other periods from Behrend (2008), Brinsfield (2007), and Fauerbach (2008).

1274 Delportia. Delportia, a Flora family asteroid, was discovered in Belgium on 1932 November 28 by E. Delporte. Data were collected on 2007 March 18 through 20, resulting in 237 data points. A synodic period of  $5.615 \pm 0.001$  h and amplitude of  $0.045 \pm 0.002$  mag were determined. Behrend (2008) reports a period of 5.5 h and 0.09 mag based on observations in 2005.

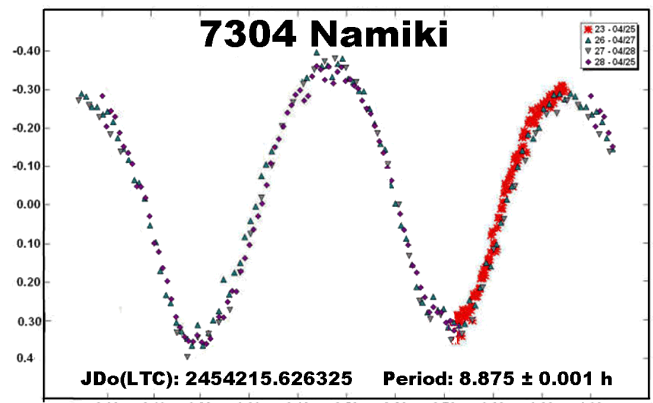
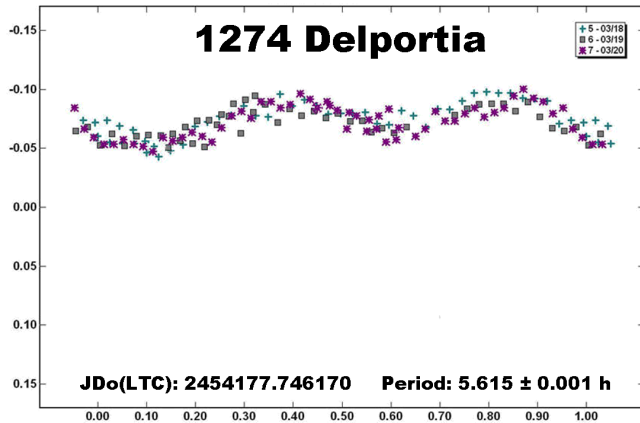
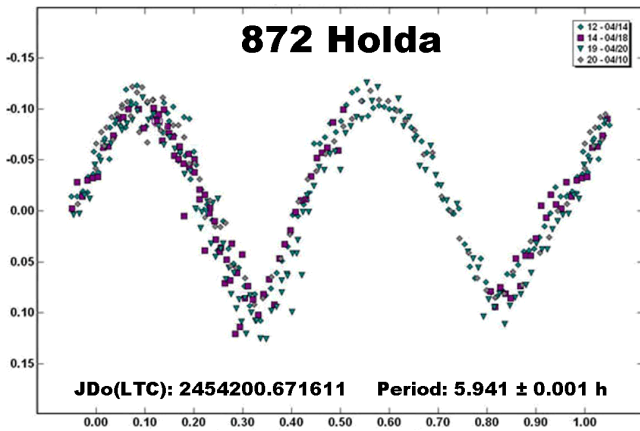
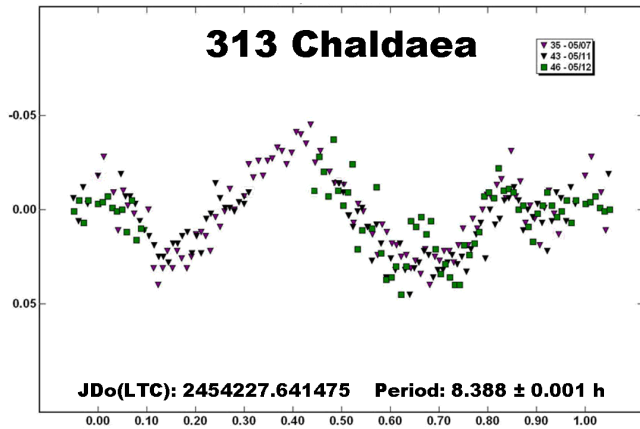
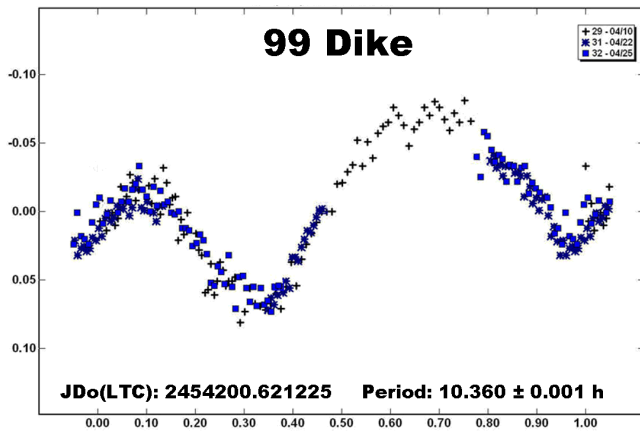
7304 Namiki. Namiki, a middle main-belt asteroid, was discovered on 1994 January 8 by T. Kobayashi at Oizumi, Japan. Data were collected on 2007 April 25, 27, and 28, resulting in 324 data points. A synodic period of  $8.875 \pm 0.001$  h and amplitude of  $0.71 \pm 0.02$  mag were determined. Several other authors have reported similar periods including Montigiani (2007), Brinsfield (2007), Wagner (2007), and Vander Haagen (2008).

Acknowledgments

Thanks to Brian Warner on three fronts: the continuing refinement and support of the program *Canopus* which was used to analyze the lightcurve data; his maintenance of the Collaborative Asteroid Lightcurve Link database; and finally his persuasive pressure to publish lightcurve data rather than have it lost.

References

- Behrend, R. (2008). Observatoire de Geneve web site, [http://obswww.unige.ch/~behrend/page\\_cou.html](http://obswww.unige.ch/~behrend/page_cou.html).
- Brinsfield, J.W. (2007). "The rotation periods of 873 [sic] Holda, 3028 Zhagguoxi, 3497 Innanen, 5484 Inoda, 5654 Terni, and 7304 Namiki." *Minor Planet Bul.* **34**, 108-110.
- Fauerbach, M., Marks, S.A., and Lucas, M.P. (2008). "Lightcurve analysis of ten main-belt asteroids." *Minor Planet Bul.* **35**, 44-46.
- Hawkins, S., and Ditteon, R. (2008). "Asteroid lightcurve analysis at the Oakley Observatory – May 2007." *Minor Planet Bul.* **35**, 1-4.
- Lagerkvist, C.-I., Erikson, A., Debehogne, H., Festin, L., et al. (1995). "Physical studies of asteroids. XXIX. Photometry and analysis of 27 asteroids." *Astron. Astrophys. Suppl. Ser.* **113**, 115-129.
- Montigiani, N., Mannucci, M., Benedetti, W., and Riccetti, S. (2007). "Lightcurve of minor planets 7304 Namiki." *Minor Planet Bul.* **34**, 108.
- Sheridan, E.E. (2002). "Rotational periods of Lightcurve Photometry of 697 Galilea, 1086 Nata, 2052 Tamriko, 4451 Grieve, and (2793) 1997 TR25." *Minor Planet Bull.* **29**, 32-33.
- Shevchenko, V.G., Chiorny, V.G., Graftonyuk, N.M., Krugly, Y.N., Belskaya, I.N., Tereschenko, I.A., and Velichko, F.P. (2008). "Asteroid observations at low phase angles. III. Brightness behavior of dark asteroids." *Icarus* **196**, 601-611.
- Wagner, R. (2007). "Lightcurve of 7304 Namiki." *Minor Planet Bul.* **34**, 112.
- Warner, B.D. (2007). "Potential Lightcurve Targets" Collaborative Asteroid Lightcurve Link (CALL) site: <http://www.MinorPlanetObserver.com/astlc/default.htm>
- Vander Haagen, G.A. (2008). "Lightcurves of minor planets 4853 Marielukac and 7304 Namiki." *Minor Planet Bul.* **35**, 5-6.



### THE CURIOUS CASE OF (162900) 2001 HG31

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The near-Earth asteroid (162900) 2001 HG31 was observed by the authors in 2008 October and November. Indications are that the asteroid may be in non-principal axis rotation. Depending on which subset of available data was used, a period of either  $59.58 \pm 0.01$  h or  $60.57 \pm 0.01$  h was found, each with a lightcurve amplitude of  $0.60 \pm 0.02$  mag. No simple, single period could be found that satisfied all observations.

Near-Earth Asteroid (NEA) (162900) 2001 HG31 was observed by the authors in 2008 October and November. With an H magnitude of 14.7 (IAU Minor Planet Center), the size of this object is likely in the range of 3 km. The specific observing dates and instrumentation are listed in Table 1. During the range of dates, the asteroid started at a phase angle ( $\alpha$ ) of approximately  $14^\circ$ , which decreased to  $\alpha \sim 4^\circ$  on Nov. 15, and increased to  $\alpha \sim 14^\circ$  at the end of the observing period. Observations by BDW and RDS were unfiltered with exposures of 240 s and 180 s, respectively. QY observed with V and R filters using exposures of 120 s. All images were measured using *MPO Canopus*, which was also used for period analysis using the Fourier algorithm of Harris et al. (1989).

Night-to-night calibration of the data sets from Warner and Stephens was done using the 2MASS-BVRI conversions developed by Warner (2007) and as described by Stephens (2008) while Ye used calibrations from a standard star reference field to place his observations on a standard system. Ye used his V and R observations from Nov. 4 to determine a  $V-R = 0.443 \pm 0.005$ . The sessions within the independent data sets could be matched to within 0.03 mag in most cases. However, the matching of the independent sets to a common zero point proved much more difficult and was so uncertain as to prevent unambiguous results. Using the single-period analysis method in *Canopus*, we found two periods that fit most (but not all) of the data when using the same subsets.

Using most of the data from only BDW and QY, we found a period of  $59.58 \pm 0.01$  h with an amplitude of 0.60 mag. Using that same set plus one other session, Petr Pravec of the Astronomical Institute, Czech Republic, also found that period (private communications). That non-fitting additional session from PDO on Nov. 10, gave rise to the possibility that the asteroid was in non-principal axis rotation (NPAR, see Pravec et al., 2005). The lack of sufficient zero-point calibration across the entire data set prevented the determination of the independent periods of a so-called “tumbling” asteroid. In hopes of obtaining sufficient data that could be well-matched, Stephens observed the asteroid in late 2008 November. Using his data from Nov. 30 in combination with a different subset of the previously obtained data, we were able to determine a synodic period of  $60.57 \pm 0.01$  h. Note that the zero-point calibration of some of the previous sessions had to be adjusted anywhere from 0.03 to 0.1 mag in order to obtain the new period. The amplitude of the curve remains at about  $0.60 \pm 0.02$  mag. It’s possible that a more thorough analysis using the entire data set with period search code designed to handle non-additive periods, as seen with tumbling asteroids, may find a solution that includes all data points. However, before that is possible, all the data would have to be placed on a common zero point with a much higher degree of certainty.

Acknowledgements

Funding for observations at the Palmer Divide Observatory is provided by NASA grant NNG06GI32G, National Science Foundation grant AST-0607505, and by a 2007 Gene Shoemaker NEO Grant from the Planetary Society. QY thanks Hsiang-Yao Hsiao and Chi Sheng Lin for their assistance on obtaining the observations. His work at Sun Yat-sen University is supported by a 2007 Gene Shoemaker NEO Grant from the Planetary Society. The 0.41-m Ritchey-Chretien telescope at Lulin Observatory is operated with support from the Graduate Institute of Astronomy, National Central University.

References

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

Stephens, R.D. (2008). “Long Period Asteroids Observed from GMARS and Santana Observatories.” *Minor Planet Bulletin* **35**, 21-22.

Pravec, P., Harris, A.W., Scheirich, P., Kušnirák, P., Šarounová, L., Hergenrother, C.W., and 14 colleagues. (2005). “Tumbling asteroids.” *Icarus* **173**, 108-131.

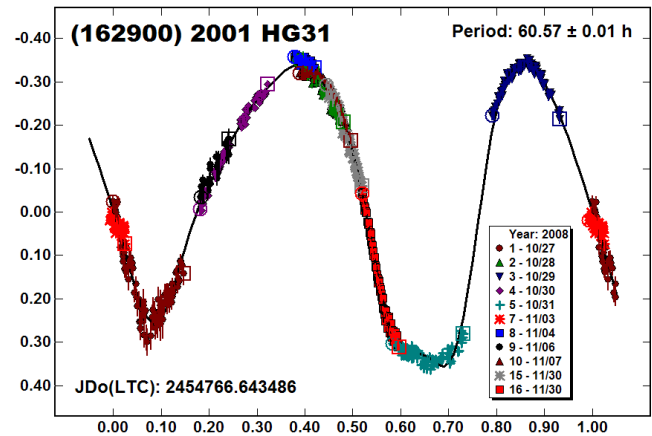
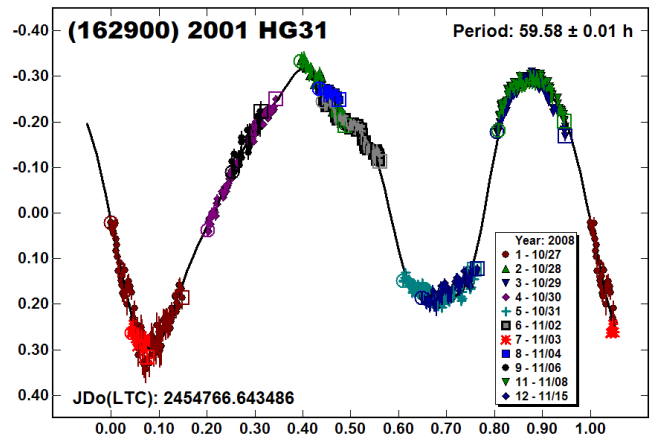
Warner, B.D. (2007). “Preliminary Results from a Dedicated H-G Project.” *Minor Planet Bulletin* **34**, 113-119.

Observer	Dates (mm/dd/2008)	Inst.
Warner	10/27-11/02, 07, 08, 15	0.35-m SCT STL-1001E
Ye	11/03, 04, 06	0.41-m R/C 4-Mp CCD
Stephens	11/29, 30	0.35-m SCT, STL-1001E

Table 1. Observer details.

Date (mm/dd/2008)	Phase	PAB <sub>L</sub>	PAB <sub>B</sub>
10/27	13.7	47.8	0.8
11/15	4.3	53.7	3.8
11/30	13.6	58.6	6.8

Table 2. Observing circumstances for (162900) 2001 HG31 at the start, middle, and end of the observing sessions.



## PHOTOMETRIC OBSERVATIONS OF EARTH-IMPACTING 2008 TC3

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(Received: 2008 Nov 30 Revised: 2008 Dec 23)

Apollo NEA 2008 TC3 collided with Earth in a deserted region of Sudan on 2008 Oct. 7 UT. Based on our observations and assuming  $G = 0.2$ , we found an absolute magnitude  $H = 30.79 \pm 0.08$ . With our  $H$  value and  $p_V = 0.09$ , we estimate the diameter of 2008 TC3 to be  $D = 3 \pm 1$  m. Our period analysis of the lightcurve, which assumed a single period, found periods 97.05 s or 194.34 s. These do not account for the tumbling nature confirmed by Pravec and Harris using other data and so probably do not indicate the true rotation characteristics of the object.

The Apollo near-Earth asteroid (NEA), 2008 TC3 was discovered by the Catalina Sky Survey on 2008 October 6 at 6:39 UT. The Jet Propulsion Laboratory (JPL, USA) predicted that 2008 TC3 would enter the Earth’s atmosphere over northern Sudan on 2008 October 7 at 02:46 UT. During its entry in the Earth’s atmosphere, a fireball was detected by United States Government satellites sensors and infrasonic emissions by a station in Kenya. 2008 TC3 was the first Earth-colliding object detected before hitting Earth, which made it a target of high interest. Photometric observations prior to impact were carried out by M. Kozubal and R. Dantowitz from Clay Center Observatory (USA). Analysis by A. Harris and P. Pravec of the Clay Center data revealed that the object was a “tumbler”, i.e., it was in non-principal axis rotation (NPAR), and showed two periods being  $P_1 = 49$  and  $P_2 = 97$  seconds. (Chesley et al., 2008).

Unfortunately, the “Descobrimdo o Céu” group was unsuccessful in its attempt to observe this object because of unfavourable weather conditions. Our analysis is based on CCD images that were kindly made available by Europeans amateur astronomers (see Table 1). Unfiltered observations were made nearly simultaneously by the three groups on 2008 October 6-7 from 21:40 to 00:40 UT. Images were made with exposure times of 2 to 10 seconds and were obtained with a maximum interval of 10 seconds. Bias, dark and flat-field images were applied to calibrate all the images. A total of 617 images were measured in *MPO Canopus* v9.3.1.0 as was the period search using Fourier analysis. It should be pointed out, that the Fourier analysis algorithm in *Canopus* is not designed for tumbling asteroids, which do not have simple additive periods. Pravec’s analysis used his software that is

capable of working with non-additive periods (see Pravec et al., 2005).

We found periods of  $0.026957 \pm 0.000005$  h or  $97.05 \pm 0.02$  s and  $0.053983 \pm 0.000004$  h or  $194.34 \pm 0.02$  s (Figure 1). Similar periods were obtained by M. Kidger using part of the sample analyzed in this study (Kidger, 2008). The results suggest that the longer period is simply twice that of the shorter and likely caused by an ambiguity in the number of rotations over the time the data were obtained. Our failure to find the true periods found by Pravec show the importance of using the proper tools for complex lightcurves. The amplitude of the curve using the shorter period is  $0.30 \pm 0.03$  mag (Figure 2). However, this result should not be taken at face value due to the dispersion in our data and because we did not fully analyze the tumbling nature of the object and so its effect on the lightcurve.

The unfiltered instrumental magnitudes, taken from the images by P. Beltrame and R. Naves, were transformed to Johnson V magnitudes using the methodology proposed by Henden (2000). In this case, we assumed that 2008 TC3 has a B-V color index equal to  $0.80 \pm 0.08$ . This value is based on mean of B-V colors of a sample of 56 NEAs (Dandy et al. 2003). The B-V colour index for each comparison star was calculated by applying the conversion equations between 2MASS J-K colour and the Johnson-Cousins system (Warner, 2007).

At 21:11 UT (average time), the apparent V magnitude was  $16.01 \pm 0.09$  and  $14.39 \pm 0.04$  at 00:21 UT. The second magnitude matches the one proposed in the ephemerides from the Minor Planet Center, with an error of 0.07%. The 16.01 V magnitude of object at 21:11 UT implies an error of 1.7% when compared with the MPC ephemerides. This error difference may be a result of SNR variation among the analyzed images. The magnitude estimate at 00:21 UT was used to find the object’s absolute magnitude ( $H$ ). Using the  $H-G$  magnitude system (Bowell et al., 1989), we found the reduced magnitude  $H(\alpha) = 31.17 \pm 0.04$ . We assumed a mean phase slope parameter and albedo of  $G = 0.2 \pm 0.2$  and  $p_V = 0.09 \pm 0.07$  for low albedo Tholen classes from Harris (1989). For phase angle  $\alpha = 12.5^\circ$ , this implies  $H = 30.79 \pm 0.08$ . This value is consistent with the JPL Small-Body Database Browser of  $H = 30.7 \pm 0.4$ . Assuming a spherical shape and using the expression proposed by Bowell et al. (1989), we estimate  $D = 3 \pm 1$  m. This diameter is in the interval between  $10^{-4}$  m and 10 m that distinguishes dust and asteroids from meteoroids as defined by Beech and Steel (1995), and so imply in the reclassification of 2008 TC3 as a meteoroid.

### Acknowledgments

A.S. Betzler and A.B. Novaes thanks to the Vitae Foundation, MCT (Ministry of Science and Technology) and the Institute of Physics of UFBA (IF-UFBA) for supporting the “Discovering the Sky” Project. We are also grateful to B. D Warner and two anonymous reviewers for the detailed revision and many suggestions, which much improved this work.

Observer	Site	Telescope	Inst.
P. Beltrame	C.A.S.T	0.35m f/5 Newt.	ST-10XME
R. Naves, M. Campàs	Montcabrer- Cabrils	0.3m f/5.5 SCT	ST-8XME + AO8
G. Muler	Nazaret	0.3m f/5.6 SCT	ST-8XME + AO7

Table 1. Contributing observers.



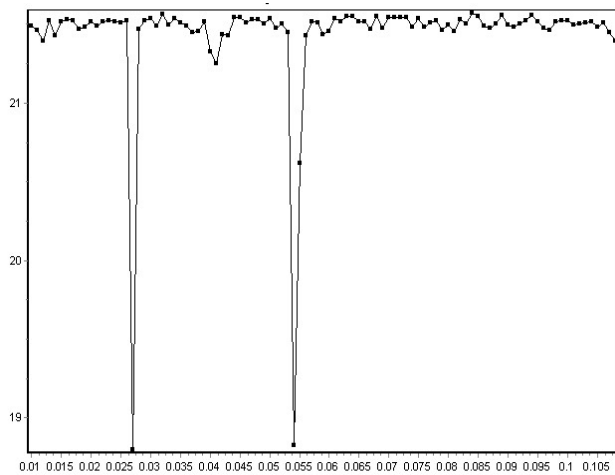


Figure 1. The period spectrum based on the authors' lightcurve data. The abscissa is the RMS (non-dimensional) of the fit and ordinate are the candidate periods, in hours.

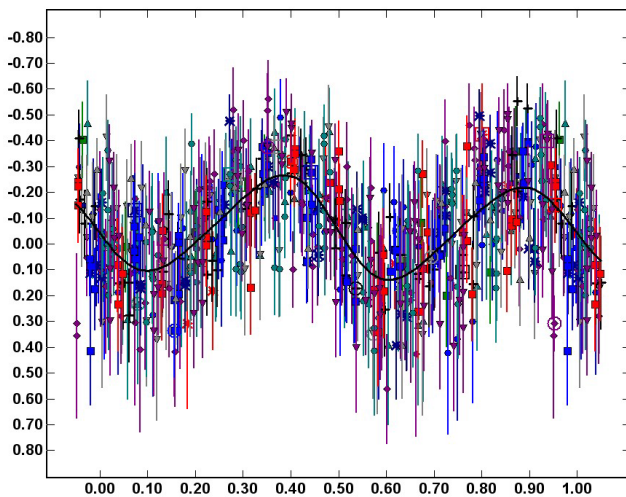


Figure 2. The 2008 TC3 lightcurve phased to a period of  $0.026957 \pm 0.000005$  h or  $97.05 \pm 0.02$  s. Zero phase corresponds to JDO (LTC) 2454746.372668. The black solid line is the 4<sup>th</sup> order Fourier curve.

#### References

- Beech, M., and Steel, D. (1995). "On the Definition of the Term Meteoroid". *QJRAS* **36**, 281.
- Bowell, E., Hapke, B., Domingue, D., Lumme, K., Peltoniemi, J., and Harris, A. W. (1989). "Application of photometric models to asteroids". in *Asteroids II* (Binzel et al., eds), pp. 524-556. University of Arizona Press, Tucson, Arizona.
- Chesley, S., Chodas, P., and Yeomans, D. (2008). "Asteroid 2008 TC3 Strikes Earth: Predictions and Observations Agree", <http://neo.jpl.nasa.gov/news/2008tc3.html>
- Dandy, C. L., Fitzsimmons, A., and Collander-Brown, S. J. (2003). "Optical colors of 56 near-Earth objects: trends with size and orbit". *Icarus* **163**, 363-373.
- Harris, A.H. (1989). "The H-G Asteroid Magnitude System: Mean Slope Parameters". *LPI* **20**, 375.

Henden, A.A. (2000). "The M67 Unfiltered Photometry Experiment". *JAVSO* **29**, 35-43.

Kidger, M.R. (2008). "The Light Curve of 2008 TC3". [http://www.astrosurf.com/comets/neos/2008tc3/2008TC3\\_light.htm](http://www.astrosurf.com/comets/neos/2008tc3/2008TC3_light.htm)

Pravec, P. and 19 colleagues. (2005). "Tumbling Asteroids". *Icarus* **173**, 108-131.

Warner, B. D. (2007). "Initial Results of a Dedicated H-G Project". *Minor Planet Bull.* **34**, 113-119.

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### ASTEROIDS OBSERVED FROM GMARS AND SANTANA OBSERVATORIES

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Lightcurves for ten asteroids were obtained from Santana and GMARS Observatories from 2008 October to December: 145 Adenona, 222 Lucia, 343 Ostara, 624 Hektor, 911 Agamemon, 1073 Gellivara, 1316 Kasan, 1437 Diomedes, 4086 Podalirius. 482 Petrina was observed in 2007.

The author operates telescopes at two observatories. Santana Observatory (MPC Code 646) at Rancho Cucamonga, CA, and GMARS (Goat Mountain Astronomical Research Station, MPC G79) at the Riverside Astronomical Society's observing site in Landers, CA. Santana Observatory uses a 0.30-m Schmidt-Cassegrain (S-C) telescope with an SBIG STL-1001E CCD camera. GMARS has two 0.35-m S-C telescopes, both also using the STL-1001E. All images were binned 1x1 with no filter. All images were measured with *MPO Canopus* using differential aperture photometry. Period analysis was also done using *Canopus*, which incorporates the Fourier analysis algorithm (FALC) developed by Harris (Harris et al., 1989).

624 Hektor, 911 Agamemnon, 1437 Diomedes, and 4086 Podalirius were selected because they are members of the Jupiter Trojan family. All of the other 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, 2008).

145 Adeona. All images were obtained at Santana Observatory. Debehogne (1982) found a period of 20.6 h based upon two runs of 8 and 9 hours. Burchi (1985) found a period of 8.1 h based upon three nights, of which one night did not agree with the period. Harris (1989) observed it on two nights in 1979 but could not derive a period. Finally, Behrend (2008) reported a period of 8.301 h based upon six nights. However, the scatter of data points in those runs was as great as the reported amplitude of 0.08 mag. Phasing the Santana sessions to either 8 or 20 h does not produce a plausible result.

222 Lucia. Both nights were obtained at Santana Observatory. Tedesco (1979) found a period of 7 h, in fair agreement with this result.

343 Ostara. Observations on October 25 and 26 were made at GMARS; all others were obtained at Santana. Binzel (1987) found a period of 6.42 h based upon two nights in 1984. The sessions from GMARS and Santana Observatories were internally linked using the method described in Warner (2007) and Stephens (2008).

482 Petrina. Images were acquired at Santana Observatory. Buchheim (2007) reported a period of 15.73 h based on a partial lightcurve gathered on two nights. Behrend (2008) reports a period of 18 h based upon a partial lightcurve gathered on one night. The current data are not consistent with the 18-hour period. Phasing the latest data to 15.73 h produces a low amplitude noisy four peaked lightcurve. While possible, the 9.427 h complete lightcurve covered by ten sessions seems more likely.

624 Hektor. All images were obtained from Santana Observatory. Hektor is a well-studied object with its period first being determined by Dunlap (1969). Kaasalainen (2002) found a shape model and pole solution with a period of 6.920509 h. This result is in good agreement.

911 Agamemnon. Dunlap (1969) found a period of 8 h and Taylor (1971) found a period of 7 h. This period is a refinement of those results. All images were obtained at Santana Observatory.

1073 Gellivara. All images were obtained at GMARS. Gellivara was observed in the same field of view as 343 Ostara. Because it was too dim to observe from Santana Observatory, and because of interference from weather and the moon, further images could not be obtained until the asteroid was too low to observe.

1316 Kasan. This Mars-crosser was suggested for observation by Warner (2005), who previously observed it and found a period of 5.83 h.

1437 Diomedes. Sato (2000) reported a period of 24.46 h from a nearly complete lightcurve based on data from five nights in 1997 November.

4086 Podalirius. All images were obtained at GMARS.

## 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.

## References

- Behrend, R. (2008). Observatoire de Geneve web site, [http://obswww.unige.ch/~behrend/page\\_cou.html](http://obswww.unige.ch/~behrend/page_cou.html)
- Binzel, R.P. (1987). "A Photoelectric Survey of 130 Asteroids." *Icarus* **72**, 135-208.
- Buchheim, R.K. (2007). "Lightcurves of 25 Phocaea, 468 Lina, 482 Petrina, 551 Ortrud, 741 Botolphia, 834 Burnhamia, 2839 Annette, and 3411 Debetencourt." *Minor Planet Bul.* **34**, 68-71.
- Burchi, R., D'Ambrosio, V., Tempesti, P., and Lanciano, N. (1985). "Rotational Properties of Asteroids 2, 12, 80, 145, and 354 obtained by photoelectric photometry." *Astron. Astrophys. Suppl. Ser.* **60**, 9-15.
- Debehogne, H., Lagerkvist, C.-I., and Zappala, V. (1982). "Physical Studies of Asteroids. VIII – Photoelectric Photometry of Asteroids 42, 48, 93, 105, 145, and 245." *Astron. Astrophys. Suppl. Ser.* **50**, 277-281.
- Dunlap, J.L. and Gehrels, T. (1969). "Minor Planets. III. Lightcurves of a Trojan Asteroid." *Astron. J.* **74**, 796-803.
- Harris, A.W., Young, J.W., Bowell, E., Martin, L.J., Millis, R.L., Poutanen, M., Scaltriti, F., Zappala, V., Schober, H.J., Debehogne, H., and Zeigler, K.W., (1989). "Photoelectric Observations of Asteroids 3, 24, 60, 261, and 863." *Icarus* **77**, 171-186.
- Harris, A.W. and Young, J.W. (1989). "Asteroid Lightcurve Observations from 1979 - 1981." *Icarus* **81**, 314-364.
- Harris, A.W., Young, J.W., Dockweiler, T., Gibson, J., Poutanen, M., and Bowell, E. (1992). "Asteroid Lightcurve Observations

Asteroid	(2008 mm/dd)	Points	$\alpha$	PAB <sub>L</sub>	PAB <sub>B</sub>	Period	PE	Amp	AE
145 Adeona	12/02-12/21	2608	1.6, 0.6, 8.2	73	-1	15.086	0.002	0.04	0.01
222 Lucia	12/29-12/30	357	4.9, 4.6	113	1	7.80	0.01	0.25	0.02
343 Ostara	10/24-11/09	1715	1.5, 0.3, 8.7	34	0	109.87	0.05	0.52	0.05
482 Petrina	07/21-08/03 (1)	813	8.3, 11.0	291	17	9.434	0.003	0.07	0.03
624 Hektor	10/17-10/18	246	2.7, 2.8	18	12	6.923	0.003	0.42	0.03
911 Agamemnon	10/20-10/22	315	5.4, 5.7	4	12	6.592	0.004	0.18	0.03
1073 Gellivara	11/08-10/09	120	5.3, 5.7	33	0	11.32	0.05	0.35	0.05
1316 Kasan	11/30-12/01	414	8.1, 8.0	74	-9	5.82	0.01	0.25	0.03
1437 Diomedes	10/25-11/29	402	4.7, 8.3	29	22	24.49	0.01	0.34	0.02
4086 Podalirius	10/25-11/08	258	4.7, 7.0	17	-14	14.51	0.01	0.08	0.03

Table I. Observation circumstances. (1) Observed in 2007. The phase angle is given for the first and last observation except when the date range includes opposition. In that case, the middle of the three values is the phase angle at opposition. Average values for the Phase Angle Bisector (PAB) are given. The period is in hours and the amplitude in magnitudes.

from 1981.” *Icarus* **95**, 115-147.

Harris, A.W., Warner, B.D., and Pravec, P. (2008). Asteroid Lightcurve Parameters <http://www.MinorPlanetObserver.com/astlc/default.htm>.

Kaasalainen, M., Torppa, J., and Piironen, J. (2002). “Binary Structures Among Large Asteroids.” *Astron. Astrophys.* **383**, L19-L22.

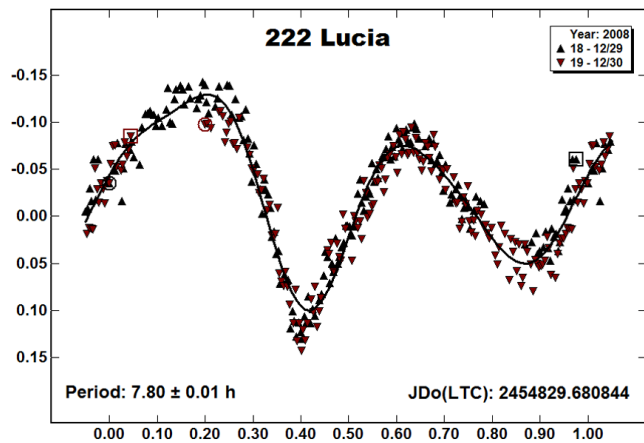
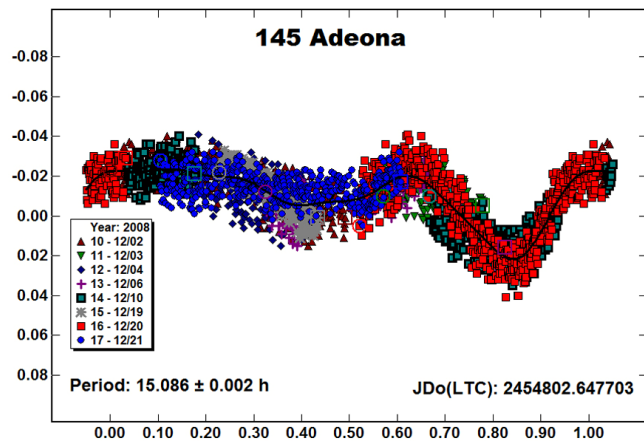
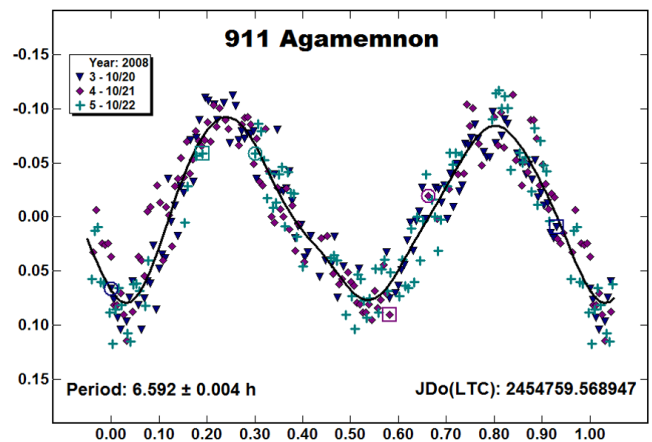
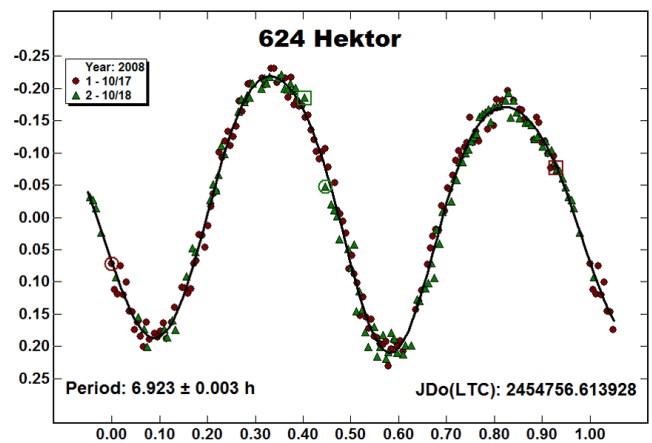
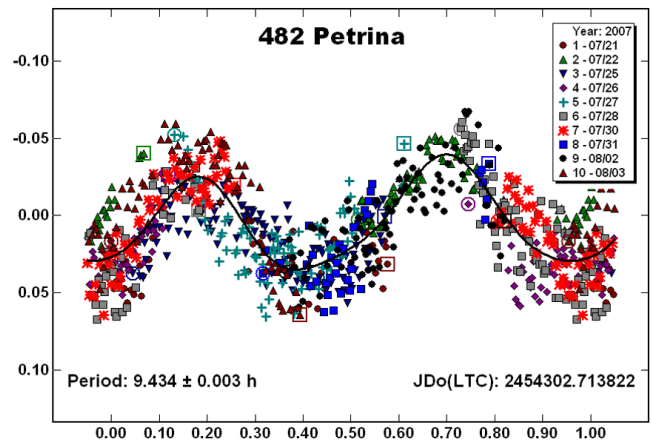
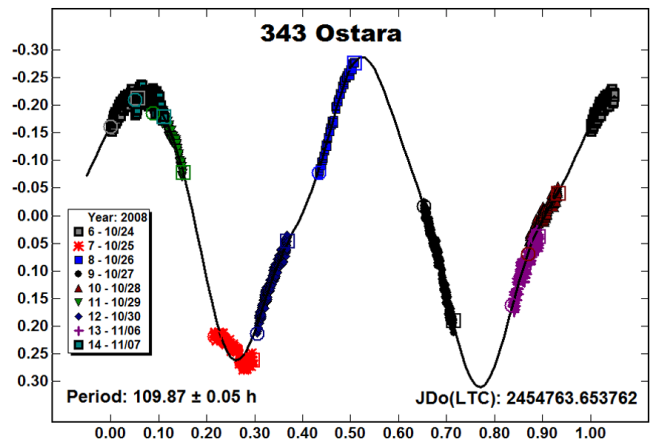
Sato, I., Sarounova, L., and Fukushima, H. (2000). “Size and Shape of Trojan Asteroid Diomedes from Its Occultation and Photometry.” *Icarus* **145**, 25-32.

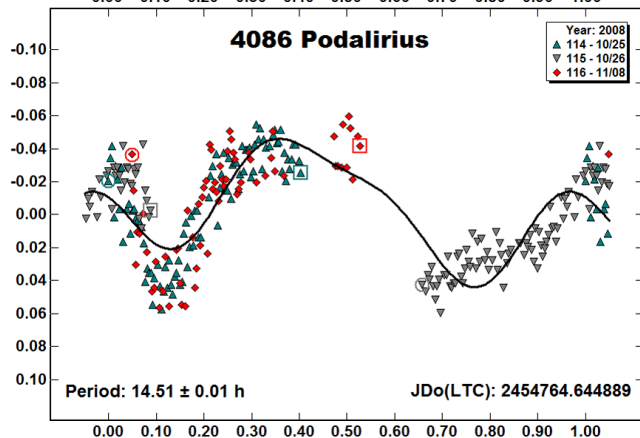
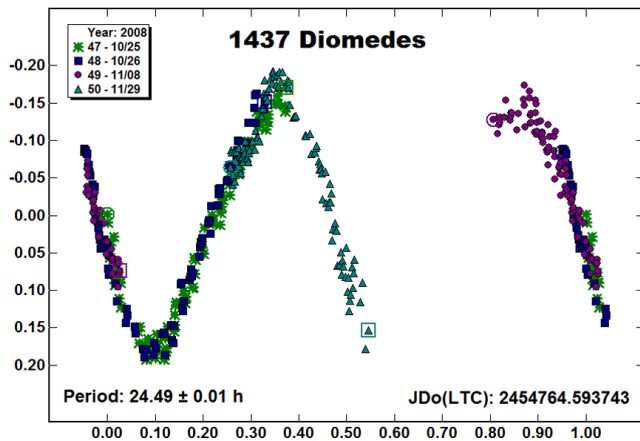
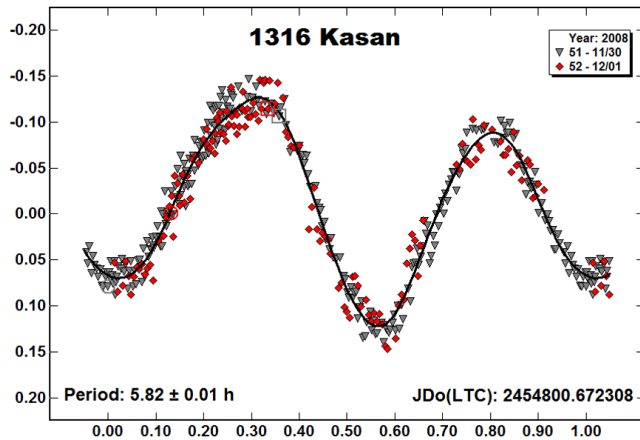
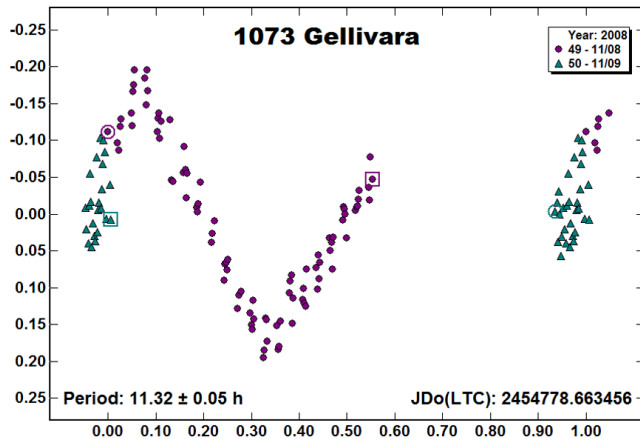
Stephens, R.D. (2008). “Long Period Asteroids Observed from GMARS and Santana Observatories.” *Minor Planet Bul.* **35**, 31-32.

Taylor, R.C. (1971). “Photometric Observations and Reductions of Lightcurves of Asteroids.” in *Physical Studies of Minor Planets* (T. Gehrels, ed.). pp 117-131. NASA SP-267, Washington, D.C.

Tedesco, E.F. (1979). PhD Dissertation, New Mexico State University. 280pp.

Warner, B.D. (2007). “Initial Results from a Dedicated H-G Project.” *Minor Planet Bul.* **34** 113-119.





## LIGHTCURVE ANALYSIS OF TWO BINARY ASTEROIDS: (76818) 2000 RG79 AND (185851) 2000 DP107

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We report on lightcurve observations of two previously known binary asteroids: (76818) 2000 RG79 and (185851) 2000 DP107. For 2000 RG79 we found a primary period of  $P_1 = 3.16640 \pm 0.00003$  h,  $A_1 = 0.14 \pm 0.01$  mag. The orbital period was  $P_{orb} = 14.123 \pm 0.001$  h. The amplitude of mutual events was 0.12-0.15 mag. We estimate the secondary-to-primary ratio to be  $D_s/D_p = 0.32 \pm 0.03$ . For (185851) 2000 DP107, we found  $P_1 = 2.77447 \pm 0.00005$  h,  $A_1 = 0.13 \pm 0.01$  mag, and  $P_{orb} = 42.201 \pm 0.005$  h. The mutual event amplitudes were 0.14-0.16 mag. We estimate  $D_s/D_p = 0.35 \pm 0.03$ .

The authors observed two binary asteroids in collaboration with the Photometry Survey for Asynchronous Binary Asteroids (Pravec, 2008). The results presented here are based on only our data but are similar to those produced by Pravec, whose findings will be presented in a future journal article.

Observations at the Palmer Divide Observatory for (76818) 2000 RG79 were made using a 0.35-m Schmidt-Cassegrain telescope (SCT) with either an FLI-1001E or SBIG ST-9XE with focal reducer. Exposures were 240 s using a clear filter and 1x1 binning. For (185851) 2000 DP107, observations were made using a 0.5-m Ritchey-Chretien with SBIG 1001E CCD camera. Exposures were 120 s using a clear filter at 1x1 binning. GMARS used a 0.35-m SCT with SBIG STL-1001E for its observations of (76818) 2000 RG79. Exposures were 240 s with a clear filter at 1x1 binning. Table I summarizes the observing circumstances.

(76818) 2000 RG79. This asteroid was found to be a binary by Warner et al. (2005). They reported a primary rotation of  $P_1 = 3.1664 \pm 0.0002$  h and  $A_1 = 0.14$  mag. The orbital period of the satellite was  $P_{orb} = 14.125 \pm 0.01$  h. Mutual occultation and eclipse events were  $\sim 0.14$  mag deep, indicating a secondary-to-primary ratio of  $D_s/D_p = 0.37 \pm 0.03$ . We observed the asteroid upon its return in 2008, obtaining a total of 1915 data points from images taken 2008 October 10 through 2009 January 3. We used *MPO Canopus* to measure the images using differential aperture photometry. The dual-period facility in *Canopus* was then used to analyze the data to find the rotation period of the primary and the orbital period of the satellite. Our results are summarized in Table II and agree very closely with the previous findings. The lightcurves showed some evolution of the system, which will help with future modeling of the system.

(185851) 2000 DP107. Warner observed this asteroid from 2008 Sept. 23 through Oct. 28, obtaining 1833 data points. The binary nature of the asteroid was first announced by Margot et al. (2000) using Arecibo radar observations. Lightcurve observations (Pravec et al., 2000) confirmed the asteroid had a binary and found  $P_1 =$

$2.7754 \pm 0.0002$  h,  $A_1 = 0.19$  mag. An orbital period of  $P_{orb} = 42.24 \pm 0.5$  h was reported as well as  $Ds/Dp \sim 0.37 \pm \sim 10\%$ . Additional analysis (Pravec et al., 2006) refined the size ratio to 0.41. Our analysis is summarized in Table II is in good agreement with previous results. Changes in the events were seen here also, giving more information for modeling of the system.

Acknowledgements

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References

Margot, J.L., Nolan, M.C., Benner, L.A.M., Ostro, S.J., et al. (2000). "Satellites of Minor Planets." IAU 7503.

Pravec, P., Kušnirák, P., Hicks, M., Holliday, B., and Warner B. (2000). "2000 DP107." IAU 7504.

Pravec, P., Scheirich, P., Kušnirák, P., Šarounová, S., et al. (2006). "Photometric Survey of Binary Near-Earth Asteroids." *Icarus* **181**, 63-93.

Pravec, P. (2008). "Survey for Asynchronous Binary Asteroids" web site: <http://www.asu.cas.cz/~asteroid/binastphotsurvey.htm>

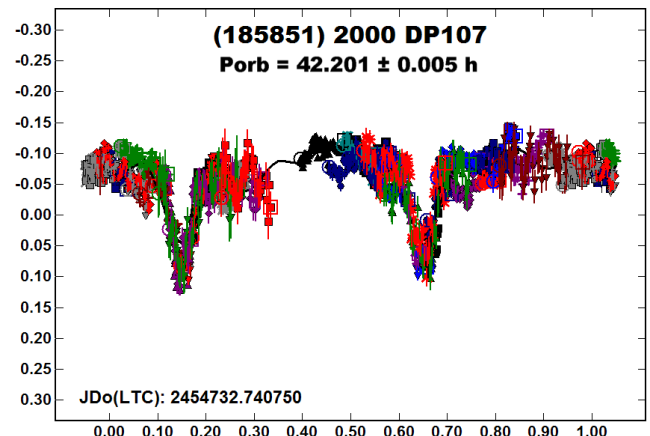
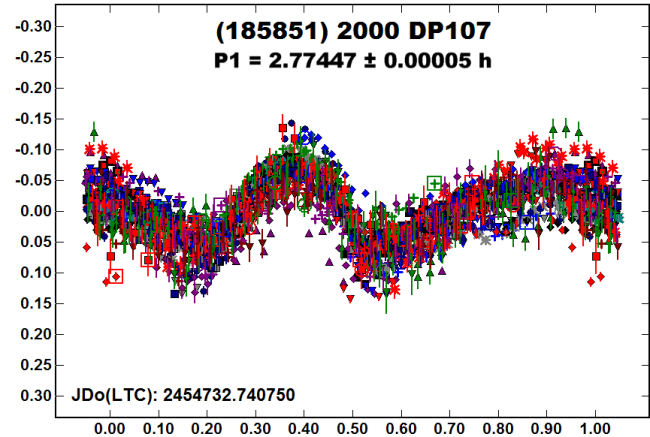
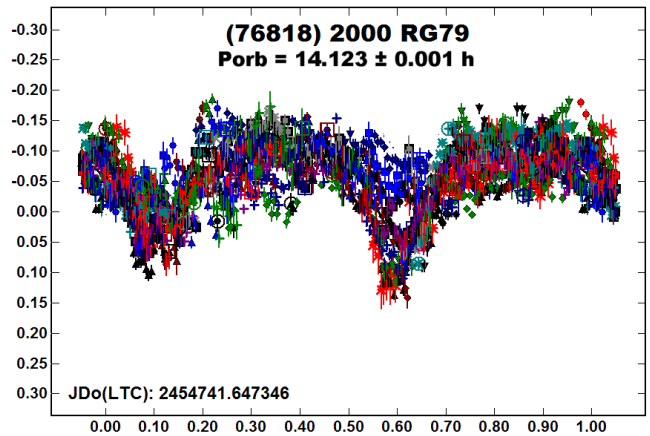
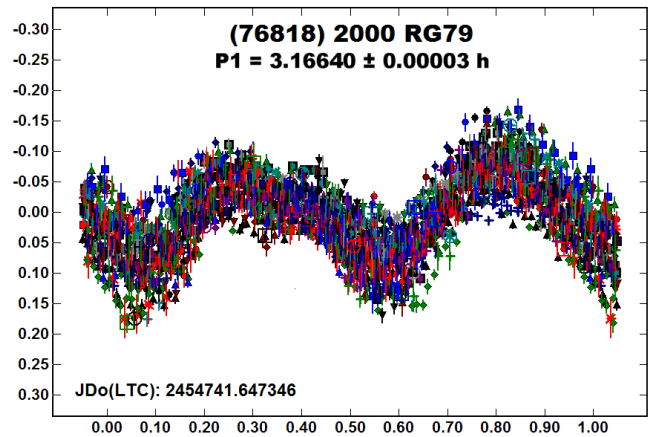
Warner, B.D., Pravec, P., Pray, D. (2005). "(76818) 2000 RG79." IAU 8592.

#	(mm/dd)	Pts	$\alpha$	PAB <sub>L</sub>	PAB <sub>B</sub>
	2008 / (2009)				
76818	10/10 - (01/03)	1915	30, 16, 24	40	19
185851	09/23 - 10/28	1833	41, 16, 20	23	8

Table I. Observing circumstances. The phase angle is given at the start and end of each date range, unless it reached a minimum, which is then the second of three values. The average Phase Angle Bisector (PAB) longitude and latitude are given.

#	$P_1$ (hr)	$A_1$ (mag)	$P_{orb}$ (hr)	$Ds/Dp$
76818	$3.16640$ $\pm 0.00003$	$0.14$ $\pm 0.01$	$14.123$ $\pm 0.001$	$0.32$
185851	$2.77447$ $\pm 0.00005$	$0.13$ $\pm 0.01$	$42.201$ $\pm 0.005$	$0.35$

Table II. Analysis results.  $A_1$  is the amplitude of the primary lightcurve.  $Ds/Dp$  is the secondary-to-primary ratio.



## ASTEROID LIGHTCURVE ANALYSIS AT THE VIA CAPOTE OBSERVATORY: 2008 4TH QUARTER

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Lightcurves for eight asteroids were measured at the Via Capote Observatory from 2008 October through December: 813 Baumeia (10.5 h), 923 Herluga (19.75 h), 1672 Gazelle (40.72 h), 1481 Tubingia (> 24 h), 1717 Arlon (binary, 5.15 h, 18.21 h), 2973 Paola (> 24 h), 3928 Randa (23.13 h), 7638 Gladman (>12 h).

Lightcurve observations of eight asteroids were made using a Meade LX200 0.36-m f/10 Schmidt-Cassegrain telescope. The CCD imager was an Apogee 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 (Harris et al., 1989). The results are summarized in the table below and include average phase angle bisector information across the observational period. Where 3 numbers are indicated for phase angle, measurements of the target occurred over opposition. The middle value is the minimum phase angle observed and the two end values are the phase angles at the beginning and end of the observing campaign. Individual lightcurve plots along with additional comments, as required, are also presented.

There are no reported results for 923 Herluga, 1672 Gezelle, or 3928 Randa. Local conditions and fading magnitude prevented more complete coverage of 1481 Tubingia or 2973 Payola. Based on the available data, I estimate the periods of 1481 Tubingia and 2973 Payola to be greater than 24 hours.

813 Baumeia. Behrend (2008) reports a period  $P = 7.44$  h. In the current study, I measure a tri-modal lightcurve with  $P = 10.544$  h. When the data are “forced” to fit a more traditional bi-model curve, a period of  $P = 7.038$  h is found. However, that fit is much less favorable than the tri-modal fit. I provide a plot of both fits in this report. Measurements of this object spanned the date of opposition (Nov 29) which may have contributed to some of the

variability in my results around lightcurve phase 0.375 and 0.89.

1717 Arlon. This is a known binary asteroid discovered by Cooney et al. (2006a). They reported a period  $P = 5.1484$  h with an amplitude  $A = 0.08$  mag. Behrend (2008) reports  $P = 5.1081$  h. Pravec (2008) reports this target as a binary system with three observable periods:  $P_1 = 5.1484$  h,  $A_1 = 0.08$  mag for the primary object and  $P_2 = 18.236$  h for the rotation of the satellite. The orbital period is given as  $P_{orb} = 117$  h. (see also Cooney et al., 2006b).

During the 11 sessions this object was observed, no attenuation events (eclipses or occultations) were observed. The observations reported here agree very well with the previous reported periods and amplitudes for both components of the system. The data were initially phased to  $P = 18.2$  h. After subtracting the effects of this period from the fitted light curve, a re-run of the phasing calculation produced  $P = 5.148$  h. The analysis of this data was performed with *Canopus* version 9.5 using the “Dual Period Search” facility.

7638 Gladman. Although lightcurve coverage was incomplete, the  $P = 17.3$  h found here is somewhat different from the provisional  $P = 15.36$  h reported by Behrend (2008).

### Acknowledgments

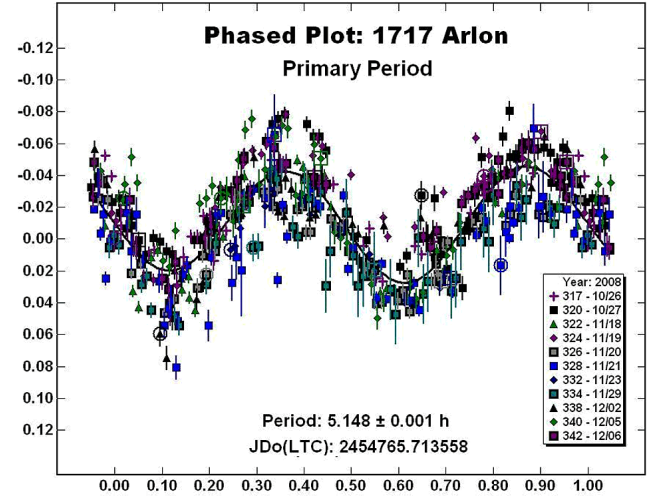
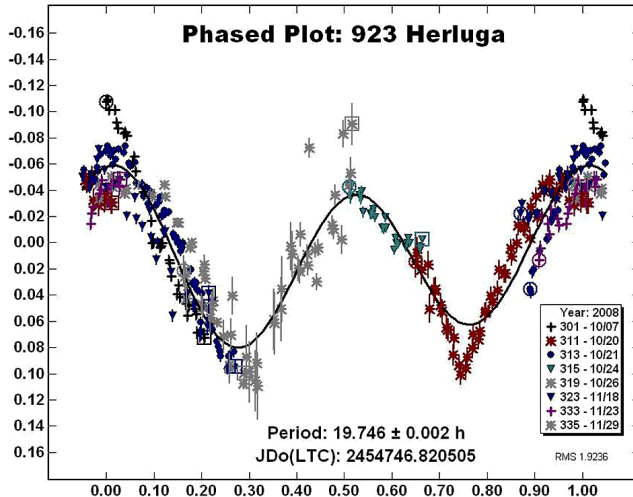
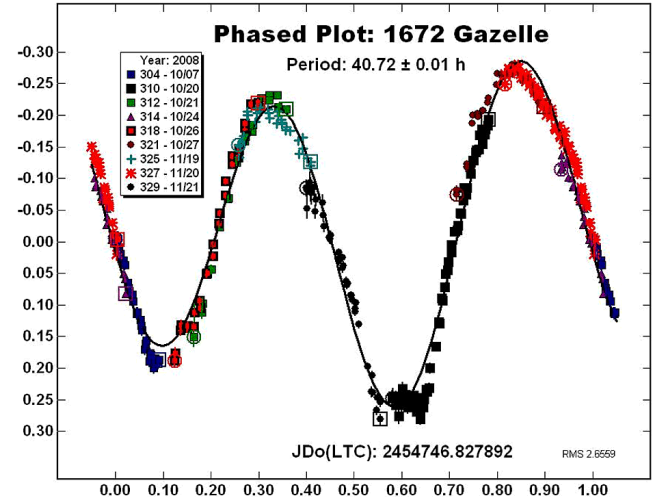
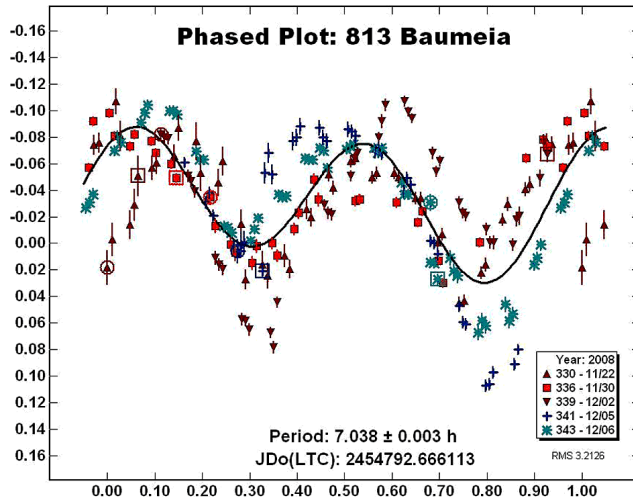
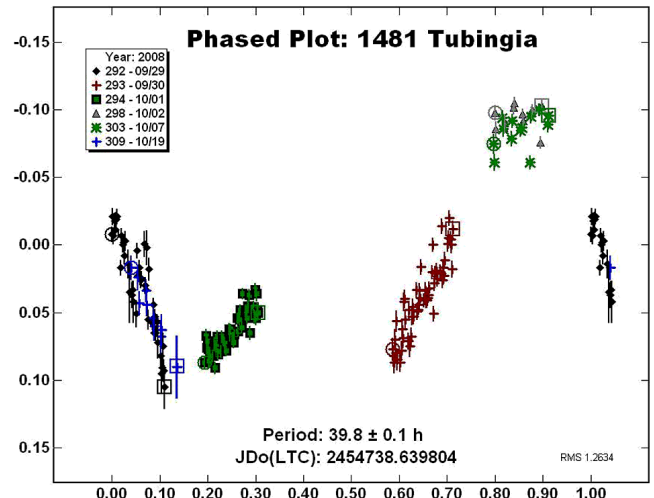
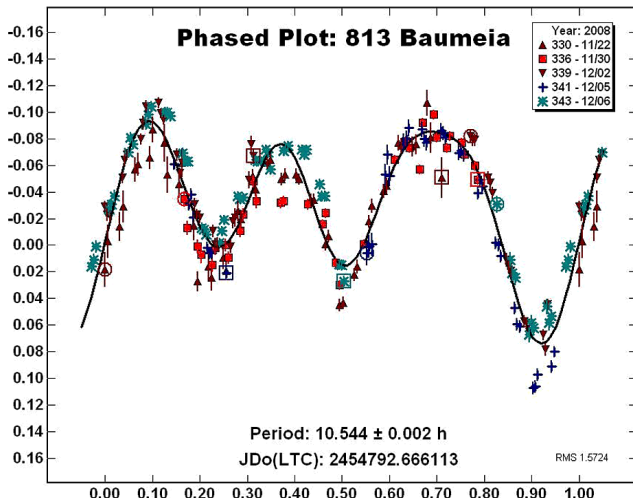
The author wishes to thank Brian Warner for his ever helpful assistance with the analysis of the 923 Herluga data set.

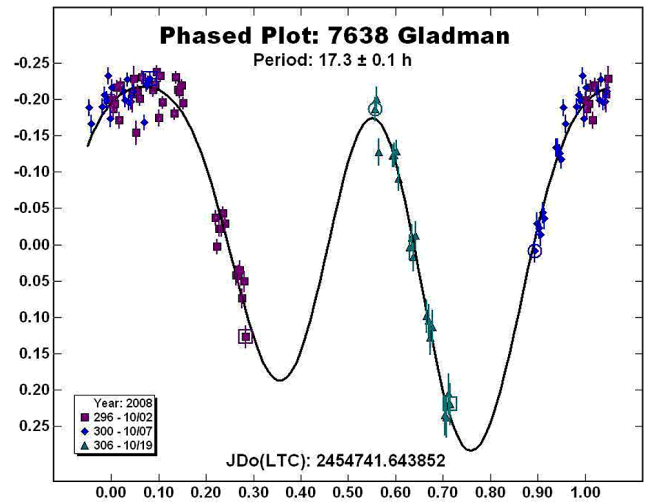
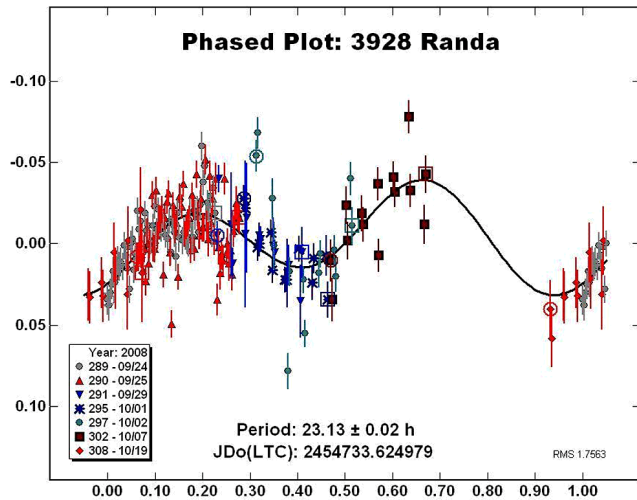
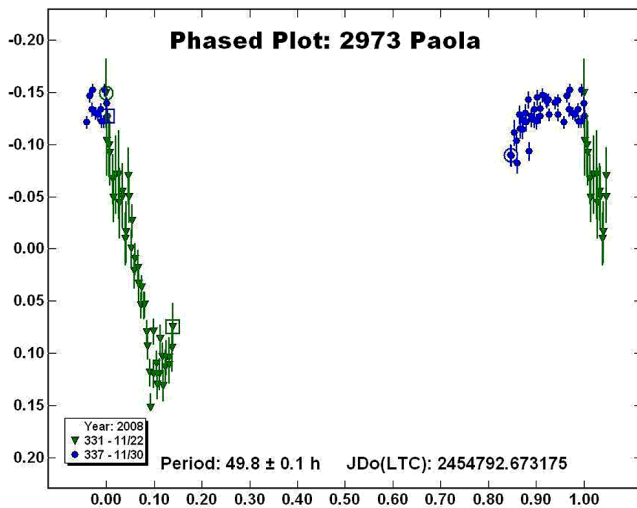
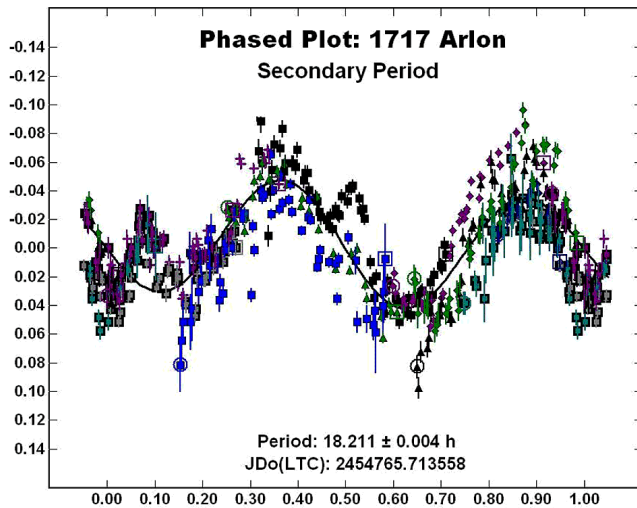
### References

- Behrend, R. (2008). Observatoire de Geneve web site, [http://obswww.unige.ch/~behrend/page\\_cou.html](http://obswww.unige.ch/~behrend/page_cou.html)
- Cooney, W., Gross, J., Terrell, D., Stephens, R., Pravec, P., Kusnirak, P., Durkee, R., and Galad, A. (2006a). CBET 369.
- Cooney, W., Gross, J., Terrell, D., Pravec, P., Kusnirak, P., Pray, D., Krugly, Yu. Kornos, L., Vilagi, J., Gajdos, S., Galad, A., Dyvig, R., Nudds, S., Nauchova, Z., Pikler, M., and Husarik, M. (2006b). CBET 504.
- Harris, A.W., Young, J.W., Bowell, E., Martin, L.J., Millis, R.L., Poutanen, M., Scaltriti, F., Zappala, V., Schober, H.J., Debehogne, H., and Zeigler, K.W. (1989). “Photoelectric Observations of Asteroids 3, 24, 60, 261, and 863.” *Icarus* 77, 171-186.
- Pravec, P., Wolf, M., and Sarounova, L. (2008). <http://www.asu.cas.cz/~ppravec/neo.htm>

#	Name	Date Range (mm/dd) 2008	Data Points	Phase ( $\alpha$ )	$L_{PAB}$	$B_{PAB}$	Per(h)	PE	Amp(m)	AE
813	Baumeia	11/22-12/06	217	4.3/1.3/4.1	67	5	10.544	0.02	0.18	0.02
923	Herluga	10/07-11/29	326	16.0/5.6/14.2	43	-8	19.746	0.02	0.16	0.02
1481	Tubingia	09/29-10/19	186	15.0	334	-1	>24		>0.1	
1672	Gazelle	10/07-11/21	345	14.5/.05/6.1	45	-1	40.72	0.01	0.56	0.03
1717	Arlon	10/26-12/06	503	16.8/6.1/10.2	60	9	5.148	0.001	0.08	0.02
2973	Paola	11/22-11/30	84	3.7	69	2	>24			
3928	Randa	09/24-10/19	209	22.9	338	3	23.13	0.02	0.08	0.025
7638	Gladman	10/02-10/19	83	22.45	343	-3	>12		>0.4	

Table I. Observation circumstances and results.





### THE ROTATION PERIOD OF 4265 KANI AND AN EXAMPLE OF THE MERIDIAN FLIP PROBLEM

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Four nights of long observing runs on asteroid 4265 Kani between 2008 Oct 24 and Oct 31 have shown that it rotates with a period of  $5.7279 \pm 0.0002$  h and that it exhibited a near-symmetrical lightcurve of amplitude  $0.75 \pm 0.02$  mag. For one observing run, photometric accuracy was found to deteriorate following telescope reversal on crossing the meridian. The problem was associated with a skewed distribution of comparison stars and was corrected for in the final analysis.

Asteroid 4265 Kani was included as one of nine new targets in a list posted by Petr Pravec on 2008 October 24 to the Survey for Asynchronous Binary Asteroids photometry group, an observing initiative managed by the Ondřejov Observatory, Czech Republic. (<http://tech.groups.yahoo.com/group/binastphotsurvey/>). To our knowledge, no previous photometry of this object has been reported in the literature. Observations were commenced by one of us (RM) that same night. A total of 589 40-sec unfiltered CCD images were obtained using a German equatorially mounted 0.28-m aperture Schmidt-Cassegrain telescope and SXV-H9 camera. Photometric analysis was performed using *AstPhot32, Version 3.45* software written by Stefano Mottola. The results reported to the list the next day spanned an interval of more than 7 hours and revealed three distinct minima and two maxima. Preliminary analysis based on the single night's data yielded a rotation period of  $5.75 \pm 0.04$  h. Unequal maxima were reported of amplitude  $0.83 \pm 0.03$  mag and  $0.76 \pm 0.02$  mag.

Following the initial night's observing run on 4265 Kani, the resultant lightcurve was examined for possible anomalies, some of



which may indicate that the asteroid is binary. There appeared to be one unusual feature in the lightcurve, notably a small difference in the depth of the first and third minima. Since, between these minima the asteroid has rotated a full  $360^\circ$ , one would expect the two minima to be identical to within a few millimagnitudes. However the difference appeared to amount to about 0.05 mag, as shown in Figure 1. To provide an independent check of the phenomenon, BDW observed the asteroid a few days later, using a *fork-mounted* 0.35-m SCT and CCD camera. The difference in mounts proved to be an important element in explaining the lightcurve's behavior.

#### Photometry and the Meridian Flip Problem

Various factors can affect the accuracy of differential photometry, especially when observing in unfiltered mode at higher air masses. Several possible causes were ruled out before the likely cause was identified. One important clue was found: when different stars were used as comparisons in the data reduction, the relative depth of the two minima changed. The two plots shown in Figure 1 below illustrate this point.

Stars 'c', 'd', 'f' and 'g' used as comparison stars for the above plots are shown in the finder chart depicted in Figure 2. Magnitude data for the stars are given in Table 1.

Note that the larger difference in the relative depths of the first and third minima was obtained using the star pair located furthest from the asteroid, namely 'g' and 'f'. The source of the problem was not directly related to the flat field used in the processing of the images, since this had been carefully checked. Instead it appeared that a shift in the relative magnitudes had taken place following telescope reversal after the field had moved westwards of the meridian.

Telescope reversal after crossing the meridian can markedly affect photometric accuracy for a variety of reasons. For asteroid work this can be especially problematic since long observing runs are often preferred, especially if an object is a slow-rotator. Observers using equatorial fork-mounted telescopes or altazimuth mounts do not have to contend with the meridian flip problem, which is associated with the fact that the telescope tube with CCD camera attached is rotated  $180^\circ$  about the optical axis and so images projected onto the CCD chip are also turned by this amount. If some residual gradient is present in the flat field due to a non-ideal source of illumination when the flat field was produced, or by scattered light within the optics, then the effect of the meridian flip can be to amplify the extent of the anomaly by up to a factor of two. A poorly-mounted dew shield can also lead to problems if the meridian flip causes it to vignette the entrance aperture of the telescope.

The solution to the problem was to treat the dataset following the meridian flip as a separate time-series, applying a magnitude offset to bring it in line with the observations during the first part of the night. The optimal offset was found to be +0.025 mag.

#### Analysis of Rotation Period

Observing runs were conducted on four nights (2008 Oct 24, Oct 27 by RM, and Oct 30, Oct 31 by BDW). These produced a data set of 320 points that was analyzed in *MPO Canopus* using a derivation of the FALC period search algorithm developed by Harris (Harris et al., 1989). The result was a synodic period of  $5.7279 \pm 0.0002$  h and amplitude of  $0.75 \pm 0.02$  mag (Fig. 3). This

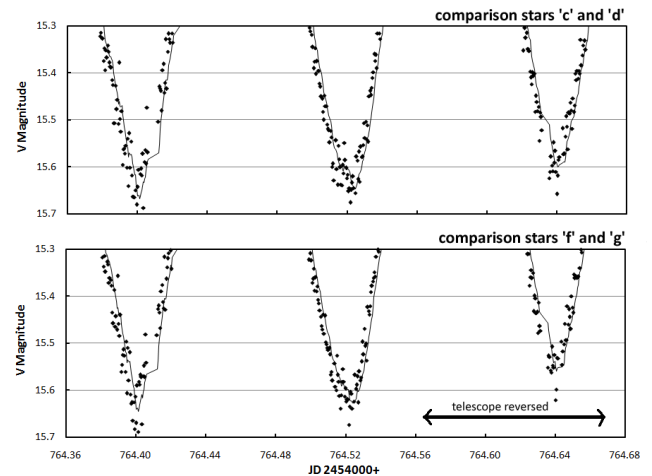


Figure 1: Details of consecutive minima on 2008 October 24/25.

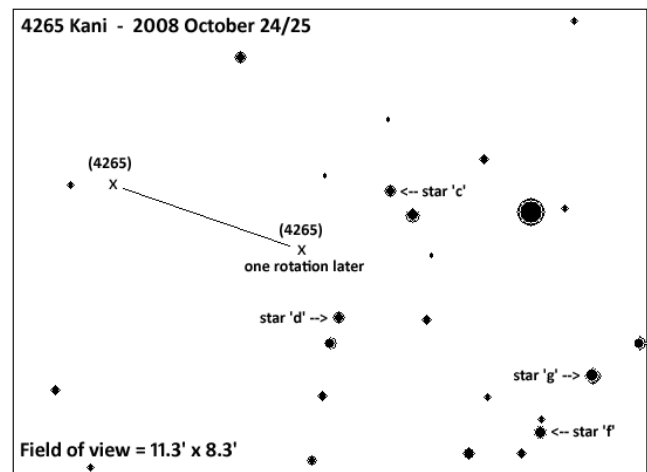


Figure 2: Finder chart created using *GUIDE 8.0* showing the motion of 4265 Kani relative to comparison stars on 2008 October 24/25. The two positions indicated by an 'x' correspond to the position of the asteroid when at its first and third minima shown in Figure 1.

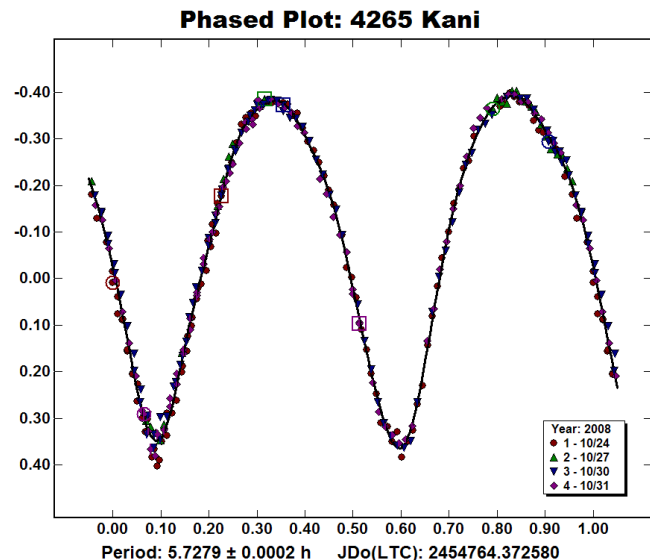


Figure 3. The lightcurve of 4265 Kani.

period was confirmed by Pravec in his analysis of the data (private communications).

#### Acknowledgment

Our thanks go to Dr Petr Pravec of the Ondřejov Observatory for proposing this target and for assistance with the analysis of the observations.

#### References

Dymock, R. and Miles, R. (2008). "A method for determining the V magnitude of asteroids from CCD images." *J. Brit. Astron. Assoc.*, accepted for publication.

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

### PERIOD DETERMINATION FOR 178 BELISANA

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Fifteen lightcurves for 178 Belisana from three widely-separated longitudes show a unique synodic rotation period of  $12.323 \pm 0.002$  h and amplitude  $0.18 \pm 0.02$  mag.

Harris et al. (1992) observed 178 Belisana on 5 nights from 1981 Oct. 23 – Dec. 3 showing a lightcurve amplitude of  $0.16 \pm 0.03$  mag. Their observations were consistent with periods of both 12.3215 h and 12.40 h, with the former favored. Oey and Krajewski (2008) obtained 12 lightcurves from 2007 Apr. 28 – July 4 that equally supported respective periods and amplitudes of 12.321 h, 0.10 mag with a monomodal lightcurve or 24.6510 h, 0.13 mag with a nearly symmetric bimodal lightcurve.

New observations were made in 2008 by Pilcher at the Organ Mesa Observatory using a Meade 14-inch LX200 GPS S-C and SBIG STL-1001E CCD camera. All exposures were unguided and used a clear filter. Benishek at the Belgrade Observatory obtained images using a Meade 16-inch LX200 GPS f/10 S-C and Apogee AP47p CCD camera. Unfiltered images were obtained at Kingsgrove Observatory by Oey using a 0.25-m S-C telescope operating at f/5.2 and a SBIG ST-402 ME CCD camera. The three authors collaborated from their widely-distributed longitudes in order to cover all phases of the lightcurve in as short of time as possible. This was the best way to remove any ambiguity seen by

	star c	star d	star f	star g
r' mag	14.837	14.801	14.232	13.767
J-K mag	0.683	0.817	0.379	0.683
V mag	15.19	15.24	14.40	14.13

Table 1. Carlsberg Meridian Catalogue (CMC-14) and V-magnitude data for selected comparison stars. The V magnitudes were calculated on the basis of the empirical equation derived by Dymock and Miles (2008):  $V = 0.995*r' + 0.628*(J-K)$ .

UT Date	RA	Dec	Phase	V
2008 Oct 25.0	02 46	+06 58	6.4	14.8
2008 Oct 28.0	02 43	+06 45	5.2	14.7
2008 Oct 30.3	02 42	+06 35	4.6	14.7
2008 Oct 31.3	02 41	+06 31	4.4	14.7

Table 2. Observation circumstances.

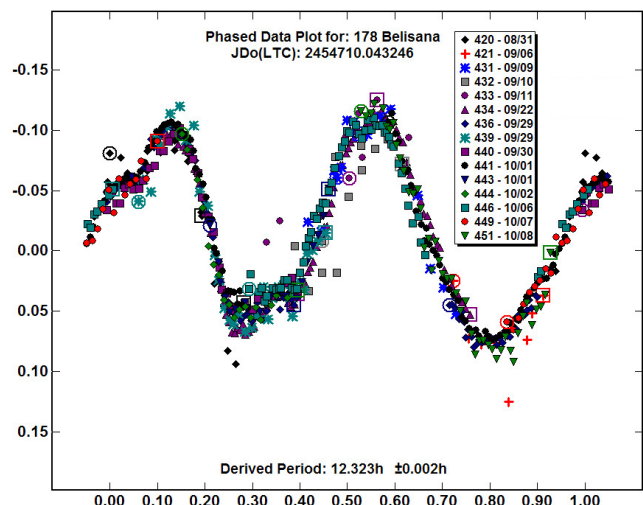
Oey and Krajewski since either period was nearly commensurate with an Earth day.

The combined data set from this collaboration shows a slightly asymmetric bimodal lightcurve with an amplitude of  $0.18 \pm 0.02$  mag and unambiguous synodic period of  $12.323 \pm 0.002$  h. The double period allowed by the 2007 observations is ruled out because, in the 2008 data, the coefficients of the odd harmonics in the Fourier series for the best fit are much smaller than for the even harmonics. The much smaller amplitude and monomodal lightcurve at the longitudes of the 2007 observations show that 178 Belisana was closer to polar aspect than at the time of the 2008 observations.

#### References

Harris, A.W., Young, J.W., Dockweiler, T., Gibson, J., Poutanen, M., and Bowell, E. (1992). "Asteroid Lightcurve Observations from 1981." *Icarus* **95**, 115-147.

Oey, J. and Krajewski, R. (2008) "Lightcurve Analysis of Asteroids from Kingsgrove and Other Collaborating Observatories in the First Half of 2007." *Minor Planet Bull.* **35**, 47-48.



## CCD LIGHTCURVE ANALYSIS OF 216 KLEOPATRA

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Filtered (Ic) CCD images for 216 Kleopatra were obtained over six sessions in 2008 November. A folded lightcurve was produced and the synodic period,  $P = 5.386$  h, calculated.

216 Kleopatra (124 km) is a main belt asteroid first discovered by J. Palisa in 1880. This asteroid, which can exhibit large changes in lightcurve amplitude ( $> 1$  mag), has a dog-bone (bi-lobed) shape. Its morphology has been extensively studied by radar (Ostro et al., 2000), interferometry (Tanga et al., 2001), and ground-based adaptive optics (Hestroffer et al., 2002).

The equipment used at UnderOak Observatory included a focal reduced ( $f/6.3$ ) 0.2-m Schmidt-Cassegrain telescope with a thermoelectrically cooled SBIG ST-402ME CCD camera operating at  $5^{\circ}\text{C}$ . Filtered (Ic) imaging was carried out on a total of six nights with unbinned, 45-second exposures taken automatically at least every 60 seconds. Image acquisition (raw lights, darks and flats) was performed with SBIG *CCDSOFT 5* while calibration and registration were accomplished with *AIP4WIN* (Berry and Burnell, 2006). Further image reduction with *MPO Canopus* (Warner, 2008) used at least two non-varying comparison stars to generate light curves by differential aperture photometry. Data were light-time corrected but not reduced to standard magnitudes.

A total of 1280 photometric readings were collected over 23.1 days. Relevant aspect parameters for 216 Kleopatra taken at the mid-point from each session are given in Table I. *MPO Canopus* provided a period solution for the folded data sets using Fourier analysis (Harris et al., 1989). The synodic period, determined to be  $P = 5.386 \pm 0.001$  h is in good agreement with rotational periods for 216 Kleopatra recently published by Warner (2006) and that found at the JPL Solar System Dynamics website. Phased data are available by request at <http://underoakobservatory.com>.

### Acknowledgement

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### References

- Berry, R. and Burnell, J. (2006). *AIP4WIN* version 2.1.10, Willmann-Bell, Inc, Richmond, VA.
- Harris, A.W., Young, J.W., Bowell, E., Martin, L. J., Millis, R. L., Poutanen, M., Scaltriti, F., Zappala, V., Schober, H. J., Debehogne, H, and Zeigler, K. (1989). "Photoelectric Observations of Asteroids 3, 24, 60, 261, and 863." *Icarus* **77**, 171-186.
- Hestroffer, D., Marchis, F., Fusco, T., and Berthier, J. (2002). "Adaptive Optics Observations of Asteroid (216) Kleopatra." *Astron & Astroph.* **394**, 339-343.

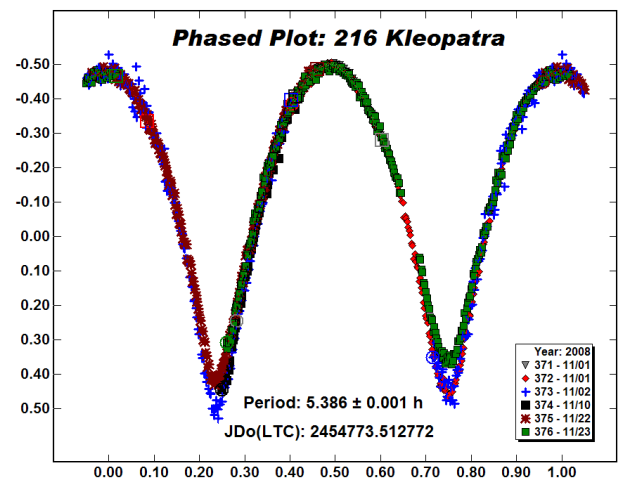
JPL Solar System Dynamics website: <http://ssd.jpl.nasa.gov/sbdb.cgi>

Ostro, S.J., Hudson, R.S., Nolan, M.C., Margot, J.-L., Scheeres, D.J., Campbell, D.B., Magri, C., Giorgini, J.D., and Yeomans, D.K. (2000). "Radar observations of asteroid 216 Kleopatra." *Science* **288**, 836-839.

Tanga, P., Hestroffer, D., Berthier, J., Cellino, A., Lattanzi, M. G., di Martino, M., and Zappalá, V. (2001) "HST/FGS Observations of the Asteroid (216) Kleopatra." *Icarus* **153**, 451-454.

Warner, B.D. (2006). "Asteroid Lightcurve Analysis at the Palmer Divide Observatory: March-June 2006." *Minor Planet Bulletin* **33**, 85-88.

Warner, B.D. (2008). *MPO Software, Canopus version 9.5.0.3*. Bdw Publishing, Colorado Springs, CO.



UT Date (2008)	No. Obs.	Phase Angle	$L_{\text{PAB}}$	$B_{\text{PAB}}$
Nov 1	135	21.7	357.2	7.9
Nov 2	285	21.9	357.4	7.8
Nov 3	288	22.2	357.6	7.7
Nov 10	64	23.9	359.1	6.9
Nov 23	208	26.2	2.4	5.4
Nov 24	300	26.3	2.7	5.3

Table I. Observation circumstances for 216 Kleopatra.

**ASTEROID LIGHTCURVE ANALYSIS AT  
THE PALMER DIVIDE OBSERVATORY:  
2008 SEPTEMBER–DECEMBER**

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Lightcurves for 17 asteroids were obtained at the Palmer Divide Observatory (PDO) from 2008 September through December: 914 Palisana, 3225 Hoag, 4031 Mueller, 5390 Huichiming, 5579 Uhlherr, 5871 Bobbell, (8404) 1995 AN, (16426) 1988 EC, 16589 Hastrup, (18906) 2000 OJ19, (24465) 2000 SX155, (37635) 1993 UJ1, (41672) 2000 TX36, (59493) 1999 JG5, (76864) 2000 XR13, (106121) 2000 TP33, and 2008 SE

Observations of 17 asteroids were made at the Palmer Divide Observatory from 2008 September through December. Four telescopes/camera combinations were 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 readout in 1x1 binning, resulting in a scale of approximately 1.2 arcseconds per pixel. All exposures were guided and in the range 120-240 s. Most observations were made with no filter. On occasion, e.g., when a nearly full moon was present, a Cousins R or SDSS r' filter was used to decrease the sky background noise. 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 (Harris et al., 1989).

The results are summarized in the table below and in individual plots. The data and curves are presented without comment except when warranted. An “(H)” follows the name of an asteroid in the table if it is a member of the Hungaria group/family, which is a

primary target of the PDO observing program. The plots are “phased”, i.e., they range from 0.0 to 1.0 of the stated period. Most of the plots are scaled such that 0.8 mag has the same linear size as the horizontal axis from 0.0 to 1.0. This is done for two reasons: 1) for easier direct comparison of amplitudes and, 2) to avoid the visual impression that the amplitude of variation is greater than it actually is, which can create the impression of a physically implausible lightcurve. There are some cases where the scale has been modified, those being mostly for low amplitude lightcurves, where the above scaling would have resulted in a nearly flat plot almost devoid of information. Even so, the vertical scale has been expanded as little as possible to avoid creating possibly misleading interpretations.

914 Palisana. Tedesco (1979) gave a period of  $> 14$  h for this Phocaea member asteroid. Ricciolo (1995) found a period  $P = 15.62$  h and amplitude  $A = 0.18$ . Data at PDO found  $P = 15.922 \pm 0.004$  h despite the low amplitude,  $A = 0.04$  mag. Given the amplitudes and the fact that the Ricioli data were obtained at phase angle bisector (PAB) longitude of  $\sim 282^\circ$  while the PDO data were at  $\sim 40^\circ$ , this implies that the longitude of the asteroid's spin axis is approximately  $40^\circ \pm 30^\circ$  (or  $220^\circ$ ).

3225 Hoag. The result of  $P = 2.3728 \pm 0.0005$  h agrees with the previous finding by the author (Warner, 2007a).

5390 Huichiming. This follow-up work to 2007 observations (Warner, 2007b) found  $P = 111 \pm 1.0$ ,  $A = 0.60 \pm 0.05$  mag. This is different from the period found in 2007,  $P = 33.6$  h. The 2007 data fit well with the longer period while the 2008 data do not fit at all with the shorter period. In 2008, a method of calibrating night-to-night data was used (see Warner, 2007c; Stephens, 2008) that allows more confidence in the new results.

(16426) 1988 EC. The lightcurve plot below shows a very asymmetrical shape. By excluding the data on Sept. 22 and 25, the result is a bimodal curve with  $P \sim 22$ h, or  $2/3$  the period reported here ( $P = 33.00 \pm 0.02$  h). Normally, this might be considered a case of “rotational aliasing” where the number of rotations between sessions was not resolved unambiguously. However, there is no justifiable reason to remove the two sessions, which

#	Name	(mm/dd) 2008/2009	Data Pts	$\alpha$	PAB <sub>L</sub>	PAB <sub>B</sub>	Per (h)	PE	Amp (mag)	AE
914	Palisana	11/07-11/15	1030	10.2, 11.0	40	19	15.922	0.004	0.04	0.005
3225	Hoag (H)	11/16-11/22	182	19.0, 21.3	35	-21	2.3728	0.0005	0.13	0.01
4031	Mueller (H)	10/18-10/25	142	30.9, 29.5	70	23	2.9420	0.0002	0.19	0.02
5390	Huichiming (H)	11/16-11/26	366	17.4, 11.2	75	-11	111	1	0.60	0.05
5579	Uhlherr (H)	12/19-12/27	146	5.1	92	7	4.754	0.003	0.20	0.02
5871	Bobbell (H)	10/29-11/15	376	28.9, 24.7	72	29	30.21	0.02	0.27	0.02
(8404)	1995 AN	12/29-01/03	98	23.2, 21.3	128	19	4.612	0.002	0.16	0.02
(16426)	1988 EC (H)	09/20-10/01	459	26.4, 23.2	31	19	33.0	0.02	0.18	0.02
16589	Hastrup (H)	09/28-10/17	441	3.9, 16.6	1	0	27.62	0.02	0.13	0.01
(18906)	2000 OJ19	11/02-11/26	509	7.1, 6.8	52	2	77.90	0.05	0.80	0.03
(24465)	2000 SX155 (H)	10/24-10/28	227	7.5, 4.7	40	1	9.156	0.006	0.13	0.02
(37635)	1993 UJ1 (H)	09/19-10/08	561	13.4, 7.9	9	11	600	5	0.80	0.05
(41672)	2000 TX36 (H)	09/30-10/17	190	16.6, 10.4	23	15	31.8	0.05	0.06	0.01
(59493)	1999 JG5 (H)	11/16-12/18	474	3.7, 20.9	57	-7	57.4	0.1	0.90	0.05
(76864)	2000 XR13 (H)	12/27-12/28	85	8.9, 8.3	109	-1	3.89	0.01	0.15	0.02
(106121)	2000 TP33 (H)	10/29-10/30	158	23.4	65	18	8.48	0.01	0.98	0.02
	2008 SE	11/02	48	4.1	42	-2	4.57	0.05	0.70	0.05

Table I. Observing circumstances. The phase angle is given at the start and end of each date range, unless it reached a minimum, which is then the second of three values. If a single value is given, the phase angle did not change significantly and the average value is given. PAB<sub>L</sub> and PAB<sub>B</sub> are the average phase angle bisector longitude and latitude.

were carefully re-measured using different comparison stars to verify the data. Further observations of the asteroid are strongly encouraged.

(41672) 2000 TX36. The solution for this asteroid is ambiguous due to its very low amplitude,  $A = 0.05 \pm 0.01$  mag. A possible solution is  $P = 31.8$  h, which is shown in the plot. However, a number of other solutions cannot be excluded.

#### Acknowledgements

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#### References

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

Riccioli, D., Blanco, C., Di Martino, M., and De Sanctis, G. (1995). "Lightcurves and rotational periods of main belt asteroids. III." *Astron. Astrophys. Suppl. Ser.* **111**, 297-303.

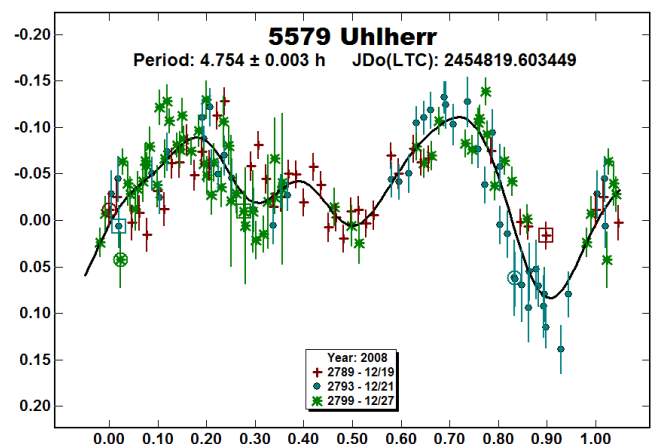
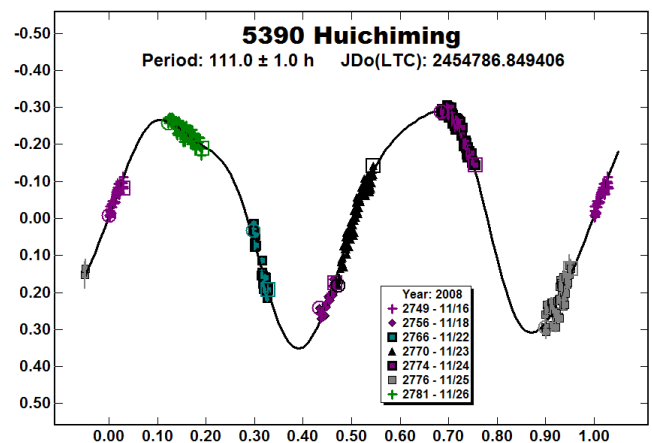
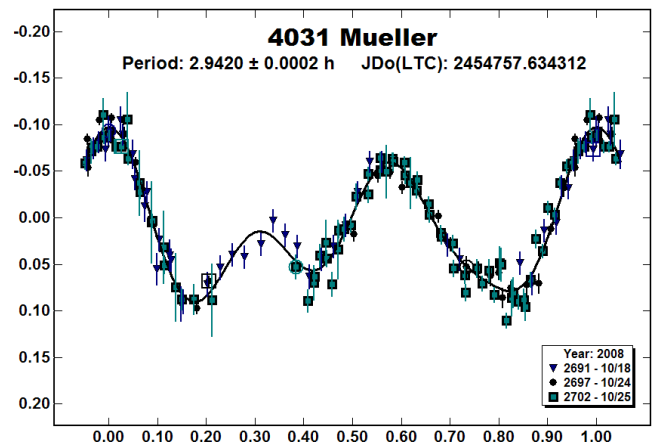
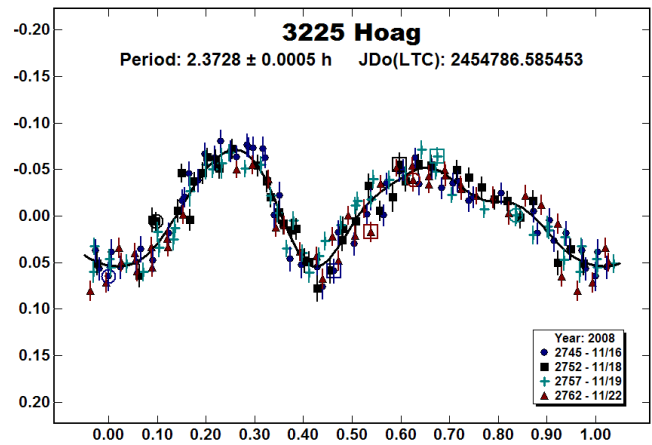
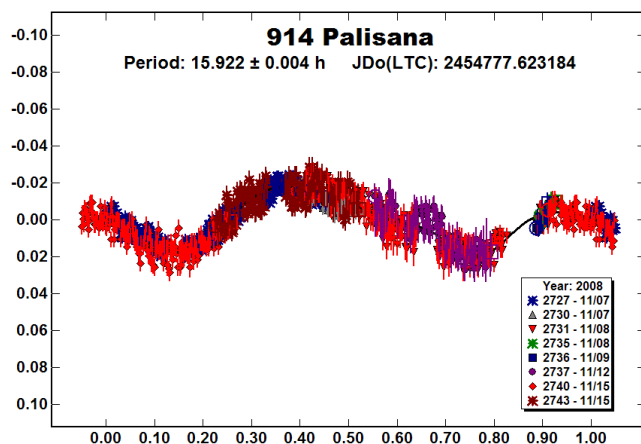
Stephens, R.D. (2008). "Long period asteroids observed from GMARS and Santana Observatories." *Minor Planet Bul.* **35**, 21-22

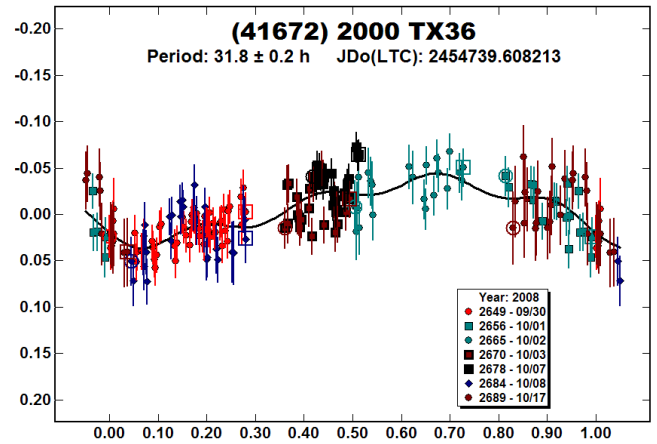
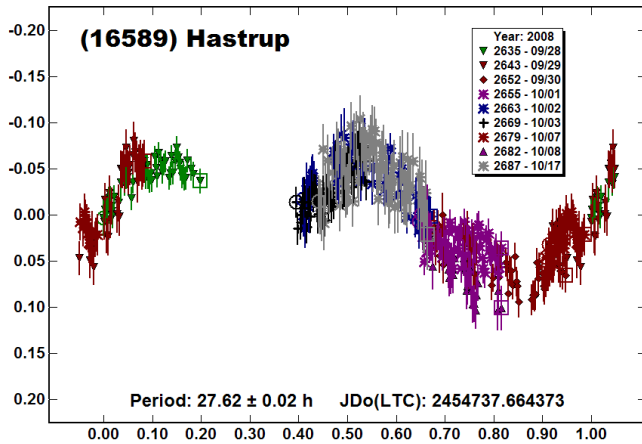
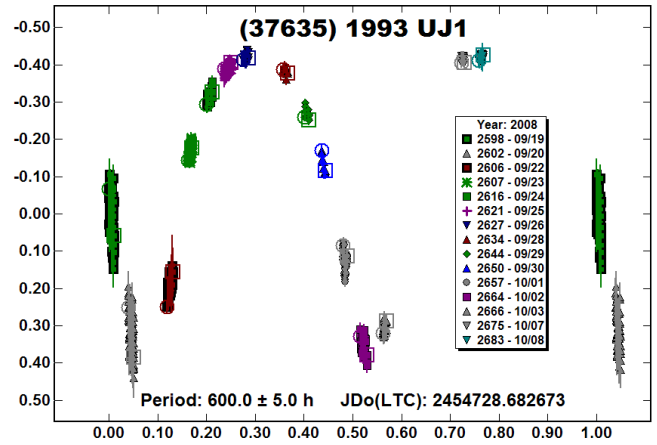
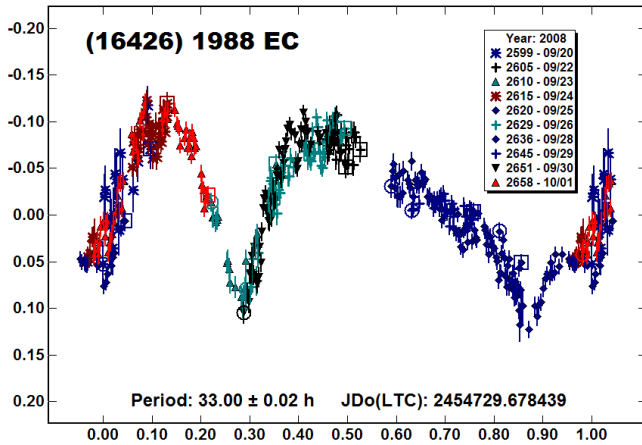
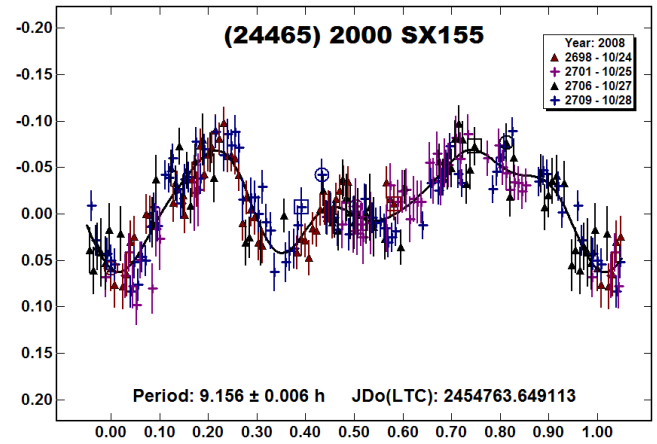
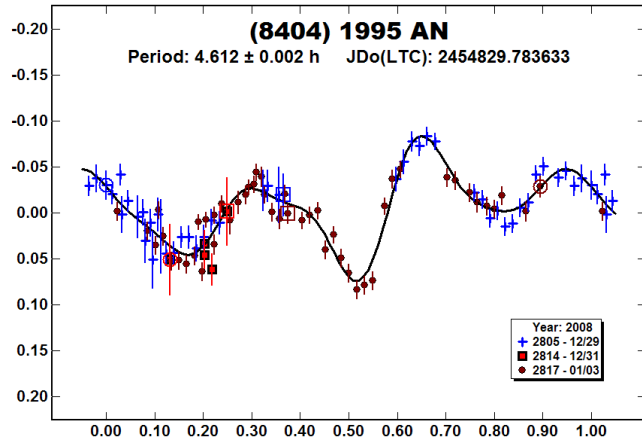
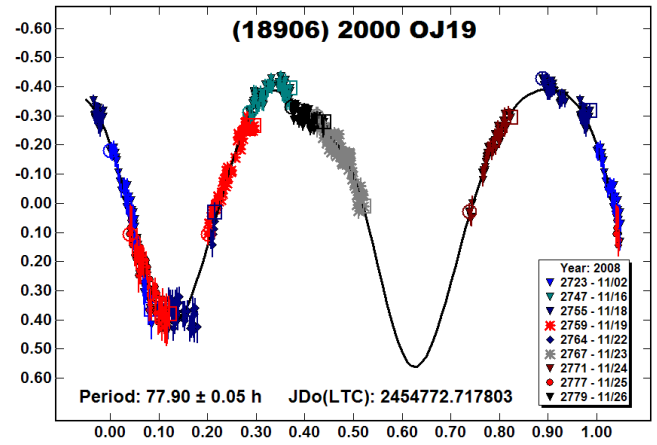
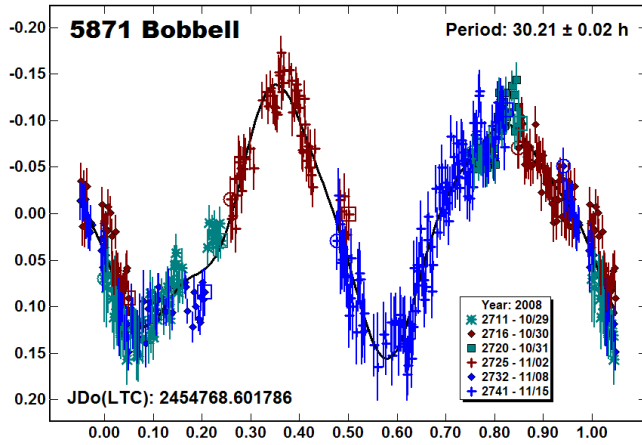
Tedesco, E.F. (1979). PhD Dissertation, 280 pp. New Mexico State University: Las Cruces.

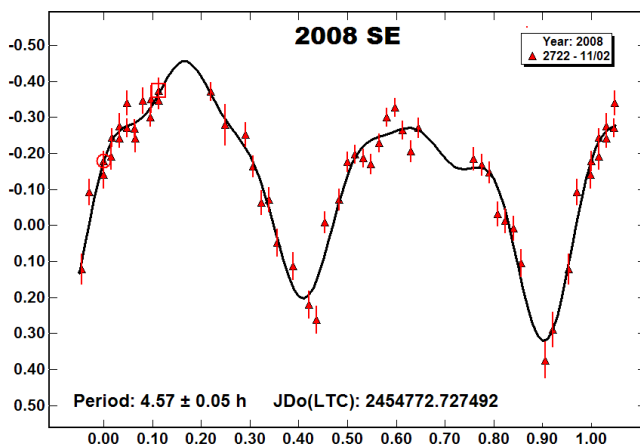
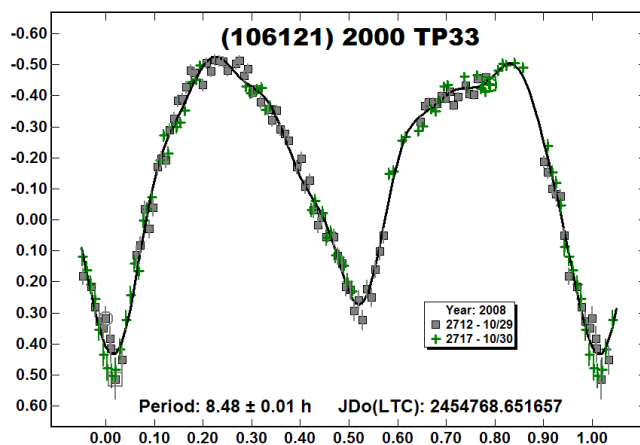
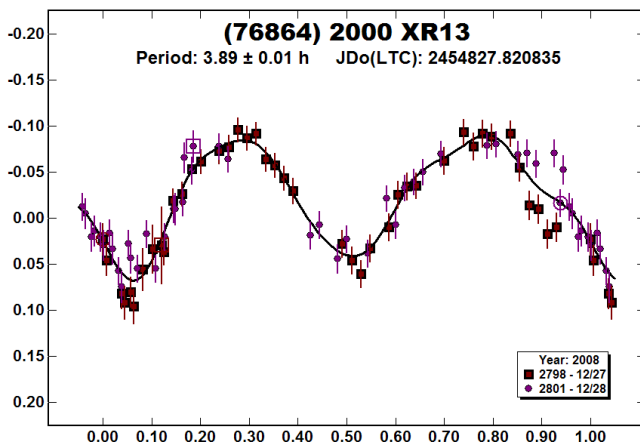
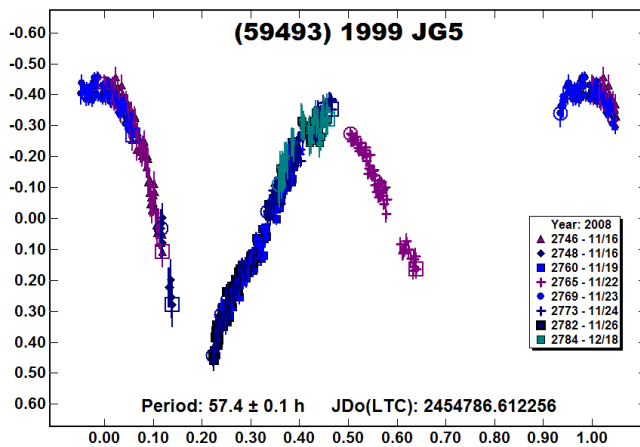
Warner, B.D. (2007a). "Asteroid lightcurve analysis at the Palmer Divide Observatory: December 2006–March 2007." *Minor Planet Bul.* **34**, 72-77.

Warner, B.D. (2007b). "Asteroid lightcurve analysis at the Palmer Divide Observatory: March–May 2007." *Minor Planet Bul.* **34**, 104-107.

Warner, B.D. (2007c). "Initial results of a dedicated H-G Project." *Minor Planet Bul.* **34**, 113-119.







## LIGHTCURVE PHOTOMETRY OPPORTUNITIES: 2009 APRIL-JUNE

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We present here four lists of “targets of opportunity” for the period 2009 April–June. 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, good relative photometry, where all differential values are based on a calibrated internal or standard zero point, is just as acceptable. 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  $15^\circ$  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 or 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](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 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.

In the first three sets of tables, Dec is the declination, U is the quality code of the lightcurve, and  $\alpha$  is the solar phase angle. For an explanation of the U code, see the documentation for the Lightcurve Database at <http://www.minorplanetobserver.com/astlc/LightcurveParameters.htm>. Objects with no U rating or 1 should be given higher priority when possible. Also note that a U = 2 rating could be the result of an ambiguous period solution. The one given here is the preferred but not necessarily the only period reported for a given asteroid. Regardless, you should not let the existing period influence your analysis since even high quality ratings have been proven wrong at times.

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### Lightcurve Opportunities

#	Name	Brightest				LCDB Data	
		Date	Mag	Dec	U	Period	Amp
5238	Naozane	4 01.5	14.6	-11			
	2008 SV11	4 02.5	13.2	+27			
4417	Lecar	4 04.5	14.5	-10			
907	Rhoda	4 05.1	13.2	+8	2+	22.44	0.16
4171	Carrasco	4 08.8	14.7	-6			
3909	Gladys	4 13.0	14.9	-15	1	6.83	0.15
4285	Hulkower	4 13.3	14.9	+7			
8359	1989 WD	4 21.1	14.8	-5	2	3.07	0.34
41588	2000 SC46	4 21.4	14.7	-38			

#	Name	Brightest				LCDB Data	
		Date	Mag	Dec	U	Period	Amp
1622	Chacornac	4 22.7	13.8	-18			
2610	Tuva	4 25.8	14.7	-13			
207	Hedda	5 01.6	12.1	-17	1	>12.	0.03
1197	Rhodesia	5 02.4	12.9	-28	2	16.06	0.22-0.32
93768	2000 WN22	5 03.8	14.7	+8			
11200	1999 CV121	5 08.9	14.4	-15			
2639	Planman	5 09.8	14.8	-7			
5773	1989 NO	5 10.3	14.9	-25			
8338	Ralhan	5 10.5	14.8	-6			
30003	2000 AO236	5 10.8	14.8	-22			
154	Bertha	5 11.9	11.7	-27	2	22.30	0.10-0.20
1195	Orangia	5 13.8	15.0	-30			
1506	Xosa	5 15.7	13.3	-19	2	5.90	0.28
1175	Margo	5 17.4	14.5	-20	2	6.01	0.31
6250	1991 VX1	5 17.4	15.0	-12			
3839	Bogaevskij	5 18.2	14.6	-20			
1068	Nofretete	5 18.2	14.7	-28	2	6.15	0.04
2635	Huggins	5 20.5	15.0	-25			
1729	Beryl	5 21.6	14.3	-24			
772	Tanete	5 23.6	11.8	-19	2	12.	0.10
6499	Michiko	5 26.8	14.9	-21			
5650	Mochihito-o	5 29.7	14.8	-24			
2182	Semirot	6 01.1	14.7	-23			
1146	Biarmia	6 01.7	12.8	-4	2	11.51	0.32
3873	Roddy	6 01.8	13.1	-21	2	2.47	0.09
3089	Oujianquan	6 02.8	14.0	-12	2	11.19	0.45
1341	Edmee	6 06.1	13.9	-11	2	11.89	0.30
2120	Tyumenia	6 06.2	14.2	-7	2	2.76	0.33
136617	1994 CC	6 06.8	12.5	-48			
1145	Robelmonte	6 06.9	13.4	-34	1	21.	0.05
2636	Lassell	6 08.0	14.7	-17			
393	Lampetia	6 09.6	10.6	-2	2	38.7	0.14
27139	1998 XX46	6 11.3	14.8	-32			
1232	Cortusa	6 13.7	13.7	-23	2	25.16	0.10
143651	2003 QO104	6 14.0	13.7	-48			
1128	Astrid	6 14.1	14.0	-24	2+	10.22	0.29
204	Kallisto	6 14.7	11.4	-10	2	14.1	0.08-0.25
1172	Aneas	6 14.9	14.7	-17	?		
1926	Medidelaer	6 14.9	14.8	-19	2	18.5	0.15
5831	Dizzy	6 15.0	15.0	-31			
884	Priamus	6 15.1	15.0	-30	?		
1543	Bourgeois	6 15.2	13.9	-33	1	2.48	0.03
6536	Vysochinska	6 15.8	15.0	-13	2+	6.10	0.53
2035	Stearns	6 17.4	13.3	-39	2	85.	0.7
3683	Baumann	6 17.9	15.0	-16			
3563	Canterbury	6 19.3	14.3	-23			
1772	Gagarin	6 20.0	15.0	-23	2	10.96	0.24
6634	1987 KB	6 20.3	14.2	-13	2	4.49	0.22
1947	Iso-Heikkila	6 21.0	14.8	-23			
23093	1999 XW136	6 22.2	14.7	-24			
7718	Desnoux	6 22.8	14.9	-27	1	19.	0.05
1609	Brenda	6 22.9	13.0	-14	2	19.46	0.16
3152	Jones	6 23.0	14.3	-33			
13832	1999 XR13	6 23.6	14.8	-26			
8260	1984 SH	6 23.8	15.0	-21			
3042	Zelinsky	6 26.4	15.0	-15			
6867	Kuwano	6 27.8	14.9	+1			
30262	2000 HP41	6 28.6	15.0	-28			
3968	Koptelov	6 29.6	15.0	-30	1	20.88	0.03
	2001 FE90	6 30.6	12.4	-22			

### Low Phase Angle Opportunities

#	Name	Date	$\alpha$	V	Dec	Period	Amp.	U
219	Thusnelda	4 06.2	0.51	12.8	-08	29.842	0.20	3
477	Italia	4 08.9	0.46	13.6	-09	19.42	0.16	0.64 3
184	Dejopeja	4 11.0	0.44	12.2	-09	6.455	0.25	0.3 3
757	Portlandia	4 21.6	0.82	13.4	-14	6.58	0.24	0.45 3
276	Adelheid	4 23.7	0.44	12.7	-11	6.32	0.07	0.18 3
429	Lotis	4 24.5	0.51	13.7	-14	13.577	0.24	3
119	Althaea	4 24.6	0.62	12.0	-11	11.484	0.36	3
74	Galatea	4 25.8	0.55	13.2	-12	8.628	0.09	3
122	Gerda	4 26.4	0.47	12.2	-12	10.685	0.26	3
207	Hedda	5 01.6	0.67	12.2	-17			
215	Oenone	5 02.1	0.27	13.2	-16	>20.	0.1	2
70	Panopaea	5 05.1	0.46	10.9	-15	15.797	0.12	3
311	Claudia	5 06.1	1.00	13.7	-14	7.532	0.16	0.89 4
24	Themis	5 06.8	0.11	11.0	-17	8.374	0.09	0.14 3
957	Camelia	5 07.0	0.86	13.8	-19	5.391	0.32	2
180	Garumna	5 11.5	0.51	13.8	-19	23.859	0.56	2
519	Sylvania	5 13.3	0.81	13.0	-21	17.962	0.40	3
1506	Xosa	5 15.6	0.22	13.3	-19	5.90	0.28	2
823	Sisigambis	5 16.8	0.94	13.7	-21	>12.	0.2	1
266	Aline	5 18.1	0.15	13.0	-19	12.3	0.05	2
26	Proserpina	5 18.9	0.53	10.3	-21	13.106	0.08	0.21 4
551	Ortrud	5 19.0	0.14	14.0	-20	13.05	0.16	2
240	Vanadis	5 19.8	0.81	13.4	-17	10.64	0.30	3



#	Name	Date	$\alpha$	V	Dec	Period	Amp.	U
149	Medusa	5 23.6	0.73	13.3	-19	26.		0.33 2
772	Tanete	5 23.6	0.55	11.9	-19	12.		0.10 2
144	Vibilia	5 30.2	0.36	11.6	-21	13.819		0.13 3
685	Hermia	5 30.2	0.88	13.4	-20	50.44		0.90 3
3873	Roddy	6 01.9	0.73	13.2	-21	2.4782		0.09 2
966	Muschi	6 02.1	0.21	12.5	-22	5.355		0.31 3
701	Oriola	6 05.9	0.72	13.2	-21	9.090		0.20 3
468	Lina	6 06.7	0.20	14.0	-23	16.33	0.10	0.18 3
441	Bathilde	6 10.6	0.43	12.5	-22	10.447		0.13 3
471	Papagena	6 11.9	0.38	11.2	-22	7.113	0.11	0.13 3
1232	Cortusa	6 13.7	0.15	13.8	-23	25.16		0.10 2
1128	Astrid	6 14.1	0.25	14.0	-24	10.228		0.29 3
158	Koronis	6 16.9	0.13	13.2	-24	14.206	0.28	0.43 4
1082	Pirola	6 25.3	0.86	14.0	-21			
367	Amicitia	6 30.9	0.59	13.4	-25	5.05		0.28 3

### Shape/Spin Modeling Opportunities

#	Name	Brightest Date	Mag	Dec	Per (h)	Amp.	U
146	Lucina	4 10.3	11.8	+10	18.557		0.08 3
54	Alexandra	4 16.3	11.3	-26	7.024	0.10	0.31 3
14	Irene	4 20.7	8.8	+01	15.06	0.08	0.12 3-
451	Patientia	5 04.8	11.4	-01	9.727	0.05	0.10 3
409	Aspasia	5 06.1	10.4	-22	9.022	0.10	0.14 3
24	Themis	5 06.8	11.0	-17	8.374	0.09	0.14 3
369	Aeria	5 07.5	12.5	-02	4.787		0.08 2
233	Asterope	5 17.9	11.7	-16	19.70		0.35 3
100	Hekate	5 25.7	11.5	-12	13.333		0.11 3
77	Frigga	5 28.3	12.5	-25	9.012	0.07	0.19 3
441	Bathilde	6 10.6	12.5	-22	10.447		0.13 3
190	Ismene	6 13.8	13.9	-15	6.52	0.12	0.15 3
372	Palma	6 14.3	13.1	-52	8.567	0.10	0.16 3
31	Euphrosyne	6 15.8	12.5	-53	5.531	0.09	0.13 2
97	Klotho	6 26.4	12.3	-08	35.15	0.07	0.25 3

### 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  $\alpha$  is the phase angle.

#### 2008 SV11 (2009 March-April)

2008 SV11 is estimated to be 2 km in size. The observing window for backyard instruments is about three weeks starting in late March; larger instruments may be able to follow the asteroid for a little longer. There are no known lightcurve parameters. Note the ephemeris interval of 3 days.

DATE	RA(2000)	DC(2000)	E.D.	S.D.	Mag	$\alpha$
03/28	3 22.76	+48 53.1	0.053	0.972	16.46	118.0
03/31	7 33.28	+51 52.0	0.037	1.003	13.93	82.6
04/03	10 39.39	+22 44.6	0.046	1.035	13.20	40.5
04/06	11 33.01	+05 23.0	0.072	1.067	13.73	23.0
04/09	11 55.49	-02 28.2	0.103	1.099	14.39	17.6
04/12	12 07.81	-06 38.9	0.136	1.132	15.01	16.2
04/15	12 15.70	-09 11.0	0.170	1.165	15.56	16.3
04/18	12 21.34	-10 51.6	0.205	1.198	16.05	16.9

#### (143651) 2003 QO104 (2009 April-June)

2003 QO104 is estimated to be 2 km in size. It will be available to backyard telescopes for the entire second quarter of 2009, favoring northern observers at first and then moving quickly south in late May. There are no known lightcurve parameters. Note the ephemeris interval of 10 days.

DATE	RA(2000)	DC(2000)	E.D.	S.D.	Mag	$\alpha$
04/01	10 58.16	+46 28.0	0.352	1.232	15.83	42.1
04/11	10 41.65	+45 55.4	0.313	1.172	15.70	50.5
04/21	10 29.21	+43 36.1	0.274	1.118	15.55	59.0
05/01	10 21.93	+39 15.4	0.232	1.074	15.36	67.4
05/11	10 19.20	+32 11.1	0.189	1.041	15.10	75.5
05/21	10 19.31	+20 25.1	0.145	1.021	14.74	82.5
05/31	10 21.22	-00 27.2	0.109	1.015	14.24	86.1
06/10	10 25.19	-33 42.5	0.095	1.025	13.78	81.3
06/20	10 38.26	-65 52.4	0.113	1.049	13.82	70.1
06/30	12 39.88	-84 53.9	0.153	1.086	14.23	59.4

#### (175706) 1996 FG3 (2009 March-April)

1996 FG3 is a known binary system (e.g., Pravec et al., 2000; Pravec et al., 2006; Scheirich and Pravec, in press). It is also a candidate for observing the Yarkovsky effect (Vokrouhlický et al., 2005), which causes the orbit of an asteroid to expand or contract due to thermal radiation of absorbed sunlight. The asteroid will be available for most of April. Although it is a little faint for backyard telescopes, it will be moving fairly slowly, which allows for longer exposures without excessive trailing. Note the ephemeris interval of 10 days.

DATE	RA(2000)	DC(2000)	E.D.	S.D.	Mag	$\alpha$
04/01	10 58.16	+46 28.0	0.352	1.232	15.83	42.1
04/11	10 41.65	+45 55.4	0.313	1.172	15.70	50.5
04/21	10 29.21	+43 36.1	0.274	1.118	15.55	59.0
05/01	10 21.93	+39 15.4	0.232	1.074	15.36	67.4
05/11	10 19.20	+32 11.1	0.189	1.041	15.10	75.5
05/21	10 19.31	+20 25.1	0.145	1.021	14.74	82.5
05/31	10 21.22	-00 27.2	0.109	1.015	14.24	86.1
06/10	10 25.19	-33 42.5	0.095	1.025	13.78	81.3
06/20	10 38.26	-65 52.4	0.113	1.049	13.82	70.1
06/30	12 39.88	-84 53.9	0.153	1.086	14.23	59.4

#### 2001 FE90 (2009 June-July)

2001 FE90 is estimated to be only 0.35 km in size. Northern Hemisphere observers will have only a few days in late June to work this asteroid. After that it moves quickly into the southern sky. There are no known lightcurve parameters. Note the ephemeris interval of 3 days.

DATE	RA(2000)	DC(2000)	E.D.	S.D.	Mag	$\alpha$
06/23	12 31.62	+39 37.1	0.038	1.010	16.23	98.1
06/26	13 57.14	+28 02.2	0.024	1.020	14.54	80.1
06/29	16 16.09	-04 35.7	0.019	1.031	12.72	37.0
07/02	18 21.94	-31 35.9	0.027	1.044	12.70	9.6
07/05	19 32.30	-40 05.5	0.042	1.057	13.98	18.1
07/08	20 09.68	-42 54.2	0.059	1.070	14.87	22.7
07/11	20 31.26	-44 01.6	0.076	1.085	15.52	24.5
07/14	20 44.64	-44 30.5	0.094	1.101	16.02	24.9
07/17	20 53.34	-44 41.1	0.112	1.117	16.43	24.7

#### (136617) 1994 CC (2009 May-June)

1994 CC is estimated to be 0.9 km in size. This one is almost exclusively for Southern Hemisphere observers since it will linger well south of the celestial equator until its close pass in the middle of June. At that time it jumps into the northern sky but also fades very rapidly. There are no known lightcurve parameters. Note the ephemeris interval of 5 days.

DATE	RA(2000)	DC(2000)	E.D.	S.D.	Mag	$\alpha$
05/01	14 02.25	-34 11.1	0.209	1.205	15.70	16.9
05/06	13 56.22	-35 08.6	0.179	1.176	15.39	19.1
05/11	13 48.87	-36 08.2	0.151	1.148	15.08	22.6
05/16	13 39.78	-37 13.6	0.125	1.121	14.74	27.1
05/21	13 27.93	-38 31.7	0.100	1.094	14.37	32.8
05/26	13 10.70	-40 17.5	0.075	1.070	13.92	40.0
05/31	12 39.90	-43 04.9	0.052	1.047	13.34	49.8
06/05	11 18.02	-47 37.4	0.030	1.026	12.66	67.7
06/10	6 44.32	-33 13.4	0.017	1.007	13.71	118.9
06/15	3 53.47	+08 24.8	0.029	0.991	18.68	151.0

## IN THIS ISSUE

This list gives those asteroids in this issue for which physical observations (excluding astrometric only) were made. This includes lightcurves, color index, and H-G determinations, etc. In some cases, no specific results are reported due to a lack of or poor quality data. The page number is for the first page of the paper mentioning the asteroid. EP is the "go to page" value in the electronic version.

Number	Name	PG	EP
31	Euphrosyne	52	18
35	Leukothea	52	18
56	Melete	52	18
99	Dike	55	21
110	Lydia	38	4
135	Hertha	38	4
137	Meliboea	52	18
145	Adenona	59	25
155	Scylla	51	17
155	Scylla	52	18
178	Belisana	68	34
182	Elsa	40	6
216	Kleopatra	69	35
222	Lucia	59	25
264	Libussa	52	18
313	Chaldea	55	21
343	Ostara	59	25
482	Petrina	59	25
541	Deborah	35	1
624	Hektor	59	25
683	Lanzia	48	14
813	Baumeia	64	30
872	Holda	55	21
911	Agamemnon	59	25
914	Palisana	70	36
923	Herluga	64	30
956	Elisa	35	1
1022	Olympiada	35	1
1071	Brita	35	1
1073	Gellivara	59	25
1274	Delportia	55	21
1316	Kasan	59	25
1339	Desagneauxa	45	11
1437	Diomedes	59	25
1481	Tubingia	64	30
1510	Charlois	45	11
1672	Gazelle	64	30
1717	Arlon	64	30
1724	Vladimir	35	1
2358	Bahner	51	17
2397	Lappajarvi	45	11
2973	Paola	64	30
3051	Nantong	45	11
3225	Hoag	70	36
3316	Herzberg	42	8
3335	Quangzhou	45	11
3407	Jimmysimms	45	11
3928	Randa	64	30
3971	Voronikhin	45	11
4031	Mueller	70	36
4086	Podalirius	59	25
4265	Kani	66	32
4512	Sinuhe	45	11
5010	Amenemhet	35	1
5390	Huichiming	70	36
5579	Uhlherr	70	36
5871	Bobbell	70	36
5905	Johnson	54	20
6377	Cagney	42	8
7304	Namiki	55	21
7516	Kranjc	50	16
7683	Glabman	64	30
7965	Katsuhiko	50	16
8404	1995 AN	70	36
8567	1996 HW1	35	1
12880	Juliegrady	42	8
14040	Andrejka	42	8
15515	1999 VN80	50	16
16426	1988 EC	70	36

16589	Hastrup	70	36
18906	2000 OJ19	70	36
24222	1999 XW74	42	8
24465	2000 SX155	70	36
32776	Nriag	42	8
37635	1993 UJ1	70	36
41672	2000 TX36	70	36
51840	2001 OH65	42	8
57478	20001 SW151	42	8
59493	1999 JG5	70	36
76818	2000 RG79	62	28
76864	2000 XR13	70	36
106121	2000 TP33	70	36
153462	2001 RE2	42	8
162900	2001 HG31	56	22
185851	2000 DP107	62	28
190637	2000 WE155	42	8
	1998 BE7	41	7
	2008 SE	70	36
	2008 TC3	58	24

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\* \* \* \* \*

The deadline for the next issue (36-3) is April 15, 2009. The deadline for issue 36-4 is July 15, 2009.